M.AETM

Master of Agri-Enterprise & Technology Management

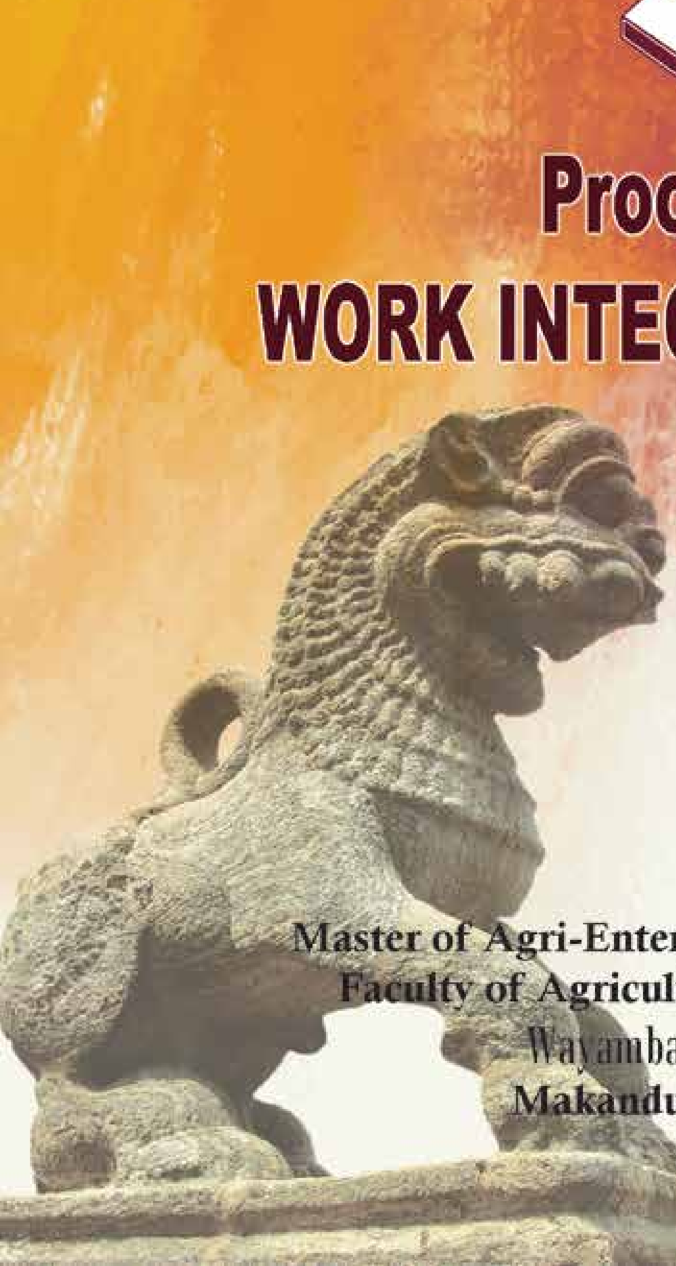
PROCEEDINGS OF WORK INTEGRATED LEARNING 2020

Faculty of Agriculture and Plantation Management

Wayamba University of Sri Lanka

Wayamba University of Sri Lanka

Proceedings of WORK INTEGRATED LEARNING 2020



Master of Agri-Enterprise & Technology Management
Faculty of Agriculture & Plantation Management
Wayamba University of Sri Lanka
Makandura, Gonawila (NWP)

Faculty of Agriculture and Plantation Management

Vision

To achieve excellence in agricultural education, research, technology and training for developing human resources to meet regional, national and global needs

Mission

To develop innovative, skilled, trained manpower and their capabilities in Agriculture to fulfill national and global needs through undergraduate and postgraduate education, research and outreach

Faculty of Agriculture and Plantation Management

With the realization of the needs of the farmers, public and private sectors, FAPM has formulated innovative courses to meet the challenges of the dynamic agriculture sector in the country and to improve links with stakeholders through in-plant training, field visits, seminars, workshops and surveys.

Currently, FAPM offers three undergraduate degree programmes, two Postgraduate degree programmes and a Diploma with the collective action of all the five Departments.

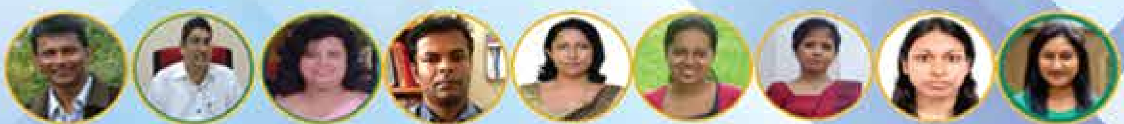
- ***Undergraduate Degree Programmes***
  - ✓ *B.Sc. Hons. (Agriculture)*
  - ✓ *Bachelor of Biosystems Technology (BBST)*
  - ✓ *B.Sc. (Plantation Management) – External*

- ***Postgraduate Degree Programmes***
  - ✓ *Master of Agri-Enterprise & Technology Management*
  - ✓ *M.Phil and PhD*

- ***Diploma Programme***
  - ✓ *Diploma in Food Business & Marketing*

FAPM has strengthened itself with a well-experienced team of lecturers to effectively disseminate multi-disciplinary knowledge on the fundamental concepts, principles, practices and technologies relevant to Agriculture.

DEPARTMENT OF
AGRIBUSINESS MANAGEMENT



Staff Members

Jagath Udith Rupika Keminda Kusum Menuka Anjalee Shashika Nimanthika

Department of Bio-Systems Engineering

"Bio-Systems engineering is an innovative field of engineering which integrates engineering science and design with applied biological, environmental and agricultural sciences. We aim to produce competent graduates with the knowledge, skills and experience to develop sustainable and resilient engineered solutions to local and global challenges and life's essentials: food, water, energy, environment, and health; at national and global scales."

Department of Biotechnology

Biotechnology...pathway for new horizons in the well-being of humans & Nature

The Department of Biotechnology at FAPM is a leading department for biotechnology education in Sri Lanka

Modern laboratory with sophisticated instruments to perform

Molecular Analysis

Genetic Engineering

Bioinformatics

Molecular Microbiology

Plant Tissue Culture

Highly qualified team of academics comprising a Chair Professor, Professor, four Senior Lecturers and a Lecturer, expertise in all aspects of Biotechnology

Impart students to excel in the field of Biotechnology by providing comprehensive & multidisciplinary Biotechnology courses & advanced research opportunities

BitSoc Outreach arm of the Department

Wajira Balasooriya

Thilak Attanayaka

Nisha Kottearachchi

Mewan Kooragodage

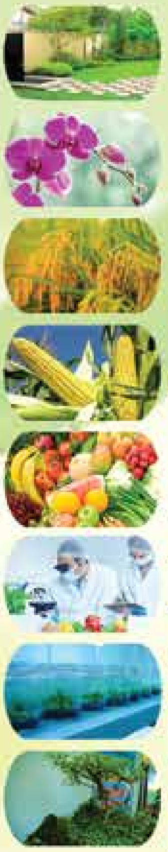
Gimhani Dikkumburage

Priyanwada Warakagoda

Madhavi Dasanayaka

Contact for more details: dept.biotec@wyb.ac.lk, https://fapm.wyb.ac.lk

Department of Horticulture & Landscape Gardening



Horticulture, as a core component of agriculture, is a science, an art and a trade which encompasses crop production and beautification of the environment

Department covers academic, research and outreach activities related to diversified areas in agriculture and train the graduates to be professional Horticulturists and Horticultural Scientists via two specialization areas, Horticulture & Landscape Gardening and Postharvest Horticulture.
The team consists of a Chair Professor, Professor, five Senior Lecturers and five Lecturers.

- **Crop Production and Improvement**
- **Landscape Design**
- **Crop Protection**
- **Postharvest Technology**
- **Food Processing, Safety & Quality Assurance**

Our Prestigious Alumni

Contact Our Team

horticulture@wyb.ac.lk

+94-31-2299704

https://fapm.wyb.ac.lk

Staff members

Prasanthi Perera

Kapila Yakandawala

Bandula Ranaweera

Wishwajith Kandegama

Kamani Rathnayake

Geethi Pamunuwa

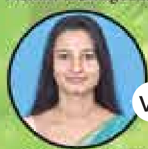
Surantha Salgadoe

Erandi Wijesinghe

Dinusha Debarawatta

Nirma Subashini

Achini Dewagedara

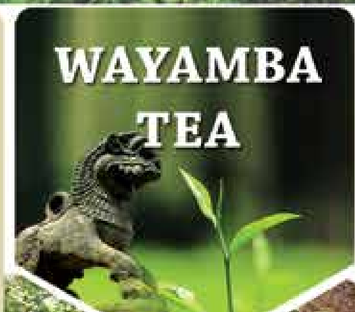


Amanda Bandara

Department of PLANTATION MANAGEMENT

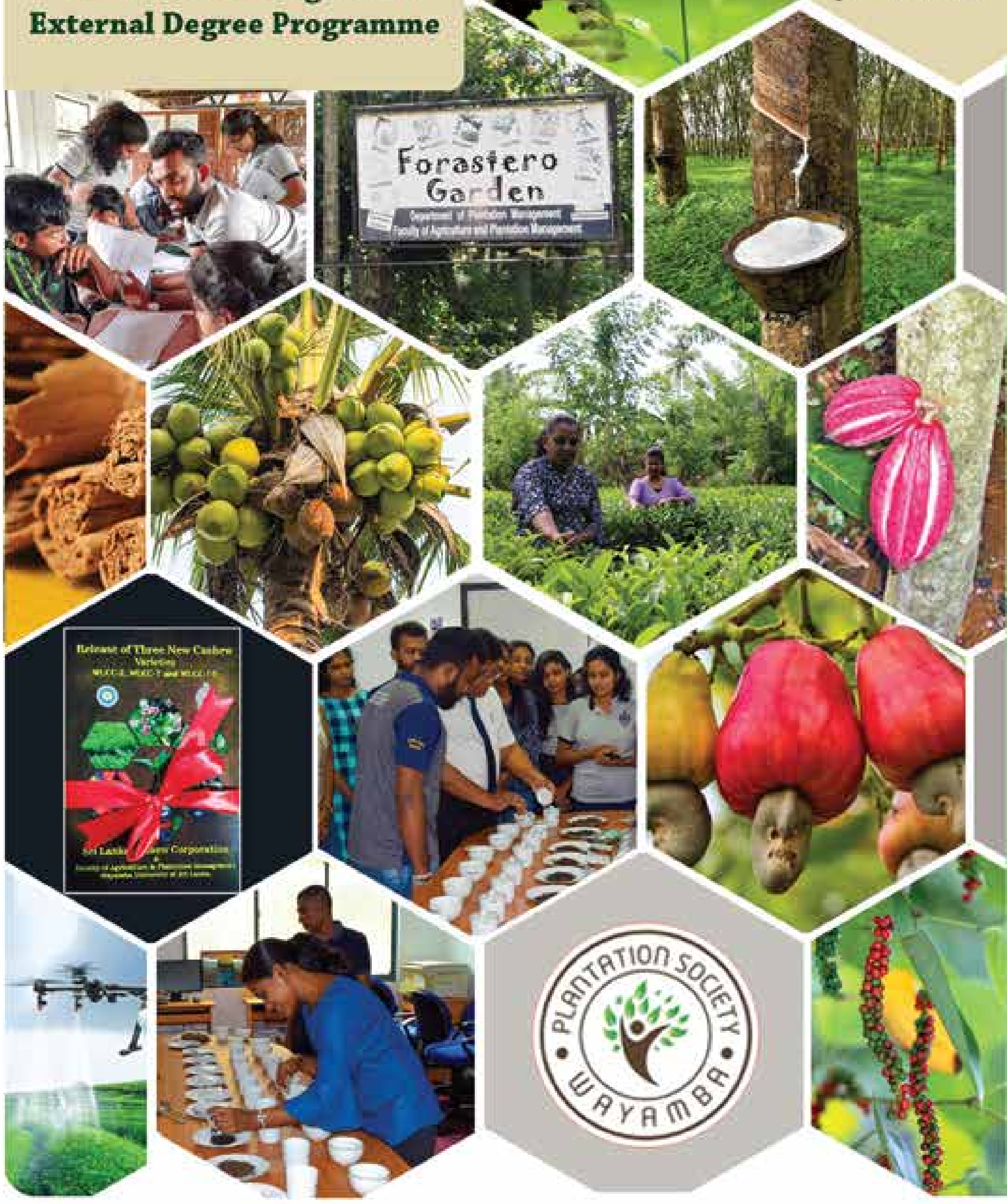
To provide the graduates with scientific knowledge and practical know-how in agronomic, manufacturing, marketing & the management aspects of plantation & other crops and inculcate managerial skills and confidence in decision making with respect to resource allocation in farms/plantations.

B.Sc.
Plantation Management External Degree Programme



Our Team

Our department is having a team of academics capable of providing knowledge and skills related to Sustainable Plantation Management, Export Agriculture, Soil Health and Precision Agriculture.
Team includes one Professor, four Senior Lecturers, and five Lecturers.



Bandara Gajanayake

Chandana Abeysinghe

Jayantha Weerakkody

Wasantha Gunathilake

Indika Herath

Shyanika Lakmali

Apsara Amarasinghe

Janaka Wickramasinghe

Indeewara Amadoru

Indika Karunarathna

Welcome to.....

M.AETM

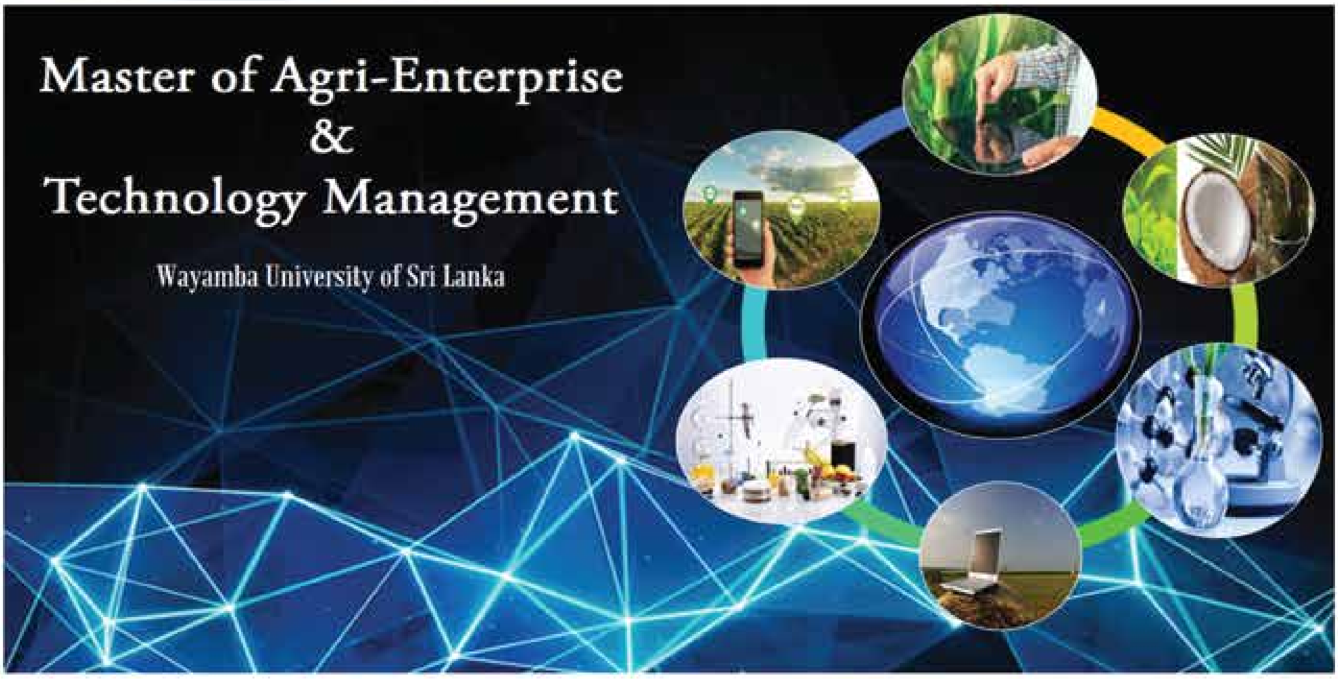
Master of Agri-Enterprise & Technology Management

Agricultural education, technology and trade have been the prime movers of economic prosperity in a country like Sri Lanka, where a majority of the population is directly or indirectly involved with activities related to agriculture, agri-food business and/or agri-food based technologies. In the light of this, the opportunities for those who are skilled in these concentrations would be in high demand and the employment potential for well-trained skilled personnel would increase from rural to urban setup.

With the realization of the present demand for Agri-Food Based Enterprises and Technologies, Faculty of Agriculture & Plantation Management launched its first-ever postgraduate degree programme as **"Master of Agri-Enterprise & Technology Management"** (**M.AETM**) from February 2019 onwards.

M.AETM is one of the most systematically set postgraduate programmes that involves the **latest teaching-learning, assessment and skills development methodologies and technologies** in higher education. It is a postgraduate programme of **ONE ACADEMIC YEAR with SIX CONCENTRATIONS** to specialize on the interests of students. In fact, this would be a fast-track approach that uses student experience and exposure into the count for assessment, rather than attending to ad-hoc classroom-based examinations.

M.AETM ....



M.AETM is designed to augment the career trajectory of the professionals and practitioners in the fields of agriculture by improving their ability to apply new and emerging scientific findings and technologies to the advancement and expansion of their disciplines through successful completion of high quality courses designed to support expertise expansion in targeted areas or disciplines (i.e. Concentrations); lively participation in an immersion-based continuous assessments, project-based experiences, and work-integrated learning-based internships media.

Director of MAETM Programme

Snr. Prof. Udith K. Jayasinghe

Board of Study

Dr. Radhika Gimhani
(Academic Coordinator)

Prof. Jagath Edirisinghe
Prof. Prasanthi Perera
Dr. Sarananda Hewage
Dr. Bandara Gajanayake
Dr. Wajira Balasooriya

Prof. Kapila Yakandawala
(Senate Nominee)

Dr. Sanathanie Ranasinghe
(External Member)

Dr. Roshan Rajadurai
(External Member)

Ms. Dulani Jayakodi
(Administrative Coordinator)

Key Features of M.AETM

Entry Qualifications

- A Bachelor's degree in Agriculture, Plantation Management or Biosystems Technology obtained from a recognized University
- A Bachelor's degree in fields of Natural Sciences, Business Studies, Management or Commerce
- A recognized Professional Qualification (analogous to a degree) related to Agriculture, Plantation Management, Bio-Systems Technology, Natural Sciences, Business Studies, Management or Commerce with a minimum of three years' post qualifying working experience in a field related to one of the Concentrations specified.
- Any other qualification not listed above, but may be considered case by case and acceptable to the Board of Study and the Senate of WUSL.

Concentrations

Students can select to study on ONE of six Concentrations, including

(1) Agri-Food Economics & Business

(2) Bio-Systems Technology

(3) Biotechnology

(4) Food Production & Manufacturing

(5) Lifestyle Agriculture

(6) Plantation Agriculture

Total Credits

30 Credits contribute to the final grade (GPA course units) and 04 Non-GPA course units

Duration

One Academic Year consists of 02 Semesters, based on Course Credit System

Key Expertise Areas of Learning

Teaching and Learning

Curriculum is designed on '**Outcome-Based Education**' **(OBE)** and an innovative and interactive '**Student-Centered Teaching and Learning Methods**' and '**Formative and Summative Assessment Criteria**'.

The '**Choice**' **of selecting a field/s of specializing an area of study of his/her personal interest** - called as **Concentration**

A variety of **Teaching - Learning Methodologies and Technologies**, including group work involving experiential learning (problem based), evaluating case studies, presentations and individual tutorials will be used to develop intellectual skills, practical, professional skills and communication skills

Agri-Food Economics & Business

Investments in Agriculture Make Life Better for Billons of People ......

Economics of Quality Management in Food & Agricultural Products

Supply Chain Management in Food & Agribusiness

Advanced Trade Policy Analysis

Applied Demand & Market Analysis

Modern Marketing Strategy for Agri-Food Business

Agri-business and food processing are important parts of modernizing the economy and agriculture to move into a phase where a more modernized agriculture economy not only helps farmers but also the consumers

Bio-Systems Technology

The Great Growing Engine of Change …..

Instrumentation and Control Applications in Agriculture

Geo-Informatics for Agriculture and Environmental Management

Cleaner Production & Green Technologies

Energy Management for Sustainable Agriculture

To improve quality of life by integrating and applying principles of engineering and biology to systems involving food, environment, energy, and health.

Biotechnology

Tool of Seeking New Potentials of the Biological World ......

Microbial Resources and Industrial Biotechnology

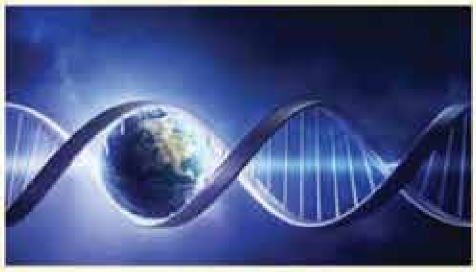
Molecular and Omics Biology

Plant Biotechnology for Advancement in Agriculture

Animal Biotechnology and Bioethics

Computational Biology

Biotechnology is a diverse discipline in which biological systems are exploited and manipulated to harness the benefits to people by creating novel and superior platforms to uplift the quality of life.



Food Production & Manufacturing

The Structure and Activities of the Whole Community Depend Upon the Question of Food Supply ......

Advanced Food Processing and Preservation Technologies

Plant Bioactive Compounds and Human Health Benefits

Sustainable Fisheries and Aquaculture Product Management

Managing Postharvest Longevity of Agricultural Produce

Chemical Residue Free Agricultural Production

Technology is reshaping the food industry. Each and every member of the industry, from farm to fork is creating a culture where food safety and nutrition is paramount.

Lifestyle Agriculture

Agriculture is Not Just a Hobby or Employment it is Life ....

Modern Postharvest Technology

Environmental Horticulture

High Yielding Farming

Seeds and Plant Genetic Resources

Urban Agriculture

Agriculture is both a way of life and a business, where the ultimate goal is nourishing and perfecting the lives of people. It is time to step up and shape the industry with a modern touch.

Plantation Agriculture

Reaping the Benefits of Technology for
Sustainable and Efficient Production ……

Plantation Produce Forecasting and Monitoring

Spatial Technologies for Plantation Agriculture

Sustainable Management Process for
Certification in Plantations

Legal Environment for
Conflicts Resolution in Plantations

e-Agriculture Applications for Plantations

Modernization of the plantation industry with three main pillars along with the scent of spices to achieve the sustainability with the intervention of precision agriculture technologies.

An Annotation……
from the Director – M.AETM / Dean - FAPM

Snr. Prof. Udith K. Jayasinghe-Mudalige

*.....the **M.AETM** was planned, since its inception,.......and in turn,........administered under my direction,.......with the intention of developing both 'hard' and 'life' skills of a potential candidate to.......*

Identify the constraints that one faced as he/she is practically involved with different types of agricultural, business, technological, socio-economic and policy/regulatory environments........

Coordinate the limited resources available to get the optimum level of output/s and outcome/s to the satisfaction of stakeholders, and.........

Recommend possible solutions to overcome the existing/potential negative effects of such issues to increase the effectiveness, efficiency and productivity of said operations..........

***We Report.... You Decide**..........extent to which we as a Faculty achieved these intentions.........*

Excellence is Not An Accident...

@ Faculty of Agriculture & Plantation Management, WUSL
04 April 2020

Note.....
from the Academic Coordinator – M.AETM

Dr. D. R. Gimhani

.......the M.AETM degree was designed, launched and coordinated by the FAPM to disseminate the state-of-the-art knowledge by integrating Agriculture-Enterprise and Technology Management aiming to model the candidates to be a partner of the re-modulating Smart Agricultural Enterprise system to fit into the present needs. As the Academic Coordinator of M.AETM, I'm happy to report....... and share......... this success story which would be witnessed......... by you.

We never....... dream about success.........but worked for it.......

@ Faculty of Agriculture & Plantation Management, WUSL
04 April 2020

Editorial Board

M.AETM Administrative Coordinators

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Note of Appreciation

The M.AETM of FAPM owns the success of its activities, as a whole, to a longstanding partnership it possesses with the private (non-government) sector enterprises and public institutions in Sri Lanka. The Board of Study in M.AETM and the Board of Editors of this publication thank very specially to the Expert Reviewers of respective articles and those Institutions that provide opportunities / give consent for M.AETM candidates to carry out this Work Integrated Learning component of their degree, and we believe firmly that the information disseminated through these articles could not be produced without their co-operation and good-will. The responsibility of the analysis, interpretations of the results, and the policy views, whether explicitly stated, inferred or interpreted from the content of each article of the Author who is fulfilling his/her partial requirement to have a Master of Agri-Enterprise & Technology Management.

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GREENING ACADEMIA: DEVELOPMENT OF SUSTAINABLE WASTE MANAGEMENT SYSTEM AT THE NATIONAL INSTITUTE OF BUSINESS MANAGEMENT (NIBM)

Nimeshika Malshani Aloysius

School of Business, National Institute of Business Management, 120/5, Vidya Mawatha, Colombo 07, 00700

INTRODUCTION

Disposal of solid waste (SW) has been considered a stinging and widespread problem for the countries, irrespective of developed or developing, and the societies, for example urban *vs.* rural. An estimated 11.2 billion tons of SW is collected annually worldwide contributing to about 5 percent of global greenhouse gas emissions (United Nations Environment Programme, 2019). The annual waste generation is expected to grow by 70 percent in 2050, with the increasing urbanization and population growth (The World Bank, 2019). Poor waste management systems that can be ranging from non-existing collection systems to ineffective disposal create serious health, safety and environmental consequences.

Current Status in Sri Lanka

Sri Lanka generates about 7,000 t of SW per day. Yet, only a half of the waste generated is, on an average, collected, as the country lacks, from one hand, well-organized methods of controlling waste and high costs associated with collection and transportation, on the other. SW in Sri Lanka typically consists of a high percentage of biodegradable material, *i.e.* about 62 percent, with moderate amounts of paper, polythene and plastics and low contents of metal and glass (Table 1).

Table 1: Composition of Waste Generated in Sri Lanka

Waste Type	Percentage (%)
Biodegradable	62
Paper	07
Polythene and Plastic	06
Metal	03
Glass	02
Other	20

Source: National Solid Waste Management Programme in Sri Lanka

The SW issue has reached a level of catastrophe in Sri Lanka primarily due to lack of public participation. For the last two decades, the relevant government institutions have attempted to come up with a waste management strategy for the country, but such programmes faced the issues with sustainability.

Justification

The increase in the number of students and facilities has led the Higher Education Institutions to accumulate large amounts of SW, which causes significant health, economic and environmental impacts. Ensuring the sustainability of methods in use for waste management is, therefore, of paramount importance to be taken care of as they are accountable for forming behavioural patterns that impact the society.

A sound environmental management is achieved when the '3R concept' (*i.e.* Reduce, Reuse and Recycle) is implemented according to its order, *i.e.* emphasizes on reducing the resources and energy used; reusing raw materials and recovered waste, and increasing the ratio of recyclable materials. This study describes the case of implementing an environmentally sound waste management project at the National Institute of Business Management (NIBM) with the objective of enhancing its efficiency and sustainability by 2025.

SOLID WASTE MANAGEMENT PROJECT

The proposed SW management project provides a new approach to change the way NIBM perceives on and act and handle its waste. The strategy prioritizes prevention of waste generation, promoting responsible consumption and avoiding waste. Awareness programmes to be organized at the institutional level for both students and staff on responsible consumption of food and other resources ensuring sustainability.

All types of waste cannot be avoided; therefore, recovery of materials and energy from waste as well as remanufacturing and recycling waste into usable products become the second option. Treatment of organic material in the waste stream is essential in order to reduce the volume of SW to be disposed. The project proposes an Integrated Organic Waste Processing Facility, which has been designed to have minimum environmental impacts (Figure 1).

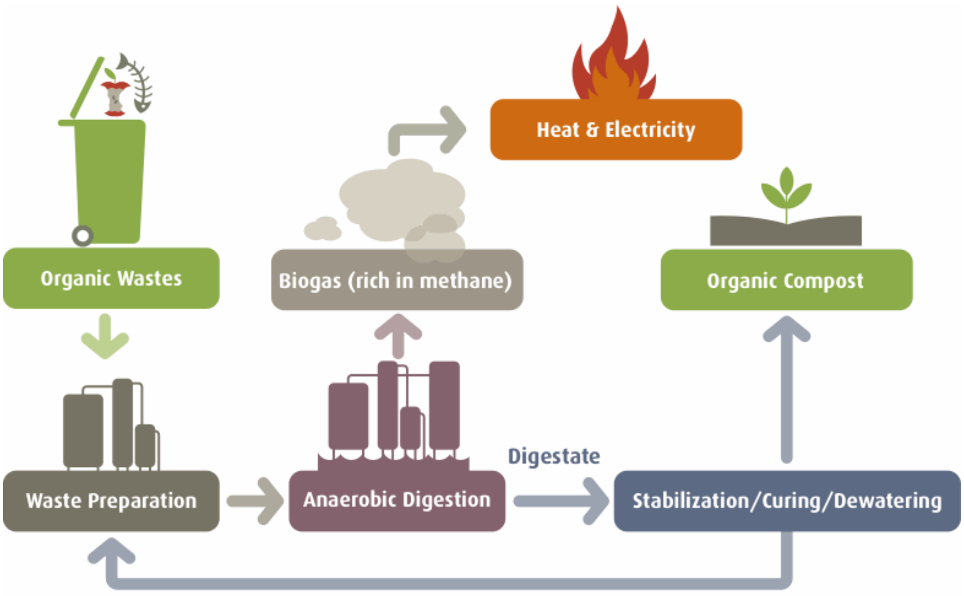

Figure 1: Organic Waste Processing Facility
Source: https://biogasdecisiontree.wordpress.com/the-science/

The design consists of a Biological Treatment Plant that has capacity to process the fast degradable, high moisture content organic waste in a Wet Fermentation Anaerobic Digestion System. Anaerobic decomposition is a naturally occurring process that produces 'biogas', containing methane, *i.e.* a greenhouse gas. The process takes place in a controlled environment where the biogas collected is combusted to produce electricity. Additionally, the plant generates liquid and solid fertilizer from biological treatment of the residuals. The process allows recovery of not only the energy, but also the nutrients in the waste stream. SW that are not likely to be recovered at the NIBM, such as plastic, polythene, metal and electronic wastes are to be transferred to recycling companies.

PROJECT IMPLEMENTATION

As a strategy to reduce the waste, the institute has already taken initiatives for a "paperless" education system by implementing an online platform: '*NIBM World Wide*'. The current waste disposal process at NIBM, where waste is discarded in separate bins highly favours the implementation of the next step of the project, *i.e.* the 'Organic Waste Processing Facility'. It is assumed that the institute will allocate the finance and human resources needed through its budget in 2021 and implementation of full project facility in all five Regional Campuses is expected to be completed by the end of 2022. The construction of anaerobic digester, biogas plant and energy converter is to be outsourced as it needs industry expertise knowledge.

The project will be monitored throughout this time and be evaluated using standard benefit-cost analysis methods in 2023. The reduced amount of organic waste collected by the municipal councils and the amount of electricity generated in the biogas plant which is used up as an alternative energy for hydroelectricity will denote the success of the organic waste processing facility.

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Author:

Nimeshika Malshani Aloysius: Lecturer attached to the School of Business, National Institute of Business Management (NIBM) of Sri Lanka. She holds B.Sc. (Agric.) [First Class Hons] from WUSL and currently engages in teaching and research in the fields of Environmental Management and Resource Economics (e-Mail: *nimeshika@nibm.lk*)

Reviewer:

Udith K. Jayasinghe-Mudalige: Senior Professor and the Chair of Department of Agribusiness Management of FAPM, WUSL. His teaching and research interests include: Food and Agricultural Economics, Development & Policy, Project Management, and Quality Assurance in Higher Education (e-Mail: *udith@wyb.ac.lk*)

A STRATEGY FOR IMPROVING FARMERS' ENTREPRENEURIAL AND MANAGEMENT SKILLS: FARM BUSINESS SCHOOL

Jagath Rohan Samarasinghe

Project Management & Consultancy Division, Industrial Services Bureau, No. 141, Kandy Road, Kurunegala, 60000

INTRODUCTION

Sri Lanka is an upper middle-income country with a GDP per capita of US$ 3,947 (2019) and a total population of 21.3 million people. The annual growth rate of GDP in Sri Lanka averaged 5.60 percent from 2003 to 2019, resulting in a significant poverty reduction. Agriculture has been an important driver of poverty alleviation and accounted for about one third of the decline in poverty over the past decade. Poverty reduction in rural areas was driven by higher agricultural wages, which grew annually by an average of 5.7 percent from 2006 to 2016, and caused the rural poverty to fall more rapidly than in other sectors (Anon, 2020). There is a risk that these income gains may not be sustainable, if the agriculture productivity is not improved through the advancement of the agricultural sector by incorporating modernization strategies, such as diversification, commercialization, and value addition.

Justification

Farmers are intensifying existing patterns of production and diversifying their farm enterprises in an attempt to improve their livelihoods, whereas technical know-how they possess is not sufficient to be competitive and take advantage of the new opportunities that are arising. Hence, it is of pivotal importance for farmers to adapt their farm business according to the market changes because adaptation improves efficiency, profitability, and income. However, farmers' skills and capacities can only be built through a process of learning and practice. The Farm Business School (FBS) has been developed by the Food and Agriculture Organization of the United Nations to assist farmers to learn the way of initiating their farming enterprises and overall farm operations profitable. It enables to fulfil market demands which takes place at the village level and the farmers' potential in entrepreneurial and management skills is built via a "learning by doing" approach (Chilemba and Ragasa, 2018).

The Project Management Unit of Kurunegala will work with five provinces, namely Northern Province, North Central Province, Uva Province, Eastern Province, and Central Province in the implementation of FBS. Moneragala, Matale, Anuradhapura, Polonnaruwa, Batticaloa, Jaffna, and Mullaitivu districts have been selected to conduct the FBS.

Project Constraints

A sum of 1750 farmers, who are 1st stage pilot scale project farmers in five provinces, are registered under this project. FBS programme is delivered only to the registered farmers. Trainers organize seasonal training programmes where farmers work in small groups at their own agreed time and duration. FBS training is not conducted during the planting and harvesting periods. The Provincial Agriculture Departments have granted permission to Extension Officers to conduct FBS training twice per week. The materials for the FBS are specially designed to work with limited resources. Participants need to be basically literate and numerate, but they do not need to have any significant formal education.

Project Assumptions

In the FBS handbook for farmer participants, the FBS concept is divided into three parts; the pre-season, on-season, and post-season. In the pre-season, farmers are taken through theories of market-oriented farm business planning and management, including the selection of profitable agricultural enterprises. Then, farmers are organized in sub-groups based on the agricultural enterprises they are most interested in. Notably, the enterprises farmers select are based on the profitability and management assessments that are developed using concepts learned in the pre-season FBS component. After the growing season, a post-season session is conducted to review the pre-season and on-season activities. During this session, farmers discuss their performance and draw lessons for better planning and management in the next growing season. First-trained farmers, regular follow-ups by FBS trainers, and extension staff of the Department of Agriculture help to increase the number of farmers trained in FBS concepts in a particular locality.

Project Dependencies

The project will also benefit the Ministry of Agriculture and the five participating Provincial Councils through the respective Provincial Ministries of Agriculture by providing the support to sector policy analysis and development, and institutional capacity building to become more effective and better coordinated public service providers and facilitators of the agriculture sector.

PROJECT IMPLEMENTATION AND SUCCESS CRITERIA

The block diagram in Figure 1 shows the approach to conduct FBS programmes. Extension Officers, such as Subject Matter Officers, Agriculture Instructors, and Technical Assistant Officers, are trained as FBS trainers, who are responsible for conducting farmer training at the field level.

Figure 1: Approach of Conducting Farm Business School

The training sessions provided participants with information on best practices in time management, calculating break-even crop prices, crop husbandry practices, such as crop rotation and appropriate spacing, record keeping, searching the markets for good prices, calculating profits and gross margins, and modern storage techniques.

After completion of the FBS programmes, the project office conducted the final evaluations from all beneficiaries. There were many success stories from each district. The comments received from the project beneficiaries revealed that the farmers had learnt to make farm records, calculate the cost of all farm inputs, income from all farm outputs, and base prices for commodities, and determine viable and profitable crop enterprises. Some FBS participants have already attended to the good practices that the programme had brought to their communities. In terms of farmers' satisfaction, the majority of participants was satisfied with the FBS facilitation and implementation. About 78 percent of participants were highly satisfied with the FBS facilitation and implementation, while 19 percent were somewhat satisfied, and the rest were not satisfied. Furthermore, some of them have suggested to arrange field visits to learn from farmers who are successfully implementing the practices that they have learnt from the FBS. A majority (65%) of FBS participants reported that they experienced positive changes in farm income as a result of the FBS participation.

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Author:

Jagath Rohan Samarasinghe: Consultant attached to the Industrial Services Bureau of Sri Lanka. He holds B.Sc. Hons. (Agric.) [Second Class Upper Division] from WUSL (e-Mail: *jrsamarasinghe@gmail.com*)

Reviewer:

Nimanthika Lokuge: Lecturer attached to the Department of Agribusiness Management of FAPM, WUSL. Her teaching and research interests include: Agricultural & Food Economics, Applied Econometrics, and Food Marketing and Agribusiness (e-Mail: *nimslkg@gmail.com*)

PROMOTING CHOCOLATE PRODUCTION AS A DOMESTIC INDUSTRY

Lakshika Samithri

Department of Export Agriculture, No. 1095, Getambe, Peradeniya, 20400

INTRODUCTION

Chocolate is one of the most popular sweet-tasting treats and flavours in the world. Its popularity has been attributed to its distinguishing characteristics of flavour, texture and colour. Sri Lankan cocoa is renowned for its better taste and aroma. Cocoa is mainly grown in Central, North-Western, Sabaragamuva, and Uva provinces. Making chocolate in domestic scale could potentially generate income for the people in cocoa growing areas. Moreover, it can immensely contribute to national economy through value addition of cocoa as an export agricultural crop.

Therefore, the present study was conducted to produce the best quality chocolate in domestic scale using optimum technology and adding minimum levels of preservatives. With this objective, a simple procedure was developed to produce chocolate from domestically processed cocoa beans.

Cocoa Beans for Chocolate Production

Chocolate is processed from the seed of the tropical cocoa (*Theobroma cacao*) tree. Cocoa has been cultivated for at least three millennia in Mexico, Central America and Northern-South America. The majority of the Mesoamerican people made chocolate beverages, including the Aztecs, who made it into a beverage known as xocolātl, a Nahuatl word meaning "bitter water". The seeds of the cocoa tree have an intense bitter taste, and must be fermented to develop the flavour.

After fermentation, the beans are dried, cleaned, roasted, and the seed coats are removed to produce cocoa nibs. The nibs are ground to cocoa mass, pure chocolate in rough form. Because the cocoa mass is usually liquefied and then moulded with or without other ingredients, it is called as ‘chocolate liquor’.

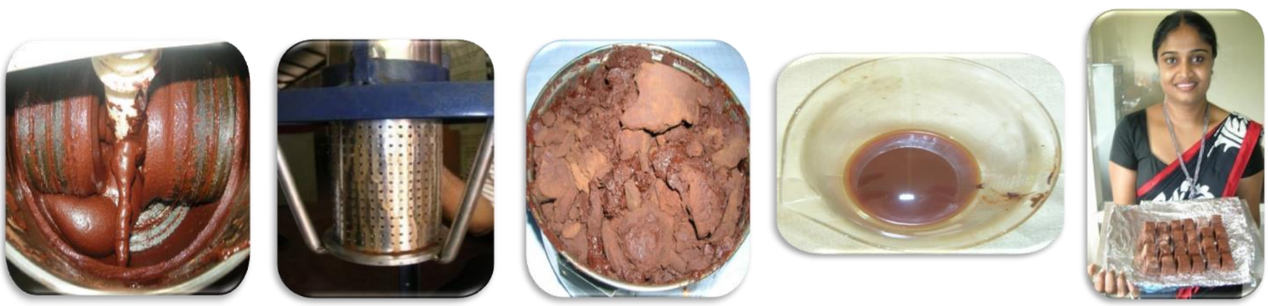
Cocoa solids contain alkaloids such as theobromine, phenethylamine and caffeine. Research has found that chocolate consumption in moderate levels could reduce the blood pressure. The presence of theobromine renders chocolate toxic to some animals, especially dogs and cats.

METHODOLOGY OF CHOCOLATE PRODUCTION

In order to obtain the desirable taste and colour from chocolate, appropriately ripen cocoa pods should be used to get the cocoa seeds. Further, to enhance the taste and colour, both fermentation and drying should be done for a duration of 5 days. The correct temperature should be maintained during the roasting process. Seeds should be ground until it becomes a liquid with a uniform texture. The correct amount of lecithin must be added to the chocolate mixture (Cook, 1982).

The cocoa butter and cocoa liquor should be mixed in the correct proportion to have a delicious chocolate. High amounts of cocoa butter and cocoa liquor make the chocolate more oily and impart a bitter taste to the final product.

As soon as the final chocolate mixture is taken out from the grinder, it should be laid on a tile and rolled back immediately. This step should be repeated several times and it helps to obain a shining appearance to the chocolate. Figure 1 represents the steps in chocolate production process.



A B C D E

Figure 1: Chocolate Production Process Showing the Steps (A) Grinding of Roasted Cocoa Seeds (B) Pressuring the Ground Mixture (C) Coco Liquor (D) Coco Butter (E) Final Chocolate Product

Trials Using Different Combinations of Ingredients

Ten types of chocolate mixtures were made adding raw materials in different ratios. Samples from each mixture were given to 10 people for a sensory evaluation and their comments were recorded (Table 1). Based on the comments on sensory properties, the Combination 5 was selected as the best formula.

Table 1: Ten Types of Chocolate Mixtures and Their Sensory Properties

Combination	Cocoa Liquor (g)	Cocoa Butter (g)	Sugar (g)	Full Cream Milk Powder (g)	Vanilla (mL)	Lecithin (g)	Comments
1	500	500	250	250	05	25	Sweetness is low
2	600	300	350	400	05	25	Mouth feel is not good
3	300	600	250	350	05	20	Sweetness is poor
4	600	600	400	400	05	20	Chocolate is oily
5	600	400	450	250	05	20	Smell, colour, sweet taste, mouth feeling are good
6	400	600	450	250	05	20	Taste is poor
7	600	400	450	350	05	40	Lecithin taste is high and chocolate is liquefied
8	400	400	400	250	05	35	Taste is poor and chocolate is liquefied
9	650	400	200	200	05	35	Sweetness is poor, taste is poor and chocolate is liquefied
10	500	400	400	350	05	50	Lecithin taste is high and chocolate is liquefied

Project Success

According to the result of the experiment, the best combination of ingredients for the chocolate production was identified. It was the 'Combination 5' which reported as having good taste, colour, mouth feel as well as pleasant smell. Therefore, this combination of ingredients (Table 1) can be recommended for future chocolate production at domestic scale. Field demonstrations need to be carried out before introducing this technology to small-scale producers.

CONCLUSION

The study proved that the chocolate production can be done at domestic level with low cost equipment. Preservatives are not added during this manufacturing process and it can be considered as a plus point of the production process. This method can be introduced for households in cocoa growing areas with the guidance and support from the Department of Export Agriculture. Extension Officers can train the villagers and promote small-scale chocolate production as a cottage industry to create more employment opportunities for rural communities. Products can be branded as "locally produced", "hand-made chocolates" and introduced to local as well as export markets in future. It is a significant value addition for the locally produced cocoa and will be a tourist attraction. It can potentially bring more income for rural communities in cocoa growing areas while contributing to the country's economy.

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Author:

Lakshika Samithri: Extension Officer, Department of Export Agriculture. She holds B.Sc (Plantation Management) from WUSL. Currently she is engaged as a Communication Officer for export agriculture crops at the National Agriculture Information and Communication Center (e-Mail: *samithrilakshi3@gmail.com*)

Reviewer:

Sarananda K. Hewage: Senior Lecturer, Department of Bio-Systems Engineering, FAPM, WUSL. His teaching and research interests include: Postharvest Technology, Food Processing Technologies & Value Addition and Product Development Technologies (e-Mail: *sarahewa62@yahoo.com*)

ENTREPRENEURIAL EXPERIENCE OF ORGANIC FARMING: STORY OF ABBA AGRI CONSULTANCY AND OWITA ORGANICS

Anuradha Udayanga Ranasinghe

ABBA Agri Consultancy, Welikatiya, Kahaduwa, Galle, 80000

INTRODUCTION

Empowering youth and youth entrepreneurship are widely discussed topics in Sri Lanka. During the last decade, the government tried to implement various strategies to attract youth for entrepreneurial activities. Nevertheless, Sri Lankans have traditionally favoured white-collar, public sector jobs that guaranteed a pension, over the 'high-risk' self-employments. Sri Lanka, however, lacks both an 'entrepreneurial culture' and a supportive economic system for entrepreneurship. Therefore, young people are reluctant to be entrepreneurs due to social, financial and legal challenges which arise at the early stage of the entrepreneurial journey. When considering agriculture-based enterprises, this situation is worse due to a lack of social recognition as well as the long delay in gaining results. Upon graduation in 2017, having recognized and accepted the challenges of being an entrepreneur, the writer initiated his social enterprise called ABBA Agri Consultancy to provide organic farm management and consultancy services. Over the past two years, the business has been steadily growing and it provided services to the interested farmers and organizations in several areas of the country while generating six employment opportunities. The writer also extended his services towards the organic product retail market chain establishing another institute called OWITA Organics Pvt. Limited which serves as a trading platform for organic farmers and consumers.

History and Background

The global demand for organic agricultural products is increasing as people are more health-conscious and seeking safe and healthy food (FiBL & IFOAM Organic International, 2018). Therefore, new market opportunities are rising which provide premium prices for organic products. The organic agriculture industry in Sri Lanka is also expanding and the country maintains a reputation in organic food production, particularly in the export of organic products adhering to international standards. As a result, many farmers and land owners switched their practices from conventional farming to organic farming during the last several years. However, most of them did not possess a fair knowledge and experience on organic concepts during the transition period when they converted their farms into organic agricultural practices. Therefore, a need for external organic agriculture consultancy and management services arose to support farmers in that process. The author identified this market opportunity and started an agriculture enterprise named *ABBA Agri Consultancy* to provide advisory services to address the needs of such farmers.

When the local demand for organic agriculture products increased, most of the farmers started to produce organically but the market access for their products was inadequate. Meanwhile, consumer complaints indicated that reliable organic products were not available to purchase from the local markets. OWITA Organics identified this market gap and launched its operation as a retail organic market platform to connect organic farmers and consumers. Its major role is to act as a fair middleman, networking organic producers and consumers under one umbrella to provide market opportunities (Table 1).

Since 2017, both firms have been dealing with challenging tasks of their entrepreneurial journey as start-ups. They are now moving towards the expansion stage while benefiting the society, identifying the risks and market opportunities (Figure 1).

CHALLENGES AND LESSONS LEARNED

After launching of any enterprise, understanding the specific stages of development is crucial for efficient management of time and resources. Entrepreneur's commitment is essential to validate the business concept at the ground level until it reaches the refinement stage. Researching the expected market segment will immensely support to bring the business to the next level. Therefore, under the prevailing economic and social circumstances of Sri Lanka, a majority of youth is reluctant to accept risks and make decisions to start enterprises to be entrepreneurs. In this context, the author accepted the hardships by identifying risk mitigation mechanisms and initiated his own business as an agriculture consultancy service and farm management company.

Identifying market needs is the most crucial factor for future development. ABBA Agri Consultancy and OWITA Organics identified those needs while they were launching the businesses. It gave a green sign during the past two years and has led both companies to reach the expansion stage within a shorter duration. Increasing the productivity of farmlands through different revenue cycles per year using mixed cropping systems and crop planning is the basic strategy implemented by ABBA Agri Consultancy to serve its clients. That concept succeeded in numerous ways and has attracted many clients to our innovative service. Provision of market linkages for organic products has been an additional benefit to them.

According to the experience, organic market expansion should take place simultaneously with the organic production. The entire market system can ruin due to mismatches between the production and sales. Unsold excess production could discourage farmers while inadequate production would harm consumer expectations. Therefore, both enterprises coordinate effectively and try their best to manage supply and demand at a satisfactory level.

Table 1: Present Status of ABBA Agri Consultancy and OWITA Organics

Service	Farm management and consultancy	Organic food trading
Client Base	08 Plus	100 Plus
Work force	06	04

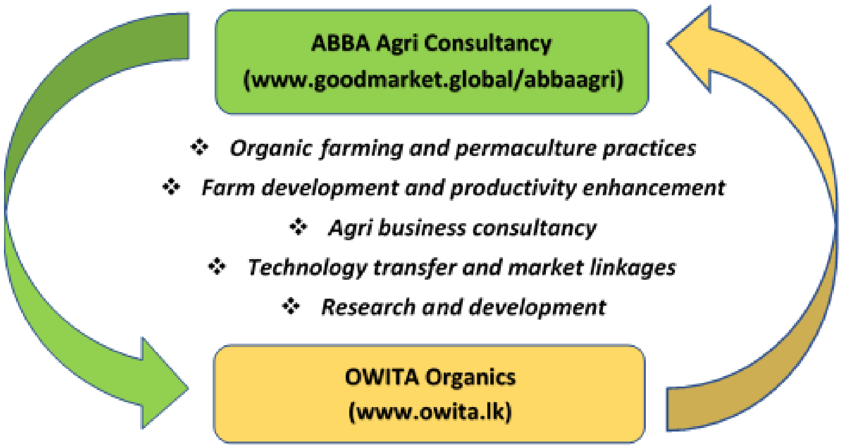

Figure 1: Functionality of the Business

While growing up, both enterprises reached the refinement stage of their entrepreneurial life and now working tirelessly to reach scaling and established stages winning the customers' trust and loyalty. In a world where the most of start-ups die during their first two years, ABBA Agri Consultancy and OWITA Organics are continuing businesses as profitable organizations which are driven by a young entrepreneur who has become an impeccable individual for the educated youth in the country.

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Author:

Anuradha Udayanga Ranasinghe: Entrepreneur and founder of ABBA Agri Consultancy and Director - Supply Chain at OWITA Organics Pvt. Ltd. He holds B.Sc. (Agric.) from WUSL and currently involves in several agri-business development projects in the country as a freelance consultant (e-Mail: *anuranasinghe89@gmail.com*)

Reviewer:

Wishwajith W. Kandegama: Senior Lecturer, Department of Horticulture and Landscape Gardening, FAPM, WUSL. His teaching and research interests include: Food Quality & Safety, Food Processing, Organic Farming and Eco-Friendly Plant Protection Systems
(e-Mail: *wishwajith@wyb.ac.lk*)

PROMOTING WELI-ANODA (*Annona reticulata)* CULTIVATION FOR EXPORT MARKET

Jayasinghe Arachchilage Gunathilaka

National Livestock Development Board, Galpokuna Farm, Pallewela, Udubaddawa (NWP), 60250

INTRODUCTION

Being located near the equator in the Indian Ocean, Sri Lanka is blessed with a unique tropical climate which is ideal for tropical horticulture. Optimum temperature and two monsoon rainfall seasons in Sri Lanka have ensured the feasibility of growing a large number of tropical fruit varieties throughout the year. In addition, the wide geographical variability of soil types with high agricultural potential has led to a high degree of year-round productivity of these crops in different parts of the island.

At present, Sri Lanka is providing notable quantities of banana, pineapple, mango and papaw/papaya to different countries. A majority of the fruits are being produced by small scale commercial producers or home garden growers, whose individual extent of land does not exceed a hectare (ha). Recently, with the realization of the true economic potential of horticultural crops, especially on fruit consumption, a number of programmes have been initiated to develop commercial fruit cultivations within the country. While identifying the opportunities in international and local markets, the present development programmes must focus on the establishment and enhancement of small farm cluster companies linked to exporters or marketing enterprises. Further, such programmes should aim to expand productivity and promote convenient processed products while ensuring sustainable income7 to the farmers. Promotion of fruit cultivation can boost productivity and also help generate both farm and off-farm employment opportunities, increase export earnings and save foreign exchange.

Current Situation of Weli-Anoda Cultivation

At present, around 600,000 t of fruits are being produced annually in Sri Lanka. Out of the total production, nearly 80,595 t of fruits are exported. As a whole, agricultural products contribute to 24 percent (Rs. 2.6 billion) of Sri Lanka's export earnings (Department of Census and Statistics, 2014). However, the most significant aspect of this sector is the gradually increasing trend in export share of fruits, whereby the fruit export sector has rapidly expanded, in comparison to the traditional and other non-traditional agricultural exports. While paying attention on major fruits, a special attention should be placed on underutilized fruit crops as there is an increasing demand for this crop category. "Weli-Anoda" (*Annona reticulata)* is one such fruit, which accounts only for an extent of around 5 ha remaining as scattered cultivations, with an average production of 40 t (Figure 1). The gross income of *Weli-Anoda* in 2019 was Rs. 2 million (Mahaweli Authority of Sri Lanka, 2019).

Justification

With the realization of the market preference and economic importance, many farmers are paying their attention towards *Weli-Anoda*. This crop can ensure a high level of export income for the farmers, with a limited level of investments. Therefore, the current project aims to establish new *Weli-Anoda* cultivations over an extent of 40 ha, and thereby increase the overall extent in the country up to 45 ha by 2024. The yield is expected to increase up to a minimum of 360 t, leading to a total export income of around Rs. 31.6 million from newly established cultivations. In turn, the proposed project would promote the commercial cultivation of *Weli-Anoda* in Sri Lanka, while generating employment opportunities. Moreover, value addition opportunities and market explorations would strengthen the rural livelihoods through better integration of small holder farmers into the modern agriculture markets.

PROJECT IMPLEMENTATION

A total of 100 farmers from the Kurunegala district will be selected based on the recommendations of the Agronomist/Agriculture Officer and Agriculture Field Officers to establish new *Weli-Anoda* cultivations. The project will be initiated in 2020, which is expected to complete in 2024 as follows:

Study area	:	Kurunegala District
Expected extent of cultivation	:	40 ha
Number of farmers	:	100 (0.98 ac per farmer)

Figure 1: Different Stages of "Weli-Anoda" Cultivation (A) Young Plant, (B) Flowers and (C) Fruits

Suitable farmers and crop lands to establish new *Weli-Anoda* cultivations will be selected by the Agronomists/Agriculture Officers. Farmers will be encouraged to form a farmer organization to facilitate the coordination of project activities. Special training programmes on novel cultivation and standard postharvest technologies related to *Weli-Anoda* production will be conducted for the selected farmers, with the financial assistance from the Department of Agriculture (DOA). Planting materials of sufficient quality and fertilizers will be provided to the farmers at discounted rates. The establishment of new cultivations will be guided and monitored by the DOA. Field visits and routine crop clinics (monitoring and inspections) will be conducted at 6-month intervals, by the Field Officers of DOA. Two workshops on postharvest processing and export quality maintenance will be conducted in the third year and "*Weli-Anoda"* will be exported from 2022 onwards as a joint-venture with a suitable exporter. A summarized cost-benefit analysis of the project is included in Table 1. The farmers are expected to secure a total of Rs. 31,616,000 as the export income in 2024 at the final stage of the project.

Table 1: Cost-Benefit Analysis for 1 Acre of *Weli-Anoda* Cultivation

Parameter	2020	2021	2022	2023	2024
Total cost Rs/40 ha	3,595,134	5,966,334	7,349,534	7,349,534	7,349,534
Income Rs/40 ha	-	-	18,969,600	31,616,000	31,616,000
Net Income Rs/40 ha	- 3,595,134	- 5,966,334	11,620,066	24,266,466	24,266,466

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Author:

Jayasinghe Arachchilage Gunathilaka: Assistant Farm Manager, Galpokuna Farm, National Livestock Development Board, Sri Lanka. He holds B.Sc. (Plantation Management) from WUSL (e-Mail: *gunathilaka300@gmail.com*)

Reviewer:

Lahiru Udayanga: Lecturer at Department of Bio-Systems Engineering, FAPM, WUSL. He has completed his PhD in Geo-Informatics and Environmental Modelling. His teaching and research interests include: Environmental Management, Geo-Informatics, Climate Science and Disaster Management (e-Mail: *udayanga@wyb.ac.lk*)

INITIATING A LABORATORY WASTE REDUCTION SYSTEM AT THE WAYAMBA UNIVERSITY OF SRI LANKA

Dhammika Menike

Department of Applied Nutrition, Faculty of Livestock Fisheries and Nutrition, Wayamba University of Sri Lanka, Makandura, Gonawila (NWP), 60170

INTRODUCTION

Reducing the generation of waste at the source is the most effective waste minimization option and it includes all measures taken before a substance, material or product has become a waste. By reducing the generation of waste in the first place, the need to handle, transport, treat, and dispose of the waste can be eliminated. Laboratory waste is an unwanted or unusable material generated as a result of day-to-day laboratory operations or as a result of overdue. These wastes can be identified as hazardous or non-hazardous solid and liquid, or degradable or non-degradable solid and liquid. The first step in waste management is to implement measures to reduce waste generation (Figure 1).

Waste minimization in the laboratory needs to be initiated in personnel level, laboratory level, departmental level, faculty level, campus premises level and finally for the entire university. The strategies for laboratory waste reduction and practical benefits of implementing reduction will be helpful not only to human resources (all staff, students, and others) but also to the environment. The waste minimization can also save money. By utilising materials and products more effectively, conserving resources and reducing waste and pollution, money required for materials, products and disposal costs can be minimised (Anon., n.d).

Justification

Laboratory waste reduction is largely dependent on the contributions of all staff (technical officer, laboratory assistant, demonstrator, academic staff and researchers) and students involved in laboratory practices and research. With the competitiveness of education, the enrolment of university students is rising and facilities need to be increased. As a result, purchases are increased and the amount of waste disposals may be relatively high. However, once everybody realizes that how waste minimization can benefit the persons and the environment, all will be more committed to the waste minimization programme. Also, suppliers, maintenance officers and contractors can play an important role in minimizing the waste. Reducing the amount of waste produced by the laboratory decreases storage and disposal space, minimizes the impact on the environment and requirement for transporting waste. Reducing laboratory waste also helps minimize economic impact and ensures maximum utilization and conservation of resources.

LABORATORY WASTE REDUCTION PROJECT

At present, there is no integrated methodology to reduce laboratory waste in the university. Under normal conditions, the waste is segregated and then disposed non-systematically. There is no common place for the storage of waste until reuse, recycling or disposal. For wastewater purification, a wastewater treatment plant is not available in the premises. The university premises is surrounded by paddy fields. Due to the fact that groundwater level is high, it is difficult to avoid possible seepage of the contaminated water to the environment from laboratory waste. Therefore, it is a timely requirement to initiate a laboratory waste reduction system for Makandura Premises of Wayamba University of Sri Lanka.

PROJECT IMPLEMENTATION

The objective of this project is to encourage laboratory waste reduction, which is expected to reduce waste by 50 percent by the end of the project. Strategies shown in Figure 2 will be initiated for the staff and students through the project. Necessary lectures and training programmes will be scheduled on the university premises.

Assumptions

1. Companies who agreed to accept their empty bottles after use, can be selected as suppliers for purchasing
2. The quality as well as the price of the laboratory items should be considered when purchasing
3. Excess and unexpired chemicals are shared with other groups
4. When research work ends, the rest of the chemicals can be used by others
5. A centralized procurement programme should be established and a suitable officer may be appointed
6. Chemicals can be exchanged among the laboratories of the faculty
7. All laboratory waste must be collected by a waste collector with a valid license
8. Well-managed inventory should be available in all laboratories and updated at the end of the semester

It is assumed that the university will allocate the finance and human resources needed through its budget 2021 and implementation of full project facility in Makandura premises is expected to be completed by the end of 2023. Finally, the success of the project at Makandura premises will be evaluated and then the same protocol will be extended to initiate in the other premises of the University. Basic data of Waste Audit Worksheet can be used to measure the waste reduction success. Calculating the waste generating rate every month (kg/Capita/Month) and comparison of the rates among each and every month can be used to determine the success of the project at the end of the year.

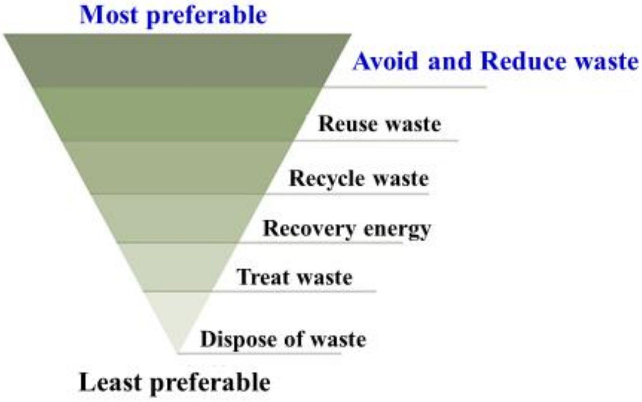

Figure 1: The Waste Hierarchy
Source: Anon., 2002

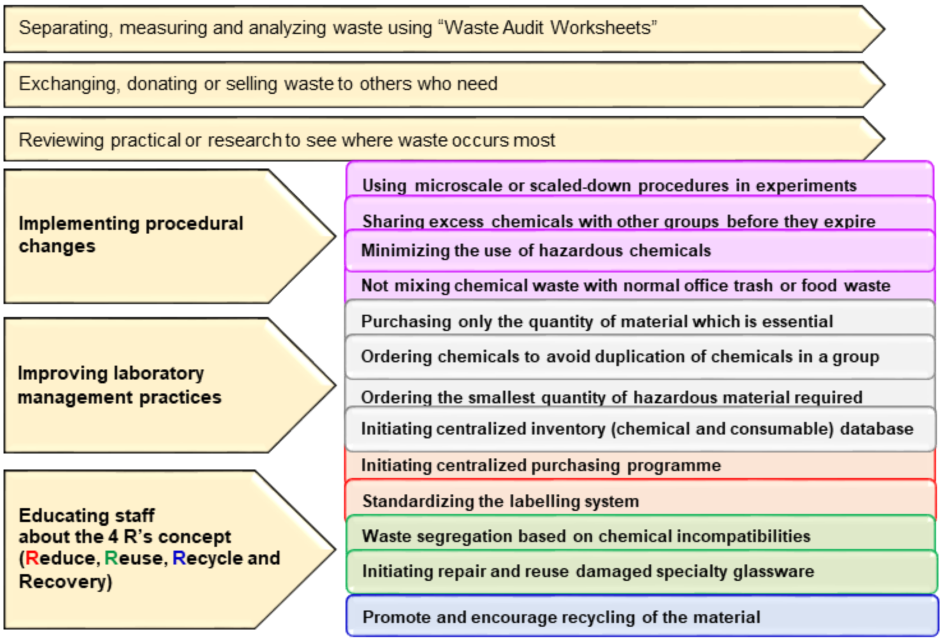

Figure 2: Effective Waste Minimization Strategies

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Author:

Dhammika Menike: Staff Technical Officer attached to the Dept. of Applied Nutrition, Faculty of Livestock Fisheries and Nutrition, WUSL. She holds B.Sc. (Plantation Management) from WUSL (e-Mail: *pgdhammikamenike@gmail.com/pgdhammikamenike@yahoo.com*)

Reviewer:

Nisha S. Kottearachchi: Professor in Biotechnology, Department of Biotechnology, FAPM, WUSL. Her teaching and research interests include: Plant Genomics and Tissue Culture (e-Mail: *kottearachchins@yahoo.com*)

AGRI-BASED TRAINING FOR SRI LANKAN ARMY PERSONNEL IN DISTRICT AGRICULTURE TRAINING CENTRE, AMBEPUSSA

Sriyangani Hemalatha

District Agriculture Training Centre, Meerigama Road, Ambepussa, 11212

INTRODUCTION

The Ministry of Defence in Sri Lanka started National Vocational Qualification (NVQ) level training courses at Non-Commissioned Officers' Training School (NCOTS) in Saliya Wewa, Kalaoya in year 2016 (Centre for Army Vocational Training, 2018). This training school has been conducting Technical and Vocational Education and Training (TVET) with the guidance of military authorities for their second carrier. This training gives the basic competence in the trade and serves as an endorsement of their prior learning before retirement of the army. Armed forces headquarters make linkage with different government organizations and continue their expected training programmes. For the first time in Sri Lanka, in year 2017, the Department of Agriculture (DOA) initiated two NVQ level agricultural courses at District Agriculture Training Centre, Ambepussa while making this linkage a success with the Ministry of Defence.

Current Situation of the National Vocational Qualification

Traditionally, the General Certificate of Education Ordinary Level (GCE O/L) and Advanced Level (GCE A/L) examinations were considered as the primary qualifications for getting employments and access to other higher levels of education in Sri Lanka. However, the quality of Sri Lankan workforce has diminished and created labour shortage in some of the industries because the students have come to accept examination results as the ultimate determinant of their fate. This has led to setting of low skilled or unskilled careers in the society. After recognizing the skill deficit of our workforce, the Sri Lankan government introduced the NVQ System (Tertiary and Vocational Education Commission, 2018). The NVQ system offers several levels of professional certification so that students can complete specific levels of training required for their desired vocation. Participants also can obtain the level of NVQ within their career. The national certificates are associated with each NVQ levels, *i.e.* NVQ Level 3 is equal to the Ordinary Level (for the required field), and the Level 4 is equal to the Advanced Level (required field). Further, the NVQ certificate is world recognized and is also a measurement of the level of skill a person possesses.

Justification

Generally, the Sri Lankan army personnel retire after 22 years of successful service to the nation. The average age of their retirement is around 40 - 45 years, *i.e.* the most critical and the well experienced age of the lifespan. They are strong enough to do some other self-employment after the retirement (Nishantha, 2018). Some of them are planning to seek foreign employment. As this NVQ certificate is recognized worldwide, it will facilitate a majority of retired army personnel to enter the world of work with confidence.

PROJECT IMPLEMENTATION

District Agriculture Training Centre (DATC), Ambepussa, under the Western Province Department of Agriculture, is conducting 6-month long, two agricultural training courses for army communities namely, (1) Plant Nursery Development Assistant Training and (2) Landscape Development Assistant Training. Both are NVQ level training courses. The army personnel are selected from all the army regiments in Sri Lanka. The members who are in their latter part of the service are given the priority to follow the courses. From year 2017 to 2020, more than 148 persons were selected for the courses by the Centre (Table 1). The training centre enrols only 30 members for each training course with the prevailing facilities. The army personnel who enrol for the courses are released full-time for the training with their monthly salary and the first training session was ceremonially commenced in year 2017 (Figure 1).

Table 1: Number of NVQ Certificates Issued by the Tertiary and Vocational Commission

Year	Number of NVQ Certificates Issued
2017	34
2018	52
2019	46
2020	16

Source: Students Attendance Register in District Agriculture Training Centre, Ambepussa

The basic training is conducted by the Agriculture Instructors at DATC, under the guidance of Assistant Director (Agriculture Service Officer). Not only the centre-based training, some field visits are also incorporated in the syllabus. The final assessment is done by the Tertiary and Vocational Education Commission while continuous assessments are also conducted. During the course, a target of 100 successful budded plants and successful 50 grafted plants to be produced as a practical assignment to gain hands-on practical experience. Most of the army personnel could achieve this target and produce plants exceeding the target within the six months period. Every group of the Landscape Development trainees are given 0.25 ac of land area in the training centre. They should develop the land by applying suitable soft landscape and hard landscape techniques.

Figure 1: Opening Ceremony of the First Training Session for Army Officers

The second objective of this training is targeting on the manipulation of retired army officers of getting into anti-social activities, because they are well skilled to use weapons. Army communities are recommended as well behaved, well disciplined and skilled people. Therefore, they can easily start a socially acceptable agricultural employment successfully after the retirement.

Project Constraints

The main constraint encountered is that the majority of the army communities are not at their basic literacy level. Therefore, it is difficult to provide them with the National Competency Level Certificate. Because of that, the DOA decided that the trainees below the recommended literacy level are provided with a Departmental Certificate for their future career development. However, they all are very keen on their practical aspects. The next constraint identified is, since the members of three forces are acting very curiously for every and each disaster and emergency situations in the country, the commanding officers of the units are not willing to release their members to get their six months of retirement training courses. It can be concluded that the project facilitates and uplift the lives of the retiring members of the three forces, who are the guardians of all Sri Lankans and who protect the country. Therefore, it is the duty of DOA, particularly the members of the training centre to assist them to enrich their lives after retirement.

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Author:

Sriyangani Hemalatha: Assistant Director of Agriculture in the Department of Agriculture (W.P.). She holds B.Sc. (Agric.) [Second Class Upper] from the University of Peradeniya and currently serving as the Officer In-Charge of the District Agriculture Training Centre, Ambepussa (e-Mail: *sriyanganihemalatha@yahoo.com)*

Reviewer:

Bandara Gajanayake: Senior Lecturer, Department of Plantation Management, FAPM, WUSL. His teaching and research interests include: Tea Production and Marketing, Climate Smart Agriculture and Resource Management in Plantations (e-Mail: *gajawyb@yahoo.com*)

INTEGRATING AGRICULTURE INFORMATION AND e-STATE LAND INFORMATION AND MANAGEMENT SYSTEM (e-SLIMS)

Shakthi Madushan Wijayawardhana

Land Commissioner General's Department, 1200/6, Rajamalwaththa Road, Battaramulla, 10120

INTRODUCTION

Land administration and information management has been a challenge for a country without proper land use data. Especially, inaccurate and outdated agricultural land use data creates difficulties in decision making and formulating policies in agriculture sector, thus actual crop production and cultivated land extent possibly will vary from crop forecast and crop cultivation target. Therefore, updated and accurate data are of paramount importance for decision making in agriculture sector.

Current Status in Sri Lanka

There were about 3,535,648 ha of agricultural land in Sri Lanka in 2015 [Department of Agriculture (DOA), 2018]. According to the crop forecast of DOA, cultivation target of paddy in *Maha* season 2019/2020 was 819,721 ha and sown extent as at end of November 2019 was 606,702 ha; it was 72 percent from the target. Cultivation progress of other field crops and up country vegetables were about 107,249 ha and 5,501 ha, respectively and those were 63 percent and 37 percent, respectively from the target in 2019 (Department of Agriculture, 2019).

Justification

Land Commissioner General's Department (LCGD) of Sri Lanka maintains the e-State Land Information and Management System (e-Slims) to implement and update State land information throughout the country whereas DOA maintains the agricultural information. Presently, LCGD and DOA are not linked together to exchange data, thus agriculture statistics are not available in e-Slims. Consequently, actual crop production and cultivated land extent highly varied from the crop forecast and crop cultivation target in the country. This indicates the importance of linking agricultural information and land information management for the development of Sri Lanka's agriculture sector. This paper describes the integration of agricultural information into e-Slims database to maintain and obtain accurate information about agricultural land use in Sri Lanka.

INTEGRATING AGRICULTURAL INFORMATION AND E-SLIMS

The e-Slims was initiated in the LCGD in 2012 to improve the State land management process which facilitate accurate nationwide representation of the land statistics with respect to the land use information of State land. Further, e-Slims provide protection of land rights, establishment of proper monitoring system for land related revenue selection and land identification and alienation. The main objective of this system is to provide highly efficient, more accurate all above State land information through online service to any authorities who require those for official activities. However, currently e-Slims is not providing agricultural information.

Technically e-Slims is linked to geographic information system, (GIS) thus land area and boundaries of land can be obtained with keyhole mark-up language (KML) file for easy geovisualization. Further, land development can be obtained with digital images using global positioning system (GPS) locations. The e-Slims is implemented and updated by LCGD officials at Divisional Secretariat level around the country (Figure 1).

Most of the land related information of State lands have already been recorded in the e-Slims database but agricultural details have not been incorporated. Therefore, this proposed project modifies the e-Slims database to integrate agricultural information and thus the authorities are able to obtain accurate State land information together with agricultural information of those lands through online service for any official activity. This implementation creates a connection between LCGD and DOA, which delivers a new approach to change the way of collecting DOA farmers' data and information into e-Slims of LCGD to create a single repository. It facilitated all agricultural information, including land use and crop production, to handle in a centralized land information management repository through e-Slims.

This project is handled by local technological officials of LCGD and DOA in Grama Niladhari Divisional level around the country. In this process, all agriculture information (crop, variety, cultivated extent, yield, *etc.*) in each and every lands are entered into the system. It requires equal contribution from all officers involved in the system since this operates (data feeds) at divisional level throughout the country.

There are some constraints on the implementation of this system where these two departments are administered under two different ministries, thus coordination between these departments is difficult. Further, it requires a special approval from the relevant Head of the Department to proceed certain tasks. Moreover, this project is based on information and communication technology (ICT) applications and therefore, special skills are required for handling ICT equipment and data entering. Accordingly, technical officers with ICT literacy need to be employed by the DOA to implement this program. Further, it is necessary to facilitate proper ICT infrastructure (Internet facility, GPS equipment, *etc*.) to proceed the system efficiently because this is purely an internet based project (Figure 1).

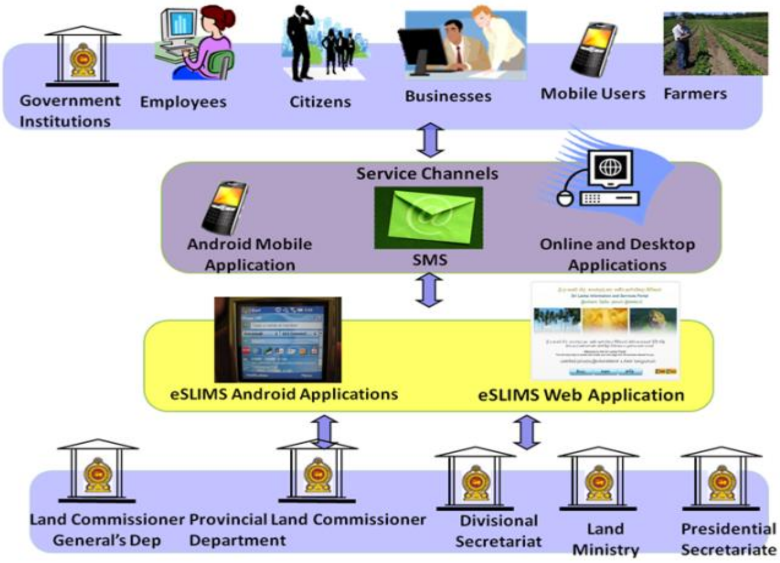

Figure 1: E-Slims Overview Process

Source: State Land Information and Management System (https://www.eslims.gov.lk)

This system integration is important to uplift the e-Government policy of the country where e-Agriculture plays a main role on it. The government's main e-Policy was implemented under the supervision of the Institute of Communication Technology Agency of Sri Lanka (ICTA) and e-Agriculture policy was implemented by the DOA. Therefore, for the functioning and monitoring of this project, the involvement of LCGD, DOA and ICTA is important. Generally, the stability of this system depends on the accuracy of data input, regular updates and duly contribution of the users in these institutions.

PROJECT SUCCESS CRITERIA

This project is a promising way to obtain accurate and up-to-date information about agricultural land use required by the government throughout the country easily and efficiently. Further, identification of new lands for agriculture, detailed information about any land (land ownership, crops cultivated, yield) can be obtained. As this modified system maintains a reliable centralized database, it can be coupled with the Department of Census and Statistics and also with research and educational institutions. It will envisage to provide necessary data and information for decision making, formulating state land policies and agriculture policies in the country.

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Author:

Shakthi Madushan Wijayawardhana: Colonization Officer attached to the Land Commissioner General's Department of Sri Lanka. He holds B.Sc. (Plantation Management) from WUSL
(e –Mail: *madukuruwita@gmail.com*)

Reviewer:

Chandana Jayathilake: Senior Lecturer, Information and Communication Technology Centre of WUSL, Makandura. His teaching and research interests include: e-Agriculture, e-Learning, ICT for Development (ICT4D), ICT4AD and Web Technologies
(e –Mail: *jayathilake@wyb.ac.lk/hackjayathilake@gmail.com*)

IMPACT OF GOOD AGRICULTURAL PRACTICES (GAP) ON SMALL VEGETABLE FARM DEVELOPMENT IN HALDUMMULLA, BADULLA

Buddika Jayashan Kannangara

Department of Agriculture (Uva Province), Rathwatta Mawatha, Badulla, 90000

INTRODUCTION

The demand for vegetables has increased with the growing consumer requirement. Export of vegetables from Sri Lanka in 2017 was 21,697 t and it was boosted up to 25,765 t (15.78%) in 2018 (Economic and Social Statistics of Sri Lanka, 2019). Currently, the quality and safety of production are the major problems faced by the vegetable production sector. Farmers used to apply excessive amounts of agro-chemicals, frequently without considering pre-harvest intervals (*i.e.* withdrawal period) and recommendations of the Department of Agriculture (DOA). Thus, vegetables with agro-chemical residues cause health hazards to humans and harm the environment.

Current Status in Sri Lanka

Farmers pay greater attention to cultivation practices while paying less attention to pre- and post-harvest activities. A study conducted by the Hector Kobbekaduwa Agrarian Research and Training Institute (HARTI) revealed that Sri Lankan farmers apply two to eight times more fertilizer compared to those of the SAARC region and that the country is the highest fertilizer consumer in the region (Tilakaratne, 2013). The handling of vegetables for the local market is also not satisfactory and hence post-harvest loss of vegetables remains as high as 30 – 40 percent.

Farmers and middlemen who are involved in the vegetable marketing channel pay minimum attention to maintain quality of vegetables during the entire process which includes, harvesting, cleaning, grading, packing, storing, loading, transporting, distributing and unloading.

Project Justification

The Division of Department of Agricultural Counselling conducted a project on "Establishment of a mechanism to ensure quality and safety of agricultural commodities to local and export markets by implementing the protocols of Sri Lanka Good Agricultural Practices (SL-GAP)". This report describes the impact of SL-GAP on small vegetable farm development in Haldummulla area of Badulla district to enhance its efficiency and sustainability by 2022. There are numerous advantages of adopting the SL-GAP (Table 1).

Table 1: Major Advantages of Adopting Sri Lanka Good Agricultural Practices (SL-GAP)

With SL–GAP	Without SL-GAP
• Healthy and good quality products to improve the nutritional security of the family	• Products in bad conditions and/or contaminated affecting family health
• Maintain high-quality standards and sustainability	• More market rejections of low-quality products and loss of markets
• Cleaned field with high sanitary condition (with appropriate toilets and deposits)	• Infrastructure and field latrine which are in bad condition
• Control of disregard production	• Confusion and disregard
• More income - Better prices for product quality - Lower costs for agro-chemicals - Higher yield (Productivity)	• Less income - Lower prices - Higher costs for agro-chemicals - Lower yields

Source: Izquierdo et al., 2007

SL-GAP PROGRAMME PROJECT EXPLAINS THE PRACTICES

This SL-GAP programme explains the best practices under the topics as: Improving the working conditions of workers, the gap in crops, the best place to plant them, handling of the crops, water management, usage and storing of agro-chemicals, fertilizer management, recommended harvesting and delivering methods (Figure 1).

HOW THE WORKING CONDITIONS OF WORKERS CAN BE IMPROVED?

- All workers will be trained, Agrochemicals/fertilizer management, hygiene and first aid, and Establish enough sanitary facilities for all workers

GAP IN CROPS WHICH IS THE BEST PLACE TO PLANT?

- Recognize the history of the field and more fertile lands with the availability of water
- Select a land free of solid wastes, chemical contaminants and no risk of water contamination with the aid of a technician

HOW CAN CROPS BE HANDLED?

- Select improved seeds and pest and disease-resistant varieties
- Practice crop rotation and if necessary do seed treatments to avoid pest and diseases
- Install rubbish bins in strategic zones and maintain waste management
- Sow seeds at an adequate distance. Select only healthy seedlings (discard feeble and diseased plants) and clean tools and disinfected equipment
- Control temperature, humidity, and wind considering the season of the year

HOW CAN WATER BE USED AND MANAGED

- Use the required amount of water for savings and care of the crop to increase the production
- Avoid the entry of animals to water sources of the field and avoid pollution of water bodies with agro-chemical preparation and applications

HOW MUST AGRO CHEMICALS BE USED?

- Apply the needed proportion of agro-chemicals in accordance with your crop and the type of weeds and diseases according to the recommendation of the technician
- Periodical observation is necessary for avoiding risks and write down the applications of agro-chemicals that are being done

HOW AND WHERE SHOULD I KEEP AGRO-CHEMICALS?

- A special construction should be made at the field to store agro-chemicals
- This place should be locked, secure, fresh and ventilated

WHAT TO DO WITH THE EMPTY CONTAINERS

- Keep them in closed bags to deliver them to the reception centers of containers

WHAT FERTILIZER SHOULD BE USED AND IN WHAT QUANTITY?

- Apply only the dose required as per recommendations of the technician and write down the applications of fertilizers being done

WHICH IS THE BEST WAY OF HARVESTING?

- Harvest on time and the fruits and vegetables harvested must be placed under plastic baskets and the storage

HOW MUST THE TRANSPORT OF FOOD BE DONE?

- Transport food stuff in a clean transport vehicle, in good conditions and in compliance with transit regulations

Figure 1: Implementation of Sri Lanka-Good Agricultural Practices (SL-GAP)

Source: Izquierdo et al., 2007

STAKEHOLDERS IN "SL-GAP" APPROACH

SL-GAP aims to bring balance into the food production equation. It helps all stakeholders of the food production chain to understand the importance of food safety, the necessity of a sustainable food production system, and the fact that products must not be wasted. Further, the SL-GAP does not prescribe techniques to increase crop productivity. However, it helps farmers to effectively produce profitable and sustainable crops, creating benefits that directly affect them.

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Author:

Buddika Jayashan Kannangara; Agriculture Instructor to the Agrarian Service Centre (ASC) Haldummulla, Department of Agriculture, Sri Lanka. He holds B.Sc. (Plantation Management) Degree from WUSL and High. Dip. In Agriculture (Aquinas UC)
(e-Mail: *Buddikajayashan@gmail.com, dbjayashan@gmail.com*)

Reviewer:

Amani Wijesinghe: Senior Lecturer, Dept. of Bio-Systems Engineering, FAPM, WUSL. Her teaching and research interests include: Food Technology, Food Safety & Quality Management and Development of Food Preservation Techniques
(e-Mail: *jaacwijesinghe@wyb.ac.lk*)

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Serendipol (Pvt) Limited, Pannala Road, Dandagamuwa, Kuliyapitiya (NWP), 60200

INTRODUCTION

The coconut industry is an essential component of the Sri Lankan economy as well as a pivotal source of foreign exchange and employment generation for Sri Lanka. Sri Lanka is the 5th largest coconut producing country**.** About 60% of the coconut production is consumed locally (Annual Report, 2016). Sri Lankans derive a substantial share of their dietary energy and protein from coconut. There are many coconut-based industries in the "Coconut Triangle", including desiccated coconut, coconut milk and virgin coconut oil. To minimize the waste products in the coconut industry, various types of value-added products can be introduced (Adkins *et al*., 2005). Out of the waste in the coconut kernel processing industry, 27 percent can be used in the manufacture of value-added products, such as dehydrated coconut haustorium (*palapi*) chips and haustorium jam (Annual Report, 2016).

Justification

In many coconut processing industries, the use of coconut "palapi" is at a minimum level. Therefore, it is important to introduce a value-added product out of these wastes. Introducing new products from coconut processing waste would lead to economic growth as well as employment generation in the same region. Numerous job opportunities can be created based on these new products. This would create good opportunities for another micro-scale industry for the Sri Lankan economy. Further, this gives an extra income and also different types of job opportunities for the civilians who live in the Coconut Triangle.

Project Constraints

The Coconut haustorium, which is known as "palapi" in Sinhala is discarded during processing of coconuts. The haustorium is palatable at the early stages of germination. It is sweet in taste and has 6 hours of shelf life at room temperature. The major project constraint is lack of the availability of the properly disposed good quality coconut *palapi*. Since this is a zero-income gaining by-product of the coconut industry, producers do not consider the quality of the *palapi* while disposing. Therefore, the haustorium should be removed with minimal damage. Collected palapi should be processed continuously within 3 - 4 hours to obtain the best quality final product to reach the international or local market.

Project Assumptions

To gain the optimum highest oil yield from green coconuts, nuts should be seasoned up to 21 days (Muralidharan and Jayashree, 2012). Producers always maintain a large nut stock for seasoning during low farmgate price to get high profit margin and for continuous production with the demand. Therefore, nut stock undergoes over seasoning up to 45 - 90 days. According to the seasonal age specified by the different producers, haustorium size, nutrient content and the taste of the *palapi* will vary. Presumably, almost all the coconut producers use over seasoned coconuts for their industry. For this current product, we have to use the *palapi* from 45 - 65 days aged nuts. *Palapi* obtained from the coconuts seasoned more than 70 days are not suitable for high quality value-added products.

Project Dependencies

The entire project will be depending on the availability of coconuts. Sri Lanka's coconut production shows a gradual decline over a period of time. Availability of coconuts will be varying for processing with the increasing population, the seasonal yield and the climatic factors. On such situations, producers have to use unseasonal or less seasonal coconuts to fulfil the demand and *palapi* will not be available on such situations. As per the figures of 2019 production data, the Coconut Development Authority (CDA) had limited the nut quantity for the commercial coconut products up to 50,000 nuts per day in order to reduce the coconut price for local consumption. In such a scenario, the availability of raw materials will be limited for the *palapi* jam production.

PROJECT IMPLEMENTATION

Jam production is a simple food preservation technique which is widely used in the world. *Palapi* is the main raw material for the *palapi* jam production. *Palapi* is a waste of the coconut industry and it is a zero cost raw material for the *palapi* jam production. Figure 1 shows the steps involved in jam production using *palapi* (Figure 1). In comparison with the other jams available in the market, *palapi* jam has the potential to become a cheaper product and therefore, would be able to market easily. According to the current trials and sensory evaluations conducted for *palapi* jam comparing it with a commercially available pineapple jam in the market, *palapi* jam has better consumer preference than the pineapple jam (Table 1). Therefore, it is a clue for the success of this project. Moreover, the product maintained microbiological sterility within the SLSI standards.

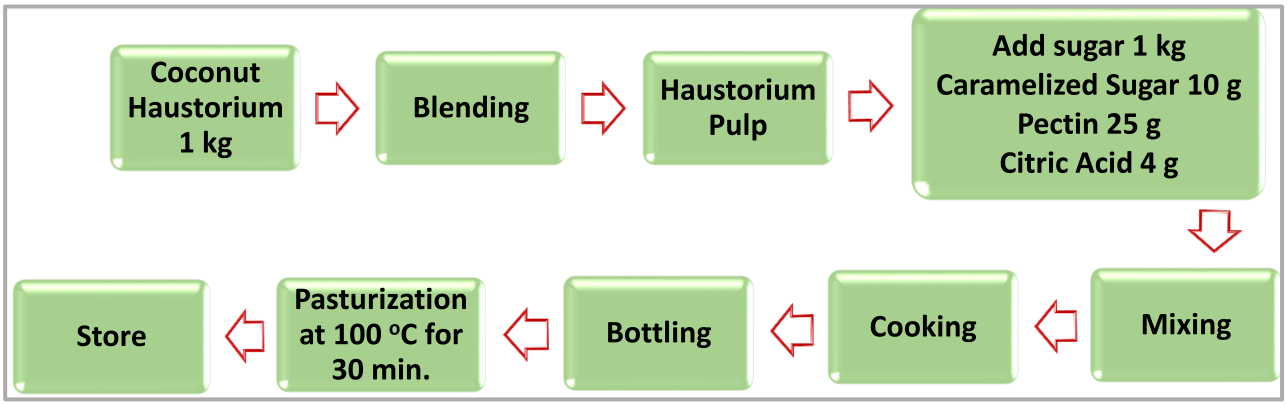

Figure 1: *Palapi* Jam Production Process

Table 1: Mean Scores Received for the Sensory Attributes of Coconut Haustorium (*Palapi*) Jam Made at Serendipol (Pvt) Limited, in Comparison to Pineapple Jam

Character	Pineapple Jam	*Palapi* Jam
Appearance	76%	93%
Colour	88%	95%
Taste	79%	97%
Texture	80%	75%
Smell / Odour	69%	89%

Source: Quality Assurance Department of Serendipol (Pvt) Limited

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Author:

Oshen Sudesh Jayathilaka: Quality Assurance Executive at Serendipol (Pvt) Ltd. He holds B.Sc. (Agric.) Hons. [Second Class Lower Division] from WUSL and currently engaged in Serendipol Organic Coconut Project and FSSC22000 Food Safety Certification activities
(e-Mail: *oshenjayathilaka@gmail.com*)

Reviewer:

Sarananda K. Hewage: Senior Lecturer, Department of Bio-Systems Engineering, FAPM, WUSL. His teaching and research interests include: Postharvest Technology, Food Processing Technologies & Value Addition and Product Development Technologies
(e-Mail: *sarahewa62@yahoo.com*)

SUSTAINABILITY IN THE TEA INDUSTRY THROUGH INNOVATIONS: DIGITAL GREEN LEAF WEIGHING SYSTEM

Daya Priyantha

Kelani Valley Plantations PLC, Kitulgala Estate, Kitulgala, 71720

INTRODUCTION

Since our plantation industry was first established over 150 years ago, it has seen many transformations from the end of colonial rule through nationalization and into the present day. One of the innovative devices, the Green Leaf Weighing System can replace the traditional manual weighing system which enhances the productivity in the plantation sector in Sri Lanka. As evident from the interviews carried out with executives, staff and workers, the digital green leaf weighing system provides accurate, reliable data on daily performance that is updated in real-time and creates a tamper-proof system for measuring the output of employees.

Current Status in Sri Lanka

There are 22 Regional Plantations Companies (RPCs) in Sri Lanka but currently only Hayleys Plantations use digital green leaf weighing system. Adequate attention is not paid to technological innovations in this sector as many companies focus only on traditional methods. They prefer low cost of production and making profits to high investment in resources and finances.

Project Justification

At a time when advanced technology is used to improve precision agriculture in most tea plantations, the common practice for the tea harvesters is to finish a session of work, bring their harvest to a collection point and manually weigh the tea leaves using analogue scales in which entries are made manually by the field staff. This traditional practice creates many issues such as mistrust between field supervisors and tea harvesters during green leaf weighing and their daily work output. Arbitrary deductions and anomalies in the weighing process create differences between check roll, field and factory weights (Peiris *et al.*, 1984). While many plantation companies have enforced strict policies against tampering with daily tallies yet the problem persists.

In most plantations, data are collected monthly, termly and on an annual basis, which involves a lot of paper work and a rigorous data collecting routine (Shanmugaratnam, 1997). With the initiation of this system high employee motivation, improved work relationships and positive work environment is visible according to many surveys and proved by researches that were carried out.

DIGITAL GREEN LEAF WEIGHING SYSTEM

In this system, every tea harvester working for these plantations are provided with a personalized NFC-enable identity card. Each of these cards is utilized to store the information on individual employee’s daily tea harvest, the results of which are weighed on digital scales that are linked directly to a common cloud-based real-time online platform developed internally at Hayleys Plantations, which is accessible by management through specially designed digital tablets distributed among estates and senior cooperate management. The information is integrated through digitized systems to monitor individual employee performance (Figure 1).

Real-time data assists for advanced decision-making process with the quick changing behaviour of the market and the business environment. In this system, there is less paper work at the field (ex-check list). A number of reports and formats are available in this digital system which makes it easy to monitor data. With these advantages, estate management is able to get information quickly and accurately in real-time.

PROJECT IMPLEMENTATION

Implementation of this project in tea plantations will enhance the productivity and sustainability of the tea industry and has direct beneficiaries which is close to two million people. This system is also a platform to share information of employee performances, valuation of their daily work and build trust between field supervisors and tea harvesters. Solutions can only come from precise data as the development of this real-time weighing system which allows the management to make decisions based on accurate information, conditions on each estate, help enhance yields and ensures that each point in the production process is monitored.

The digital green leaf weighing system in plantations go beyond the traditional method of leaf weighing in the plantation sector. It is a remarkable change in the process of every aspect of data collection and analysis.

Constraints

There are many factors which hinder the plantation management from implementing this system, such as high initial investment and maintenance cost, the complicated geographical environment of plantation areas with less network coverage, workers' unwillingness to adapt to new technology, less commitment of estate management and staff, influence of trade unions, political parties and less knowledge on new technology.

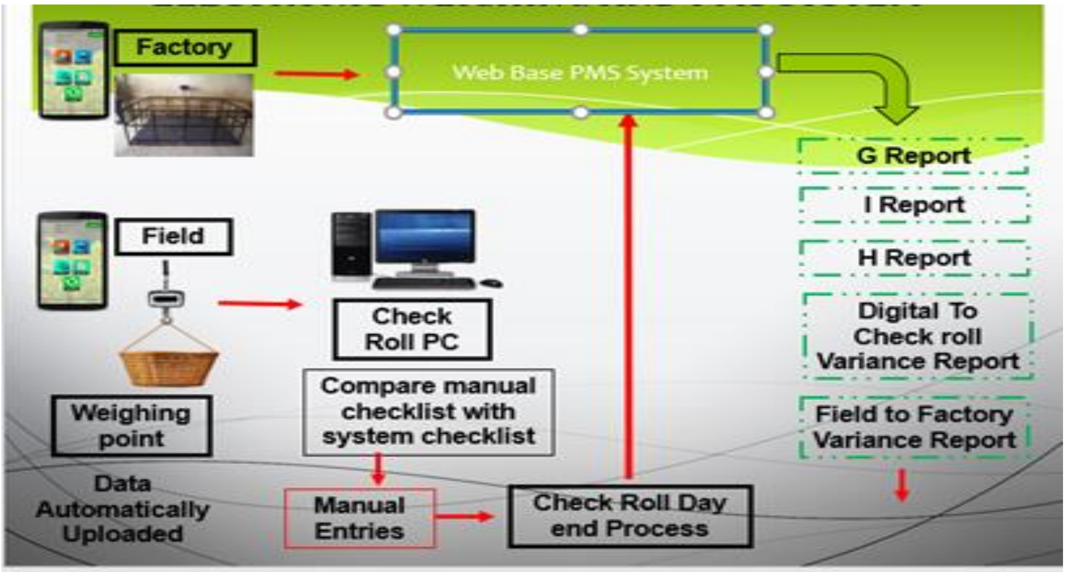

Figure 1: The Diagrams showing Digital Weighing and PMS System

Project Success Criteria

Applying new technological knowledge and integrating it to traditional practices of tea plantations amplifies opportunities to grow their business not only in terms of revenue and sales, but also in human relations and psychosocial development of employees. Digital green leaf weighing system is an accurate digital tool that can monitor and manage tea plantations which can be used to overcome the traditional barriers and face the challenges in the global tea industry.

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Author:

Daya Priyantha: Estate Manager attached to Kelani Valley Plantations. He holds B.Sc. (Plantation Management) from WUSL (e-Mail: *priyan_lk@yahoo.com/daya750830@gmail.com*)

Reviewer:

Jayantha Weerakkody: Senior Lecturer attached to the Department of Plantation Management, FAPM, WUSL. He is also the Director of ICT Centre, WUSL Makandura Premises. His teaching and research interests include: Microbiology, Organic Agriculture, Environment & Forestry and ICT (e-Mail: *wjskweera@gmail.com/weera@mkd.wyb.ac.lk*)

EMPOWERING WOMEN AGRI-ENTREPRENEURSHIP DEVELOPMENT PROGRAMME AT WELISARA

Tharanga Sumudu Priyarshani

Divisional Secretariat, Wattala, 11300

INTRODUCTION

Sri Lanka is a country with a vast botanical diversity and varying climatic conditions. Since floriculture industry has ornamental and commercial values it is popularizing among the women growers. Government bodies such as the Department of National Botanical Gardens and various non-governmental organizations have developed a supportive network system to provide infrastructure facilities, training and other inputs to empower women floriculture growers. In Sri Lanka's floriculture sector, women grower associations perform better with supportive networks and strong links with government institutes (Padmini and Kodagoda, 2017).

Dendrobium, Vanda, Oncidium, Cattleya, Cymbidium and *Phalaenopsi*s are the most common orchid Genera commercially grown in Sri Lanka. Orchids are mainly grown as potted plants for the local market while they are also sold as cut flowers to florists, indoor decorators and hotels in the country. Gampaha district produced the second largest quantity of potted orchid plants in 2018 supplying 244,281 plants to the local market (Department of Agriculture, 2018).

Justification

Welisara is situated within the Wattala Divisional Secretariat (DS) Division and its total population is around 6,000 while the female population is 2,900. Among the total population, 1,900 (32%) are unemployed. Welisara Grama Niladhari Division (GND) of Gampaha district is located along the Puttalam-Colombo main road. As it is an urbanized area, agricultural activities are limited. Nevertheless, floriculture business can be popularized among unemployed women and pensioners in this area because they have direct and easy access to the Colombo commercial city and Katunayake International Airport.

Being a highly urbanized area, it is in close proximity to Kerawalapitiya Interchange of the Katunayake-Colombo Highway, Colombo-Puttalam A3 Road, Thewatta Bacilica (an iconic church), Ragama Railway Station and popular beach side hotels. Therefore, the potential market segments for floriculture products are comparatively high and diversified.

The major constraint for net house orchid cultivation is its high initial cost. Therefore, a government grant was offered at the initial stage under the Western Provincial Development Grants Scheme which was coordinated by the Wattala Divisional Secretariat. The Benefit Cost Ratio (BCR) for orchid production in Gampaha district is calculated as 1.73 (Table 1).

Table 1: Cost Benefit Analysis for Orchid Production in Gampaha District

Component	Year 1	Year 2	Year 3	Year 4	Year 5	Net Present Value (Rs.)	Benefit Cost Ratio
Total Cost (Rs./1000 ft^2)	860,994	220,350	220,350	228,350	220,350	1,117,970	1.73
Gross Income (Rs./1000ft^2)	660,000	660,000	660,000	660,000	811,167		

Source: AgStat, 2018, Department of Agriculture, Sri Lanka.

Project Assumptions

It is assumed that water supply and environmental conditions do not affect orchid production during the project cycle.

'ELINA MAL SANGAMAYA' FLORICULTURE PROJECT

A floriculture project was designed by the Wattala DS to empower the unemployed women in Welisara GND. The project was started in January 2019. In its first stage, 25 unemployed women who were interested in floriculture business were selected and registered as a community organization named *Elina Mal Sangamaya* at Wattala DS in 2019. Among the members, a majority were widows and a Contributory Fund was formulated within the membership. Common infrastructure costs prevailing through the marketing channel, such as transportation costs, costs associated with organizing exhibitions and training programmes were paid by the Contributory Fund. As a registered community organization, it was able to obtain government grants effortlessly. Therefore, a proposal was submitted in January 2019 to obtain Rs. 750,000 under the Western

Provincial Development Grants Scheme. The aforesaid grant money was allocated to construct 25 net houses (10 ft^2 x 10 ft^2 x10 ft^2) for 25 households (Figure 1). Planting materials were procured by growers' own funds.

All 25 women entrepreneurs were trained by the National Botanical Garden, Asgiriya, and by another volunteer resource person who was a trainer and instructor for orchid cultivation and lived in the same village during that period. In addition, separate entrepreneurship development training programmes were arranged in August 2019 in collaboration with the Ministry of Small Enterprise Development. Growers were specially trained to maintain their accounts in each cropping cycle. Continuous training and technical support have been assured by the National Botanical Garden, Asgiriya and the Agriculture Instructor. Overall coordination and facilitation of market, annual auditing of accounts and continuous monitoring are carried out by the Wattala DS up to 2021. Market facilities have been organized by Wattala DS with the support of Wattala Municipal Council, Wattala and Ja-Ela *Pradeshiya Sabha* in the form of flower exhibitions and flower stalls along the roads. The first flower exhibition of *Elina Mal Sangamaya* was held in December 2019 (Figure 2).

Figure 1: Orchid Net House at Welisara

Figure 2: Orchid Exhibition at Welisara

PROJECT SUCCESS CRITERIA

The first lot of orchid plants has been already sold by 15 women and they have started their second cycle. They were able to cover the total cost of production excluding the cost for net house which was granted by the government in their first cycle. The remaining 10 women are still in their first cycle of the business. Twenty five agri-entrepreneurs were built up by this project. As the next step, actions will be taken to expand the market capacity by reaching the tourist hotels along the beachside by November 2020.

ACKNOWLEDGEMENT

Financial assistance from the Western Provincial Council is gratefully acknowledged.

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Author:

Tharanga Sumudu Priyarshani: Assistant Divisional Secretary, Divisional Secretariat, Wattala. She holds B.Sc. (Agric.) [Second Class Hons] from WUSL and Diploma in Public Administration from SLIDA (e-Mail: *sanggulu@yahoo.com*)

Reviewer:

Kamani Ratnayake: Senior Lecturer, Department of Horticulture and Landscape Gardening, FAPM, WUSL. Her teaching and research interests include: Postharvest Physiology & Technology and Horticultural Science
(e-Mail: *kamani.ratnayake@uqconnect.edu.au/kamani@wyb.ac.lk*)

ESTABLISHMENT OF BIG ONION TRUE SEED PRODUCTION VILLAGES WITH ADVANCED TECHNICAL PACKAGE

Asanka Appuhamy

Niraviya Farm, Mahaweli Authority of Sri Lanka, System H, Thambuttegama, 50240

INTRODUCTION

Big onion (BO) is an essential component of the daily diet in Sri Lanka creating a relatively constant year round consumer demand. It has been popular among the growers due to its high profitability and the high returns that can be earned in the short run. BO is mainly cultivated in Mahaweli System H (MSH), Matale and Anuradhapura districts. The local production of BO was 17,838 t from a cultivation extent of 901 ha in the year 2019 (Table 1). This is not sufficient to meet the annual demand of BO which is approximately around 270,000 t/year. In 2018, Sri Lanka imported about 246,237 t of BO by spending about Rs. 4,718 mn. The unavailability of good quality seeds of recommended varieties in adequate quantities is considered as the main constraint in boosting production of BO in Sri Lanka.

Table 1: Production and Extent of Big Onion in Sri Lanka 2015 - 2019

District	2015		2016		2017		2018		2019	
	Prod. (t)	Ext. (ha)	Prod. (t)	Ext. (ha)	Prod. (t)	Ext. (ha)	Prod. (t)	Ext. (ha)	Prod. (t)	Ext. (ha)
Anuradhapura	22,816	1,342	20,960	997	7,834	486	6,486	282	4070	192
Kurunegala	-	-	-	-	-	-	-	-	8	0.3
Mahaweli H	16,920	940	12,537	729	8,836	515	4,137	197	3,558	158
Matale	36,040	1,802	27,608	1,446	20,972	1,056	9,240	462	9,023	472
Mannar	-	-	-	-	-	-	-	-	18	6
Vavuniya	-	-	-	-	-	-	-	-	79	5
Mullaitivu	-	-	-	-	-	-	-	-	10	5
Polonnaruwa	3,276	234	2,450	146	1,443	72	2,184	104	1,068	63
National Total	79,052	4,318	63,555	3,318	39,085	2,129	22,047	1,045	17,833	901

Source: Department of Census and Statistics, 2020; Prod.=Production; Ext.=Extent cultivated

The total true seed supply of BO comprised of local production as well as imports. The local true seed supply has been estimated as 40 percent of the total seed requirement. Department of Agriculture and Mahaweli Authority, as well as a few private companies have initiated various programmes to increase the production of BO seed in Matale and Anuradhapura districts and MSH (Samantha *et al.*, 2012).

Justification

MSH consists of 25,390 ha of irrigated land. Generally, 250 - 400 ha of BO is cultivated in MSH during the *Yala* season. The total requirement of BO true seeds during *Yala* is 1,750 – 2,800 kg and in the last few years cultivated extent of BO drastically dropped due to unfavourable climatic conditions, unavailability of quality seeds, and unstable market price. Considering the national BO requirement, MSH is planning to increase its BO cultivation extent up to 1,000 ha in 2025 and achieve self-sufficiency in BO true seeds through the Big Onion Seed Production Villages (BOSPV) with well-planned extension service and a hi-tech package. The price of local BO true seed is five times higher than that of the imported seeds. However, because of the high quality, there is an increasing demand for locally produced BO true seeds over the imported seeds. Hence, there is a high potential to expand the local true seed production.

PROJECT OF ESTABLISHING BIG ONION TRUE SEED PRODUCTION VILLAGES (BOSPV)

Two Collective Farmer Organizations (CFO) will be established in the year 2020 by selecting 20 big onion farmers per each distribution channel. Two rain shelters (each 50 m^2 in size), drip irrigation kit, onion seed bulb stores and basic true seeds of the variety MIBO-1 will be supplied to each selected farmer with a 50% MSH contribution. The project has planned to establish two new BOSPVs in every year up to 2025. MSH will provide free transportation for vernalization, and extension and training programmes throughout the process (Figure 1).

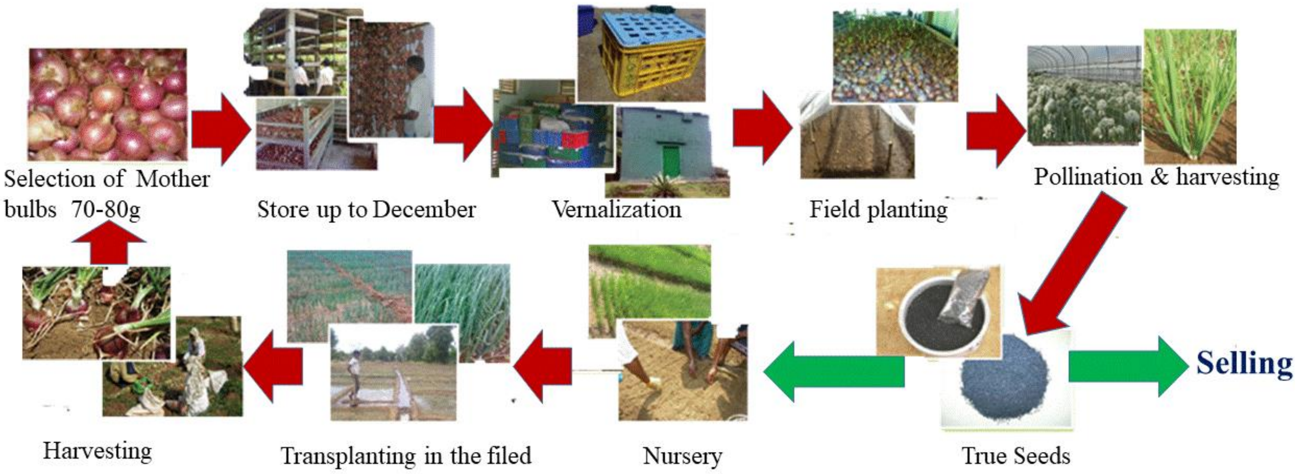

Figure 1: Big Onion True Seed Production Process

Major Constraints

BO true seed production programme takes place in *Maha* season and due to the rainy conditions in *Maha* season, probability of occurrence of diseases is high. As a result, there is a risk of not getting a better production. All mother bulbs need to be sent to Rahangala area of Nuwara Eliya district for the vernalization process within a short period of time. Providing transport facilities is a problem due to high cost and in some cases, low germination due to damages in long distance transportation. Adverse climatic conditions during the harvesting period and improper fertilizer usage may affect against proper curing of seed bulbs. Hence, high rate of losses of mother bulbs occurred at storage until the next *Maha* season and high cost of production are the major drawbacks to increase the number of farmers for the production of BO true seeds.

Project Assumptions and Dependencies

Project assumes that, well-trained farmers may continue BO true seed production for years and at least each selected farmer will engage in true seed production more than five years from the project cease. CFO will increase their members and remain strong to make their brand prominent in the market.

All selected famers of BOSPV will register under the Seed Act. Produced seeds will be tested in seed testing laboratories of the Department of Agriculture and packed in properly designed packages and stored in cold storages. Finally, the project expects to market seeds among MSH big onion farmers. Although there is a high risk in the production of big onion seeds as the crop is more sensitive to climatic conditions, the production of local true seeds is financially more profitable. A higher rate of revenue of BO cultivation will uplift the farmers' lifestyle. By looking at them, new farmers will gather around them and invest on BO true seed production. Increasing the number of farmers and cultivated extent will meet the national requirement of BO and save foreign exchange spent for BO and BO seed importation.

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Author:

Asanka Appuhamy: Farm Manager attached to the Mahaweli Authority of Sri Lanka. He holds B.Sc. (Agric.) [Second Class Hons] from WUSL and currently engages in dairy processing, animal husbandry, orchard management and food processing (e-Mail: *nimeshasa@gmail.com*)

Reviewer:

Jagath C. Edirisinghe: Professor in Agribusiness Management, Department of Agribusiness Management, FAPM, WUSL. His teaching and research interests include: Agricultural Marketing, Supply Chain Management, International Trade, Environmental Economics and Bayesian Econometrics (e-Mail: *jagath@wyb.ac.lk*)

EFFECTIVENESS IN BIOLOGICAL CONTROL OF COCONUT MITE USING A PREDATORY MITE *Neoseiulus baraki*

Amila Munasinghe

Kurunegala Plantations Limited, P.O. Box 25, No.80, Dambulla Road, Kurunegala, 60000

INTRODUCTION

The coconut mites (*Aceria guerreronis),* first reported from Mexico in 1960 is considered as a serious pest of coconut. Since the first report, it has spread to over 17 countries in the Caribbean region, Central and South America, seven countries in Africa and Oman. In 1998, the mite was reported from India and Sri Lanka. In Sri Lanka, the first appearance of the coconut mite was in the Kalpitiya peninsula and now it is present in all coconut growing areas of the country, particularly in drier areas. It has been estimated that about 15 percent of crop loss occurs in the infested areas (Aratchige *et al*., 2008).

Justification

Feeding of coconut mites beneath the perianth of developing nuts, results in the scarring of the nut surface (Figure 1). In severe infestations, reduced nut size and nut malformation can also occur. The percentage of damaged nuts due to coconut mite was significantly different among the coconut estates of the mid country intermediate zone. There were also variations relative to nut size and shape. Irrespective of spatial and temporal variability, nut loss per mite-infested palm was estimated to be 15.9 percent per annum. A two to three percent slowing down in the growth of annual national coconut production was projected due to coconut mite infestation. The loss to the coconut grower, selling at the rate of Rs. 15/nut, was estimated to be Rs. 6,240/ha (US$ 57.25/ha) if the estate was mite-infested.

Due to hidden habitat underneath the tight perianth of developing coconuts, high breeding rate, wind dispersal of the coconut mite, all-year-round flowering nature and massive size of the coconut palm, management of the coconut mite has been difficult in all the countries. Many countries use toxic insecticides to reduce the pest populations; but to keep the pest densities at low levels, the treatments have to be carried out repeatedly at short intervals. Due to the practical difficulties in the application of insecticides and their hazardousness to the environment it could not be considered as a viable option to manage coconut mite.

Several biological control agents (BCAs), particularly predatory mites, had been reported in several countries, but only a few could move underneath the tight perianth of nuts in search of the coconut mite making biological control limited. The predatory mite (*Neoseiulus baraki)* that is naturally present in the coconut mite affected plantations in Sri Lanka, is a mite with a flat body and found preying in coconut mite underneath the perianth (Aratchige *et al*., 2008). The predatory was considered as a prospective agent for the management of coconut mite. However, their natural propagation is inadequate to significantly suppress the coconut mite population.

Therefore, the present project was conducted to determine the effectiveness of releasing predatory mites in terms of the quality and quantity of the harvest. The objective was to ascertain the effectiveness of using the biological method of controlling the coconut mites as it is the most sustainable and environment-friendly method to control the pest apart from the interim recommendations, mainly based on chemicals, which may cause residual effect in the environment.

PROJECT IMPLEMENTATION

This project was carried out in a plantation situated in the intermediate mid-country region (IM_3) of Sri Lanka. Three replicates were used including three control blocks and three treatment blocks representing 10 randomly selected mite-infested coconut palms in each block. Samples were selected with the same age level in an estate belongs to Kurunegala Plantations Limited. Each block was at least 10 rows apart. The three control blocks were located 500 m away from the treatment blocks. In the field the laboratory-reared predatory mites were released onto the selected palms hanging the cut open sachets on 3 - 5 months old bunches containing 5,000 predatory mites. Those mite sachets were placed on the palms by the climbers. The release frequency undertaken in this experiment was at 4 months interval for one year. Pre-releases data were collected from one harvest of mature nuts in three replicates 2 weeks prior to the first release of mite predators. Thereafter, mature nuts were harvested at monthly intervals and data on damaged nuts, undamaged nuts, fruits with discontinued scars, the weight of fresh nuts, kernel thickness, the diameter of husked nuts and total nuts were collected at 4 months intervals.

Success Criteria

Experimental evidence revealed that, by releasing predatory mites according to the proposed manner, at the end of a period of a year, it was able to reduce the percentage of damaged nuts by 65%. This is one of the important elements in the control strategy of the coconut mite from a grower's point because small-sized nuts can considerably account for the economic loss due to mite damage. Moreover, it was noted that the increase in husked nut weight by 23.6%, fresh husk weight by 78.8%, kernel thickness by 20%, the diameter of husked nut by 22.6% and the nuts per palm by 26.3 % would increase the income of the coconut growers. The calculated benefit-cost ratio was 4:1 (Table 1).

The release of predatory mites is ideally suitable for organic coconut growers as well. Economies of the release of *N. baraki* to control coconut mite is a serious concern of growers especially due to the tall structure of coconut palms, that incur a higher cost in releasing the predators compared to many other crops. By way of collecting harvesting data over a long period after termination of the release of the predator, expected yield gain and the post-release residue period of the control measure could be determined. Therefore, the collection of yield data is useful to evaluate the long term effectiveness of the release of *N. baraki*.

Figure 1: Mite Infected Button Nuts

Table 1: Variation in Yield Related Attributes of Coconut Nuts in Treatment Blocks in Comparison to the Control after the Last Release of Predatory Mites

Description	Percentage of Variation (%)
Decrease in Damaged Nuts	65.1
Increase of Husked Nut Weight	23.6
Increase of Fresh Husk Weight	78.8
Increase of Kernel Thickness	20.0
Increase of Diameter of Husked Nut	22.6
Increase of Total Nuts	27.2
Increase of Nuts per Palm	26.3

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Author:

Amila Munasinghe: Estate Superintendent in Kurunegala Plantations Limited. He holds B.Sc. (Plantation Management) from WUSL. He is currently engaged in managing and developing multi-cropped estates (e-Mail: *amilamunasinghe@gmail.com*)

Reviewer:

Radhika Gimhani: Senior Lecturer, Department of Biotechnology, FAPM, WUSL. Her teaching and research interests include: Plant Biotechnology, Molecular Plant Breeding and Gene Mapping (e-Mail: *dgimhani@wyb.ac.lk*)

DairyLive® HERD MANAGEMENT SOFTWARE TO IMPROVE PRODUCTIVITY OF DAIRY FARMS

Wimalasiri Dharmarathna

National Livestock Development Board, Siringapatha Farm, Badalgama, 11538

INTRODUCTION

National Livestock Development Board (NLDB) is committed to foster the livestock and dairy industry in Sri Lanka by developing quality breeding materials, livestock and agricultural products. It is being infused with new technology and innovations in due awareness of the national wide effort, making the country self-sufficient in livestock and dairy products. The main goal of management is to increase the milk production. Therefore, a special attention is paid to postpartum period and to estrus and gestation. The other major objective is to obtain a pregnancy rate of 90 percent. Generally, the farms record the data associated with management related variables/activities namely the udder health, cow cell counts, teat dipping, antibiotic management, controlling milking machine, postnatal period, prevention of infectious and parasitic diseases, alimentation, preparing of the young cattle for reproduction with requirement weight gain and culling and slaughtering of less productive dairy cows.

Justification

For a long time, the traditional approach was used to collect and record the data in farms. The mangers of respective farms used to collect and record required data by maintaining individual history sheets, each belong to a separate cow. If a manager needs to analyze the herd, he should read all history sheets. With time, management realized that it is a time consuming exercise and integration of Information and Communication Technology (ICT) is very useful to solve problems of this nature. Many software have been introduced in various agri-businesses to make the management convenient and efficient, however, it was applied at limited scale in the dairy industry due to non-awareness of the subject among the dairy community. A Computer programme of health and production management software *viz*. "Dairy champ" was first implemented in NLDB managed four upcountry farms namely Dayagama, Bopaththalawa, New Zealand and Ambewela, in year 1992 with the assistance of Netherlands government funding programme. This programme was further extended to NLDB-managed Coconut Triangle farms having around 3,000 animal herd in 2005. However, the software could not be used until by 2010 due to some technical problems. In year 2010, some changes were made in the activity of the NLDB with the importation of pregnant heifers from Australia to upcountry farms. Advanced animal breeding programme and maintenance of individual data sheet of animal were important for herd management purposes. A comprehensive set of data of the cow population should be maintained for the breeding programme. This requirement resulted in introduction of the modern software "DairyLive®" which is a Windows version, on dairy management. As a result, Windows-operated DairyLive® software was successfully introduced to four upcountry farms in year 2011.

PROJECT IMPLEMENTATION

According to a decision taken by the management, the new software DairyLive® was used to collect, record and analyze the data. All data of the animals were collected daily and they were analyzed weekly. Then, reports were provided to the management. Since the database has all the information of the animals, when any animal gets sick, quick supervision and treatments were given making the management very convenient. Hence, there is no any delaying for any treatment, animals got pregnant before 90 days of the calving. In order to get calf within 365 days of calving interval, DairyLive® software assisted in achieving the target. Eight variables were considered to quantify and judge the success of the project, as given below:

Variables Used to Measure the Success of Project

1. Open animals more than 90 days after calving
2. Overdue cows (not calving in due days)
3. To be dry animals for last 60 days of gestation
4. Low weight gain heifers
5. Pregnancy diagnosis animals after services have been done
6. Offspring of higher producing animals
7. Heifers not bred more than 18 month of age
8. Peak production of each lactation cows

Additional technical support was taken from the respective software company through communication via internet making an additional payment for such advice. Management of the farms were motivated to carry out the programme continuously with the help of software and the company. Top Management of the NLDB later authorized to carry out this programme in farms within the Coconut Triangle in order to increase production performances and achieve their targets.

Project Constraints

This was a novel challenge for the farm managers and veterinarians to learn and work actively, both at the farm level and in the whole herd production chain using the DairyLive® software. Generally, software was updated time to time, therefore, managers and assistant managers should be aware with the updated software to get the best results. Maintaining the data was major constraint for managers and veterinarians. Proper identification of the animal was the other constraint of this programme. The NLDB administration has empowered the farm managers to use proper branding system facilitating easy identification of the animals to eliminate such situation.

RESULTS

In the annual estimate of a respective farm, they have estimated target for a respective years. Our objectives could be achieved with the introduction of new information system and intensive breeding programme. The milk production per cow per year was from 2,000 L to 6,000 L from year 2011 to 2018 among European breeds in the up country farms (Table 1; NLDB Progress Report, 2018). Apart from the changes mentioned here, in cattle housing designs were also altered during the mentioned time frame. Currently this new programme with DairyLive® software has been recognized as the best ICT software for the farms, where parlor milking machines are not available. Therefore, this new programme was introduced to ten NLDB farms in the Coconut Triangle.

A 5-year estimated target was prepared to achieve the expected targets in farms managed by NLDB in the Coconut Triangle (Table 2).

Table 1: Data Extracted from NLDB-Managed Dayagama Farm – 2010 and 2018

Description	2010	2018
Age at 1st Calving (Months)	40	30
Calving Interval (Days)	460	390
Average Milk Production (L/cow/day)	6.5	15.5
Lactation Production (L)	2,000	6,000

Table 2: Five Year Estimated Target for all NLDB Farms in Coconut Triangle

Description	2020	2025
Age at 1st Calving (Months)	40	30
Calving Interval (Days)	460	390
Average Milk Production (L/cow/day	5	10
Lactation Production (L)	2,000	3,000

ACKNOWLEDGEMENTS

Author extends his thanks to the Management and the staff of NLDB for providing forecast targets and other necessary information on the software, which have been successfully used to-date.

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Author:

Wimalasiri Dharmarathna: Assistant General Manager, National Livestock Development Board. He holds B.Sc. (Plantation Management) and a MBA degrees from the WUSL and Post-graduate Diploma on Tropical Animal Production from Wageningen University, Netherlands (e-Mail: *dareejub@gmail.com*)

Reviewer:

Kanchana S. Weerasinghe: Senior Lecturer attached to the Information Communication Technology Centre of WUSL. Her teaching and research interests include: Information Systems, Database Management System and ICT in Agriculture & Education (e-Mail:*kanwyb@yahoo.com)*

CULTIVATION OF CAVENDISH BANANA IN CLUSTER LEVEL FOR EXPORT

Wasantha Malkanthi

Fruit Research and Development Institute, Kananvila, Horana, 12400

INTRODUCTION

Banana is a common cash crop grown in Sri Lanka at both home garden and commercial level. Commercial level banana plantations are found especially in Embilipitiya, Ambalantota and Mahaweli regions of Sri Lanka. *Ambul*, *Kolikuttu* and *Seenikesel* are the main banana varieties grown in commercial farms, whereas, *Amban*, *Ambul* and *Seenikesel* varieties are grown mostly at home garden level in the wet zone. However, these varieties are not suitable for export market due to their poor keeping quality and susceptibility to Panama disease except *Ambul* banana. Banana variety "Cavendish" which receives a high demand worldwide has excellent keeping quality of 40 - 45 days after harvesting. In addition the variety is resistant to the Panama disease (Newly *et al.*, 2008).

Justification

Currently, cultivation of Cavendish banana in Sri Lanka is limited for a few commercial companies. However, with its best keeping quality and resistance to diseases, Cavendish banana is a good alternative for farmers at commercial or home garden level. This project by Fruit Research and Development Institute (FRDI) of the Department of Agriculture (DOA) on "Cultivation of Cavendish Banana in Cluster Level" aims to support banana farmers to produce high quality banana for the export market.

CAVENDISH BANANA PROJECT

The Project was implemented initially in selected areas in three main banana growing districts, *i.e.* Hambantota (Ridiyagama), Kurunegala (Mahawa) and Puttalam (Mylamkulama). The beneficiaries of the project were selected from among farmers having a minimum of one acre land with a good water supply throughout the year. Those farmers were selected as a cluster within 1 km^2 to facilitate quick packaging after harvesting. Usually, Cavendish banana should be packed within 2 hours after harvesting for better keeping quality. The DOA supplied planting materials free of charge and 50% subsidies for micro irrigation systems. Banana cultivated lands are regularly monitored by the DOA Extension Officers and instructions for cultivation practices and correct packaging are provided free of charge. The harvest is purchased by an exporter selected by the DOA at pre-agreed rates based on the Grades of Banana (Table 1).

Table 1: Criteria and Purchasing Prices for Different Grades of Cavendish Banana

Grade	Criteria	Price Rs/kg	
		Year 1	Year 2
Grade 1 – Cal. Size: 42 - 45	Length of the fingers > 18 cm Appearance – without any damage, good appearance	55.00	60.00
Grade 2 - Cal. Size: 36 - 42	Length of the fingers – 15 – 18 cm Appearance – without damage	30.00	40.00
Grade 3	Length of the fingers < 15 cm	15.00	15.00

Cultivation Practices

Cavendish banana plantations need removal of additional suckers up to 3 months, deflowering in fruits and covering the fruits with bags to minimize pest attacks and improve the quality of fruits (Figure 1).

Banana Packing Procedure

Correct harvesting of Cavendish banana at required length is critical for its quality and receiving a good market price (Table 1). Banana reaches the caliper size 42 at 10 -14 weeks after flowering. After harvesting, hands and fingers (4 - 6 per bundle) are separated, washed with 5% Alum solution twice and treated for fungal infections before packing in boxes. Packed banana are stored in a cold room at 13 – 15°C temperature.

PROGRESS OF THE PROJECT

Number of beneficiaries in each district and their average harvests (kg/ac) of Cavendish banana in comparison to *Ambul* and *Kolikuttu* are given in Table 2. Average harvests for Cavendish banana were higher than *Ambul* and *Kolikuttu* in all three districts. First harvest of Cavendish banana was obtained at 7 - 8 months after planting while that was 10 months for other two types. The second harvest of Cavendish and *Ambul* were obtained after 5 - 6 months. However, *Kolikuttu* cultivations were destroyed after first harvest by the Panama disease. Those fields can be reusable for other banana after growing the resistant variety, *Ambul* for 6 - 8 years before cultivating susceptible banana varieties. The project expects to collect annual data on cost of production and profits to determine which type of banana is more profitable and sustainable for banana farmers in Sri Lanka.

Figure 1: Cultivation Practices for Growing Cavendish Banana, (A) Removal of Suckers, (B) Deflowering, (C) Bagging the Fruits and (D) Packing

Table 2: Number of Beneficiaries and Harvests for Different Types of Banana in Different Districts

District	No. of Beneficiaries	Harvest kg/ac				
		Cavendish		*Ambul*		*Kolikuttu*
		Year 1	Year 2	Year 1	Year 2	Year 1
Hambantota	21	18,500	23,000	15,300	17,500	17,000
Kurunegala	17	18,000	20,000	13,000	13,750	-
Puttalam	11	16,500	17,800	11,000	12,000	-

Project Constraints

The main constraint of the project is finding an export market. To solve this problem initially an exporter (S.R. Bio Food Product Pvt. Ltd.) was introduced to the farmers with and agreement.

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Author:

Wasantha Malkanthi: Assistant Director of the Fruit Research and Development Institute, Department of Agriculture. She holds B.Sc. (Agric.) from University of Peradeniya
(e-Mail: *mawmalkanthi@gmail.com*)

Reviewer:

Wajira K. Balasooriya: Senior Lecturer of Department of Biotechnology, FAPM, WUSL. Her teaching and research interests include: Industrial Microbiology and Biotechnology, Environmental Biotechnology, Agricultural Chemistry and Molecular Techniques
(e-Mail: *wajirab@wyb.ac.lk*)

ELEPHANT DUNG COFFEE: A VALUE ADDED COFFEE PRODUCT

Eranda Bandara

Department of Export Agriculture, Race Course Road, Nuwara Eliya, 22200

INTRODUCTION

Coffee (*Coffea arabica* L.) is one of the world's most popular beverages, with annual global consumption of over 2.25 billion cups (Ponte, 2002). There is a growing demand for a variety of coffee flavours, which has led to numerous research and development of speciality coffees with unique tastes and flavour profiles (Table 1). An unconventional method of coffee preparation that results in a unique flavour has been the use of animal digestive systems, such as the Asian palm civet cat (*Paradoxurus hermaphroditus*) and Asian elephants (*Elephas maximus maximus*) during coffee bean fermentation prior to processing (*e.g.* Kopi Luwak from civet cats and Black Ivory Coffee or elephant dung coffee from elephants). Sri Lanka is one of the few countries where both good quality coffee is produced while having a large population of captive and semi-wild Asiatic elephants, which could be used to make quality elephant dung coffee.

Table 1: The Most Expensive Coffees in the World – 2019

Name of the Coffee	Unique Attribute	Average Prices (US$ / kg)
Black Ivory Coffee (Thailand)	Elephant Dung Coffee	1,100
Finca El Injerto Coffee (Panama)	Location-specific	1,100
Hacienda La Esmeralda	Location specific	770
Kopi Luwak (Indonesia)	Civet Coffee	352
Saint Helena Coffee (Africa)	Location-specific	174
Blue Mountain Coffee (Jamaica)	Location-specific	110
Fazenda Santa Ines (Brazil)	Location-specific	110
Los Planes Coffee (El Salvador)	Location-specific	88
Hawaiian Kona Coffee (Hawaii)	Rare variety	75

Source: University Magazine, 2020

Economics of Elephant Dung Coffee

Elephant dung coffee was first developed and is still only being produced by Black Ivory Coffee Company in Thailand. Their total production for the year 2018 was 150 kg, which was sold at an average price of US$ 1,880 per kilogram or US$ 13 for an espresso sized cup (Thammarat *et al*., 2018). Production is limited by the availability of coffee cherries and the appetite of elephants. Further, a proportion of beans is destroyed through chewing and it is needed that the elephants are followed to collect the dung and recover intact beans. To produce 1 kg of this specialized coffee in this process, it requires 33 kg of raw coffee cherries.

Elephant conservation organizations have raised concerns on the ethics of elephant dung coffee. These valid concerns could be addressed by having a strong focus on diet, welfare and ethical treatment of captive elephants. In addition, by developing a coffee that is related to elephant welfare, conservation and coffee producing farmers could result in a positive environmental, social and economic outcome for both elephants and farmers. The Department of National Zoological Gardens and the Black Ivory Coffee Company will be the key institutions to initiate this project.

PROCESS OF ELEPHANT DUNG COFFEE PRODUCTION

Hand picked ripe Arabica coffee cherries will be mixed with other typical feeds such as, fruits, vegetables, green parts of coconut and fish tale palm (*kithul*) trees and fed to captive elephants. The coffee beans will be digested and fermented inside the elephant's gastrointestinal tract in about 12 - 70 hours (Thammaratt *et al*., 2018). The partly digested beans will be passed out as elephant dung, from which the individual beans will be hand-picked, washed and dried under sunlight with a certain percentage of a moisture level. The cherries should be then hulled and sorted to obtain the green beans (Figure 1).

Each stage of processing needs to be controlled carefully as it has an effect on the final coffee taste. Protein in coffee beans is one of the factors responsible for the bitter taste in coffee. Fewer proteins in processed coffee beans has been linked to a reduced bitter taste in coffee. The characteristic taste of elephant dung coffee is described as "very smooth without the bitterness of regular coffee", and this taste is influenced by the elephants' digestive enzymes, which breaks down the coffee's proteins.

In this proposal, the suppliers of the raw coffee cherries shall be from the farmers of Kothmale valley in Nuwara Eliya and the process is proposed to be executed at the elephant orphanage located at Pinnawala in Kegalle.

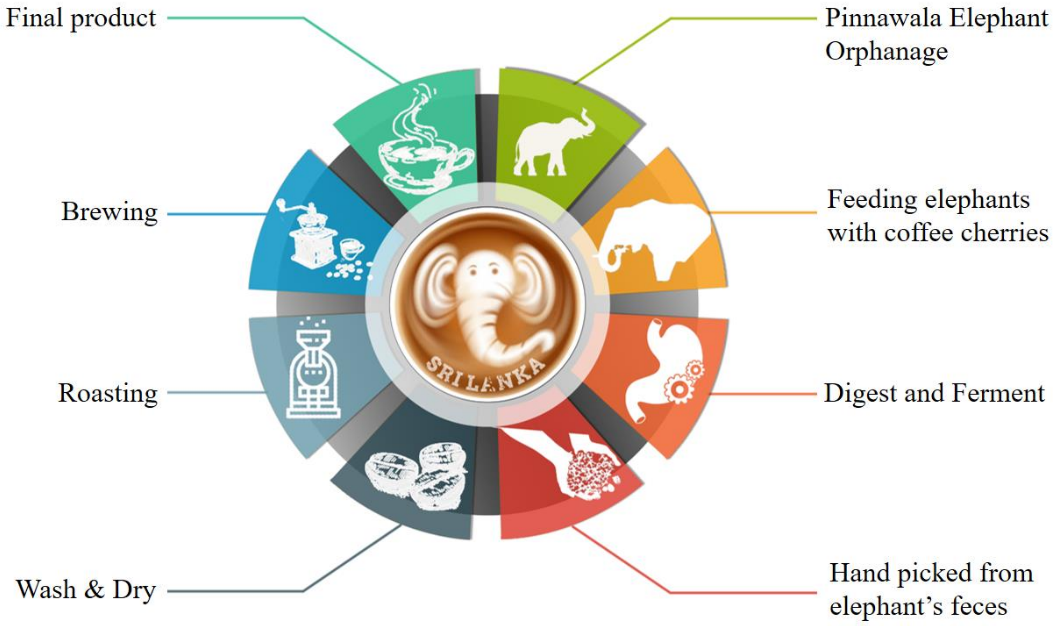

Figure 1: Elephant Dung Coffee Manufacturing Process

Benefits of Elephant Dung Coffee Production

Even though Sri Lanka is producing high-quality coffee, the total quantity produced is low compared to other coffee producing countries. Value addition is a potential method to increase income in the industry. Sri Lanka is rich with Asian elephants. Both coffee and elephants hold symbolic, cultural and economic importance to Sri Lanka as they are having a high tourist attraction. Due to this reason, the production of elephant dung coffee provides valuable income generation for coffee farmers, as well as elephant caregiving families.

The income generated through this project generally tends to be supporting favouring the aging parents, health expenses, school fees, food and clothing expenses of coffee farmers in Kothmale valley, which is one of the best quality coffee producing regions in Sri Lanka. Premium prices can be offered to coffee farmers for coffee cherries provided for this process. Additionally, a fixed percentage of sales proceeds of the proposed elephant dung coffee production can be donated for the betterment of the Pinnawala Elephant Orphanage, the place where the core production process of this project could be located.

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Author:

Eranda K. Bandara: Export Agriculture Extension Officer at Department of Export Agriculture. He holds B.Sc. (Plantation Management) from WUSL and currently engages in activities on developing local coffee production in Nuwara Eliya district (e-Mail: *eranda.dk.bandara@gmail.com*)

Reviewer:

Geethi K. Pamunuwa: Senior Lecturer, Department of Horticulture and Landscape Gardening, FAPM, WUSL. Her teaching and research interests include: Food Science and Technology, Nutraceuticals and Nanotechnology (e-Mail:*geethipamunuwa16@gmail.com*)

DEVELOPING A LOW CARBON BUSINESS MODEL

Krishna Ranagala

Talawakelle Tea Estates PLC, No. 400, Deans Road, Colombo 10, 01000

INTRODUCTION

Greenhouse Gas (GHG) emission from human activities is the dominant cause for global climate change. Continued emission of GHG may cause long-lasting changes around the world, increasing the likelihood of severe and irreversible impacts for people and ecosystems. The world first five-business risks faced by the current business are associated with environment and include extreme weather events (Wang *et al.*, 2019). Previous studies highlighted that the low carbon economy is the ideal approach for efficient energy consumption, low pollution, low emission and high effectiveness. The UN Climate Change Conference – COP 25, highlighted the importance of working on this to promote this transition to low carbon economy, while developing new concepts and policies (Yang *et al.*, 2012). Sri Lanka as a country is highly vulnerable to climate change in terms of physical and socio-economic impacts. The Global Climate Risk Index based data on weather-related loss events during the period 1998 to 2017; the annual average recorded figures for Sri Lanka emphasize the urgent need of policy planning and real actions on climate change.

Justification

The requirement of business model to struggle climate change and its impacts are becoming increasingly clear because climate change is going to alter the planet, resulting two-fold effects, namely (1) its complex environmental impact will directly affect business, society, and ecosystems; and (2) governments will seek to mitigate its effects with far-reaching regulations. This study proposes that the future trends of businesses are towards the transition of low-carbon economy and applicable model for Sri Lankan business context.

ANALYSIS AND DISCUSSION

1. Low-Carbon Economy

A low-carbon economy is a less use of fossil fuel for economic activities; otherwise, it is called decarbonized economy (Yang *et al.*, 2012). According to the fifth assessment report of the Inter-governmental Panel on Climate Change (IPCC), it is clear that the country needs to take measures to avoid a rise in average global temperature of above 2˚C. In emission wise, the countries need to reduce the global average per capita CO_2 emissions up to 70 percent by year 2050 and achieve zero net emission by year 2100. Under the current situation, there are numerous risks and opportunities due to climate change that need to be considered as drivers of change in business environment (Table 1).

Table 1: Business Drivers for Low-Carbon Economy with Risk and Opportunity Analysis

Category	Risk	Opportunity
Investments	Possible loss of investment on fossil fuel base and high-carbonized industries	High attraction of investors on clean energy base company and low-carbonized industries
	Facts- Investment of world power sector, as a one single category Renewable Energy sector absorbing 39%, which is biggest single component. *Source: World Investment Report 2019 by UNCTAD*	
Competitiveness	High-carbonized industries having high risk on energy shortage and high cost	Low-carbonized industries obtaining less cost factors and more subsidies
	Facts- 67% consumers interesting on carbon footprint labelling *Source: "Value-action gap" Survey 2019 by Carbon Trust International*	
Regulations	Increasing trend of business discouragement regulations on high-carbonized industries	Developing number of business encouragement regulation on low-carbonized industries
	Facts- European Commission announced their long-term vision climate-neutral economy by 2050 *Source: Communication of European Commission – COM (2018) by European Commission*	

Source: Output of the Published Literature Analysis by Author

2. Business Leaders in Low-Carbon Economy

Most of the leading companies are adopting low-carbon business models with the aim of mitigating climate change (Table 2).

Table 2: Strategy and Performance of Low-Carbon Economy Oriented Companies

Company	Low-carbon Strategic Action	Achievements
Tesco	Reduce scope 1 and 2 GHG emissions 60% by 2025 and scope 3 GHG emissions 17%	1. 41% emission reduction per square feet 2. Switched to 100% cost-zero renewable energy
Procter & Gamble (P&G)	Reduce emissions from operations 50% by 2030	1. Significant reduction of GHG emissions, have saved US$ 500 million

Source: Output of the Low-carbon Oriented Companies' Strategy and Performance Analysis by Author

3. Managerial Implications

The proposed low-carbonizing business model with triple steps namely, measure, reduce and compensate, could be elaborated as in Figure 1. This model further emphasizes four stages, *viz.* inputs, process, outcome and impact within the business case.

Steps	Low-Carbonizing		
	Measure	Reduce	Compensate
Input	Identify, Quantify and Verify	Reduction targets and strategies	Insetting and Offsetting
Process	Quantify direct/indirect or scope 1,2,3 emission by adopting ISO 14064 or GHG Protocol	Switch energy sources to renewable/clean energy and execution of reduction actions	Invest solar, wind, biofuel, projects and forest restoring projects to earn carbon credits
Outcome	Capture all direct emission & max. possible indirect sources	Reduce maximum possible emission until net-zero emission	Unavoidable emission offset 100% or above
Impact	**"Carbon/Climate Conscious Organization"**	**"Low/De-carbonized Organization"**	**"Carbon Neutral or Climate Ready organization"**

Figure 1: Proposed Low-Carbon Business Model

CONCLUSION

The future outlook of low-carbon economy is apparent which could bring substantial benefits. The strategies in the proposed business model seek to achieve social, economic and environmental development goals while reducing long-term GHG emissions contributing to limit global warming to well below 2°C. Finally, this create an environment increasing the resilience to climate change impacts. According to current business risks and challenges, companies will be required to adopt and transit to low-carbon economy with significant reduction of emissions. Companies who do not response to this situation, they will be met with unavoidable consequences in future in aspects of finance, operation, reputation and competitiveness. Pressure from international and national regulations and standards also accelerating the transition of low carbon economy with radical trend. The leading and competitive companies have already begun to respond this transition. Within current business context, foreword looking companies must change their business strategies toward the low-carbon economy with the right regulatory and policy support and global initiatives such as the partnership for market readiness (PMR), companies could effectively implement such low-carbon business strategy. This will ultimately strengthen the business readiness and resilience to future challenges.

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Author:

Krishna Ranagala: Assistant Manager - Sustainability and Quality Systems Development attached to the Talawakelle Tea Estates PLC, Company of Hayleys Group. He holds B.Sc. in Eco-Business Management Special Degree from FMS, SUSL (e-Mail: *ranagala.k@gmail.com*)

Reviewer:

Bandara Gajanayake: Senior Lecturer of the Department of Plantation Management, FAPM, WUSL. His teaching and research interests include: Tea Production and Marketing, Climate Smart Agriculture and Resource Management in Plantations (e-Mail: *gajawyb@yahoo.com*)

INTRODUCING RUBBER PLANTATIONS TO THE DRY ZONE: EVIDENCE FROM THE EASTERN PROVINCE OF SRI LANKA

Ranjith Wickramasinghe Udawaththa

Rubber Development Department, Regional Office, No.03, Kachcheri Road, Monaragala, 91000

INTRODUCTION

All rubber cultivated lands spread over 3,496 *Grama Niladhari* (GN) Divisions located in 137 Divisional Secretariat (DS) Divisions of 15 administrative districts in the island. The total extent of rubber lands in Sri Lanka by 2016 was 171,126 ha (Anon., 2017). Traditional rubber growing lands are also extensively used for other plantation crops such as oil palm and other development activities. Early in this decade, the government of Sri Lanka launched a program to grow rubber in the some parts of the dry zone (DZ) and intermediate zone of the island to expand the extent under rubber which are regarded as non-traditional rubber growing areas. The majority of people in these areas are the rural farmers, especially who are either below or hovering on the poverty line. The Eastern Province can be identified as an 'extraordinary' province under this program. The programme began in 2010 expecting to reach a target of 10,000 ha of rubber by 2018 (Anon., 2011). This study attempts to review the success of this project at the end together with underlying constraints.

RUBBER PLANTING PROJECT IN DRY ZONE AT IMPLEMENTATION

First in the Eastern Province, rubber plantations were introduced to Marawa, Komana, Helakomana, Kirawana, Kehelulla areas which belong to the Padiyathalawa DS division of the Ampara district. Thereafter, it was spread over the DS divisions of Mahaoya, Aranthalawa, Uhana, Mangalagama and Gonagolla. The objective of this project was to establish 500 ha of rubber in 2010 and gradually increase area under rubber up to 10,000 ha by 2018. There were 4,000 identified beneficiary farmer families in the Eastern Province from this project. Rs. 2,000 million had been allocated for this project and it was implemented through the Ministry of Plantation Industries (MPI), Rubber Development Department (RDD) and Rubber Research Institute of Sri Lanka (RRISL) with the support of International Foundation for Agricultural Development (IFAD). This author was also a part of this project and was in-charge of growing rubber in Padiyathalawa and Mahaoya areas from 2013 to 2016.

Farmers were provided with financial and material resources by several government institutions for this project. For those who did not own freehold lands, the Forest Department and the Mahaweli Authority have provided them with 1 ha of land on a 40-year lease and the rubber plants and rubber fertilizers required for planting the land were provided by the RDD and IFAD. In addition, a subsidy of Rs. 225,000/ha has been provided by these institutions in eight instalments. In addition, a subsidy of Rs. 6,000/ac has been provided for banana, pineapple and maize which are recommended for cultivation as intercrops. Once mature, the "Thuru Saviya" fund grants loans for tapping lands for the application of rain guards, purchase rubber-rolls which are used to grind the rubber and build smoke houses. Government and Semi-Government institutions such as the RDD, RRISL and IFAD have provided technical advices to the farmers to make the project success.

Success in Achieving Expected Targets

Lands received subsidies until the 4th premium after planting on permits, lands received 5, 6 and 7 premiums of subsidies and the lands which were on tapping condition were regarded as successful lands in the project. Figure 1 shows the disparity between expected target and the archived targets of rubber cultivation during the project (from 2010 to 2018). Although end project target of the project was 10,000 ha of cultivated rubber lands, only 1,480 ha of cultivated rubber lands were reported at the completion of the project in 2018. This is a 14.8 percent achievement of the expected target of the project which is a low success. By 2020, it is reported that about 40 percent of the plants have died due to various causes, *viz.* prolonged drought conditions prevailed during project period, damage to the root board of poly-bagged plants during transportation of plants and lack of mulching practices by growers (about 90%). Consequently, at present the cultivated rubber lands in the respective areas remain less than 1000 ha.

Compared to rubber cultivation in wet and intermediate zones, rubber from DZ lands reports comparatively high Dry Rubber Content (DRC) and thus gets a high price. Moreover, leaf diseases and the panel diseases found in the wet zone are relatively low in the DZ. Dry zone farmers, who are struggling with the earth to cultivate short-term crops every season, get benefited for rubber cultivation since it provides comparatively easy operation and year-round economic benefits. Because of these benefits, DZ farmers are more inclined to cultivate rubber which was a great strength towards the success of the project.

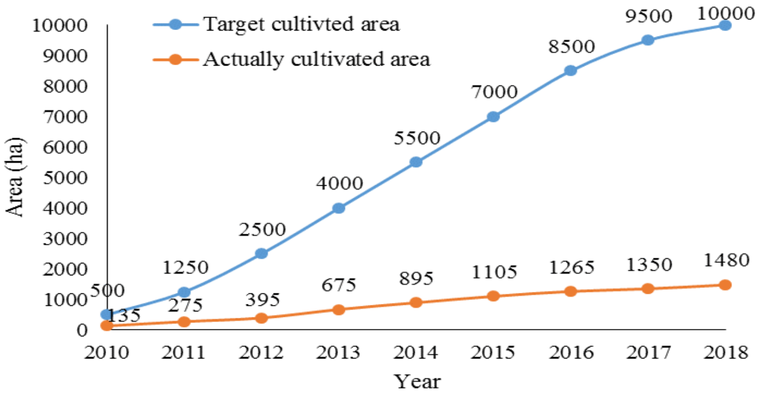

Figure 1: Expected and Achieved Targets of Rubber Cultivation in Eastern Province from 2010 - 2018
Source: RDD, RRISL and AFAD Census 2010-2018

Constraints for the Success of Project
Major constraints for the project were limited freehold lands available for rubber cultivation and the issues of land ownership. The Mahaweli and Forest Departments were unable to issue the total amount of the allocated lands as promised at the beginning of the project. A significant fraction of farmers reported abandoned rubber lands intentionally after obtaining subsidies, rather than continuing with the cultivation. Some of the farmers failed to continue with rubber cultivation sine their short term earnings from traditional framing (short term cropping) were stalled by cultivating rubber in their lands initially. Water management and cropping cycle were critical on dry zone rubber cultivation. It was central to plant rubber in second or third weeks of the inter-monsoon period in *Maha* for a successful establishment which was mostly failed due to improper supply of rubber plants by the authorities due to some institutional issues. Consequently, a large number of plants died in the next year due to the drought consequently reporting unsuccessful rubber lands.

In addition, farmers were in the wrong perceptions and did not properly adopt the technical guidelines, recommended by the RRISL for the DZ. Especially, they ignored proper practices of moisture conservation, *viz*. planting 4 rods in 5 ft. height of *Gliricidia* at a distance of 1 m around the rubber plants and apply a deep (0.5 – 1.0 ft.) mulch at a radius of 3 ft. around the plants. As a result, evapotranspiration, drying the ground and depleting ground water levels took place causing the death of rubber plants.

CONCLUDING REMARKS
Rubber cultivation can secure the livelihood of rural farmers in the Eastern Province being a year-round permanent income source. It also secures the land ownership of farmers and establishes a tree cover in the region on which intuitional barriers should be sorted out. The water management is crucial on the success of establishment of rubber plantations and thus farmers must be well aware and encourage adopting proper moisture management practices through a proper extension service. For the DZ areas in the Eastern Province, a user-friendly and low-cost irrigation scheme should be introduced for small holders through proper research.

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Author:

Ranjith Wickramasinghe Udawaththa: Rubber Processing Adviser at Rubber Research Institute of Sri Lanka and Senior Rubber Development Officer at Rubber Development Department (RDD). He holds B.Sc. (Plantation Management) from WUSL (e-Mail: *wickramaudawaththa@gmail.com*)

Reviewer:

Keminda Herath: Professor in Applied Statistics, Department of Agribusiness Management, FAPM, WUSL. His teaching and research interests include: Statistical Inference, Project Analysis & Management and Time Series Econometrics (e-Mail: *kemindaherath@gmail.com*)

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Master of Agri-Enterprise and Technology Management, Wayamba University of Sri Lanka

BEAUTIFYING KULIYAPITIYA: URBAN AGRICULTURE FOR SUSTAINABLE CITY DEVELOPMENT

Madushani Sewwandika Jayathilaka

Kuli / J.R Jayawardhana National College, Dummalasooriya, 60260

INTRODUCTION

One of the biggest challenges mankind is facing in the next decades is the growing population and increasing urbanization. The rapid urbanization progress is associated with changes in land use resulting in challenges such as food insecurity, poverty, hazards to public health, pollution, urban waste as well as environmental degradation. Sustainable city concept assures economically viable, environmentally sound and socially acceptable cities in the world. The creation of "sustainable cities" and the identification of ways to provide food, shelter and basic services to the city residents is a challenge to many city authorities. This project is therefore, targeting institutions and individuals confronted with the task of initiating sustainable urban development in Kuliyapitiya by practicing Urban Agriculture (UA).

Justification

Increasing of the urbanization in Kuliyapitiya causes many issues under social, environmental and economic aspects. UA can be beneficial for all pillars of sustainable development, be it social, environmental or economic. UA contributes to social development in three ways. Firstly, UA is an important element of food security strategies. Secondly, UA can be used for community development. This refers particularly to urban gardening as an activity in order to increase social cohesion between different groups in the society, to provide work and training experience for unemployed workers, and as a tool for crime prevention. Thirdly, UA is used in cities for educational purposes. It can be done through workshops, courses and tours. Increasing biodiversity, improving water infiltration and reducing pollution are some of the environmental benefits of UA.

UA offers economic benefits for cities in various ways. Firstly, it can be regarded as a new way of generating income. Also, UA may offer the potential for recreational, tourist and marketing purposes. Many urban farms are open for the public and organized tours, and as such, they could be compared to other tourist attractions. Moreover, working on a farm is a productive way of spending free time and escaping stressful daily life, especially for workers with a high income. Therefore, this project aims to promote UA in the Kuliyapitiya area in order to achieve sustainable city development concept.

URBAN AGRICULTURE PROJECT

Urban Agriculture can be described as the growing of plants and the rearing of animals primarily for food and other domestic use within a city or a town and its environs. It involves activities such as the production, processing, marketing and delivery of farming products. UA can also involve animal husbandry, aquaculture, urban beekeeping and horticulture. Urban agriculture consists of a number of production systems (Table 1). They vary from domestic production and household level processing to large-scale agriculture.

Table 1: Types of Urban Agrıculture

Type	Description
Community gardens	Single piece of land gardened collectively by a group of people
Institutional gardens	Food production in schools, hospitals, prisons and other non-profit organizations
Guerrilla gardening	Gardening in public spaces without permission
Urban farms	Commercial food production by professional farmers using advanced growing systems.
Vertical farming	Growing produce in vertical stacks
Plant factories with artificial lighting	Indoor farming combined with resource utilisation efficiency and closed plant production system
Zero acreage farming	Growing food without using any additional land or acreage
Agro-park	Clusters of agro activities in which various links of the food chain are located in one place
Agro-tourism	Involving in any agriculturally based operation or activity that brings visitors to a farm

Source: Erwin et al., 2018

PROJECT IMPLEMENTATION

As the initial step, awareness programmes are conducted to educate urban peripherals on UA since it is a new concept for Kuliyapitiya. A major limitation of urban agricultural production in Kuliyapitiya is the availability of suitable plots. Solutions to limitations on space can be found in alternative farming methods. Vertical spaces can be used to establish vertical gardens (Figure 1). Walls can be used to hold cages for poultry and livestock as well as to train vines. Hydroponic and aeroponic systems can be used because they have the capacity to increase crop yields by 15 to 20 percent, without requiring large plots of urban land. Further, institutions including both public and private institutions like hospitals, government and private offices, courts, auditoria, cinema halls and hotels can be designed as institutional gardens.

The yard around the house can be used as it is the best-known place to grow food within an urban area. While the backyard is the most significant for food production, side yards and front yards are also exploitable. The front yard, however, presents some particular concerns that it is more accessible and therefore more exposed to theft and vandalism, and the crops are more easily contaminated by pollutants from vehicle exhausts. Therefore, the backyard is highly suitable for gardening. If yard space is unavailable, other household surfaces such as rooftops, patios, or balconies can be used to grow vegetables.

It is assumed that urban agricultural activities are on-going and that the growers have a clear understanding about the variables (type of crop, yield per year, rain/irrigation, types of markets, pricing of produce and storage facilities) influencing food security in the area. It is also assumed that the growers are transparent and truthful in doing all agricultural activities (Irrigation, fertilization and harvesting).

The degree of project success depends on many factors including the 'mix of activities'. Other success factors include the 'mix of products' for example, the balance between high value crops and other products and the degree to which subsidies are possible. Both men and women engage in UA. Their age, education level, occupation, marital status, number of family members, state of dependence of the family members and monthly income are considered for the success of the project.

Figure 1: Vertical Gardening

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Author:

Madushani Sewwandika Jayathilaka: Teacher at Kuli/J.R. Jayawardhana National College, Dummalasooriya. She holds B.Sc. (Agric.) [Second Class Upper Division] from WUSL
(e-Mail: *rmmsewwandi@gmail.com*)

Reviewer:

Kapila Yakandawala: Professor and the Chair of Department of Horticulture and Landscape Gardening, FAPM, WUSL. His teaching and research interests include: Landscape Gardening, Environmental Horticulture and Urban Agriculture
(e-Mail: *yakandawalakapila@gmail.com/kapilay@wyb.ac.lk*)

AGRO VILLAGE DEVELOPMENT PROGRAMME IN VELLANKULAM, MANNAR DISTRICT

Randima Lakmayura Jayantha

Sri Lanka Army Farm, Vellankulam, Mulankavil, Mannar (NP), 41000

INTRODUCTION

Agricultural development is the ability to develop some better systems of agricultural production. Agriculture sector plays a highly important role in the process of economic development of a country and it is the basic source of food supply to the world. Due to the heavy pressure of population in under-developed and developing countries and its rapid increase, the demand for food is increasing at a fast rate. If agriculture fails to meet the rising demand of food products, it will affect adversely on the growth rate of the economy. Sri Lanka is a middle-income country with a total population of 21.7 million people. Out of the total population in Sri Lanka, 31.8 percent engages in agricultural activities (The World Bank, 2019). Ministry of Agriculture implements various programs to increase local food production and to minimize food import expenditure.

Vellankulam village is located in Manthai -West Divisional Secretariat in Mannar district. Three hundred and twenty-five families live in this village with a total population of 825 people. The majority of people are farmers with low income rate (poverty 20.1%) while 20 percent of people are unemployed (The World Bank, 2017). Climatic condition is semi-arid with 1000 -1500 mm average annual rainfall (DL_3). The main soil type is Red Yellow Latosol and it is suitable for paddy cultivation and for low country vegetables such as long bean, brinjal, okra, pumpkin, ash pumpkin, cucumber/*kekiri*, radish, bitter gourd, *etc.* (Agriculture Division, 2014). All cultivations are mainly based on the annual rainfall patterns of this area.

Project Justification

This project will be implemented in Vellankulam area to eradicate the poverty of the people and to improve the villagers' income through the improvements of irrigation system, application of new technologies (sensor based agriculture, climate smart agriculture and high yielding farming system), rain water harvesting system, organic fertilizer production and postharvest technology. It will also improve the productivity of agricultural crops and produce a network of agricultural markets to sell the products. This project will motivate a majority of youth in this area to take up agriculture. The project will be started in 2021 and will be completed by the end of 2023.Various government and non-government bodies will involve with this project such as Sri Lanka Army Farm in Vellankulam, Divisional Secretariat Manthai - West, provincial and central agriculture offices in Mannar, farmers union in Vellankulam and trade unions of Mannar. The finance, human resources and technology will be provided by the relevant government sectors.

This project gives a long-term effect to farmers by increasing their agricultural productivity and obtaining a good market for the products while increasing their income. The goals will be achieved by conducting series of awareness and training programmes with several practical sessions for the farmers of the village regarding correct and modern techniques, providing fertilizer subsidies, coordinating with the government sector, improving irrigation systems, introducing Integrated Pest Management (IPM) methods and providing a good market for the products.

PROJECT PROCEDURE

The project will develop infrastructure facilities of the villages (agro wells, irrigation canals, irrigation system), provide awareness regarding the correct and modern technology (new agricultural projects that are implemented in other areas of the country, packaging techniques, value addition for product quality, and export market), introduce newly released high yielding varieties instead of traditional varieties and introduce new agricultural equipment to the farmers. Apart from that, this project will also implement a seed production programme with the help of other Departments. The Army Farm of Vellankulam has already produced 1 ton of maize hybrid seeds with the assistance of Department of Agriculture.

The final objective of this project is to increase the revenue of the farmers in Vellankulam area and to get the maximum participation of youth for agriculture. There are two main types of project dependencies, direct dependencies and indirect dependencies. Farmers of Vellankulam area and villagers are direct dependencies involving in this project. Consumers, raw materials and equipment suppliers, transporters, agricultural product sellers (wholesalers and retailers) and field officers are the indirect dependencies. Indirect dependencies are not directly involved with the project (Figure 1).

One of the main barriers of this project will be the communication problem because most of the people in this area are less educated and they are not willing to use the modern technology instead of their traditional methods. Less infrastructure facilities, pest and disease problems, irrigation problems, postharvest losses of fruits and vegetables, less market availability (long distance markets are available - Dambulla, Thabuttegama, Jaffna), less involvement of youth and adverse climatic conditions (long drought period) will also negatively affect on this project. Wild elephant attacks will be a special challenge for farmers. Government organizations sometimes take a long time to release subsidies to the beneficiaries due to limited resources and heavy documentation part. The initial investment for this project is high so at the initial stage there will be a less profit for the farmers.

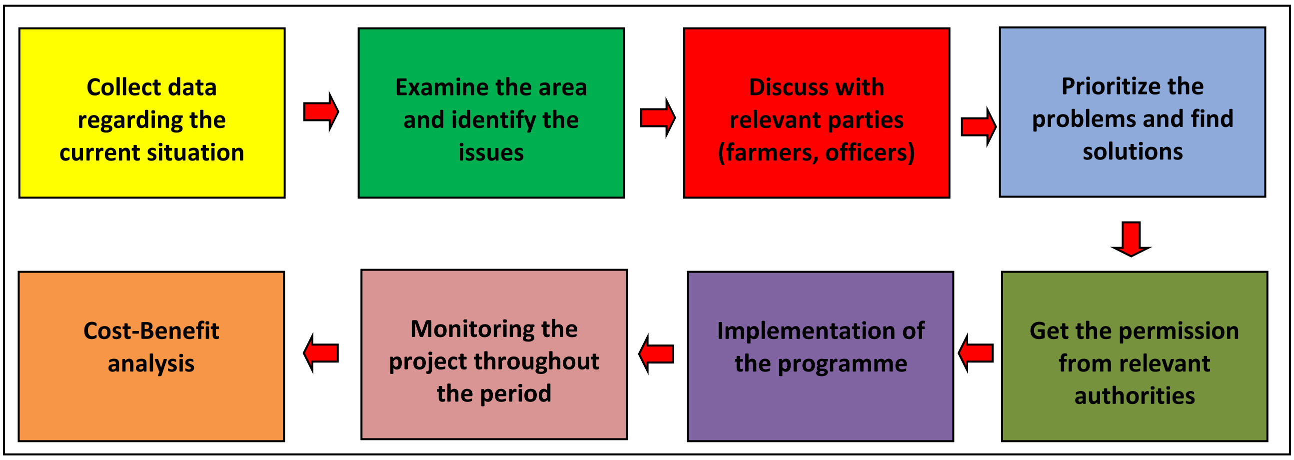

Figure 1: Process of Agro Village Development Programme

The project will be monitored throughout the time and be evaluated using the cost benefit analysis method. Sustainability of this project will be high because there will be less damage to the environment and it will accelerate organic cultivation as well as organic fertilizer production. This project will introduce a rain water harvesting technology and develop the irrigation system and it will be beneficial to farmers at the end of the project. Agriculture using new technology will be a better solution for youth unemployment in this area.

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Author:

Randima Lakmayura Jayantha: Agriculture Officer in Sri Lanka Army. He holds B.Sc. (Agric.) [Second Class Lower] from WUSL (e-Mail: *randimalakmayura@gmail.com*)

Reviewer:

Kusum Wijesinghe: Senior Lecturer, Department of Agribusiness Management, FAPM, WUSL. Her teaching and research interests include: Organizational Management and Human Resource Management (e-Mail: *kusum_wijesinghe06@yahoo.com*)

IMPLEMENTATION OF OUT-GROWER SYSTEM IN TEA ESTATES OF JANATHA ESTATES DEVELOPMENT BOARD (JEDB)

Hiran Kossinna

Rockwood Estate, Janatha Estates Development Board, 55/75, Vauxhall Lane, Colombo 02, 00200

INTRODUCTION

Out-grower farming or contract farming is referred to as "agricultural production carried out according to an arrangement between farmers and a buyer or land owner which places conditions on the production and marketing of the commodity" (Shyamalie and Wellala, 2012). In this system, a plot of underutilized or unproductive land which is abandoned due to lack of worker is allocated to a worker family residing in the estate on an agreement between Plantation Company and workers. To manage the out-grower land, those workers are provided inputs such as fertilizers on credit basis and technical guidance to manage the tea land. In return, out-growers are required to supply their green leaf to the factory and green leaf price is paid for them according to the agreement.

Current Status in Sri Lanka

Sri Lanka is the world's fourth-largest tea producer and accounts for two percent of GDP. Plantation sector is considered as a highly labour intensive sector which requires a regular supply of workforce throughout the year. Labour productivity in tea sector has greater relation with cost of production (COP) in Sri Lanka (Figure 1). At present, Sri Lankan tea industry is facing many crucial challenges such as low productivity and shortage of workers. Further, some of the productive lands have to be abandoned due to non-availability of workers resulting declined productivity. On the other hand, worker shortage leads to higher worker demand resulting continuous wage increase granted to plantation sector. As a result, the COP of tea in Sri Lanka is the highest in the world when compared to major tea producing countries. Therefore, tea is becoming a less profitable venture today.

Project Justification

There is a greater need for enhanced productivity particularly in tea plantations. Also, there is a drift of estate population to urban areas, looking for alternate sources of income that would provide higher living status and reduce poverty. Therefore, the major challenge for JEDB plantations is to find a way to decrease the COP by increasing the productivity and arresting the worker drift by increasing their income. As a solution, some developing countries have attempted to decrease COP and arrest this drift through the stimulation of out-grower systems of production with workers' participation.

Taking everything into account, the Agricultural Economics Division of the Tea Research Institute of Sri Lanka (TRISL) had conducted preliminary studies on out-grower systems in tea estates. It revealed that the productivity has increased through sustainable production resulting in low COP of tea and workers' family income too has increased, thereby preventing worker out-migration and increasing their living standards. (Shyamalie and Wellala, 2012). A similar system would be a solution to the current issues faced by JEDB tea plantations in Sri Lanka.

Project Constraints

As JEDB is under the purview of Ministry of Plantation Industries, it should follow all the government policies, rules and regulations. In this context, difficulties in changing attitudes of some workers on out-grower concept, time to work on out growers' plots, no provision to increase number of plucking rounds, difficulties in motivation due to low green leaf prices are identified as major constraints associated with out-grower system. In addition, risk associated with land ownership to the estate, conflicts between out-growers and other workers in the estate, violation of conditions in the agreement, low quality of green leaf because payments are made on kilogram basis, are other major risks and limitations while implementing the system.

Project Assumptions

Low yielding fields below 500 kg/ha/year and abandoned seedling tea fields are allocated initially among 250 estate worker families. Production will be initiated 30 days after implementing the model and 12 months onwards, average monthly productivity of out-growers' fields will be increased by 40 percent through timely application of fertilizer, weeding, soil conservation and proper plucking practices adopted by the out-growers. Consequently, a low operational cost is resulted decreasing the COP by 25 percent. The allocation of land for each out-grower should be on the basis of 1 ha where the bush population is 5,000 - 6,000 to enable worker to obtain a reasonable harvest. Average estimated monthly income per out-grower's plot is Rs. 15,000.

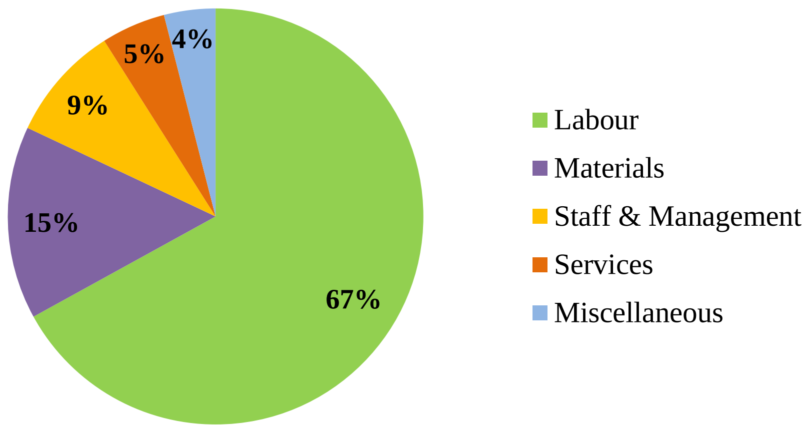

Figure 1: Labour Productivity of Tea in Relation to Cost of Production in Sri Lanka - 2018
Source: Annual Report, Hayleys PLC, 2020

Project Dependencies

Ministry of Plantation Industries is the main stakeholder who is influenced by the implementation of out-grower system. JEDB and estate workers are partners in implementing the system. JEDB is the main implementation agency of the project (providing inputs and technical guidance) while estate workers participate in cultivation activities. Dependencies are created through redefinition of use rights to customary land and through the redefinition of cash flows into out-grower communities.

Project Success Criteria

The main outcomes of this model are reduced COP by increasing the sustained productivity, thereby increasing the income of the estates as well as the worker families. As a result, efficiency of tea industry will increase contributing to agribusiness development and strengthening value chain development. The success of an out-grower system is determined by many factors. As out-grower system introduces some changes to management system in tea estates, all the stakeholders in the system should be clued-up of and persuaded to accept the system and conditions at establishment period as well as continuation period. During initial stage of establishment of the system, there should be an effective monitoring system involving a holistic approach. Risk factors are minimized by building up of a strong relationship with the out-growers and developing confidence among them and timely supervision of all cultivation activities by the responsible people. When implementing this model, the out-grower should develop the allocated land with the standard bush population (12,500 plants/ha). As the plant density is increased, it will assist the climate change mitigation activities through carbon sequestration.

Expansion of tea plant density is the main output of this system. After completing one pruning cycle, the economic and financial analysis is carried out using economic internal rate of return/financial internal rate of return, expected net present value/financial net present value, payback period, cost benefit ratio and cost effectiveness analysis methods.

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Author:

Hiran Kossinna: Superintendent, Rockwood Estate, Hewaheta, Janatha Estates Development Board, Sri Lanka. He holds B.Sc. (Plantation Management) [First Class] from WUSL and is a fellow member of NIPM. Currently engages in managing tea plantations by supervising all field operations and tea manufacturing tasks (e-Mail: *kossinnah@gmail.com*)

Reviewer:

Chandana Abeysinghe: Professor in Plantation Management, Department of Plantation Management, FAPM, WUSL. His teaching and research interests include: Tea Agronomy & Processing, Crop Physiology, Bioactive Compounds in Foods, and Antioxidant Properties of Food (e-Mail: *abeysinghedc@yahoo.com*)

INTERNAL FACTORS AFFECTING LOW CONCEPTION RATE AT RIDIYAGAMA FARM OF THE NATIONAL LIVESTOCK DEVELOPMENT BOARD

Mahendra Karunathilake

National Livestock Development Board, No. 40, Nawala Road, Narahenpita, Colombo 05, 00500

INTRODUCTION

Ridiyagama farm of the National Livestock Development Board (NLDB) is the largest dairy farm in Sri Lanka, which maintains around 3,500 dairy cattle (Department of Census and Statistics, 2019). It is located at Ambalantota in the dry zone of Sri Lanka. In the year 2014, the farm was converted as a modern dairy farm to maintain European Dairy Cattle. In 2015, there were 2,500 dairy cattle in the breeds of Jersey and Jersey x Friesian crosses imported to the farm from Australia and maintained them under Intensive Management System (*i.e.* controlled environmental conditions). During last few years, the farm has been showing a low conception rate on Artificial Insemination (AI) and it has caused for High Calving Interval and Low Calving Rate that resulted low milk production and poor financial performances (Table 1).

Table 1: Impact of High Calving Interval on the Financial Performance at Ridiyagama Farm

Year	No. of Births		Avg. No. of Milking Cows		Avg. Calving Interval (Days)		Avg. Yield/ Cow/Day (L.)	Approx. Milk Loss due to Less Milking Cows (L)	Avg. NSA/L of milk (Rs.)	Approx. Loss of Income (Rs.Mn)
	Tar.	Act.	Tar.	Act.	Tar	Act.	Act			
	1,492	1,396	1,877	1,814	-	-	13.6	312,732	86.45	27.0
2017	1,730	1,860	1,700	1,393	400	443	14.5	1,624,796	88.00	143.0
2018	2,029	1,712	1,716	1,669	400	536	13.3	228,162	88.33	20.2
2019	2,092	1,663	1,742	1,489	400	524	13.1	1,209,720	93.54	113.2
Total	7,343	6,631	1,759	1,591	400	501	13.6	3,375,411	89.08	303.3

Source: Database of M&E division of NLDB Head office. Act.-Actual; Avg.-Average; Tar.-Target

Project Justification

Breeding is one of the major activities in dairy farming which directly support to maintain a standard herd composition in the farm. In the dairies rearing European breeds, the Conception Rate of AI plays a key role in breeding. The conception rate (50-60%), calving rate (90%) and calving interval (400 days) are the key performance indicators used to evaluate the performance of breeding. High repetition of AIs is the major problem of Ridiyagama farm which has caused a high calving interval (Over 500 days) and low calving rate (72%). The current conception rate of Ridiyagama farm is around 15-20% which is very low against the standard and it has led to heavy financial losses in the farm every year. In the light of these, this case study was mainly focused to find out the real factor/s causing the above situation. The outcome of such analysis would be beneficial for the developments in dairy industry of the country.

PROJECT IMPLEMENTATION

The farm has failed to maintain a suitable 'comfort zone' for European cattle throughout the year where the mean shed temperature and relative humidity should be at 28°C and 60-70%, respectively. Under the above controlled climatic conditions, the Temperature-Humidity Index could be maintained at around 78. In addition, lack of quality roughages can be considered as another main constraint faced by the farm mainly due to lack of pivot irrigation systems provided by the contractor although there are six water irrigation points available in the farm. If those irrigation systems are operated, the farm would be able to cultivate the total extent of 1,080 acres of fodder throughout the year.

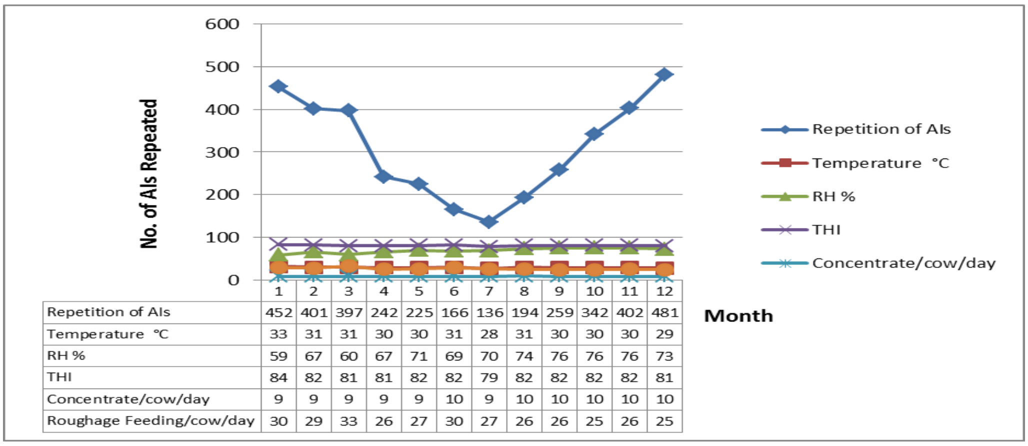
All types of concentrate feeds are manufactured and supplied by outside large-scale feed millers according to the feed formula given by the project and the nutritional values of such concentrate feeds are analyzed batch-wise after delivering them to the farm. If there is any shortage of energy or protein in any feed sample, the respective feed miller is informed and it is corrected by the supplier accordingly. Roughage feeding has also been carried out on the recommended norms throughout the year. As there is experienced technical staff, it is assumed that the AIs, pregnancy diagnosis and disease control are taking place accurately.

Project Dependencies

Among the "internal factors" on which the project is dependent, temperature, relative humidity, heat stress, quality of semen, nutritional value of cattle feed, animal body temperature, skill of AI technicians, veterinary and disease control and financial allocation are considered decisive towards farm/animal performance. Various local and international contractors and suppliers who supply required goods and services, such as concentrate feed, roughages, machinery and equipment, breeding materials, veterinary, laboratory analysis facilities and fresh milk buyers are considered as "external factors" on which the project is dependent.

PROJECT SUCCESS CRITERIA

When analysing the internal factors affecting the high repetition of AI, it is revealed that the Temperature-Humidity Index (THI=0.8T+RH (T-14.4) +46.4) is the key factor which has affected severely on the high repetition of AIs at Ridiyagama farm (Figure 1). The cooling system should, therefore, be operated in order to maintain the inside mean temperature and relative humidity at around 29°C and <60%, respectively, which support to maintain the THI always at <78. By maintaining above climatic indices in the sheds, the farm could be able to improve the conception rate up to the expected level in order to maintain the Calving Interval at 400 days and Calving Rate at 90% which make direct impact on achieving the targeted annual milk production, 10 million litres and issue 500 heifers and 1,000 bull calves to the local farmers for breeding purposes in future.



	1	2	3	4	5	6	7	8	9	10	11	12
Repetition of AIs	452	401	397	242	225	166	136	194	259	342	402	481
Temperature °C	33	31	31	30	30	31	28	31	30	30	30	29
RH %	59	67	60	67	71	69	70	74	76	76	76	73
THI	84	82	81	81	82	82	79	82	82	82	82	81
Concentrate/cow/day	9	9	9	9	9	10	9	10	10	10	10	10
Roughage Feeding/cow/day	30	29	33	26	27	30	27	26	26	25	26	25

Figure 1: Repetition of Artificial Inseminations (AIs) against Temperature-Humidity Index (THI), Temperature, Humidity and Feed

Source: Database of Ridiyagama Farm, 2019

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Author:

Mahendra D. Karunathilake: Assistant General Manager - Planning and Feed Resource Development attached to the Head Office of National Livestock Development Board. He is involved with Planning, Monitoring & Evaluation, Marketing and Feed Resource Development in the NLDB (e-Mail: *karunathilakamahendra@gmail.com*)

Reviewer:

Udith K. Jayasinghe-Mudalige: Senior Professor and the Chair of Department of Agribusiness Management of FAPM, WUSL. His teaching and research interests include: Food and Agricultural Economics, Development & Policy, Project Management, and Quality Assurance in Higher Education (e-Mail: *udith@wyb.ac.lk*)

PASSING ON THE GIFT: A SUSTAINABLE INTERVENTION TO IMPROVE LIVELIHOODS IN KILINOCHCHI DISTRICT

Rawusdeen Muhammad Rushnee

Industrial Services Bureau, No. 141, Kandy Road, Kurunegala, 60000

INTRODUCTION

The concept of sustainable livelihoods is increasingly central to the debate about rural development, poverty reduction, and environmental management. A sustainable livelihood is one that acknowledges a condition of avoiding insecurity rather than only a lack of wealth. “Passing on the Gift” model is one of the successful models by Heifer International which aimed to end hunger and poverty in a sustainable way by supporting and investing alongside local farmers and their communities (Heifer International, 2004). People in the Northern Province were struggling to find good livelihoods in resettlement after 30 years of terrorist war. A three-year project Sustainable Interventions in Livelihood in Kilinochchi (SILK) was started in October 2013 to focus on empowering the women-headed households in the district with the support of Livestock Breeders Cooperative Societies (LIBCOs).

Brief Description

The SILK project adopts the Passing on the Gift model introduced by Heifer International. This model distributes animals, along with agricultural and values-based training, to families in need around the world as a means of providing self-sufficiency. Recipients must agree to "pass on the gift" by sharing animal offspring, as well as the skills and knowledge of animal husbandry and agricultural training with other impoverished families (Heifer International, 2004).

The project target is to facilitate and develop the possible supportive structures and services for dairy development through technical training programmes, pasture development activities, and linking the beneficiaries to the principle institutions (*e.g*. LIBCOs, Veterinary Offices and Department of Agriculture, *etc*.).

Justification

After the resettlement, people in the Northern Province struggled to find a good livelihood, especially the women-headed households in Kilinochchi District. According to the households’ perception, dairy farming ensures routine income since they can produce the milk and sell it on a daily basis. Further LIBCOs officials recorded that there is a high demand for milk by national level processors (*e.g*. MILCO, Nestle and Cargills) and high potential to produce from Kilinochchi district. Therefore, dairy farming is identified as the most potential to bring livelihoods back to normal in these households. The model “Passing on the Gift” is ideal for passing the first female calf to other beneficiaries to popularize this dairy farming and focus to strengthen the livelihoods of the women in this region. This study describes the implementation of Passing on the Gift model in the Kilinochchi district to improve livelihood by empowering female dairy farmers for a sustainable tomorrow.

PROJECT IMPLEMENTATION

The SILK project was implemented in all four Divisional Secretariats of Kilinochchi District: Karaichchi, Kandavalai, Pachhilaipalli and Poonahari divisions. The project targeted 960 families for their livelihood development, wherein the tools deployed in dairy development and conservation farming, covering 40 farmer groups. The project was implemented through the selected Women Rural Development Societies (WRDS) of the Kilinochchi district by LIBCOs of Karaichchi and Kandavalai.

In this project, the beneficiaries who get the dairy cows will pass on the first female calf to other beneficiaries. They will have to keep the calf with the mother at least for 6 months till they pass it to the assigned pass-on beneficiaries. Initially, the project targeted 480 direct beneficiaries to give the cows during the project period. Another 480 beneficiaries, who were absorbed for the conservation farming would be the pass-on beneficiaries who get the first female calf. This process was widely accepted by the beneficiaries who have obtained the cows at the first step as well as at the second step in receiving the first calf. Further, the stakeholders such as LIBCOs, Department of Animal Production and Health, and Department of Agriculture have interested of this model. The beneficiaries who got the male calves would buy a female calf and provide to the assigned pass-on beneficiaries.

The dairy cows are procured from the local suppliers who select and buy the cows from the rural dairy farmers from Jaffna, Vavuniya and Kilinochchi districts. During the procurement process the Veterinary Surgeon, field staff, and the representatives from the WRDS were actively involved in selecting the cow prior to buy from those local suppliers. These suppliers should have a permit obtained from the Department of Animal Production and Health for selling these cows. The Jersey crossbreeds which are suitable to the low country dry zone of Sri Lanka are mostly selected and purchased on either 1st, 2nd, or 3rd lactation stage or in the pregnancy stage. Some of these cows were purchased together with the calves. All the cows were insured within one month of delivery to the beneficiaries.

RESULTS

The calculated milk production details based on the report of cattle and milk production statistics in national and district level in 2013 are depicted in Table 1 (Department of Census and Statistics, 2015a; 2015b). With the first provision of 480 dairy cows, milk production has increased by 12% in the Kilinochchi district during the project period. Further, at the end of the project the total milk production has increased by 23% in the district when adding the contribution of first calves' milking to it. According to the Sri Lanka Center for Development, there was a 20% increase in milk production in the year 2013. This project was a success by 70% in the Kilinochchi district and it could be further increased if they were provided with the improved crossbreeds.

Table 1: Calculated Milk Production Details in Year 2013

Details	Calculations	Amount
Percentage of Milking Cows (National Level) in year 2013	305,930 / 1,169,040	26.2%
Estimated Number of Productive Cows in Kilinochchi in 2013	31,790 * 0.262	8,265.4
Average Annual Productivity of a Cattle at National Level (L)	265,161,600 / 305,930	866.7
Average Productivity of a Cattle at National Level (L/day)	866.7 / 300	2.89
Estimated Milk Production in Kilinochchi in 2013 (L/day)	8,265.4 * 2.8891	23,879.57
Average Productivity of a Cattle given by Project	6 L per day	
Estimated Productivity by the given 480 Cattle	480 * 6	2,880
% Increase in Milk Production in the District by the end of 1st year	2,880 / 23,879.57	12%

**Assumptions: 1- The ratio of productive cattle in Kilinochchi is equal to the ratio of productive cattle at national level*
2- Average annual milking days of a cattle is 300 days

CONCLUSIONS

The SILK project has increased the total milk production by 23% in the district, thus it was well recognized by the beneficiaries, stakeholders, and government authorities in the Kilinochchi District. Therefore, this can be extended to other districts as well. Since there is a high demand for fresh milk in the country, this “Passing on the Gift” model can be used by the relevant authorities as a sustainable intervention to increase dairy production and meet the local demand. Therefore this intervention is recommended as a sustainable implementation to improve the livelihood in the country.

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Author:

Rawusdeen Muhammad Rushnee: Project Coordinator at Industrial Services Bureau, Kurunegala. He holds B.Sc. (Agric.) Hons. Specialised in Agricultural Economics and Business from WUSL. Interested areas are Agri-Enterprising, Entrepreneurship, Agri-Value Chains and Market System Analysis (e-Mail: *ruzzny@gmail.com*)

Reviewer:

Chandana Jayathilake: Senior Lecturer, Information and Communication Technology Centre of WUSL, Makandura. His teaching and research interests include: e-Agriculture, e-Learning, ICT for Development (ICT4D), ICT4AD and Web Technologies
(e –Mail: *jayathilake@wyb.ac.lk/hackjayathilake@gmail.com*)

A VALUE CHAIN APPROACH FOR SHEEP FARMING: COMMERCIAL SCALE SHEEP BLOOD HARVESTING FOR LABORATORY PURPOSES

Jayantha Wijerathna

National Livestock Development Board, No. 40, Nawala Road, Narahenpita, 00500

INTRODUCTION

Sheep farming is a popular business in the world for purposes such as wool, meat and milk. However, it is not that popular in Sri Lanka where at present, nearly 10,000 sheep are reared. Approximately, 6,000 animals of tropical breeds *viz*. Red Madras X Bannur crosses and 'Jaffna Local' are reared in Horakelley, Kottukachchiya, Oyamaduwa and Rukattana farms owned by the National Livestock Development Board (NLDB). The animals are traditionally used for meat production, but more recently for commercial scale harvesting of blood for laboratory purposes, which is the novel value addition approach in the sheep farming sector of Sri Lanka.

Sheep blood is one of the constituents of 'Sheep blood agar' which is used extensively for culturing of microbes for laboratory investigations in health, animal and food sectors in the world. It is reported that when compared to other culture media, use of 'Sheep blood agar' increases the clarity and the visibility of the cultured bacterial colonies which is of immense importance and also critical for improving the accuracy of diagnosis of a disease. However, until 2015, there has not been any commercial sheep blood supplier in Sri Lanka, thus microbiologists had to mostly depend on human blood for their laboratory investigations.

Justification

Creating value-chains in agro-livestock industry is one of the crucial factors for socio-economic development of any country in the world. As world leading three sectors with ever increasing demand, taking part in the health, animal and food sectors by supplying them a vital ingredient for their routine laboratory analyses, would be a successful approach for the sustainable development of the sheep farming industry. This has been emerging as a new commercial industry for sheep farming in Sri Lanka providing a good example for effective utilization of locally available agro-bio resources for the development of the country. Therefore, NLDB has started a project to supply sheep blood for national and private hospitals, universities and food laboratories in order to improve the quality of their testing methods up to the standard levels over the past five years. So far, nearly 30 L of sheep blood have been supplied to laboratories across the country which generated significant income for respective farms while uplifting the quality of the microbiological tests to international standards. With this background, this business, therefore could be further extended up to export market, targeting the laboratories in Asian region, which has its potential to serve as a novel source of generating additional foreign exchange to the country.

PROJECT IMPLEMENTATION

The husbandry of animals, from which blood is harvested on a regular basis, is of critical importance if they are to maintain body condition and replace harvested blood. This is particularly important for younger animals which need to maintain a normal growth rate. Responsibility of the day-to-day management of the animals should be taken by an experienced stockperson, who is capable of ensuring provision of each and every husbandry aspects including appropriate nutrition, shelter, parasite control, foot and tooth care, *etc*. The overall health of animals should be supervised by a veterinarian, and the health program should be documented. Young sheep are particularly susceptible to gastro-enteric parasitism and should be controlled by regular treatment with an effective anthelmintic. The requirement for treatment and its efficacy can be assessed using fecal egg counts before and after treatment. Blood donor animals should be fed more than the standard maintenance rations, which depends on the intensity of the blood harvesting, *i.e* volume and the interval. Protein content of the diet is an important consideration for the prevention of anemia, and iron supplements should be given if indicated by veterinary assessment.

Feed supplements should be provided unless sufficient good quality pasture is available. In drought periods, *adlib* feed and water supply is essential along with great care. By-products from breweries, hay, compound feed and feed additives can be used for feeding of donor animals. Good health and proper body condition score are essential for blood donor sheep and they should be restrained properly with minimum disturbances without exhausting. Excitement and fear can cause splenic contraction which results in altered blood parameters. Body conformation should allow easy access to veins for harvesting. Non-pregnant females and castrated males are more appropriate donors. Pregnant or lactating females should not be used. Matured young animals over 1 year of age should also be used as blood donors. Blood harvesting is done using normal human blood collecting packs which contain CPDA-1 and it is important to use trained personnel for restraining and harvesting the blood under the guidance of an experienced veterinarian. Blood should be collected aseptically and the storage and transport facilities are critically important to maintain the quality of the harvested blood at 4°C (Figure 1).

Figure 1: Steps of Blood Harvesting Procedure Adopted in NLDB Farm, Horakelley

Selection of donor animals should be carried out by experienced veterinarians. The animal should be in good health with proper history of regular parasitic control (both internal and external) and should be active and alert. Rectal temperature should be checked initially during the clinical examination. The colour of conjunctival mucosae is essential to assess the level of anemia and other septicemic diseases.

Project Success Criteria

The present selling price of 1 mL of aseptically harvested citrated sheep blood is Rs. 10 and a maximum of 1,250 mL of blood can be collected from a healthy sheep per annum (Virginia Tech, 2017) ensuring approximately Rs. 12,500/year/animal from this project whereas selling of a young sheep with a body weight of 20 kg is about Rs. 10,000. Hence, above project is more profitable than selling animals for meat itself. Presently, Horakelley farm has a monthly demand of 30,000 mL aseptically harvested citrated sheep blood generating approximately Rs. 3.6 million for the farm in addition to the earnings generated by selling of sheep.

Further Improvement of the Project

In order to meet the future demand, expansion of infrastructure facilities is one of the important factors to be considered. It is also important to obtain the relevant international quality and standard certifications prior to increase the capacity of the project. In addition, continuous supply of blood collecting packs should also be ensured. Moreover, there are some limiting factors, such as shelter and roughage supply for sheep farming in Sri Lanka especially during dry and rainy seasons. Slatted floor housing facilities and silage making is essential for the maintenance of sheep herd to get the maximum productivity throughout the year. It is also important to improve the hybrid vigour of animals to make it profitable, and thus the genetic upgrading is vital. NLDB recently imported deep frozen semen from Australia to upgrade and increase the genetic potential of existing sheep herd. Further, it is recommended to establish a blood collecting centre at Horakelley farm and accordingly to improve relevant facilities and training on visual appraisal, clinical examinations, body weights and haematological parameters, such as Packed Cell Volume (PCV) to monitor the well-being of blood donors. In addition, it is also suggested to adopt suitable precautionary steps to minimize the risk of having injuries caused by projecting objects, wires, sharp corners and slippery floors.

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Author:

Jayantha Wijerathna: Assistant General Manager, attached to NLDB. He holds B. Sc. (Plantation Management) from WUSL and an International Dip. In Dairy Farm Management from Oenkerk, The Netherlands (e-Mail: *jayantha.nldb@gmail.com*)

Reviewer:

Mudith Mewan Kooragodage: Senior Lecturer, Department of Biotechnology, FAPM, WUSL. His teaching and research interests include: Molecular Biology and Biotechnology, Tea Biochemistry, Quality, Standards & Value Addition
(e-Mail: *mewankm@gmail.com/mewankm@wyb.ac.lk*)

IDENTIFICATION OF CONSTRAINTS AND PROPOSED SOLUTIONS TO DEVELOP LOCAL VEGETABLE SEED PRODUCTION

Amila Madushanka Hemachandra

Vegetable Seed Centre, Department of Agriculture, Gannoruwa, Peradeniya, 20400

INTRODUCTION

Annual production of vegetables in Sri Lanka is approximately 710,000 t (Anon, 2018). Vegetable sub-sector is an important segment in Island's agriculture as many farmers are involved in vegetable cultivation representing almost all districts of the country. In order to enhance and sustain the vegetable production, provision of certified seed material of superior quality is an essential practice and should be considered as a priority.

The Department of Agriculture (DOA) initiated several seed production programs to fulfil the local requirements of quality seed material within the country. Two of those were embarked upon late 1950s and 1970s under the purview of the National Seed Certification Service (SCS). In 1996, National Seed Policy (NSP) was approved to develop quality seed production in the country. National Seed Act was promulgated in 2003 to regulate and monitor the seed production programmes. Seed and planting material development centre (SPMDC) of DOA carries out these seed production programmes which consist of two categories, named as Basic Seed (Ba) production and Standard Seed (St) production. DOA undertakes the basic seed production program in 21 government seed production farms with open pollinated (OP) varieties. The standard seed production of OP varieties is carried out by both government and the private sector under the supervision of the SCS. The SPMDC produces 53 seed varieties using 18 major vegetable crops and is also involved in hybrid vegetable seed production. When the national requirement is considered, the DOA supplies only around 3.8 percent (Udakumbura *et al.*, 2002). The balance is provided by the private seed producers and seed importing companies (Figure 1).

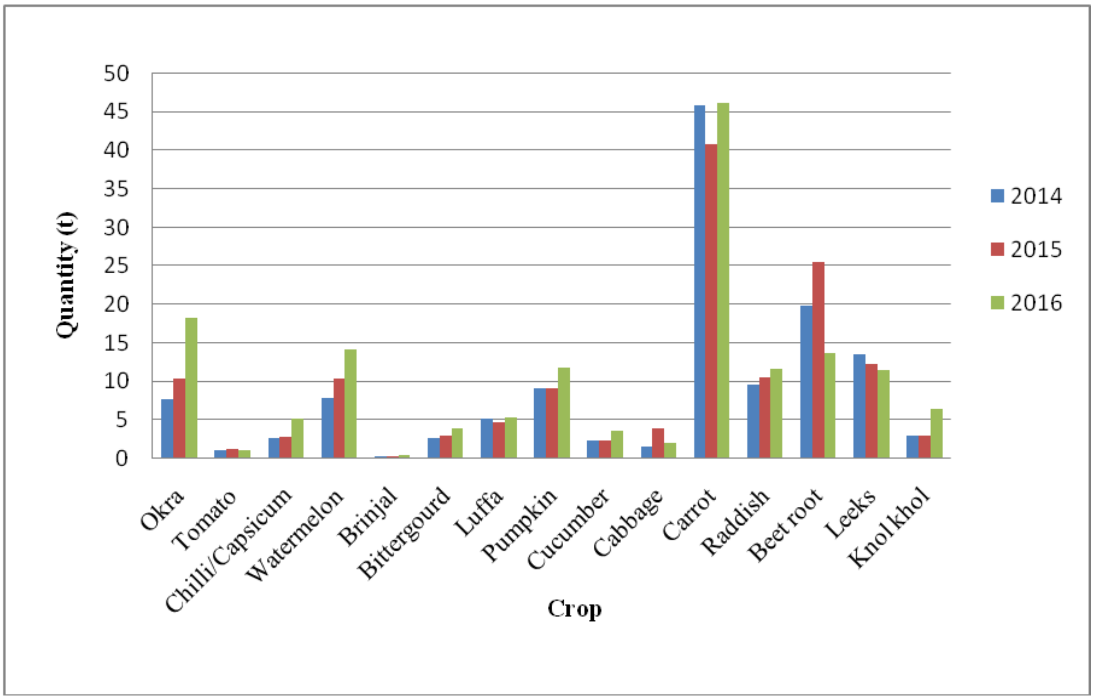

Figure 1: Imported Quantities (t) of Low Country and Exotic Vegetable Seeds

Justification

Rice is considered as the staple food in the country and is often consumed with vegetables. Therefore vegetable seed production should be continued to supply required planting materials for vegetable growers. The agro ecological locations coupled up with favourable climatic conditions in the country have been a positive factor in development of seed production programs. As a result, vegetable seeds can be produced with proven high quality within the country. Therefore, implementing a proper strategy for local seed production may lead the country towards self-sufficiency in vegetable planting materials in future.

CONSTRAINTS FOR DEVELOPMENT OF LOCAL SEED PRODUCTION

Seed production is a seasonal activity and the plants are grown in field conditions which are subjected to environmental extremes and crop failures. The inflorescence setting in most vegetables is a vulnerable factor, as it is influenced by climate changes, flowering and pollination efficiency of vegetables. The seed production is practiced in a large land area as a monoculture to avoid cross pollination; these conditions are favourable for outbreaks of pests and diseases leading to crop failure with impacts on cost of production. The availability of basic seeds materials is limited and seed producing farmers do not receive the same during cultivation period, generating further burdens on the cost of production. To overcome this situation, farmers attempt to produce seeds on their own using planting materials with low genetic potential. They do not have adequate knowledge in maintaining certified seed crops. National level research has not been conducted effectively to identify the reasons for delay in releasing improved seed varieties. This has resulted in farmers who would prefer to purchase imported seeds due to their high performance in comparison to local material. This is a drawback in growth of the local seed production. Although there are few outlets available to purchase quality seeds, poor distribution network has negatively affected this process. A fixed price control mechanism is not available, resulting in inflated pricing being borne by the producers. It should also be noted that, vegetable seeds should be stored under 55 - 45% relative humility and 15° - 20°C temperature, but farmers do not have such storage facilities which is a prohibitive factor.

PROPOSED SOLUTIONS FOR IMPLEMENTATION AND THE WAY FORWARD

Cultivation of vegetables has tremendous potential in Sri Lanka as an agro based enterprise. It is of much significance as the country's majority of people have adopted farming as their livelihood. There is a high requirement for quality seed at a reasonable price. The statutory bodies and enforcement authorities have a commitment towards the growers in providing this requirement under strict enforcement of the law which prevents inferior seed material infiltrating into the market. The government also has to regulate import and export of quality seeds and planting materials. Strengthening of the public sector in research and development is vital to compete with the private sector. The actual assessment of the country's seed requirement and developing a seed production strategy is a necessity. Extending subsidies is the key to increase the local seed production together with new technology. The introduction of a database or computer software is important in updating latest information. Conducting proper research to identify demand and supply of vegetable seed and commencing a distribution network is essential. The Government must focus on quality, efficiency and the profit margins in the lines of the private sector whilst adopting actions on capacity building of the seed producers. The state should encourage the small scale seed producer through incentives and training on modern technology. The country can be self-sufficient in vegetable seed requirement only with proper focusing on strategy and the commitment of policymakers.

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Author:

Amila M. Hemachandra: Agriculture Instructor, Vegetable Seed Centre, Department of Agriculture, Sri Lanka. He holds B.Sc. (Plantation Management) from WUSL
(e-Mail: *amilakingswood@gmail.com*)

Reviewer:

Wishwajith W. Kandegama: Senior Lecturer, Department of Horticulture and Landscape Gardening, FAPM, WUSL. His teaching and research interests include: Food Quality and Safety, Food Processing, Organic Farming and Eco-Friendly Plant Protection Systems
(e-Mail: *wishwajith@wyb.ac.lk*)

NEEM LEAF EXTRACT FOR THE CONTROL OF LEAF CURL COMPLEX DISEASE IN CHILLI

Madusha Surangi Rodrigo

Agriculture Instructors Office, Agrarian Service Centre, Mugunuwatawana (NWP), 61014

INTRODUCTION

Green chilli (*Capsicum annuum*; Family: Solanaceae) is one of the main cash crops cultivated in Sri Lanka. Chilli Leaf Curl Complex Disease (LCCD) results in yield loss in chilli cultivation. The LCCD is a viral disease caused by Begomovirus (Family: Geminiviridae), distributed by a complex of insects and mites. White flies (*Bemisia tabaci)*, aphids (*Aphis gossypii* and *Myzus persicae*), mites (*Polyphagotar sonemus latus)* and thrips (*Scirtothrips dorsalis* and *Thrips palmi)* spread the leaf curl virus when they suck plant cell sap, thus enhancing LCCD severity by their infestation and colonization (Kannangara and Karunathilake, 2013). The disease can infect at any stage of the chilli plant's life cycle from nursery to harvesting (Figure 1). Once infected and the symptoms are shown, the plant must be uprooted and destroyed. The major method of controlling chilli LCCD is by controlling the vectors. Nevertheless, the disease mainly reduces photosynthesis in plants which results in low production. Other methods of LCCD management are appropriate cultural practices, application of bio-pesticides and recommended synthetic chemicals.

Neem (*Azadirachta indica*; Family: Meliaceae) is an evergreen and prominent tree which is commonly found in Sri Lanka except in the Wet zone. Azadirachtin is a bio-chemical compound found in neem leaves, neem seeds and neem bark and is used as a natural pesticide. It is a well-known chemical that effectively controls over 200 insect species and some fungi, bacteria, nematodes and viruses (Anon, 2020a). Neem leaf extraction is prepared by boiling 1 kg of fresh neem leaves in 5 L of water. Extraction is considered as completed when leaf colour is faded and extract turns into golden green colour. It is mixed with 5 parts of water and can be sprayed on to the plants once a week.

Justification

Neem leaf extract contains the chemical compound, Azadirachtin which has an insect repellent effect and can be used to control insects efficiently. Chilli LCCD is caused by 4-complex of pests, namely white flies, aphids, mites and thrips. Therefore, neem leaf extract can be used to control these pests to prevent infection by the virus. Neem leaf extract can be popularized among growers due to the easy preparation process and common availability of neem leaves. Hence, farmers can be motivated to apply neem leaf extract instead of other bio-pesticides which have complex preparation processes and commercially available expensive ready-to-use bio-pesticides.

Synthetic pesticide application may be hazardous to human health and to the environment. In addition, the present day consumers are more conscious about the hazards caused by irrational application of pesticides, especially on short-term crops, such as chilli. Therefore, the demand for organically produced chilli, or chilli produced with Good Agricultural Practices (GAP) has dramatically increased. Therefore, application of bio-pesticides to control pests is an environmental friendly and human benevolent practice.

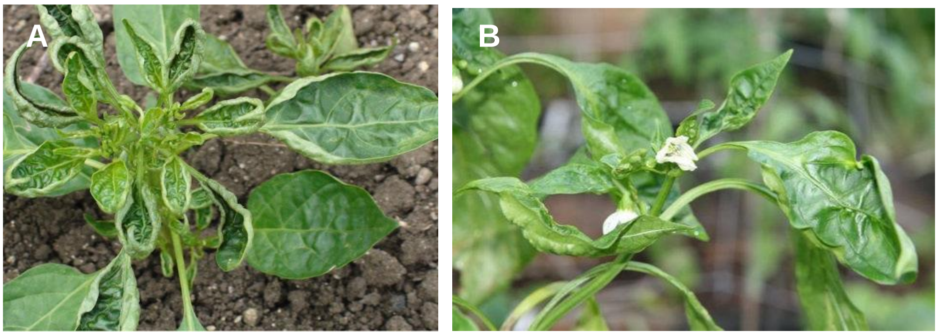

Figure 1: Symptoms of Chilli Leaf Curl Complex (A) Upward Curling of Leaves, (B) Reduced Leaf Size
Sources: http://agropedia.iitk.ac.in/content/chilli-leaf-curl; https://www.houzz.com/discussions/2078456/pepper-leaf-curling-problem

OBJECTIVES

The project is especially orientated to identify and increase the effectiveness of neem leaf extraction on LCCD in chilli varieties that have been introduced by the Department of Agriculture (DOA). Of the varieties introduced by the DOA, MI-1 is susceptible to LCCD while some varieties - MI-2, KA-2, Arunalu, MI-Hot, MI-Green, Galkiriyagama line, MI Waraniya-1, MICH-3, MICH HY-1 – are moderately resistant (Anon, 2020b). As those varieties have moderate resistance to LCCD, the project can be implemented to enhance the resistance of chilli plants by applying a natural insect repellent that has no hazards to humans as well as to the environment.

Project Constraints

As the neem leaf extract is a bio-pesticide, the efficiency and the effectiveness are lower than the recommended synthetic chemical pesticides. Prime factors influencing the efficiency are frequency of application and the time of application (*e.g.* application before pest attack). Once attacked by the pest, the plants will decrease the production and the damage cannot be recovered. Therefore, neem leaf extraction should be applied before the pest attack, as a preventive method.

Project Dependencies

Efficiency of neem leaf extract application depends on frequency of application, and rainfall. The effectiveness of treatment will be drastically reduced due to rains. Therefore, frequent application in the rainy season is essential although the effect of pest attack is negligible during the rainy season. Cultivation should be started according to a cropping calendar, otherwise plants might be vulnerable to pest attack. Selection of a variety which has moderate resistance to chilli LCCD is highly important. It is also advisable to start chilli cultivation on a land where crops of Solanaceae family were not cultivated at least in the last three consecutive seasons. It is recommended to apply cultural practices such as appropriate land preparation, balanced fertilizer application and frequent inspection in order to maintain a healthy cultivation. The funds allocated for synthetic fertilizer as well as for synthetic pesticides can be reallocated for cultural practices that enhance the quality of the produce.

As the consumers' preference is for organic products, instead of synthetic fertilizer, organic fertilizer can be applied. Hence, higher consumer attraction as well as higher income can be obtained if the cultivation is done under organic requirements.

PROJECT SUCCESS CRITERIA

The success in controlling LCCD is solely depending on the efficiency of neem leaf extraction. If the cultivation is not affected by LCCD vectors and the other crop growth factors remain at optimum level, a yield closer to the potential yield can be obtained. In Sri Lanka the average dry chilli yield is 1.0 t/ha and the potential yield is 3.0 t/ha (Kannangara and Karunathilake, 2013). The actual yield is less than the potential yield due to diseases, pest attacks and improper management of cultivation. Further, the demand from the consumers can be taken into account to measure the success of the project. Once chilli is produced without chemical residues, 'Sri Lanka Standard for Organic Agriculture and Processing' certification can be obtained under SLS 1324 for organic produce in addition to the GAP certification by the Department of Agriculture, Sri Lanka.

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Author:

Madusha Surangi Rodrigo: Former Agriculture Instructor of the Department of Agriculture (NWP) of Sri Lanka. She holds HNDT (Agri) from SLIATE Naiwala and B.Sc. (Plantation Management) [First Class] from WUSL. Her professional interests include Agricultural Economics and Biotechnology (e-Mail: *dushr21@gmail.com*)

Reviewer:

Bandula Ranaweera: Senior Lecturer, Department of Horticulture and Landscape Gardening, FAPM, WUSL. His teaching and research interests include: Plant Protection, Pest Management, Biorationals, Bio Pesticides & Bio Fertilizers and Toxin-Free Crop Production
(e-Mail: *branaweera@gmail.com/branaweera@wyb.ac.lk*)

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Master of Agri-Enterprise and Technology Management, Wayamba University of Sri Lanka

MICROGREENS PRODUCTION TOWARDS NUTRITIONAL SECURITY AND INCOME GENERATION

Theja Wimalasena

Department of Agriculture (NWP), Dambulla Road, Kurunegala, 60000

INTRODUCTION

Over the past 20 years, 'microgreens' have become popular with the interest of general public on fresh, functional and nutraceutical foods. Consumption of microgreens has been on the rise as consumers are questing for new products that support health and longevity combined with gastronomic delight (Kyriacou *et al.*, 2016). Microgreens are small sprouted plants, often *brassicas*, generally harvested at the soil level, *i.e.* cotyledon stage or with 1 - 2 true leaves. Usually, they are used as a fresh-cut product or value-added component. Small diversified farmers may benefit from growing microgreens because they can be grown year-round, have a short production cycle, and a high market value.

Justification

Chronic diseases are one of the major health problems in Sri Lanka. Accumulated data suggest that consumption of vegetables can significantly reduce the risk of many chronic diseases. Therefore, microgreens have a significant potential in terms of nutritional ability to cure various deficiencies. Furthermore, they present a homestead option towards nutritional security (Koley, 2016).

In Sri Lanka, microgreens can be grown under 60 – 80 percent shade and both outdoors and indoors. Therefore, it has the potential to address the constraints emerging in local vegetable production mainly from adverse weather conditions. As microgreens can be grown year-round, it is an ideal source of consistent income for micro-scale vegetable producers while improving the nutritional value of human diet (Table 1).

Table 1: Nutritional Value of Microgreens

Raw Microgreens (1 cup)	Calories	Protein (g)	Fiber	Vitamin C	Iron	Folate
			% Daily Value			
Alfalfa	10	1.3	3	5	2	3
Mung bean	26	2.5	4	23	4	9
Radish	16	1.4	n/a	18	2	9
Soybean	86	9.0	3	17	8	30
Wheat	214	8.0	4	5	11	10

Source: U.S. Department of Agriculture

MICRO-SCALE MICROGREEN PRODUCTION PROJECT

Production of microgreens can be considered a high value crop to the small-scale farmers in the North Western Province of Sri Lanka, as it does not require inorganic fertilizer, is a fully organic product and can be marketed as an organic product. This study describes the case of micro-scale microgreen production project from its production, to selling at "Wayamba Isuru Farmers' Market" in Kurunegala District, North Western Province with the objectives of contributing to the food and nutritional security and increasing the income of the micro-scale vegetable producers.

Project Constraints

The main constraints and limitations of this project were, lower yield of microgreens and rapid senescence and very short shelf-life adversely affecting the expansion of their commercial production. Maintaining product quality was also a challenge due to mechanical damages that occurred during the washing, spinning and drying steps. Sanitation remains a critical process for the establishment of ready-to-eat packaged microgreens. Therefore, technological evolution in agriculture is a key requirement for the expansion of commercial microgreen production. Applications of microgreens are endless: they can be incorporated into salads, sandwiches, and other well-known dishes. However, building awareness and changing habits of people pose a challenge.

Project Implementation and Success Criteria

Three micro-scale vegetable farmers were involved during the implementation of this project. Each farmer produced 20 trays of microgreens in the first month and 40 trays in the second month. This amount could vary depending on the labour skills and time allocation. Growing facility included a processing area, product storage and office space of about 100 ft^2 (could be an indoor growing facility such as a greenhouse).

Year-round production was ensured with the provision of sterilized soil + compost + coir dust medium in 20 standard greenhouse trays. Vertical farming techniques were used by placing racks on four levels of growing, *i.e.* four trays per level (16 trays per rack). About 140 – 170 g of microgreens could be harvested from each tray at 7 − 14 days intervals after germination. Microgreens can be harvested at the soil level, *i.e.* cotyledon stage or with 1 - 2 true leaves stage (Figure 1). The lighting system used was a CFL bulb to enhance production of different phytonutrients in microgreens. Large fans were established to provide ventilation to the microgreens to prevent fungus infections.

Figure 1: Harvesting of Microgreens

Table 2: Net Profit Generated Through Sales of Microgreens for Two Months Period

Variable	January 2020 (Rs.)	February 2020 (Rs.)
Total Revenue	28,800	57,600
Fixed Costs	(11,400)	(4,100)
Variable Costs	(16,572.50)	(31,722)
Net Profit	827.50	21,778

Source: Farm Record Keeping Book at Wayamba Isuru Farmers' Market, Kurunegala

The project was monitored throughout the period and evaluated using standard Benefit-Cost Analysis methods in March 2020. The mean net profit generated through the sales of fresh cut packs and sales of value-added sandwiches of three producers illustrated the success of this project (Table 2).

Stakeholders of the Project

Microgreens can improve the nutritional value in human diet and its commercial scale production provides a consistent income for micro-scale vegetable producers. It helps all stakeholders of the vegetable production chain to understand the importance of microgreens and help farmers to effectively produce profitable and sustainable crops, creating benefits that directly support them.

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Author:

Theja N. Wimalasena: Agriculture Instructor of the Department of Agriculture. She holds B.Sc. Special Degree (Palm and Latex Technology & Value Addition) [Second Class Upper] from Uva Wellassa University (e-Mail: *thejawimalasena@gmail.com*)

Reviewer:

Menuka Udugama: Senior Lecturer, Department of Agribusiness Management, FAPM, WUSL. Her teaching and research interests include: Food and Agricultural Economics; Environmental and Resource Economics (e-Mail: *menukaudugama@gmail.com*)

ESTABLISHMENT OF A NEW COCONUT SEED GARDEN FOR HYBRID COCONUT PRODUCTION IN THE WET ZONE OF SRI LANKA

Tharika Sewwandi Baddegama

Genetics and Plant Breeding Division, Coconut Research Institute, Bandirippuwa Estate, Lunuwila, 61150

INTRODUCTION

Coconut is an important plantation and a livelihood crop which can only be propagated using seed nuts. Since coconut is naturally cross pollinating plant, controlled pollination using seed gardens/seed production units is essential for seed nut production (Liyanage *et al*., 1988). Establishing a seed garden is an expensive and long term task which requires a large land area and total replanting with the specific mother palms. Certain criteria are needed to be considered when selecting lands for establishing seed gardens and Coconut Research Institute (CRI) has no suitable lands to use for this purpose.

Current Status in Sri Lanka

The National Replanting Programme (NRP) for coconut is one of the key strategies taken by the government to maintain the sustainability of coconut production through the replacement of senile coconut plantations. The annual seed nuts requirement for NRP has been estimated as 2 million (Coconut Research Institute, 2018). In addition, there is a high demand for seed nuts from non-traditional areas and home gardens increasing the annual seed nut demand over 5 million.

CRI has produced six improved coconut cultivars for planting and five of these cultivars are hybrids (Coconut Research Institute, 2020; Figure 1). Coconut hybrids are characterized by early flowering and produce 40 - 50% more yields compared to tall cultivars and therefore, ideal for increasing the coconut production and productivity of the country.

Of these five hybrid cultivars, only one cultivar (CRIC65) has a seed garden (Isolated Seed Garden, Ambakelle) established to produce it on mass scale. Another seed garden (Kiniyama Seed Garden, Bingiriya) is at the establishment stage for coconut hybrid *Kapruwana*. Other hybrids are produced in limited quantities by hand pollination using materials from field gene banks. As a result, in 2018 the total hybrid seed nut production was only 58,000 seed nuts, *i.e*. 1 percent of the total seed nut demand (Coconut Research Institute, 2018). This production is hardly enough to meet the demand for hybrid seed nuts.

Project Justification

The coconut hybrid *Kapsuwaya* was recommended for commercial planting in 2012 and it has a high yield potential of 22,000 nuts/year. However, so far there is no mechanism established to produce planting materials of this cultivar in large-scale to cater the demand from growers. Also, coconut palms at seed gardens are vulnerable to both droughts and high mite infestations. Recently, 50 percent of seed nuts produced in the dry zone seed garden at Maduruoya, were rejected due to mite damage. However, all the coconut seed gardens of Sri Lanka are established in the dry and dry-intermediate zones. Therefore, year to year variation in national coconut seed nut production highly affects the planning of NRP and this effect can be minimized by establishing a seed garden in the wet zone to produce *Kapsuwaya* hybrid seedlings.

Project Constraints

As CRI is under the purview of the Ministry of Plantation Industries, it should follow all the government policies, rules and regulations. Moreover, management practices are usually carried out by a Regional Plantation Company (RPC). Therefore, if they poorly manage, that will affect the final outcomes of the project. In addition, it will take around six years to get the returns of the project. Other than that, irregular droughts will affect this project.

PROJECT IMPLEMENTATION

A seed garden will be established with 4,500 mother palms. The hybrid seed nut production will be initiated seven years after planting. After yield establishment (12 years after planting) over 100,000 hybrid seed nuts will be added annually to the national coconut seed nut production at least for 40 years. For that, the following conditions are expected to fulfil:

1. A controlled pollination programme will be conducted in Kegalle, Gampaha and Puttalam districts to multiply the parent palm, Sri Lankan Brown Dwarf.
2. A suitable 30 ha land will be selected from the wet zone to plant 4,500 Sri Lankan Brown Dwarf mother palms.

3. After the plant establishment, these mother palms will be used to produce at least 100,000 Kapsuwaya hybrid seed nuts annually at least for 40 years.

Other than that, it is expected that around Rs. 30 mn will be contributed by the domestic fund of CRI and another Rs. 30 mn (Nominal estimated value for 30 ha land) will be contributed by Public-Private Partnership (PPP). Thereby, a total amount of Rs. 60 mn will be allocated to this project.

Figure 1: Coconut Hybrids in Sri Lanka (A) CRIC65, (B) CRISL98, (C) Kapruwana, (D) Kapsuwaya and (E) Kapsetha

Source: Coconut Research Institute, 2020

Project Dependencies

Ministry of Plantation Industries is the main stakeholder who is influenced by the implementation of this project or achievement of its result. CRI and RPCs are partners who will join as the executors in implementing the project. Here, CRI is the main implementation agency of the project (Establishment of the seed garden) while RPCs provide land for the establishment of seed garden and subsequent management.

Project Success Criteria

The direct outcome of this project is the sustained supply of high yielding improved *Kapsuwaya* seedlings to the sector which will subsequently increase the national coconut production. As a result, the efficiency of all the coconut industries will increase contributing to agribusiness development and strengthening value chain development. The project is proposed as a PPP with a selected RPC. The high yielding seed nuts produced at the proposed seed garden will be raised at public and privately owned nurseries. This will promote partnership arrangements between the public/private sector and small coconut nursery holders and will promote technology diffusion. This proposed project will direct RPCs to explore new niche markets by providing coconut seed nuts. In addition, it will follow the blue-green initiative to encourage low emission economic development. Planting of 4,500 coconut plants will assist the climate change mitigation activities through carbon sequestration.

Expansion of Brown Dwarf parent palm pool and establishment of the 30 ha seed garden are the main outputs of this project. Economic and Financial Analysis is carried out using Economic Internal Rate of Return/Financial Internal Rate of Return, Expected Net Present Value/Financial Net Present Value, Payback Period, Cost-Benefit Ratio and Cost-Effectiveness Analysis (especially for social infrastructure projects) methods.

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Author:

Tharika Sewwandi Baddegama: Technical Officer, Genetics and Plant Breeding Division, Coconut Research Institute of Sri Lanka. She holds B.Sc. (Plantation Management) [First Class] from WUSL and currently engages in research related molecular work
(e-Mail: *tsbaddegama@gmail.com*)

Reviewer:

Radhika Gimhani: Senior Lecturer, Department of Biotechnology, FAPM, WUSL. Her teaching and research interests include: Plant Biotechnology, Molecular Plant Breeding and Gene Mapping
(e-Mail: *dgimhani@wyb.ac.lk*)

DIGITALIZATION OF THE TEA INDUSTRY – HAYLEYS PLANTATIONS

Lakshitha Samudra Bandara

Talawakelle Tea Estates PLC, No. 400, Deans Road, Colombo 10, 01000

INTRODUCTION

Ceylon Tea is one of the oldest and best commercial products Sri Lanka ever had. This 150-year-old British invented industry has earned significant amount of foreign currency for Sri Lanka and contributed immensely to its Gross Domestic Product (GDP). Although this industry has survived for 150 years in this country, it is surprising to observe that this is the least developed industry in terms of technology.

Tea industry is long overdue in technological enhancement. Tea factories are in the same technology where it was in 150 years ago in most companies. Harvesting is yet manual and labour driven. Tea fields are at the same standard and untouched by advanced technologies. Therefore, we suggest that this industry has a significant potential to introduce major technological advancement in Agricultural practices to manufacture and then to reach its end customer. This article is concentrating on the Hayleys Plantations Sector and its benchmark digitalisation applications in the tea industry. Benefits and challenges will be discussed through application of practical scenarios. Untouched potentials will be identified for future enhancements. These applications will be used to enhance land and labour productivity, performance monitoring, field operations and finance and controlling and connectivity.

Project Justification

This article is focusing on the challenges in digitalisation of tea industry in the context of Regional Plantation Companies (RPCs). Sri Lanka possesses 6.55 million hectares of land area and only 50 percent of such land is suitable for agriculture. The per capita arable land area is limited to 0.15 ha and hence a high pressure is developed on agricultural land use. At present, the 40 percent of land out of suitable extent is used for agricultural purposes. About 73,445 ha of land is managed by the 20 RPCs and 9,383 ha are managed under the government institutes while 121,267 ha are managed by tea smallholders of the country (Mapa *et al.*, 2002).

Project Constraints

As the tea industry is highly labour intensive it is natural that computerisation or digitalisation may create a doubt about job security for some people unless an extensive awareness program is launched. It was observed that more than the external pressure on the change, it is highly significant to manage internal change resistance for which training and development is the key for such re-engineering attempts. Initial capital investment may be higher for some entities but it is worth to burden cash flows for some time until we start to see the benefits of the project.

Project Assumptions

It is assumed that existing systems and methods were documented properly, most suitable people are assigned for the implementations, most suitable system providers are available and most importantly, the top level management consent has been obtained for all initiatives.

Project Dependencies

Any digitalisation project will depend on execution of project plan, its service providers and the suppliers.

PROJECT – DIGITALISATION OF HAYLEYS PLANTATIONS

Digitalisation of tea industry begins from Hayleys Plantations. This process is linked with every aspect of its operation from field to auction house and office to residence of employees (Figure 1).

1. Monitoring - Everything That Can be Monitored Can be Improved

Digital platform for weighing of harvest at the field level was introduced to the group from 2015. At present all tea estates of the sector are using digital weighing systems and employees were given accurate poundage at the time of harvesting. Therefore, the old industrial corruptions have come to an end. Monitoring has been linked with real time performance monitoring system in Colombo head office with wide screen display for the analysts and all estate management has equipped with laptops and tablets to help with day to day operations.

Manufacturing is updated in the web based system managed centrally from the head office which is capable of tracking its production until the reach of its end customer.

2. Reporting
All operational sub systems are interlinked with company accounting system and have been connected with Hayleys PLC and its other subsidiaries for group reporting. Hayleys Plantation sector is the first plantation company in Sri Lanka to move to world with most advance Enterprise Resource Plan (ERP) namely SAP S4-HANA. Accurate and timely reporting is key in every organisation, which gives credibility to its management from the various stakeholders.

3. Remunerating
Employee remunerations have been automated and connected with digital weighing, centralised payroll system and banking platform. This has been an inspirational change that we looked forward to change the 150-year-old manual cash payment habits of estate workers. Estate community has been disconnected from banking platform for ever and it reflects from their consumption patterns, education and living standard. As a responsible corporate citizen, this has been a remarkable achievement by the group.

4. Sustainability
Every sustainability initiative has been recorded in the web based portal designed for sustainability reporting for the Hayleys Group. Tea Plantation Companies are engaged in endless work for its community in terms of sustainability and Corporate Social Responsibility (CSR) over the years, however the due notice has not been given for their contribution and has not been marketed properly. Result of this, the goodwill of the trade has been challenged continuously and undue influence has taken place, which significantly hinders the progress of the industry.

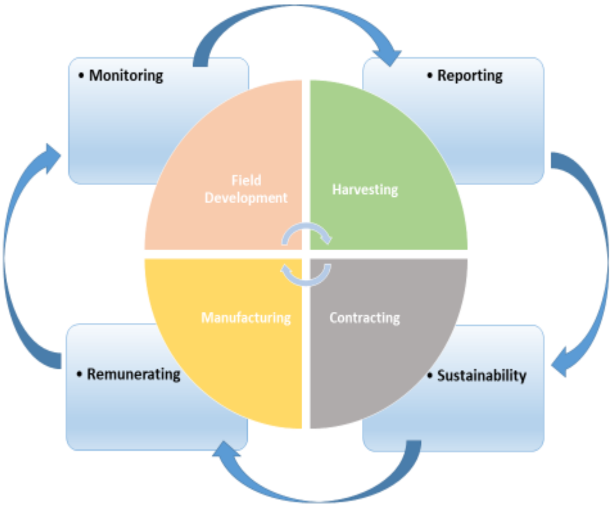

Figure 1: Digitalisation Road Map - Hayleys Plantations

PROJECT SUCCESS CRITERIA
Business re-engineering is a critical decision of any organisation, which requires a lot of commitment, resources and most importantly right tone at the top. Proposed concept of digitalisation will add value to the organisation, which resolve industry issues, and improve productivity, most importantly in a crisis situation the organisation can operate with minimum disturbances compared to others.

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Author:

Lakshitha S. Bandara: DGM Finance – Talawakelle Tea Estates PLC. He holds B.Sc. Accounting (Special) from University of Sri Jayawardenapura and ACA, ACMA
(e-Mail: *lak.bsamudra@gmail.com/lakshitha.bandara@ttel.hayleys.com*)

Reviewer:

Jayantha Weerakkody: Senior Lecturer attached to the Department of Plantation Management, FAPM, WUSL. He is also the Director of ICT Centre, WUSL Makandura Premises. His teaching and research interests include: Microbiology, Organic Agriculture, Environment & Forestry and ICT (e-Mail: *wjskweera@gmail.com/weera@mkd.wyb.ac.lk*)

CUSTOMER PERCEPTION ON THE ONLINE BANKING FACILITIES OFFERED BY PRIVATE BANKS

Wajira Sirisena

Sampath Bank PLC, Marandagahamula, 11260

INTRODUCTION

During the last two decades the environment within which the banks operate has changed due to many reasons. Globalization, technology revolution, fast developing communication models and financial liberalization have facilitated this change, intensifying the competition in the banking industry. Many such efficient delivery and processing channels, innovative products and services have been developed through online banking. Online banking offers customers with almost every service which is traditionally available through a local branch (*i.e.* deposits, transfers, and online bill payments, *etc*.). Virtually every banking institution has some form of online banking, available both on “desktop versions” and through “mobile apps” (Amin, 2007). The purpose of providing online banking is to reduce the physical distance between modern world customers and the banks. The promotion of online banking technology enabled the banks to enhance their operations cost-effectively and efficiently to handle daily banking affairs via online banking channels. Customers are being facilitated by reducing their visits to banks and they can carry out their transactions via Internet or ATM Machines instead of personally visiting the branches.

Retail Banking and Corporate Banking

Retail banking which is also termed as consumer banking or personal banking is the aspect of banking that directly deals with retail customers. Retail banking is the visible face of banking to the general public along with the bank branches. Corporate banking or business banking refers to the banking process which deals with corporate customers. Corporate banking is the key profit center for most banks. The eligibility of a customer for a separate method differs according to the bank. Even though during the past years online banking acceptance has been rapidly developed worldwide, it shows much lower acceptance in the Sri Lankan context. Conducting retail and corporate banking facilities online would enable to open up numerous benefits which can uplift the efficiency of the banks. Subsequently, it is important to attract local customers towards online banking services to enhance the banking sector much effectively.

Online banking in this study is referred to both retails and corporate banking. Popularizing of these respective online banking methods solely depends upon the benefits that can be gained by the customer. Therefore, it is of paramount importance to find out the eligibility of the customer to use this online banking services and also customer perceptions, preferences, and problems about respective online banking methods.

RESEARCH METHOD AND FINDINGS

A preliminary study was conducted in Gampaha district with a sample of 150 customers selected through the simple random sampling technique. Descriptive statistics revealed that both male (53.3%) and female (46.7%) customers utilized online banking facilities. Concerning the Occupation, the majority of customers were businessmen/businesswomen (34%) followed by salaried employees (25.3%), students (21.3%), other professions (8.0%) and housewives (7.3%). The Age of the customers was also a matter of interest. It was found that about 30 percent of online banking customers were within the age of 30 to 39 years, followed by 28 percent within the age of 20 to 29. A significant portion of customers (12%) who were below 19 years and above 50 years used online baking.

The amount of information customers have on online banking has been identified as a major factor impacting the adoption. Additionally, findings of the study emphasize that the customers expect several benefits through online banking techniques. One of the key issues in delivering online banking is the ease of use. The ability of the user to identify the banking information of interest and also the ability to execute required banking tasks without any error are among the major concerns. Two types of Online Banking products were familiar in the market as they introduced new features. The eligibility to obtain such products and key benefits associated with each product were classified in turn.

Retail Online Banking Services and Expected Key Benefits

The eligibility for the products is restricted to the bank’s existing account holders. However, the non-customers could use the facility by opening an account online. The credit cardholders of the respective bank are also eligible, even if the customer does not have an account with the bank.

Expected Benefits

- Responsive design - Automatically adjusted application to fit the screen, making it easily accessible with any device that the customer use
- Open new account - Savings Accounts, Fixed Deposits, PFCA Accounts, View ABC Bank credit card transaction details, balances online in real-time
- Link third party accounts/credit cards to your profile
- Access for various account information such as account balances, transaction history, cheque status, stop payments, the status of deposited cheques
- Fund transfers - between own accounts/to third party accounts (ABC Bank/other banks)/to credit card accounts (ABC Bank/other banks)/fund transfers to any other bank accounts through the Common Electronic Fund Transfer (CEFT) system, is available at the online system
- Utility bill payments - Save personal bill details as payment templates for future use/schedule payments for designated accounts and utility companies
- Requests - Cheque books/ Current account statements
- Stop Payments - Stop payments of cheques can be made by the customer by selecting the cheque number and the account number via the online system
- Ability to customize

Corporate Online Banking Services

The eligibility for these products is restricted to corporate, partnerships, and proprietorships who maintain accounts at a particular bank.

Expected Benefits

- Multiple authorization levels can be facilitated (horizontally and vertically)
- Fund Transfer Management - Fund transfers to other banks/fund transfers to Mobile/save transfers as templates
- Payment Management - Bulk payment processing/scheduling of payments/save payments as templates/online real-time SLPA payments/EPF/ETF payment processing
- Ability to view account details and download statements
- Trade Services - Establish DC's online/amendments to DCs/manage DCs, manage amendments/manage shipping guarantees and parcel guarantees/manage Export Bills/ Import/Export Bill Settlements

To encourage frequent use of online banking by the customers, bankers should emphasize on the expected benefits for customers. Since both products are user-friendly and designed to meet customer expectations, by addition of new features to the existing products, the Bank could target to increase their market share and enhance its operations cost-effectively and efficiently in order to handle daily banking affairs via online banking channels.

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Author:

Wajira Sirisena: Assistant Manager at Sampath Bank PLC, Maradagahamula Branch. She holds B.Sc. Mgt. (Special) degree (e-Mail: *wajirasirisena1980@gmail.com*)

Reviewer:

Sashika R. Guruge: Lecturer, Department of Agribusiness Management, FAPM, WUSL. She is reading for her PhD in Environmental Economics and holds B.Sc. (Agric.), Masters in Business Studies (Colombo), CIM, Diploma in Banking and Finance (IBSL) (e-Mail: *guruge84@yahoo.com*)

FACTORS AFFECTING LOW YIELD IN MATURE RUBBER PLANTATIONS AND POTENTIALS FOR YIELD ENHANCEMENT

Najith Nishantha

Rubber Research Institute of Sri Lanka, Dartonfield, Agalawatta, 12200

INTRODUCTION

Rubber *(Hevea brasiliensis*) is a perennial crop, which can be maintained for a long economic life span using conventional exploitation systems. The extraction of latex through tapping of rubber plants, is a crucial factor that influence the productivity. Natural rubber is a highly valuable polymer and it cannot be replaced by other synthetic materials for many vital applications. It is a strategic raw material used in numerous important products, as well as many latex products including medical devices. Thus, the global rubber industry has frequently been concerned regarding the fluctuating supply and spiraling prices of natural rubber. At present, rubber industry remains as a major contributor to the Gross Domestic Production of Sri Lanka. The annual full yield potential of rubber in Sri Lanka has been estimated to vary between 2,000 to 2,500 kg/ha under recommended clones with good agricultural practices [Rubber Research Institute of Sri Lanka (RRI), 2009].

Justification

Currently, rubber growers in Sri Lanka are facing serious challenges from an increased cost of production as well as barriers in reaching the potential yield. Low rubber prices have induced them to convert rubber plantations to other more profitable crops such as oil palm and cinnamon. In Sri Lanka, the rubber productivity or the Yield per Hectare (YPH) has dropped down up to 774 kg/ha/year (Central Bank Annual Report, 2018). However, timely adaptation of good agricultural practices would allow them to achieve an average potential yield around 2,000 kg/ha/year and to minimize the yield gap (Figure 1). While the rubber estates deal with less than 1,000 YPH, the cost of production tends to increase rapidly due to the high labour cost mainly associated with tapping and weeding. The yield reduction in rubber plantations could be attributed to many parameters. Current project aims to identify such factors and to adopt possible remedial actions to increase the potential yield to ensure optimum productivity of rubber by 2023.

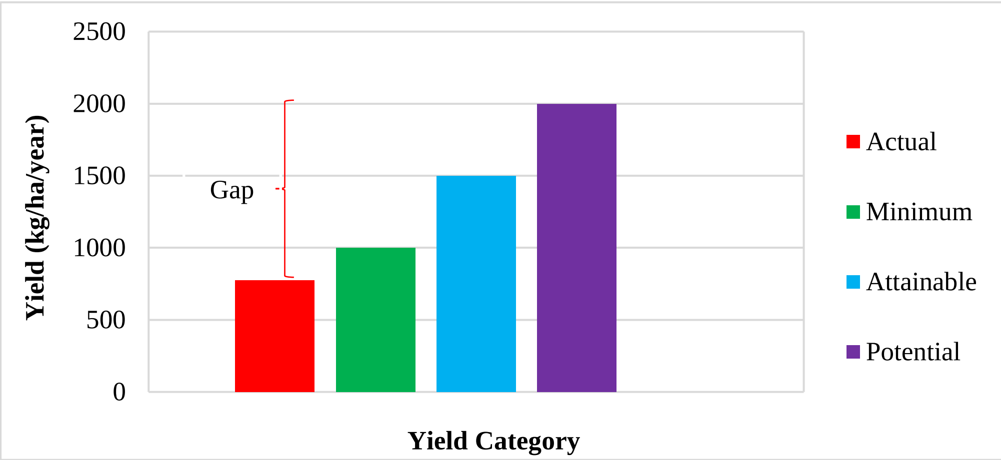

Figure 1: Rubber Productivity Levels in Sri Lanka (Yield per Hectare)

MAJOR CONSTRAINTS TO INCREASED PRODUCTIVITY

According to the global and national predictions, weather irregularities are expected to occur in many parts of the world including Sri Lanka, due to climate change. Especially, frequent incidence of extreme rainfall events are expected to occur in the wet and intermediate zones of the country, which could directly influence the productivity of the rubber industry. Total annual yields depend on the number of tapping days in particular estate. Thus, around 30 percent of the potential yield could be lost due to such extreme rainfall events each year (RRI, 2017). In addition, poor nutrient levels in soil could also hinder the rubber formation and latex flow through, by influencing the photosynthesis and mechanical stability of the tree.

YPH tends to reduce proportionately with the drop in the stand. Although the full stand is present, the potential yield cannot be estimated if the plants are not healthy and vigorously growing. In the majority of the rubber estates, more than 10 percent of trees are already dead due to white root disease, which act as a dominating factor for the lower degree in the stand per hectare. Poor standards of tapping that lead to serious damage to the tapping panel could also influence the productivity. Meanwhile, high rate of bark consumption particularly due to unskilled tappers and use of improper tapping knives, has intensified this. In addition, Tapping Panel Dryness (TPD) has become a common issue in many estates, due to over-extraction of latex.

PROJECT DESIGN AND DEPENDENCIES

Current project intends to utilize special measures to popularize a series of productivity enhancing techniques and good management practices among rubber estates. Correct adoption of such technological advancements, especially during the yielding phase of the tapping cycle, could secure a potential yield of 2,000 kg/ha/year or at least an attainable yield of 1,500 kg/ha/year. Subsidies for fixing rain guards and purchasing suitable tapping machines are expected to be funded and supported by the government. In addition, the technology transferring mechanisms in rubber estates would be enhanced to ensure an adequate level of knowledge and technology transfer to the lowest level.

A participatory bottom-up approach that intends to innovate more efficient and effective agricultural practices based on a concerted technology is a crucial requirement for the current project. Attitudinal and behavioural changes of the involved labourers are highly necessary to improve the overall estate performance. Universities and other relevant institutes in both public and private sectors will be joined as collaborators for this project, especially to raise awareness at the institutional level for both managers and field staff on responsible novel practices to ensure higher productivity.

PROJECT IMPLEMENTATION

Tapping systems will be introduced to the rubber estates to ensure a high potential yield from low-frequency tapping, along with effective stimulants. Further, tappers will be trained to enhance their tapping skills and effectiveness, while minimizing TPD issues. Vacant land areas in the estates due to white root disease will be utilized for cultivation of short term crops such as banana, pineapple to increase the overall income. Fertilizer application strategies in the estates will be enhanced by provision of technological know-how on the application of ideal plant nutrients at the correct rate, time and at the correct place to ensure optimum plant nutrition levels to increase the sustainability of the production. In addition, estate management will be motivated to utilize rain guards that could increase tapping days per year, while restricting the number of late taping days. This could directly contribute to a 20 percent yield increase in traditional rubber estates (RRI, 2017). In addition, prophylactic practices for bark rot disease will be promoted, especially during May to September to enhance the overall yield of the estate.

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Author:

Najith Nishantha: Experimental Officer, Rubber Research Institute of Sri Lanka. He holds a BIS Agric. from OUSL & Dip. In Agric. from Sri Lanka School of Agriculture. Currently he engages in Plant Protection activities in Rubber Industry (e-Mail: *nedirimanna@yaoo.co.uk*)

Reviewer:

Lahiru Udayanga: Lecturer at Department of Bio-Systems Engineering, FAPM, WUSL. He has completed his PhD in Geo-Informatics and Environmental Modelling. His teaching and research interests include: Environmental Management, Geo-Informatics, Climate Science and Disaster Management (e-Mail: *udayanga@wyb.ac.lk*)

VALUE ADDED PRODUCTS FROM VIRGIN COCONUT OIL FOR THE SUSTAINABILITY OF COCONUT INDUSTRY IN SRI LANKA

Upul Senadeera

S. A. Silva & Sons Lanka (Pvt) Limited, Loluwagoda, Mirigama (WP), 11200

INTRODUCTION

Sri Lanka is one of the leading coconut producing countries. The coconut industry in Sri Lanka is governed by the Coconut Development Act No. 46 of 1971, which is monitored by the Coconut Research Board, the Coconut Cultivation Board (CCB) and the Coconut Development Authority (CDA) (Jayawardene, 2018). Some of the major coconut-based products amongst the most popular Sri Lankan exports to the global market are desiccated coconut, virgin coconut oil (VCO), coconut water, bristle fibre products and activated carbon made with coconut shells (Sri Lanka Export Development Board, 2018).

However, from the beginning of the year 2017, the VCO industry declined very sharply. As a result, virgin oil producers lost their production capacity negatively affecting on their turnover reflecting a large number of dependents losing employment opportunity and the coconut growers missing a reasonable price for their produce. The investors of the VCO industry became helpless due to this trend.

Justification

As shown in Table 1, VCO production data of Giriulla Mills (Pvt) Ltd., a major producer of different coconut-based products to the world market, from year 2016 to 2019, a drastic decline and finally zero production was observed from 2018. The capital invested in the industry has become defunct. Though the current demand for VCO is less from the local and international market, it generated a considerable income to the producers and the Sri Lankan economy 2 - 3 years ago. Therefore, revitalizing the industry is very important.

The objective of this project is to develop a VCO-incorporated hair oil to the local and international markets as a value-added product and to create a commercial market for VCO. It would help the stakeholders of the VCO industry, while establishing a reasonable market price for coconut growers for their produce.

VIRGIN COCONUT OIL INCORPORATED HAIR OIL PRODUCTION PROCESS

The production process of VCO-based herbal hair oil is not arduous. It could be done by mixing 99.5% (v/v) of VCO with 0.45% (v/v) of *Aloe vera* oil, and then adding 0.05% (v/v) of the fragrance of different choices to increase customer attraction (Table 2). The mixture is then filtered and bottled under hygienic conditions. They are then labelled and packed for sale (Figure 1).

Project Assumptions, Dependencies and Success Criteria

Application of oil would improve hair health of the public (especially among ladies) which has been well known from the ancient times. This would strengthen the product's acceptance. The present male population is also concerned about their appearance. Availability of VCO-based hair oil products are scarce and would become a new product which could attract market attention. The value addition through different fragrances and attractive labelling would increase customer satisfaction. Further, the equipment needed in the production process is less and is of low cost. With lower working capital, the production cost could be lowered and the product could be marketed at a competitive price. Due to lower capital investment, the market risk could be reduced. It is also assumed that there would be sufficient stocks of coconut available at the market when required through a combined effort through Coconut Research Institute, Coconut Cultivation Board and Coconut Development Authority.

Table 1: Annual Coconut Utility and Virgin Coconut Oil Product Quantities of Giriulla Mills (Pvt) Ltd.

Coconut Utility and Product Receiving	Year 2016	Year 2017	Year 2018	Year 2019
Coconut (t)	20,450	5,720	0	0
Virgin Coconut Oil Product (t)	2,034	570	0	0

Source: Annual Virgin Coconut Oil Production Reports of Giriulla Mills (Pvt) Limited

Table 2: Sensory Evaluation for Virgin Coconut Oil Incorporated Hair Oil

Character	Willingness of Panel
Appearance	81%
Colour	78%
Smell / Odour	84%

Source: Research & Development Department of Silvermill Group

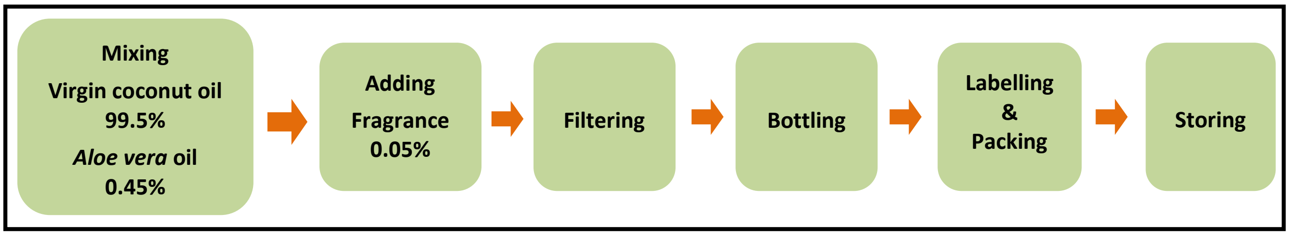

Figure 1: Production Process of Virgin Coconut Oil Incorporated Hair Oil

PROJECT IMPLEMENTATION

Vigorous market penetration strategies will have to be adopted due to the present low market demand locally and internationally. As the oil refinery plants have been idling for some time, they would need a thorough service before being put into use. It would demand some capital expenses. Some of the highly skilful labour would have found employment elsewhere due to the closure of the plants. Training employees to achieve expected skill levels would take some time and hiring skilled labour would be at the expense of the production cost. The cost of labour within Sri Lanka too is high and would be a key factor in deciding shelf price. The constant fluctuation of coconut prices has also become a major constraint.

The production of coconut-based products is dependent on the coconut crop of the country. In Sri Lanka, sufficient coconut is available only for 7 - 8 months of the year for coconut-based products. The price of coconut is decided by the nut availability and market demand and is a major factor affecting the production cost of VCO. Maintenance of a consistent price is very important in consumer loyalty towards a product. A fluctuating product price would result in a decline in market potential when considering the number of other competitive products. The product price is decided considering the production cost and hence, the project success is heavily dependent on the coconut availability within the country. *Aloe vera* oil, the next major ingredient, is imported from India which is taxed when imported into the country. Consequently, the project would also depend on the taxation criteria of Sri Lanka. Therefore, a project could be initiated on establishing an *Aloe vera* supply.

The costs involved in revitalizing virgin coconut oil production in Giriulla Mills (Pvt) Ltd., and further investments for the production of hair oil and value addition will be accounted. Initial marketing expenditure too would be calculated. The total cost would be accounted to be depreciated in the straight-line method during a 20-year period. The fixed and variable costs of production and marketing would be accounted during a 2-year period with the depreciation added for the respective 2 years. The income of the 2-year period will be calculated and the success would be evaluated by a comprehensive Benefit-Cost Analysis for Giriulla Mills considering a 20-year production cycle as against increasing production capacity of other coconut-based products. Further, improvement of income of the existing employees, new direct and indirect employment generation and income improvements to the community and increased tax income to governing authorities would be analysed during the 2-year period.

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Author:

Upul Senadeera: Factory Manager, S.A. Silva & Sons Lanka (Pvt) Ltd. He counts experience in Coconut Product Manufacturing, Quality Assurance & Machine Maintenance. He holds B.Sc. (Plantation Management) [Second Class Lower Division] from WUSL, Advanced Diploma (Manufacturing Management) from NIBM and Diploma (Computer Programming) from Tech Sri Lanka, Negombo (e-Mail: *cocos@sillvermillgroup.com*)

Reviewer:

Wasantha Gunathilaka: Senior Lecturer, Department of Plantation Management, FAPM, WUSL. His teaching and research interests include: Agriculture Engineering, especially Farm Machinery and Irrigation (e-Mail: *haws.gunathilaka@gmail.com*)

ENHANCEMENT OF YIELD AND NET RETURN OF SMALL-SCALE COCONUT LANDS BY COCONUT BASED FARMING SYSTEMS

Chaminda Irosh Bandara

Coconut Cultivation Board, Coconut Model Garden, Randeniya, Wariyapola, 60400

INTRODUCTION

Sri Lanka is one of the leading countries in coconut production. It has a significant share in the world coconut market mainly through the supply of desiccated coconut. Current annual production in the country varies from 2,500 to 3,000 million nuts. The coconut sector strategic development plan focuses mainly on increasing yields to achieve a target of 3600 million nuts/year (Anon, 2018). Long term research evidence has shown that coconut as a mono-crop is less profitable. Increasing land use intensity may enhance productivity and profitability of coconut lands by integrating with appropriate farming systems, *i.e.* Coconut-Based Farming Systems (CBFS). However, the adoption of CBFS has found to be minimal due to unawareness of the growers on economic benefits. Attempts should be taken to increase adoption of CBFS through awareness.

Justification

The majority of coconut lands in Sri Lanka are cultivated by small-scale farmers (≤2 ha). These smallholdings are mainly committed to mono crop, where it does not generate adequate income. Considering the land utilization, a pure stand of coconut occupies only 22 percent of the area leaving nearly 75 percent of the area underutilized (Gunathilake, 2009). A well-spaced coconut garden provides adequate inter and intra-row spaces thus it is possible to grow a variety of seasonal and perennial crops resulting in increased productivity and profitability. Intercropping and mixed cropping are the two main systems in CBFS. By intercropping coconut with banana, the yield of coconut can be increased by 20 percent (Anon, 2019). There are numerous research evidence available in support of improvement in coconut yield in CBFS in contrast to coconut mono-cropping (Table 1).

Table 1: Effect of Mixed Cropping Models on Coconut Yield in Farm Trials conducted in Different Agro-Ecological Regions

Crop Model and Agro-Ecological Zone	Mean Nut Yield (nuts/ha/year)			Mean Copra Yield (g/nut)		
	No Mixed Crop	Mixed Crop	% Increase	No Mixed Crop	Mixed Crop	% Increase
Coconut + Pepper + Coffee + Ginger-WL$_3$	6,406	7,427	16.0	197.3	217.8	10.4
Coconut + Pepper + Coffee + NFT-IL$_1$	4,541	6,970	53.5	204.0	237.6	16.4
Coconut + Cashew + Banana IL$_3$	5,134	6,794	32.0	163.6	185.4	13.3

IL- Low country intermediate zone, NFT- Nitrogen fixing trees, WL- Low country wet zone
Source: Gunathilake, 2009

Moreover, the land use efficiency in CBFS is high which can be identified by looking at the economic advantages. Research evidence shows that the net return of coconut as a monocrop is low but adoption of mixed or inter-cropping significantly increase coconut yield (Table 2). Thus, it is clear that CBFS is a fine option to increase national productivity levels and socio economic status of the growers.

Constraints

Despite positive attributes, adoption of CBFS has shown relatively slow progress in Sri Lanka due to the presence of several constraints namely, risk of drought, price fluctuation and marketing difficulties. Moreover, the demand for management of the crop and its inputs and requirement of skilled knowledge compared to mono cropping can also be listed as constraints. These management demands include provision of disease free planting materials, fertilizer and agro-chemicals. Unavailability of enough machinery and equipment, pest and disease incidents has also been identified as critical issues. Land fragmentation, shortage of hired and family labour, theft of harvest; ethical and religious reasons for raising livestock are among the socio-economic constraints (Gunathilake, 2009).

Table 2: Estimated Income from Various Coconut-Based Farming Systems

Condition	Gross Return (US$/ha/year)	Net Return (US$/ha/year)
Under Rain-fed		
Coconut as a mono crop	1,369	319
Intercropping with cassava	2,153	694
Intercropping with ginger	3,535	896
Under Irrigated		
Coconut as a mono crop	2,988	1,450
Multi-cropping	4,108	1,895
Mixed-farming	5,965	1,821

Source: Gunathilake, 2009

SMALL SCALE MODEL ESTATE TO POPULARIZE COCONUT BASED FARMING SYSTEMS

This is a project initiated by Coconut Cultivation Board (CCB) in the agro-ecological region IL_{1a} (Narammala, Kurunegala district). This project occupies a 5 ac coconut land. Crop model includes mixed cropping coconut with banana (2.5 ac), sweet potato (1 ac) and mung bean (1 ac). To ensure optimum land utilization, at least 320 coconut seedlings, 650 banana suckers (variety: Nadee), 23,000 bushes of sweet potato (variety: Wariyapola Red) and 29,600 bushes of mung bean (variety: MI-1) will be established as per the recommendation by Gunathilake (2009). The remaining 0.5 ac will be kept as reserved areas for water and natural habitats. Gliricidia, wild sunflower and *Kathurumurunga* are established as nitrogen fixing trees (NFT) and to obtain green manure and some economic advantages. Sprinkler and hose irrigation methods will be established. Measures such as proper labor management and scheduled harvest are carried out to decrease cost of production (COP) and to increase net sale average (NSA). In addition, 10 bee keeping units (2 units/ac) will be established as a measure of supporting cross pollination and enhancing biodiversity.
A comprehensive cost benefit analysis was carried out and the summary of the net benefits (nominal terms) per annum from coconut, banana, sweet potato and mug bean are respectively; Rs.53,728.40, Rs.89,250.00, Rs. 99,000.00 and Rs.193,000.00. The Net Present Value (NPV), Benefit-Cost Ratio (BCR) and Internal Rate of Return (IRR) are Rs. 1,070,000.00, 1.21 and 28%, respectively (Duration: 10 years, Discount rate: 15%).

Success Criteria

The model estate provides evidence for the success of CBFS in terms of both yield and economic benefits. For commercial viability of CBFS, it is necessary to make the owners aware on benefits that can be received by adopting it for which model estates can be used as demonstration models. Training of growers on agronomic practices of crops other than coconut (as they may not familiar) and having regular extension services to address the issues on time will also needed for the sustainability of the project. Moreover, provision of government subsidies would help to motivate the initiation of CBFS. Furthermore, it is very important to carryout field practices according to estimates and cash flow on time.

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Author:

Chaminda Irosh Bandara: Estate Manager, Coconut Cultivation Board. He holds B.Sc. (Applied Science) from University of Sri Jayawardanapura, Sri Lanka and currently engaged in coconut plantation management (e-Mail: *iroshbandara70@gmail.com*)

Reviewer:

Keminda Herath: Professor in Applied Statistics, Department of Agribusiness Management, FAPM, WUSL. His teaching and research interests include: Statistical Inference, Project Analysis & Management and Time Series Econometrics (e-Mail: *kemindaherath@gmail.com*)

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Master of Agri-Enterprise and Technology Management, Wayamba University of Sri Lanka

FINANCING AGRICULTURAL VALUE CHAINS BY COMMERCIAL BANKS IN SRI LANKA: AN OVERVIEW

Janaka Lewkebandara

Sampath Bank PLC, Branch Office - Yakkala, No. 97, Kandy Road, Yakkala, 11870

INTRODUCTION

In Sri Lanka, there are 26 Registered Licensed Commercial Banks in operation, which are regulated by the Bank Supervision Department of the Central Bank of Sri Lanka (CBSL) or the Monitory Board under special provisions covered by the Banking Act No.30 of 1988 (Central Bank of Sri Lanka, 2019). The agriculture sector in any country plays an important role in the economy. The foundation of the rural-agro economy of a country like Sri Lanka is strengthened by the individual farmers who engage in farming traditional crops, such as rice and other field crops, over the years. The role of commercial banks in Sri Lanka with special reference to funding activities favouring agriculture value chains is briefed in this case. Further, the perspectives of farmers in the production stage of the agricultural value chains are highlighted.

As per the guidelines issued by the CBSL, agricultural sub-sectors are known as, paddy and other crops, animal husbandry, poultry farming, livestock, dairy, fisheries, tea, coconut, rubber, cinnamon, pepper and non-traditional crops, vegetables, fruit cultivation and processing, and horticulture. In accordance with the directive issued by the regulator in 2009, all the commercial banks are required to contribute a minimum of 10 percent out of their lending portfolios to the agriculture sector.

FINANCING AGRICULTURAL VALUE CHAINS

Funding flows pertaining to agricultural value chains are considered by the banks in their attempt to lending proposals (Figure 1).

Empirically, it has been observed that a “less priority” has been given to a farmer or a producer who represents the growing or production pillar of the value chain. As can be seen from Table 1, the country’s Gross Domestic Product (GDP) has been more or less “stagnated” over the years, and the ‘relative’ and ‘absolute’ contribution of agriculture sector to the overall economy, which is commonly referred to as ‘Structural Transformation’ is also not taking place appreciably. This necessitates the allocation of right amount of funds towards key points/segments across the value chain.

Not only the capital investments made by the investors of the bank together with the funds raised by other sources of financing, but also the depositors’ money is indeed utilized for lending purposes by the banks. Borrowers’ failure on timely repayments would, therefore create adverse effects to the smooth functioning of the financial intermediary business. To mitigate such risks, lending institutions can call for sufficient securities from the borrowers together with a number of documents.

Due to multiple reasons, including lack of knowledge, inability to guarantee suitable collaterals, and vulnerability to natural disasters, farmers’ requests to get a loan facility are regularly getting rejected. On the other hand, in its attempt to finance agriculture, the banking sector too experiences countless challenges towards management of their portfolios (KPMG Sri Lanka, 2019). For example, in view of the performance of “cultivation loans” granted under the refinance schemes by commercial banks, one can observe that the default amounts have been increased (Figure 2).

Despite the fact that the commercial banks play a major role in providing credit to the stakeholders in agriculture sector, it was noted that “private money lenders” yet account for nearly 6.5 percent of the lending market. This phenomenon clearly demonstrates the fact that ‘informal lending’ is still considered as a ‘convenient’ and ‘popular’ mode of transaction in the country. In fact, in a world where most of the credit facilities intended for cultivation purposes are ended of being “default”, there is a need that farmers to be directed to deal with more scientific and meaningful mitigation strategies like insurance schemes. Further, farmer movements towards adoption of climate smart agriculture practices are warranted. Moreover, it is ideal if the commercial banks can execute their lending attempts to the farmers with the collaboration of public-partnerships enabling a proper monitoring system that can secure pay-back of loans. Allowing guaranteed prices with the involvement of government or the private sector processors may be an added advantage to the farmers as well as the lending institutions.

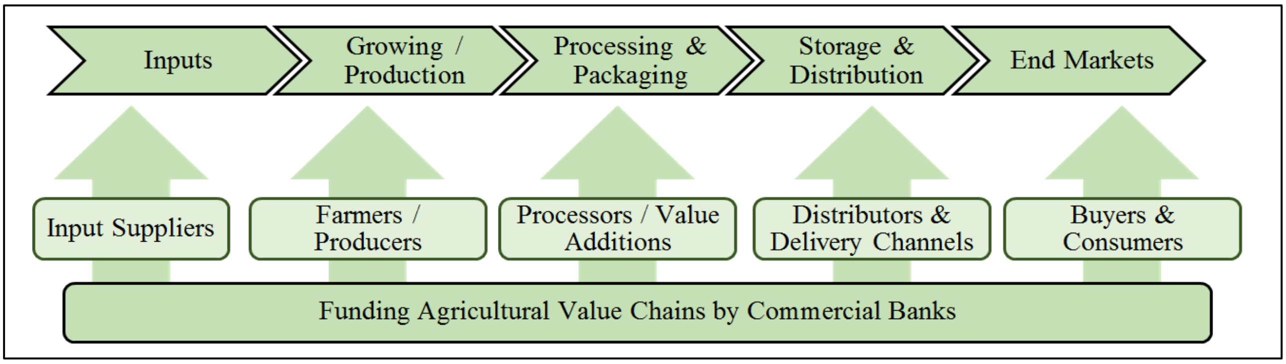

Figure 1: Financing Agricultural Value Chains

Table 1: Sectorial Contribution to the Economy of Sri Lanka

Year	Agriculture (%)	Industries (%)	Services (%)
2016	7.1	26.5	56.7
2017	6.9	26.7	56.8
2018	7.0	26.1	57.7

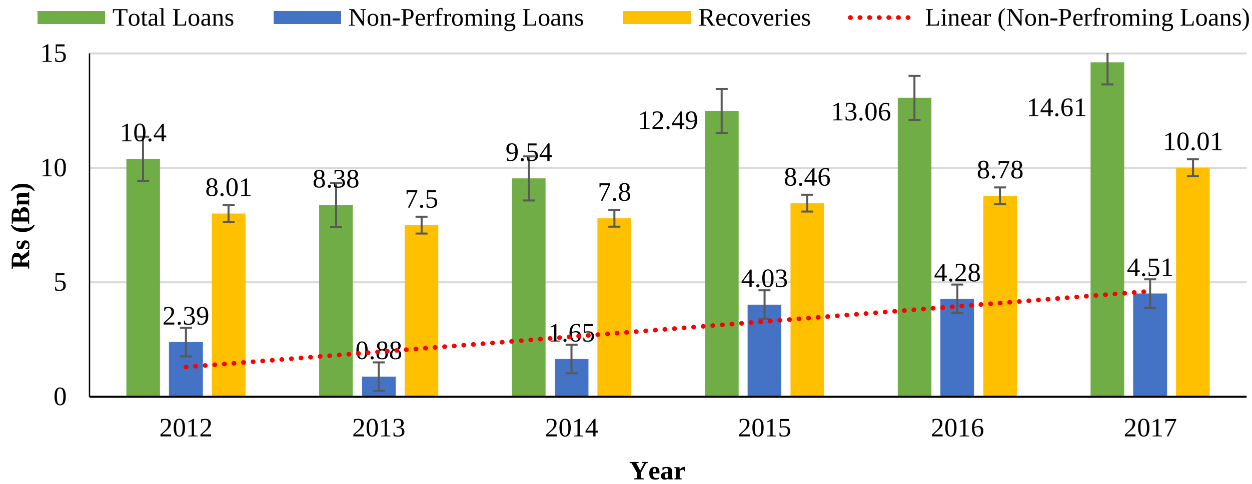

Figure 2: Cultivation Loans under the Refinance Credit Schemes by Commercial Banks

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Author:

Janaka Lewkebandara: Banking Senior Executive with 26 years of experience covering the areas of Branch Banking, SME Lending & International Trade Finance. He is attached to Sampath Bank PLC - Yakkala Branch as the Branch Manager
(e-Mail: *lewkebandara1970@gmail.com*)

Reviewer:

Nimanthika Lokuge: Lecturer attached to the Department of Agribusiness Management of FAPM, WUSL. Her teaching and research interests include: Agricultural & Food Economics, Applied Econometrics, and Food Marketing and Agribusiness (e-Mail: *nimslkg@gmail.com*)

PRESENT STATUS AND CONSTRAINTS OF SRI LANKA GOOD AGRICULTURAL PRACTICES (SL-GAP) PROGRAMME

Nadira Sajevani AssalaArachchi

Office of the Deputy Provincial Director of Agriculture, Sri Bodhi Road, Gampaha, 11000

INTRODUCTION

The Sri Lanka Good Agricultural Practices (SL–GAP) programme was introduced in 2015, which was initiated by the government of Sri Lanka to provide safe agriculture commodities to its people and to overcome the technical barriers for international trade. Presently SL–GAP is being implemented by the Department of Agriculture (DOA) and is executed through the division of Agribusiness Counselling of the Extension and Training Centre. Division of Agribusiness Counselling is responsible for overall coordination and implementation of the programme while the certification is carried out by the SL–GAP certification of the Seed Certification Service [Sri Lanka Good Agricultural Practices (SL-GAP), 2020].

The objective of developing SL-GAP programme is to provide quality, fresh and safe agricultural products to consumers allowing traceability and reducing the risk of pathogens, heavy metals and pesticide residues in the product. Other benefits of the SL-GAP programme are to ensure workers' health, safety and to protect the sustainability of the environment.

Project Justification

Producing safe and healthy agricultural products under acceptable certification is a needy requirement to mitigate the prevailing health hazards in society. Introducing SL-GAP program is one of the best solutions. Therefore, the DOA planned to increase the number of GAP farms to achieve this objective and introduced new methods of implementation by providing 'A' and 'B' Grade Certification to increase the availability of safe food.

SL–GAP is still in its initial stage of implementation and identification of barriers and constraints for the successful implementation of the GAP program would be beneficial in this context. For this study, primary data were collected through observation of GAP procedure and direct communication with officials who have a sound knowledge and experience in the relevant field.

PROJECT IMPLEMENTATION

Implementation of GAP procedure (both export-oriented and local based) was inspected and monitored by Agribusiness Counsellors. Each selected GAP farmer was provided with a crop record book to record every practice of the farm and the following elements were scrutinized throughout the programme: site history and site management, farm structure, maintenance and management, cultural practices, Integrated Pest Management (IPM), pesticide management, post-harvest technology, market accessibility, *etc.*

Out of all GAP registered farms in Sri Lanka, 751 farms have already been certified. A vast range of fruits and vegetables are produced under the GAP programme. Paddy was developed under SL-GAP standards (SLS 1523 Part 2:2015 – GAP) recently.

Adding the GAP programme has helped to boost the yield and income of farmers especially those who supply fresh fruits and vegetables to the export market, which receive a higher premium. Market accessibility is a crucial factor in the GAP programme and hence the DOA has signed agreements with leading supermarket channels and opened their own sales outlets to provide the market facility for farmers as well as consumers in some districts (Figure 1). Furthermore, the GAP Village programme has initiated product differentiation in order to capture new market niches or creating new opportunities for small scale farmers.

Project Constraints

Even though the SL-GAP programme is running successfully, some constraints were identified as barriers and it is required to identify suitable solutions (Figure 2). The favourability of farmers to adopt SL-GAP in the future would be guided by their knowledge and understanding of GAP procedure and GAP elements. For the successful implementation and fulfilment of the eligibility requirements of the SL-GAP certification, farmers need to follow the regulated SL-GAP elements. For that, they need to have some knowledge about IPM, Integrated Plant Nutrient Systems (IPNS), soil-test based fertilizer application and pre-harvest intervals (PHI) of respective crops (Pongvinyoo *et al.*, 2014). Influence of external factors and control measures such as marketing and price for the GAP produce create a big impact to retain the farmers in SL-GAP programme. It is needed to have a global accreditation for exports under the GAP and Good Handling Procedures (GHP) which enable the GAP farmers to find European Union (EU) Markets easily. More extension facilities are required to implement new A and B Grade Certification systems owing to higher number of official involvements. Collection of data (production and extent) of GAP farms is a needy requirement for decision making and statistical analysis hence maintaining the database is an essential activity.

Figure 1: Department of Agriculture Sales Outlet at Peradeniya

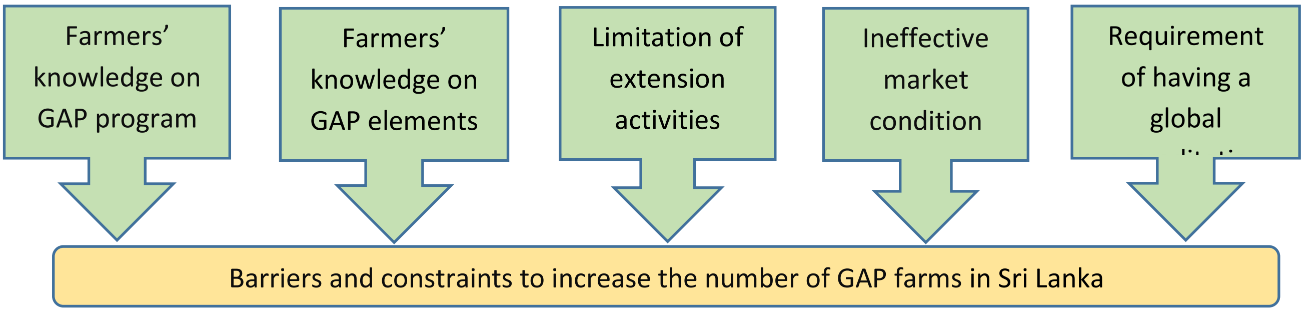

Figure 2: Identified Barriers and Constraints in SL-GAP Programme

PROJECT SUCCESS CRITERIA

SL-GAP programme has become the major activity in the extension mandate of Department of Agriculture and they are stepping towards solving these constraints under their purview. Regular and periodical training programmes are conducted for officers, farmers and mass media programmes are organized to make the consumers aware in order to update their knowledge about the SL-GAP programme. To achieve the global accreditation, Sri Lanka Standards auditing authority is making every effort to obtain the international GAP certification by the end of this year to facilitate the EU market. To attain sustainability of this programme, more attention should be paid to increase the number of GAP farms in the country by empowering the knowledge of the farmer on specific areas and to offer economic incentives, which will lead more adaptation of Good Agriculture Practices**.**

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Author:

Nadira Sajevani AssalaArachchi: Assistant Director of Agriculture, Department of Agriculture, Sri Lanka. She holds B.Sc. Agric. (Hons) from University of Peradeniya and currently engages in Extension Division in Gampaha district (e-Mail: *nsajevani@gmail.com*)

Reviewer:

Kapila Yakandawala: Professor and the Chair of Department of Horticulture and Landscape Gardening, FAPM, WUSL. His teaching and research interests include: Landscape Gardening, Environmental Horticulture and Urban Agriculture
(e-Mail: *yakandawalakapila@gmail.com/kapilay@wyb.ac.lk*)

MINIMIZING AGRICULTURAL RISKS THROUGH NON-STRUCTURAL MEASURES: WORKINGS ON WEATHER-RELATED CROP INSURANCE

Yasaranga Godawela

SANASA General Insurance Company (Pvt.) Limited, Colombo 08, 00800

INTRODUCTION

Farmers have been severely affected by various natural calamities, for example floods, droughts and excessive rainfalls and the trend of happening such events has been reported "increasing" during the recent years (Lobell *et al.*, 2011). Such events, in fact, possess severe impacts on the level of production of food and agricultural commodities. At the macro level, for example, the decrease in paddy production in Sri Lanka in 2019 due to the unfavourable weather conditions, including the prolonged droughts, was almost one quarter when compared to the previous year.

Risk management is part of farmers' business strategy as the production is subject to many uncertainties that could threaten returns or the viability of farms. The sources of risk in agriculture are diverse (Figure 1).

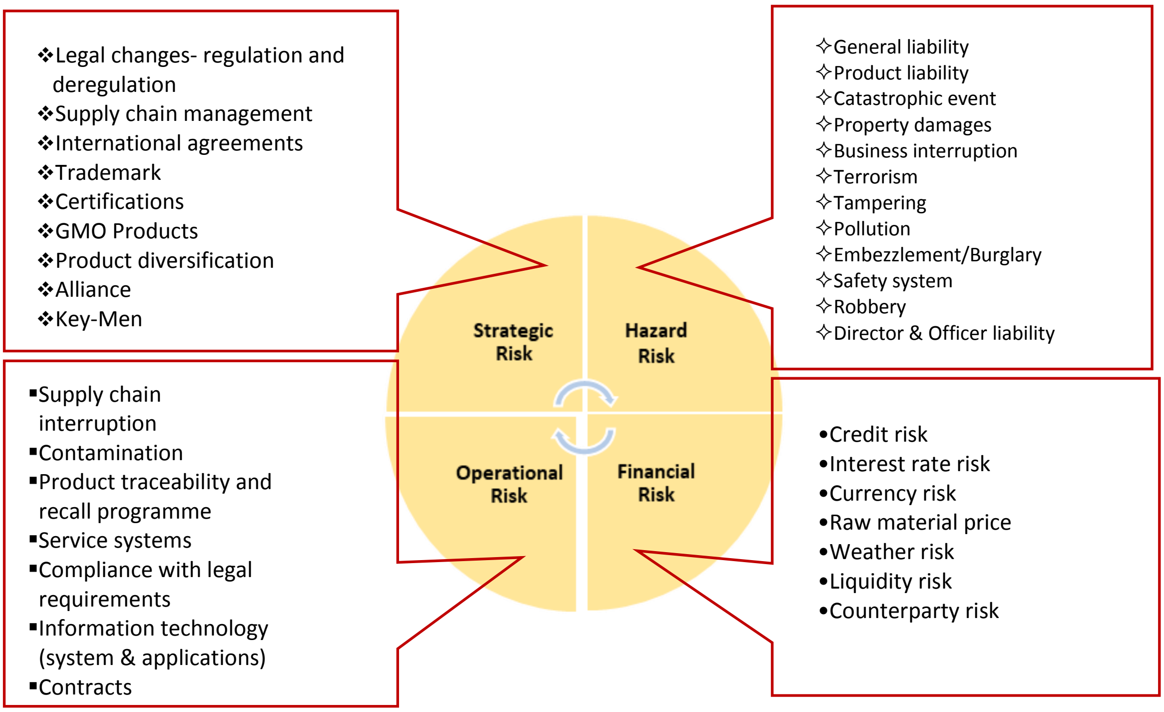

Figure 1: Risk Management Perspectives

A diversity of hazards related to weather determines production in ways that are outside the control of farmer. The prevalence of sources of risk that affect many farmers at once, such as weather-related hazards, is specific to agriculture. Some "weather-related risks", such as drought and floods have a systemic component in that they affect most farmers within an entire region or country. Others, such as storms are more location specific. Agriculture as an economic sector is, therefore, most vulnerable and most exposed to climate extremes.

In the light of these, effective risk management involves anticipating possible difficulties and planning to reduce their consequences, not just reacting to unfavourable events after they occur. The two primary aspects of risk management are: (1) anticipating that an unfavourable event may occur and acting to reduce the probability of its occurrence, and (2) taking actions which will reduce the adverse consequences should the unfavourable event occur.

WEATHER RISK MANAGEMENT

'Weather risk management' is defined as identifying, understanding and ultimately mitigating financial exposure to the weather/climate system. Over the past decades, a wide range of methodologies that use different models/metrics, time horizons and assumptions have been developed and applied for assessing adaptation benefits and costs associated with such risks. Both 'structural' and 'non-structural' measures are important to reduce the impact of climate variability, including extreme weather on crop production. While the structural measures include strategies, such as irrigation, water harvesting and windbreaks, *etc*., the non-structural measures include the use of the medium range weather forecast and crop insurance (Lobell *et al*., 2011).

Crop Insurance with Special Focus on Paddy

'Insurance' can be considered a strong non-structural measure to handle unmanageable/uncontrollable risks and some controllable risks. Most of the farmers invest money which they raise through loans from banks or from private money lenders, and hence, they cannot afford to lose it. An unfavourable season can result in detrimental effects on the livelihood of the poor farmer. Therefore, it is vitally important that the farmer covers themselves against possibility of such losses. "Crop insurance", under such circumstances, plays an important role not only in minimizing the risk which farmers face, but also in stabilizing the economy.

Sri Lanka was the first developing country in the Asian region to launch a comprehensive crop insurance scheme for paddy. In this process, the 'SANASA General Insurance Company' (SGIC) has played a momentous role to introduce it to the right stakeholders, especially to the "rural agricultural poor traditional" farmers. These crop insurance schemes are planned to give coverage against the total or partial crop loss resulting due to flood, drought, excess water, plant disease and pest damage or for the cases of damage by wild animals. The coverage starts on the date of planting till the harvest of the crop. The insurance coverage and the premiums in crop insurance depend on the risk level. The "Principal", *i.e.* Insurance Company, has the authority to decline a claim if damage is caused by wild animals and if it is proved that the farmer has not taken any precautionary measures to avoid them. In addition, if the loss or damage to cultivation is caused by domestic animals, it will be rejected. Further, if the farmer has not planted seeds according to the approved standards and if he has not utilized suitable manure and chemicals in appropriate time, the company has the right to reject such claims.

Weather Index Based Crop Insurance for Paddy

The weather insurance products introduced by the SGIC are very specific to the area, the season, crop and peril insured. The compensation would be based on the variation between the "*Weather Index Set*" and the "*Actual Observed Index*" recorded in a Reference Weather Station (RWS) based on which the model has been developed.

The crop period is divided into "three cover phases" considering the different levels of rainfall required in each phase. In the proposed product, the insurance company shall insure the farmers for the losses that will happen if the rainfall goes below or above a prescribed limit which are defined as payment trigger levels. The RWS for procuring weather data during the policy period would be specified stations of the Meteorological Department. Upon receipt of the data, the SGIC would submit a copy of which to channel partners. Claims would be normally settled within a month's time from the receipt of certified data. It is clarified that claims would be solely assessed on the basis of agreed weather indices and actual survey of the field would not be carried out. Based on the analysis of 30 years data of rainfall, product configuration will be carried out by the actuarial expertise per each RWS.

Selecting appropriate customers, avoiding insurance cover for high risk areas and building trust among customers are challengeable circumstances to implement this type of system. Challenges such as lack of awareness and customer confidence on reliability of rainfall data, negative attitude of farmers towards insurance, inability to pay premium upfront *etc.* impede the process of implementation of weather index insurance program.

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Author:

Yasaranga Godawela: Assistant General Manager of SANASA General Insurance Company (Pvt.) Ltd. He holds B.Sc. (Risk Mgt.) [Sanasa Campus], Higher Dip. in Insurance (WUSL), Dip. in Insurance (NIBM), C. Risk. Mgt. (Falia, Japan), C. Micro Ins. (TATA Academy, India) (e-Mail: *yasaranga@sgic.lk*)

Reviewer:

Udith K. Jayasinghe-Mudalige: Senior Professor and the Chair of Department of Agribusiness Management of FAPM, WUSL. His teaching and research interests include: Food and Agricultural Economics, Development & Policy, Project Management, and Quality Assurance in Higher Education (e-Mail: *udith@wyb.ac.lk*)

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Master of Agri-Enterprise and Technology Management, Wayamba University of Sri Lanka

PROMOTION OF HAND-MADE GREEN TEA AS A RURAL INDUSTRY

Buddhika Chamantha Samarasekera

Sri Lanka Tea Board, Tea Commissioner's Division, 574, Galle Road, Colombo 03, 00300

INTRODUCTION

Being the highest income earner in the agriculture sector, tea industry contributes 1.5 percent to the Gross Domestic Product (GDP) of Sri Lanka. More than 1.5 million workforce is employed in the sector directly and indirectly from land preparation to packing (Colombo Tea Exporters Association, 2020; Table 1). The small holding sector occupies over 70 percent from the total tea land extent of the country.

It is a known fact and a trend around the world that the consumption of green tea delivers much more health benefits due to its higher level of antioxidants over other types of tea. There is no exemption for Sri Lanka in this context. It is apparent that the Sri Lanka's green tea production is insufficient to cater the foreign demand (Table 2). This situation leads to a less supply of green tea to the local market and fetch a higher market price. Thus, there is a market vacuum for green tea in Sri Lanka though the product claims a significant demand. In order to encounter this issue, the production of hand-made green tea could be introduced as a solution to fill above market gap as well as to generate an income for the rural-households. It is required to form a society of growers to manufacture a product in uniform standard.

Table 1: The Summary of Tea Production in Sri Lanka - January to December 2019

Category	Quantity (t)
Orthodox	273,907
CTC	23,585
Green	2,642
Total	300,134

Source: Colombo Tea Exporters Association, 2020

Table 2: Category-Wise Sri Lanka Tea Exports-2019

Category	Quantity (t)
Orthodox and CTC	287,908
Green Tea	4,749
Total	292,657

Source: Colombo Tea Exporters Association, 2020

PROJECT IMPLEMENTATION

The tea clone – TRI 2043 developed by the Tea Research Institute (TRI) of Sri Lanka is suitable and recommended for this project as it is a unique variety which is used to produce speciality teas, such as Silver-Tips and Golden Tips. The plant *Camellia sinensis* (tea) could be grown in areas with a fertile soil with organic matter, a well spread rain pattern/an irrigation system, shades and sunlight.

Women who are not employed and own bare-land area could join this project by growing several tea plants in their gardens. The households those who do not possess their own bare-lands may partner with this project by growing two plant rows as a fence around their court-yard/home garden.

The project aims to produce hand-made green teas domestically and cater to a niche market which looks for it. Thereby, it will generate an income source for the rural women who are living as "dependents" and empower them to be active contributors to the rural economy.

The planned channels of distribution of the finished products to the market are initially placed near the Post-Office-network of the country targeting the customers of that particular area who are keen to purchase by ordering via telephone calls. Subsequently, the markets will be created through specialised hotels/restaurants targeting foreign customers at higher prices while promoting it as "hand-made products" in collaboration of the Tour-Guide Association of Sri Lanka. It is expected that a high income could be earned by the rural women (producers) easily as there is no intervention of the middlemen. With regard to standardization of the product, the manufacturing process and product quality could be advocated, supervised and monitored by Sri Lanka Tea board.

Project Constraints

As the project targets to implement in the low-income rural community, it could be difficult to maintain product standards such as unique product characteristics and hygienic aspects of the manufacturing process. Government approval for the marketing through Post Offices would be a challenge. Promotion channels will be lacking while difficulties could arise in training of women in the manufacturing process. Large scale manufacturers (factories) could stand against the proposed project as the availability of raw materials for their current factory operations is expected to be affected. The farmer may be reluctant at the initial stage of the project assuming that the difficulties could arise in selling the products and identifying the effective channels of dispose. Joining of new farmers to the project could be difficult as it takes at least 1.5 years to harvest after planting.

Project Assumptions

A close supervision in manufacturing process, intervention in creation of distribution channel through the sales points close to Post Offices and promoting the wellness and health benefits of drinking green tea over black tea need to be considered with more attention. For marketing effort to be more effective, the younger generation is required to be targeted at the initial phase of this exercise as they are more health–conscious and likely to be trend-setters. Introduction of the product to Tourism Promotion Bureau and Sri Lanka Tour Guides Association could be done to find markets. The project targets to sell 1 kg for Rs.1,100 as the lowest price. The projected average monthly income is calculated as given in Table 3.

Table 3: Calculation of the Income per Farmer

Planted Area	Harvest (Green leaf/kg)	Production of Green Tea (kg)	Gross Income Per Month Rs.	Cost of Production Rs.	Net Income Rs.
0.5 acre	200	43	(43*1100.00) = 47,300.00	5000.00	42,300.00

Project Dependencies

The government bodies such as Post Offices and the Sri Lanka Tea Board deliver services for implantation of the project in the areas of product development, manufacturing and marketing. In addition, local media agencies could play a role at the point of promotion of tea the particular areas. All these facts are dependent on the success of the project. Research agencies and the universities could also play a role in further developments of the project.

Project Success Criteria

At the initial year, the project highly targets to supply to the local market through the sales points near Post Offices. Later, with the development of the products (differentiated products/value added products) it could be merged with the tourism industry. Prices and types of the products could be changed according to the market demand and the market segment. Accordingly, a target farmer who has 0.5 acre area of tea land could generate Rs. 507,600 per annum.

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Author:

Buddhika Chamantha Samarasekera: Tea Inspector/Instructor, Sri Lanka Tea Board, Tea Commissioner's Division. He holds B.Sc. (Plantation Management) Degree from WUSL, Dip. in Agriculture, Dip. In Quality Management (SLSI), and Dip. in Landscaping/Gardening (e-Mail: *chamantha81@gmail.com*)

Reviewer:

Kusum Wijesinghe: Senior Lecturer, Department of Agribusiness Management, FAPM, WUSL. Her teaching and research interests include: Organizational Management and Human Resource Management (e-Mail: *kusum_wijesinghe06@yahoo.com*)

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Master of Agri-Enterprise and Technology Management, Wayamba University of Sri Lanka

AN INTEGRATED STRATEGIC PLAN TO DEVELOP THE AGRICULTURAL AND IRRIGATION SYSTEMS IN THE MAHAWELI SYSTEM 'H'

Ubaya Kalyana Kumara

Mahaweli Authority of Sri Lanka, System H, Thambuththegama, 50240

INTRODUCTION

The Mahaweli Development Project was initiated by the Government of Sri Lanka, with the construction of Pologolla dam in 1970s, of which one of the key intensions was to supply water to the Dry Zone of the country. The '*Mahaweli System H*' (MSH) is the first such system established under this project and the area under coverage to which is still recognized as "very important" amongst all of the Mahaweli systems. This is mainly because of high income generation and above average yields from Paddy and Other Field Crops cultivation. Noteworthy to mention, the MSH possesses a high "water usage efficiency" compared to others in the system.

Current Status of 'Mahaweli System H'

In the past, there was a 'Cascade System' in this geographical area, but no such a system can be viewed since the inception of Mahaweli Development Project (United Nations Development Programme, 2019). Consequent to this, an adequate amount of water is not available at present for cultivation of crops, especially during the "*Yala*" season. Despite the shortage of water, the farmers have, however, been continued to cultivate their crops and harvest above the National levels (Figure 1).

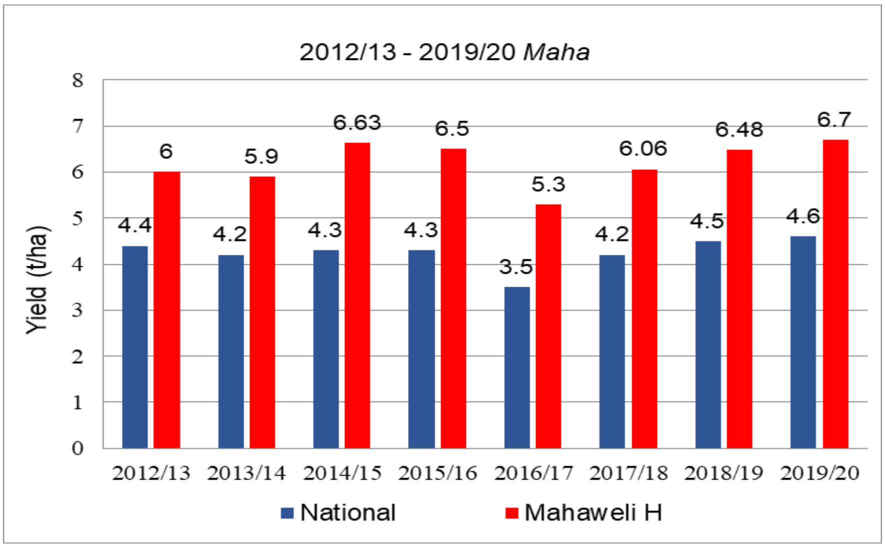

Figure 1: Average Paddy Yield of Mahaweli System H in Comparison to the National Yield
Source: Department of Census and Statistics Sri Lanka

The MSH has been fed by the "*Kalawewa Tank*" through a network of 126 minor tanks. In addition to that, it provides drinking water to manage the livelihood of people attached to the system. To supply water in both "*Yala*" and "*Maha*" seasons of a year, the Kalawewa Tank must, however, be filled to its 'full capacity' at least six times.

Although the MSH provides the highest yield for any crop amongst the competitive regions, due to the shortage of water, nearly 68,000 farm families are being heavily inconvenienced. Improper land use, unprovoked physical planning and failures in decision making have, amongst the others, led the MSH to face this dilemma. In fact, the thousand years old Cascade System belongs to this geographical area was also affected by the rapid and inadvertent development work under the Mahaweli Project.

AN INTEGRATED STRATEGIC PLAN TO ENHANCE WORKINGS OF MSH

In this case, the key aspects that the policymakers must take into account to enhance the overall efficiency; effectiveness and productivity of the MSH are highlighted. Those aspects are, in turn, "integrated" into a common framework as depicted in Figure 2. It is imperative to implement the tasks included in the framework systematically as a step-by-step process, as the 'outputs' and 'outcomes', and then the 'impacts' arising from which would not only be confined to the MSH, but all other adjacent systems would get the direct and indirect benefits.

Figure 2: Development Plan for Mahaweli System H

The key constraints that hinder achieving these aspects would include the "Climate change". It is believed that even if the reservoirs are built, they might not receive an adequate amount of water. Considering the massive size of the project, it is, therefore, very important to have a comprehensive 'Feasibility Study'. "Land encroachment" can be considered another constraint associated with achieving a balanced development. "Political interference" and "Lack of funds" also act as other two key constraints limiting the implementation of this type of comprehensive scientific framework.

To make implementation of this strategic framework a reality, we must call for the support of all linear institutions; assure farmers' willingness to extend their fullest cooperation, guarantee adequate funds, backing of environment related organizations, *etc*. Out of all, the fullest cooperation of the 'line agencies', including the Mahaweli Authority and financial institutions are warranted. No need to say, that the backing of the National to Provincial as well as the local "*Pradeshiya Sabha*" level political authorities is of paramount importance to make this type of long-term comprehensive system to become productive and sustainable.

If the program is implemented as planned, it would guarantee that farmers will be in apposition to get more yields and income from agriculture/agribusiness; establish environment friendly farming systems; increase ground water level in the area; increase crop intensity of the area; ability to cultivate a "third season"; enhanced water capacity of reservoirs, and more importantly, recover all Cascades into normalcy within 5 years.

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Author:

Ubaya Kalyana Kumara: Resident Project Manager of the Mahaweli Authority of Sri Lanka System "H". He obtained B.Sc. (Agric.) Hons. Degree from Faculty of Agriculture, University of Peradeniya in 1997 (e-Mail: *thevindubandaraihalagama@gmail.com*)

Reviewer:

Udith K. Jayasinghe-Mudalige: Senior Professor and the Chair of Dept. of Agribusiness Management of WUSL. His teaching/research interests include: Food and Agricultural Economics, Development & Policy, Project Management, and Quality Assurance in Higher Education (e-Mail: *udith@wyb.ac.lk*)

EFFECT OF HOMOGENIZATION PRESSURE ON THE CONSISTENCY OF ULTRA-HEAT TREATED (UHT) COCONUT MILK

Hasitha Thiwanka Bogoda

Department of Quality Assurance, Renuka Agri Foods PLC, Block B, Export Processing Zone, Wathupitiwala, Nittambuwa, 11880

INTRODUCTION

Coconut milk is used as a vital ingredient in a variety of foods and it is the milky white juice prepared by pressing grated coconut flesh with or without added water (Khuenpet *et al*., 2016). Coconut milk is not physically stable and is prone to phase separation, thus homogenization process is used to avoid it. Consistency plays an important role in determining the organoleptic properties of coconut milk (Figure 1). The objective of this project is to analyse the effect of homogenization at different pressures and temperatures on the consistency, serum viscosity and serum separation of UHT (ultra-heat treated) coconut milk from different cultivars with varying initial consistency.

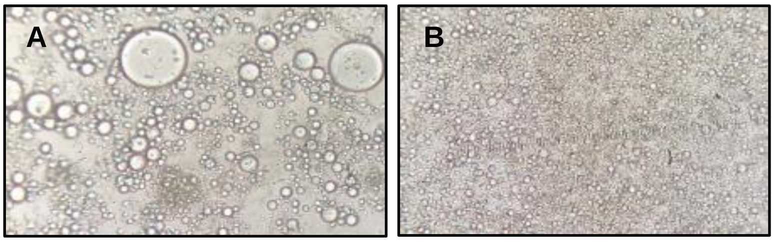

Figure 1: Microscopic View of (A) Non-Homogenized and (B) Homogenized Coconut Milk

Justification

Less information is available on the effect of homogenization pressure for the consistency of coconut milk. Outcome of this experiment will help fill that gap and it will increase the quality of coconut milk products. Therefore, the benefits of this project can be shared among coconut milk-based industry and research institutes that are interested in organoleptic and physicochemical properties of coconut milk. Products with low consistency may be sold at lower prices or can even be rejected (Chichester, 1959). Hence, it will be necessary to identify the appropriate homogenization pressure for high consistency by studying the behaviour of consistency against homogenized pressure difference. As a consequence of this, customer satisfaction will be increased, and manufacturing companies can maintain the quality of their products. The project has been planned to conduct at the factory premises of Renuka Agri Foods Company.

METHODOLOGY

Raw coconut milk (without water) samples will be collected to check initial viscosity. It will be processed through a two-stage homogenizer at different pressures and infusion UHT plant (sterilization temperature at 140˚C for 6 s). Consistency of the control and the homogenized coconut milk will be measured at room temperature (28˚C) by determining their efflux viscosity and by the Cone penetration method (deMan and Hayakawa, 1982). Homogenized milk samples at different pressures and temperatures will be aseptically filled into sterilized aseptic bags using Alfa Larval Aseptic filler and kept at room temperature before the quality determination. Then, the data related to consistency and homogenization efficiency will be analysed through a microscopic view with different homogenization pressures. Experiments will be conducted using five levels of homogenizing pressures (Figure 2). Data will be analysed using SPSS statistical software.

Figure 2: Process of Coconut Milk Production

Assumptions

Other parameters that affect the consistency, such as additives used for emulsifying and stability should be constant. Thus, a constant additive amount should be used. UHT condition (sterilization temperature/holding time) and additive mixing process (agitating speed/additive mixing temperature) should be general for different homogenization pressures. Recommended quality assurance tests should be done by trained personnel to avoid possible practical errors. Equipment and machines used for the experiment should be calibrated by an accredited organization. Machine errors, such as homogenization milk leakage, non-uniformity in homogenization pressure, homogenization seal leakage, Alfa Larval filler errors, should be minimized.

Dependencies

Dependencies of the project are customers, suppliers, and competitors in the corporate sector. Customer satisfaction will be increased with improved quality of products (Figure 3).

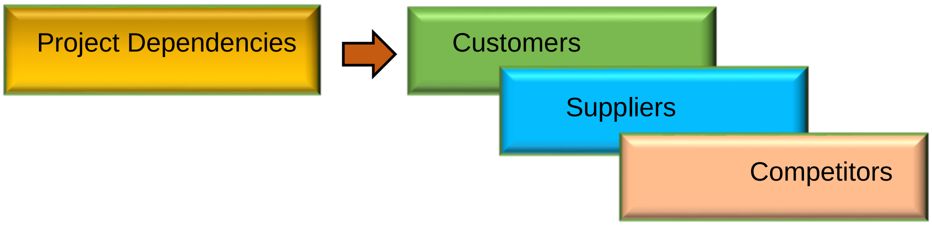

Figure 3: Project Dependencies

Therefore, the competition among the companies will be increased for the manufacture of high-quality products. As a result, the customer encounters high-quality coconut milk products in the market. Consistency checking of the raw coconut milk will be an opportunity for categorizing suppliers according to quality. The milk loads purchased from suppliers can be adjusted according to the production plan. As a result, suppliers will tend to supply high-quality coconut milk.

PROJECT IMPLEMENTATION

This project has already been proposed for the annual activity plan of the company. The project will be started in January 2021 and will be completed within 2 months (by February 2021) with the company approval. Financial support will be allocated from the Annual Budget of the company. Technical support will be given by the Engineering Department of the company. Chemicals, quality testing equipment and supportive staff will be facilitated by the Quality Assurance Department and R & D Section. The proper homogenization pressure and temperature for the required consistency in the coconut product will be the outcome of the project. It will contribute to produce high-quality coconut milk products to meet the consumer satisfaction and to improve the brand name of the company.

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Author:

Hasitha Thiwanka Bogoda: Quality Assurance Executive, Renuka Agri Foods Company (Pvt.) Ltd. He holds B.Sc. in Environmental Sciences and Natural Resources Management Special Degree from Faculty of Applied Sciences, Sabaragamuwa University of Sri Lanka. His professional interests include: Quality Assurance, Environmental Science and Waste management (e-Mail: *baht.bogoda@gmail.com*)

Reviewer:

Amani Wijesinghe: Senior Lecturer, Department of Bio-Systems Engineering, FAPM, WUSL. Her teaching and research interests include: Food Technology, Food Safety & Quality Management and Development of Food Preservation Techniques
(e-Mail: *jaacwijesinghe@wyb.ac.lk*)

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REDUCTION OF CARBON FOOTPRINT THROUGH THE USE OF EXTENSIBLE SACK KRAFT PAPERS IN BULK TEA PACKAGING

Chanaka Susinil Athukorala

St. Regis Packaging Private Limited, No.33-34, Lanka Industrial Zone, Sapugaskanda, 11640

INTRODUCTION

The recent study carried out by MIND Lanka shows that the carbon footprint generated through the production of 1 kg of tea is 35.56 kg of CO_2 and 47% of this, is directly from the packaging related operations (Figure 1).

With the disruptive innovation of paper sacks to pack bulk tea in Sri Lankan tea industry producers and exporters successfully manage to replace the wooden tea chest with paper sacks. Elimination of wooden tea chests is necessary because they were of high cost and caused damages to the environment for several decades. The weight of wooden tea chest amounts to 5 kg each whereas, paper sack is only 0.65 kg. This innovation took place in the year 1990 and there onwards the tea industry still uses the same packages which were innovated thirty years back. These packages are mainly manufactured using normal sack Kraft papers with four plies of 70 gsm natural sack Kraft papers. However, during these 30 years, paper technology has evolved fast to compete with polythene, as there is a global demand to minimize the use of polythene to prevent environmental pollution. It has created a vast improvement in paper quality in terms of its bursting strength and tensile energy absorption (TEA) value. As a result, extensible sack Kraft papers were innovated to replace and minimize the raw material usage by paper products to become a more viable and sustainable environment-friendly product in order to replace the polythene in different industries, *e.g.* cement and grocery bags.

Significance of the Project

Sri Lankan tea industry currently produces around 300 million kg of made tea annually and 90 percent of our produce are exported to different destinations globally. The packaging plays a major role in the tea industry as a supportive industry. The current usage of bulk tea sacks amounts to 7 million sacks by tea producers and 3 million sacks by tea exporters. The price of these sacks varies from Rs.165.00 to Rs.175.00 and are mainly manufactured by normal sack Kraft papers. The price of normal sack Kraft papers is around US$ 850 per ton and an extensible sack Kraft papers cost around US$ 870 per ton. All these raw materials are imports from various parts of the world into Sri Lanka for different packaging purposes.

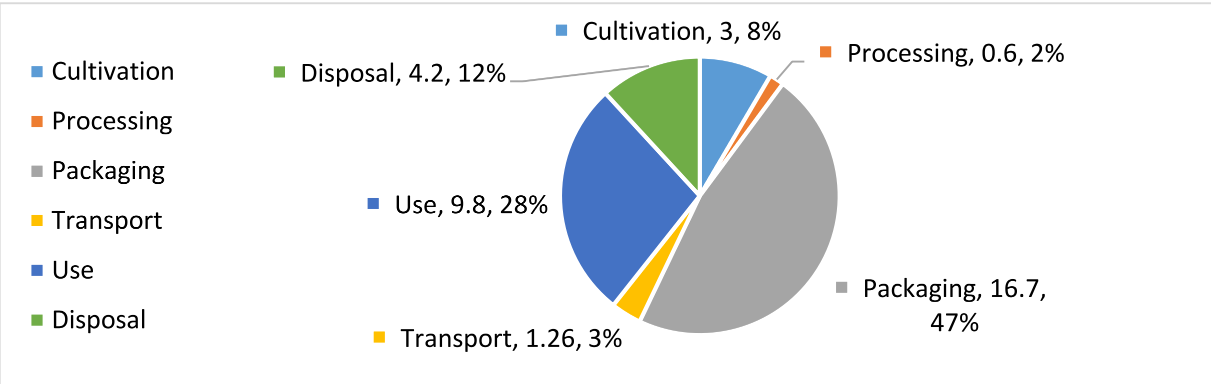

Figure 1: Carbon Footprint of Sri Lankan Tea Industry per Kilogram of Tea
Source: Munasingha et al., 2017

Project Justification

Use of improved extensible sack Kraft papers instead of normal sack Kraft papers can reduce the raw material consumption to manufacture bulk tea sacks and reduce the carbon footprint, waste dumps and benefit the industry by price reduction.

Project Constraints

The use of multiwall extensible sack Kraft papers are not suitable for long and flowery leafy tea grades, *e.g.* OPA, OP, OP1, BOP1, FBOP1, FBOP, and Pekoe. These grades are more towards style and shape, which is an important aspect at the point of selling. Therefore, such grades could pack in rigid sacks which are manufactured by 270 gsm Kraft liner boards for outer plies and 60 gsm inner ply same as multiwall paper sacks (Table 1).

Table 1: Sack Composition and Weight Comparisons

Normal Kraft Paper Sacks		Extensible Kraft Paper Sacks	
Sack composition	**gsm**	**Sack composition**	**gsm**
Ply 1 NKP	70	Ply 1 EKP	80
Ply 2 NKP	70	Ply 2 EKP	80
Ply 3 NKP	70	Ply 3 (Inner) EKP	60
Ply 4 (Inner) NKP Aluminium foil/Metalized Polyester Laminated with LDPE Aluminium/ Metalized Polyester	60 20 19	Aluminium foil/Metalized polyester Laminated with LDPE Aluminium/Metalized Polyester	 20 19
Total Sack weight	650 g	Total Sack weight	550 g

NKP= Normal Kraft papers; EKP= Extensible Kraft paper, LDPE= Low density polyethylene
Source: Sri Lanka Standards 1492:2014 (2014)

Project Assumptions and Dependencies

Lesser number of plies and reduction in the sack weight may lead to create an uncertainty in stakeholders' mind about the compatibility of extensible multiwall paper sack to hold high-density small grades, for example, PFI, PF, PD, BOPF and Dust1. Therefore, it is important to make awareness about the combination of this product and its strength when compared to normal Kraft paper sacks.

The success of this innovation is fully depending on the stakeholders of the Sri Lankan tea industry, as they are using the existing normal Kraft paper sacks for more than 25 years and they are comfortable with the current product. Therefore, the new product needs to cater to the market requirements, while reducing the carbon footprint. Further, it has to comply with the SLS 1492: 2014 standard (Sri Lanka Standards, 2014) and Ceylon Tea Traders Association set standards/requirements.

PROJECT SUCCESS CRITERIA

The use of extensible sack Kraft papers can reduce the production cost of multiwall paper sacks while reducing the amount of raw material use directly by 15 percent and the sack manufacturer can pass this benefit to the industry in terms of sack price. Further, it can save a considerable amount of foreign exchange, as theses raw materials are fully imported from paper mills which are located in the USA, Canada and Europe. There are other indirect benefits of this product as it may reduce the cost of logistics, from raw materials to its end-user/customer throughout the supply chain. Use of extensible sack Kraft papers can benefit the tea industry by reducing its carbon footprint on bulk tea packaging directly 15 percent from 16.70 kg CO_2 to 14.19 kg CO_2.

ACKNOWLEDGEMENT

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Author:

Chanaka Susinil Athukorala: Manager Sales & Marketing at St. Regis Packaging Pvt. Ltd. He holds B.Sc. (Plantation Management) from WUSL and M.Sc. in Strategic Marketing from Cardiff Metropolitan University, United Kingdom (e-Mail: *csathuko@gmail.com*)

Reviewer:

Chandana Abeysinghe: Professor in Plantation Management, Department of Plantation Management, FAPM, WUSL. His teaching and research interests include: Tea Agronomy and Processing, Crop Physiology, Bioactive Compounds in Foods, and Antioxidant Properties of Food (e-Mail: *abeysinghedc@yahoo.com*)

MILK TOFFEE FROM COW'S MILK: A CASE STUDY ON RURAL DAIRY FARMER EMPOWERMENT THROUGH EFFECTIVE VALUE CHAINS

Rohan Chaminda Karunasena

National Livestock Development Board, Oyamaduwa Farm, Elayapaththuwa, 50014

INTRODUCTION

Sri Lanka's milk production was 374 million liters in 2019, which accounts for approximately 90 percent of the total consumption. Practicing of a single milking round per day, poor nutrition, lack of storage facilities, limitations in the evening milk collection system, and lack of infrastructure facilities to increase the productivity in rural smallholder farmers could be identified as the major factors associated with low productivity of dairy cows in Sri Lanka (National Livestock Development Board, 2016). Recently, a value-chain approach has been adopted in agriculture, aiming to promote integration of smallholders into efficient and competitive value-chains, not only to enhance productivity, but also to increase the value of agricultural products. In addition, such attempts would create more job opportunities for local people, and contribute to the socio-economic development in rural areas.

Justification

Making milk toffee is one of the simplest, convenient and effective value addition methods for diary milk (Figure 1). It could gradually promote evening milking practices, which may increase the lactation length and herd life, elevating the productivity of cattle herds at rural smallholder level. Further, it could eliminate the necessity of using refrigerator facilities to store milk, while milk toffee production is easily affordable even for poor farmers with low infrastructure facilities. Current study aims to promote making milk toffee from fresh milk, which could elevate the income generation by approximately 190 percent, than selling fresh milk itself. In addition, it can increase the lactation length, average milk production of a cow, create market and employment opportunities for farming community strengthening the rural livelihoods.

Figure 1: Milk Toffee Production by Rural Farmers

MILK TOFFEE PRODUCTION PROJECT

Mahawilachchiya Divisional Secretariat Division, in Anuradhapura District will be selected as the intervention area. A total of 100 rural dairy farmers residing in eight villages of Mahawilachchiya will be identified with the support of the Dairy Farmers' Society in the area.

Milk toffee production is a simple food preservation technique, which can be widely promoted in Sri Lanka. Fresh cow's milk is used as the main raw material for production, with only one requirement of maintaining a higher purity level of milk. Therefore, several training programs on good dairy farming practices will be conducted for the farmers, with the support of the National Livestock Development Board (NLDB), Oyamaduwa Center. Family labour would be sufficient for the production of milk toffee, which could notably cut down the labour costs. To familiarize farmers with the production process, two workshops will be conducted for the dairy farmers and selected family members on the milk toffee production process and packing aspects.

With the support of the NLDB, polythene sealing machines and other packaging materials will be provided to the dairy farmers under a soft-loan scheme. Routine quality inspection visits will be conducted at 3-month intervals by the field officers of Oyamaduwa NLDB farm to ensure the quality of production. Once milk toffee is produced, the products will be marketed through the NLDB stalls and welfare stalls of the dairy farmers' association in the region. At present, 1 L of fresh milk can be marketed at a price of Rs. 82.00 at the local market, thereby ensuring an income of Rs. 8,200.00 from 100 L of fresh milk. On the other hand, processing of fresh milk into milk toffee could enable the dairy farmer to secure a total income of Rs. 22,800. Thus, an additional profit of Rs. 7,627.50 can be obtained for 100 L, through milk toffee production as indicated in Table 1.

Table 1: Cost-Benefit Analysis of Milk Toffee Production

Expenses	Rs.	Income	Pkts/Rs.
Fresh milk 100 L x Rs. 82.00	8,200.00	Production from 1 L of liquid milk (250 g)	1.9 pkts
Sugar – 400 g for 1 L fresh milk 40 kg x Rs.105.00	4,200.00	Accordingly, the income from 100 L of milk	190 pkts
Labour charges (03 days ‹ Rs. 750.00)	2,250.00	Income from 190 pkts 190 x Rs 120.00	22,800.00
Packing charges	522.50		
Total expenses	15,172.50	The total additional profit from 100 L of milk	7,627.50

The best performing dairy farmers in the area will be encouraged to register their products and develop the production process further to higher scales, which could create alternative employment opportunities and entrepreneurships in the area. Meanwhile, additional joint-ventures would be encouraged to broaden the market for milk toffee. Regardless of the economic feasibility, milk toffee production can be done with evening milk in rural areas where chilling facilities are not available. Furthermore, this could restrict income losses caused due to poor storage facilities. Therefore, the current project could enhance the economy of rural dairy farmers in Mahawilachchiya area, while catering for the local market requirements of quality sweets.

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Author:

Rohan Chaminda Karunasena: Assistant Manager, National Livestock Development Board, Oyamaduwa Farm, Ellayapaththuwa. He holds B.Sc. (Plantation Management) degree from WUSL (e-Mail: *chamindanldb@gmail.com*)

Reviewer:

Lahiru Udayanga: Lecturer at Department of Bio-Systems Engineering, FAPM, WUSL. He has completed his PhD in Geo-Informatics and Environmental Modelling. His teaching and research interests include: Environmental Management, Geo-Informatics, Climate Science and Disaster Management (e-Mail: *udayanga@wyb.ac.lk*)

POPULARIZATION OF THE PARACHUTE TECHNOLOGY FOR RICE FIELD ESTABLISHMENT

Kanishka Bandara Weerakoon

Department of Agriculture - Central Province, No. 25, Labuduwa Sri Damma Mawatha, Peradeniya, 20400

INTRODUCTION

Rice (*Oryza sativa* L.) which belongs to family Poaceae is the staple food of Sri Lankans. Sri Lanka currently produces 2.7 million tons of rough rice annually and satisfies around 95% of the domestic requirement. It is projected that the demand for rice will increase by 1.1% per year and to meet that, rice production should grow at the rate of 2.9% per year. Therefore, increasing the cropping intensity and national average yield are the options available to achieve this production target. Accordingly, rice field establishment can be identified as an essential practice influencing to increase the yield per unit area. Further, rice establishment methods directly affect the cost of production because the labour cost has risen at a higher rate than other costs over the last few years. The highest percentage of total cost of production of rice is stipulated from labour compared to material and power (Figure 1; Anon, 2018). For instance, the Department of Agriculture (DOA) has introduced specific '*yaya 01*' and *'yaya 02'* cultivation programmes in 2012 to boost the average rice production from 4.3 t/ha to 7 t/ha. These programs have emphasis on adopting new techniques such as 'Parachute Method' in rice crop establishment in the field. Parachute technology is such novel rice crop establishment method that may be effective, low cost and increase rice yield compared to traditional direct sowing method.

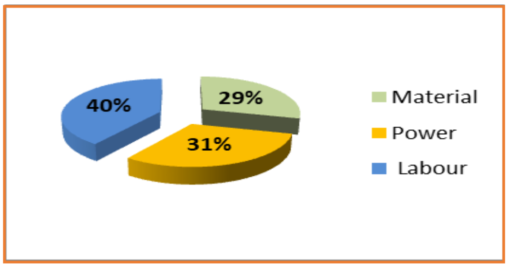

Figure 1: Major Components of the Cost of Cultivation of Paddy

Benefits of Using the Parachute Technology

Rice is cultivated as a wetland crop in all districts of Sri Lanka. In parachute technique, seedlings are raised until 12 - 15 days old (Figure 2) in small bubble plastic nursery trays with mud and then broadcast directly into paddy fields. Greater benefits of this technique compared to traditional methods of rice establishment are; it requires less labour and has reported a 60 - 70 percent saving in cost of labour (Weerakkody *et al.*, 2011), there is no transplanting shock or seedling mortality at the early seedling stage, optimum plant density can be achieved, and saves considerable quantity of water (60%), less seed paddy requirement (10-12 kg/ac) and gives higher crop yields. Therefore, the parachute technique is a better alternative for field establishment of rice seedlings.

Figure 2: Uprooted Rice Plants from a Parachute Nursery

Challenges in Adopting Parachute Technology Among Rice Farmers

Although the parachute technique has greater benefits farmers drift away from the interest in the technology due to lack of knowledge and skills. One area is that farmers normally draw less attention in performing the proper parachute nursery establishment. As a result, it causes difficulties in ‘seedling broadcasting’ due to high tangling of roots. Other limitations are that establishment of parachute nurseries are not practical and profitable in drought or in areas with water shortage due to the reason that parachute nurseries require high water input. Finally, a farmer with more than 1 ac rice cultivation extent has to purchase a number of parachute rays which is initially costly. This study describes the case of popularizing to increase of adoption of parachute technology as a high yielding and low cost rice establishment technology among field level rice farmers in Sri Lanka.

PROJECT IMPLEMENTATION

The DOA is the main organization involving in this project to conduct awareness creation and skill training programs via extension personnels. Therefore, Agriculture Instructors (AI) can be identified as key persons who can disseminate the awareness of parachute technology among farmers. To successfully promote parachute method several actions can be taken by AIs, such as timely execution of demonstration programs in creating an initial awareness, giving priority to farmers who are innovative, successful and dedicated in the extension programs. It is essential to increase effectiveness of disseminating technology to early majority and late majority of farmers.

Further, mass information methods, such as banners, leaflets, television and radio programmes and campaigns through farmer organizations and cyber extension units can be optimized as powerful sources for communication. By educating farmers on income and expenditure of parachute method, an attitudinal change towards new technology can be achieved. Furthermore, DOA has some subsidy schemes such as 50% subsidy scheme for parachute trays to promote this technology. Meantime, the government can strengthen the promotion by introducing a controlled price for parachute trays in the local market or by facilitating a decrease in price of trays with elimination of taxes.

Measurable Outcomes of the Project

Successful promotion of parachute technology will fulfil the satisfaction of rice farming community in Sri Lanka and will ensure both household and national food security. Around 6,000 ha of major irrigated areas have now been successfully covered using this technology. The outcome of promoting parachute technique can be measured in terms of rice yield. According to Table 1, a 77.5% increase in yield has been reported using parachute method compared to direct seed sowing/broadcasting (Weerakkody *et al.*, 2011).

Table 1: Yield Comparison Between Parachute Technology and Seed Broadcasting Methods

Indicator	Yield	
	Parachute method (Bushels/acre)	Broadcasting (Bushels/acre)
Mean Yield	159.78	90
SD	44	28

Source: Weerakkody et al., 2011. SD- Standard Deviation

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Author:

Kanishka Bandara Weerakoon: Agriculture Instructor attached to the Department of Agriculture (Central Province). He holds B.Sc. (Plantation Management) [First Class Hons] from WUSL and Diploma in Agriculture from School of Agriculture, Kundasale. He currently engages with the Extension Division in Kandy district (e-Mail: *kesiri87@gmail.com*)

Reviewer:

Surantha Salgadoe: Senior Lecturer, Department of Horticulture and Landscape Gardening, FAPM, WUSL. His teaching and research interests include: Crop Remote Sensing, Precision Plant Pathology and Crop Production Technology (e-Mail: *surantha@wyb.ac.lk*)

INTRODUCTION OF MUSHROOM HUTS TO IMPROVE THE LIVING STANDARDS OF MUSHROOM FARMERS

Rupika Karunarathna

Provincial Agricultural Department - Sabaragamuwa, Muwagama, Rathnapura, 70000

INTRODUCTION

Mushroom cultivation is a profitable agribusiness for farmers who are interested in an additional income. Mushrooms possess high nutritional and medicinal properties and also has a high demand in local and international markets. Mushroom cultivation programmes have been hosted by government and non-government organizations to upgrade the living standards of mushroom farmers in Sri Lanka. The production process has to be modified for a more durable product, thus adding value to mushrooms. Empowerment of women and lack of time for cooking also increases demand for convenient products such as mushrooms. In Sri Lanka, value addition to mushrooms is lower than that in some developing countries, resulting in the need to improve marketing systems and increase value addition (Thilakaratna, and Pathirana, 2018).

Justification

Mushroom cultivation in Sri Lanka is mostly done at household levels as a small business. Even though there is a good market demand for good quality mushrooms in Sri Lanka, the farmers are scattered around the country. There are several advantages for mushroom farmers, such as a good return on investment, availability of low cost raw material, ability to start the cultivation within a small space, harvesting being possible in a short duration of time and the ability to start cultivation with prevailing infrastructure facilities, *etc.*

However, there are several issues and challenges that are hindering the development and popularity of the mushroom industry in Sri Lanka. Most growers refrain from cultivation due to unstable farm-gate prices and profit margins, lack of well-organized market channels and distribution networks within the country and the unavailability of a stable marketplace to sell mushrooms and mushroom products. Therefore, this study aims to introduce the “Mushroom Hut” concept for mushroom farmers. The objective of this project is to improve the living standards of mushroom farmers through promoting value added products of mushrooms to the local market.

MUSHROOM HUT CONCEPT

The Mushroom Hut is a new technological concept of the food and agriculture sector in Sri Lanka. It is an outlet which includes fresh mushrooms, all mushroom related food, value added products and raw materials. Different types of economic channels are automatically created through this project by connecting fresh mushroom suppliers, mushroom related food manufacturers, suppliers of raw material, such as mushroom seeds, polythene and insect proof nets, *etc.* (Figure 1).

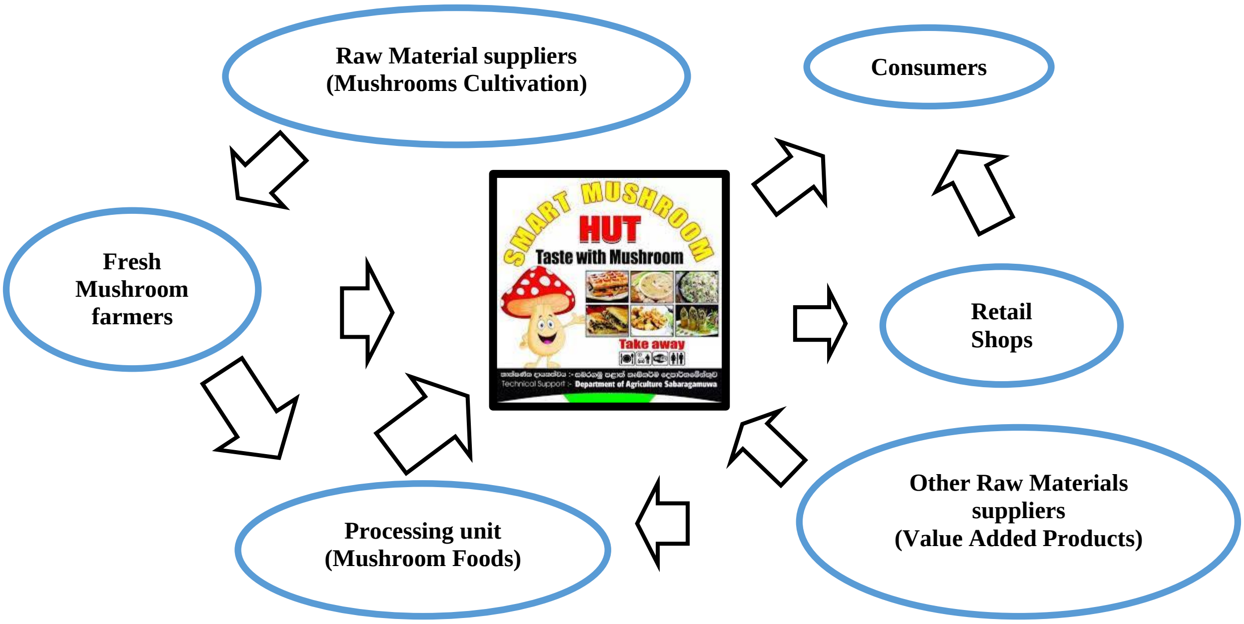

Figure 1: Overview of the Process of Mushroom Hut Concept

PROJECT IMPLEMENTATION

There are about 35 mushroom farmers in the Agriculture Instructor Region in Thimbolketiya (Udawalawa area). They are implementing their mushroom cultivation under the supervision of the Provincial Department of Agriculture, Sabaragamuwa. They are holding a mushroom society under the same organization. Therefore, this project proposes to introduce the Mushroom Hut concept through the Mushroom Growers' Society. Members of the society are responsible for maintaining the mushroom hut and they can gain benefits through every economical channel. All the activities are inspected by the Provincial Department of Agriculture, Sabaragamuwa.

Project Constraints

There are many obstacles for implementing this project. There should be an attractive place close to a main road for a Mushroom Hut; this is the main constraint of this project. There should be an initial finance in order to rent or to purchase such a place and to build a Mushroom Hut. As this is a food processing project, it should be managed under the government rules and regulations.

Project Success Criteria

The Mushroom Hut mainly depends on the consumer base of the mushroom products. Mushrooms are perishable food and quickly get spoiled. Therefore it is important to apply new techniques for increasing the shelf life. Government contribution for this project is essential in terms of widening extension services and subsidies, involvement of new research and development programs and introducing new production and postharvest technologies. This project is one suggestion for the enhancement of the mushroom industry where consumer satisfaction is a vital factor for its success.

CONCLUSION

The main objective of this project is to improve the living standards of mushroom farmers. This objective is automatically achieved by creating a unique marketplace called a Mushroom Hut which gives a price even for excess mushroom harvest. Instead of giving up self-employment opportunities, household level mushroom growers will be able to become large-scale mushroom suppliers, based on the improvement of the concept of "Mushroom huts".

Other than these benefits, some indirect income chains are also generated, such as raw material supplement, facilitation for transportation and other allied industries (*e.g.* packaging material)

In an area where the tourism industry is popular, this project also helps to uplift the tourism industry. Therefore, as a second step, the Mushroom Hut project is suitable to be introduced to other tourism zones in order to extend the project.

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Author:

Rupika Karunarathna: Agriculture Instructor attached to the Provincial Agriculture Department, Sabaragamuwa. She holds B.Sc. (Plantation Management) from WUSL
(e-Mail: *rupikakarunarathne89@gmail.com*)

Reviewer:

Kapila Yakandawala: Professor and the Chair of Department of Horticulture and Landscape Gardening, FAPM, WUSL. His teaching and research interests include: Landscape Gardening, Environmental Horticulture and Urban Agriculture
(e-Mail: *yakandawalakapila@gmail.com/kapilay@wyb.ac.lk*)

FINANCING AGRICULTURE IN SRI LANKA: OPPORTUNITIES BEYOND A 'SECURITY-BASED LENDING'

Inesh Amarasinghe

Sampath Bank PLC - Wariyapola Branch, Nawinne Office Complex, Wariyapola, 60400

INTRODUCTION

Investment in food and agriculture is an effective mode of stimulating economic growth and reducing poverty in developing countries which struggle to increase food production through sustainable markets. Financial uncertainty is a particular challenge that causes the reduction of the availability of all types of resources as well as the increase of fear and scrutiny of risk. Moreover, the environment for global agricultural finance is influenced by the growing concentration of control (by increasing vertical and horizontal integration) in the sector such as the gains from economies of scale and globalization of the food value chains, multi-accesses to resources and other interconnected agribusiness activities.

Project Justification

Value chains in agriculture comprise a set of actors involved in the sequence of value-additions in bringing a product from its raw material stage to the final consumer (farmer-to-table). Financing 'Agricultural Value Chain' (AVC) refers to offering financial services that flow to or through any point in a value chain that enable investments which may increase the returns of value-chain-actors and growth of the chain.

The country's GDP has been recorded as Rs. 14.5 trillion while the contribution from agriculture sector was 7 percent (Sri Lanka Socio-Economic Data, 2019). There are 70 registered Authorized Financial Institutions (AFIs) in Sri Lanka which claim Rs. 14 billion worth assets. Further, almost all the AFIs are being engaged in financing agriculture through various means. However, the agriculture sector is lack of lead-firms as well as large scale investors. Instead, there are numerous smallholder farmers or farmer clusters all over the country who work together with processors, traders and other intermediaries in the same locality or another. Such communities create rich cash flows in the rural economy which lead to eliminate poverty and generate employment. Further, the records indicate that there is only a nominal growth in the agriculture sector and that the AFIs engagement in the agriculture sector is minimal. Thus, contribution of the novel strategic approaches that are beyond the conventional methods of lending against traditional sources of collateral is of vital importance. Accordingly, this article is intended to provide some insights on the same.

Project Rationale

One of the key concepts of value chain financing is to use 'the chain, its products and transactions' for securing the same finance activity (Miller and Jones, 2010). Based on the said concept, five main modalities of AVC financing instruments can be identified (Figure 1).

All these instruments incur a cost to the receiver, but it may vary with the level of risk taken by the service provider. AFIs are keen on security-based lending (SBL), since the borrowers are urged to provide tangible securities and due to the unavailability of such collaterals at most of the times, they divert into other sources of finance even at higher rates. AFIs usually consider the above discussed 'finance instruments' as sources of the financial flows (generally materialized as conditions) or pre-qualifications for lending (as proofs) and not accepted as securities. However, AFIs would be able to convert those instruments into accessible collaterals and design facilities embedded with the same collaterals, in order to serve the sector while following the approaches of other countries. In the recent past, some AFIs have achieved higher success rates utilizing several credit products (by converting AVC financing instruments into secured segment) favouring large AVCs as well as small farmers and their suppliers and traders (Figure 2).

Further, new product development shall be focussed on the areas such as export oriented agribusinesses, contract farming and agriculture value additions. Exploring product features in such product developments so as to enhance the advances product portfolios of the AFIs that shall be based on the financial instruments derived from AVCs and other conventional securities (Figure 3).

PROJECT IMPLEMENTATION

The AFIs may be reluctant to further expose themselves to the agriculture sector for the highest non-performing advance ratio is represented by the agriculture sector in the last 2 years. To remedy this situation the managers of the AFIs shall possess special skills such as responsiveness to changing macro-economic factors, clever risk assessment capabilities, commitment towards continuous monitoring and follow-ups, *etc.* Though the Central Bank has mandated the Licenced Commercial Banks to maintain a minimum sector exposure of 10 percent favouring agriculture, the very total exposure born by the entirety of AFIs is only 8.1 percent. Thus, it is a key requirement for each AFI to contribute a minimum exposure of 10 percent or more to make this attempt a success. Further, enhancing the legal provisions for litigation on the recovery processes and reviewing the existing legal aspects already available; are of utmost important. Implementing comprehensive policy and regulatory frameworks should also be considered while interest subsidies and exemptions shall be availed for the government levies over legal instruments pertaining to the facilities extended to subject sector (i.e. stamps duty) in order to promote the same. Priority should also be given to the identified major food commodities as a strategy to overcome the above challenging situation and move forward.

Product Financing	• Trader Credits, Input Supplier Credits, Marketing Firm / Lead Firm Financing **(provided by the AVC actors; themselves or with financial assistance from AFIs)**
Receivables Financing	• Trade Receivable Financing, Receivable Factoring, Forfaiting **(provided by AFIs)**
Asset Collateralization	• Warehouse Receipt, Repurchase Agreements, Financial Leases **(provided by AFIs)**
Risk Mitigation	• Insurance and Guarantees **(by the Insurance Firms / AFIs)** and Forward Contracts and Futures **(provided by AFIs)**
Structured Enhancement	• Shares, Loan Guarantees and Joint-equity Options **(provided by Equity Managing Firms with or without the participation of AFIs)**

Figure 1: Modalities of Value Chain Financing Instruments

Factoring Facility	• Granted against an assignment of rights over invoices pertaining to supplies to the AFI; covered only by a tri-party agreement among borrower, supplier and AFI.
Warehouse Financing	• Granted against an undertaking over goods stocked at a warehouse owned by a third party; covered only by a tri-party agreement among borrower, warehouse and AFI
Financial Leases	• Granted against a Lease Agreement; not only to purchase a vehicle / machinery but also to finance against own vehicle / machinery, covered only by a letter of consent.
Pledge Loans	• Granted against a Mortgage over goods, stocked as a pledge (under dual control) located at a store where the AFI retains free access at any given time..
Forward Contracts	• Granted against a mere agreements over confirmed foriegn bills (import/export) to minimize the exchange rate risks and hedging to minimize risk on price volatility.

Figure 2: Emerging Credit Products Secured by AVC Financing Instruments

Low Risk	• Cash in Bank, Bank-Drafts, Money-Orders, Commercial Paper, Treasury-Bills, Life Insurance, Shares & Debt-Instruments (Government/Foreign/Corporate Bonds & Debentures), Pawning.
Moderate Risk	• Mortgages over Properties [immovables (Land, Buildings and Machines fixed to the ground) and movables (Vehicles, Machinery and all types of Stocks), Lease Agreements (Finance Leases and Operating Leases), Hire-Purchase Agreements, Pledges, Hedging Agreements, Trust Receipts.
High Risk	• Agreements over Documentary Credit (LC) and Trade-related Documents (*i.e.* Bills of Lading, Commercial Invoices), Contractual-rights to Receive or Deliver (Accepted Bills of Exchange and Cheques), Import/Export Bills (DP/DA) and Financial Derivatives (Options, Futures, Forwards), Delivery/Purchase Orders and Supply Agreements, Invoices/Lease Receivables & Book-debts, Co-Signing and Guarantee, Promissory-notes, Loan or Overdraft Agreement, Undertaking to Mortgage.

Figure 3: Securities Derived from AVCs and Other Conventional Securities

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Author:

Inesh Amarasinghe: Banking Executive Attached to Wariyapola Branch of Sampath Bank PLC as the Assistant Branch Manager. He is an associate member of the IBSL and holds a MBA from London Metropolitan University (e-Mail: *ineshamarasinghe@gmail.com*)

Reviewer:

Sashika R. Guruge: Lecturer, Department of Agribusiness Management, FAPM, WUSL. She is reading for her PhD in Environmental Economics and holds B.Sc. (Agric.), Masters in Business Studies (Colombo), CIM, Diploma in Banking and Finance (IBSL) (e-Mail: *guruge84@yahoo.com*)

IMPROVED TEA SEEDS AS A SOURCE OF PLANTING MATERIAL: A STRATEGY FOR ADAPTATION TO CLIMATE CHANGE

Ashoka Kumara Mudalige

Plant Breeding Division, Tea Research Institute, Low Country Station, Ratnapura, 70000

INTRODUCTION

Tea (*Camellia sinensis* L.) plays a considerable role in the economy of Sri Lanka. In year 2018, the total land area of the country under tea was 201,000 ha which produced 303.8 million kg of made tea and export earnings of 231,750 million rupees (Anon., 2018). Though the tea cultivation was initiated in mid country of Sri Lanka, with the expansion of tea industry, tea cultivation has been extended to moderately suitable or even unsuitable lands such as drought prone or low productive lands (marginal lands) that limit productivity potential of vegetative propagation (VP) cultivars. Moreover, as a rain-fed crop, tea may have to face anticipated consequences of climate change such as drought, heat stress, *etc*. In contrast, seedling tea shows a wide adaptability to soil and climatic conditions resulted by heterogeneity, in terms of variation in growth, vigour, and resistance to pests and diseases.

Justification

Seed was the traditional source of planting material at the beginning of the tea industry. Initially, planters kept tea seeds in their pocket while they visit the estate and planted them simply using a stick in their hand. Then the seedlings were raised in bags for several months before planting them in the field. Later on, seed was replaced by the VP cutting mainly due to higher and uniform shoot yield in VP tea. However, VP tea is more susceptible to climate change, especially less tolerance to drought. Therefore, it is important to introduce improved seed materials to the industry as a strategy to face climate change and it is also necessary for such seeds to possess both better resilience to biotic and abiotic stresses and reasonably high and uniform yield (Wijeratne *et al*., 2007).

DEVELOPMENT AND EVALUATION OF IMPROVED SEED MATERIALS

As improved seeds are quite important to combat the climate change, Tea Research Institute of Sri Lanka (TRISL) established several commercial level tea seed gardens (Figure 1), of which, their VP parents were known to have important superior characters. Seeds picked from such gardens were tested against known commercial VP cultivars (control) in a number of adaptive trials in different agro-ecological regions of Sri Lanka. Those seed stocks were then evaluated for their yield, resistance to dry weather and pests and diseases. Results of those evaluations are given in Table 1.

Figure 1: Tea Seed Garden at Salawa Estate, Hanwella

Based on the overall results (Table 1), TRISL is on the verge of recommending a few promising seed stocks, especially to the marginal areas where the lands are more vulnerable to the effects of climate change.

PROJECT IMPLEMENTATION AND DISTRIBUTION OF IMPROVED SEED MATERIAL AMONG STAKEHOLDERS

With the recommendation of improved seeds as an alternative planting material, the demand for tea seeds is very high. Therefore, it is necessary to exploit the maximum seed harvest from the existing gardens and to establish new gardens to fulfil future demand. As the seed availability is seasonal, experiments are in progress to determine the periodicity of mature seed availability (phenology) to streamline the seed collection programmes. Ministry of Plantation Industries has already approved funds to establish some new tea seed gardens. On the other hand, awareness programmes on seed handling and propagation among the estates and smallholders are already in progress. Seed requests are attended by systematic procedure by the TRISL on first come first served basis.

Table 1: Summary of the Results of Promising Seed Stocks

Seed Stock*	Yield level Compared to Controls	Resistance / Tolerance Level to Drought and Major Pests & Diseases Compared to Controls		
		Drought	Canker	Shot Hole Borer
Rucastle	High	High	High	Moderate
Salawa	High	High	Moderate	Moderate
Sapumalkanda.	Moderate	High	Moderate	Moderate
Anhettigama.	Moderate	High	Moderate	Moderate
St. Coombs	High	High	Moderate	Moderate

** Named based on location of the garden (Estate)*
Source: Piyasundara et al., 2012

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Author:

Ashoka Kumara Mudalige: Experimental Officer attached to the Plant Breeding Division, Tea Research Institute of Sri Lanka, Low Country Regional Center, Ratnapura. He holds B.Sc. (Hons.) Agricultural Sciences degree from Sabaragamuwa University of Sri Lanka. He is currently engaged in research related to tea breeding and cultivar evaluation (e-Mail: *asokamudalige@gmail.com*)

Reviewer:

Chandana Abeysinghe: Professor in Plantation Management, Department of Plantation Management, FAPM, WUSL. His teaching and research interests include: Tea Agronomy and Processing, Crop Physiology, Bioactive Compounds in Foods, and Antioxidant Properties of Food (e-Mail: *abeysinghedc@yahoo.com*)

IMPROVING CUSTOMER SATISFACTION BY INCREASING THE AVAILABILITY OF ESSENTIAL ITEMS AT LANKA SATHOSA OUTLETS

Sasini Udeshika Rajapaksha

Lanka Sathosa Limited, No. 27, CWE Secretary Building, Vauxhall Street, Colombo 02, 00200

INTRODUCTION

Lanka Sathosa Limited (LSL) is the largest retail network in Sri Lanka in the Fast-Moving Consumer Goods (FMCG) category with over 400 outlets dispersed throughout the country. Lanka Sathosa intends to reach out to the extreme niche markets in rural areas as well to facilitate the rural public even without considering the financial benefits.

The Quality Assurance Unit of LSL conducts periodic quality audits at outlets to identify major issues related to quality assurance. In this project it is expected to focus on finding solutions for a major quality issue which is the unavailability of essential provisional items and grocery items for customers at the time of purchasing.

Project Justification

When conducting quality audits, Quality Assurance Officers discuss with customers in the outlets to identify the issues faced by them at LSL outlets. The customers often complain that they face difficulties due to unavailability of essential provisional items and grocery items at the time of purchasing. Due to the less order quantity by tenders, outlets do not receive enough quantities of provisional items. Warehouse Managers, Outlet Managers and Regional Managers also have informed that they received complains and they are reproached by customers because of this issue. When customers find that several items required are not available, they leave the outlet without purchasing anything at all resulting a drop the income of the outlets (Figure 1).

Literature suggests that a satisfied customer shares his/her experience with 5 to 6 people and equally a dissatisfied customer shares his/her experience with 10 other people (Singh, 2006). Also the more satisfied the customers are, the greater is their retention and the positive word of mouth (Ranaweera and Prabhu, 2013). Therefore, it is important to increase the availability of essential items to improve customer satisfaction, retention and thereby spread positive word of mouth regarding LSL outlets.

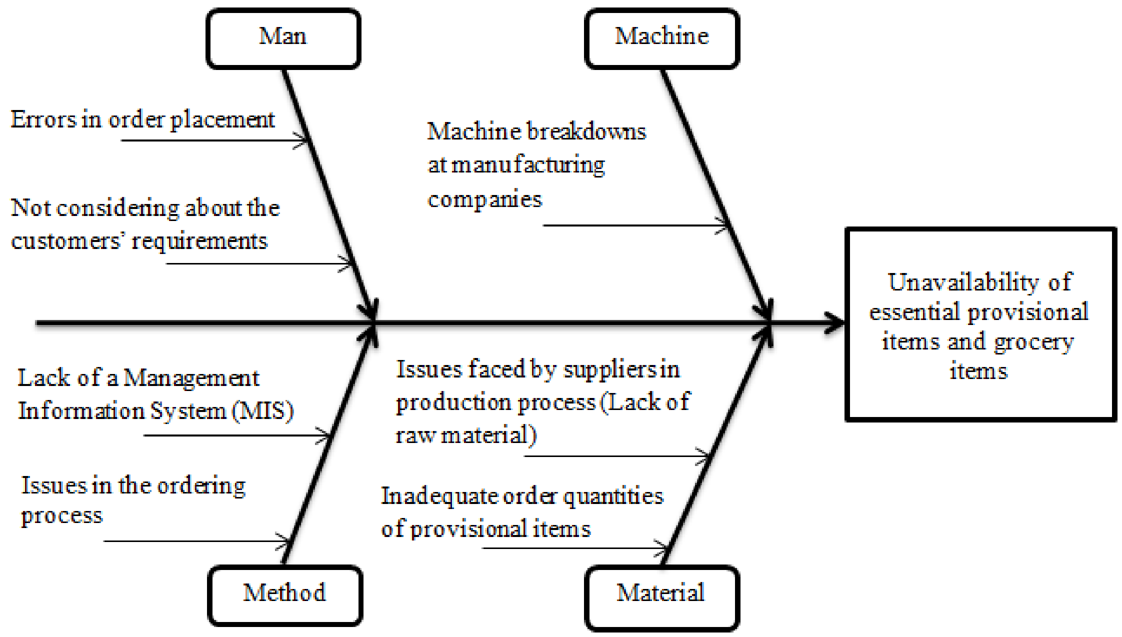

Figure 1: Root Cause Analysis to Identify Reasons for Unavailability of Essential Items and Grocery Items

PROJECT IMPLEMENTATION

Absence of a Management Information System (MIS) is a main reason for drawbacks in decision making at LSL. Currently only 117 outlets are controlled through a system and Management is planning to implement a new Enterprise Resource Planning (ERP) system and to link all the outlets through a Point of Sales (POS) system which will be a pronounced support for the LSL Management. This system will be useful in festive seasons to understand the sales patterns in outlets and provide the essential provisional and grocery items without any delay and deficiency.

The Procurement Division (PD) of LSL has implemented a common procedure for all outlets for their monthly order placement as shown in Figure 2. This has minimized issues of the ordering process and PD is currently identifying its drawbacks and taking steps for necessary improvement of the system.

Figure 2: Grocery Item Ordering Process Introduced by the Procurement Division

In occasions where suppliers are unable to fulfil the full order, PD can focus on purchasing substitute products from other suppliers. Because it is better to satisfy the customers' requirements with a substitute product of good quality rather than mentioning the outlet is out of stock for a product requested by the customer.

A higher percentage of customers visit LSL outlets for purchasing provisional items. LSL Management will focus on allocating more money for purchasing provisional items as their sales acquire a large percentage of turnovers in LSL outlets. It is expected that these steps, increasing the availability of essential provisional items and grocery items, will directly affect to increase the customer satisfaction and customer retention in LSL outlets.

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Author:

Sasini Udeshika Rajapaksha: Quality Assurance Officer at Lanka Sathosa Ltd. She holds B.Tech Food Engineering & Bioprocess Technology [Second Class Upper] from Faculty of Science & Technology, Uva Wellassa University of Sri Lanka (e-Mail: *sasini.udeshika@gmail.com*)

Reviewer:

Ananda Chandrasekara: Senior Lecturer of Department of Applied Nutrition, Faculty of Livestock, Fisheries and Nutrition, WUSL. His teaching and research interests include: Diet and Diseases, Diet Therapy, Sports Nutrition, Human Physiology and Biochemistry
(e-Mail: *a.chandrasekara@deakin.edu.au*)

EFFICIENT WATER GOVERNANCE WITH SPECIAL REFERENCE TO THE KALA OYA RIVER BASIN MANAGEMENT

Supurni Wimalasena

Ministry of Agriculture, 80/5, "Govijana Mandiraya", Rajamalwatte Lane, Battaramulla, 10120

INTRODUCTION

Water, the commonest liquid on the earth that covers 71 percent of the earth's surface serves the mankind since times immemorial and usage of water in agriculture is of paramount importance. However, the Sri Lankan as well as the world history is evident of the fact that increasing populations affected the water cycle as human needs ranging from the daily domestic consumption to industrial uses increased whereby implementation of effective water governance and management became the most crucial. Thus, integrated water governance approaches have been introduced in order to manage water resources. River Basin Management (RBM) is one such outstanding approach which refers to the management of water resources of a basin as part of the natural ecosystem and in relation to the respective socio-economic setting. The concept emphasizes on social equity, economic efficiency and environmental sustainability in connection with the said water resources. Accordingly, RBM includes the effective management of hydropower generation, irrigation, flood control, urban water supply, river channel dynamics, trans-boundary navigation and environmental protection. RBM ultimately ensures water productivity (physical or economic output per unit of water application) and optimum allocation of water among users resulting in improving human productivity (Wimalasena *et al.,* 2016).

Justification

In view of the irrigated agriculture being a significant contributor of the local food supply of Sri Lanka, application of RBM in irrigation has been given priority over the other development programs in Sri Lanka so as to address the interlinked social, economic and political problems arisen due to lack of water particularly in the irrigation areas. The ancient reservoir network of Sri Lanka well supported the irrigation of agricultural land in the dry zone as well as several other uses such as fishery production, animal husbandry, brick making, domestic water supply, bathing, tourism, *etc.* Given that the irrigation plays a critical part mainly in the livelihoods of rural people including the poor, several issues did arise between the users of irrigation water in the agricultural and non-agricultural sectors of the dry zone due to the inefficiencies in allocation of water in the recent past. Therefore, it is high time the water resource management is revisited and re-evaluated based on the relative value of each use of water rather than merely expanding water supply that can lead to futile outcomes in the long term.

Water Management

At present, the decisions pertaining to water allocation of the reservoirs which includes RBM in Sri Lanka are taken by the government authorities and farmer societies as per collective agreements at the first cropping meeting and the priority is unconditionally given for rice farming wherefore the other beneficiaries of the same water resources are being neglected. It is with the village leaders that the decision making powers as to water allocation in the reservoirs are vested who hardly deviate from prioritizing rice farming and ignoring the other users even during the severe droughts, for example, allocation of water for *Bethma* cultivation.

RIVER BASIN MANAGEMENT RELATED TO KALA OYA RIVER BASIN

While it is observed that only a handful of studies have been carried out on the water allocation for multiple users in different agricultural and non-agricultural sectors in Sri Lanka, research work of Wimalasena *et al.* (2016) has covered policy and management options for more pro-poor and more efficient water management, with special reference to Kala Oya River Basin in 2016. According to the said study, the highest technical efficiency of the uses of water was for fisheries (64.2%) followed by livestock farming (57.0%), rice farming (55.7%) and brick making (55.2%). The study also indicates that the marginal value (the respective productivity as per a unit of water) based on water consumption, fisheries ranked the highest (41.9) followed by livestock farming (15.3), rice farming (1.9) and brick making (0.9). However, in contrast to the technical efficiency and marginal value of the uses of water observed, the water allocation of the river basin did not correspond to the same and rice farming tops in water allocation irrespective of the unit value produced in each sector. In another study by Wimalasena *et al.* (2015), the lowest Water Poverty Index which evaluates the accessibility and availability, had been reported in the Dewahuwa reservoir situated in the upper region of Kala Oya river basin followed by Usgala-Siyambalangamuwa, Kala Wewa, and Siyambalangamuwa, which are located in the lower regions of the river basin where water is used for irrigation and other consumptive uses (Table 1). In addition to the above facts, water stress (the status where the demand for water exceeds the availability or the poor quality of water restricts its use) could be recognised, *i.e.*, dead water level in the instant context. There were instances for example, where the minimum water available in the river basin is released for farming which affects fish breeding or the same is retained which affects essential seasonal cultivations and *vice versa*.

Table 1: Water Poverty Index of Kala Oya River Basin

Reservoir	Water Poverty Index (WPI)*
Dewahuwa	63.82
Usgala-Siyambalangauwa	64.10
Kala Wewa	64.41
Siyambalangamuwa	68.03

**WPI: 100 is the lowest possible level of water poverty and 0 is the maximum possible level of water poverty*
Source: Wimalasena et al., 2015.

CONCLUSION

An analysis of the above facts discloses that irrigation water is imperative for the country's agriculture and that water management pertinent to river basin management is worth reviewing in which sense the requirement arises as to the determination of the most effective, economical and sustainable options for increasing the productivity of water. Primarily, the existing policies and procedures in RBM could be evaluated; rather amended and even novel rules could be imposed so as to regularize water allocation in a more effective way in line with the demands of the multiple uses around a particular reservoir, *e.g.* processes based on the unit value or technical efficiency, *etc*. To explain, paddy cultivation does not appear to be of the most efficient use of irrigated water wherefore transferring entitlements of user rights of water to alternative users will increase the capacity to manage water as an economical good. Preferably, the farmers could promote cultivating cash crops that needs less water consumption. On the other hand, improving drinking water supplying schemes and expanding the same could be recommended to overcome the current issues related to poor accessibility to water which eventually boosts RBM. As the common objective of the existing policy schemes to develop irrigation infrastructure to guarantee the supply water is to meet the demand for agricultural activities, new policies could be implemented to cater to enhance the objectives of RBM. Novel schemes for effective field-level water management best practices, compulsory or seasonal distribution of water among selected categories of agriculture and reuse of agriculture water, could be established. Re-allocating water through minimizing the inefficient volume of water use in the different sectors and other RBM strategies of the like may increase the productivity of the reservoir water. On the other hand, a thorough understanding of the farmers' practices and their opinions enriched with practical experiences and a moderate intervention of selected farmers in stages of reviewing and/or new implementations for the advancement of RBM would also be beneficial. Conclusively, RBM in Sri Lanka is recommended to be reviewed and upgraded so as to facilitate efficient use and productive allocation of irrigation water guided by which the total reservoir water productivity and water management of the country could ultimately be developed.

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Author:

Supurni Wimalasena: Development Officer, Ministry of Agriculture, Sri Lanka. She holds B.Sc. (Agric.) from WUSL and currently engages in financial activities related to inorganic fertilizer importation of both private and public sector (e-Mail: *supurni.wimalasena@gmail.com*)

Reviewer:

Dileepa de Croos: Senior Lecturer attached to the Department of Aquaculture and Fisheries, Faculty of Livestock, Fisheries and Nutrition, WUSL. His teaching and research interests include: Marine Biology, Marine Ecology, Fisheries Management and Population Genetics
(e-Mail: *dileepa_dc@yahoo.com*)

EXPORT MARKET FOR ORGANIC COCONUT KERNEL PRODUCTS: CONSTRAINTS, OPPORTUNITIES AND FUTURE SCOPE

Iroshani Sandamali

Cocotana Coconut Products, No. 10, Batapaththala Junction, Katana, 11534

INTRODUCTION

Sri Lanka is the fourth largest exporter of coconut products to the world (Coconut Statistical Yearbook, 2017). Organic production is defined by the United States Department of Agriculture (USDA) as a system that integrates cultural, biological and mechanical practices that foster cycling of resources, promote ecological balance and conserve biodiversity (National Organic Programme, 2001). Fresh coconut, desiccated coconut, virgin coconut oil, coconut cream, coconut flour and coconut water are Sri Lankan coconut exports to the global market. Exporting companies of organic products should be certified through an internationally recognized certification body, such as Control Union, to enter the global organic coconut market. In major organic coconut export markets of the Europe, United States of America (USA) and Japan, organic certification is legally regulated. According to above international regulations, the certifier, the certification process and the products, all have to comply with the minimum legal standards. Growers who wish to engage in exporting of organic products, need to go through a 3-year conversion period to achieve organic certification.

Justification

In the future, the coconut exports need to be necessarily organic as the demand for organic coconut products is increasing in the world. Therefore, this study attempts to find out the opportunities and constraints of organic coconut export sector with the objective of promoting the organic coconut export in Sri Lanka. To accomplish the objective, key informant interviews were conducted with the selected organic and non-organic coconut exporters in Sri Lanka.

Project Constraints

There are no official data in government sources or information available on the number of farmers involved in organic coconut cultivation and export statistics of organic coconut kernel products. The export company owners were also reluctant to provide export statistics of their companies. Therefore, it was difficult to collect statistical data regarding organic coconut export in Sri Lanka.

PROJECT DELIVERABLES

Literature review and key informant interviews with registered coconut kernel products exporting companies were used to extract the necessary information for the study. There are 30 registered coconut kernel products exporting companies in Sri Lanka and a random sample of 10 companies was interviewed for this purpose. According to the literature review, as illustrated in the Figure 1, exporters have different business models for the production and supply of organic coconut products for export.

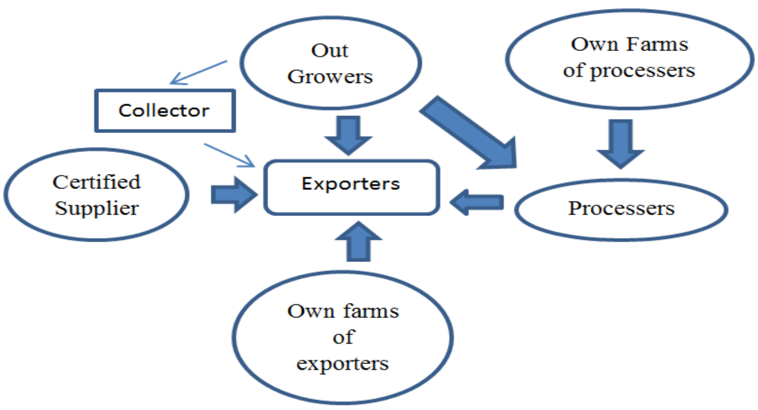

Figure 1. Marketing Channels for Organic Coconut Exporters

SWOT analysis was done to identify Strengths, Weaknesses, Opportunities and Threats on organic coconut industry and their suggestions for the expansion of the industry (Figure 2).

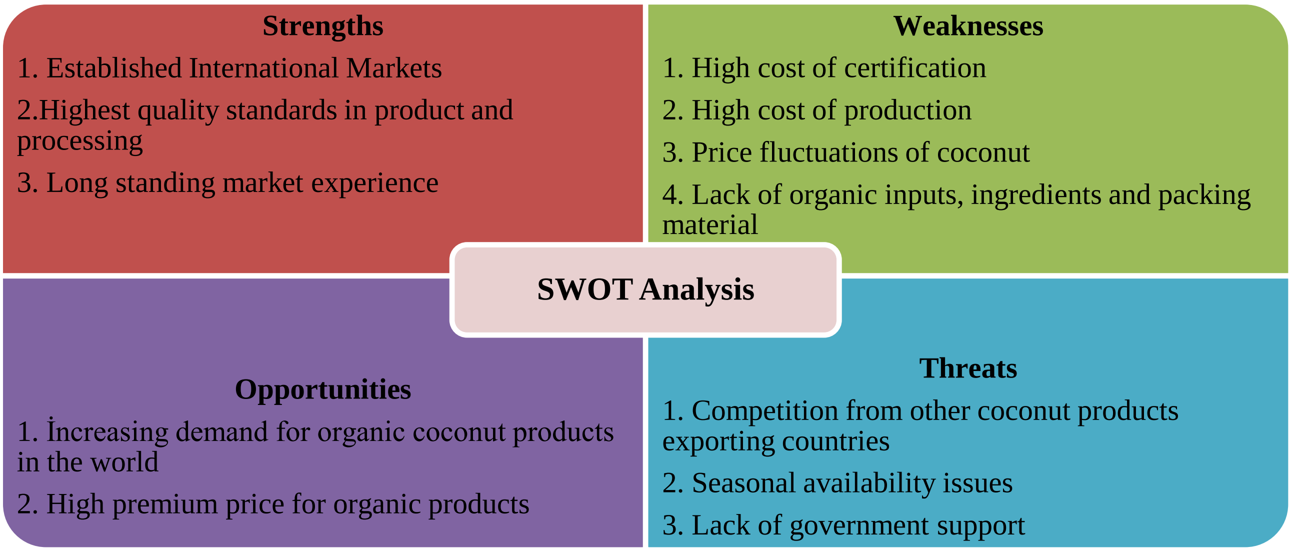

Figure 2. Strengths, Weaknesses, Opportunities and Threats in the Organic Coconut Kernel Products Export Market

According to the SWOT Analysis, the major constraints faced by the coconut exporters were high cost of certification, competition from other exporting countries due to high cost of production, fluctuations of price of raw material, and lack of organic inputs, ingredients and packing material. Lack of government support and high cost of certification were the severe barriers for new entrants to the industry. Indonesia, Philippines and Malaysia are the major competitive countries for organic coconut industry in Sri Lanka.

Sri Lanka has a potential in expanding and generating significant foreign exchange earnings from the organic coconut kernel products industry because there is a huge rising demand for coconut based products such as organic coconut water, organic virgin coconut oil, organic coconut flour in Europe and USA. To expand the organic coconut export industry in Sri Lanka, recommendations such as developing national policies for export market of organic coconut kernel products, establishing government organic certification body which is internationally recognized and raising awareness regarding organic coconut kernel product development can be suggested.

ACKNOWLEDGEMENTS

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Author:

Iroshani Sandamali: Quality Assurance Executive at Cocotana Coconut Products. She holds B.Sc. (Agric.) [Second Class Upper Division] from WUSL (e-Mail: *iroshanisandamali91@gmail.com*)

Reviewer:

Rupika Abeynayake: Professor in Applied Statistics, Department of Agribusiness Management, FAPM, WUSL. Her teaching and research interests include: Econometrics, Statistical Quality Control, and Time Series Analysis (e-Mail: *rabeynayake@hotmail.com*)

AN INTEGRATED PEST MANAGEMENT (IPM) PLAN FOR CINNAMON CULTIVATION IN KALUTARA DISTRICT

Vijitha Kumara Vithana

Biochemistry & Physiology Department, Rubber Research Institute, Dartonfield, Agalawatta, 12200

INTRODUCTION

Cinnamon *(Cinnamomum zeylanicum)* is the dried bark of the perennial tree of the Lauraceae family. Ceylon Cinnamon is one of Sri Lanka's primary exports. At present Cinnamon cultivation has concentrated along the coastal belt from Negombo to Matara and Kalutara, Ratnapura area. When considering about the pests in cinnamon cultivation, wood boring moth is identified as a major pest. The adult moth lays eggs in the bases of the cinnamon plant and caterpillar eats into the plant stem near the soil surface. As a result, new shoots may die and some mature shoots collapse from the base and the bush will gradually die. Other minor pests are cinnamon shoot borer, plant ticks and mites, leaf miner and cinnamon butterfly. The average yield loss due to these pests is 50 – 60 percent when the damage is severe. Therefore, pest management in cinnamon cultivation is very important in order to obtain a high quality yield.

The use of chemical controls can reduce pests, but pesticides are detrimental to the environment and produce considerable damage to ecosystems. Also, pesticides affect the natural biological equilibrium and diminish biodiversity. Furthermore, they are harmful for non-target species and pollute air, water and soil. Integrated Pest Management (IPM) approach will aid in maintaining ecosystem stability while controlling pest problems.

Project Justification

At present, most of the cinnamon growers apply chemical pesticides to control pests. However, there are many disadvantages in using chemical pesticides. Pesticides reduce nitrogen fixation, reduce the population of natural pollinators, and destroy natural habitats of animals. In addition, pests may become resistant to those pesticides. In contrast, IPM gives priority to non-chemical control components such as host-plant resistance, biological and cultural controls. It uses chemical controls only when alternatives are unlikely to afford sufficient protection. Therefore, the IPM approach is more efficient and can be profitable in controlling pests of cinnamon cultivation in Kalutara district in order to reduce high usage of chemical pesticides.

INTEGRATED PEST MANAGEMENT PROGRAMME (IPM)

IPM combines the use of biological, cultural and chemical practices to control insect pests in agriculture. Cultural control is the non-chemical management of pests using manual or mechanical means to change the soil and crop environment to discourage pest establishment. Biological control is where predatory or parasitic insects and mites known as 'beneficial' or 'good bugs' help to control chewing and sucking insects that affect the quality and productivity of crops by killing them or disrupting their breeding cycle. Chemical control involves the use of pesticides in the management of pests. It is used in IPM when biological and cultural control has not been enough to protect the productivity of the crop. Where chemical control is required, selective insecticides are chosen which target the pest, leaving the beneficial population unharmed.

Economic Injury Level (EIL) and the Economic Threshold (ET) are fundamentals in IPM concepts. IPM aims to suppress pest populations below the EIL (Figure 1). EIL is the smallest number of insects (amount of injury) that will cause yield losses equal to the insect management costs. ET is the pest density at which management action should be taken to prevent an increasing pest population from reaching the EIL.

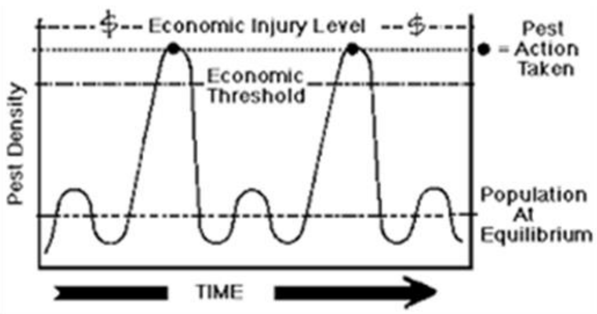

Figure 1: Economic Injury Level (EIL) and Economic Threshold (ET) for Integrated Pest Management

PROJECT IMPLEMENTATION

Five steps (Table 1) are adopted for implementing the IPM plan in Kalutara district. Focus is given on proper planting and cultural practices, along with selecting resistant or tolerant varieties and the preventive actions are taken at the correct time. Moreover, farmers are trained adequately in the techniques for better adoption.

Table1: Steps of Integrated Pest Management Plan

Step	Description
1) Monitor	Inspect plants on regular basis
2) Identify	Accurately diagnose the problem using information about the plant, the environment, and the pest.
3) Assess	Use thresholds to determine if action is necessary. Will the plant survive? Will yield decrease or will the appearance be compromised beyond your threshold level?
4) Implement	Formulate an action strategy based on all options available. This is the “integrated” part of IPM. Consider what is economical, physically feasible, effective, and least toxic
5) Evaluate	What were the results of the action? Did it produce the desired results?

Source: Frank et al., 2018.

Project Constraints

It is assumed that the control start to suppress the pest population when it is below the EIL. At present, lack of knowledge among cinnamon growers on IPM is considered as a major constraint. Another constraint is the attitude of the growers. They think that chemical pesticides are highly effective and simple to apply. Therefore, to overcome all these barriers, awareness programmers are conducted to give them a sound knowledge on IPM and to educate them on advantages of following IPM.

Project Success Criteria

For IPM to be a success, it must be sound in technical and economic parameters. Technical feasibility is judged by change in the pesticide use and yield change over the conventional chemical control. Community participation also affects the success of the IPM plan. Successful pest control needs collective efforts. There are a number of management practices, such as use of resistant varieties, proper soil preparation, proper irrigation, and proper fertilization, that require close cooperation among farmers to achieve maximum pest control efficiency. It also aims to encourage local bodies and non-governmental organizations to shoulder this responsibility by giving incentives and awards to those cinnamon growers who are following the IPM approach.

Continuous monitoring is done throughout the cultivation period to make the project a success. This IPM project ensures economic viability at consumer and producer levels, environmental safety through a balanced use of all available pest control options, and social acceptability as IPM-based food is safe and affordable.

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Author:

Vijitha Kumara Vithana: Attached to Biochemistry & Physiology Department, Rubber Research Institute of Sri Lanka. He holds B.Sc. (Plantation Management) from WUSL
(e-Mail: *vijithavithana82@gmail.com*)

Reviewer:

Indika K. Herath: Senior Lecturer attached to the Department of Plantation Management, FAPM, WUSL. Her teaching and research interests include: Soil Science & Plant Nutrient Management, and Environmental Impact Assessment (e-Mail: *indikaherath@hotmail.com*)

WASTE INTO RESOURCE: A CASE STUDY ON BENEFICIAL USES OF CORNCOB

Dedunu Bandara

Agriculture Instructors' Office, Department of Agriculture (Uva Province), Ethimale, Monaragala, 91000

INTRODUCTION

Maize is one of the famous Chena cultivation crops in Sri Lanka, which is mostly cultivated (85%) in the dry zone from October to January under the North West monsoonal rains (*Maha* Season). A relatively lower extent is maintained for maize during the *Yala* season under additional irrigation facilities. Anuradhapura, Monaragala and Ampara districts remain as the major cultivating districts for maize, while around 340,000 t of maize have been estimated as the total local consumption in 2018, especially as animal feeds (Department of Census and Statistics, 2019). Corncob is one of the main wastes in maize cultivation, which approximately accounts for 20 percent of corn production. It is a highly absorbent, biodegradable and a renewable material that can be used for a wide range of applications. Four major parts of corncob can be identified as shown in Figure 1. Those are: Pith **-** white centre, highly absorbent, carbon and used for absorbents and carriers; Woody ring – internal ring, hard composition and used for abrasives and fuel; Chaff – white and soft moderately light, highly absorbent and used for absorbents; Beeswing **–** white or pinkish, very light, highly absorbent and used for absorbents.

Current Situation in Sri Lanka

At present, notably high quantities of corncob are produced during maize processing within the country (Figure 2), which is often destroyed by the farmers considering it as a waste. Meanwhile, a limited number of farmers tend to utilize corncob for compost production. Even though a few government initiatives have attempted to promote diverse uses of corncob for industrial and livestock purposes, the majority of such programmes have not been successful due to various issues.

Justification

Regardless of being neglected by the farmers, the physical and chemical structure of corncob makes it highly useful for a variety of industrial applications, especially as a raw material. This could provide an additional income to the farmers while reducing the production cost and enhancing the environmental performance of industries. At present, corncob is used in Sri Lanka as a fuel in clay bricks and pottery industry, as a growing medium in mushroom production, as animal feed and litter and in active charcoal production.

UTILIZATION OF CORNCOB WASTE

Corncob should be collected after maize threshing and delivered to storage by the farmer similar to the grain handling process. It must be stored in a safe place preventing any pest attacks. In addition, any chances of contacting with water should be avoided as it may gradually reduce the quality of corncob. Collectors can store and sell them for various industrial purposes as indicated in Figure 3.

Currently, sawdust is used as the major growing medium in mushroom cultivation, which is being rapidly popularized in many parts of the country. Instead of the expensive sawdust, corncob chips or dust can be effectively used as a cheaper growth medium. For this, the mushroom farmers should be provided with adequate technical knowledge on the growth media preparation through training programs. In addition, dry corncob could be used as an ideal fuel source for clay brick production, which could dramatically reduce the costs associated with using firewood, restricting environmental issues such as deforestation and over extraction. With few minor modifications in the stove, brick producers could readily use corncob as the fuel source in brick production, in an environmentally friendly manner. On the other hand, the addition of active charcoal is being practiced to enhance the soil fertility by farmers. Even though, paddy husk and coconut shells are mainly used for active charcoal production at present, corncob could also be used for this purpose. Any additional amount of active charcoal could be marketed for electronic, hygienic and purification equipment industries at the local level. The government entities in Sri Lanka could focus on these aspects and provide the necessary technical knowledge to promote the above mentioned alternative uses of corncob.

In the livestock sector, paddy husk is used as the common poultry litter/feed, which is having less water absorbent capacity compared to corncob chip. Due to high water absorbent capacity and nutrient richness, corncob could be used as litter and feed for domestic poultry husbandry, particularly in areas where maize is available. This could assure an additional income to maize farmers, while increasing the productivity of the poultry industry. Facilitation of the above alternative uses through knowledge and attitude enhancement could increase the economy of rural maize farmers, while providing economic and environmental benefits to the livestock and industrial sector in Sri Lanka.

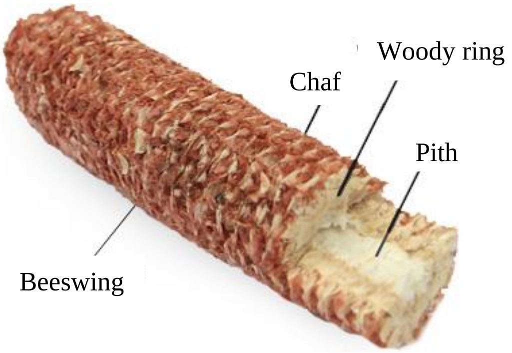

Figure 1: Parts of Corncob

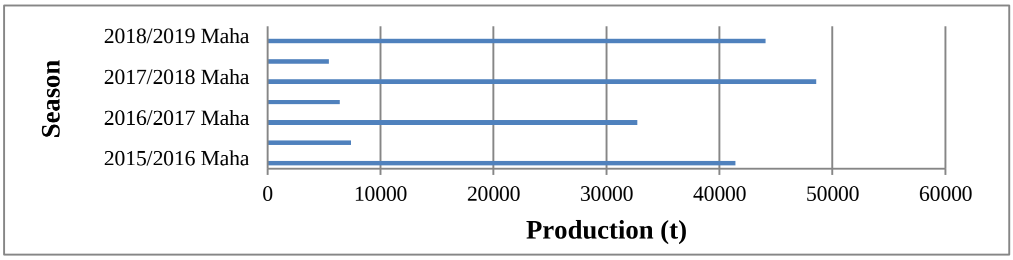

Figure 2: Annual Corncob Production in Sri Lanka

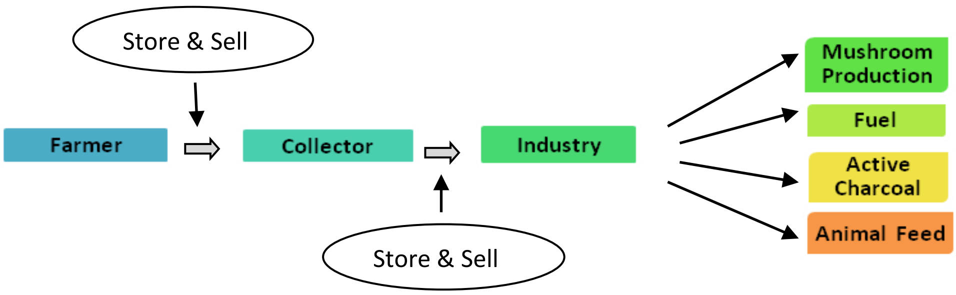

Figure 3: Corncob Supply Chain

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Author:

Dedunu K. Bandara: Agriculture Instructor, Department of Agriculture (Uva Province). He holds B.Sc. (Plantation Management) from WUSL and currently engages in the Special Agriculture Modernization Projects in Monaragala district (e-Mail: *wrdkbandara@gmail.com*)

Reviewer:

Lahiru Udayanga: Lecturer at Department of Bio-Systems Engineering, FAPM, WUSL. He has completed his PhD in Geo-Informatics and Environmental Modelling. His teaching and research interests include: Environmental Management, Geo-Informatics, Climate Science and Disaster Management (e-Mail: *udayanga@wyb.ac.lk*)

RE-EMERGING SERICULTURE INDUSTRY IN SRI LANKA: AN EFFECTIVE APPROACH FOR RURAL DEVELOPMENT

Shammi Wijesiri

Chief Engineer's Office, Department of Buildings, Kurunegala, 60000

INTRODUCTION

'Sericulture' is the cultivation of silkworms to produce silk (silk-fibres), believed to have first been initiated as early as in the Neolithic Period in China, the starting point of the ancient 'Silk Road'. Silk is a fibroin made of proteins secreted in fluid state as a single filament by a caterpillar known as the 'Silkworm' and it has a number of various distinct natural properties compared to the other natural and artificial fibres. There are four types of commercially produced natural silks among which 'Mulberry-Silk' is the most prominent, contributing 90 percent of the total production of silk in the world (Sivakumar, 2015).

The operation of producing silk starts by raising silkworms (hatching from the eggs laid by silk-moths) feeding with 'Mulberry' leaves. In a specific period, the silkworm grows up and spins a cocoon of silk-thread around itself, and afterwards, it transforms into a pupa and remains inside the cocoon. Prior to the pupa changing into moths and emerging out through a spit-soaked opening of the said cocoon, the raw-silk is reeled by an industrial process and then turned into silk yarn (spun-thread for knitting) or woven into silk fabric (Figure 1).

'Silk' possesses only 0.2 percent or lesser out of the global textile fibre market, however, the actual trading value of silk is much more impressive since the unit price of raw silk is approximately 20 times of that of raw cotton. The average global silk production for the last 2 years has been reported as 180,000 t (US$ 5.1 billion) out of which 75 percent is supplied by China and 20 percent by India (Dias, 1989). For the betterment of the industry, an inter-governmental organization called 'The International Sericultural Commission' (registered under the United Nations Organization - UNO) was established in early 1948.

Sericulture in Sri Lanka

It is as far back as the Dutch-Ceylon era that the silk industry has been introduced in Sri Lanka. It was launched as a government sponsored plantation industry and continued over centuries obviously with ups and downs in time to time (Figure 2).

However, the fully integrated commercial operation in the South was continued, though it was on a small scale. Even though the 'Mulberry-Silk' operation was going on well, it was ceased by the authorities in the year 1998, mainly due to the said religious sentiments back again (Sivakumar, 2015).

Sri Lanka imports silk (or silk yarn) as raw material and most of the ready-made silk and silk mixed garments are exported. If Sri Lanka would restart producing silk, it would lead to minimize cost of production whereby the local market could achieve a competitive edge over the other countries while contributing to the country's economy. Such minimization of import expenditure of raw silk or ready-made silk clothing as well as the added export income would certainly support bridging the trade-balance. Further, as practiced in the history, silk farming could be extended to most of the rural areas in the country so as to decrease unemployment (especially the unskilled) and urbanization. Even in India, 7.9 million people in rural areas survive on sericulture. Women labour is considered the ideal allocation for silk raring which would cater to women and family welfare by reducing women unemployment and migration of workers. Silk raring would also enhance land use optimization as mulberry could be an interplant in coconut cultivation and it would also match well with degraded tea-lands.

PROJECT CONSTRAINTS AND ASSUMPTIONS

In the event sericulture re-emerges, the industry will require new investments in several aspects, such as infrastructure for breeding, filatures, farms and research and development. However, in view of the top potentials of the industry identified during the period the industry was ceased (Figure 3), it is expected that the industry, if supported with a positive, fair and reasonable policy approach, would succeed. The approach meant is the same that which allows food and agriculture industries, such as poultry farming and fisheries, irrespective of the prevalence of the public concerns of the concepts, *i.e*. animal-rights and animal-welfare.

PROJECT DEPENDENCIES AND SUCCESS CRITERIA

Irrespective of several attempts taken by the successive governments to develop sericulture in the past, they failed due to the half-hearted approach taken and lack of persistence. Therefore, the private sector investor engagement with its quick and timely decision making is highly recommended, in its re-launch. However, the most crucial necessity to support re-implementation of the industry is the cohesive address of the social concerns arisen through the religious sentiments. In addition, initiating the project in the northern and eastern provinces of the country, where multi-religious people reside is also recommended, in order to reduce the interference of the religious sentiments. Conclusively, as the discussion of the foregoing facts establishes the significance of sericulture in the Sri Lankan context in view of strengthening the country's economy and rural development in the long run, it is proposed that the perished sericulture should be given life forthwith.

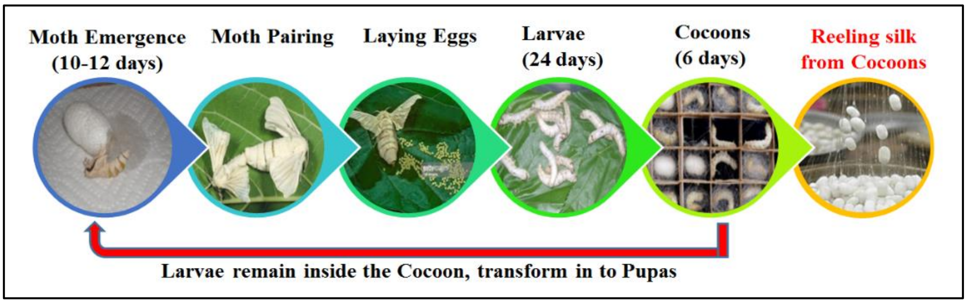

Figure 1: Life Cycle of Silk Moth and The Industry Flow of Making Silk

1943	• With foreign assistance, 16 sericulture farms were functioned by the Department of Minor Export Crops under the Ministry of Cottage Industries of the British-Ceylon Government.
1946	• The Industry has been extended to Jaffna in the dry zone by 1946, with a new silk reeling unit and operations were carried out in the northern region in a very succesful manner.
1958	• The Industry collapsed due to religious sentiments in the south, highlighting the fact that the silk reeling process require to boil cocoons with live pupas inside in order to prevent damaging the coccon.
1976	• Silk and Allied Products Development Authority (SAPDA) was established as the only raw silk producer in the country with a self-maintained filature, 4-large scale farms and number of clusters of farmers.
1983	• United Nations Development Program (UNDP) / Food and Agriculture Organization (FAO) project was initiated, whereas activities in the northern and eastern areas were abandoned due to the then prevailing war.

Figure 2: Milestones of the Sericulture Industry in Sri Lanka

Favourable agro-climatic factors & soil	• Temperature (24-28°C), Rainfall (600-2500 mm/p.a.), Humidity (65-80%), Sunshine (9-13 h/day), Water 340 m^3/ha (once in 10-15-Days), Land elevation up to 1000 m.
Rural labour at low cost	• Mulberry cultivation and silkworm rearing would be managed with rural labour that also possesses with a relatively high level of education and literacy at a low cost.
Availability of plant varieties	• There were local varieties of mulberry and Kanva-2 from Indian origin that were more suitable and the local varieties were of good yield potential and drought resistant.
Silkworm breeding stock	• Silkworm breeding stock that were self-sufficient in supplying (46 purelines) and availability of highly recognized varieties.
Technological approach	• SAPDA had sufficient technological knowledge relating to planting, silkworm rearing, stifling and reeling and weaving of fabrics (the integrated operation).
Land use optimization	• Along with the provided irrigation, farming in the dry-hot zones was possible and even as a secondary crop in coconut-lands or as an alternative for the degraded tea-lands.

Figure 3: Summary of the Recognized Top Potentials of the Industry before its Termination

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Author:

Shammi Wijesiri: Development Officer currently attached to the Department of Buildings under the Ministry of Housing & Constructions. She holds B.Sc. (Business Administration) degree from the University of Sri Jayewardenepura (e-Mail: *swshammi@gmail.com*)

Reviewer:

Nimanthika Lokuge: Lecturer attached to the Department of Agribusiness Management, FAPM, WUSL. Her teaching and research interests include: Agricultural and Food Economics, Applied Econometrics, and Food Marketing and Agribusiness (e-Mail: *nimslkg@gmail.com*)

IMPROVING THE KEEPING QUALITY OF COCONUT MILK THROUGH A SUPPLY CHAIN APPROACH

Chathura Ruwan Pathirana

Department of Quality Assurance, Renuka Agri Foods PLC, Block B, BOI Export Processing Zone, Wathupitiwala, Nittambuwa, 11880

INTRODUCTION

Coconut (*Cocos nucifera*) is one of the major plantation crops in Sri Lanka which accounts for approximately 12 percent of all agricultural produce in Sri Lanka. Total land area under cultivation is 395,000 ha and about 2,500 million nuts are produced per year**.** There are about 60 coconut mills in Sri Lanka and the approximate total production per annum is 75,000 t. All mills have quality control laboratories which are closely monitored by the government authorities. Coconut product manufacturers take seasoned coconut from the coconut growers in all areas of the country. Growing several other crops in association with coconuts is a widespread practice in coconut cultivation.

Coconut milk is obtained by extraction of fresh coconut wet gratings with or without water. This is an instant product, which can either be used directly/diluted with water to make various preparations such as fish and meat dishes, curries, sweets, deserts, and other food products. It can also be used in the manufacture of bakery products and for coconut milk flavouring food stuffs. Preserved forms of coconut milk such as canned cream or milk and dehydrated whole milk are now available in many coconut growing countries. Commercial production of these products has been promoted in the Philippines, Thailand, Indonesia, Western Samoa, Sri Lanka and Malaysia and to some extent in India.

The main components of coconut milk are water, fat, carbohydrates and protein. Additionally, it contains fat-soluble and water-soluble vitamins but it has relatively poor stability due to the insufficient quantity and quality of the proteins present (Seow and Gwee, 1997).

Justification

In the industry, there are numerous coconut shelling and pairing centres located in Kurunegala district because of high production capacity and being in the Coconut Triangle. Most of them are small scale and household producers. Coconut manufacturers collect raw kernels and store in the cold room for further manufacturing processes.

Reduction of pH value (5.85 - 6.20) of coconut milk is one of the major problems in the coconut manufacturing industry due to acid development in milk leading to rancidity. Therefore, keeping quality of coconut milk reduces due to becoming sour taste and unacceptable odour. According to the long term analysis of coconut milk pH value reports, we have identified that the first quarter of the year shows a low pH value than the mid and last quarters (Figure 1). It directly affects the quality of the final product and makes it unable to meet the expected quality standards of the manufactured products. It is presumed that this issue occurs due to dry season which affects the entire country, but especially the intermediate zone (Kurunegala district).

Extended processing delays and storage durations also contribute to reduce pH level by increasing microbial growth on raw coconut kernels. According to the smallholder shelling centres, they have to work for about an average of 6 - 8 hours for processing 2000 kg of raw coconut kernels per day. In this long pre-processing period, fresh coconut meat may be exposed to normal environment. Microorganisms grow in aerobic conditions under moderate temperatures of 20 - 45°C. These microbes utilize metabolites and some of them convert materials into acids in the catabolic process increasing the acidity of the medium. In addition, transport duration and unloading durations contributes to these contaminations. Poor hygiene and cleanliness of the raw material containers are also integrated with main supply chain problems to decrease pH and keeping quality of the product (Kothalawala *et al.,* 2018).

STRATEGIES TO IMPROVE KEEPING QUALITY OF COCONUT MILK

The organizations have already suggested some preventive actions to reduce contaminations during the pre-processing and post-processing stages, such as good manufacturing practices (GMP), continues supplier evaluations, trainings as well as awareness programmes reviewing the quality of products in previous deliveries.

The suggested action plan (Figure 2) was introduced by the Quality Assurance Department of the organization in 2019 through the Supply Chain and Procurement Department to overcome the above burning issues. When the initial order is made, the Planning Department communicates with all departments of the organization, transport services, raw material suppliers, and utility services regarding the time and the quantities of material needed. By scheduling the deliveries, it is possible to avoid the overlapping at the time receiving. Therefore, it prevents unloading delays and long storage durations. Limiting the quantity per delivery using reefer containers makes is possible to keep quality of the product at a higher level although it is relatively expensive compared to the existing delivery system. However, it shows higher effectiveness.

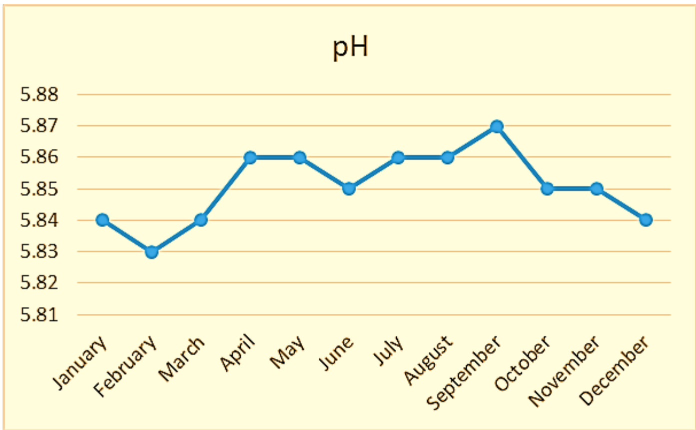

Figure 1: Average pH Value of Coconut Milk during the Year 2018

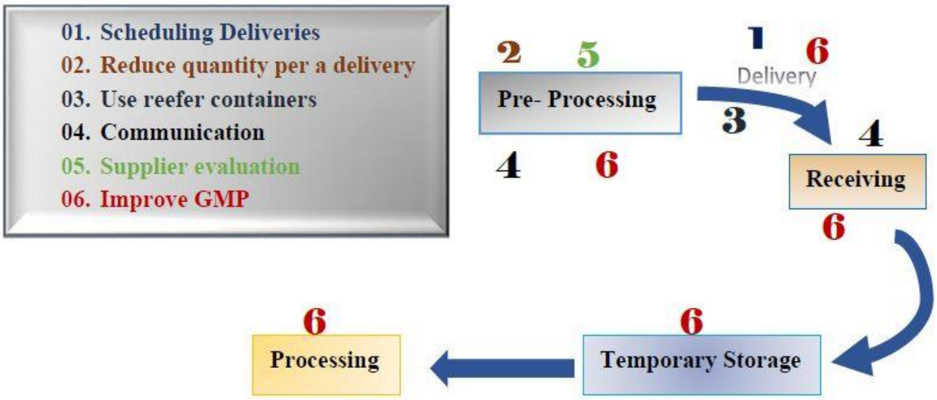

Figure 2: Suggested Action Plan to Improve Keeping Quality of Coconut Milk

The suggested action plan will be monitored during the 2019 and onwards. The trend analysis expressed that there are some improvement of raw coconut milk pH and keeping quality after the implementation of new plan. The rejection percentage of raw material has also been reduced. Nevertheless, the suggested plan should be more dynamic and strategic to get better consequences.

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Author:

Chathura Ruwan Pathirana: Quality Assurance Executive attached to the Renuka Groups. He holds B.Sc. (Plantation Management) from WUSL (e-Mail: *chathuramalindu@gmail.com*)

Reviewer:

Nisha S. Kottearachchi: Professor in Biotechnology, Department of Biotechnology, FAPM, WUSL. Her teaching and research interests include: Plant Genomics and Tissue Culture (e-Mail: *kottearachchins@yahoo.com*)

METHYL BROMIDE FUMIGATION: A QUARANTINE TREATMENT FOR SAFE MOVEMENT OF PLANT COMMODITIES IN INTERNATIONAL TRADE

Chandrika Wijayasundera

Department of Agriculture, National Plant Quarantine Service, Canada Friendship Road, Katunayake, 11450

INTRODUCTION

Plant quarantine treatment is any kind of treatment that is applied for quarantine purpose for elimination of pest in accordance with phytosanitary regulations of the importing country. Methyl Bromide (MB) as a fumigant is recognized as an important tool for control of pests. It facilitates safe biosecurity in the international trade and prevents accidental import of exotic pests that may have severe impact on agricultural and other native plants. According to the Montreal Protocol MB is considered as an Ozone Depleting Substance and planned to phase-out by 2025 but for Quarantine and Pre-Shipments is an allowable exemption for production and consumption of MB. National Plant Quarantine Service (NPQS) is the national contact point of the International Plant Protection Convention (IPPC) member countries. Behalf of NPQS, Treatment Technology Division (TTD) is responsible for all the MB fumigation activities in Sri Lanka.

Project Justification

Methyl bromide fumigant is a colourless, odourless and non-flammable gas widely applied earlier as a soil sterilant and, general purpose fumigant to kill a series of pests. MB is the most efficient chemical pest control agent for which no other alternative chemical is available at present. If there is a lack of MB, the international trade and agriculture sector will be at risk. Fumigation with MB is a mandatory phytosanitary requirement for some countries, *viz.* Australia and New Zealand (Australian Fumigation Accreditations Scheme, 2020). According to the International Standards for Phytosanitary Measures 15 (ISPM 15) wooden packaging materials should be treated with MB prior to export (Anon, 2017). Pre-shipment applications consist of the applications within 21 days prior to export to meet the official requirements of the importing country or the existing official requirements of the exporting country. As Sri Lanka is signatory for both IPPC and Montreal Protocol, it has to comply with the matters included in both agreements.

Constraints for Fumigation with Methyl Bromide

Economic issues include application of lower dosages and over use of MB while application of MB for non-quarantine and pre-shipments are administrative issues. As a requirement of exporting or importing country, MB fumigation has to be done 21 days prior to export/shipment even though a quarantine pest is present or not. All pre-shipment purpose fumigations are not supervised by the quarantine officers due to lack of staff. Further, there is no government owned container yard. No Risk allowance for TTD officers are paid and no transport facilities provided. The dosage requirement of different countries for the same commodity is diverse; *e.g.* for coir products, Australia – 48 g/m^3 and French Polynesia – 300 g/m^3. Most of the countries require MB fumigation to eradicate Kaphra Beetle in consignments.

CURRENT PROCEDURE FOR METHYL BROMIDE FUMIGATION

Duly filled official request has to be made by the private fumigators to NPQS/TTD prior to the shipment. Then TTD identifies whether fumigation is an official requirement of the destination country. Decision is made according to the Montreal Protocol acceptance or rejection. If accepted, MB fumigation standards are specified, dosage and duration are determined according to the commodity. Supervision of fumigation activities is done by NPQS. Authorized RP-8 is prepared by private fumigators. Fumigation is done in a container yard where, shippers go down and properly de-gassed. Then, it is transported to the seaport. Chamber fumigation (Figure 1A) and stack fumigation (Figure 1B) are done. The commodities namely, coir, logs and sawn timber, wooden packaging materials, dunnage, pallets, fruits and vegetables, grains, pulses, spices and dried food stuffs are treated with MB for QPS purposes.

REGULATIONS ON METHYL BROMIDE IMPORTATION AND USAGE

Import and export licensing system for MB is enforced by Gazette Extra Ordinary No 1007/14, 24th Dec 2007. According to that, MB importation licenses are issued by the Controller of Imports and Exports on the recommendation and the permit issued by the Registrar of Pesticides. NPQS has been recognized as the institution for regulation of MB usage for QPS activities from March 2012. Even though it is regulated by NPQS, MB fumigations are performed by private companies in Sri Lanka. There are 11 fumigation companies including three importers. Registrar of Pesticides achieves successful verification of MB usage for QPS activities by comparing the RP-8 forms completed and get the authorization from NPQS submitted by the private fumigators. At present, importation of MB is regulated at zero level for non QPS activities.

Figure 1: Some Steps of Methyl Bromide Fumigation (A) Chamber Fumigation, (B) Stack Fumigation, (C) Heat Treatment and (D) Joint System Review Audit Australia and Sri Lanka.

Success Criteria

Introduction of proper request form, development of guidelines and SOPs, supervision of quarantine purpose MB fumigations, random supervision of pre-shipment fumigations, conducting continuous awareness programs, auditing of six fumigation companies and their fumigation activities, especially under Australian Accreditation Fumigation Scheme (AFAS), Joint System Review (JSR) audit Australia and Sri Lanka (Figure 1D) are some activities launched to streamline the MB fumigation process. Every exporter should get the export consignments tested and confirmed for absence of pests by submitting a sample to NPQS prior to export. As alternatives to MB, we are practicing Heat Treatment under ISPM 15 (Figure 1C), Phosphine, ECO_2 Fume, Controlled Atmosphere and Vapour Heat Treatment (VHT). We NPQS do prevent pest movements internationally to provide quarantine security as the Border Agency/National Plant Protection Organization of Sri Lanka.

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Author:

Chandrika Wijayasundera: Assistant Director of Agriculture, Department of Agriculture, National Plant Quarantine Service, Katunayake. She holds B.Sc. (Agriculture) Hons. [Second Class] from University of Peradeniya (e-Mail: *cwijayasundera@gmail.com*)

Reviewer:

Jayantha Weerakkody: Senior Lecturer attached to the Department of Plantation Management, FAPM, WUSL. He is also the Director of ICT Centre, WUSL Makandura Premises. His teaching and research interests include: Microbiology, Organic Agriculture, Environment & Forestry and ICT (e-Mail: *wjskweera@gmail.com/weera@mkd.wyb.ac.lk*)

TRANSFORMING THE CONVENTIONAL COCONUT INDUSTRY INTO A HIGH END VALUE ADDED PROCESSING INDUSTRY

Rathnayaka Athukoralalage Chandana

Coconut Development Authority, No. 54, Nawala Road, Colombo 05, 00500

INTRODUCTION

Coconut (*Cocos nucifera*) is one of the most useful trees found in tropical countries around the world. Coconut industry plays an imperative role in the Sri Lankan economy as it has been supplying to the export market for the last 50 years amounting to US$ 609 million by the year 2019 [Coconut Development Authority (CDA), 2020]. Products that are manufactured from coconut are categorized as kernel and non-kernel products and shell-based products. Desiccated coconut (DC), virgin coconut oil (VCO), and regular coconut oil are conventional products categorised as primary products. Ultra-high temperature (UHT) milk, coconut milk, coconut milk powder and medium-chain triglyceride (MCT) are considered as high-end value added products. Coconut milk has emerged as a high- demand consumer product in the recent past with a promising market growth potential of 54 percent annually (Alouw and Wulandari, 2020).

Coconut Development Authority (CDA) is the key regulatory body for the coconut industry in Sri Lanka holding the mandate to develop the industry empowered by the Parliamentary Act No. 47 of 1971. As per the mandate, CDA introduced ISO 22000:2005 system certification as a compulsory requirement for the annual manufacturer registration in 2014. This milestone empowered most of the related industries to become direct exporters through value added products with accredited validation of quality. As a result, export income from coconut started to increase over the years as illustrated in Figure 1.

With the opening of new market opportunities, gradually, a fraction of the industries was converted as value added production firms with primary processing. Under the new market demand dimensions, a competition was created among the manufacturers for raw materials which led to an offering of the highest value for a nut kilogram, recording Rs. 125 in 2018 (Coconut Development Authority, 2020). This price increase was further supported by a low harvest due to environmental factors such as drought which affected the cultivation areas.

Justification

This study focused on developing a framework to convert existing primary coconut processing industry to a high-end downstream value addition which compulsorily required,

1. Sustaining the industry
2. Penetration to niche and upmarket segments
3. Provision of a reasonably fair price for plantations

PROJECT DESCRIPTION AND IMPLEMENTATION

As a new approach, primary processing coconut industries are required to transform to industrial facilities that have the calibre to produce downstream value-added products from premium quality raw materials. Desiccated coconut, coconut oil, virgin coconut oil, copra, coconut cream, coconut milk, and coconut milk powder are considered as major export-oriented products which are directly made from nuts. Oil cake, creamed coconut, coconut water, and coconut shells are considered as by-products of the coconut industry.

According to the report on the export performance of coconut products for 2019, the highest income per nut was generated from high-end value-added products than conventional products (CDA, 2020). Table 1 indicates export performance during 2019 with the income per nut against the major products. When considering the income generated per nut from exports in 2019, the DC industry recorded the lowest compared to other products. The maximum income per nut was earned from coconut milk and it recorded the highest income during the considered period. This trend continued through the last 3 years. According to the current situation, the demand for value added products is higher than the demand for conventional products. This is mainly due to the fact that some of these products are raw material in the production of lifestyle products which has a high margin compared to most of the competitive products.

In the year 2019, 58 manufacturers were registered under the category of DC, and 17 of them have been registered as an exporter too. DC industry consumed 431.88 million coconuts demonstrating the highest amount of coconuts used by producer category exceeding 40 percent and recording lowest income per nut.

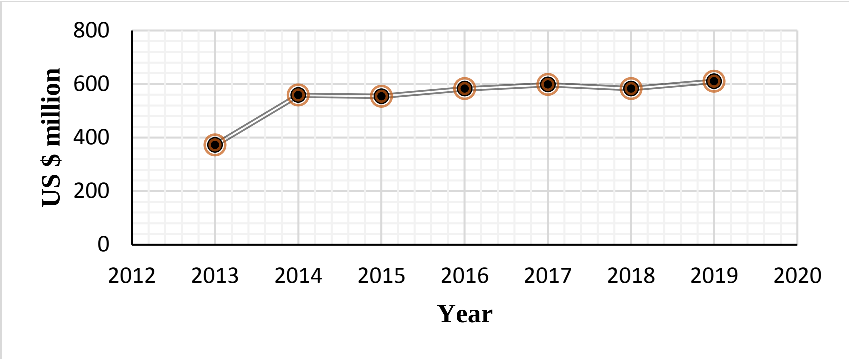

Figure 1: Export Income from Coconut Based Products in US $ (2013-2019)
Source: Coconut Development Authority (n.d.)

Table 1: Export Performance of Coconut Products - 2019

Product	Volume (t)	Value (Rs/Mn)	No. of coconuts (Mn)	Income/nut (Rs.)
Coconut oil	4,056	1,903.45	40.56	46.92
Virgin coconut oil	12,344	8,972.02	148.12	60.56
Desiccated coconut	49,667	15,501.87	431.88	35.89
Coconut cream	10,987	4,177.91	95.53	43.72
Coconut milk	42,459	11,852.62	157.25	75.37
Coconut milk powder	7,448	5,476.05	95.16	57.54

Source: Coconut Development Authority, 2020

As a strategy, a newcomer to the industry needs to be encouraged to adopt downstream value addition concepts considering the limitations of issuing the new DC manufacturing license in depth. Issuing registration for new manufacturers without any control creates competition among the manufacturers and also generates issues of sustainability for the industry through commercial pressure. As a result, shortage of raw material and distribution issues can emerge, and the ultimate result would be the decrease in income earned from a nut. In the last several years, more than 10 mills have been shut down due to business losses.

As a regulatory body, the CDA has a responsibility to involve in these issues and take necessary control measures for the survival of the coconut industry. Manufacturers can be encouraged through the provision of matching grants, subsidies, funding facilities, technical knowledge, guidance for value added products, such as coconut milk powder, UHT coconut milk, MCT oil and other consumer end products.

Transforming the conventional coconut industry into a high-end value added production industry is directly influenced by the country's economy and income earned, creation of new entrepreneurs and generating employment to the people in rural areas.

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Author:

Rathnayaka Athukoralalage Chandana: Senior Inspector at Coconut Development Authority. He holds B. Agri (Tech), IARS, University of Colombo
(e-Mail: *chandanahra.cda@gmail.com*)

Reviewer:

Menuka Udugama: Senior Lecturer, Department of Agribusiness Management, FAPM, WUSL. Her teaching and research interests include: Food and Agricultural Economics, Environmental and Resource Economics (e-Mail: *menukaudugama@gmail.com*)

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Master of Agri-Enterprise and Technology Management, Wayamba University of Sri Lanka

POSTHARVEST HANDLING OF CUT FLOWERS AND FOLIAGE AT PRODUCTION AND RETAIL SITES IN SRI LANKA: A STRATEGY FOR IMPROVING QUALITY

Kishan Dhananjaya Thrimanna

Horticulture and Landscape Gardening Division, The Greenery Company (Pvt.) Limited, No. 622, E. W. Perera Mawatha, Ethul Kotte, 10100

INTRODUCTION

Floriculture is a discipline of horticulture concerned with the production of flowering and ornamental plants for gardens and for floristry, comprising the floral industry. Floriculture has now become a profitable agri-business in Sri Lanka due to its potential to generate a higher income per unit area. The country's diverse climatic conditions and the geographic terrains from sea level up to 2,200 m have created macro and micro environments to accommodate a range of tropical, subtropical and temperate plants. Anthurium (*Anthurium spp.*) and Orchids (*Dendrobium spp.*, *Cattleya spp.*, *Phalaenopsis spp.*) for cut flowers and Dracaena (*Dracaena sanderiana* varieties), Queen palm (*Livistonia rotundifolia*) and Cane palm (*Dypsis lutescens*) for cut leaves are commercially grown in Western and North Western provinces for exports as well as for the local market.

Product types including cut flowers of Alstroemeria (*Alstroemeria spp.*), Oxe-eye daisy (*Leucanthemum vulgare*), Gerbera (*Gerbera jamesoni*), Roses (*Rosa spp.*), Chrysanthemum (*Chrysanthemum indium L.*), Lilium (*Lilium spp.*), Anthurium (*Anthurium spp.*), Asters (*Aster amellues*), Orchids (*Dendrobium spp.*) and cut foliage of Ivy (*Hedera helix*), Kithul (*Caryota urens*), Dracaena (*Dracaena sanderiana*), Cypress (*Cypressus spp.*) and Leather fern (*Rumohra adiantiformis*) are grown in the up country region. However, since the beginning of commercial floriculture industry in the 1970s, it has faced postharvest problems. Inadequate knowledge on proper postharvest care and handling methods among the majority of growers and sellers contributes to rapid postharvest quality deterioration of cut flowers and foliage.

Project Justification

Sri Lanka presently accounts for less than 0.2 percent of the global flower trade and has the potential to secure a much larger share. The Greenery Company produces floriculture products for export and local market. Of the company's total floriculture exports at present, approximately 60 percent is to Europe while 40 percent is to Asian countries. The floriculture industry in Sri Lanka has grown in the past 25 years and provides direct employment to around 4,000 people from semi-urban and rural areas. Sri Lanka has an outstandingly rich ecological and bio-diversity which has 3,771 species of flowering plants, of which 926 (28.3%) are endemic (Anon, 2019). This study describes the case of implementing strategies for postharvest handling of cut flowers and foliage at The Greenery Company's production and retail sites in Sri Lanka with the objective of enhancing product quality and securing a much larger share in global floriculture industry by 2025.

Project Constraints

Cut flowers and cut foliage are often transported long distances from the place of production to markets. Through this channel, the product quality declines due to food depletion, microbial attack, wilting, bruising and crushing, fluctuating temperature during storage and transit, ethylene and other hormones, poor water quality and other sub optimal handling practices or conditions (Faragher *et al*., 2002). A majority of cut flowers and foliage reach retailers by normal road transport in dry condition. Long periods of normal non-refrigerated road transportation and the compact and inappropriate dry packaging have caused external and internal damages to cut flowers. Lack of adequate infrastructure facilities for quick disposal of the produce in the market and inadequate support to postharvest management including grading, storage, marketing and processing can be seen.

Due to poor recognition of the floriculture industry by finance institutes, there is a reluctance to grant loans to growers. Growers as well as the government need to work together to develop proper production, transport and marketing facilities for floriculture products nationally and internationally. Majority of growers, retailers and middlemen are unaware of the importance of using proper postharvest treatments including, flower food, pulsing with preservatives, anti-ethylene treatments, special hydration treatments or bud opening solutions. The few who knew the advantages of such treatments do not practice because such products are commercially unavailable. The potential increase in the cost is also a reason. Within the floriculture distribution channel (Figure 1), postharvest losses can be seen in every stage. As the retailers have to store products for a relatively longer time, the highest losses can be observed at this stage.

Figure 1: Sri Lankan Cut Flower and Foliage Distribution Chain

Project Dependencies

Florists have marketing problems such as competition created by newly entered retailers in floriculture industry and difficulty to enter the export market. The industry is very competitive and hence quality, variety, freshness and price are of paramount importance. Therefore, an effective supply chain management from seed to final customer is crucial. Asian countries such as China, India, Thailand and Malaysia are direct competitors.

PROJECT IMPLEMENTATION

As strategies for postharvest handling of cut flowers and foliage at production and retail sites, The Greenery Company has already identified that the implementation of cold chain management is essential for preserving the quality of harvested cut flowers. Maintenance of cool conditions during transportation and at production and retail sites is important. Growers' main aim is to maintain the marketable quality and export quality of the products. This can be achieved under protected environmental conditions. Therefore, a majority of Anthurium growers use net houses and all Dracaena, Orchid, Queen palm and Cane palm are grown under shade nets. An institutional framework is a crucial need to establish and expand the floricultural industry in Sri Lanka.

Establishment of at least one model village of floriculture near urban areas supported with modern sales centres at nearby city and linkage with Sri Lanka Export Development Board for export and infrastructure development including roads for floriculture units, electric supply, water, cold storage at airport and training of custom officials for faster and careful clearance are identified as top priorities. Given the multitude of challenges and threats on the one hand, and the emerging lucrative opportunities on the other, it is imperative to effectively deal with the challenges while capturing the emerging opportunities locally and abroad. This undoubtedly demands a holistic approach with global perspectives and the participation of key stakeholders. The type of interventions required in this regard range from policy, production, technology, innovation and infrastructure to marketing. The introduction of ICT and e-commerce in the supply chain management will facilitate speedy and cost effective transactions.

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Author:

Kishan Dhananjaya Thrimanna: Project Executive, The Greenery Company (Pvt.) Ltd. He holds B.Sc. (Agric.) [First Class Honours] specialized in Agribusiness Management from FAPM, WUSL. His professional interests include: Agribusiness Management, Horticulture & Landscape Gardening and Project Management (e-Mail: *kishanthrimanna@yahoo.com*)

Reviewer:

Kamani Ratnayake: Senior Lecturer, Department of Horticulture and Landscape Gardening, FAPM, WUSL. Her teaching and research interests include: Postharvest Physiology & Technology and Horticultural Science
(e-Mail: *kamani.ratnayake@uqconnect.edu.au/kamani@wyb.ac.lk*)

NATIONAL VOCATIONAL QUALIFICATION (NVQ) SYSTEM: ALTERNATIVE ACCREDITED PATHWAY TO PRODUCE A SKILLFUL GRADUATE

Thakshila Danaranjani Jayawardana

Technical College, Pannala Road, Kuliyapitiya, 60200

INTRODUCTION

Technical education system has been currently recognized as a vital component of education system in Sri Lanka. At present, there are 39 Technical Colleges and nine Colleges of Technology scattered throughout the country. These are managed by the Department of Technical Education and Training, which functions under the Ministry of Skills Development and Vocational Training.

National Vocational Qualification (NVQ) System in Sri Lanka has designed to be matched with the Vocational Skills Qualification System introduced by many countries in the world. NVQ is designed for the students who are seeking for jobs soon after the completion of their Ordinary Level or Advanced Level examinations. NVQ System allows these school leavers to enter the global job market as nationally and internationally recognized professionals in the respective sectors. NVQ in Sri Lanka has 07 Levels to qualify (Vocational Training Authority of Sri Lanka, 2020; Figure 1).

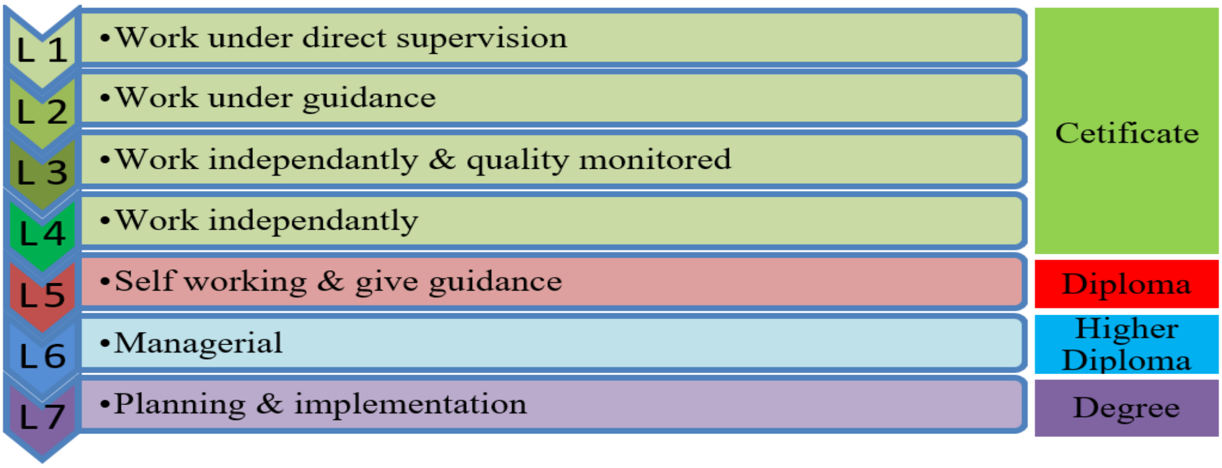

Figure 1: Seven Levels of NVQ System in Sri Lanka

NVQ SYSTEM: OBJECTIVES AND PROCEDURES

Traditionally, the G.C.E. Ordinary Level and Advanced Level examinations have been the primary qualifications used by the educational bodies and employers in Sri Lanka to determine the eligibility for their higher education or recruiting as an employer in their workforce. It has resulted a "skill deficit" of its workforce in all sectors, especially in agriculture.

In light of this, entering into the NVQ System allows a student to acquire a professional certificate to facilitate the entry for those deficit areas in local and international job markets as skilled personnel. Recognizing vocational skills locally and internationally, matching and catering vocational training with market demand, and creating an internationally competitive workforce in Sri Lankan agricultural sector, were emphasized as the main objectives of setting up the NVQ System for the National Diploma in Agriculture.

Accreditation assessment in the system is carried out based on the 'National Competency Standards' (NCS), and the Training Delivery Documents (*i.e.* lesson plans, scheme of training, weekly time tables, student record books, *etc*.), are supposed to be prepared to prove that the said institution delivers those "competencies" specified in the NCS. The Tertiary and Vocational Education Commission (TVEC, 2020) is responsible for quality assurance of Tertiary and Vocational Education and Training (TVET) sector of Sri Lanka. The criteria set out under the extraordinary Gazette No. 887/8 dated 07 September 1995 has been used in this respect.

Accreditation assessment is carried out by a two-member evaluation panel comprising a trade expert and a senior officer at the TVEC. Upon receipt of the completed application with supporting documents, the TVEC officials visit the training institution for an onsite evaluation, and the accreditation procedure comprises of multiple tasks to be performed by the applicant. The TVEC grants a three-year validity period for the accreditation and renewal is expected at the end (TVEC, 2020; Figure 2).

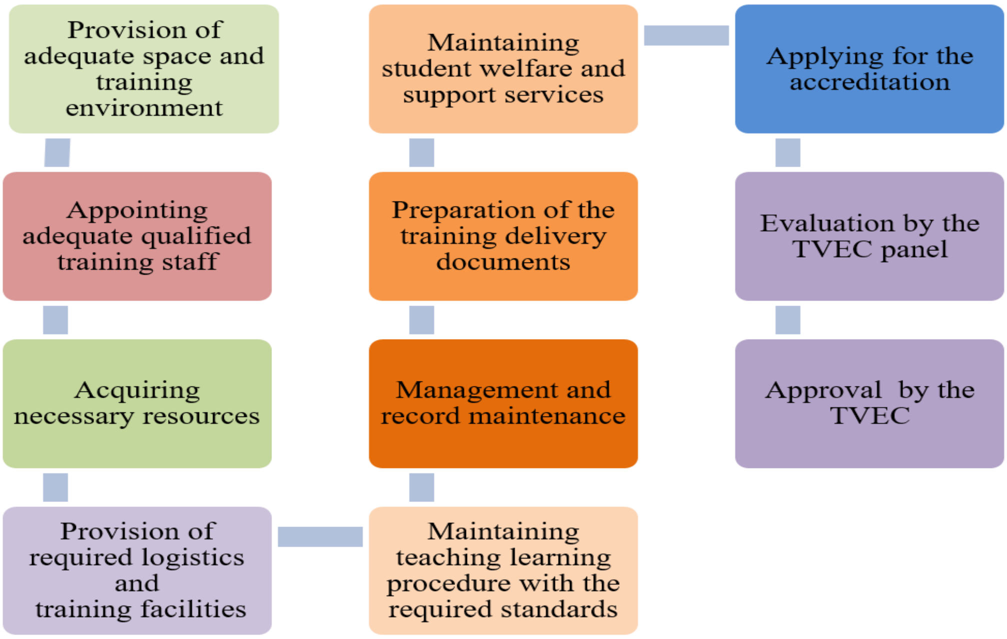

Figure 2: Procedure of Acquiring Accreditation for Issuing NVQ Certificates

Limitations and Dependencies

It has been observed that, despite the fact that the TVEC has accredited the Certificates of NVQ several years ago, certain private sector establishments in Sri Lanka are still "unaware" of the system of NVQ. While this hinders the recruitment of those graduates into the private sector suitably. The "unusual delay" in issuing and distributing certificates to the graduates by TVEC also triggers it badly. The potential students are hesitant to enrol into the system, because of the "cultural stigma" attached with the vocational education system in Sri Lanka.

Success Criteria

By accomplishing all the standards set forth by the TVEC, the proposed NVQ system was successfully implemented for the 'Higher National Diploma in Agricultural Production Technology' (HNDAPT) offered by the Technical College, Kuliyapitiya in 2017. At the end of year 2018, the first batch of students which comprised of 20 had obtained their HNDAPT Certificate, followed by another 47 in 2019. Noteworthy to mention, the majority of them have been absorbed to the related workforce in agriculture sector in Sri Lanka as NVQ qualified professionals. Thanks to the fact that the NVQ system is orientated to be a 'skills evaluation system' that has a tremendous potential and higher tendency to obtain foreign employment, it has been reported that those who applied to international job markets were quite successful in getting those in the recent past.

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Author:

Thakshila Danaranjani Jayawardana: Instructor at the Technical College, Kuliyapitiya, Sri Lanka. She holds B.Sc. (Agric.) from WUSL and Post Graduate Diploma in Education from Open University of Sri Lanka (e-Mail: *thakshilahptd@gmail.com*)

Reviewer:

Udith K. Jayasinghe-Mudalige: Senior Professor and the Chair of Department of Agribusiness Management of FAPM, WUSL. His teaching and research interests include: Food and Agricultural Economics, Development & Policy, Project Management, and Quality Assurance in Higher Education (e-Mail: *udith@wyb.ac.lk*)

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Master of Agri-Enterprise and Technology Management, Wayamba University of Sri Lanka

INTRODUCTION OF CARDAMOM CULTIVATION TO HOME GARDENS THROUGH THE CLUSTER VILLAGE PROGRAMME

Sanjeewa Abeyawickrama

Department of Export Agriculture, 1095, Getambe, Peradeniya, 20400

INTRODUCTION

Cardamom ***(****Elettaria cardamomum*) is known as the "Queen of Spices". It is a perennial herbaceous plant grown in South Asian countries. Dried fruit of cardamom capsule is the trade commodity. In the world market, it owns a high market value. Large scale cardamom cultivations face diverse problems. Major constraints are damage caused by cardamom thrips and limitation of natural forest land area for new cultivations. Recently, the cardamom thrip (*Sciothrips cardamomi*) has become a widespread pest problem in South Asian countries (Dharmadasa *et al.*, 2008). They are emerging as a devastating pest against cardamom in major growing areas. With the increase of this problem, reduced potential yield is expected in land areas. It tends to reduce the total cultivated land area due to poor yield and government restrictions.

Current Situation in Sri Lanka

Sri Lanka's total land extent of cardamom cultivation is about 6,082 acres. The major growing areas of cardamom can be found in the central hills, where the elevation is about 600 m above mean sea level. Especially, most of vastly diffused cultivation lands are located under the natural forest areas and only a limited land extent is found in home garden level. Sri Lanka has a high potential to further expand its cultivation, but several issues overlap with the cultivation. Damage caused by thrips is one of the major constraints in the production of cardamom. Potential yield from 1 ha of cardamom is 1,300 kg of dried capsule although Sri Lankan farmers are unable to obtain such harvest due to damage by thrips. The infested capsules are light in weight, inferior in quality and of very low market value. It is estimated that 78 percent by weight and 82 percent by number of capsules are damaged due to thrips (Agriculture and Environment Statistics Division, 2020).

Government policies and regulations based on natural forest conservation affect the farmers in establishing new cultivations in the natural forest areas.

Justification

In Sri Lanka, there is a limited land area suitable for cardamom cultivation. Yet, they are faced with the risk of damage by thrips. Recently, the attack by thrips has largely increased. As a result, commercial cultivations of cardamom gradually collapsed and maintenance is not carried out properly because the maintenance cost is higher than the expected yield. Therefore, year by year, total cultivation lands become unprofitable, and it tends to abate the quantity of yield. In large scale plantations, they achieved nearly 300 kg of dried fruit from 1 ha. It was a poor yield and not economical or beneficial to the owner. To overcome those issues, there was no any successful control measure or any other tactical methods. Limitation of natural forest lands result limited cultivation.

To enhance cardamom production while overcoming the aforementioned problems, introduction of cultivations to the home garden level will be beneficial.

PROJECT DESIGN

Cluster Village Programme

Development of clusters in villages can be introduced as a new approach to boost cardamom cultivation in Sri Lanka. Project will give vast benefits to the farmers. With the 'Cluster Village Programme', expected goals can be achieved successfully. This overall procedure will benefit each and every farmer. Convenient guidance and handling is one of the super benefits for the officers who are involved in the programme. Sustainability of the village, increase livelihood and creation of market opportunities are the future benefits for the farmers. Finally, the programme will help enhance qualitative and quantitative yield. Development of mini cardamom plantations as clusters is a new approach for the selected areas (Figure 1). The programme will be conducted in the areas where there is high potential for cultivation of cardamom, with the help of related Government Departments.

Figure 1: Cardamom Cultivation in a Home Garden

PROJECT IMPLEMENTATION

The cluster village programme is a better foundation to control damage caused by thrips and to enhance the cultivation of cardamom. Establishment of standard nurseries is appropriate to multiply pest and disease free healthy cardamom suckers. Awareness programmes are to be organized in selected areas with the help of Technical Officers. People who are willing to engage in the programme, should register under the government rules and regulations. Field visits and issuing of planting material can be decided after a proper investigation of selected lands. A minimum of 50 plants per land will be introduced to each farmer.

Awareness of farmers to take the full responsibility of their cultivation is essential to achieve future goals. The cluster village programme is easier to maintain than large cultivations. Throughout the project period, support will be given to the farmers for replanting and gap filling. They will be made aware about the crop protection measures. The project will be monitored until the plants give their first harvest, which will help denote the success of the project.

This project will help overcome the shortage in supply of cardamom within the country and reduce the involvement of middlemen who are engaged in controlling price in the marketing channel.

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Author:

Sanjeewa K. Abeyawickrama: Extension Officer at Department of Export Agriculture, Sri Lanka. She holds B.Sc. (Plantation Management) [Second Class Upper Division] from WUSL (e-Mail:*sanjeewaabeyawickrama@gmail.com*)

Reviewer:

Geethi K. Pamunuwa: Senior Lecturer, Department of Horticulture and Landscape Gardening, FAPM, WUSL. Her teaching and research interests include: Food Science and Technology, Nutraceuticals and Nanotechnology (e-Mail:*geethipamunuwa16@gmail.com*)

AN INTEGRATED PEST MANAGEMENT (IPM) SYSTEM FOR PINEAPPLE CULTIVATION

Saranga Kumara Chandrasiri

Superintendent Bungalow, Kolan Kanda Estate, Diddeniya, Hanwella, 10650

INTRODUCTION

Overuse and misuse of agro-chemicals are detrimental to the environment. Agro-chemicals such as pesticides and herbicides are widely used in the Sri Lankan agriculture system. These chemicals may be harmful for non-targeted organisms and can pollute air, water, soil or carried away through run-off water. At present, there is an increasing trend in the country to produce high quality safe foods and crop products.

Integrated Pest Management (IPM) is a holistic approach for sustainably cultivate crops that focuses on managing pests, such as insects, weeds and diseases through a combination of cultural, physical, biological and chemical methods that are cost effective, environmentally sound and socially acceptable (United States Environmental Protection Agency, 2017).

Project Justification

Pineapple is one of the leading commercial fruit crops grown in Sri Lanka. In 2018, pineapple was cultivated in an extent of 5,543 ha producing 34.65 million of fruits. A total earning of Rs. 443.1 million was gained by exporting pineapple in 2018 (Agricultural Statistics, 2019).

The environmental and food safety concerns have focused attention on IPM. The concept of IPM is to employ several techniques simultaneously to solve specific pest and disease problems for the long term rather than in the short term. Success relies on an in-depth understanding of the pineapple production system and the ecology and biology of each pest or disease and associated organisms (*e.g.* vectors, natural enemies). The IPM techniques are needed to monitor changes in populations of pest and levels of disease or pathogen populations. The changes must be correlated with yield and quality of pineapple. Pineapple is affected by several different pests, pathogens and weeds that result in significant crop loss. The major problems faced by Sri Lankan pineapple farmers are mealybug wilt, Phytophthora heart (top) rot and Chinese violet weed. In most pineapple production systems, mealy bug wilt must be controlled by the management of ants and mealybugs. Severe infestation may have an impact on the production system and final product in several ways. As a direct pest, feeding reduces plant growth, fruit quality and yield. The presence of mealybugs on fresh fruit may become a quarantine issue, as well as a quality issue when present in the canned product. The indirect effect and the most severe impact are the resulting mealybug wilt, with high rates of field infestation.

Presently, the high use chemical production method is less safe for humans and the environment. An IPM approach is essential for the long term sustainability of the cultivation while producing safer foods. Therefore, this study describes the case of introducing IPM for pineapple cultivation in Sri Lanka.

IPM SYSTEM FOR PINEAPPLE

The proposed IPM system helps produce safe food and addresses the ecological concern from the negative impact of conventional pineapple cultivation practices and their pressure on an ecosystem. IPM focuses on long-term prevention of pests or their damage by managing the ecosystem rather than curing/treating after the damage. The basic components of IPM are:

- Pest identification
- Monitoring and assessing the number of pests or damages
- Understanding the action threshold level
- Preventing pest problems
- Action, using a combination of biological, cultural, physical/mechanical and chemical management tools
- After the action is taken, assessing the effect of pest management.

Once identification, monitoring, and action thresholds indicate that pest control is required, and preventive methods are no longer effective or available, the IPM programme then evaluates the proper control method both for effectiveness and risk. Effective, less risky pest controls are chosen first, including biological and cultural such as pheromones to disrupt pest mating, or mechanical control, such as trapping or weeding. If further monitoring, identifications and action thresholds indicate that less risky controls are not working, then additional pest control methods would be employed by chemical applications, such as targeted spraying of pesticides (Anon., 2018). Broadcast spraying of non-specific pesticides is a last resort. Approaches for managing mealybug are categorized as shown in Table 1.

Table 1: Mealybug Control Based on Integrated Pest Management (IPM) System

Control Method	Use
Biological	Parasitoids: *Anagyrus ananatis, Anagyrus kamali* Predators: Ladybird beetles, Dragonflies, Spiders, Fire ants, *Cryptolaemus montrouzieri*
Cultural	Destroy ant population, remove alternate host plants
Mechanical and Physical	Remove infected plants by hand and destroy them
Chemical	Use ant bait traps, apply recommended pesticides

Source: Department of Agriculture and Cooperation Ministry of Agriculture Government of India (Anon., 2018)

The most effective, long-term method to manage pests is by using a combination of control measures rather than a single method. The gaps in the existing policy and institutional set up, poor attitudes of farmers and officers on IPM, insufficient human resources in the current extension system and their capacity lags, and complicated practices involved in IPM technology are the major factors behind the low level of adoption of IPM.

IMPLEMENTATION

The initial field-level implementation of this IPM system will be launched through the Department of Agriculture. With the help of Farmer Field School (FFS), participatory pineapple IPM trials will be setup in major pineapple growing districts to motivate farmers towards IPM. Further, Agriculture Instructors (AI) can act as 'messengers' to transfer information on IPM related awareness and troubleshooting.

These trials and training programmes will develop the confidence required in pineapple farmers as primary decision makers in implementing IPM strategies. The success of any IPM program relies on a good understanding of the crop production system as well as of the ecology and biology of each pest or disease. This will result in an attitudinal change in farmers by seeing and physically experiencing the IPM approach in trial pineapple fields. Continuous training of pineapple farmers will be carried out occasionally.

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Author:

Saranga K. Chandrasiri: Assistant Superintendent of Kolan Kanda Estate, Hanwella. He holds B.Sc. (Plantation Management) Degree from WUSL (e-Mail: *Saranga_k@gmail.com*)

Reviewer:

Surantha Salgadoe: Senior Lecturer, Department of Horticulture and Landscape Gardening, FAPM, WUSL. His teaching and research interests include: Crop Remote Sensing, Precision Plant Pathology and Crop Production Technology (e-Mail: *surantha@wyb.ac.lk*)

MINIMIZING INCOME LOSS DURING THE REHABILITATION PERIOD OF TEA RE-PLANTING

Nandana Muhandiram Wijesinghe

Tea Small Holdings Development Authority, Kaliyadasa Road, Matara, 81000

INTRODUCTION

Tea, which was originated from south-west China, has now become a beverage commonly used in day to day life. It is a main source of foreign exchange for Sri Lanka while creating job opportunities for many people across the country. Tea small holders contribute to about 75 percent of the country's tea production (Anon, 2018). Although, tea production of the main countries showed a significant increase, Sri Lankan tea production has not shown a dramatic increase during the past years (Tables 1 and 2).

Table 1: Main Countries of Tea Production

Country	Tea Production (t)		
	2006	2012	2018
China	1,020,000	1,915,000	2,616,000
India	955,907	1,111,760	1,311,360
Kenya	310,607	369,562	492,999
Sri Lanka	310,822	326,278	303,843
Indonesia	139,761	130,500	131,000

Source: Anon., 2020a (Global Production and Exports of Tea, Statista)

Table 2: Total Tea Production in Sri Lanka (in Million Kilograms)

Year	2000	2005	2010	2015	2019
Total Tea Production (million kg)	305.84	317.19	331.42	328.96	300.13

Source: Anon., 2020b (Sri Lanka Tea Production, Forbes & Walker Tea Brokers Pvt. Ltd.)

Project Description

The yield of a tea plantation decreases with the age of tea plants and therefore, replanting is required along with soil rehabilitation. Due to the enormous cost and time consumption, the small-scale holders tend to continue with the same tea plants or continue re-planting without soil rehabilitation. This project describes on identified methods to minimize the income losses during the rehabilitation period of tea re-planting which motivates the tea small holders to follow the correct procedures and accordingly, achieve a high-quality tea yield in large quantity.

Project Justification

Implementation of Agri technology management is essential to overcome the lower tea production growth in Sri Lanka. The project mainly aimed the tea small holders as they are the higher contributors for the Sri Lankan tea production. In view of improving the tea production, methods such as tea re-planting, infill vacancies of the tea land, following soil and water conservation methods, good agricultural practices (GAP) and intercropping have been identified.

In order to minimize the income losses during the rehabilitation period of re-planting, intercrops such as Papaya and *Tibbatu* have been proposed after systematic study on the profits that could be obtained. The concept of generating an income from intercrops during the soil rehabilitation period will stimulate the tea small holders. The project is expected to be beneficial to them as well as to the country's tea production because the replanted tea crop yield would be high in quality and quantity. Tea small holder's income would be persistent as the intercrops' harvest would compensate the revenue generation.

Project Assumptions and Dependability

It is assumed that, the green leaf prices would remain at a steady phase during the study period. It was also assumed that tea small holders would uproot old tea plants, kept for soil rehabilitation for 1.5 years with grass and replant in a manner where tea small holders in one region doing the same in a periodical term. Otherwise it will have a pronounced impact on tea production as it would take almost 4 years to again get a yield. Another assumption is that the tea small holders will execute the project in segments of their lands at a time.

The project is mainly dependable on the contribution and input of the tea small holders. Further, it is highly dependable on Government subsidy scheme encouragements for rehabilitation. The prices of tea would be another dependent factor as the expected outcome will be achievable upon receiving higher tea prices. Since the proposed main intercrop would be papaya, the market or demand for papaya, the climatic conditions, vulnerable diseases and suitable soil for papaya would be dependable factors too. The project is further dependent on the availability of resource persons who will provide technical knowledge to tea small holders on planting material, high yielding varieties of the proposed intercrop, papaya.

Project Limiting Aspects and Success Measures

The major constraint of the project is that, most tea small holders are reluctant to adopt new systems. Some of the tea small holders are not willing to invest on replanting and would continue with the overaged tea plantations which do not produce a higher yield and would not attempt to cultivate intercrops. Rising costs in tea production, decreasing productivity and lack of labour are other limiting factors. The climate changes due to global warming is another constraint to continue the project. Fluctuation of green leaf prices too has a negative impact on the execution of the project.

The project success would be evaluated through the data on income generation during the said period and it would set guidance to the other tea small holders. The concept of intercropping during the rehabilitation period is advantageous to the tea small holders since intercrops would not impact the rest of the tea plantation as there is no competition for nutrients and no harm to other tea plants from pests and diseases of papaya cultivation. The care for the intercrop automatically leads to a properly maintained *Mana* grass cultivation, drains and terraces which are beneficial for healthy tea cultivation. Ultimately, project success would be determined by the tea small holders' financial stability achieved during the rehabilitation period of tea re-planting and eventually, their contribution towards high quality increased tea production.

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Author:

Nandana Muhandiram Wijesinghe: Zonal Tea Development Extension Officer at Tea Small Holdings Development Authority. He holds B.Sc. (Plantation Management) from WUSL, Diploma in Agriculture (Aquinas College) and Diploma in Marketing (SLIM)
(e-Mail: *wijesinghenandana76@gmail.com*)

Reviewer:

Sashika R. Guruge: Lecturer, Department of Agribusiness Management, FAPM, WUSL. She is reading for her PhD in Environmental Economics and holds B.Sc. (Agric.), Masters in Business Studies (Colombo), CIM, Diploma in Banking and Finance (IBSL) (e-Mail: *guruge84@yahoo.com*)

PROMOTION OF INTEGRATED PEST MANAGEMENT (IPM) TO MINIMIZE PESTICIDE USE IN PADDY CULTIVATION

Shanthi Ranasinghe

Office of the Deputy Provincial Director of Agriculture, Sri Bodhi Road, Gampaha, 11000

INTRODUCTION

Among the food grains, paddy occupies a major component in human food requirements. Paddy is grown under different agro-climatic conditions and the crop is damaged by more than a hundred species of insect pests. This pest causes considerable grain yield losses; which may vary from 20 – 50 percent if not protected. The greater incidences of pest and diseases lead to greater chemical application resulting in higher input cost and agro ecological imbalance. Therefore, it is important to manage the pests by selecting an appropriate method to minimize the risks of human health, beneficial and non-target organisms and the environment (Shiepard *et al.,* 1987). Integrated Pest Management (IPM) is a process that can be used to solve pest problems while minimizing risks to people and the environment. It is an ecosystem-based strategy that focuses on long term prevention of pest or their damage through a combination of non-chemical and chemical treatments. Farmers are advised to practice the non-chemical managements unless and until the damage does not cross the threshold limit.

Justification

IPM is used to minimize the indiscriminate and injudicious use of agrochemicals. Agrochemicals are silent killers in Sri Lanka. They are now stored in the bodies of the vast majority of human beings regardless of age. As a result, they occur in the mother's milk and in the tissues of the unborn child.

All these have occurred because of the sudden rise and prodigious growth of the agrochemical industry producing manmade or synthetic chemicals with insecticidal properties. “What sets the new synthetic insecticide apart is their enormous biological potency. They have immune power not merely to poison but to enter the most vital process of the body and change them in sinister and often deadly ways. They destroy the enzymes whose function is to protect the body from harm, they block the oxidation process from which the body receives its energy, they prevent the normal function of various organs and they may initiate in certain cells, the slow and irreversible change that leads to malignancy” (Rachel Carson; Silent Spring). Now this silent spring is echoing in our North Central Province. There prevails a deadly silence of a Chronic Kidney Disease (CKD) which has already killed hundreds of innocent poor farmers. To avoid indiscriminate use of agrochemicals, first it is important to educate farmers about the natural balance of the environment of rice cultivation. To do this, we must use adult education techniques to conduct farmer training programmes in selected areas of paddy farming.

IMPLEMENTATION OF INTEGRATED PEST MANAGEMENT (IPM) PROGRAMME

IPM is a broad ecological approach for pest management which employs all available skills, techniques and practices such as cultural, genetical, mechanical and biological methods including application of chemicals as a last resort in a harmonious and compatible manner with a view to suppress pest population below economic injury level, based on regular crop pest surveillance and monitoring.

To adopt IPM technology in the field, farmer groups were selected in Dompe and Weke areas. They were then provided with required information and knowledge by conducting a farmer training programme in selected paddy fields.

Pest Monitoring

The agroecosystem was analysed every week. The field situation with regard to pest defenders, soil conditions, plant health the influence of climatic factors, *etc.* was analysed (Figure 1).

Field Observations

A site with a dimension of 1 m^2 was selected for the study. Visual observations were recorded on flying insects (both pest and defenders) which feed on rice plants. Disease incidences, insect damages, types of weeds, their size and population in relation to crop plant were also recorded (Figure 2).

Pests and defenders found were drawn on a sheet of paper. Soil condition, weed population and climatic condition were also indicated. Pests and defenders were drawn in appropriate part of the plant where they were seen at the time of observations.

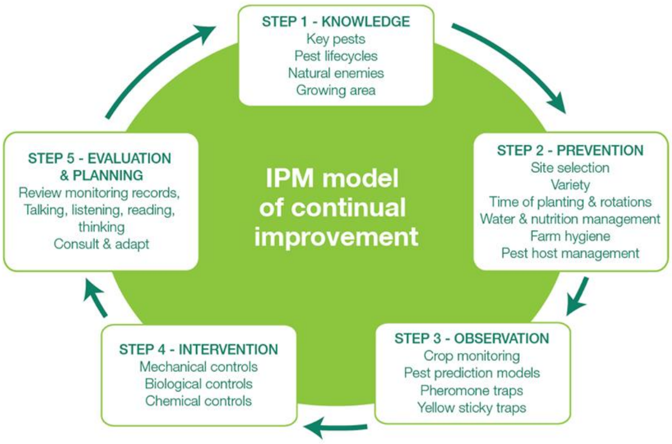

Figure 1: The Integrated Pest Management (IPM) Model for Continual Improvement
Source: Anon., 2020 (Animal Health Australia and Plant Health Australia Limited)

Figure 2: Pest Monitoring in Paddy Field

Group Discussions and Decision Making

The observations recorded on the paper were discussed with the farmers. Those observations which included factors such as pest population defender population, influence of prevailing weather, and soil conditions were critically analysed during the discussion. Decisions were taken regarding the release of defenders and application of safe pesticides to be used for specific pest situation. This experiment led to the avoidance of indiscriminate application of pesticides.

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Author:

Shanthi Ranasinghe: Assistant Director of Agriculture, Department of Agriculture (Western Province), Sri Lanka. She engages in Extension Division in Gampaha district and holds B.Sc. (Agri) [Second Class Hons] from University of Peradeniya
(e-Mail: *shanthiranasi@gmail.com*)

Reviewer:

Menuka Udugama: Senior Lecturer, Department of Agribusiness Management, FAPM, WUSL. Her teaching and research interests include: Food and Agricultural Economics; Environmental and Resource Economics (e-Mail: *menukaudugama@gmail.com*)

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OVERCOMING HEAT STRESS TO ENHANCE THE PRODUCTIVITY OF INTENSIVE DAIRY CATTLE FARMS IN DRY ZONE

Kaluarachchi Gamage Pathmasiri

National Livestock Development Board, Nawala Road, Narahenpita, 00500

INTRODUCTION

The domestic average annual milk production in Sri Lanka is about 375 million litres (Table 1) which contributes to only 42 percent of dairy requirement of the nation (Department of Census and Statistics, 2020). Central province of Sri Lanka provides about 25 percent of the national milk production. Although, a significant percentage of European breeds are maintained in this province, further expansion of industry is heavily constrained by some geographic, climatic and socio-economic factors.

Table 1: Annual Domestic Milk Production (L) in Sri Lanka

Year	Production (L)
2016	306,142,447
2017	329,011,951
2018	391,530,600
2019	374,015,943

Source: Department of Census and Statistics, 2020

Dry zone (DZ) of the country was not traditionally considered as suitable for rearing European breeds; but now it has been recognized as a potential area for establishing large scale dairy farms. This enables the capacity to produce large volumes of milk to fulfil the shortage of domestic milk.

Heat Stress as the Key Constraint to Promote Production

The main challenge that has to be addressed in the DZ milk production is the heat stress. If it can be overcome successfully, there are many desirable factors, such as large extents of land, flat lands, fertile soil, favourable sunlight intensity and irrigation facilities, readily available in DZ for expansion of the dairy industry. There are numerous reasons behind the heat stress and the consequences are quite significant (Figure 1).

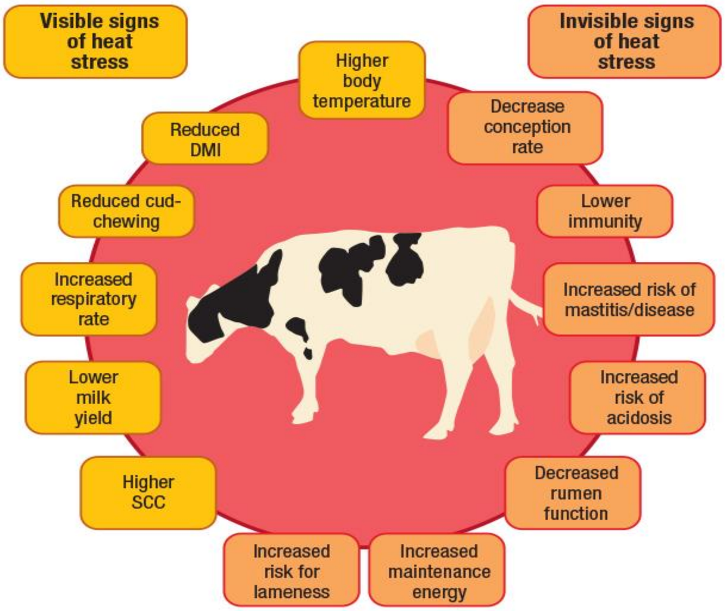

Figure 1: Consequences of Heat Stress to a Dairy Cow
Source: https://www.progressivedairycanada.com/topics/herd-health/

Maintenance of proper conditions are, however, important for avoiding heat stress and its adverse consequences. For example, the Comfort Zone of a Friesian and/or a Jersey cow ranges from 6˚C - 18˚C (±5 ˚C). When the temperature goes above 24˚C, the dry matter intake will be decreased by about 3 percent for every rise in 1.2˚C. Moreover, the appetite of the cow will be depressed and the biological and economical efficiencies will be declined when the temperature goes beyond 27˚C (Meat and Livestock Australia Ltd., 2011).

MEGA FARM PILOT PROJECT: STATE OF OPERATION AND LIMITATIONS RELEVANT TO HEAT STRESS MANAGEMENT

The Mega Farm Pilot Project was started in early 2015 in Hambanthota district with the intention of introducing European high yielding dairy breeds into DZ, where the heat stress is the major constraint. Soaking method, a cooling system was initially used to control the heat stress which was later found as inadequate. Thereafter, a local cooling method using a mist line was introduced in late 2015 as an additional support to the Soaking method. The idea of introducing the mist lines was to reduce the air temperature further, and thereby to further improve the comfort zone of animals. The Mist line doesn't have an automated turn on/turn off system, yet the Soaking method had. Misting units and water lines were assembled using the items locally available for agriculture irrigation systems. The humidity of project implementing area is usually very high which could be further aggravated by mist lines. This could be sometimes undesirable for animals which can be regarded as a constraint of the cooling system.

Apart from the heat control remedy, all the other environment parameters were maintained as is in the environment during the project period. The farm management system, including feeding management were practices as per the standard recommendations. The entire cattle herd was continuously monitored and compared with the reported performance before mist lines were introduced. Records were maintained on the productive and reproductive parameters as well as other measurable performance parameters. It was assumed that the change of lactation has no effect to the heat stress. Only the performance of milking cows and heifers were considered assuming that dry cows are having minimum effect to the heat stress and because most of them are pregnant at the time of dry off. Further, there were no significant variation in the workforce reported throughout the project.

Heifers' Breeding Performance after Introducing Additional 'Mist Line' System

During the study period seven hundred and sixty seven (n=767) heifers had reached breeding weight (275 kg for Jersey breed and 300 kg for Jersey crosses) at average of 16.5 ± 2.1 months of age. Their average age at first service was 16.5 ± 2.1 months and average age at conception (604 were confirmed pregnant) was17 ± 2.0 months. Number of services per conception was 2.0. 748 services (61%) out of 1233 total services done on heifers using sex sorted semen (SSS) and the balance was served using conventional semen. Conception rate for SSS was 46.8% and for conventional semen it was 53%. The average age at first calving was 26 ± 2.0 months. The findings were found to be in line with international breeding standards for European dairy breeds. Moreover, the heat detection rates for the years 2016, 2017 and 2018 were 65%, 65% and 70% respectively.

CONCLUDING REMARKS

Compared to the other attempts in the country to introduce European dairy breeds into DZ, this project shown a remarkable success as a result of the strategies used to manage the heat stress of animals creating a conducive environment. Thus mist line system can be prescribed to be used together with soaking method to manage heat stress of European Dairy cow in DZ.

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Author:

Kaluarachchi Gamage Pathmasiri: Former General Manger of National Livestock Development Board. He has gathered 25 years of experience in livestock sector in the NLDB (e-Mail: *pathmasirikag@gmail.com*)

Reviewer:

Keminda Herath: Professor in Applied Statistics, Department of Agribusiness Management, FAPM, WUSL. His teaching and research interests include: Statistical Inference, Project Analysis & Management and Time Series Econometrics (e-Mail: *kemindaherath@gmail.com*)

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DIRECT MARKETING OF 'SANSTHA TEA' BRAND TO CONSUMER: PILOT PROJECT FOR SUSTAINABLE MARKETING AND PROFITABILITY

Nishantha Pushpakumara Jinasena

Sri Lanka State Plantation Corporation, No. 21. Meeraniya Street, Colombo 12, 01200

INTRODUCTION

Sri Lanka is one of the leading tea producing countries in the world. It is the fourth largest producer of tea and the second exporter in the world. 'Ceylon Tea' is world famous for its superior quality and therefore, has a high demand, fetching higher prices in auctions. Its unique taste and the impeccable aroma make it famous around the globe. Tea for us is literally second only to water and every single person of our nation enjoys at least three cups a day. It is considered as the poor man's drink of choice as well as the rich man's.

For years, the tea industry has been playing a vital role in the Sri Lankan economy as one of the main foreign income generating sources to the country. Tea produced in different elevations of Sri Lanka are categorized into three main types namely, low-grown, mid-grown and high-grown. Those could be further categorized into seven teas, *i.e.*, Nuwara Eliya, Dimbula, Uwa, Uda Pussellawa, Kandy, Ruhuna, and Sabaragamuwa tea, based on their growing region and are referred to as 'Special Teas'.

History of Ceylon Tea Industry

The 1st tea plant (*Camellia sinensis* L) was introduced to Sri Lanka in 1824 from China by the British and planted in the Royal Botanical Gardens in Peradeniya, Kandy. Later, devastation of coffee plantations paved the way to establishment of country's 1st commercial tea plantation in 1867 by James Taylor, growing tea on just 19 acres of land at Loolecondera Estate in Kandy.

Current Status of Tea Production in Sri Lanka

Made tea production of Sri Lanka for the year 2019 is 300 million kg, recording decrease of 4 million kg when compared to the year 2018 and the contribution to the total production from private tea factories is 67 percent more prominent than to the Regional Plantation Companies' (RPC's) 37 percent (Sri Lanka Tea Board, 2020).

'SANSTHA TEA' MARKETING PROJECT

Presently, 90 percent of the made tea produced by the three factories owned by the Sri Lanka State Plantations Corporation (SLSPC) namely Kellabokka, Mildland and Rangala is sold through the Colombo Tea Auction and only 10 percent is going to local market with the brand name 'Sanstha Tea" which has little market space (Table 1).

Table 1: Sri Lanka State Plantations Corporation Factory-wise Made Tea Sales Quantity – Auction *Vs* Direct Marketing

Tea Factory	At Auction (kg)	Direct Marketing (kg)
Kellabokka	29,750	2,500
Mildlands	19,000	2,500
Rangala	18,850	2,650
Total	67,600	7,650

Source: Monthly Progress Report, 2020, Sri Lanka State Plantations Corporation

In general, the average NSA (Net Sales Average) of the made tea produced by SLSPC owned factories ranged between Rs. 360.00 - 420.00, whereas the selling price of 'Sanstha Tea' in the local market is about Rs. 950.00 per kg. This is a significantly higher value than the price obtained at the tea auction, which secure a better profit per kilogram of made tea. Almost all the tea producers from the RPCs are already supplying a significant portion of their production directly to the local market and gaining more profit through this approach; *e.g.,* Watawala, Bogawanthawa, Maskeliya, *etc*. Therefore, increase of local market share of 'Sanstha Tea' would be a viable and timely approach for the sustainable development of the company as it will obviously increase the cash inflow and the SLSPC profit. SLSPC has started production of 'Sanstha Tea' in November, 2017 with an average sale of 700 kg/month, which has been increased to 7,500 kg/month by February, 2020, which proves its consumer loyalty and market share.

Apart from direct sales, SLSPC believes this as a contribution to social responsibility as this approach gives the local consumer a golden opportunity to purchase high quality tea products with no adulteration under 'Sanstha Tea' brand.

Project Expansion

Presently, the Corporation is supplying an average of 7,500 kg/month of 'Sanstha Tea' to the local market. The Corporation is going to increase that volume step-by-step in several phases. As the first step, local market sales will be increased by 50 percent from total output, as per the following plan with the projection of generating additional revenue worth Rs. 33 million per month while making a gross profit of Rs. 19 million when compared to the auction revenue for the anticipated quantity (Table 2).

Table 2: 'Sanstha Tea' Project Benefits Compared to Auction Sales Revenue

Factory	AMT (kg)	AT-NSAM (Rs.)	STNMKT (Rs.)	ARA (Rs.)	ARSTDM (Rs.)	AGPST (Rs.)
Kellabokka	15,000	400.00	950.00	6,000,000	14,250,000	8,250,000
Rangala	10,000	430.00	950.00	4,300,000	9,500,000	5,200,000
Midlands	10,000	380.00	950.00	3,800,000	9,500,000	5,700,000
Total	35,000	402.00	950.00	14,070,000	33,250,000	19,180,000

AMT- Anticipated made tea, AT-NSAM- Anticipated auction NSA per Month, STNMKT- 'Sanstha Tea' net market price, ARA- Anticipated revenue from auction, ARSTDM- Anticipated revenue from 'Sanstha Tea' direct marketing, AGPST- Anticipated gross profit benefit against Auction sales through this project.
Source: Weekly Sales Report, 2020, Fobers & Walkers Brokers PLC

Project Marketing Strategy

Adhering to marketing principles, our 4Ps will be executed as depicted in Table 3.

Table 3: Execution of 4Ps in the Marketing Strategy

Marketing Mix	Marketing Strategy
Product	Brand- Sanstha Tea, Services- Best Quality Tea, Packaging- 50 g, 100 g, 250 g, 500 g, 1 kg and tea bags.
Price	Maximum Retail Price - Rs. 1200/kg, Discount for Wholesale Market - Rs. 250/kg, purchase over 100 kg per order, Discount for Retail Market – Rs. 100/kg, purchase over 25 to 99 kg, Direct Marketing Price - from our outlets Rs. 1200/kg.
Place	Factory Outlets, SLSPC Head Office and Wholesale Shops, Super Markets and Retail Shops.
Promotions	Gift Items: T-Shirts, Caps, Water Bottles and Umbrellas, Paper Advertisement and Social Media Advertisement- Facebook, YouTube and Digital Marketing in 'Sanstha Tea' Website.

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Author:

Nishantha Pushpakumara Jinasena: General Manager, Sri Lanka State Plantation Corporation. He holds B. Sc. (Plantation Management) from WUSL. His working experience in plantation sector counts for 22 years in plantation management (e-Mail: *slspcgm@gmail.com*)

Reviewer:

Mudith Mewan Kooragodage: Senior Lecturer, Department of Biotechnology, FAPM, WUSL. His teaching and research interests include: Molecular Biology and Biotechnology, Tea Biochemistry, Quality, Standards & Value Addition
(e-Mail: *mewankm@gmail.com/mewankm@wyb.ac.lk*)

AN EFFECTIVE MOSQUITO REPELLENT CREAM BASED ON COCONUT OIL AND NATURAL ESSENTIAL OILS

Rangana Sasinath Chandranayake

Serendipol Pvt. Limited, Pannala Road, Dandagamuwa, Kuliyapitiya, 60200

INTRODUCTION

Members of mosquitoes (genera of *Aedes*, *Anopheles*, and *Culex*) are known vectors for various disease-causing protozoans, viruses, and bacteria. These mosquitoes are known to transmit many life-threatening diseases, such as filariasis, malaria, yellow fever, Japanese encephalitis, chikungunya and dengue, worldwide (Yadav *et al*., 2014). These vectors have been considered as a major barricade to the socio-economic development in the developing countries, especially in the tropical region. In Sri Lanka, despite substantial efforts in recent years to control vector-borne diseases, a total of 51,659 and 18,279 suspected dengue cases were reported throughout the island from January – March in year 2018 and in 2020, respectively (Epidemiology Unit of Sri Lanka, 2019). Therefore, preventive measures for mosquitoes such as mosquito repellents on exposed skin areas are strongly recommended.

Project Justification

Insect repellents normally work by providing a vapour barrier deterring the arthropod from coming into contact with the skin surface. Most of the commercial mosquito repellents consist of non-biodegradable synthetic chemicals, *e.g.* N, N-diethyl-3-methylbenzmide (DEET), dimethyl-phthalate (DMP), and allethrin, which may lead to their higher exposure and bioaccumulation in the environment. Thus, these chemicals may cause health risks in human and other biota. With an increasing concern on public safety and environmental pollution, a renewed interest in the use of natural products of plant origin has been developed at present. Natural products are not only environment friendly, biodegradable and inexpensive but also readily available and effective. The main objective of this project is to develop an effective, eco-friendly and inexpensive mosquito repellent skin cream using several plant essential oils.

PROJECT IMPLEMENTATION

Constituents of the coconut oil based novel mosquito repellent cream are given in Table 1. Several available plant essential oils with known mosquito repellent properties were incorporated.

Table 1: Formulation for 100 mL of Mosquito Repellent Cream

Ingredient	Properties
Oil phase:	
Coconut oil (*Cocos nucifera*)	Oil base
Stearic acid	Emulsifier and oil base
Citronella oil (*Cymbopogon* sp.)	Mosquito repellent
Clove oil (*Syzygium aromaticum*)	Mosquito repellent
Cinnamon oil (*Cinnamomum cassia*)	Mosquito repellent
Maduruthala oil (*Ocimum tenuiflorum*)	Mosquito repellent
Neem oil (*Azadirachta indica*)	Mosquito repellent
Aqueous phase:	
Propylene glycol (PG)	Humectant, plasticizer
Potassium hydroxide (KOH)	Saponifier
Distilled water	
Preservatives:	
Propylparaben	Oil-soluble preservative
Methylparaben	Water-soluble preservative

Source: R & D Department of Serendipol Pvt. Limited

Project Constraints

The product was formulated using a prototype of the manufacturing plant which has no automatic temperature controller in the jacketed vessel (Figure 1). Ingredient mixing, emulsification and cream formulation are time and temperature-dependent. Therefore, continuous temperature variation was monitored manually to maintain the quality of the final product. Characterization and optimization of the cream formulation was difficult. Aesthetic appearance (physical appearance, colour, odour, and texture) was evaluated by 10 individuals over a period of 4 months. Determination of texture and viscosity and skin irritation study was not conducted yet due to limited resources. A volumetric cream filler was not used due to the high cost, however bottles were filled manually by maintaining proper hygienic conditions. The prototype of the plant needs to be improved as the present form can only produce a limited quantity of the final product. Thus, commercialization of the project requires high capital cost.

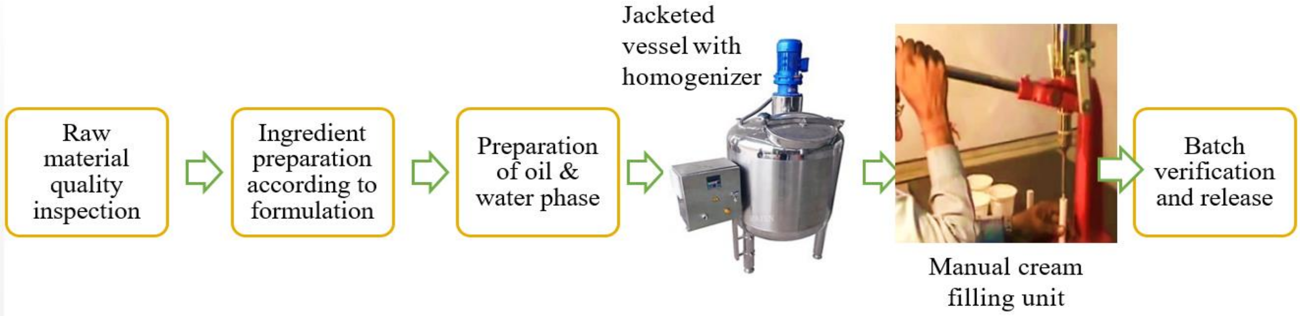

Figure 1: Layout of the Mosquito Repellent Cream Manufacturing Plant

Project Assumptions

Product finalization was completed without the results of texture and viscosity data and a skin irritation study. We assume that the allergic reactions can be minimized due to the use of well-known commonly used ingredients in topical formulations (Yadav *et al*., 2014). As this is a novel product with high-value addition, a favourable market potential is available in Sri Lanka as well as in export markets.

Project Dependencies

The project highly depends on the availability of essential oils to produce continuously and thus, it is important to ensure their supply. As the Sri Lankan Ayurvedic Drug Corporation approval is essential for this product, it is necessary to maintain standards, such as Good Agriculture Practices (GAP), Good Collection Practices (GCP), Good Ethical Practices (GEP), Good Procurement Practices (GPP) and Good Safety and Storage Practices (GSP).

PROJECT SUCCESS CRITERIA

A safe and effective mosquito repellent cream based on coconut oil and several plant essential oils was developed successfully. This product can also be used as a moisturizing cream. Costing was done according to various parameters, such as product cost, product cost with 40% administration and other costs. Several market prices were suggested according to different volumes. A sachet packet (5 mL) is sufficient for four numbers at a time and it can be marketed at a reasonable price. This product has a good potential to create a market for Sri Lankan essential oil manufacturing industry and to increase the production volumes. Besides, the project will encourage small scale entrepreneurs to start extraction of essential oils as a rural industry.

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Author:

Rangana S. Chandranayake: Production Manager, Serendipol Pvt. Ltd., Kuliyapitiya, Sri Lanka. He holds B.Sc. in PLT (Export Agriculture) from Uva Wellassa University of Sri Lanka, and currently engaged in company's R&D activities, organic and quality certifications
(e-Mail: *hsmrscplt@gmail.com*)

Reviewer:

Wajira K. Balasooriya: Senior Lecturer, Department of Biotechnology, FAPM, WUSL. Her teaching and research interests include: Industrial Microbiology and Biotechnology, Environmental Biotechnology, Agricultural Chemistry and Molecular Techniques
(e-Mail: *wajirab@wyb.ac.lk*)

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Master of Agri-Enterprise and Technology Management, Wayamba University of Sri Lanka

A BIOTECHNOLOGICAL APPROACH TO CONTROL FRUIT FLY (*Dacus dorsalis*) ATTACK: STERILE INSECT TECHNIQUE

Dilkashan Rasika Jayasinghe

Department of Agriculture (NWP), Dambulla Road, Kurunegala, 60000

INTRODUCTION

Fruit flies (*Dacus dorsalis/Bractocera dorsalis*) are recognized by plant protection and quarantine personnel, farmers and exporters as one of the most serious pests of horticultural production and trade (Figure 1). The pests have spread throughout the tropical, sub-tropical and temperate regions of the world. Fruit fly larvae causes complete destruction of host fruit and vegetables and infested crops often drop prematurely (Figure 2). Losses of fruits due to fruit fly infestation are greater as the fruit approaches to ripening stage of maturity. Mango, avocado, guava and wood-apple are the major susceptible fruits while as vegetables, cucurbit family crops, such as muskmelon, bittergourd and snakegourd get severe attack from this pest.

Figure 1: Adult Fruit Fly

Figure 2: Fruit Fly Larvae in a Ripe Fruit

Current Status in Sri Lanka

Fruit fly damage is turning out to be a national issue affecting the field of agriculture. The annual loss of fruits and vegetable crops exemplifies how much of an impairment the fruit fly has caused to Sri Lankan economy in the recent past. Records indicate that there are more than 20 percent of yield loss in cucurbits and more than 40 percent yield loss in mango crop due to fruit fly attack [Departent of Agriculture (DOA), 2020].

Justification

In 2014 with the rejection of some imports from Sri Lanka by the European Union due to the warning of fruit fly problem and the yield loss of 20 and 40 percent of cucurbits and fruits, respectively in local conditions, the DOA took an initiative to introduce a cohesive long term island wide project on sustainable fruit fly eradication. As a result the combined public private partnership successfully introduced a synthesized pheromone trap to manage the fruit fly problem in Sri Lanka. Use of pheromone trap is difficult and not very efficient in large scale farming due to, minimal distribution among rural areas around the country and continuous renewal of the trap according to the cropping seasons due to reducing the power of synthesized pheromone with time. These situations could be easily overcome by using the sterile insect technique, thereby inducing the farmers' participation in organic farming.

Release of sterile insects achieves an increasingly higher sterile to fertile ratio and thus becomes progressively more efficient, which is an advantage over the incecticides, where the killing in each generation remains constant also when implemented on an area-wide basis and a scaled rearing process. Sterile Insect Technique (SIT) is cost-competitive with conventional control, in addition to its environmental and socioeconomic benefits.

THE STERILE INSECT TECHNIQUE (SIT)

The Sterile Insect Technique (SIT) is a technique of biological controlling of insect, whereby overwhelming numbers of sterile insects are released into the wild (Ezhilmathi, 2017). In this technique the sterile males are released to the field for mating with wild female insects. Females that mate with a sterile males produce no offspring, thus reducing the next generation's population.

Sterile insects are not self-replicating and therefore they cannot become established in the environment. Repeated release of sterile males makes over low population densities which can further reduce and in case of isolation, eliminate pest populations. Cost-effective control with dense target populations is subjected to population suppression prior to the release of the sterile males (Ezhilmathi, 2017). Sterilization is induced through the effects of irradiation on the reproductive cells of the insects or by chemical sterilants. SIT does not involve the release of insects modified through transgenic (genetic engineering) processes. Moreover, SIT does not introduce non-native species into an ecosystem.

PROJECT IMPLEMENTATION

When practicing this type of technique, mainly it should be guaranteed that the sterile fruit flies do not damage fruits of the particular crop or, any other crops or, any livestock or human by monitoring and assessment programmes before releasing. In addition, it should be assured that sterile fruit flies interact and mix together with the female fruit flies as normal male fruit flies.

Constraints

There are common constraints due to various situations when implementing this kind of project, for example, 1) Possibility of reducing male mating fitness due to radiation, transport and release treatments, 2) Difficulty of sex separation on a large scale, 3) Requiring repeated pesticides treatment at the initial stage for the reduction of population. These constraints can be overcome by various strategies and close monitoring systems. Difficulty of sex separation can be overcome by using a genetic marker based fixing system. Area wide pest management approach (AWPM) could be implemented as migration of wild insects from outside the control area could recreate the problem and reduce the pesticide usage at the beginning.

Dependency of the Project and Success Criteria

Implementation of the project by developing the technology and checking the quality and progression is authorised to perform by the relavent institutions attached to the DOA, Sri Lanka. Institutions such as Fruit Crops Research and Development Centre (FCRDC), Horana and Horticultural Crops Research and Development Institute (HORDI), Gannoruwa have the capacity to get the responsibility of this project as their priority research area is fruits and vegetables and also there are well qualified staff such as Research Officers, Agriculture Instructors, Research Assistants, *etc.* to launch the project. However, giving adequate training for the relevent staff or to initiate the project as a collaborative project linked to a foreign country which has obtained successful results previously from SIT would be advisable.

Many other countries of the world are practicing this technique and have achieved successful good results related to the fruit fly attack. Such positive incidents have been reported on the screw-worm fly (*Cochliomyia hominivorax*) from North and Central America, Mediterranean fruit fly (*Ceratitis capitata*) and the Mexican fruit fly (*Anastrepha ludens*). Therefore, observing such successful cases, it is worthwhile to implement such a project in Sri Lanka to control or to eradicate the fruit fly from the fruit and vegetable cultivation and to uplift the life of local farmers and commercial producers while giving benefits to the processing organizations and government of the country.

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Author:

Dilkashan Rasika Jayasinghe: Agriculture Instructor attached to the Department of Agriculture, Sri Lanka. He holds B.Sc. (Plantation Management) [Second Class Upper Division] from WUSL. His professional interests include: Plant Tissue Culture and Micro-propagation
(e-Mail: *e2rasika@gmail.com*)

Reviewer:

Nisha S. Kottearachchi: Professor in Biotechnology, Department of Biotechnology, FAPM, WUSL. Her teaching and research interests include: Plant Genomics and Tissue Culture
(e-Mail: *kottearachchins@yahoo.com*)

POTATO (*Solanum tuberosum*) MINI TUBER PRODUCTION UNDER AEROPONIC CULTURE AT HOUSEHOLD LEVEL

Gayan Harshana Weerasinghe

Freelance Agriculture Entrepreneur, No. 02, Meepilimana, Nuwara Eliya, 22200

INTRODUCTION

Potato (*Solanum tuberosum* L.) is a perennial, starchy, tuberous crop which belongs to family Solanaceae and it is the fourth important food crop in the world. It is an excellent source of potassium and the vitamins C and B_6. Potato is one of the most popular crops among the farming community in upcountry wet and intermediate zones of Sri Lanka due to its high yields and high net return.

Soilless production techniques such as Nutrient Film Technique (NFT) and Aeroponic have been used successfully for certified seed tuber production in potato (Farran *et al.*, 2006). Aeroponic culture is an alternate method of soilless culture under growth-controlled environments. In aeroponic culture, the underground organs enclosed in a dark chamber are supplied with a nutrient solution by way of a misting device. Aeroponic culture optimizes root aeration which is a major factor for yield increase compared to the classical hydroponics.

Current Status in Sri Lanka

In 2007 the potato production was 75,263 t under 5,238 ha of land extent (Department of Census and Statistics, 2018). However, it drastically declined due to high seed cost, poor seed quality and unavailability of seed potatoes at the time of planting. In 2017, potato production was 52,998 t under 3,300 ha of land extent (Department of Census and Statistics, 2018; Table 1). The government of Sri Lanka launched a National Seed Potato Production Programme, using tissue culture (TC) and rapid multiplication techniques (RMT) at Sita Eliya to increase annual potato production in Sri Lanka.

Table 1: Potato Cultivated Extent and Production in Sri Lanka

Year	2007	2010	2013	2015	2017
Land Extent (ha)	5,238	3,783	4,279	4,447	3,300
Annual Production (t)	75,263	51,308	68,778	70,377	52,998

Source: Department of Census and Statistics, 2018

Justification

In Sri Lanka, 80 percent of the seed potato used by the farmers are of poor quality because they are produced by farmers themselves without adopting proper technology. Therefore, it is important to introduce appropriate low-cost technologies to produce high quality seed potato. Availability of high-quality seed potato at right time will increase the productivity and reduce the cost of production. Aeroponic technology can be used to produce pre-basic seed potato. In this method, repeated harvesting is done and a higher tuber yield (10-times or higher) can be obtained compared to the conventional methods. By introducing this technique for Sri Lankan potato farmers, the annual seed potato production can be increased and thereby, foreign exchange for importing seeds can be reduced. Furthermore, farmers can earn an extra income and improve their living status.

MINI POTATO TUBER PRODUCTION PROJECT

Steps involved in the potato mini tuber production are,

1. Production of virus free *in vitro* plantlets
2. Production of rooted stem cuttings for mini tuber production in insect proof net house
3. Production of mini tubers in aeroponic system

For an aeroponic system, table frames are constructed using either wooden or iron bars. Top and sides of this table is covered with black polythene so that no light is penetrated into the free space (Figure 1). One side should be fixed in such a way that it can be opened whenever necessary. The ground is constructed with cement with appropriate slope so that the excess sprayed liquid solution can be collected towards one end of the table and eventually into the nutrient solution tank. “Albert” mixture can be used as the major nutrient and its electrical conductivity (EC) should be around 1500 dS/m. A water pump is used for pumping the solution through PVC pipe into the inner compartment of the table. Nozzles are fixed at of this pipe with space and they are used to spray the nutrient solution. A timer is connected to the pumping unit to control spraying interval (Pushpanjie *et al.*, n.d.).

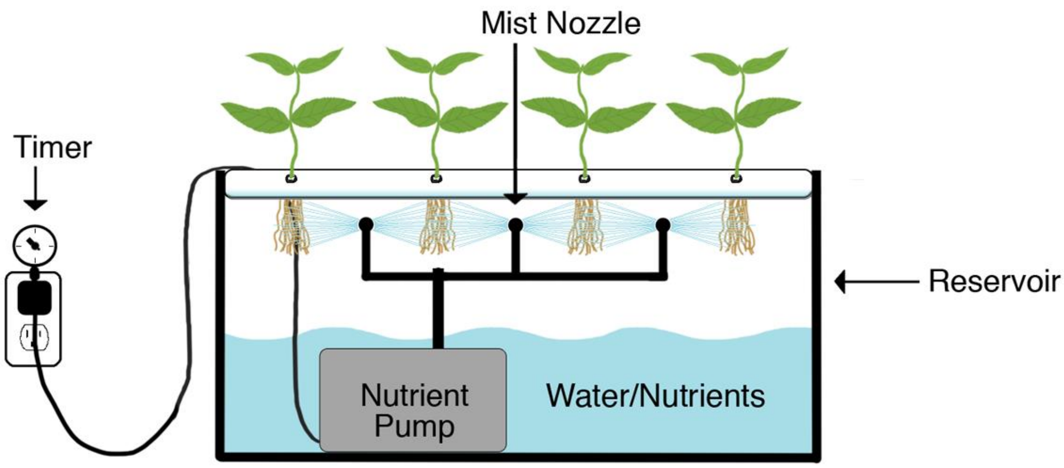

Figure 1: Structure of a Simple Aeroponic Unit

Harvesting can be started four weeks after planting but it depends on the variety. When the tubers reach the required size (minimum 10 mm diameter) they are harvested by giving a gentle twist from the stolon. Tubers can be harvested at 3 - 4 days interval for 3 ½ - 4 months. Continuous supply of nutrient solution is important for a healthy harvest.

Project Constraints

The initial cost is high compared to the geoponic method. Therefore, small scale farmers need a sponsor or government subsidies to start the project. Certain level of technical knowledge is also required to handle the electronic devices, *e.g.* – automated nutrient sprays will run under programmed timing system and the farmer should be able to handle the system.

It is hard to produce the planting materials themselves because the system will require virus free and pathogen free *in vitro* potato mother plants. Therefore, laboratory facilities are necessary to produce planting materials. To maintain the quality of mini tubers, farmers will have continuous supply of rooted stem cuttings by the Department of Agriculture. A major risk is the need for electricity to run the system. Prolonged failures in electricity supply will be fatal for plants. Therefore, standby generator power is required.

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Author:

Gayan Harshana Weerasinghe: He holds B.Sc. (Agric.) [Second Class Lower Division] from FAPM, WUSL. He specialized in Horticulture & Landscape Gardening
(e-Mail: *harshanawag@gmail.com*)

Reviewer:

Kamani Ratnayake: Senior Lecturer, Department of Horticulture and Landscape Gardening, FAPM, WUSL. Her teaching and research interests include: Postharvest Physiology & Technology and Horticultural Science
(e-Mail: *kamani.ratnayake@uqconnect.edu.au/kamani@wyb.ac.lk*)

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Master of Agri-Enterprise and Technology Management, Wayamba University of Sri Lanka

PRODUCTIVITY BASED INCENTIVE MODEL FOR PLANTATION WORKERS TO INCREASE THEIR DAILY WAGE

Kenath Dilroy Manohar

Hayleys Plantations Talawakelle Tea Estates PLC, No. 400, Deans Road, Colombo 10, 01000

INTRODUCTION

Tea is one of Sri Lanka's major export commodities which sustains livelihood of the majority of estate population in Sri Lanka. Furthermore, it contributes to 10 percent of the agricultural Gross Domestic Production and 12 percent to the value of total exports of the country. Despite the sector's prominence, however, the high poverty rate (8.8% compared to 4.3% rural and 1.9% urban) is significant among the estate population (Demographic and Health Survey, 2017).

Global Trend

At present, many plantation companies are continuing to incur losses due to the significant decrease in world tea prices. Sri Lanka exports around 95 percent of its tea but has failed to compete with its competitors in the global market. This is mainly due to higher labour pricing combined with lower productivity and shortage of skilled labourers. Table 1 shows that the cost of plucking in Sri Lanka is higher than its competitors, such as India and Kenya (Thevarajah, 2020).

Table 1: Comparison of Plucking Productivity between Global Competitors

Description	Kenya	South India	Assam	Sri Lanka
Plucking Average (lucked raw leaf kg/worker)	60	50	36	18
National Norm (kg)	40	34	24	16-18
Green Leaf Cost (Rs./kg)	14.08	14.73	17.17	41.56

Source: Oxford Business Group, 2019

Project Justification

Although there have been significant improvements over the years, living standards of the estate sector community have not developed compared to other areas in the country. Low wages of the workers are partly responsible for this situation. Recently, a proposal was submitted to the president requesting Rs. 1,000 per day as the minimum wage for an estate worker. Since Sri Lanka's plantation workers had already been granted a pay hike in January 2019, under the two-year Collective Bargaining Agreement (CBA) between Regional Plantation Companies (RPCs) and trade unions, it was not possible to afford further increment in wage. If the RPCs command to proceed this proposal, there should be a pragmatic wage structure which needs to shift away from the age-old attendance-based wage model to a productivity-based, self-managed wage model which will enable workers to earn more and plantation companies to sustain operations in a competitive market.

Current Wage Model

Under the CBA of 2016-18, workers received a daily basic wage of Rs. 500 and other eligible allowances (Table 2) Also, tea pluckers who achieved a daily target of 18 kg were entitled to an 'over kilo payment' of Rs. 25/kg for each additional kilogram of raw leaves. The latest revision 2019/2021 raised the workers' basic daily wage up to Rs. 700. The Price Share Supplement payment increased up to Rs. 50 but the attendance incentives and the productivity incentives were eliminated from the beneficiaries.

PROPOSED NEW WAGE MODEL

Since the national plucking average for a female worker is 21 kg, realistically, a female could work for minimum of 20 kg/day earning Rs. 700 as the basic. They are also entitled to Rs. 40 for each additional kg of raw leaf. Additionally, they will be entitled to an attendance incentive of Rs. 50 and productivity incentive of Rs. 95. If a female could reach the average plucking quantity, she will earn a total of Rs. 1,040/day. This will enable workers to earn more and RPCs to increase the daily production with the limited labour force and overcome the current losses through productivity increase.

Table 2: Collectively Bargained Wages: Past, Present and Proposed Models

Category	2013-16	2016-18	2019-21	Proposed
Basic wage (Daily target-minimum 18 kg)	450		700	(Daily target min 20 kg) 700
Price Share Supplement (PSS)	30	30	50	50
Attendance Incentives	140	60	0	50
Productivity Incentive	0	140	0	95
EPF/ETF (RPCs contribution)	67.50	75	105	105
Total Wage (w/o extra plucking)	687.50	805	855	1,000

Source: Living Wage Report - Sri Lanka Estate Sector (2019)

Way Forward

According to the proposed model, plucking an additional quantity of 2 kg will reach the daily target, enabling a worker to earn more than Rs. 1,000/day. However, the amount of over kilo bonus payment which is received by a worker can vary significantly due to temporal and seasonal variations in the daily kilo threshold target. Individual plucking differences related to the physical and psychological capacity of the worker should also be considered in this regard. Also, the RPCs should initiate technological advancements in mechanization harvesting, e-weighing and factory process to obtain the maximum outcome per day. Companies should pay more attention to worker-welfare including access to medical facilities, maintenance of estate housing, provision of water to the houses, child development centers, and rations facilitating, and uplifting their working and living conditions.

Limitations

There will be significant limitations in this model. A collective mutual agreement between the Planters' Association, RPCs, trade unions and the government is critical to proceed with the new wage structure. In such uncertain policy environment, an in-depth economic analysis is crucial to highlight the strengths and drawbacks of this model considering the Global Living Wage Coalition (GLWC) calculation on remuneration that can provide a decent standard of living for the workers and their families.

CONCLUSION

Productivity based wage model encourages the participation of workers in economic activities that makes the best use of their talents, efforts, experience, competencies and skills by enabling them to improve their earnings. This proposed model will attract plantation workers as the current model eliminates the attendance and the productivity incentives from the beneficiaries. However, in the long run, tea sector of Sri Lanka needs a sustainable productivity-based, self-managed, wage model where the workers can maximize their earnings with a sense of ownership to the property where they work.

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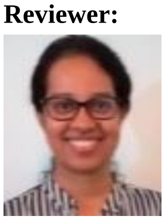
Author:

Kenath Dilroy Manohar: Tea Estate Manager, works for Talawakelle Tea Estates PLC, Sri Lanka. He holds B.Sc. (Plantation Management) from WUSL and is a Fellow member of NIPM (e-Mail: *thomiandilroy@yahoo.com*)

Reviewer:



Menuka Udugama: Senior Lecturer, Department of Agribusiness Management, FAPM, WUSL. Her teaching and research interests include: Food and Agricultural Economics; Environmental and Resource Economics (e-Mail: *menukaudugama@gmail.com*)

SEED TESTING OF MAIZE VARIETY "MI MAIZE HYBRID 01" IN PELWEHERA REGION

Wathsala Winodinee Balasooriya

Seed Testing Laboratory, Seed Certification Service, Department of Agriculture, Mahailluppallama, 50270

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important crops in the world. It has been used as a human food, livestock feed, building material, a fuel and in different alcoholic and non-alcohol drinks. In Sri Lanka, maize is largely used as an animal feed and for commercial starch production. Maize production of Sri Lanka increased from 2,900 t in year 2000 to 35,100 t in 2019 growing at an average annual rate of 16.73 percent (Performance Report, 2019).

Local Hybrid Maize Seed Production Project

This project was established in 2018 covering Pelwehera, Dambulla, Sigiriya, Habarana and Galewela areas towards achieving Sustainable Development Goal 02: End hunger, achieve food security and improved nutrition and promote sustainable agriculture. MI Maize Hybrid 01 pedigree is CML 161 and CML 194 and the type of the cultivar is F1 hybrid. Cob shape is conical, cob length is 16-20 cm and seed colour is orange. This hybrid variety has become popular due to their uniform growth, high yield potential and high plant vigour. It is propagated by seeds and the average yields recorded in 2018 for *Yala* and *Maha* seasons were 4.5 and 5.5 t/ha, respectively (Central Bank Report, 2018). The seed production in 2018 was 75,000 kg and approximately 2,000 farmer families were benefited (Performance Report, 2019). Seed testing services are essential to gain information on quality standards of seed lots from a seed testing laboratory which acts as a hub for seed quality control.

Justification

A number of maize (MI Maize Hybrid 01) samples were received for seed testing from Pelwehera region during *Yala* and *Maha* seasons in 2019. Based on the collection method, there were two sample types. Non-processed samples were collected as pods and processed samples were collected as seeds (Figure 1). All samples were tested for moisture content, physical purity, lot control test (Other Distinguishable Varieties; ODV) and germination.

Figure 1: Non-processed (A) and Processed (B) Maze Seed Samples for Testing

Maize seed testing is essential to identify quality problems and their probable causes, to determine their suitability for planting, need for drying, processing and specific procedures that should be used and to determine whether the seeds meet established quality standards or labeling specifications. Seed testing is carried out to determine the quality status of seed samples drawn from seed lots to be used for cultivation.

SEED TESTING FOR MAIZE

Moisture content – High constant temperature air oven method is used to calculate the moisture content of seed samples. Seed sample is evenly ground and dried in oven for a period of 4 h at 130-133°C temperature. The moisture content is determined by weighing the ground sample before and after drying and determining the difference.

Lot control test – For this test about 1,000 g of seed sample is tested for the presence of ODVs, weed seeds, other crop seeds, insect/mechanical damages and the appearance.

Physical Purity – The purity analysis is done for a working sample of prescribed weight drawn from a submitted maize sample. The working sample is separated into its components of pure seed, other crop seeds, weed seeds and inert matter.

Germination test – This is conducted with a pure seed fraction using a minimum of randomly selected 200 seeds in eight replicates (25 x 8). The test is conducted under favourable conditions of moisture, temperature, suitable substratum (river sand) and light.

Importance of Using Processed Samples for Seed Testing of Maize

The seed testing was carried out according to the ISTA (International Seed Testing Association, 2019) guidelines. Figure 2 illustrates separately the percentages of moisture, germination and purity of 150 processed and 150 non-processed samples after testing. According to the ISTA guidelines, both processed and non-processed samples should have below 12% moisture content, above 75% germination rate and above 99% purity. The overall appearance and, smell should be "Good". All non-processed samples were rejected as they contained high moisture content (15.5%). With increased moisture contents, reduced germination percentages were resulted and fungal contaminations were also observed. Processed samples always presented moisture contents below 12% and higher germination percentages. Inadequate drying of pods in presence of cobs might be the reason for high moisture contents resulted by non-processed samples. As a result, whole non-processed rejected lots were subjected to dry and resubmit to the laboratory for repeated testing. Such repetitions are a waste of resources. Further, separating seeds from cobs at the laboratory is a labour intensive task when non-processed samples are submitted for testing.

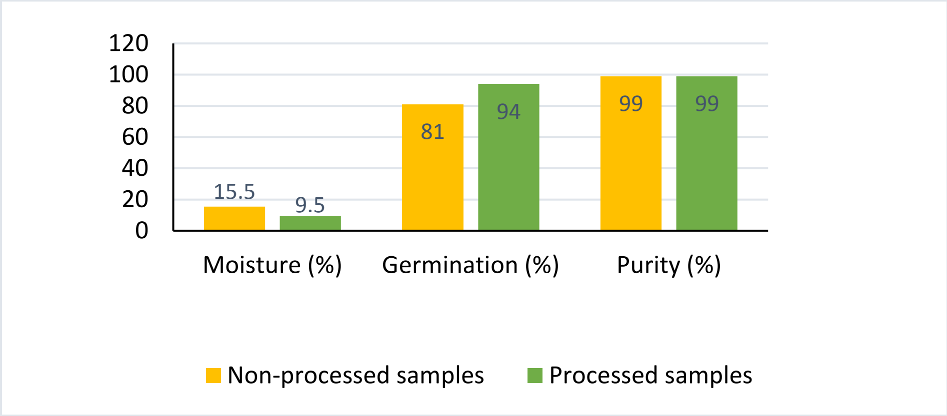


Figure 2: Mean Moisture, Germination and Purity Percentages of Maize Seeds

CONCLUSION

Local hybrid maize seeds production project at Pelwehera region is highly important to increase the productivity of maize in Sri Lanka. Continuous rejection of non-processed maize samples during seed testing and repeated resubmission until acceptance resulted waste of time and added additional operational and labour costs. Under high moisture contents, fungal contaminations and reduced germination rates were also resulted. Accordingly, it is required to encourage farmers to submit processed seed samples for seed testing. Further recommendations on how to process and store maize seeds intended to be used as planting material are essential.

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Author:

Wathsala Winodinee Balasooriya: Agriculture Instructor attached to the Department of Agriculture. She holds B.Sc. (Plantation Management) [Second Class] from WUSL
(*e-Mail: wbalasooriya@gmail.co*)

Reviewer:

Priyanwada S. Warakagoda: Senior Lecturer at Department of Biotechnology, FAPM, WUSL. Her teaching and research interests include: Micropropagation/Tissue Culture Techniques, *In vitro* Conservation and Screening Techniques and Yield Improvement Strategies for Secondary Metabolites (e-Mail: *priyanwadawarakagoda@gmail.com*)

RAINGUARDS: A SUCCESSFUL TECHNOLOGY TO OVERCOME RAIN INTERFERENCES ON RUBBER HARVESTING

Udaya Kumara

Rubber Development Department, Regional Office, Ranwala, Kegalle, 71000

INTRODUCTION

Rubber (*Hevea brasiliensis*) is an economically important plantation crop in Sri Lanka. The total rubber extent of Sri Lanka is around 136,800 hectares while the extent under harvesting is around 101,800 hectares. It provides more than 500,000 direct and indirect employment opportunities. Further, natural rubber production of the country in the year 2017 was 83,072 t and earnings through raw rubber exports were Rs. 5,920 million. Moreover, contribution to the Gross Domestic Product from rubber is 0.8 percent (Rubber Research Institute of Sri Lanka, 2018).

Rain can be considered as a major factor that affects harvesting of rubber. Latex harvesters find rain as a significant barrier for harvesting. The most popular method adopted by growers to overcome this problem is to carry out harvesting when weather permits. Therefore, rainguard technology can be considered as an effective method to overcome the effect of rain on rubber harvesting.

Justification

Wet zone of Sri Lanka where the highest extent of rubber plantations exists, receives heavy and continuous rainfall during June to September because of the monsoonal rain. Although there is high yield potential during this monsoon season, around 100 working days are lost due to the rain. In 1/2S d/2 tapping system, 60 tapping days out of 160 are lost. The annual loss of income per hectare calculated considering the total number of rubber trees per hectare as 500 is shown in Table 1.

Table 1: Loss of Income Due to Rain in Wet Zone Rubber Plantations

Description	Amount
Yield per tree for one tapping	0.05 kg
Price per 1 kg	Rs. 250.00
Income loss per year for 1 tree	0.05*250*60 = Rs. 750.00
Income loss per year from 1 hectare	750*500 = Rs. 375,000.00

A significant amount of the loss of income due to rain can be reduced by adopting the rainguard technology. Further, usage of rainguards in rubber plantations will be a great investment for rubber growers all over the country as it will result high yields for prolonged periods of time.

Constraints and Assumptions

Installation of rainguards must be carried out within the period of February to mid-April before the beginning of the South-west monsoon. Following conditions are expected to exist within the considered period of time for the project to be a success.

- Rain is assumed to be seasonal and the effect of long droughts or heavy rains due to sudden climatic changes are assumed to be null.
- Rubber plantations are assumed to be disease-free or healthy throughout the considered period of time of the project.
- Various economic crises that may affect the rubber plantations are assumed to be unlikely throughout the considered period of time of the project.

RAINGUARDS

There are two types of rainguards which are recommended by the Rubber Research Institute of Sri Lanka namely, Skirt Type (Apron Type) and Kisaan Type. Apart from those two types, Gutter Type and Cap Type rainguards can also be used in Sri Lanka (Figure 1).

GROWER PERCEPTIONS

Although rainguards significantly minimize the loss of income of the rubber growers, the perception of rubber growers towards adopting rainguards is not satisfactory. The major issue raised by the growers is that the rainguard results condensation of water on the tapping panel and thereafter it leads to infections and tapping panel dryness. The condensation of water is said to be taken place due to the covering of the entire circumference of the tree by the rainguard preventing any ventilation. However, with the correct adoption of the rainguard technology, sufficient space is made available to provide the necessary ventilation to prevent any condensation of water and infections (Jayakody, 2016).

Moreover, traditional growers complain that the raingaurds increase the time taken for harvesting. Growers also remark that hazardous animals such as serpents and tarantulas have been found inside rainguards. Further, the growers show a dislike towards fixing rainguards as the monkeys tend to damage the rainguards. However, most of these issues can be solved with the proper installation and maintenance of rainguards.

Generally, it can be stated that the project depends upon skilled labourers and their skillful work of installing the rainguards. The knowledge on techniques or the proper and correct methods of installing the rainguards must be well-communicated to the labourers.

Figure 1: Types of Rainguards (A) Skirt Type, (B) Kissan Type, (C) Cap Type and (D) Gutter Type

IMPLEMENTATION AND SUCCESS CRITERIA

By the end of the project, it is expected that the rubber growers will be benefitted with high yields for prolonged periods of time and also the loss of income due to the effect of rain will be avoided. Along with the rubber growers, the labourers and other workers related to the rubber plantations will be benefitted. Further, with the successful implementation of the project throughout the rubber growing areas all over the country, a significant amount of revenue on rubber plantation can be gained. Finally, it can be concluded that the success of this project could create a notable positive impact on the country's economy.

Moreover, with the use of rainguards, the recommended tapping system (1/2S d/2) can be properly followed resulting in less bark consumption, less tapping panel dryness (TPD) and diseases caused by fungi will also be reduced. Considering all the success criteria, it can be concluded that adopting rainguards in rubber plantations is a climate-smart practice in the plantation sector.

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Author:

Udaya Kumara: Senior Rubber Development Officer at Rubber Development Department, Kegalle. He holds B.Sc. (Agriculture) from University of Peradeniya and a Diploma in Agriculture from Sri Lanka School of Agriculture, Pelwehera (e-Mail: *mmrudayakumara7@gmail.com*)

Reviewer:

Thilak Attanayake: Professor in Biotechnology, Department of Biotechnology, FAPM, WUSL. His teaching and research interests include: Plant Molecular Biology, Genetics and Plant Breeding (e-Mail: *dpstga@yahoo.com*)

EFFECT OF TRADE UNION MOVEMENT ON QUALITY OF LIFE OF PLANTATION WORKERS

Asela Chandima Abeywarne

Rangalla State Plantation, Rangala, 20922

INTRODUCTION

Trade unions in Sri Lankan plantation sector are embedded with ethnic bound politics. As an inter-ethnic group subordinated by both Tamil and Sinhala nationalisms, the hill country Tamil workers represent the most organized sector of the economy, among the most poverty stricken and marginalized workers (Chandrabose, 2015). Therefore, it is important to analyse the role of trade union involvement in the lives of estate workers to obtain an in-depth understanding on the positive and negative effects, towards the quality of life of the plantation workers. Further, the quality of life of plantation workers (social capital in plantations) are related to their labour productivity and it is ultimately associated with the development of the plantation industry.

History of Worker Unions

The first ever trade union was formed in between the early 1900s and late 1935, where initial trade unions were functioning nearly as voluntary organizations and were required to register under the Trade Union Ordinance. However, in late 1935, The Employers Federation of Ceylon became the first ever registered trade union of Sri Lanka and working planter society/union, which represented the Sterling companies who mutually agreed upon to play an active role to achieve better basic human or working conditional rights with the workers (Dunham *et al.*, 1997).

CURRENT STATUS OF WORKER UNIONS IN SRI LANKA

Currently six plantation worker trade unions are registered in Sri Lanka with a considerable number of members having a gender composition with more males (Table 1). In general, multiple factors are associated with the quality of life of a plantation worker. These factors can be broadly categorized into three segments namely (1) Industry, (2) Worker unions and (3) Other factors (Figure 1).

Table 1: Composition of Worker Unions (Trade Unions)

Number of members	Name of the Worker Union					
	CWC	LJEWU	NUW	JPTUC	UPF	SRFU
Total	383,007	148,242	21,280	4,556	3,966	1,850
Male		90,701	11,770	2,521	2,980	1,100
Female		57,541	9,510	2,035	986	750

CWC – Ceylon Workers' Congress, LJEWU – Ceylon National Estate Workers Union, NUW – National Union for Workers, UPF – Upcountry People's Front, JPTUC – Estate Sector Workers Alliance, SRFU – Sri Lanka Red Flag Union

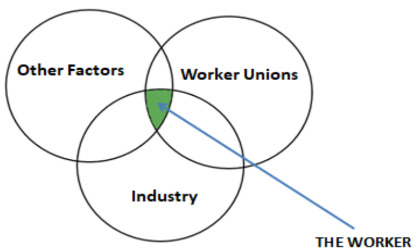

Figure 1: Factors Associated with the Quality of life of a Plantation Worker

Positive Factors Associated with Quality of Life of a Plantation Worker

There are some factors associated with quality of life of a plantation worker positively. The factors associated with Industry can be identified as mechanization of factories and installation of machineries, which reduce direct physical contact. Infrastructure Development coming under other factors include providing housing, early childhood care, quality drinking water projects, improved road network, sanitation facilities and sport centres (Figure 2). Technological advancements and improvement are also coming under other factors and they include use of crop harvesting machines, laboratory facilities and drip irrigation systems. Some factors are associated with worker unions such as equal opportunity provision (men and women were equally treated and remunerated in comparison to old era) and favourable political influence. Such factors significantly contributed for electing representatives through which workers were able to achieve civic rights, voting rights and ultimately, the right to select a person to the Parliament representing their ethnic group.

Negative Factors Associated with Quality of Life of a Plantation Worker

Mostly, plantation communities are an economically unstable and ill-treated segment, where some families find it difficult to come out of the vicious cycle, mainly because of the limitations in their remuneration systems adopted by different Regional Plantation Companies and other private sector employers.

Figure 2: Infrastructure Development in Plantations (A) Modern Child Development Centre, (B) New Housing Projects, (C) Modern Water Projects for Quality Drinking Water, (D) Upgrading Roads.

CONCLUSION

The trade unions, operating in plantation communities have been successful in achieving many claims or requests by negotiating or by demanding and were able to achieve many benefits towards uplifting the quality of life of workers through civic rights, voting rights, improved housing and infrastructure facilities. It is evident that they have provided a mega workforce representing social capital for the country which has been a very positive point. Meantime, the plantation community has improved tremendously and significantly contributed to accomplish certain certifications namely ISO 22000, HACCP, Rain Forest Alliance and Fair Trade. With the improvement of the quality of life of workers, some of their children were able to continue their higher studies in state universities and contributed to the country's economy as graduates, which was merely a dream for plantation workers in the past.

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Author:

Asela Chandima Abeywarne: Superintendent, Sri Lanka State Plantations Corporation at Rangalla State Plantation, Rangala. He holds National Diploma in Plantation Management from National Institute of Plantation Management and B.Sc. (Plantation Management) from WUSL (e-Mail: *aabeywarne@gmail.com*)

Reviewer:

Bandara Gajanayake: Senior Lecturer, Department of Plantation Management, FAPM, WUSL. His teaching and research interests include: Tea Production and Marketing, Climate Smart Agriculture and Resource Management in Plantations (e-Mail: *gajawyb@yahoo.com*)

INCREASING DAIRY MILK PRODUCTION BY ENHANCING DAIRY FARMER SATISFACTION

Indunil Karunatilaka

Cargills Quality Dairies Private Limited, Gaspe, Banduragoda, 11244

INTRODUCTION

Dairy products or milk products are type of food primarily produced from the milk of mammals such as cattle, buffaloes, goats, sheep and camels. Dairy products include food items such as milk (scalded milk, condensed milk and powdered milk), yoghurt, cheese, butter, cream and ice cream.

Current Status in Sri Lanka

In Sri Lanka, 30 percent of the total land area is used for agriculture activities. Out of that, 70 percent is solely devoted to crop production and the remainder consists of mixtures of crops and livestock. Livestock sector contributed to around 0.6 percent of the national GDP in 2017 (Samarasundara *et al.*, 2017).

The annual per capita consumption of milk and dairy products in Sri Lanka is about 36 kg. Since 1980's Sri Lanka has been importing dry milk powder as their main dairy commodity from Australia and New Zealand. The level of milk consumption is low with per capita consumption of fresh and powdered milk at 110.33 ml per month and 341.36 g per month, respectively (Widanapathirana, 2019).

Project Justification

The total annual milk production of Sri Lanka was 467,691,264 L in 2018 (Table 1). Contribution of the domestic milk production to the total milk requirement is 42 percent. The deficit is met by imports, mostly in the form of powdered milk, which costs an average of Rs. 33.6 billion a year. A total quantity of 94,000 t of powdered milk was imported in 2016 (Widanapathirana, 2019).

Following the detection of dicyandiamide (DCD) in imported milk powder in 2013, consumers have become more cautious when purchasing imported milk products for consumption. This project mainly focuses on enhancing the dairy milk production up 800,000,000 L per year by 2025 to fulfil the dairy requirement from locally produced milk.

The average farm-gate price per litre of milk was Rs. 66.34 in 2017 and the average cost of production of a litre of milk was recorded as Rs. 34.69 under intensive management systems (Figure 1; Widanapathirana, 2019).

INCREASING MILK PRODUCTION VIA DAIRY FARMER SATISFACTION

The main objective of this project is to increase the dairy milk production (both quantity and quality) via increasing the level of satisfaction of dairy farmers.

Awareness programmes, dairy farmer communities, welfare systems to be built in Divisional Secretariat (DS) Division. Milk collecting centres to be built in each DS Division and guaranteed price to be offered to farmers. By satisfaction of farmers, they tend to expand their farms. Awareness programmes to be conducted in collaboration with the company and the Agrarian Services Centres. With right guidance and the financial support, farmers can be attracted to raising cows and gradually enhance them to start new farms to gain an additional income.

Equipment, instrument and chemicals to be provided to milk collecting centres in order to assure the quality of purchasing milk by tests, such as adulteration tests, keeping quality (KQ) test and milk composition test to calculate solid non-fat (SNF) percentage and fat percentage.

PROJECT IMPLEMENTATION

As a strategy to increase the dairy production (quantity wise), dairy farmer communities will be built up with a new welfare system. As a benefit, it suggests to give some financial support to start small farms and expand existing farms through loans. Further, farmers can be encouraged by giving some allowances to their children who pass the Grade 5 Scholarship Examination and to students who follow higher education. In addition, an allowance could be given when there is a funeral in farmer's family.

Moreover, to enhance the quality of milk, awareness programmes will be conducted for the farmers to educate them on farm operations and maintenance, proper milking practices, transportation and the adverse effects of adulteration of milk. Staff of the milk collecting centres will also be rewarded and guided to follow instructions to assure the quality of milk. It is assumed that the company will allocate the finance and human resources through the Budget in 2021. Firstly, the project will be implemented basically in the Western, North Western and Central provinces, and gradually it will be expanded to all areas of the country by 2025.

Table 1: Cow and Buffalo Milk Production in Sri Lanka

Year	Average Monthly Milk Production (L)		Total Monthly Milk Production (L)	Annual Milk Production (L)		Total Annual Milk Production (L)
	Cow Milk	Buffalo Milk		Cow Milk	Buffalo Milk	
2015	25,945,110	5,926,890	31,872,000	311,341,320	71,122,680	382,464,000
2016	25,511,871	5,087,512	30,599,382	306,142,447	31,050,139	367,192,586
2017	27,417,600	5,741,964	33,159,627	329,011,951	68,903,569	397,915,520
2018	32,627,550	6,346,722	38,974,272	391,530,600	76,160,664	467,691,264
2019***	31,167,995	6,130,530	37,298,525	374,015,943	73,566,360	447,582,303

****Provisional*

Source: Agriculture and Environment Statistics Division (2019), Department of Census and Statistics, Sri Lanka

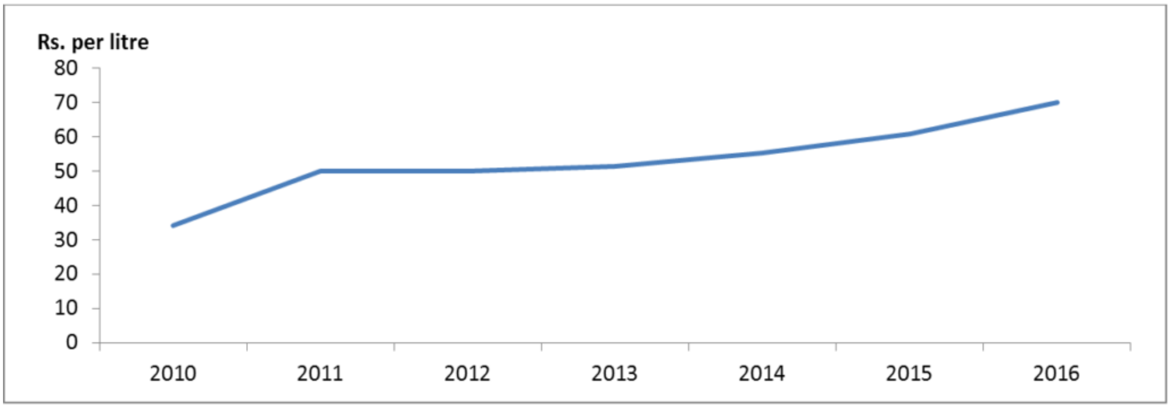

Figure 1: Farm Gate Price of Milk (2010 – 2016)

Source: Ministry of Finance, Sri Lanka

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Author:

Indunil Karunatilaka: Former Trainee, Quality Assurance Section, Cargills Quality Dairies Private limited. She holds B.Sc. (Agric.) [Second Class Upper Division] from WUSL (e-Mail: *induníldaladawatta123@gmail.com*)

Reviewer:

Rupika Abeynayake: Professor in Applied Statistics, Department of Agribusiness Management, FAPM, WUSL. Her teaching and research interests include: Econometrics, Statistical Quality Control, and Time Series Analysis (e-Mail: *rabeynayake@hotmail.com*)

REDUCING AGROCHEMICAL USE IN PADDY CULTIVATION WITH PARTICULAR REFERENCE TO POLONNARUWA DISTRICT

Gamini Bandara Karagahawaththa

Agrarian Service Centre Medirigiriya, Polonnaruwa, 51000

INTRODUCTION

Paddy is the most important cereal crop and staple food in Sri Lanka. The total extent of paddy cultivation in Sri Lanka during 2018/2019 *Maha* season is 748,028 ha. Out of that 65,970 ha were cultivated in Polonnaruwa district and 20 percent of the total white rice production was also reported from this district (Department of Census and Statistics, 2019). Cultivation of paddy is the main livelihood of people in Polonnaruwa district. Further, paddy cultivation can be considered as an important component of the agriculture sector and the national economy of the country. However, with the increase of paddy production, agrochemical usage also demonstrated an increasing trend during previous cultivation seasons in Polonnaruwa district (Department of Census and Statistics, 2019). As a result of heavy agrochemical usage in paddy cultivation, various environmental, health, social and rice quality-related impacts are at public debates.

Project Justification

As recorded by local health clinics, common health problems such as liver disorders and cancers are often attributed to long term exposure to pesticides while lung disorders and skin disorders are frequently associated with short term exposure. However, no validated and statistically proven data are available. However, pesticide poisoning in farmers is repeatedly recorded. Loss of biodiversity, particularly aquatic species is another problem associated with agrochemicals. However, at the moment there are no systems to regularly monitor the risks associated with the use of agrochemicals.

In addition to that, the increasing cost of production, destruction of pollinators leading to poor crop yields, elimination of natural enemies of pests, development of resistance to pesticides and contamination of the soil and water bodies are also allied with agrochemical usage.

Project Constraints

Less use of agrochemicals for paddy cultivation is not an easy task. Farmers’ knowledge on agrochemical usage, including correct and timely use of pest and disease control methods is very low resulting in heavy use of nitrogen fertilizer and other agrochemicals, less or no use of organic fertilizer and unplanned irrigation leading to pest and disease outbreaks. Further, agrochemical companies and local agrochemical sellers are unnecessarily motivating farmers to use agrochemicals without proper guidance. Lack of Agriculture Extension Officers in the Department of Agriculture (DOA) to facilitate proper extension system for paddy farmers in the Polonnaruwa district is also a major constraint.

Project Assumptions

Prevailing agro-climatic conditions (especially high temperature and high moisture) are favourable for spreading pest and disease outbreaks during the upcoming *Yala* season. Government decision on providing free inorganic fertilizer and agrochemical/agrochemical subsidies, government policies on banning some of the agrochemicals and availability of the adequate amount of irrigation water on a timely basis are the key assumptions of this project.

Project Dependencies

Support of the other departments related to agriculture is useful to reduce high agrochemical usage. The DOA needs to closely work with the Department of Agrarian Development, Mahaweli Authority and Department of Irrigation to facilitate other services required by the farmers. For example, on time and adequate provision of irrigation water and technical know-how and awareness building, *etc* are of utmost importance. Additionally, enhancing the capacities of farmer organizations to encourage farmers to gain knowledge and training and to make requests from responsible bodies for the timely allocation of resources for paddy cultivation is crucial.

PROJECT IMPLEMENTATION STRATEGIES

First, it is required to popularize crop diversification and intensive agronomic and crop management practices which will help minimize the usage of agrochemicals in paddy cultivation. Secondly, it is needed to adopt farmers to use integrated pest management (IPM) practices through farmer education and training which will ultimately keep farmers away from agrochemicals. Further, public awareness of health hazards associated with pesticide misuse needs to be enhanced regularly. In addition to that, introduction and expansion of modern technology, adapting to improved cropping patterns and farming methods, improvements in strategies related to efficient soil and water management, allocation of adequate resources to implement national plant protection policy and raising farmer awareness on hazards associated with agrochemical misuse are also essential to be reiterated.

Following key activity will be adopted to reduce the usage of agrochemical in paddy cultivation. Capacities of the farmers will be enhanced through awareness-raising, training and continuous technical guidance regarding the agronomic and cultural practices related to paddy farming. Further, the farmers will be motivated to cultivate the entire area of paddy field at the same time to interrupt the pests' life cycle and minimize spreading of pests and diseases. Timely allocation of the water and other resources will be adopted along with the start of cultivation to enhance the plant vigour to resist pests and diseases. The IPM methods in paddy cultivation, including the use of biological and cultural methods, and with the help of natural enemies will be promoted to reduce the reliance on synthetic agrochemicals. It will be implemented to work closely with the DOA and the Registrar of Pesticides to strengthen the IPM activities. Besides, the site-specific fertilizer recommendations will be practiced, and thus reduce the usage of excessive inorganic fertilizer application and enhance the use of organic manure as much as possible to develop soil structure and texture while nourishing the plants.

Project Success Criteria

A balanced ecosystem can be built through reduced use of agrochemicals. For example, by adapting to IPM practices, outbreaks of brown plant hopper and stem borer can be reduced. Development of pest resistance can also be eliminated which will ultimately help to avoid usage of highly toxic alternative pesticides to control such incidents. Further, minimum use of chemical fertilizers helps reduce environmental pollution, especially the soil and water. Health hazards associated with high exposure to agrochemicals can also be terminated. As a direct benefit, up to 10 – 70 percent increase in yield can be expected by minimizing losses due to severe pest attacks (Rice Knowledge Bank, 2020). Increased yield and reduced cost of production combined with healthier soil allow farmers to retain a greater percentage of their revenues as profits.

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Author:

Gamini B. Karagahawaththa: Agriculture Extension Officer, Agrarian Service Centre, Medirigiriya, Polonnaruwa. He holds B.Sc. (Plantation Management) from WUSL (e-Mail: *bandara84k@gmail.com*)

Reviewer:

Priyanwada S. Warakagoda: Senior Lecturer at Department of Biotechnology, FAPM, WUSL. Her teaching and research interests include: Micropropagation/Tissue Culture Techniques, *In vitro* Conservation and Screening Techniques and Yield Improvement Strategies for Secondary Metabolites (e-Mail: *priyanwadawarakagoda@gmail.com*)

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Master of Agri-Enterprise and Technology Management, Wayamba University of Sri Lanka

BRUSH CUTTING AS A COST EFFECTIVE WEED MANAGEMENT METHOD IN TEA PLANTATIONS: THE CASE OF CECILIYAN ESTATE

Ariyasena Amarasekara

Ceciliyan Associates Private Limited, Ceciliyan Estate, Thapassarakanda, Kalawana, Rathnapura, 70000

INTRODUCTION

Since recently, weed management in tea cultivation, which is one of the main sources of foreign exchange in Sri Lanka, has been given higher attention. It is because weed management can be considered as the second highest costliest practice next to harvesting (Peiris and Gunarathne, 2015). Several methods have been adopted for weed management, including manual, chemical, biological, ecological and mechanical methods. Integrated weed management is a combination of all the above mentioned methods while considering population threshold levels and effect of weed management practices on the ecosystem. Among the combined methods, brush cutting as a mechanical method, is considered as a sustainable method for weed management in tea plantations (TRI Advisory Circular, 2013).

Justification

Integrated weed management has been used combining manual (hand pulling, slash weeding) and chemical (using herbicides) methods of weed control in Ceciliyan Tea Estate throughout the year. Although manual and chemical methods are being used for weed management, there are several drawbacks. Altering nutrient composition of soil, increasing soil erosion by exposure of soil, and man power issues are the main drawbacks of manual methods whereas destruction of soil structure, change of cation exchange capacity of soil and phytotoxic effects on tea by chemical method are due to use of herbicides. Brush cutting can be used to overcome above issues successfully, enhancing the efficiency of weed management by reducing time and manpower requirement, increasing quality and low or minimum effect on soil. However, cost effectiveness of each method plays an important role due to its direct relationship with the annual profit of the estate. Therefore, this study investigates the cost effectiveness of brush cutting as a method of weed management.

BRUSH CUTTING WEED MANAGEMENT PROJECT

The proposed brush cutting weed management project has been implemented as an alternative method of weed management in Ceciliyan Estate. The strategy is mainly focused on finding a cost effective weed control method with enhancing sustainability. The tested area was 3 acre of No.8B field of the plantation. Each acre was treated with one of the studied weed control methods (*i.e.* manual, chemical, brush cutting) throughout the Year 2016.

According to the results of the study, the lowest total cost for weed control in 1 acre of tea field was obtained by brush cutting method while the highest cost was obtained by manual method. The results revealed that brush cutting method can be suggeted as a cost effective method compared to manual and chemical methods (Table 1 and Figure 1).

PROJECT IMPLEMENTATION

The management of Ceciliyan Estate has already taken initiatives for application of brush cutting as a method of weed control in combination with manual and chemical methods. In addition, financial and human resources are being allocated by the estate management through its Budget starting from 2016. After the implementation of this project, brush cutting method is being applied to most of the estate from 2016 to present.

Table 1: Cost Calculation for Each Weed Control Method in 1 Acre Field

Cost	Brush Cutting	Chemical	Manual
Labour	Rs. 9,228.75 (For 11.5*)	Rs. 4,815.00 (For 06*)	Rs. 32,100.00 (For 40*)
Chemicals	Nil	Rs. 7,500.00 (For 03#)	Nil
Machine operation	Rs. 2,266.60	Nil	Nil
Total	Rs.11,495.35	Rs. 12,315.00	Rs. 32,100.00

**No. of labour units; #No. of liters of chemicals (Glyphosate); Values refer to year 2016*
Cost for one labour unit = Rs. 802.50 (With contributions to ETF & EPF)
Cost for 1 L of chemical (Glyphosate) = Rs. 2500.00
Source: The Book of Brush Cutter Proceeding for Tea Fields, Ceciliyan Tea Estate

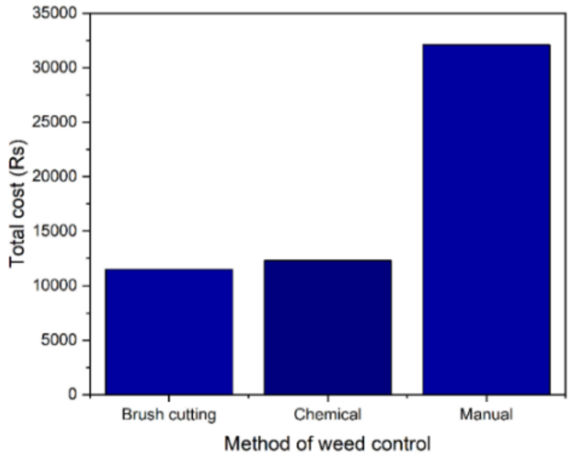

Figure 1: The Total Cost of Brush Cutting, Chemical and Manual Methods of Weed Control in 1 Acre Field in Year 2016

Project Constraints

When cosidering the constrains of this project, technical knowledge and resources were significant limitations. Initial investment for the brush cutting method is another major constrain. Lack of maintenance knowledge of brush cutters can be considered as a technical knowledge constrain whereas unavailability of spare parts of brush cutters as limitation of resources. The project implementation has to be monitored continuously to overcome the constraints as much as possible. Necessity of organizing awareness programmes for workers about brush cutting methods was identified during the monitoring of this project. Lack of facilities to study on the environmental cost of chemical methods was another shortcoming of current project.

ACKNOWLEDGEMENTS

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Author:

Ariyasena Amarasekara: Assistant Superintendent of Ceciliyan Estate attached to Ceciliyan Associates (Pvt.) Ltd., Ratnapura. He holds B.Sc. (Plantation Management) Degree from WUSL (e-Mail: *ariyasena@live.com*)

Reviewer:

Bandula Ranaweera: Senior Lecturer, Department of Horticulture and Landscape Gardening, FAPM, WUSL. His teaching and research interests include: Plant Protection, Pest Management, Biorationals, Bio Pesticides & Bio Fertilizers and Toxin-Free Crop Production
(e-Mail: *branaweera@gmail.com/branaweera@wyb.ac.lk*)

PROMOTION OF VALUE ADDED PRODUCTS FROM MUSHROOM

Buddhika Chathurangani Bodhipaksha

Department of Agriculture, District Agriculture Training Centre, Walpita, 11226

INTRODUCTION

Mushroom is the fleshy fruiting body of a fungus that consists typically of a stem bearing a pileus. It is a highly nutritious and delicious food in the world. Edible mushroom cultivation in Sri Lanka was established as a profitable small industry only after 1986. Sri Lanka mainly relies on Oyster (*Pleurotus ostreatus*) and Abalone (*Pleurotus cystidiosus*) cultivation (Thilakaratna and Pathirana, 2018). There are various food items, which are prepared in many processes from mushrooms in the country, such as mushroom dishes, soup, salad, cutlet, and dried mushroom, etc.

Project Justification

Mushrooms are low in fat and simple carbohydrates, and they are rich in digestible protein, high molecular weight polysaccharides among other nutritional constituents, and a good source of fibre. It contains unsaturated fatty acids, which constitute over 70 percent of the total content of fatty acids, contain essential fatty acids, and are low in calories, and high in vegetable proteins, minerals and vitamins (Thilakarathne and Pathmanathan, 2018). Therefore, it is a valuable food, which contains essential nutrients (Table 1). Mushroom is also called as "vegan meat", because of its high nutritional value. At present, the demand for mushroom has grown as mushrooms can satisfy the needs of health-conscious consumers and as a nutritive alternative food, especially for vegetarians.

Table 1: Nutritional Value of Mushroom (Per 100 g of Fresh Weight)

Nutrients	Amount
Water	91.0 g
Energy	13.0 Cal
Protein	2.5 g
Fat	3.0 g
Calcium	20.0 mg
Iron	10.0 mg
Thiamine	120.0 µg
Riboflavin	500.0 µg
Niacin	5.8 µg
Vitamin C	3.0 µg

Source: Mankotte, 2012

Value addition is the most important component of nutritional security. It increases the value of primary agricultural commodities through a particular production process. Accordingly, value additions to food commodities reduce the postharvest losses, create more opportunities in the export market, reduce the risk of marketing, and increase the financial stability of farmers.

Sri Lanka is gradually experiencing the risk of food security, due to the lack of arable land area and the impact of climate changes. Therefore, it is very important to focus on foods that can be grown in low space using less fertilizer and other inputs. Moreover, attention should be given to food preservation concerning food safety. With a busy lifestyle, it is usually difficult to prepare fresh mushrooms at home, and some people dislike the taste of mushroom curry, salad like products. Therefore, there are good opportunities to produce value added products from fresh mushrooms. However, mushroom farmers have no idea about consumer preference and how they can increase the profit by engaging in more value added activities for their products. Also, it was noted that even though there is high growth in the mushroom industry, due to various mushroom growing programmes introduced by the government and non-governmental organizations as poverty alleviation programmes, little attention was given to the production of value added mushroom products.

Therefore, there is a high necessity for the promotion of the production of value-added mushroom products not only for increasing profitability but also to satisfy consumer preferences by increasing the availability of protein-rich non-meat processed food in the market.

Project Constraints

As Sri Lanka is growing only a few varieties, few mushroom products are available in the market. The shelf life of commonly grown mushrooms in Sri Lanka is about two days under ambient conditions. Also, the shelf life of the processed mushroom products is low compared to other value added products like meat sausage as the value addition processes of mushrooms are free from the addition of chemical food preservatives. Therefore, the choice of consumers is limited.

VALUE ADDED PRODUCTS FROM MUSHROOM

The present project has focused on the promotion of manufacturing value added preserved food, *i.e.* sausage and chutney from fresh mushrooms.

Chutney Production

Required ingredients: 400 g of mushroom (Oyster), 20 g of salt, 9 g of curry powder, 2 g of ginger, 20 g of red onion, 400 g of sugar, 12 g of dry chilli, 10 g of garlic, 50 mL of vinegar and 2 g of cinnamon. Processing steps are summarized in Figure 1. The products can be kept for 1 year without deterioration.

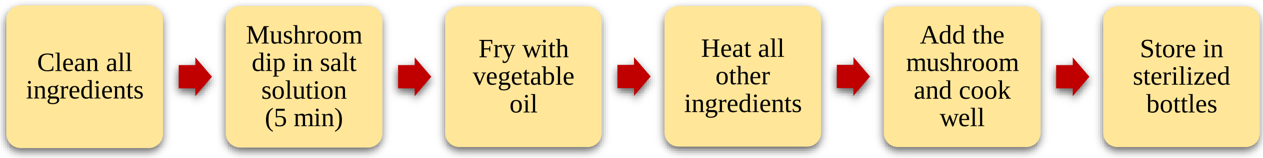

Figure 1: Mushroom Chutney Production Process

Sausages Production

Required ingredients: 80 g of fresh mushrooms, 200 g of soy flour, 50 mL of corn oil, 8 g of onion, 0.5 g of cinnamon, 0.5 g of cloves, 0.5 g of nutmeg, salt and pepper to taste are used to make these. Figure 2 summarizes the steps of the production process. These products can be kept for about 3 months.

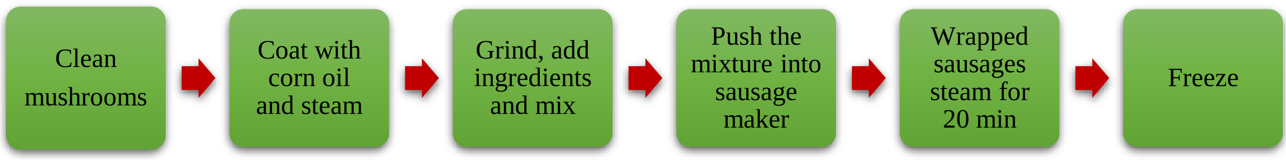

Figure 2: Mushroom Sausages Production Process

PROJECT IMPLEMENTATION

District Agriculture Training Centre, Walpita is mainly engaged in the promotion of value-added mushroom production. Training programs are conducted free of charge at the Centre on value added mushroom production introduced by the Department of Agriculture. The institute provides theoretical and practical knowledge on how to prepare the food, quality preservation, preparation of gross estimates, presenting to the market and registering the products. The main target groups of these training programs are unemployed young people and women. Then, they can build up a strong economy by successfully producing and selling high quality products like mushrooms chutney and sausages. Therefore, the institute produces well-trained entrepreneurs who sell value-added mushroom products.

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Author:

Buddhika Chathurangani Bodhipaksha: Agriculture Instructor attached to the District Agriculture Training Centre, Walpita, under the Department of Agriculture, Sri Lanka (W.P). She holds B.Sc. (Agric.) from WUSL (e-Mail:*bhbcbuddhika@gmail.com*)

Reviewer:

Radhika Gimhani: Senior Lecturer, Department of Biotechnology, FAPM, WUSL. Her teaching and research interests include: Plant Biotechnology, Molecular Plant Breeding and Gene Mapping (e-Mail: *dgimhani@wyb.ac.lk*)

COMPOSTING AT SCHOOL USING BLACK SOLDIER FLY LARVAE FOR ORGANIC WASTE TREATMENT

Theja Kaushalya

Kuli/Moragane Maha Vidyalaya, Moragane, 60354

INTRODUCTION

Solid waste management has become a major environmental challenge in Sri Lanka due to the rapid urbanization in the recent past. Improper solid waste management systems such as open dumping sites have become a national concern. In Sri Lanka, each person generates an average of 0.4 – 1.0 kg of waste per day (Environmental Foundation Limited, 2017). Commonly accepted waste management concepts follow 3Rs - Reduce, Reuse, and Recycle. A proper waste management system should incorporate disposal methods, recycling methods and avoidance and reduction methods. As individual citizens we need to be responsible for our own waste, starting from minimizing waste generation to ensuring responsible for waste disposal. While reducing plastic and polythene use, it is our responsibility to separate the waste as perishables and non-perishables (not compostable) and handover non-perishables (plastic/polythene, glass, metal, *etc*.) to recycling centers. This study describes the case of implementing an organic waste treatment project using Black Soldier Fly Larvae at Kuli/Moragane Maha Vidyalaya with the objective of encouraging students for organic composting.

Black Soldier Fly (BSF)

Black soldier flies are small, harmless insects that have the potential to compost waste. BSF (*Hermetia illucens* L) is a Diptera of the Stratiomyidae family commonly found throughout the world in tropical and temperate regions. BSF completes its life cycle in four stages (Figure 1). The female BSF has a life span of 5 - 8 days and deposits a mass of about 500 eggs in decaying matter, such as compost or waste.

Figure 1: Black Soldier Fly (*Hermetia illucens L.*) Life Cycle
Source: http://www.freshroomslifesciences.com

Black soldier flies are not regarded as vectors of diseases or pests. They are beneficial in several ways, *e.g.* houseflies and other insects will not lay eggs in the material inhabited by BSF larvae (BSFL). The adults do not have digestive organs, relying on stores of body fat from the larval stage. Larvae of BSF has a high potential for consumption of organic waste such as food waste, rotting fruits, and vegetables, grass, coffee bean pulp, fish offal, human excreta and animal manure. This consumption is associated with a strong reduction in organic matter volumes opening the possibility for innovative waste treatment technology through the bioconversion by BSF (Myers *et al.,* 2008). In addition, the larvae represents a biomass rich in proteins and lipids that can be used as feed for livestock such as fish, poultry and pig or incorporated into biodiesel production and compost production.

Project Justification

Organics such as food scraps, rotting fruits and vegetables, paper products, leaves and grass of the waste stream are completely recyclable by composting. Composting is a natural process to turn organic waste into a soil amendment. This can be achieved using different techniques. Establishment of small worm (BSFL) compost bins in a school classroom for composting will encourage student to apply it in their household as well. If waste management and composting forms part of the education, students learn to become wiser consumers who will use more responsible and environment friendly approach to use natural resources in future.

ORGANIC WASTE MANAGEMENT PROJECT

The proposed BSFL organic waste treatment project provides knowledge and practice about composting. Awareness programmes to be organized at the school level for students, teachers and parents. BSFL can be used easily as an organic waste treatment in school. BSFL composting, as a treatment of organic waste, has been proven to significantly reduce the volume of wastes. In addition, composting can also provide nutrients that are suitable for agriculture that can be used as fertilizer for the school garden. All types of waste cannot be composted and therefore, all kind of polythene products are banded in school premises to ensure sustainability. Starting the compost production in school will take a commitment to change the status and implement for long-term change. It is important for the process to continue even if students and teachers move on school. The project addresses the students in classroom not only with knowledge but also starting to give practical knowledge to find other technologies to heal the world.

PROJECT IMPLEMENTATION

As a strategy to reduce waste, the school has already introduced normal composting method for students. As the initial step of the BSFL composting project, involvement of all students can be obtained by dividing them into small groups. Food waste and fruits waste will be incorporated in bins having a capacity of 10 kg with holes at the bin surface. The experiment will be performed in three replicates. The ovipositing BSFs come from the natural surroundings. The bins will be incubated in natural environmental conditions. The experiment will be performed till 60 days after which the whole waste will be converted into manure. BSFL composting programme would encourage students to prepare waste treatment bins using BSFL in their classroom and household level. Maintaining data recording book, including how much of organic waste is added to the bin, is under the supervision of class teacher**.** The project will be monitored throughout the year and reduced amount of organic manure can be measured and incorporated to the school farm as an organic fertilizer. The project confirms the application potential of the BSF in solid waste management.

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Author:

Theja Kaushalya: Teacher of Kuli/Moragane Maha Vidyalaya, Moragane. She holds B.Sc. (Agric.) [Second Class Upper Division] from WUSL (e-Mail: *mgmtheja@gmail.com*)

Reviewer:

Wajira K. Balasooriya: Senior Lecturer, Department of Biotechnology, FAPM, WUSL. Her teaching and research interests include: Industrial Microbiology and Biotechnology, Environmental Biotechnology, Agricultural Chemistry and Molecular Techniques (e-Mail: *wajirab@wyb.ac.lk*)

FORMULATING A STABLE PRICE FOR COCONUT TO OVERCOME ADVERSITIES OF PRICE VARIATIONS

Brian Milroy Peiris

Udapussellawa Plantations PLC, Yatawatte Estate, Yatawatte, Matale, 21300

INTRODUCTION

Coconut (*Cocos nucifera*) is a plantation crop, a major food source and an income earner for the country. The crop production is co-related to the weather pattern, especially the distribution pattern of the rainfall. Consequently, there is a marked contrast in cropping pattern due to climate change (Ranasinghe, 2009). Wide fluctuations in the crop are adversely affecting the pricing levels when considering the interests of the growers, processors and the consumers.

Current Status in Sri Lanka

In 2019, the crop production showed a sharp increase and the price of fresh coconut a sharp decrease. Consequently, producers could not meet their production costs. In 2017 and 2018, the coconut production was low (Table 1). Prices escalated as a result (Progress Report, 2018), and processers could not keep their produce prices at a competitive level in the international market, thus losing their market share. Increased demand to produce desiccated coconut resulted in a scarcity of coconut for the local consumers, who paid a high price to purchase coconut.

Table 1: Coconut Production in Sri Lanka 2017 - 2020

Year	Production (Nuts in Million)	Farm-gate (Auction) Price (Rs.)	Market (Retail) Price (Rs.)
2017	2,445	48.62	70.70
2018	2,623	45.55	70.76
2019	3,106 - Forecast	27.55	Not Available
2020	1,986 - up to August - Forecast	45.68 – end January	Not Available

Sources: Progress Report, 2018 (Ministry of Plantation Industries); Coconut Research Institute of Sri Lanka; Coconut Development Authority

Justification

Though a sharp increase in prices was observed in the second half of 2017 and the first half of 2018, the year to-date, farm-gate price for the respective years were Rs. 56.59 and 57.06, respectively in Yatawatte Estate (Figure 1) and Rs. 48.62 and 45.55 at the Colombo Coconut Auction (Progress Report, 2018). It indicates to the high degree of monthly price fluctuation contributing towards the diminishing market share.

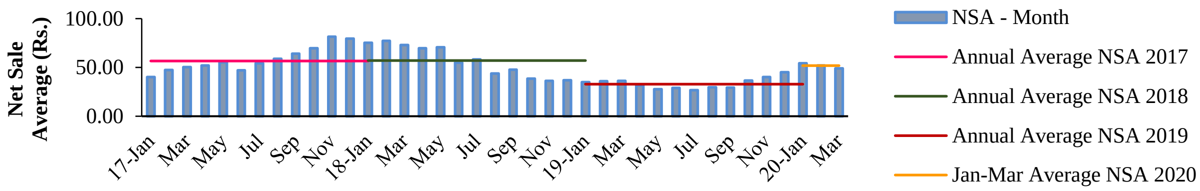

Figure 1: Fluctuation of Monthly Net Sale Average (NSA) against Annual NSA in Yatawatte Estate

Losing the market share has a devastating effect for 2020. Processors have to restrict production due to the decline in orders. High production costs of processing units due to increases in fixed costs have compelled them to purchase coconut at a lower price. With a very low crop production in 2020 due to the dry conditions in 2016 and the first half of 2019 and low market prices which does not meet the production costs, the growers are facing hardship in maintaining their land. Restricted work has brought hardship on employees. Some parts of the country experiences high consumer prices due to reduced coconut supply. This accentuates the necessity of the government mediation in price stabilization in fairness to all parties concerned.

PRICE FORMULATION METHODOLOGY

Historical data are collected on market information and price inflation of other coconut producing countries, production costs of local growers and processing units, and inflation in Sri Lanka. Production costs, technological advancements and future production capabilities of competing countries are collected as additional information in case these become a factor in determining international pricing levels, but not considered in the present price formulation. Forecasts are made for future international market prices, price inflation, local production costs, and inflation rates. An average of a 4-year production cycle is considered as an annual baseline.

Local FOB price is set keeping in line with forecasted annual price levels in the international market. The proportion of production costs for the grower and processor is derived. Considering the set FOB price and cost proportions a formula is worked out for future annual farm-gate prices of a kilo of fresh coconut (Figure 2).

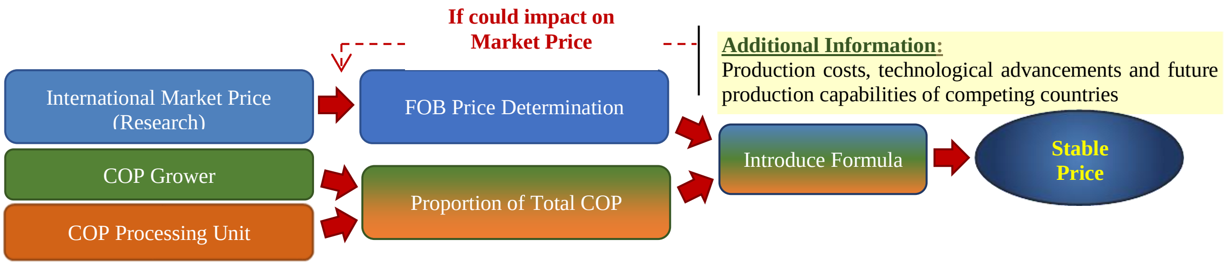

Figure 2 : Price Stabilization Framework

STABILIZED PRICE IMPLEMENTATION

Due to seasonal fluctuations of crop, the processor and especially the grower would feel temporary economic shocks from time to time. They would be able to overcome these shocks within the 4-year cycle, as the markets for produce would be intact due to price consistency. Price consistency would enable better organization of operational activities. The production cost of the grower is forecast considering the inflation rate of the country, but the wage factor is highly volatile when considering the plantation sector.

Formula is based on competition from international market factors, and pricing does not consider the interests of the local consumer. The local consumption is assumed to be consistent and to be free of competition due to market protection mechanisms in the country. The FOB price forecasts are based, assuming the international pricing to be dependent on market demand. Shocks of short supply due to adversities of weather will be transferred to the local consumer, which should be negated through imports if felt in unprecedented levels.

The pricing formula is dependent on accurate production and market information. Information must be gathered from different sources and verified to produce accurate and reliable data. To obtain recent historical data a considerable time is needed. Obtaining current data from statistical sources of different origins and consolidating them is time-consuming. Historical data already exists with statistical sources. Gathering further market information and data verification could be completed within 6 months of the project implementation. With adequate data at hand a pricing mechanism could be formulated.

The export earnings of the country, profit margins of the grower and processing units, the wage structure of the employees and the consumer price levels at the retail market would be monitored during the next 4-year period. Variations can be measured and analyzed with past conditions, and success evaluated by a comprehensive Benefit-Cost Analysis.

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Author:

Brian Milroy Peiris: Estate Manager attached to Finlays Tea Estate Lanka PLC. He holds B.Sc. (Plantation Management) [First Class Hons] from WUSL and counts experience in tea, rubber and coconut cultivation and management (e-Mail: *brian.bmp@finlays.net*)

Reviewer:

Keminda Herath: Professor in Applied Statistics, Department of Agribusiness Management, FAPM, WUSL. His teaching and research interests include: Statistical Inference, Project Analysis & Management and Time Series Econometrics (e-Mail: *kemindaherath@gmail.com*)

AN EASY TO USE VERMIWASH UNIT TO PRODUCE NUTRIENT RICH FOLIAR FERTILIZER USING DOMESTIC WASTE

Punya Sanjeewani Dissanayaka

Kadigawa Maha Vidyalaya, Kadigawa, Nikaweratiya, 60470

INTRODUCTION

Foliar feeding is a technique of feeding plants by applying liquid fertilizer directly to the leaves. Plants can absorb essential elements through epidermis and through stomates of leaves. Transport is usually faster when absorbed through the stomata, however, total absorption may be higher through the epidermis. In addition, plants are capable to absorb nutrients through their bark. Foliar applications are being used to avoid the problem of leaching-out in soils and to prompt a quick reaction in the plant. A mid-season foliar spray of fertilizers will balance and complete plant nutrition that help to retain healthy and fruitful growth. A relatively small amount of fertilizers applied through leaves can lead to dramatic improvement of crops to achieve optimal growth curves (Nath *et al.*, 2009).

Foliar uptake of nutrients is much faster than root uptake. Therefore, foliar feeding is suitable when nutrient deficiency symptoms appear, and prompt correction of deficiencies is required. A precise timing of foliar nutrition leads to growth and yield improvement. Certain phases of plant development are highly important in determining the final yield. Foliar nutrition supply during these specific phenology stages ensures optimal growth and the best possible yield. In relatively low concentrations at these critical stages, foliar nutrition boosts physiological processes of the plant, ensures optimal development, and contributes significantly to higher yields and better quality (Zambare *et al.*, 2008).

VERMIWASH

Vermiwash is a liquid extract of organic waste material, which is collected after the passage of water through an earthworm culture in the same material and different layers of filters. It is a collection of excretory products and mucus secretion of earthworms along with micronutrients from the soil organic molecules. These are absorbed by roots and transported to the leaf, shoots and other parts of the plants in the natural ecosystem.

Justification

Presently, the use of chemical fertilizers is rapidly increasing in agriculture, which can ultimately destroy the fertility of soil. The hazardous effect of chemical fertilizers can be reduced using organic fertilizers. Vermiwash can protect the environment by replacing chemical fertilizers. It is a liquid with major nutritive and enzymatic elements required to promote plant growth.

Vermiwash contains plant growth hormones like auxins and cytokinin in addition to nitrogen, phosphorus, potassium and other macro and micro nutrients. It contains Nitrogen fixing bacteria like *Azotobacter* sp., *Arobactericum* sp. and *Rhizobium* sp. and some phosphate solubilizing bacteria (Table 1).

Table 1: Composition of Vermiwash

Component Type	Examples
Plant Hormones	Cytokinin, Auxin
Macro and Micronutrients	Nitrogen, Phosphorus, Potassium, Sodium, Calcium, Ferrous
Microorganisms	*Azotobacter* sp., *Arobactericum* sp., *Rhizobium* sp.

Vermiwash acts as a plant tonic and helps to manage many plant diseases. A mixture of vermiwash (1 L) with cow urine (1 L) in 10 L of water acts as bio-pesticides and liquid manure. Additionally, there are other major benefits such as increasing the rate of photo synthesis in crop/plant, population of micro-organisms in the soil, resistance to pest and diseases and increasing rate of decomposition of compost resulting in crop yield enhancement.

Principle of Vermiwash Preparation

Worm worked soils have burrows formed by earthworms. Bacteria richly inhabit these burrows that are named as drilospheres. Water passing through these passages washes the nutrients from these burrows to the roots to be absorbed by plants. This process is applied as the principle in preparation of vermiwash by allowing water to percolate through the tunnels made by earthworms in the kitchen waste and cow dung substrate kept in a plastic barrel. Water is supplied to fall drop by drop from top of the barrel (Figure 1).

ESTABLISHMENT OF THE VERMIWASH UNIT

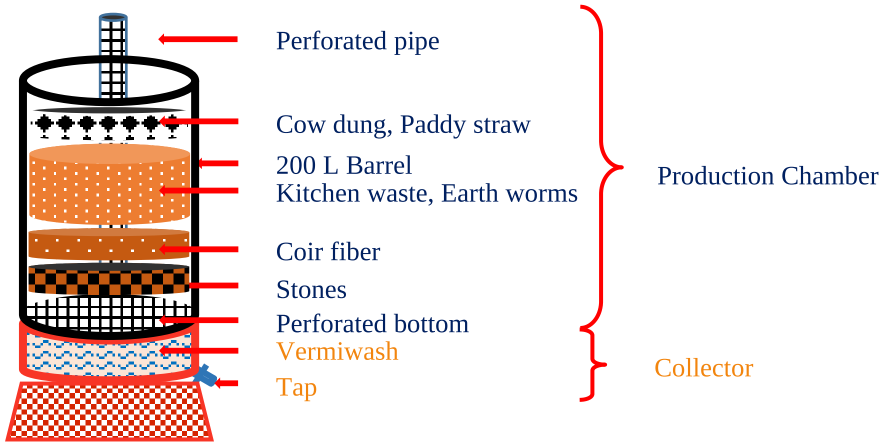

Figure 1: Vermiwash Unit

Vermiwash units can be established either in barrels or in buckets or even in small earthen pots using above principle. The design discussed here is made using two empty 200 L plastic barrels (Figure 1). First one with a completely removed lid and a bottom with drilled holes to be used as the production chamber. Other one has to be cut into two parts and the lower part will be used as the collector. First, drill holes at the base of the production chamber. A hole should be drilled at the base of the collector to fix a tap. Subsequently, production chamber has to be mounted on top of the collector. A layer of gravel must be placed on the base of the production chamber up to a height of 10-15 cm. On top of the gravel layer, a layer of coir fiber followed by layers of kitchen waste and organic litter (*i.e*. cow dung, paddy straw, *etc*.) should be placed. However, residues of citrus, onion, meat, oily foods and over cooked foods should not be included in kitchen waste layer. Moistening is essential before adding each layer. Consequently, after introduction of about 2000 earthworms into the production chamber vermiwash unit must be kept in a shaded place.

Vermiwash Collection

About 5 L of water must be supplied to the system daily. During first 15 days, water should be drained out through the tap without collection. After the first 15 days, vermiwash can be allowed to fill in the collector. Every day, about 3 - 4 L of vermiwash can be removed from the collector.

Application on Crops

Collected vermiwash can be diluted in water in 1:8 ratio and sprayed on the foliage of crops.

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Author:

Punya Sanjeewani Dissanayaka: Government Teacher for Agri Science. She holds B.Sc. (Agric.) [Second Class Hons.] from WUSL and currently engages in teaching and research in the field of Agriculture (e-Mail: *punya.sanjeewani11@gmail.com*)

Reviewer:

Bandula Ranaweera: Senior Lecturer, Department of Horticulture and Landscape Gardening, FAPM, WUSL. His teaching and research interests include: Plant Protection, Pest Management, Biorationals, Bio Pesticides & Bio Fertilizers and Toxin-Free Crop Production (e-Mail: *branaweera@gmail.com/branaweera@wyb.ac.lk*)

NETTING SUPPORT METHOD FOR HIGHER PRODUCTIVITY IN LONG BEAN

Samindra Nilmini Semasingha

Department of Agriculture, Seed Testing Laboratory, Mahailluppallama, 50270

INTRODUCTION

Long bean (*Vigna unguiculata*) of family Leguminosae is one of the most highly consumed and cultivated vegetable crops in Sri Lanka. As a vine crop, the quality and quantity of harvest is directly associated with the cultural practice of training the plant to trellises. From the past until now farmers have been using natural material such as wooden stakes as trellises to train long bean vines. Presently, farmers have a challenge in supplying enough wooden stakes for long bean cultivation. As a solution, Crop Climbing Netting Support (CCNS) method offers an alternative to use a net between minimum numbers of wooden stakes in the field instead of using a large number of stakes. This method also improves the yield per unit area and yield quality while facilitating easy maintenance.

Project Justification

Usually, around 18,150/ha of wooden stakes are required for long bean cultivation. Long bean is a seasonal crop with a 3-month crop duration. In every three months, the damaged stakes have to be replaced or new stakes should be installed. Due to this reason there is a rising threat on woody trees and forest patches as farmers tend to cut down more woody branches and transport them out of the habitat to be used as wooden stakes. Therefore, the CCNS method may reduce the threat on environment due to the minimized use of wooden stakes. In CCNS method, used shark nets (used for fishing shark) can be used and those can be purchased from fishermen at a low price. Once fishermen are ready to dump their nets farmers can purchase them and this practice would also reduce the amount of nylon residues depositing in the environment.

Wooden stakes can be used in fields only for three cultivation seasons. However, with this CCNS method, stakes can be continued approximately for seven cultivation seasons which is economical and environment friendly.

Another advantage of shark nets is that they can also be used for other crops such as cucumber, bitter gourd, watermelon and luffa (Long Bean Netting, 2018).

Project Constraints

Although the use of shark nets is beneficial than using wooden stakes, farmers have to face several problems in supplying the material in ways, such as the availability of nets is low in the interior of the country, and the farmer has to spend a considerable amount of cash to buy shark nets for the first time, inability to afford brand new nets, and poor availability of the nets when demand is high.

Project Dependencies

In order to implement the project, the potential farmer categories have to be identified. This new method can be more applicable on long bean seed producing farmers and commercial long bean producers than on small scale farmers. Long term suppliers are necessary for the long run of the project.

PROJECT IMPLEMENTATION

CCNS Method has been introduced to the long bean seed producing farmer groups at Sripura village in the Trincomalee district by Bathalagoda Agro (Pvt) Limited. The company's objective is to buy quality seeds from the farmers who are using the CCNS method.

In order to understand the performances, a comparison of income and cost between the conventional and CCNS long bean cultivation methods has been done in Table 1. Information was gathered from farmers who followed the CCNS method. The listed values are corresponding to one quarter of the cropping field.

Table 1: Profit Analysis of Long Bean Cultivation (for 25% of the Cropped Field)

Staking Method	Cost (Rs.)	Income (Rs.)	Profit (Rs.)
Conventional method	77,280.00	96,000.00	18,720.00
CCNS method	87,000.00	156,000.00	71,400.00

According to Table 1, CCNS method had recorded Rs. 52,680 higher profit than the conventional wooden staking method. Although, setting up the CCNS was costlier than the conventional approach, the income earned was almost double of what was obtained from the conventional method. This is due to the low expenses/costs incurred during maintenance of the crop under CCNS method. When CCNS method is adopted, one labour is sufficient for field work and machines can be used for weeding. In addition, easy application of pesticides and fertilizers and hazel free harvesting can be achieved.

Figures 1 and 2 are pictorial examples of conventional and CCNS methods, respectively. It is clear that the space between two wooden stakes is well utilized by the CCNS method (Figure 2). This feature helps gain high productivity of the crop and reduces post-harvest damages.

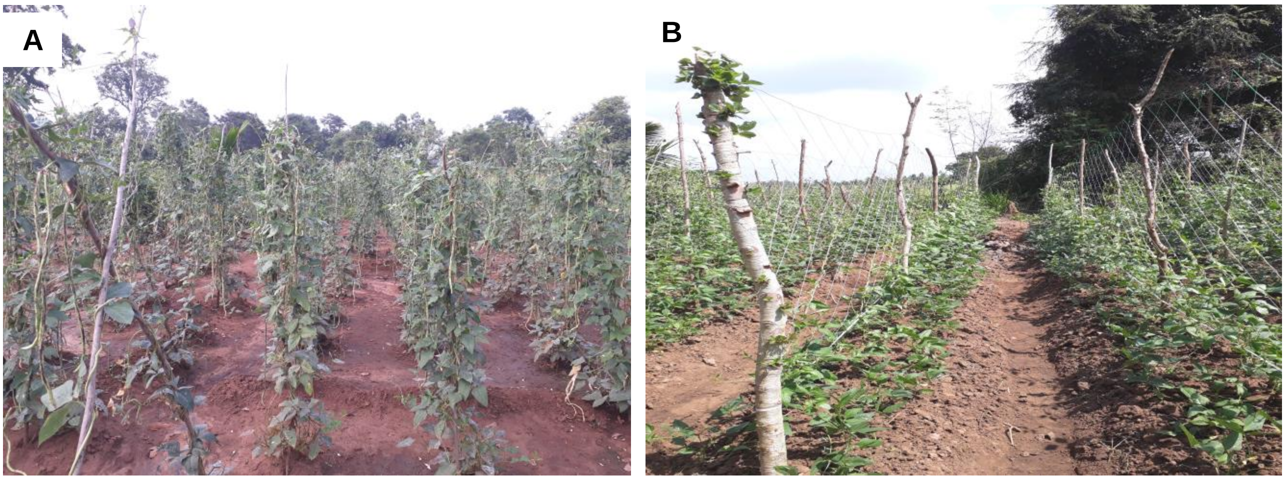

Figure 1: Cultivation of Long Bean with (A) Conventional Method and (B) Crop Climbing Netting Support (CCNS) Method

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Author:

Samindra N. Semasingha: Technical Assistant at Seed Testing Laboratory, Mahailluppallama. She holds B.Sc. (Plantation Management) WUSL (e-Mail: *shasamindra@gmail.com*)

Reviewer:

Surantha Salgadoe: Senior Lecturer, Department of Horticulture and Landscape Gardening, FAPM, WUSL. His teaching and research interests include: Crop Remote Sensing, Precision Plant Pathology and Crop Production Technology (e-Mail: *surantha@wyb.ac.lk*)

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Master of Agri-Enterprise and Technology Management, Wayamba University of Sri Lanka

FLORICULTURE INDUSTRY: A CASE STUDY OF DEMAND AND SUPPLY ANALYSIS IN COLOMBO DISTRICT

Ruwini Wilasinie Gomes

Henarathgoda Botanical Gardens, Minuwangoda Road, Asgiriya, Gampaha, 11000

INTRODUCTION

Cultivation of flowers for various religious and cultural festivals has existed in Sri Lanka for many decades. It was only after the British rule that floriculture really came into practice not as an industry but mainly as a hobby for pleasure by the rich and famous. Later with many new introductions of tropical plants, the trend was gradually passed down to other levels of society. Presently, Western, North Western and Central provinces in Sri Lanka are the major areas where cut flowers are grown commercially (Padmini, 2017). Cut flowers grown in the country can be divided into two main categories based on their temperature requirements, such as temperate cut flowers and tropical cut flowers (Reid, 2009). Temperate cut flowers include carnations, roses, statice, *Gypsophila*, *Alstroemeria*, chrysanthemum, lilies and iris. Anthuriums and orchids are the most popular tropical cut flowers which are being grown commercially for exports as well as for the local market. The cut flower market in Sri Lanka has not been able to create auction centres as many other countries have done. Retail outlets scattered through production areas are the popular centres where cut flowers are sold.

Justification

Floriculture, or flower farming, is a discipline of horticulture concerned with the cultivation of flowering and ornamental plants for gardens and for floristry, comprising the floral industry. The development, via plant breeding, of new varieties is a major occupation of floriculturists. Floriculture crops include bedding plants, houseplants, flowering garden and pot plants, cut cultivated greens, and cut flowers. As distinguished from nursery crops, floriculture crops are generally herbaceous (Prasad and Kumar, 2013). It is a high income generating agri-business and can open up unlimited opportunities to growers in Sri Lanka encompassing both domestic and international trade. Consumers buy floricultural products because of traditions, culture and lifestyle. Buyers require products with constant quality, price and added value. Therefore, a study was conducted to find the present status of supply of cut flowers and the demand of cut flowers in the local market. The demand for flowers has two components such as steady component and a seasonal component. The steady demand for flowers comes from the use of flowers for religious purposes, decoration of homes and for making garlands and wreaths. The bulk of seasonal demand comes from festivals and marriages and is generally for specific flowers.

Project Constraints

Limited availability of literature and lack of data sources are the main barriers for this study.

PROJECT IMPLEMENTATION

The data were collected from 25 sales outlets in Colombo District. Random sampling technique was applied to gather the appropriate data. Personal interviews were conducted using a questionnaire. Floricultural products contain a wide variety, such as wreaths, bouquets, bunches, garlands and table decors. In this study, we considered about eight flower varieties majority of which were grown in the up country region, such as *Gerbera*, *Alstroemeria*, chrysanthemum, daisies, lilies, roses, orchids and anthurium. According to gathered data *Gerbera* flower has the highest demand and anthurium gets the lowest whereas *Gerbera* has the highest supply and anthurium gets the lowest.

According to Figure 1, supply is insufficient to fulfil the demand throughout the year except for a few months. Thus, the supply should be improved to meet the demand. In floriculture sector, the limited supply is resulted as the growers do not apply correct postharvest techniques. Most of them do not have appropriate storage facilities and therefore, the vase lives of the cut flowers get reduced and the quality of flowers is not good as consumer caters. It is required to educate the growers to use appropriate facilities and they should be trained to improve the supply to meet the demand. To minimize the postharvest losses of cut flowers, they can modernize the process and supply flowers to the latest trendy markets, such as using dried flowers, making cards, *etc*.

In Colombo district there is an opportunity to cater the market with orchids and anthuriums. Thus, it is necessary to improve the quality and the quantity for those two flower types to meet the demand.

According to the growers, high cost of transportation and financial constraints are the highlighted barriers they faced. To eliminate above highlighted constraints and expand the floriculture sector in Sri Lanka, establishment of financial assistance programmes, provision of tax free vehicles, establishment of an efficient marketing system similar to other agricultural sectors, establishment of a separate institute for research and promotion of floriculture products in local and international markets can be suggested.

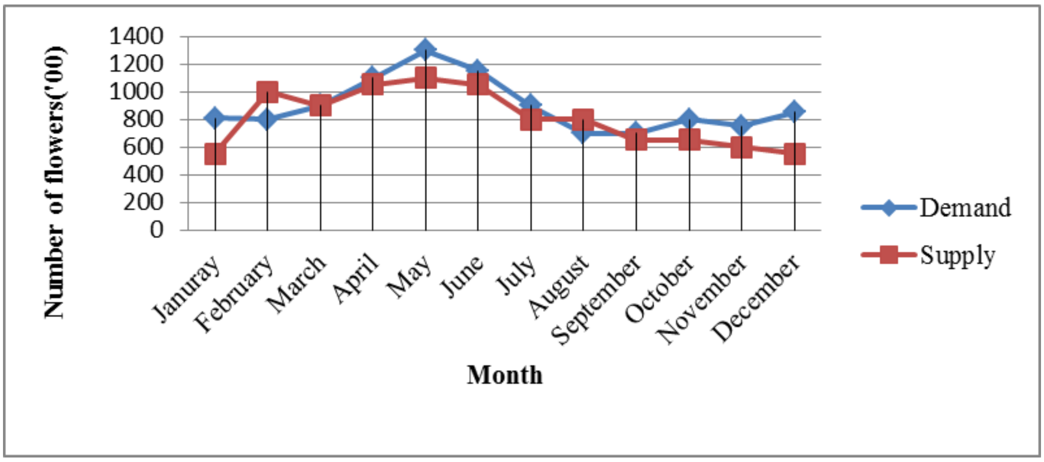

Figure 1: Demand and Supply for Cut Flower Products

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Author:

Ruwini Wilasinie Gomes: Assistant Director at Henerathgoda Botanical Gardens, Gampaha. She holds B.Sc. (Hons.) Botany (Sp.) from University of Colombo (e-Mail:*ruwiniwilasinie@gmail.com*)

Reviewer:

Wishwajith W. Kandegama: Senior Lecturer, Department of Horticulture and Landscape Gardening, FAPM, WUSL. His teaching and research interests include: Food Quality and Safety, Food Processing, Organic Farming and Eco-Friendly Plant Protection Systems (e-Mail: *wishwajith@wyb.ac.lk*)

STRATEGIES TO MINIMIZE RISKS ASSOCIATED WITH IMPORTED SEED POTATO

Subani Thenuwara

National Plant Quarantine Service, Canada Friendship Road, Katunayake, 11450

INTRODUCTION

Potato (*Solanum tuberosum* L.) is a perennial root vegetable in the family Solanaceae. The plant grows to about 28 - 45 cm in height and has many underground starchy tuberous roots. According to PotatoPro (2020), Sri Lankans consume 228,000 t of potatoes annually, and the per capita consumption of potato has increased by more than 5 kg in the last 14 years.

Justification

In Sri Lanka potato, has become an increasingly popular agricultural crop, especially among upcountry farmers, due to amplified consumer demand over the years and its shorter lifespan compared to other field crops. Both these reasons have placed potato at the top as a good cash crop in the country.

In 1948, the Department of Agriculture (DOA) began working on potatoes. The production is now successfully established in four regions; Nuwara Eliya, Badulla, Jaffna and Puttalam. However, only 35 percent of the requirement has been produced locally. Weather, poor storage conditions, varying availability of good seeds and the diseases are the major problems limiting potato production in Sri Lanka (PotatoPro, 2020). On the supply side, farmers require approximately around 15,000 t of quality seed potatoes annually to meet the production. A major portion of imports arrives from European countries, such as Holland, Germany, France, Australia, Netherland and USA (Potato Imports, 2020; PotatoPro, 2020; Table 1).

QUARANTINE AS A STRATEGY

In order to comply with quarantine standards prescribed by the DOA, seed potatoes in consignments are visually inspected at the port of entry, and laboratory investigation procedures are also adopted to investigate the presence of pests and pathogens in consignments. Pathogens identified at quarantine in imported seed potatoes during the period of 2018 - 2019 are given in Table 2.

Spongospora subterranea is considered as a quarantine pathogen in Sri Lanka. Therefore, the lot identified as positive for that pathogen was rejected at the quarantine. However, other pathogens were non-quarantine regulated pathogens and they did not exceed the permissible level according to the Dutch scale. Dutch scale is an international standard for preventing diseases and maintaining quality seed production given by the Netherlands. It has been accepted by the DOA under the Seed Potato Permit Condition Act 1999. Hence, the lots identified with those non-quarantine regulated pathogens were released by the National Plant Quarantine Service (NPQS) to be used for cultivation. However, there is a possibility of introducing sub-species of those pathogens via such imports to the country which may have potential of spreading under local conditions.

Laboratory Investigation Procedures

Ten percent of seed potatoes from the whole consignment are taken randomly for visual observation to check the quality of seeds. According to the permit condition, at the same time 100 tubers are randomly separated for further laboratory testing to identify latent infected seeds. These 100 tubers are used for pathological testing. Ten tubers out of 100 tubers are taken for culturing to identify bacteria and fungi. Small segments are removed from tubers, grown on Potato Dextrose Agar (PDA) medium and incubated at 28°C for 3 - 4 days. Then, spores of mycelia growth are observed under the inverted light microscope and cultured bacterial colonies are tested for further identification using ELISA test, PCR test and Biochemical Tests.

Table 1: Potato Imports into Sri Lanka from 2010 – 2017

Year	2010	2011	2012	2013	2014	2015	2016	2017
Import Quantity (t)	129,878	130,511	110,823	123,204	118,220	142,183	148,081	133,686

Source: Department of Census and Statistics, Sri Lanka (www.statistics.gov.lk)

STRATEGIES TO BE IMPLEMENTED

During the past, fungal, bacterial, viral, phytoplasma and nematode pathogens were responsible for causing a number of major diseases. Strict adherence to plant quarantine procedure is necessary to minimize the entry of harmful organisms with seed potatoes. Importers are highly responsible for making success in the whole quarantine process.

At NPQS, quarantine pathogens are strictly prohibited from entering to the country while non-quarantine regulated pathogens are allowed since they are under permitted limits. However, there is a risk if certain sub species of non-quarantine regulated pathogens reach harmful levels with time, especially under local environmental conditions.

Table 2: Common Diseases and Pathogens Identified During the Period of 2018 - 2019

Disease	Pathogen
Netted Scab	*Streptomyces* spp
Common Scab	*Streptomyces scabies*
Soft Rot	*Erwinia carotovora*
Black Dot	*Colletotrichum* spp
Dry Rot	*Fusarium* spp
Early Blight	*Alternaria solani*
Fusarium Wilt	*Fusarium* spp
Late Blight	*Phytophthora infestans*
Powdery Scab	*Spongospora subterranea*
Black Scurf	*Rhizoctonia solani*
Robbery Rot	*Geotricum candidum*

Source: Thenuwara, 2019

Therefore, awareness programmes should be conducted for potato farmers by the Department of Agriculture on how to avoid spreading of pathogenic diseases via planting materials and about proper agronomic practices. Further, the permitted limits should be regularly updated and aligned with globally reported new pathogens. The updated information should be circulated immediately among agriculture officials, importers, and farmers who are engaged in cultivating imported seed potatoes.

Currently, the DOA is conducting a programme to enhance the production of quality seed potatoes at Agriculture Research Station, Seetha Eliya. However, the government should improve the facilities further to encourage local farmers and private sector to enhance the local seed potato production.

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Author:

Subani I. Thenuwara: Research Assistant attached to the National Plant Quarantine Service, Department of Agriculture. She holds B.Sc. (Plantation Management) from WUSL
(e- Mail: *subanitdsit@gmail.com*)

Reviewer:

Priyanwada S. Warakagoda: Senior Lecturer at Department of Biotechnology, FAPM, WUSL. Her teaching and research interests include: Micropropagation/Tissue Culture Techniques, *In vitro* Conservation and Screening Techniques and Yield Improvement Strategies for Secondary Metabolites (e-Mail: *priyanwadawarakagoda@gmail.com*)

INCREASING THE PRODUCTIVITY OF PADDY CULTIVATION IN LOW COUNTRY WET ZONE BY INTEGRATED AGRICULTURAL PRACTICES

Nuwan Navinda Edirisooriya Arachchi

Deputy Director's Office, Department of Agriculture, Sri Bodhi Road, Gampaha, 11000

INTRODUCTION

The main objective of this project is to increase the productivity of paddy lands in the Low Country Wet Zone (LCWZ) by introducing integrated agricultural techniques to minimize the cost of production of local paddy cultivation and to divert the local paddy cultivation from its current subsistence level towards a commercial agriculture business.

In the 1990s, the contribution of the LCWZ to the local production was only 20 percent and the cultivated extent was 23 percent of the whole area. Total sown extent under paddy cultivation during the 2015/16 *Maha* season in Sri Lanka was 756,000 ha out of which 7.5 percent of the extent was from LCWZ (Department of Census and Statistics, 2015). In the 2015/16 *Maha* season, the average paddy yield of the country was 4.43 t/ha but, at the LCWZ it has come down to 3.02 t. During the past decade, the total paddy production of the country has shown a decreasing trend (Figure 1). The proposed project presents a practical approach to uplift and give a new impetus to the productivity of paddy cultivation in the LCWZ in the 21st century.

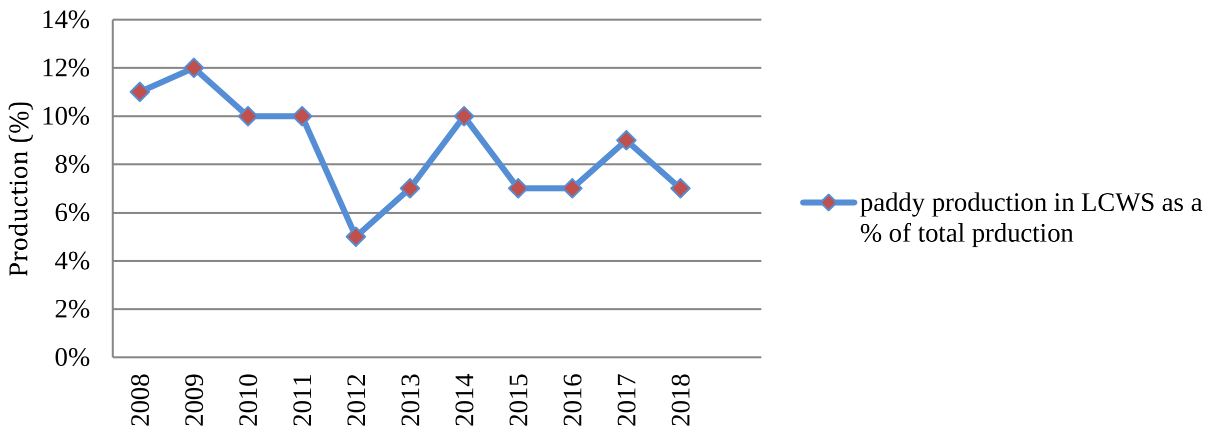

Figure 1: Low Country Wet Zone Contribution to Total Paddy Production in Sri Lanka

Justification

Food production for the growing population has become a challenge for all countries in the world. The impact of climate change on food production is enormous. LCWZ, which inherits more stable rice production despite changing environmental factors, plays a major role in seed paddy production and rice production. It is a timely necessity to maintain the LCWZ as a buffer zone for paddy production in order to ensure food security under current changing climatic conditions.

Project Constraints

The major problems associated with paddy cultivation in the LCWZ are, flooding due to improper drainage of rainwater, iron toxicity, salinity, acidity, and the existence of bog and half bog paddy fields. Also, another major challenge in paddy cultivation in this climatic zone is the shortage of suitable seed paddy for the area.

Due to the scarcity of paddy varieties, the farmers in the LCWZ use seeds of high yielding paddy varieties that are suitable only for the dry zone for their paddy fields. It causes a considerable yield loss to those farmers.

INTEGRATED AGRICULTURAL PRACTICES FOR LCWZ

The basic objective of the proposed project is to increase the availability of improved seed paddy suitable for the LCWZ. Accordingly, it is planned to produce suitable paddy seeds for fields subjected to flooding, iron toxicity and salinity, and for bog and half bog fields. It is achieved through the establishment of seed farms and encouraging farmers to produce seed paddy by themselves and utilize those in their fields.

Promoting the parachute transplanting method among farmers and providing parachute trays to farmers can help reduce their production cost of paddy cultivation, particularly through minimizing the effort on controlling weeds and diseases. When transplanting 8 - 10 days old mature plants in the field as practiced by the parachute method, it is not necessary to apply weedicides to control weeds for the next 7 - 12 days. This method of transplanting shows good repression under different soil conditions, *e.g.* salinity. This technique is also suitable for bog and half bog fields located in the area. Manual transplanting cannot be practiced in bog and half bog soils in the LCWZ due to its boggy nature. The amount of seed paddy that is sown per acre by parachute transplant method is 12 kg.

Furthermore, farmers in LCWZ face problems due to the inefficient use of nitrogen fertilizer. The application of nitrogen fertilizers over the recommended dosage may enhance pest and disease problems in the cultivation, and thereby increase the cost of production due to practicing of pest and weed control methods. Therefore, it is also planned to introduce the Leaf Colour Indicators, to understand the status of nitrogen requirement by the rice plants in order to promote efficient use of nitrogen fertilizer in paddy cultivation. Another major activity is to develop a methodology for testing soil pH to monitor soil acidity and to educate and train farmers on the use of burned paddy husks in their fields to enhance the soil fertility.

By using the above mentioned integrated farming techniques, field demonstrations were conducted in the Gampaha district during the *Yala* season in 2013 (Table 1). It was noted that the productivity was significantly influenced by practicing integrated techniques.

Table 1: Results of Field Demonstrations Conducted in Gampaha District

Gampaha Division	Paddy Variety	Cultivated Extent (m^2)	Yield (kg)	Productivity (t/ha)
Minuwangoda	Bw 272-6b	4,000	1,200	3.00
Andiambalama	Bw 272-6b	4,000	1,200	3.00
Galahitiyawa	Bw 367	4,000	1,400	3.50
Nittambuwa	Bw 367	4,000	1,500	3.75

PROJECT IMPLEMENTATION

It is recommended to obtain the support of all pilot companies contributing to agriculture from farmer organizations to the national level. Innovations are to be implemented by identifying the fields with relevant problems, especially by the Extension Officers of the Department of Agriculture and the Field Officers of the Agrarian Services Department. Awareness and adaptation to innovations would be given to the farm organization level through demonstrations at the field days. Conducting of crop cutting surveys and obtaining of yield data will be done through the extension agents.

Due to the problems discussed above, the productivity of paddy in LCWZ remains between 2.0 - 2.5 t/ha. By using the above mentioned integrated farming techniques in those areas, the cost of production will be reduced and the yield will be increased up to 3.5 - 4.0 t/ha. Therefore, this project will help to increase the productivity of paddy lands in the LCWZ, boost the economy of the farmers who serve the country and build a prosperous LCWZ.

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Author:

Nuwan Navinda Edirisooriya Arachchi: Agriculture Instructor, Department of Agriculture, Western Province. He holds B.Sc. (Plantation Management) from WUSL and HNDT (Agric.) from SLIATE, Naiwala and is currently engaged in Advisory and Extension Activities in Agriculture Sector (e-Mail: *nuwannavinda430@gmail.com*)

Reviewer:

Radhika Gimhani: Senior Lecturer, Department of Biotechnology, FAPM, WUSL. Her teaching and research interests include: Plant Biotechnology, Molecular Plant Breeding and Gene Mapping (e-Mail: *dgimhani@wyb.ac.lk*)

A STRATEGY TO OVERCOME PROBLEMS RELATED TO CONVENTIONAL FEEDING OF IMPORTED DAIRY CATTLE

Srimal Pathirana

National Livestock Development Board, No. 40, Nawala Road, Narahenpita, Colombo 05, 05000

INTRODUCTION

Quality forage production and conservation practices are critical to maintain a good dairy project. The quantity and quality of pasture given to an animal is an important factor in increasing the production capacity of animals, maintaining health and avoiding many breeding problems. High producing dairy cattle imported from Australia are maintained by the National Livestock Development Board (NLDB) at Menikpalama, Bopaththalawa, Dayagama, and Ridiyagama farms. Identifying the issues related to the quality and quantity of pasture supplied to animals can increase the national milk production by increasing the daily quantity of milk obtained from one cow. The main objective of this project is to save US$ 295 million of foreign exchange on imported milk powder (Central Bank Report, 2019; Figure 1).

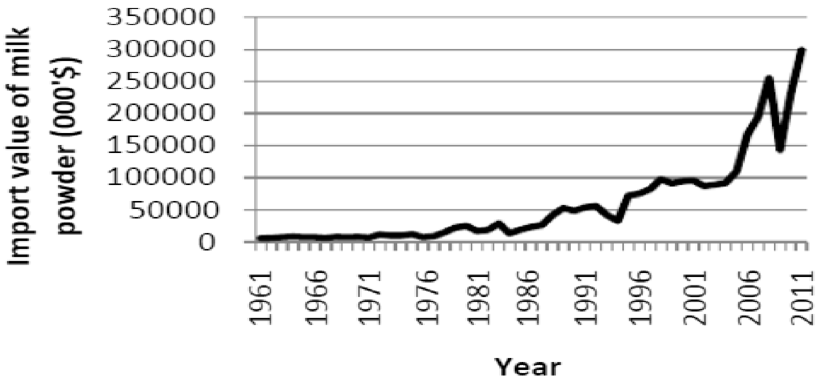

Figure 1: Value of Imported Milk Powder from 1961 - 2011
Source: Mendis and Edirisinghe, 2014

Justification

Inferior quality of the animal feed leads to poor production performances and breeding issues in dairy cattle in Sri Lanka. Introducing suitable fodder varieties and feed preservation techniques will help to reduce the current issues. Identifying and addressing the problems of quality and quantity in the production of silage and forage feed will help to improve local milk production by solving the problems of feeding animals of the superior breeds imported to Sri Lanka. Introducing bunker type and bail type silo making will improve the quality of the existing fodder varieties and give better outcomes with improved fodder crops (Bal *et al.*, 1997). Developing feed producing farms or community will enhance the national feed resources and lead the line of advanced feeding for cows. Conventional silage is low in nutrients and high in losses of nutrients in silage making. New improved silage production process to produce nutritionally compact and nutritionally enriched silage (TMR silage) using alternative low cost feed ingredients for the use of dairy sector in Sri Lanka is needed. Development of an advanced feeding system for cows has proven records with the farms at Bopaththalawa, Menikpalama, Dayagama and Ridiyagama with imported cow herds (Figure 2).

Project Constraints

The NLDB has to face some issues, such as project constraints and significant restrictions. Finding additional capital and lack of necessary machinery and equipment are the main issues. Apart from that, lack of technical personnel in the subject, labour problems and shortage of workers need to be addressed. Due to its topography, the maximum effective use of machinery is limited in Sri Lanka. Other constraints include, increased input costs due to periodic changes in public policy, climatic changes and its adverse impact, and finding solutions to emerging infrastructure problems. The expected grass yield is difficult to be obtained due to the reduced soil pH and soil fertility as a result of increased soil erosion.

PROJECT IMPLEMENTATION STRATEGIES

Usage of good planting materials, recommended fertilizers, feeding the cattle according to the animal's weight basis are important criteria. Other strategies include, transportation of the harvested grass silage in short time, cutting and chopping the grass according to the standards, filling and pressing, closing the pit immediately after filling, and completing the process within three or four days ensuring no leakage of air (Figure 2).

Project Dependencies

The project will benefit the Ministry of Agriculture, National Livestock Development Board and the suppliers of raw materials and planting materials. Services of maintaining machinery and equipment, workers involved in silage production, supervision and monitoring officers are also benefitted.

PROJECT BENEFITS

This project is expected to be implemented from 2021 and the following benefits are expected. Production and supply of quality and quantitative silage and forage will solve the feeding problems of animals, produce healthy offspring and reduce the mortality rate. This will increase the number of calves issued to farmers. Further, increasing the amount of milk produced by animals will increase up to the optimum level from 1.2 L to an average of 12 L/cow/day. Practicing advanced feeding will lead to improve the national cow population as well as the production parameter. Developing local food resources will reduce the cost of importation of raw materials.

Figure 2: Steps of Silage Production (A) Maize cultivation, (B) Harvesting, (C) Chopping, (D) Pressing and (E) Sealing

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Author:

Srimal Pathirana: Manager, National Livestock Development Board. He holds B.Sc. (Agric.) Degree from University of Peradeniya (e-Mail: *pathiranasrimal@gmail.com*)

Reviewer:

Dileepa de Croos: Senior Lecturer attached to the Department of Aquaculture and Fisheries, Faculty of Livestock, Fisheries and Nutrition, WUSL. His teaching and research interests include: Marine Biology, Marine Ecology, Fisheries Management and Population Genetics (e-Mail: *dileepa_dc@yahoo.com*)

DYNAMICS OF PRODUCTION AND PRICE COMPETITIVENESS OF CEYLON TEA IN THE WORLD MARKET

Tharaka Gunawardena

Sri Lanka Tea Board, No. 574, Galle Road, Colombo 03, 00300

INTRODUCTION

The tea industry in Sri Lanka still continues to occupy a vital role in the economy of Sri Lanka in terms of government revenue earnings and foreign exchange earnings even though relative contribution has declined in recent years (Central Bank of Sri Lanka, 2018). The industry also provides direct and indirect employment nearly to one million people. Currently, Sri Lanka is positioned as the fourth largest tea producer in the world and has become the third largest tea exporter (Tea Exporters Association of Sri Lanka, 2017). Tea is the most consumed beverage in the world next to water and Ceylon tea thrives in the international market because of its world renowned taste and aroma. Price competitiveness has become a key indicator of market stability and describes the dimensions like profitability, resource usage efficiency and productivity of a producer when compared with other producers in a particular market.

Significance of the Project

Annual tea production records of the past 10 years indicate that the Ceylon tea production has been on a declining trend, while the tea prices were subject to significant fluctuation, with other productivity and marketing related issues (Table 1). Although it seems challenging to face such multiple problems, it is a necessity to restructure the industry in view of achieving the global competitiveness for a long-term sustainability in the world market. Considering the above facts, it is essential to identify the changing effects of tea production to evaluate the upcoming trends in the export market and understand the price competitiveness in the world market.

Table 1: Annual Tea Production (t) and Net Sales Average (NSA) (Rs/kg) for the Past 10 Years

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Tea Production (t)	331,426	327,533	328,397	340,028	338,031	328,771	292,574	307,720	303,944	300,121
NSA	370.61	359.89	391.64	444.42	461.86	402.07	468.62	618.18	581.93	544.54

Source: Statistical Data, Sri Lanka Tea Board

Justification

The secondary data on revenue generated from tea exports after purchasing from the Colombo Tea Auction, along with individual country-wise revenue gained will be collected. The data will then be systematically analysed. The strategic approaches for marketing of tea and the potential foreign markets need to be identified based on the analysis. The process will enable the tea exporters to identify their drawbacks to obtain a higher price for tea, to create plans to overcome the situation and to direct them on how to enter the international market through a sustainable and cost-effective manner. The project will further focus on enhancing the price competitiveness of Ceylon tea by improving productivity with cost reduction.

Limitations

The prices at the Colombo Tea Auction depends on 10 major exporters/buyers as they are the active buyers and contribute more than 30 percent of the total volume. These exporters/buyers are the main decision makers at the Colombo Tea Auction, which is the major constraint of the project. The high cost of raw materials which are used in value-added tea production is another constraint. There exists an undesirable trend on undervaluing the selling price (CIF-Cost, Insurance and Freight for the importing country) or FOB price (Free On Board for the exporting country) in the customs declaration. This also creates a difficulty of collecting the accurate information on exact amounts of foreign exchange earned from tea exports.

Assumptions

It is assumed that the information disclosed in the Customs Declaration Form (price, type of tea, quantity), FOB, CIF price are not fake and the actual revenue earned is declared. The total volume of tea sold through the Colombo Tea Auction and the locally consumed quantity of tea will be assumed as the entire production during the specified period in Sri Lanka. The highest price obtained in the Colombo Tea Auction would be assumed as the maximum price a specific tea grade could achieve.

Project Dependencies

It is a considerable fact that the tea prices are dependent on the purchasing power of tea buying countries. The exchange rate is another dependent factor. Tea prices are depending on the price of the Crude oil in the world market as it has a direct impact on the purchasing power of tea in Gulf countries. Raw material prices for value-added tea production, increasing transportation charges, high production cost of tea, expenditure on specific machinery, droughts, outbreaks, riots, wars in tea buying countries are other depending factors for tea prices. Moreover, environmental factors, such as droughts and floods due to climatic changes and labour issues have a direct impact on tea production.

Project Success Evaluation

Tea exporters and tea producers are the beneficiaries of the project. The monetary benefits would be assessed using standard cost analysis methods. The findings would be disseminated to identify the drawbacks, potential for tea production, price fluctuation trends and reasons and degree of price competitiveness at the Colombo Tea Auction market. The facts will enable the main exporters to figure out the limiting factors and to make strategic approaches to enter into new markets. The broadened market potential will open new avenues to local tea growers for improving their income. Hence, this will create a new value chain and contributes to socio-economic development of the people of this country and will eventually support to strengthen the Sri Lankan economy.

ACKNOWLEDGEMENTS

The author would like to express his gratitude to the members of the Sri Lanka Tea Board and colleagues for their valuable support to make the project a success.

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Author:

Tharaka Gunawardena: Tea Inspector/Instructor attached to Sri Lanka Tea Board, possessing 15 years of service experience. He holds B.Sc. (Plantation Management) from WUSL and NDT (National Diploma Technology) in Agriculture (e-Mail: *thrakagunawardena@gmail.com*)

Reviewer:

Bandara Gajanayake: Senior Lecturer, Department of Plantation Management, FAPM, WUSL. His teaching and research interests include: Tea Production and Marketing, Climate Smart Agriculture and Resource Management in Plantations (e-Mail: *gajawyb@yahoo.com*)

MANAGEMENT OF BULK FERTILIZER STORAGES FOR MINIMIZING WASTAGE DUE TO DELIQUESCE

Shantha Nimal Amarasiri

University Experimental Station, Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Kundasale, 20168

INTRODUCTION

Fertilizers are hygroscopic in nature. They adsorb moisture from the atmosphere if the atmospheric relative humidity (RH) is higher than the individual fertilizer's Critical Relative Humidity (CRH). Deliquescence **(**becoming liquid) is the process by which a substance absorbs moisture from the atmosphere until it dissolves in the adsorbed water and forms a solution. All the chemical fertilizers are deliquesce in nature. Deliquescence occurs when the vapour pressure of the solution that is formed (which is theoretically equals to CRH if expressed with respect to saturated vapour pressure as a percentage) is less than the partial pressure of water vapour in the air (Adams and Merz, 1929).

Therefore, it keeps on dissolving until the surrounding RH becomes less than the CRH, which never happens in most of the cases. Table 1 shows the CRH values for commonly used fertilizers. The lower the CRH of fertilizers more severe the problem of storing them. As an example, ammonium nitrate requires the ambient RH to be lower than 59.4% and is difficult to achieve without dehumidification. On the other hand, potassium nitrate, in which CRH is 90.5%, does not require any modified atmosphere to store them even under Sri Lankan humid conditions.

Table 1: Critical Relative Humidity of Commonly Used Fertilizers

Fertilizer	Critical Relative Humidity (%)
Calcium nitrate	46.7
Ammonium nitrate	59.4
Sodium nitrate	72.4
Urea	72.5
Potassium nitrate	90.5

Source: Adams and Merz, 1929

Justification

Because of water absorption, the fertilizer becomes sticky and difficult to handle. Bagged fertilizers and mixtures become lumpy leading to difficulties in handling and application in the field. Consumers are generally reluctant to handle wet fertilizers. Further, the loss of fertilizer and the environmental pollution due to disposal of dissolved fertilizers are major industrial concerns.

Control of ambient relative humidity to keep it below the CRH of selected fertilizers is the only solution to minimize the problem of fertilizer getting wet during storage. Out of the industrial methods in dehumidification, condensation at dew point is the most suitable method for the fertilizer storage (Figure 1).

It has following advantages compared to other industrial methods: (1) Low initial cost (2) Low running cost (3) Easy handling and controllability (4) Reliability (5) Low maintenance cost and (6) Ability to increase the capacity if the facility expands.

Assumption

The CRH of all the fertilizers and mixtures in any fertilizer storage should be measured to understand the needs of dehumidification. After measuring the CRH, the fertilizers to be dehumidified should be prioritized based on economics of its operations.

MANAGEMENT OF FERTILIZER WASTAGE IN BULK STORAGE

As a strategy, reducing the store humidity where the fertilizers are kept below CRH is the only solution to the problem. There are several industrial methods of reducing the relative humidity (dehumidification) of space. The method used often is dependent on the specific temperature and humidity conditions required in the space and the climatic conditions of the site.

The systems used in a specific application are chosen based on their effectiveness and efficiency in achieving the desired conditions. In addition, a life-cycle-cost analysis that compares first cost, operating costs, and maintenance costs is applied.

PROJECT IMPLEMENTATION

The selected dehumidifying area should be isolated from the environment by air tight partitioning. There is no need of heat insulation. It should isolate a bay in the existing fertilizer store at the premises with 44 m x 12 m dimensions where there are pillars for supporting the partition. This area has a volume of 4,646 m^3. For this volume two units of 13 kW dehumidifiers are needed.

The dehumidifiers with a technology of dew-point method will be designed, fabricated and installed in two appropriate locations inside the isolated area. The units will be capable of setting the RH as necessary depending on the fertilizer placed in the store. Typical methods of dehumidification include dew point condensation, liquid and solid desiccants, and compression.

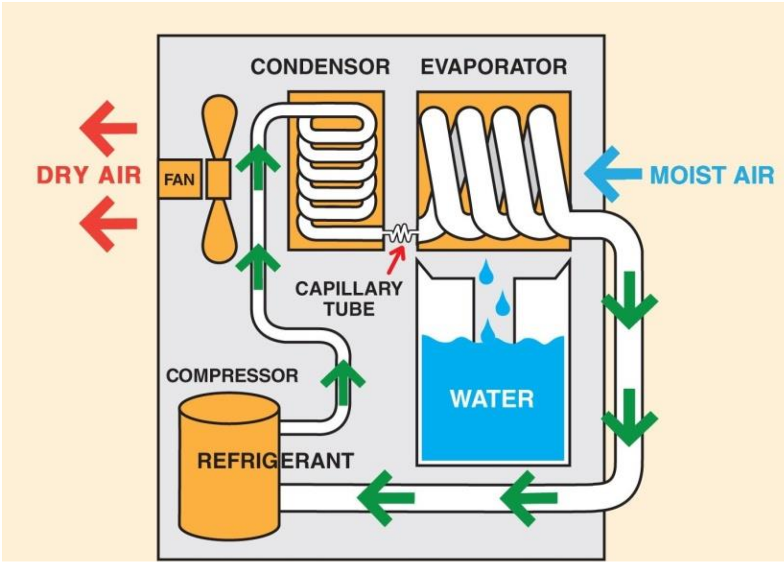

Figure 1: Principle of Dehumidification

Source: Pure and Natural Systems, 2020 (https://purennatural.com)

Project Success Criteria

The project will be implemented during the *Maha* season 2020 and monitored throughout the season. It will be evaluated using standard Benefit-Cost Analysis methods of the reduced amount of disposed dissolved fertilizers in bulk storage.

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Author:

Shantha Nimal Amarasiri: Senior Farm Manager at University Experimental Station, Faculty of Agriculture, University of Peradeniya, Kundasale. He holds a B.Sc. Degree from University of Peradeniya (e-Mail: *nimalamarasiri@yahoo.com*)

Reviewer:

Kamani Ratnayake: Senior Lecturer, Department of Horticulture & Landscape Gardening, FAPM, WUSL. Her teaching and research interests include: Postharvest Physiology & Technology and Horticultural Science
(e-Mail: *kamani.ratnayake@uqconnect.edu.au/kamani@wyb.ac.lk*)

IMPROVING THE QUALITY OF AGRICULTURE TRAINING THROUGH INFORMATION AND COMMUNICATION TECHNOLOGY AT AGRICULTURE TRAINING CENTRE, WALPITA

Chandrika Mahanada

Department of Agriculture, District Agriculture Training Centre, Walpita, 11226

INTRODUCTION

Information and Communication Technology (ICT) is rapidly developing and is being implemented steadily in various sectors throughout the world. With respect to ICT development, Sri Lanka possesses a global rank of 117 out of 166 countries and a regional rank of 20 out of 29 countries, as per the ICT Development Index (IDI) in year 2017. In addition, the country has a global rank of 76 out of 148 countries in the Networked Readiness Index (NRI) (ICT Development Index, 2017). There are a variety of ICT implementations in the Agriculture sector of Sri Lanka, namely "Krushi Advisory Service", "Agri Staff", "Govipola" and "Sri Lanka Paddy Fertilizer", which are important for the farmers (Sri Lanka E-Agriculture Strategy, 2016).

Justification

The Western Province of Sri Lanka, which has an area of 3,684 km^2 and consists of three administrative districts (Colombo, Gampaha and Kalutara) is being administrated by the Western Provincial Council of Sri Lanka. It has implemented several projects related to agriculture and the District Agriculture Training Centre (DATC), Walpita is one such project. It is governed by the Western Province (WP), Department of Agriculture. The DATC, Walpita conducts agriculture training courses to farmers, non-farmers, school dropouts and other institutes. Table 1 shows an increasing number of trainees registered annually from year 2017 to 2019.

Table 1: Training Courses and Registrations at District Agriculture Training Centre (DATC), Walpita

Training courses	2017	2018	2019
Shor term - Trainees	800	899	900
Long term - NVQ L-IV	27	26	40

Source: Student Register- DATC Walpita

Many clients frequently visit the centre to collect agriculture related information and to register for the training courses. With such background, there is a rush to manage the process which is time-consuming and thus, the clients have to stay for a long time. Usually, once the people start their training, the centre used to make a payment for them. There are occasions that the trainees register for the same course repeatedly and try to get the payment. The management does not possess a method to prevent such malpractices. Furthermore, since there was no technique to record lecture hours which is a mandatory administrative requirement, it was a critical issue for the management. Therefore, the need for introducing an Information System to manage the whole process, including registration, information, training, avoiding unnecessary payments, evaluating lecturers, auditing and removing unpopular training courses, *etc*., was recognised. As a result of these necessities, the Kiosk System has been introduced to the DATC, Walpita by the Provincial Director of Agriculture - WP as a pilot project.

PROJECT OF INTRODUCING KIOSK INTERACTIVE TOUCH PANEL SYSTEM

An interactive Kiosk is a computer terminal featuring specialized hardware and software which provides access to information and applications. It can be implemented according to the organization's requirements. Interactive Kiosks are indispensable in today's modern environment. Therefore, the management of DATC decided to implement the Kiosk System Project providing a new approach to rectify the issues and facilitate the management of the training centre (Figure 1). The clients can register for the ongoing training courses and can access through mobile devices or visit to the centre. They are able to watch related videos, learning materials, and get the prints of the documents through the Kiosk system without getting the assistance of the officers of the centre. Kiosk panel consists of registration facilities, course time table, results of examinations, ranking system, evaluations of lectures and information on latest agriculture technology, details of training centres and news portal. Many reports can be generated from Kiosk application, for example, student registration, completed course details and quarterly registered students.

From the Kiosk Interactive touch panel system, farmers and students are encouraged and motivated to acquire knowledge in a user friendly manner. The stakeholders in the WP can also access Kiosk application by mobile phones or tablets. The management has assigned qualified personnel for helping, running and updating the Kiosk system and connected network printer to take printouts free of charge for any client. The Kiosk application has been secured from malware and vulnerabilities and directly linked to the audit.

Figure 1: Kiosk System
Source: https://datc.wp.gov.lk/

There are two types of dependencies in the Kiosk application: “Finish to Start” on the registration process and “Start to Start” on the information sharing process. The whole Kiosk system can be categorised as Logical, Preferences and Resources based and it is very important to achieve success of the application and to run smoothly on any platform of the cloud hosting.

RESULTS

Because of the Kiosk system, paperwork was reduced by 80 percent, efficiency of the evaluation of lecturers and training courses was increased by 95 percent and it was able to identify popular training courses by 90 percent in 2019. The management can also control and restrict registration process for every training course. Eventually, Kiosk system could control the unnecessary expenditures by 98 percent.

The modern technological features of the interactive touch panel system “Kiosk” has advanced in line with other related ICT media and there exist an endless possibility in future to use this in agriculture training centers. The features of Kiosk system enable farmers to search important agriculture information rapidly and manage the overall training process effectively in any organization. Therefore, Kiosk systems are very important for the agriculture training centers in the country for enhancing quality of training programmes and sharing information.

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Author:

Chandrika Mahanada: Assistant Director of Agriculture, District Agriculture Training Centre, Walpita. She holds B.Sc. (Agric.) [Hons] from University of Peradeniya and her field is ICT and Agriculture Training (e-Mail: *lalanthimahanada@gmail.com*)

Reviewer:

Kanchana S. Weerasinghe: Senior Lecturer attached to the Information and Communication Technology Centre of WUSL. Her teaching and research interests include: Information Systems, Database Management System and ICT in Agriculture & Education (e-Mail: *kanwyb@yahoo.com)*

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Master of Agri-Enterprise and Technology Management, Wayamba University of Sri Lanka

DETECTION AND CONTROL OF CONTAMINANTS IN PLANT TISSUE CULTURES

Isuru Sampath

Provincial Agriculture Department - Sabaragamuwa, Muwagama, Ratnapura, 70000

INTRODUCTION

Plant tissue culture is a technique which is used to maintain or grow plant cells, tissues or organs under sterile conditions on a nutrient medium ('culture medium') of known composition. It encompasses several different applications, including the technique micro-propagation which is basically a type of vegetative propagation method used to produce a large number of clones (exact copies) of a plant ('plantlets') by means of tissue culture and then planting them out in the field. It ensures rapid propagation of a large number of true-to-type, disease-free plants in a relatively short time period which is an ideal technique applied in production of plant material, especially for large-scale commercial cultivations, such as pineapple and banana. Contaminations are the main limitation in this technique and prevention or avoiding microbial contaminations is critical for successful micro-propagation of any plant.

Present Situation

Since 2004, in order to promote and facilitate cultivation of tissue-culture derived plantlets, the Tissue Culture Laboratory of the District Agriculture Training Center (DATC), Ratnapura initiated a micro-propagation programme mainly focusing on pineapple and recently, their scope was further extended to banana varieties. Detection and control of contaminants in each and every stage of the micropropagation in correct time is highly important for the success as well as for the cost effectiveness of the plant propagation programme. Due to the comparatively high contamination percentage observed especially in the culture initiation (40%) and early subculture stages (15%) (Table 1 and Figure 1), a considerable amount of additional inputs including time and labour has to be allocated to complete the process which ultimately become more expensive thus making the whole programme a loss.

Table 1: Current Contamination Percentages Observed in Different Stages of Micropropagation of Banana

Stage	Percentage
Initiation	40%
Subculture 1	15%
Subculture 2	10%
Subculture 3	10%
Subculture 4	10%
Subculture 5	10%
Subculture 6	10%

Source: Ratnapura District Agriculture Training Centre Laboratory Records

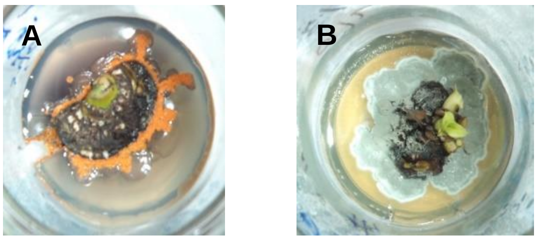

Figure 1: Contamination Stages (A) Culture Initiation (B) Early Sub Culture

Justification

When any culture becomes contaminated, upon identification or detection, irrespective of its importance or developmental cost, it should be destroyed immediately as it could serve as a source for contaminating other cultures. Therefore, contamination should be minimized in any laboratory since it directly and drastically affects the quality, quantity and most importantly the cost of micro-propagated plantlets. Therefore, every step of the process which includes handling of stock plants, handling of *explants*, media preparation and storage, culturing of *explants*, sub culturing, incubation, and storage of sterile culture vessels, media, *etc*. should be considered in order to prevent contamination. Even though, it is also ubiquitous as well as difficult to identify and eliminate all the contaminants, still, it is a must to introduce, and adopt every possible good practices to overcome contaminations, which will ensure a bulk of high quality plantlets at a minimum cost of production.

DETECTION AND CONTROL OF CONTAMINANTS

In an intervention towards prevention of contamination, identification of its sources is one of most important factors. Biological contamination in plant cell cultures originates from two sources namely, from the tissue or *explant* used to initiate the culture, and from the laboratory environment itself. Therefore, the contaminants transferred in or on the plant material include plant pathogens and also the microorganisms available in the environment. For example, bacteria which cause a contamination of plant culture may originate either from *explants,* laboratory environments, technicians and operators, mites and thrips, or from ineffective sterilization techniques. 'Indexing cultures' provide key messages to identify risks of the relevant cultures. Visual inspection of the medium at the base of the plant may provide evidence of some contaminants. Most common contaminants can be detected by screening them on two or three commercially available bacteriological media (Kane, 1995). Nowadays, 'identification and characterization' is one of the most essential practices when concern about the specific prevention of contaminants. For example, in an attempt to identify and characterize a bacterial contaminant, the contaminant can be purified using standard bacteriological methods and characterization with biochemical tests, such as motility, gelatinize, oxidase (Buckley *et al*., 1995). Use of 'antibiotic treatments' is also a common method applied to minimize most common problems. Entophytic bacterial contamination is an important problem in many plant tissue culture systems which cannot be eliminated with any surface sterilization techniques, thus requiring antibiotic treatments to control (Buckley *et al*., 1995). It is also of paramount importance to timely and proper dissemination of technology to relevant parties and stakeholders and also to update them with the developments in the field.

PROJECT IMPLEMENTATION

The project will be carried out at the Tissue Culture Laboratory of the DATC, Ratnapura, to where many stakeholders from different sectors are routinely visiting for numerous agricultural purposes. In order to upgrade and develop infrastructure facilities, developmental plans and estimates have already been submitted and action has already been taken to obtain financial support from Sabaragamuwa Provincial Agriculture Department to construct infrastructure and to purchase other inputs by the end of 2020. Meantime, with the aim of dissemination of the knowledge, training center has planned to develop interactions with the stakeholders by introducing awareness programmes, such as 'types of contaminations' and 'common causes and prevention of microbial contamination in plant tissue cultures' and also by conducting training programmes for related stakeholders from different sectors. On the other hand, it is also planned to upgrade and introduce new tools and technologies for the betterment of the system. For identification of microbial contaminations, Settle Plate Technique and Swabbing Techniques have been planned to carry out appropriately. Introducing better alternate sterilization technologies and establishment of media experiments for *explants* are planned. Concerns are also towards maintaining quality standards and accordingly, plan to follow hazard analysis report's guidelines, critical control points, monitoring, corrective action, validation, record keeping procedure and to reach eligibility of Hazard Analysis Critical Control Points (HACCP).

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Author:

Isuru Sampath: Agriculture Instructor of Provincial Agriculture Department (Sabaragamuwa). He holds B.Sc. (Plantation Management) from WUSL and currently engaged in agricultural training and extension (e-Mail: *sampathisur@gmail.com*)

Reviewer:

Mudith Mewan Kooragodage: Senior Lecturer, Department of Biotechnology, FAPM, WUSL. His teaching and research interests include: Molecular Biology and Biotechnology, Tea Biochemistry, Quality, Standards & Value Addition
(e-Mail: *mewankm@gmail.com/mewankm@wyb.ac.lk*)

AUTOMATION OF VIRGIN COCONUT OIL PROCESSING AT ADAMJEE EXPORTS (PVT) LIMITED

Madhawa Premathunga

Adamjee Exports (Pvt) Limited, No. 310, Kuliyapitiya Road, Elabadagama, Pannala, 60160

INTRODUCTION

For an industry annual growth, required cost containment or expense reduction in food processing plants is as vigorous as ever. For most food processing companies, sacrificing the quality of the product they produce to get to a lower cost is just not the answer. Similar to most other processing industries, food companies are finding ways to improve productivity throughout the plant with the use of factory automation.

"Adamjee Exports" has a new processing facility for Virgin Coconut Oil (VCO) which is located in the heart of the Coconut Triangle with a modern, well designed food processing plant. This facility is being upgraded to FSSC 22000/ISO14000/BSCI/BRC/USDA Certification. With the fast gaining acceptance of VCO being one of the healthiest oils in the world, Adamjee Exports is correctly poised to bring its superior product to the world market. Their commitment towards R&D will soon bring to the market more innovative solutions in coconut products.

Highly competitive buyers, constantly squeezing down prices, rising raw material costs, seasonal effect of agricultural commodity and soaring utility charges in a labour intensive manufacturing environment have forced the company management to look towards automating their VCO manufacturing processes. This total investment is Rs. 150 million and it is expected to increase the daily production capacity from 80,000 nuts to 130,000 nuts per day and the target cost deduction is Rs.20/kg.

Virgin matured coconut water (VMCW) is a major value added by-product in the VCO production process, and therefore, the company focuses on that area to improve water collection and increase the VMCW production. The other by-products are also typically collected through the automated environment and it is expected to reduce the wastage/labour cost and practice capacity enhancement to reduce the fixed cost.

COMPANY AUTOMATION PROJECT

According to the company's environmental analysis (Figure 1), consecutive relationships between quality and cost are the main barriers. The only option which is determined by SWOT analysis is that, the company should improve productivity by improving all key areas to the production through an automated system.

STRENGTHS	OPPORTUNITIES
▪Rich history and reputation among certain markets ▪Capability to supply quality products complying to highest standards ▪Handling capacities ▪Large customer base ▪Financial stability to expose to certain level of risk ▪Certifications for certain products which make good impression for buyers	▪Reaching out untouched markets, such as East Asia and Russia ▪Extending the range of products ▪Reaching the target customers more effectively ▪Reaching new leads through web tools (social media, blogs, web boosting) ▪Developing own brand to international supermarket shelves ▪Start selling products through e-commerce locally and internationally
WEAKNESSES	**THREATS**
▪High indirect cost, overheads leading to non-competitive pricing ▪Delays in responding to certain requirements of customers ▪Bottleneck in certain operations during peak time ▪High human involvement into production	▪Severe price competition results in loosing existing customers ▪Continuous upgraded certification requirements and quality parameter requirements ▪Risk of forward contracts getting defaulted ▪Trend of increasing prices of raw materials

Figure 1: SWOT/Environmental Analysis of the Company
Source: Adamjee Exports (Pvt) Limited Development Plan (2018-2022)

The benefits of converting to an automation system are, increased labour productivity which results in reduced labour costs, mitigating the effects of labour shortages, reduced or eliminated routine manual tasks, improved worker safety, improved product quality and reduced manufacturing lead time. It implies that, an automated plant could produce a safer and better product at a lower cost. According to the financial feasibility indicators, NPV (Net Present Value) is positive, IRR (Internal Rate of Return) is more than the current discount rate (17%) and ROI-Payback period is 60 months, and the project is a viable investment for the company.

Project Constraints

Project time (6 months; Figure 2) is one of the most important constraints in this project because the existing manual process runs in parallel to these developments and clashes often take place between construction work and operational work. Project cost (Figure 2) is another important constraint as the cost reduction is one of the key objectives of this project. Project operations should be under control with the scope of the project otherwise unnecessary deviations will occur on budgets. Risk is through unexpected opportunities that may arise and therefore, the risk is one of the prominent constraints.

Project Assumptions and Dependencies

The financial assumption is that all future cash flows are worth more than the current investment. The technology assumption is that the full technology of the project will be used. All quality parameters are maintained according to certifications, infrastructure facilities, such as a good communication system, proper network system and smooth energy supply, will be provided to production processes. The business assumption is that the business will increase profitability in the future.

Both outside and inside dependencies are important for the automation project. As inside dependencies, the company owners, stakeholders, director boards and employees act the main role. Outside dependencies include, suppliers (goods and services), Government sector (CDA, CRI, IRD, District Environment Authority and EDB), buyers, competitors, certification bodies, community, bankers and insurance companies.

					Mar-19			Apr-19			May-19			Jun-19			Jul-19			Aug-19
Monthly task allocation on project					7%			23%			14%			19%			19%			17%
Monthly Target %					7%			30%			44%			64%			83%			100%
SN Activity	Activit	Value																		
01 Civil construction	A	12,640,750	25%	50%	75%	100%														
02 Coconut Elevators	B	2,024,300					25%	50%	75%	100%										
03 Counting and measuring S	C	2,133,300													25%	50%	75%	100%		
04 CW collecting system	D	9,500,000									25%	50%	75%	100%						
05 Conveyor System	E	33,538,700					25%	50%	75%	100%										
06 De-shilling Machine	F	14,000,000			25%	50%	75%	100%												
07 Electrical wiring & Panel b	G	5,500,000				25%	50%	75%	100%											
08 Supply lines - Vacuum/Wat	H	2,850,000		25%	50%	75%	100%													
09 Oil lines	I	2,100,000														25%	50%	75%	100%	
10 Coconut dryers installatior	J	6,000,000									25%	50%	75%	100%						
11 Expellers installation	K	5,800,000										25%	50%	75%	100%					
12 Stock Tank installation	L	2,400,000											25%	50%	75%	100%				
13 Packing system	M	45,000,000													25%	50%	75%	100%		
14 IT & AI	N	4,000,000															25%	50%	75%	100%
15 Other		2,512,950																		
					10,714,285.71			34,285,714.29			21,428,571.43			28,928,571.43			28,928,571.43			25,714,285.71
Total project cost		150,000,000			10,714,285.71			45,000,000.00			66,428,571.43			95,357,142.86			124,285,714.29			150,000,000.00

Figure 2: **Activity Dependencies and Time Frame of the Automation Project**
Source: Production Automation Project Report 2019

PROJECT SUCCESS CRITERIA

Production outturns are the main criteria for project success. Raw material outturn standards are pre-calculated based on past data and industry norms, deviations are monitored on runtime. As an example nuts consumption per 1 kg of VCO should be less than 7.5, oil yield should be 63% - 65%, coconut cake oil contains less than 12%, coconut water production should be under the optimum level.

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Author:

Madhawa Premathunga: Executive at Adamjee Exports (Pvt) Ltd, Pannala. He holds a Bachelors Degree of Commerce (B-Com) (e-Mail: *madhawaonline7@gmail.com*)

Reviewer:

Sarananda K. Hewage: Senior Lecturer, Department of Bio-Systems Engineering, FAPM, WUSL. His teaching and research interests include: Postharvest Technology, Food Processing Technologies and Value Addition and Product Development Technologies
(e-Mail: *sarahewa62@yahoo.com*)

AN ADDITIONAL VEGETABLE SUPPLY CHAIN TO MEET FARMERS' COST OF PRODUCTION THROUGH FARMERS MARKET

Duminda Udagedara

North Western Provincial Department of Agriculture, Dambulla Road, Kurunegala (NWP), 60000

INTRODUCTION

Sri Lanka produces around 710,000 t of vegetables annually (Export Development Board, 2013) and the vegetable cultivation accounts for Rs.101,830 million of gross national income (Central Bank of Sri Lanka, 2018). Because of the diversity in agro-ecology in Sri Lanka, a number of vegetable types can be grown. Department of Agriculture (DOA) mainly focuses on 20 types of such vegetables and facilitates to improve the technology and the production of those vegetables. The North Western Province (NWP) of Sri Lanka has a high potential of cultivating vegetables among the other provinces in Sri Lanka (Table 1).

Kalpitiya and Irudeniyaya are the two major vegetable cultivation areas in the NWP of Sri Lanka. These two vegetable growing areas supply 80 percent of the vegetable demand in the NWP. Irudeniyaya supplies a considerable amount of up country and low country vegetables to the country through Dambulla Dedicated Economic Centre (DEC) because it is located within 30 km from the Irudeniyaya vegetable zone. About 98 percent of its production goes to the Dambulla DEC. Dambulla DEC is the main link in the vegetable supply chain which determines the price. Price determination takes place according to the daily amount of vegetables that arrives at the Centre from various parts of the country. Therefore, the prices of vegetables at Dambulla DEC do not always cover farmers' cost of production.

Justification

The number of stakeholders taking part in the supply chain usually influences the length of it. This is the case of the vegetable supply chain, where several numbers of intermediaries take part (Figure 1). This leads to higher prices of vegetables at retail market and the lower price at the wholesale market at Dambulla DEC, thereby reducing farmers' profit margin. This study describes how to increase the profit margin at the farmers' level and lower the vegetable prices at the consumer level by the introduction of a 'Farmers Market'. Department of Agriculture - North Western Province (NWP) has already introduced a Farmers Market for the organically produced vegetables from Kurunegala district at their premises. However, this may not meet the expectations of a majority of vegetable producers in the Irudeniyaya vegetable zone because a majority of their production does not fall into organic category. Thus, implementation of a new Farmers Market is the solution to overcome this problem.

Table 1: Major Types of Vegetables and Their Production in the North Western Province in Comparison to the National Production (t)

Crop	Production (t)	
	Sri Lanka	North Western Province
Beans	94,633	254
Capsicum	41,876	8,354
Tomato	129,434	2,871
Beetroot	55,001	13,560
Radish	63,720	12,594
Knol Khol	21,667	714
Long Beans	74,701	17,605
Okra	84,478	10,131

Source: Crop Production Programme Maha 2016/2017, Yala 2017

Project Assumptions

In the implementation of this project, it is assumed that weather and climatic conditions would be favourable to agricultural activities in the area and events such as natural disasters or extreme climatic events would not unnecessarily influence the supply and prices.

PROJECT IMPLEMENTATION

Several farmers in the area are already participating in the Farmers Market at Department of Agriculture (NWP) premises in Kurunegala. Therefore, current situation is highly supportive to implement this project easily. New Farmers Market will commence next year at Melsiripura area where Ambepussa – Trincomalee main road lies.

Farmers' organizations take responsibility in collecting and transporting vegetables whereas no other buyers or intermediaries are involved. Farmers' organizations are strong enough to facilitate transportation of goods with their current assets. Department of Agriculture - NWP and the Local Government (*Pradesheeya Sabha*) will be taking the full responsibility of managing the Farmers Market.

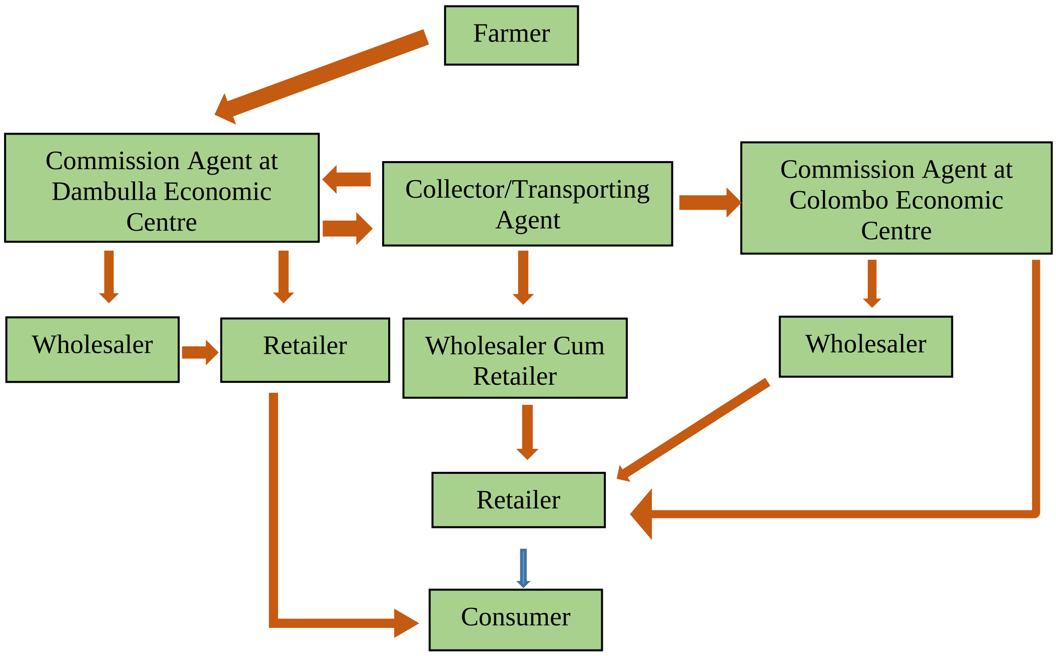

Figure 1: Vegetable Supply Chain Comparison

Project Dependencies and Constraints

The strength of this project is the well-established farmers' organization in this area, which can have a considerable influence on farmer activities. Through this farmer organization, Extension Officers can organize awareness programmes to introduce this project to them and establish the project in the farmer fields. Therefore, the project's outcome will critically depend on the behaviour of the farmer organizations in the area.

PROJECT SUCCESS CRITERIA

The outcome is a well-established Farmers Market in the area, with a shorter supply chain. The Department of Agriculture - NWP and the Local Government will evaluate the success of the project and finally the project will be expanded to other vegetable cultivation areas throughout the country by the respective authorities.

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Author:

Duminda Udagedara: Agriculture Instructor attached to the Department of Agriculture - North Western Province. He holds B.Sc. (Agric.) from WUSL
(e-Mail: *dumindaudd@gmail.com*)

Reviewer:

Jagath C. Edirisinghe: Professor in Agribusiness Management, Department of Agribusiness Management, FAPM, WUSL. His teaching and research interests include: Agricultural Marketing, Supply Chain Management, International Trade, Environmental Economics and Bayesian Econometrics (e-Mail: *jagath@wyb.ac.lk*)

EVALUATION OF POTENTIAL CROP INJURY BY PROFOXYDIM 75 G/L EC ON COMMON RICE VARIETIES: A QUALITATIVE ASSESSMENT

Ruwan Chaminda

Hayleys Agriculture Holdings Limited, Colombo 10, 01000

INTRODUCTION

There are 20 popular rice varieties in Sri Lanka. The maturity ages of those varieties vary from 75 -135 days. All are *Indica*-type varieties and some may have a mix of *Japonica* genome due to the use of hybrid parents by the International Rice Research Institute [Rice Research and Development Institute (RRDI), 2020]. It was observed that the genome of some varieties which produce small-bold grains is slightly different from other *Indica* varieties and sensitive to some of the selective rice herbicides. Different herbicides are used for better control of weeds. It has been observed that most of the farmers use recommended dosage of the product whereas some farmers tend to deviate and apply higher or lower doses (Abeysekara *et al.*, 2015). This study was conducted to determine the phytotoxicity in different rice varieties for the herbicide, Profoxydim 75 G/L EC (a grass killer).

Justification

Evaluation of the level of phytotoxicity (crop injury) is a prerequisite in Sri Lanka for all new selective herbicides prior to being commercialized. In order to comply with the guidelines of the Department of Agriculture (DOA), Sri Lanka, Profoxydim 75 G/L EC needs to be evaluated against all popular rice varieties cultivated in Sri Lanka. Evaluation of the level of phytotoxicity will ultimately benefit farmers.

METHODOLOGY

An experiment was conducted in a farmer's field at Minneriya, Polonnaruwa during 2019 *Yala* season. Crop injury levels of 20 popular rice varieties (Table 1) were observed after application of four different treatments with three replications for each treatment: T1-Profoxydim with recommended dosage (1000 mL/ha), T2-standard weedicide, Metamifop 10% EC (1250 mL/ha), T3- Profoxydim with high dosage (1250 mL/ha) and, T4- unweeded control. MCPA 600 g/L SL (1800 mL/ha) was applied to both test and reference plots on day 21 to kill sedges and broadleaves. Each treatment plot was 9 m^2 in size and the experiment was laid out in Randomized Complete Block Design (RCBD).

All 20 varieties with different maturity age groups were established in the field on the same day. Spraying of Profoxydim 75 G/L EC and Metamifop 10% EC were performed at the stage at which grass weeds possessed three leaves on seedlings (7-10 days after sowing). Herbicide application was done according to the recommendation of the RRDI, Batalagoda. All plots were facilitated with independent irrigation and drainage lines. Crop injury of each plot was determined with 1 - 9 scale of phytotoxicity symptoms by observing leaves of plants [Table 2; International Rice Research Institute (IRRI), 2002] with 3-day intervals up to 15 days after application and at 1-week intervals up to harvesting of each variety. Any deviation of the maturity age was noticed compared to unweeded plot of the same variety.

Table 1: The Selected Rice Varieties and Their Maturity Ages (Days)

Variety	Maturity Age	Variety	Maturity Age	Variety	Maturity Age	Variety	Maturity Age
Bg 250	75	Bg 352	105	Pokuru Samba	120	Bw 374	105
Bw 272-6B	90	Bg 357	105	Ld 365	105	Bg 379-2	120
Bg 300	90	Bg 358	105	Bg 366	105	Bg 403	120
At 307	90	Bg 359	105	Bw 367	105	Bg 406	120
At 308	90	Bg 360	105	Ld 368	105	Bg 450	135

Source: Rice Research and Development Institute, 2020

Table 2: Phytotoxicity Symptoms Scale for Rice

0	1, 2	3, 4	5	6	7	8	9
No symptom observed	Pale green leaves	Pale green to yellow leaves	Distinct yellow leaves	Light yellow leaves	Yellow leave	Yellow to orange leaves	Dark yellow leaves

Source: IRRI (2002). Standard Evaluation System for Rice

RESULTS

According to the observations made, crop injuries were not observed at 3-day intervals up to 15 days after application and at 1-week intervals up to harvesting of each variety (Figure 1). However, for T1, pale green to yellow colour leaves were observed during the third week for variety Bg 360. It was recovered during the fourth week. According to the present qualitative analysis, it can be concluded that the used concentrations of Profoxydim 75 G/L EC have no phytotoxic effect on all tested rice varieties.

Figure 1: Experimental Setup (A) Land Preparation, (B) Before Maturity, (C) Mature Crop

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Author:

Ruwan Chaminda: Management Executive-Research & Development at Hayleys Agriculture Holdings Limited. He holds B.Sc. (Plantation Management) from WUSL. He is currently engaged in agro chemical research and new product development (e-Mail: *ruwan.chaminda@agro.hayleys.com/chaminda.ruwan@gmail.com*)

Reviewer:

Priyanwada S. Warakagoda: Senior Lecturer at Department of Biotechnology, FAPM, WUSL. Her teaching and research interests include: Micropropagation/Tissue Culture Techniques, *In vitro* Conservation and Screening Techniques and Yield Improvement Strategies for Secondary Metabolites (e-Mail: *priyanwadawarakagoda@gmail.com*)

CO-OPERATE MODEL STRUCTURE FOR A SELF-SUFFICIENT DAIRY SECTOR

Sumedha Nawarathna Bandara

National Livestock Development Board, No. 40, Nawala Road, Narahenpita, 00500

INTRODUCTION

Sri Lanka is a tropical country with a 22 million population and a total land area of 65,525 km^2 with favourable weather conditions throughout the year. However, only 8 percent contributes productively to the GDP of the country although 40 percent of the land is available for agricultural activities. Out of agriculture, livestock only contributes 3 percent to the GDP (Perera and Jayasuriya, 2008). Further, before the introduction of 'Open Economy' in 1977, Sri Lanka fulfilled 80 percent of its milk requirements, but at present it has reduced to 40 percent. Due to change of policies and new investment plans, total milk production has recorded a notable increase of 19 percent in 2018/2019, but it was not a sufficient gain. Cow's milk production highlights an increase of 17.7 percent to 385.7 million litres (Central Bank of Sri Lanka, 2019). The number of milking cows has been increased by 11.2 percent to 329,380, while the number of milking buffalo cows recorded 8.9 percent increase to 94,200 during 2018. Despite the increased production, milk powder imports grew by 6.3 percent to 99,028 t at a value of Rs. 50.3 billion during 2018. Since the domestic milk production is only sufficient to meet around 45 percent of the total demand of the country (Department of Census and Statistics, 2018), it is essential to address the existing issues in the sector while encouraging milk producers to enhance their production capacity. Present annual milk requirement per annum is 1,100 million litres (fresh and powdered) of milk and at present, Sri Lanka is only producing 484 million litres of fresh milk per year. Sri Lanka imports 95,000 tons of milk powder worth of US$ 295 million per annum which equals to Rs. 53.5 billion (Figure 1). Sri Lanka possesses a high potential to save this money by proper investment. The annual growth rate of consumption of milk and milk products is around 11 – 13 percent of the total annual requirement, implying that the industry is growing by Rs. 5 billion in each year. The newly created resistance to imported powdered milk initiated a fresh milk trend by giving an opportunity for investors and present dairy sector stakeholders.

Justification

Including all nine Provinces, Sri Lankan dairy community consists of 0.12 million farmers and 1.2 million cows, which produce 482 million litres of milk. Of the milk production, 2/3 is coming from the Central Province itself and the average milk production per cow is around 9 L. All other eight Provinces contribute to the rest of the total milk production. As depicted in Figure 2, the concept is to develop a 'dairy village' or 'dairy hub' which can help each other by diversification of the production procedure. The definition of a farmer should be categorised with significant animal number and production capacity. Most of the Sri Lankan dairy cattle are reared as free range or semi intensive system which make low profit with low income. The proposed project is an initiation to structure the existing dairy industry by systemizing, which will ultimately benefit all the stakeholders in the dairy chain. To reach the expected goal, we need to produce 11,000 million litres of milk. The concept is to develop 50-cow dairy units which can be conducted by family labour, with an average production of 15 L/cow/day. *"One family, 50 cows and producing 250,000 litres per annum"* is the slogan we need to develop to create 2,500 new farmers in the country, while upgrading from 1 - 10 cow units to 50-cow units.

Project Constraints

Sector diversification allows a smooth functioning and field expertise, which are essential for the necessary growth in any industry. However, with a limited diversification, the dairy sector in Sri Lanka has not been expanded with the time as an industry. Farmers are extra burdened with fodder creating, milk processing, breeding, *etc*. Poor connectivity in the dairy sector value chain is another constraint. The majority of the dairy farmers are from the lower middle income families and are above 40 years of age. This automatically limits any financial assistance from the banking sector, constraining the investment capabilities and financial facilities. Lands are either not recognised or under-utilized for dairy development, and hence, lands should be recognized in accordance with suitable crop varieties and topographical variations with ecological suitability. Further, dairy farmers lack proper breeding materials, equipment, and technical know-how which are necessary to empower themselves with essential knowledge. Moreover, in the absence of project planning, designing, and implementation plans, Sri Lanka's national dairy policy is in a dormant stage where successive governments fail to maintain a consistency in extending timely plans focusing the dairy sector.

Project Assumptions

There are approximately 120,000 dairy farmers in Sri Lanka, where 2,500 farmers can be converted to the hub concept while the rest of the dairy community is transformed to fodder and supportive service providers. Regions should be selected to create these dairy hubs with developed inter-relationships which assist the dairy value chain. A dairy hub should consist of individual clusters with a minimum group of 25 - 30 farmers with 50-cow units which produce 650 L/day. By creating a minimum of 8 - 9 dairy hubs in all provinces, the expected target of 2,500 selected farm families, who are capable of producing 25,000 L per annum, can be achieved. Further, a dairy hub is capable of producing 300,000 L/day, allowing the milk processor to take the lead automatically.

Project Dependencies

Through the strategy of forming regional dairy hubs and dairy clusters, the small scale, the medium scale farmers and new dairy investors will benefit and receive the needed encouragement to be stakeholders of the industry. It will uplift medium and large scale milk collectors and processors while developing the dairy sector to a sustainable level.

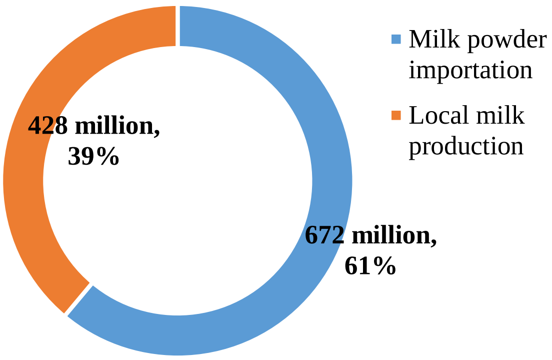

Figure 1. Market Share of Dairy Milk

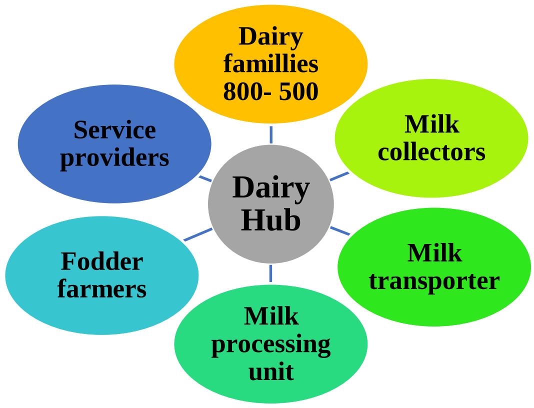

Figure 2. Model Structure of the Dairy Hub

PROJECT SUCCESS CRITERIA

The project expects to save Rs. 535.5 million per annum spent by the government on dairy imports which is the 3rd largest expenditure in the government. Given that, the population of 22 million will be benefited from having access to a consistent supply of food and new employment opportunities, such as fodder farmers, milk collectors, and additional service providers, while 0.12 million stakeholders will be able to utilize the direct benefit. Further, the government will be able to increase 'food security' and the reinvesting capacity. This will eventually lead to land utilization and improved productivity, and an increase in the contribution to the national GDP, while creating space for supportive services to decrease the unemployment rate.

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Author:

Sumedha Nawarathna Bandara: Manager attached to the National Livestock Development Board. He holds B.Sc. (Agric.) from University of Peradeniya and specialized in Animal Science. He obtained an International Diploma in Animal Feed and Nutrition from India and Dip. in Financial Management from NIPM (e-Mail: *srilankadutchdairysolutions@gmail.com*)

Reviewer:

Nimanthika Lokuge: Lecturer attached to the Department of Agribusiness Management of FAPM, WUSL. Her teaching and research interests include: Agricultural and Food Economics, Applied Econometrics, and Food Marketing and Agribusiness (e-Mail: *nimslkg@gmail.com*)

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Master of Agri-Enterprise and Technology Management, Wayamba University of Sri Lanka

LOW FREQUENCY HARVESTING SYSTEM FOR RUBBER SMALLHOLDER SECTOR IN DRIER AREAS OF SRI LANKA

Gamini Sirisena

Department of Rubber Development, Regional Office, New Town, Ratnapura, 70000

INTRODUCTION

Rubber industry plays a vital role in the Sri Lankan economy. It is generating income by raw rubber and rubber products. Rubber plantations in Sri Lanka lie in the wet zone (WZ). The Ministry of Plantation Industries had decided to expand rubber into the drier areas. The Department of Rubber Development expected to increase yield from 82,500 t to 100,000 t by conducting low frequency harvesting systems. Those systems reduced the intensity of harvesting by 50 percent and increased the harvester productivity by 100 percent.

Significance of Using Rubber Low Frequency Harvesting Technology

Low Frequency Harvesting (LFH) system in the drier climates is done by tapping half of the tree circumference once in four days (S/2 D_4) instead of traditional system which is done once in two days (S/2 D_2).

Reduction of harvesting frequency to improve the efficiency in the usage of skilled harvesters has become an internationally accepted management system in rubber cultivation. LFH allows each harvester to be allocated a higher number of tapping blocks resulting in reduced harvester requirement when compared with the traditional S/2 D_2 tapping system. In order to compensate the yield loss due to less number of tapping days per tree, ethephon is used as the yield stimulant.

LFH results in enhanced daily intake per harvester and therefore, the wages can be increased. Furthermore, the overall increase in harvester's productivity results in reduction of cost of production. Less bark consumption in LFH results in increased economic life of the tree providing an additional benefit to growers (Table 1).

Table 1: Yield Parameters of S/2 D_2 and S/2 D_4 Harvesting Systems

Tapping System	Actual Tapping Days	Yield per Tree per Year (kg)
S/2 D2	128	2.6
S/2 D4	69	3.0

Source: Rubber Research Institute of Sri Lanka

Limitation to Popularize Low Frequency Harvesting Technology

Lack of knowledge and skills on the LFH technology is a significant limitation to promote this system. Poor performance of LFH in dry months could be expected as more water would be taken out as latex on each tapping day of this system and this in turn, is affected by the poor water status in the rubber plant. Demand for harvesters is higher in the rainy period due to the establishment of seasonal crops in drier areas (*e.g*. Monaragala, Ampara, Padiyathalawa).

Project Assumptions

It is assumed that promotion of LFH method by increasing the initial awareness of the farmers and demonstration programmes is prominent and carried out timely. Further, attractive mass information methods can be adopted, such as banners, leaflets, television and radio programmes and campaigns through farmer organizations and cyber extension units. These programmes should give attention to educate farmers about the income and expenditure of LFH method and change their negative attitudes towards new technologies. The declining rubber price and labour shortages in the context of climate variability are problems for rubber smallholders. A low frequency tapping system that may be a solution to those issues. It is suggested to apply LFH system only during wet periods in drier areas.

PROJECT IMPLEMENTATION

Rubber Development Department is the main organization that conducts awareness creation and skill training programmes via extension personnel. Rubber Development Officer (RDO) can be identified as a key personnel who can build up awareness about LFH technology among farmers. Rubber Development Department has some subsidy schemes to promote this technology. During wet months, the average yield and income were significantly higher when trees were tapped with low frequency tapping (S/2 D_4) (Figure 1).

With the traditional system (S/2 D_2) by hired labour, it gave the least financial benefit. In some months financial benefit is higher in low frequency tapping system even with the use of hired labour than use of own labour in S/2 D_2 harvesting (Figures 1 and 2).

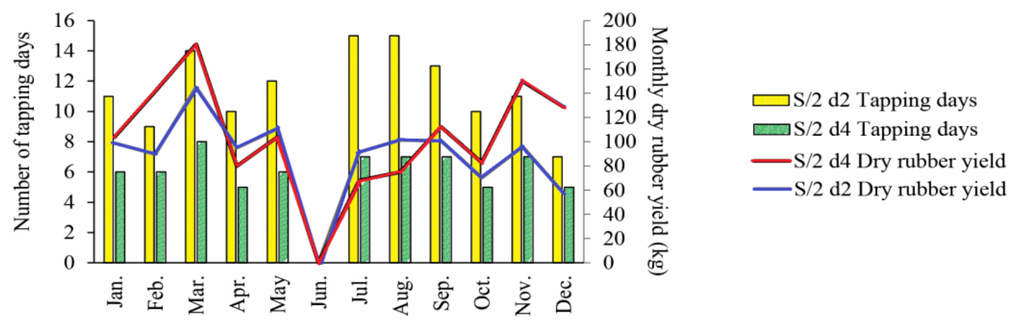

Figure 1: Seasonal Variation in Tapping Days and Expected Dry Rubber Yield to be Received From One Hectare of Rubber Land

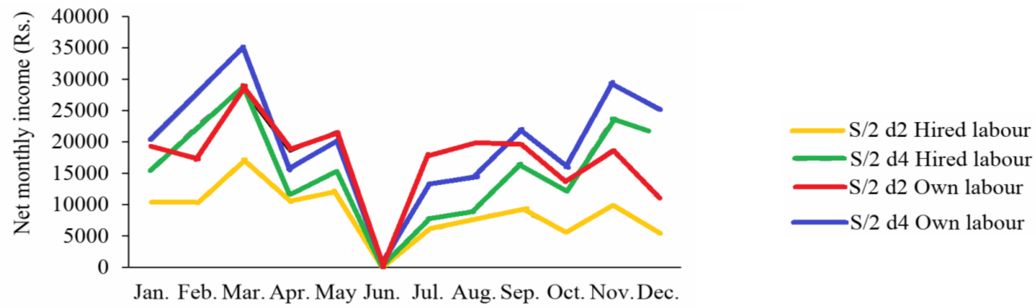

Figure 2: Net Monthly Income of One Hectare of Rubber Land Managed with Hired Labour and Own Labour Condition

During wet periods, farmers need to be engaged in other farm operations required for seasonal crops. Therefore, the best option would be to have a combination of harvesting systems. LFH system can be practiced only during wet periods (September to March in the following year) whilst engaging in farm operations for other crops and then traditional system can be practiced during dry months (April to August).

OUTCOME OF THE PROJECT

This modern harvesting technology can be promoted to the satisfaction of all rubber tapping communities in drier areas. All outcomes/benefits of low frequency harvesting technology are clearly measurable. Previous survey data clearly indicate a yield increase (Table 1) when compared with traditional tapping (Kudaligama *et al.*, 2018). It is a low cost technology due to less requirement of tappers. Furthermore, it reduces the cost of production, increases intakes and improves income to the harvester. It also enhances the longevity of the tree and has a positive impact on the cash flow of rubber estates. The low frequency harvesting system could be successfully adopted in combination with traditional tapping system for harvesting rubber in drier areas.

ACKNOWLEDGEMENT

The author is thankful to the Rubber Research Institute of Sri Lanka.

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Author:

Gamini Sirisena: Senior Rubber Development Officer of Rubber Development Department. He holds B.Sc. (Plantation Management) [Second Class Upper Division] from WUSL (e-Mail: *sirisenaga@gmail.com*)

Reviewer:

Thilak Attanayake: Professor in Biotechnology, Department of Biotechnology, FAPM, WUSL. His teaching and research interests include: Plant Molecular Biology, Genetics and Plant Breeding (e-Mail: *dpstga@yahoo.com*)

DEVELOPING THE TRAINING PROGRAMME ON FARM MACHINERY CONDUCTED AT DISTRICT AGRICULTURE TRAINING CENTRE, AMBEPUSSA

Udaya Kumara Sampath

District Agriculture Training Centre, Ambepussa, 11212

INTRODUCTION

Young people are currently moving away from Agriculture. This is one of the main problems of the agriculture sector in Sri Lanka. However, the trend of youth enrolment in agriculture has somewhat changed recently with the introduction of modernized farm machinery. Thus, expert technicians in farm machinery have become a valuable asset to the country. Locally, vocational training centres provide the best technicians in farm machinery. Those institutes have evidently shown that proper education and training in farm machinery could attract youth and convert them to qualified technicians. Recently, new technologies have been launched for teaching of agricultural machinery equipment parallel to the changing concepts in agriculture engineering and farm machinery. Thus, proper identification of current local status in farm machinery in relation to international conditions has become one of the most important steps to be taken on improving quality in local teaching and training of agricultural machinery problems.

Justification

Farm mechanization saves time and labour, cuts down crop production costs in the long run, reduces postharvest losses and boosts crop output and farm income. In Sri Lanka, out of the total work force, 25 percent deal with agriculture (World Bank Development Indicators, 2019). Further, 70 percent of the fields used in agriculture are below 2 ha. Small scale agricultural machinery producers are forced to work according to the local demands. As a result, the related firms cannot adapt themselves to the new technologies and work with low capacity. In this point, it is clear that the agricultural machinery sector in our country needs to be supported by increasing the quality of technology and the quality of its workers as well as the productivity.

Project Constraints

The average land holding size in western province is about 1 ha. The majority of paddy farming lands are small fragmented fields. However, paddy cultivation system is almost fully mechanized except for bund reconditioning and plant establishment. Mechanization of other field crops, such as maize cultivation as the second major crop, needs to be strengthened. In addition, the production of vegetable, fruit and plantation crops has been mechanized yet in relatively low level (Table 1).

Table 1: Level of Mechanization in Agriculture Sector in Sri Lanka

Cultivation Type	Level of Mechanization
Paddy cultivation	High
Vegetable cultivation	Low
Other field crops	Moderate
Fruit sector	Low
Plantation crops	Low
Spices	Very low

Source: Farm Mechanization Research Center, Mahailluppallama, Sri Lanka.

Project Dependencies

Youth platforms (rural youth and young farmers) would be created to determine training and capacity building needs, support linkages between public and private initiatives among research institutes, universities and the training authorities. The private sector training providers and the public sector providers are bringing together in public-private partnerships (PPP) that lead to more efficient use of existing public sector facilities. Further, the incentives encourage private sector participation in skills development activities. Efforts in rehabilitating training centres and programmes in agricultural mechanization tend to rebuild on old systems instead of promoting modernized systems.

FARM MACHINERY EDUCATION DEVELOPMENT PROJECT

The proposal identified the trends and challenges in developing Farm Machinery Education Project which would provide new technologies to school leavers, farmers and NVQ Level 4 and Level 5 students. Development in farm machinery sector and introduction of new technology are continuing processes engaged with Agricultural

Machinery and Equipment Sustainability Technology (AMEST) course. Human resource development in the sector has to be updated in parallel with the technology improvement. The strategy prioritizes prevention of youth moving away from agriculture. AMEST will be promoting the generation of modernized smart agriculture.

PROJECT IMPLEMENTATION

District Agriculture Training Center (DATC) Ambepussa is a national level training institute for farm machinery in Sri Lanka. The institute was established in 1985 by the Sri Lankan Government and in 1990 it was further developed with collaboration of Japan through JAICA project. The institute is situated in Meerigama, Gampaha district in the Western Province. Total extent of lands belonging to the institute is about 30 ac which contains vegetables, fruits, coconut, tractor driving track, training field and other utility buildings. The AMEST course was designed for school leavers, NVQ 4 and 5 Agriculture Diploma holders, and farmers. The main skill development areas in AMEST are given in Figure 1. DATC, Ambepussa can provide food and lodging facilities for about 60 trainees at a time.

Avoiding traditional cultural methods by using machinery of two wheel and four wheel tractors, power tiller, tractor implements, rice transplanter, rotary slashes, tine tiller, rotary tiller, disc plough, combine harvester, and other light and heavy machinery equipment practical operating and maintenance programmes to be organized at the institutional level for both students and farmers (Figure 1). The project implements and promotes usage of integrated organic farming equipment such as semi auto knapsack sprayer, power sprayer, mist blower, hand sprayer, hoe, brush cutter, multi chopper, rotomasters and water pumps.

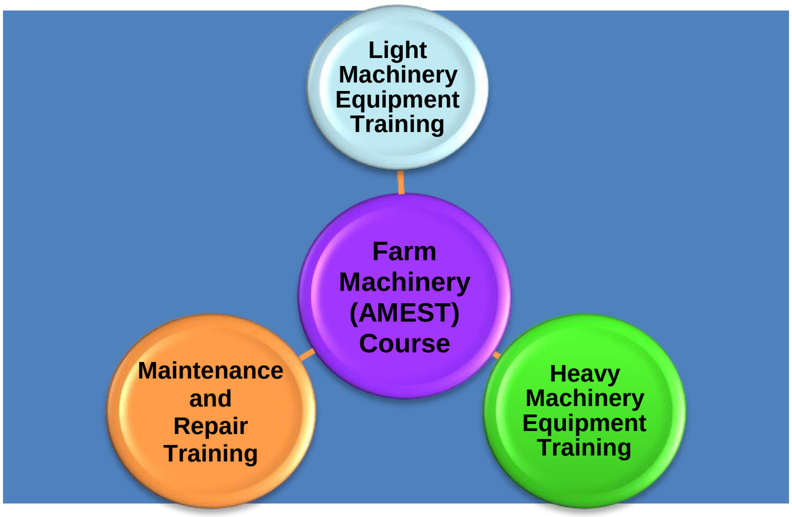

Figure 1: Agricultural Machinery and Equipment Sustainability Technology (AMEST) Course Practical Skill Improvement Areas

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Author:

Udaya Kumara Sampath: Agriculture Instructor attached to the District Agriculture Training Centre, currently engages in Farm Machinery Engineering Unit (DATC) Ambepussa. He holds B.Sc. (Plantation Management) from WUSL and HNDT (Agriculture)
(e-Mail: *udayaksampath@gmail.com*)

Reviewer:

Wasantha Gunathilaka: Senior Lecturer of Department of Plantation Management, FAPM, WUSL. His teaching and research interests include: Agriculture Engineering, especially Farm Machinery and Irrigation (e-Mail: *haws.gunathilaka@gmail.com*)

IMPLEMENTATION OF GOOD AGRICULTURAL PRACTICES (GAP) IN TEA SMALLHOLDER LANDS FOR SUSTAINABLE TEA CULTIVATION

Indika Abeysena

Tea Small Holdings Development Authority Sub Office, Govijana Kendraya, Kuruwita, 70500

INTRODUCTION

Good Agricultural Practices (GAPs) are a collection of principles to apply for on-farm production and post-production processes, resulting in safe and healthy food and non-food agricultural products, while addressing economic, social and environmental sustainability (FAO, 2013). A range of factors such as soil fertility, soil loss, nutrients, pest management, biodiversity, product value, energy, water, social/human capital and local economy would contribute to good practices for a sustainable production. In the past decade, the tea industry in Sri Lanka has shifted towards more environmentally and socially sustainable type of production, partly affected by the global requirement for socially responsible supply chain and by market trends favouring sustainable products. Sustainable tea production on the other hand, is intended to make continuous yield well over a considerable period of time while land is maintained as productive and fertile. It will ensure that the tea lands could be passed to the next generations and continue to generate higher revenues from tea lands irrespective of the climate extremes.

Current Status in Sri Lanka

The tea industry in Sri Lanka plays a vital role in the economy of Sri Lanka in terms of government revenue earnings and foreign exchange earnings even though relative contribution has declined in recent years (Central Bank of Sri Lanka, 2018). Moreover, Sri Lankan tea has a special position in the global marketplace. To retain its position, Sri Lanka needs to implement various strategies and policies. Although Sri Lanka is one of the major tea producing countries in the world, her tea production for last ten years has been declining (Table 1).With a declining production, the producers are facing many challenges such as low profitability, unbearable cost of production, pesticide contamination of products, shortening of economic life of tea plantation, soil fertility degradation and landslide, flood and water pollution. Major reasons associated with issues related to the field production are unscientific crop management practices which are noncompliance to TRI (Tea Research Institute) recommendations. There are two major stakeholders in production of green leaves namely, the Regional Plantation Companies (RPC) and tea smallholders. The tea smallholders grow and supply green leaf to the factories. The average size of a smallholding is less than 0.33 ha. Overall, the contribution by the tea smallholders to the national production is 71 percent. The tea smallholders are a major contributor to the rural economy which also create thousands of employment opportunities and thus it is the primary means of livelihood for tens of thousands of families.

Table 1: Tea Production in Sri Lanka (Million Kilograms of Made Tea)

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total Tea Production (million kg)	331.43	327.53	326.28	340.23	338.03	328.96	292.57	307.07	303.84	300.13

Source: Forbes & Walker Tea Brokers, 2020

Justification

The district of Ratnapura is about 89 km from the capital city of Colombo and is the largest tea growing district in the province of Sabaragamuwa. Nearly one-third of people are engaged in traditional tea growing as tea smallholders. However, low yield per land area (productivity) is a common bottleneck that adversely affects their income and livelihood. High rainfall in this area contributes to substantial soil erosion where soil fertility is subject to decline significantly over the time by lowering overall soil health which has a negative impact on long term green leaf yield. To face the above challenge, the Tea Research Institute of Sri Lanka (TRI) has introduced a set of sustainable management practices known as Good Agricultural Practices (GAP) which is productive, competitive and efficient, while at the same time protecting and improving the natural environment and conditions of local communities.

This approach could play a significant role in identifying suitable cultural practices for sustainable tea cultivations in order to overcome the above problems. Pilot plots are maintained by TRI and Tea Small Holdings Development Authority (TSHDA) to demonstrate the practices with significant positive results. Meantime, the reasons behind the yield decline need to be identified by a team of experts and remedial actions must be taken promptly to rectify the issues with smallholders and finally to secure the livelihoods of tea smallholders, the main contributors for the Sri Lankan tea production sector.

The aim of this project is to introduce Good Agricultural Practices (GAP) to increase the sustainability of tea production and thereby, improve the income of tea smallholders and make their production more resilient to extreme weather events with climate change.

GAP PROJECT IN TEA SMALLHOLDER LANDS

The proposed GAP project provides a new approach to change the way and handle the tea smallholders' lands for sustainable tea production. The project depends on TRI and TSHDA support to conduct demonstration, train on GAP and mobilize the technical knowledge effectively. Tea smallholders' contribution is another major dependent factor for the success of the project as the cost of the agronomic practices to be borne by the tea smallholders themselves. It is also dependable on government policies such as subsidy arrangements to tea smallholders to motivate the participation. To make the project with positive results, it is assumed that the economic condition of the country and world to be steady and thereby, tea prices would remain stable. All the tea smallholders need to adopt GAP and extend their fullest support to make the project a success.

PROJECT IMPLEMENTATION AND EVALUATION

Initially, tea smallholders of Ratnapura district will be taken as the target group. They will be exposed to the plots maintained by TRI and TSHDA to provide hands on experience on applying GAP and demonstrations will be conducted by experienced technical personnel. The tea smallholders will be given technical advice on appropriate GAPs related to ten identified criteria namely, (1) proper soil conservation / rehabilitation practices, (2) proper planting materials, (3) proper shade management practices, (4) proper cultural practices to improve soil organic matter, (5) good fertilizer application protocols, (6) proper pest and disease control measures, (7) proper pruning practices, (8) proper weed management, (9) correct harvesting practices and (10) proper infilling. Once the knowledge mobilization is completed on GAP, selected group of tea smallholders are asked to execute GAPs at their respective tea cultivations to improve the tea yield. Prior to starting the project, each land will be evaluated by a group of experts and their initial data will be collected related to above ten criteria.

The project success will be evaluated through follow up visits to the tea smallholders' lands by tea inspectors. The collected data will be systematically analysed to evaluate the progress. Project success will be quantified by analysing the changes in their green leaf yield and other variables related to each GAP. Improved soil health due to application of GAP will be evaluated by several soil analyses. The soil health improvements will enhance the soil water holding capacity which in turn, will help the tea cultivations to be more resilient to drought conditions.

Once the project is established and executed, it will be expanded to other areas of Sri Lanka. Adopting GAP would not only support to increase the tea production but also would be helpful for sustainable tea production which is beneficial for tea smallholders from generation to generation.

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Author:

Indika Abeysena: Zonal Tea Development/Extension Officer attached to Tea Small Holdings Development Authority Sub Office, Kuruwita. He holds B.Sc. (Plantation Management) from WUSL (e-Mail: *indikaabeysena2014@gmail.com*)

Reviewer:

Kanchana S. Weerasinghe: Senior Lecturer attached to the Information Communication Technology Centre of WUSL. Her teaching and research interests include: Information Systems, Database Management System and ICT in Agriculture & Education (e-Mail:*kanwyb@yahoo.com*)

ENHANCING THE ACTIVE INVOLVEMENT OF FEMALE STUDENTS FOR SCIENCE PRACTICAL SESSIONS AT WATHUPOLA MAHA VIDYALAYA

Isuru Madhushan

Puttalam / Wathupola Maha Vidyalaya, Pallama (NWP), 61040

INTRODUCTION

Science is one of the core subjects in the formal school curriculum. Students must have theoretical knowledge as well as practical knowledge to enhance the level of performance in the subject. At present, from grade 6 - 9, in the term test the marks for Science are given as 85 percent for the written paper and 15 percent for the practical test. Most of the male students score higher marks for practical examination while female students get lower marks. Therefore, it is essential to encourage female students to achieve better scores for the practical examination.

Project Justification

It was observed that most of the female students were not actively involved in Science practical sessions whereas most of the boys were well engaged. This poor engagement of female students could be identified as the major reason behind their lower scores in Science practical examination. Therefore, this project aims to improve the Science practical skills in grade 7 students by increasing their active participation. This practice will also motivate students towards selecting the Science stream for the Advanced Level Examination. Moreover, it will improve their technical skills and potentially increase the opportunities for a variety of higher education options and for employability.

Project Constraints

The proposed project will be carried out in normal school hours within the formal timetable while teaching to all students in the classroom. More attention should be paid for proper classroom management. When female students are given more opportunities for activities in the class, the male students might get bored and their interest could diminish. When the school is running multiple programmes, the time available for the project will be limited. Other constraints include, lack of laboratory equipment and chemicals, technical issues, such as no internet connectivity and poverty of parents. These barriers could preclude students from active individual performances in the practical sessions.

PROJECT DESIGN AND IMPLEMENTATION

Twenty-five female students were selected from grade 7 class of Wathupola Maha Vidyalaya in Pallama Division, Puttalam Educational Zone, North Western Province. The project period is from early 2019 to end of 2020. It is presumed that by creating an effective classroom environment, students' participation for laboratory practical sessions can be increased. An effective study environment can develop students' creativity and encourage them for innovations.

To motivate students with a pleasant and attractive environment, in the first week of first term in 2019, flower beds were established around the laboratory. Female students were exposed to lab environment and laboratory equipment to eliminate their fears. Group activities were designed to promote peer learning and develop inter-personal relationships. In that manner, it was possible to start with simple experiments. This procedure could be applied to all the slow learners in secondary level classes (Athukorala, 2011; Figure 1).

Students were properly guided to rectify their minor mistakes during initial stages of the project. Negative attitudes of other teachers towards those students are not applicable in this project. Students are given opportunities to complete most of the activities during school hours and instructions are given to do some other simple activities at home.

Project Dependencies

In this project, student-based factors can be identified as internal factors. Teacher based, family based, school based (physical equipment, environment) factors can be categorized as external factors. In this mix-school, many female students are reluctant to actively participate in laboratory practical activities possibly due to their shyness, fear of breaking equipment, adolescence, family background and their attitudes towards social behaviours (Abepala, 2015). The time allotted for one period is not sufficient for some practical activities. Further, due to non-functional equipment and expired chemicals, students fail to obtain accurate observations. This could lead to demotivate students. Diversity of the students in terms of their future prospects also leads to less participation in Science practical. In rural areas, most of the parents are farmers and therefore, some students do not have enough money to spend on extra activities conducted based on Science.

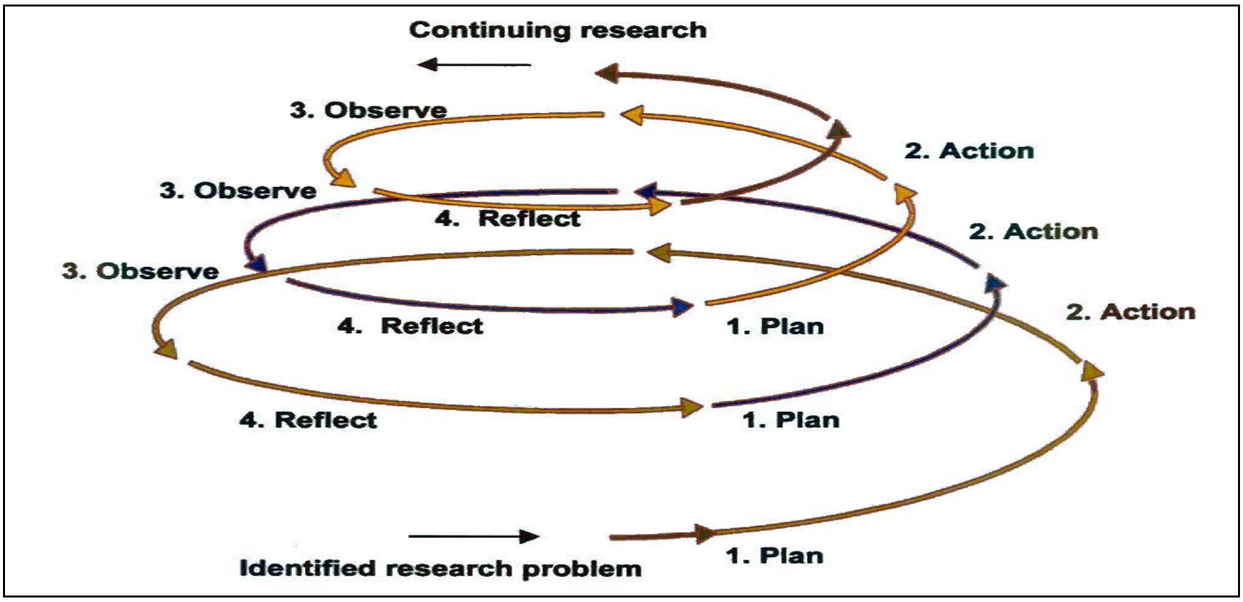

Figure 1: Planning Circle of Action Research Project
Source: Kemmis and Mctaggart, 1998

Project Success Criteria

Project success is measured on how the project outcomes contribute to improve the performances of female students in Sciences practical sessions. At the end of this initial project, students' scores obtained throughout the year for Science practical examinations will be assessed against their performance prior to implementation of the project. The result will reveal the immediate impact of adopting new strategies. Based on the results, a consistent programme would be adopted to assure credibility, sustainability and continuity of the practices.

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Author:

Isuru Madhushan: Government School Teacher (Grade 2-ii). He has B.Sc. (Agric.) Hons. [2nd Class Lower Division] from WUSL (e-Mail: *cmimadhushan@gmail.com*)

Reviewer:

Kamani Ratnayake: Senior Lecturer, Department of Horticulture and Landscape Gardening, FAPM, WUSL. Her teaching and research interests include: Postharvest Physiology & Technology and Horticultural Science
(e-Mail: *kamani.ratnayake@uqconnect.edu.au/kamani@wyb.ac.lk*)

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DROUGHT MITIGATION OF TEA PLANTATIONS IN TEA SMALLHOLDINGS

Samantha Ranathunga

Tea Small Holdings Development Authority, No. 70, Parliament Road, Pelawaththa, Battaramulla, 10120

INTRODUCTION

Tea [*Camellia sinensis* (L.) O. Kuntze], is a popular, non-alcoholic and easily affordable healthy beverage and one third of the world's population has the pattern of drinking tea. Sri Lanka is a producer of high quality black tea, at present producing nearly 303.8 million kilograms of made tea. The tea smallholders continued to be dominant among the producers by contributing over 76 percent of national production. The tea industry faces many uncertainties of their survival due to change of global climate and decline of worker population. Tea is more vulnerable to climate change when compared to other perennial crops in Sri Lanka. Serious problems have been caused to tea industry in Sri Lanka due to climatic changes (Anon., 2018).

Current Status in Sri Lanka

There is a severe dry period from January to March and from August to September in the year, in low-elevation tea growing regions. This is the short but intense inter-monsoonal dry period in drought. Tea growth and yield retardation can be seen due to water stress. The tea growers are severely suffering from the drought experiencing from 1992, 2007, 2012, 2016 and 2020.

Justification

The rainfall requirement of tea is depending on the evaporation demand of the atmosphere, soil type, type of cultivar and the plant growth stage. An even distribution of rainfall is ideal for tea growth. Optimum annual rainfall is 2,500 – 3,000 mm, minimum rainfall requirement is 1,200 mm and the minimum monthly rainfall requirement is around 100 mm, monthly average rainfall is not less than 50 mm. Tea yield reduction due to lack of rainfall could be in the range of 29 – 81 kg/ha/month/100 mm rainfall.

Table 1: Effect of Low Rainfall on Tea Production

Tea Growing Area	Optimum Rainfall (mm/month)	Yield Drop due to 100 mm Reduction in Rainfall per Month (kg/ha)
Up Country Wet Zone	350±20	29±3
Mid Country Wet Zone	417±49	36±6
Low Country Wet Zone	223±38	55±7
Up Country Intermediate Zone	303±34	39±3
Mid Country Intermediate Zone	227±10	81±11

Source: Wijeratne, 2007

Tea growing patterns and its geographical locations make it difficult to mitigate the effects of drought. During dry weather periods, considerable damage can be caused to both young and mature tea, with extensive casualties and loss of green leaf production. Therefore, more appropriate measures are to be adopted by tea growers to minimize adverse impacts of drought on tea growth, yield and quality.

Assumptions

It is assumed that, measures are to be adopted by tea growers to minimize adverse impacts of drought on tea growth, yield and quality, conservation of soil environment, and finally protection and sustainability of the tea smallholding industry.

Project Dependability

The future sustainability of the tea small holding industry will depend on effective response to mitigate drought effect. The project is mainly dependable on the contribution and active participation of the tea smallholders. Following precautionary measures need to be adopted prior to and following a drought.

LONG TERM DROUGHT MITIGATION STRATEGIES

Selection of the most suitable lands for tea cultivation and establishment of drought tolerant tea cultivars are the most important factors. Proper establishment of medium and high shade trees is important. It is more beneficial to plant shade trees to mitigate drought effects on tea. Also, shade management by planting shade trees is particularly important in the low and mid country and in Uva region to mitigate drought effects on tea. They help reduce ambient temperature and prevent sun scorch thereby plant casualties. Rainwater harvesting can be done during heavy rains for use during a dry spell with construction of ponds and lakes. Watershed management is another strategy with development of forests covers on hill crests and planting trees on boarders and fences.

MEDIUM TERM DROUGHT MITIGATION STRATEGIES

Proper land preparation and forking to retain more water in soil and cutting of lateral drains of 'lock and spill' type provided with silt pits can be done to improve soil conservation and water absorption. Other strategies include, soil rehabilitation with a grass to increase organic matter content above 2 percent and increase porosity, which help minimize the drought casualties, rain water harvesting from house roof, burying of pruned litter and soil moisture conservation through establishment of green manure crops.

SHORT TERM DROUGHT MITIGATION STRATEGIES

It is important to follow all soil moisture conservation measures, such as mulching the ground surface with a grass at 37 t/ha, lopping of cover crops and green manure crops or refuse tea at 15 - 20 t/ha. If a water source is available, micro-irrigation can be practiced mainly during new clearing, young tea stage. To reduce weed competition for moisture, the weed management should be practiced prior to dry spell. To reduce water loss by transpiration, it is possible to practice spraying 2% of sulphate of ammonia and kaolin starting one month prior to drought and continue at 2 - 4 weeks intervals. For 2nd to 4th year plants, do a light pruning to remove top most 2 – 3 inch. of foliage which remained wilted during morning hours, to minimize transpiration.

PROJECT IMPLEMENTATION

For this 3-year project, it is assumed that the Tea Small Holdings Development Authority (TSHDA) will allocate the finance for inputs through its budget 2021, and for implementation of project by resource persons of field staff at all regional offices of TSHDA. The project is expected to be completed by the end of 2023. The project will be monitored throughout this period and evaluated using yield and plant casualties.

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Author:

Samantha Ranathunga: Assistant Regional Manager in Tea Small Holdings Development Authority of Sri Lanka. He holds B.Sc. (Agri. Sci. & Mgt.) from Faculty of Agricultural Sciences & Management, Sabaragamuwa University of Sri Lanka (e-Mail: *sujeewatshda@gmail.com*)

Reviewer:

Indika K. Herath: Senior Lecturer attached to the Department of Plantation Management, FAPM, WUSL. Her teaching and research interests include: Soil Science & Plant Nutrient Management, and Environmental Impact Assessment (e-Mail: *indikaherath@hotmail.com*)

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IMPROVEMENT AND EXPANSION OF *HELA BOJUN HALA* OUTLETS

Nishanthi Jayawickrama

District Agricultural Training Centre, Gabadawatta, Homagama, 10200

INTRODUCTION

"*Hela Bojun Hala*" is serving quality Sri Lankan local food at subsidized prices. The majority of Sri Lankans regularly consume home-made foods. *Hela Bojun Hala* has been commercially introduced as a traditional food court. The consumers will be able to experience the art of Sri Lankan food making processes and taste freshly made foods for a reasonable price by visiting the outlets (Biodiversity for Food and Nutrition Sri Lanka, 2015).

"*HELA BOJUN HALA*" CONCEPT OF THE DEPARTMENT OF AGRICULTURE

The concept of "*Hela Bojun Hala*" was originated at "Gannoruwa Agro Technology Park" under the guidance of Dr. Rohan Wijekoon, former Director General of Agriculture, in 2006. It was further streamlined with the dawn of Agriculture Department's Centenary in 2012 and a new *Hela Bojun Hala* was established in the same premises with the theme of "True Sri Lankan Taste". Currently about 100 *Hela Bojun* outlets are scattered all over the island and are attracting both the locals and the foreigners (Figure 1 and Table 1).

The concept of *Hela Bojun Hala* was initiated to promote the agriculture based employments and empower private enterprises, and the business provides a sustainable and stable family economy for the wellbeing of rural women. Main ingredients for food processing at *Hela Bojun* outlets are locally grown rice, coconut, finger millet, cassava, jack fruit, vegetables, leafy vegetables and a vast range of local fruits. Reduction of imported foods, while creating a demand for local products which get higher prices, increases the income of farmers and minimizes the postharvest losses.

The concept of *Hela Bojun* outlets also helps combat the malnutrition problems in Sri Lanka. Currently the young generation is addicted to the habit of eating junk food. The *Hela Bojun* concept promotes the consumption of healthy and nutritious foods without artificial flavours, colouring and preservatives. As an eco-friendly method, PVC related materials, such as polythene are strongly prohibited to use for packing.

Limitations of Existing Hela Bojun Hala Outlets

When the people are more attracted to the traditional food consumption, the government and the non-governmental agencies are demanding more and more *Hela Bojun* outlets to be established in their premises. It is difficult to fulfill the high demand due to lack of workforce. Some women are reluctant to engage in this enterprise on full time basis due to family commitments. Accordingly, it is advisable to manage those *Hela Bojun* outlets by deploying those who are dedicated to work on shift basis.

However, within the Colombo district, it is somewhat hard to deploy two teams per day under the shift basis due the traffic congestion which is time wasting. It is also difficult for those women to find out local food ingredients, when they reach their home after completing their routine duty. To avoid this situation, a sales outlet has been established at Battaramulla for the women entrepreneurs to easily buy their food ingredients. Unavailability of sufficient number of government officers is hampering the smooth function of operating system.

Figure 1: *Hela Bojun* Food Outlets Showing (A) Authentic Local Foods, (B) Outlet at the Ministry of Agriculture and (C) Outlet at Nalanda College, Colombo.

Table 1: Recently Opened "*Hela Bojun Hala*" Outlets in Colombo District

Place of Outlet	No. of Women Employed
Visaka Vidyalaya	05
Health Ministry	14
Colombo University	13
Nalanda Vidyalaya	08

SUGGESTIONS FOR FURTHER DEVELOPMENT OF *HELA BOJUN* OUTLETS

With my two years of experience, I propose that the talented women should be selected through the public media and priority should be given to the nearby entrepreneurs. Training programmes should also be conducted for them through the Farmer Women's Unit of the Department of Agriculture. For the thorough supervision, it is eligible to appoint responsible government officers at each outlet and such officers should report the progress and issues if any, to the higher authority for speedy solutions. Furthermore, Agro-crop sales outlets (for supplying vegetables, fruits and other raw ingredients) should also be established at the close proximity. The protection and cooperation should also be provided to the *Hela Bojun* outlets by the institutions where outlets are established. As a matter of national interest, government patronage is essential to uplift the level of health immunity of the public and thereby, to build up a healthy nation.

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Author:

Nishanthi Jayawickrama: Assistant Director of District Agricultural Training Centre of Western Province at Gabadawatta, Homagama. She holds B.Sc. (Agric.) [Second Class Hons.] from University of Peradeniya (e-Mail: *nishajayash@gmail.com*)

Reviewer:

Ananda Chandrasekara: Senior Lecturer of Department of Applied Nutrition, Faculty of Livestock, Fisheries and Nutrition, WUSL. His teaching and research interests include: Diet and Diseases, Diet Therapy, Sports Nutrition, Human Physiology and Biochemistry (e-Mail: *a.chandrasekara@deakin.edu.au*)

WET PROCESSING METHOD FOR COMMERCIAL SCALE VIRGIN COCONUT OIL PRODUCTION

Thamali Dinushi Chandrapeli

Coconut Research Institute, Bandirippuwa Estate, Lunuwila, 61150

INTRODUCTION

Coconut palm (*Cocos nucifera* L.) is one of the major plantation crops in Sri Lanka, which accounts for approximately 12 percent of the country's agricultural produce. As a major beneficial harvest in the country, the coconut industry provides a number of employment opportunities throughout the coconut processing steps. It also helps to earn foreign revenue to improve country's economy.

There are many industries based on coconut products. Coconut kernel is a main part of the coconut fruit and it is used for development of a wide range of products, such as desiccated coconut, coconut oil and coconut milk. From those, coconut oil plays a key role in the world market. There are several types of coconut oil in the world. Among them, Virgin Coconut Oil (VCO) is the newest, valuable therapeutic source of coconut kernel with a novel trend as a functional food.

Current Status in Sri Lanka

VCO is extracted from fresh coconuts sourced from Sri Lanka's finest coconut plantations, both organic-certified and conventional. Sri Lankan VCO is highly sought-after in the USA, Europe, Japan and South Korea. Sri Lankan VCO is identified as one of the finest products frequently used in the food processing and confectionery industries all over the world. Currently, there are many leading companies in Sri Lanka that produce VCO commercially and export their products to foreign countries. They include, VSS Company, Lanka Exports, Adamjee Luckmanjee & Sons, AS Agri Exports Pvt. Limited, Ceylon Coco Green Manufacturing Pvt. Limited.

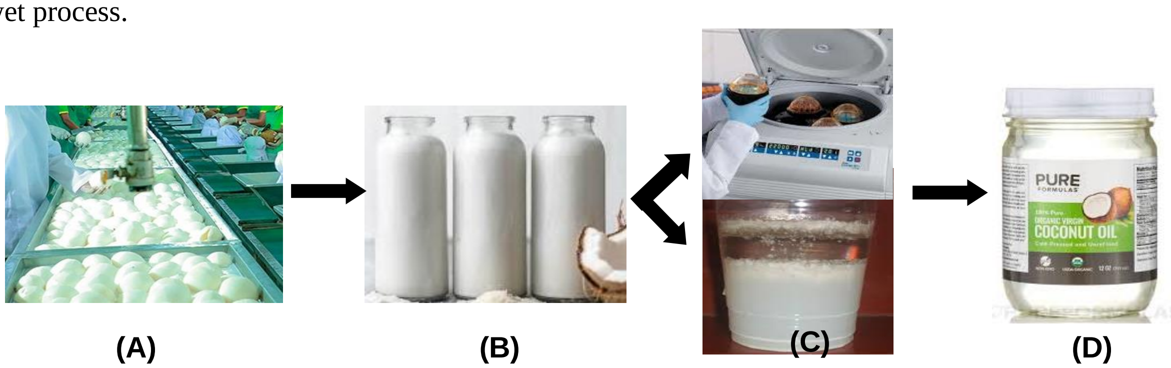
Justification

The demand for VCO has increased dramatically due to its health benefits for the consumers over the variety of other oil types in the world. Therefore, capable people are seeking to obtain knowledge on VCO processing to start new factories of VCO to furnish the world demand. The leading companies in Sri Lanka are using dry method to produce VCO because it is the standard and profitable method in the world. Other than that, the wet method can be used as an alternative method to produce VCO. This study describes the protocol of wet processing of VCO production in commercial scale.

WET PROCESSING METHOD FOR VIRGIN COCONUT OIL PRODUCTION

The fermentation method or centrifugation process can be used as two methods of wet processing of VCO. Both methods need manually or mechanically extracted coconut milk with or without water (Figure 1).

Firstly, brown testa is removed. Then, split coconut kernels are grated and milk is extracted either manually or by hydraulic pressure vertical screw type milk extractor machine with or without adding of water (Figure 1). Then, coconut milk is filtered to remove adhering particles and take fresh coconut milk or coconut cream (oil-in-water emulsion). This emulsion contains protein and coconut oil which can be separated by fermentation process or a high centrifuge force. This is the basis for the development of VCO processing technologies under the wet process.



(A) (B) (C) (D)

Figure 1: Wet Processing Method (A) Removal of Brown Testa (B) Extracted Coconut Milk (C) Centrifugation and Fermentation Process (D) Virgin Coconut Oil

Project Constraints

Knowledge on wet method of VCO extraction is limited among communities. If centrifugation applies to bulk stock, it needs a large centrifuge machine. If natural fermentation process is not properly controlled, it produces a sour smell in oil and a relatively higher free fatty acid content. Further, it is not possible to say the volume exactly that builds the oil layer. In both wet methods, oil layer is present in the upper part between the two coconut cake layers of the container. Therefore, it is difficult to separate the oil layer by syphoning.

Project Dependencies

In wet process, the quality and the yield of extracted VCO will depend on the oil content of coconut milk, time and speed of the centrifugation and the fermentation time in fermentation process. Therefore, producers should pay attention to select fresh and mature kernels of the coconut and appropriate time durations of the centrifugation and the fermentation processes. If improperly administered, it will affect the quality and shelf life of the VCO product.

Benefits of Using Wet Method for Commercial Production of Virgin Coconut Oil

Wet method is a simple method because coconut milk can be used as the major input for virgin coconut oil extraction. It is not linked with technical methods or technical assistance. Hence, any of them can be initiated using primary raw materials of fresh coconut. Therefore, wet process has the least energy input and the lowest labour requirement for extraction process over the dry method of VCO extraction. Because of the lowest labour requirement, the labour cost can be reduced from the cost of production. If the process goes through mechanical milk extraction, milk extraction machine and coconut grating machine need to be purchased as an initial investment in the fermentation method. If the process undergoes through centrifugation method, additional centrifuge machine is combined as an initial investment. Because of those reasons, the initial cost of production of VCO is reduced for the producer.

Under the wet method, fermentation method is one of biotechnology processes without using machine or other external substances. Without adding any chemicals, the pure coconut milk is allowed to stand in containers for more than 10 hours under favourable conditions to separate oil naturally from the water and protein. The higher fermentation time can be used as an effective measure for the producer in processing of VCO by fermentation method to engage in other duties as a part time job.

SUCCESS CRITERIA

Many other countries of the world are practicing this method and have achieved successful results with numerous research about wet processing method in VCO production. Therefore, coconut related government institutions and private institutes can deliver the knowledge about the wet processing method among the VCO manufacturing communities through training and awareness programmes to produce standard good quality VCO from the wet process in Sri Lanka in the near future.

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Author:

Thamali Dinushi Chandrapeli: Technical Officer in the Coconut Research Institute of Sri Lanka. She holds B.Sc. (Plantation Management) [First Class] from WUSL.
(e-Mail: *thamalidinushi@gmail.com*)

Reviewer:

Sarananda K. Hewage: Senior Lecturer, Department of Bio-Systems Engineering, FAPM, WUSL. His teaching and research interests include: Postharvest Technology, Food Processing Technologies and Value Addition and Product Development Technologies
(e-Mail: *sarahewa62@yahoo.com*)

ANALYZING THE COST OF PRODUCTION OF PADDY TO OBTAIN A SENSIBLE CONTROL PRICE

Lahiru Kanchana

Plant Protection Division, Hayleys Agriculture Holdings Limited, No. 25, Foster Lane, Colombo 10, 01000

INTRODUCTION

Rice (*Oryza sativa L.*) is one of the most commonly consumed cereals by a large percentage of human population. Further, rice is the staple food of most Asian countries, including Sri Lanka and paddy cultivation is the main livelihood of most farmers. Control price is the government-mandated minimum or maximum price which is set for specified goods. It is a way of regulating prices and set them either above or below the market equilibrium. In the absence of a sensible control price of specific goods, it may adversely affect the socio-economic standards of the producers.

Current Status in Sri Lanka

Paddy is cultivated mainly in two seasons, *Yala* and *Maha* in Sri Lanka and paddy farmers sell their harvest to sustain throughout the year while getting prepared for the next cultivation cycles. The consumption of rice amongst Sri Lankans is approximately 108 kg/person/year, which is two times the global average rice consumption of 54 kg (Fernando, 2020). The large scale millers have already become wholesale dealers of rice and thus, control the market in Sri Lanka. The Paddy Marketing Board (PMB) regularly decides on control prices for paddy and currently, the control price is Rs.50.00 per kg (Anon, 2020; Paddy Marketing Board, 2020).

Justification

Paddy farmers in Sri Lanka face numerous hardships in selling their harvest for profitable prices. While the cost of seed paddy, fertilizer, pesticides, and weedicides are on an upward scale, large scale millers are trying to control the paddy market price. It is a challenge for the farmers to survive and continue paddy farming practices under these circumstances. In this context, PMB can act to prevent unfair deals and maintain controlled prices. It is clear that, in the absence of a sensible control price for paddy, it adversely affects the socio-economic standards of paddy farmers. This study describes the case of analysing the cost of paddy production in Sri Lanka with the aim of identifying the cost components separately, to plan on how the resources should be allocated methodologically and how their costs can be controlled.

PROJECT IMPLEMENTATION

The project was carried out in Hambantota, Embilipitiya and Monaragala districts. Face-to-face interviews supported by a pre-tested structured questionnaire were conducted with a randomly selected sample of 100 farmers from above three districts. The questionnaire comprised of questions related to costs for each production step during the period of 2018/2019. Collected data were analyzed using systematic data analysis methods. Based on the results, average costs for each component were identified and the cost of paddy production per hectare was calculated (Table 1).

Table 1: Cost of Paddy Production (Rupees per Hectare)

Paddy Production Step / Particulars	Cost per Hectare (Rs.)
Land preparation (Phase 1 & Phase 2)	31,500.00
Seed paddy	10,500.00
Sowing	11,500.00
Weeding (with weedicide cost)	16,250.00
Pesticide (single application)	3,750.00
Fertilizer (with subsidy)	6,500.00
Harvesting	25,000.00
Transport	5,000.00
Miscellaneous	11,000.00
Total cost of production per hectare	121,000.00

Source: Author's Unpublished Data

The results showed that the calculated cost of production of paddy per hectare was Rs.121,000. The average yield of paddy estimated for 2018/2019 *Maha* season was 4,747 kg per net hectare and the recorded average paddy yield was 5,500 kg per net hectare in the above three districts (Paddy Marketing Board, 2020). Accordingly, it revealed that the cost of production for 1 kg of paddy was Rs.22 in the area where the project was implemented.

It was assumed that the lands were owned by individual farmers, the government fertilizer subsidy scheme was continued and application of pesticides and weedicides was carried out once in a production cycle throughout the project irrespective of climatic zones and irrigation system differences. However, there were several constraints observed during the project period. The government policies have changed and it affected the subsidy allocations for fertilizer and thus, it directly affected the cost factor. Most farmers used leased lands and they had to either pay rent for the land or compensate by paddy harvest to the landlords. In addition, the accuracy of data received from some of the participants was not up to the level of expectation.

The project depends on the active participation of farmers in the project area, government policies for subsidy allocations, and willingness of authorities to evaluate and nominate control prices. Further, the prices of pesticides, weedicides, labour charges, transportation, and machinery costs are other dependent factors for the project.

CONCLUSION

The project success was evaluated by comparing the control prices with the calculated cost of production for paddy. Eventually, adopting sensible control prices by the government based on the cost of production will offer a better income for paddy farmers. It is recommended that these types of projects can be carried out in different climatic zones with different management practices to get more realistic, climatic zone-based cost of production calculations as the results would be mainly dependent on climatic zones and irrigation systems, *etc*. Further, this analysis can be used for other commodities, such as potatoes, onions, and maize. The concept of obtaining a sensible control price based on the cost of production for crops will be beneficial for the development of the rural economy and for the sustainable livelihoods of farmers.

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Author:

Lahiru Kanchana: Technical Sales Representative attached to the Plant Protection Division of Hayleys Agriculture Holdings Ltd. He holds B.Sc. (Plantation Management) from WUSL, NDT (Agric.) from SLSA, Angunakolapelessa and Diploma in Marketing from University of Sri Jayewardenepura (e-Mail: *lahiru_kanchana@yahoo.com*)

Reviewer:

Chandana Jayathilake: Senior Lecturer of Information and Communication Technology Centre of WUSL, Makandura. His teaching and research interests include: e-Agriculture, e-Learning, ICT for Development (ICT4D), ICT4AD and Web Technologies (e –Mail: *jayathilake@wyb.ac.lk/hackjayathilake@gmail.com*)

A SELECTIVE PLUCKING MACHINE FOR TEA PLANTATIONS

Pabasara Manik Rathnasekara

Tea Small Holdings Development Authority, Kegalle Regional Office, Kegalle, 71000

INTRODUCTION

Plucking is one of the most important practices in tea cultivation which is carried out at 7 - 14 days intervals throughout the year. It is a highly labour-intensive and costly operation accounting for about 60 - 70 percent of the total field labour requirement and 35 - 40 percent of the total cost of made tea production (Wijeratne, 2012).The majority of the Sri Lankan tea fields are harvested manually and the use of mechanical harvesters can hardly be seen due to the limitations identified with manually operated and non-selective machines introduced to-date (Wijeratne, 2012; Pathiranage *et al.*, 2017).

However, estate workers tend to shift from plantations to urban areas with the fast social development to obtain better education facilities and new job opportunities with higher wages. Thus, there is a severe labour shortage in tea plantations (Wijeratne, 2012).

Mechanical plucking is becoming popular and has been used in large scale in many other countries with labour shortage, such as Japan, China, Russia, Argentina, South Africa, Zimbabwe, Uganda, Kenya, Australia, Papua New Guinea and Indonesia. Portable plucking machines (hand operated or driven by a small motor), riding machines, rail tracking system, *etc* are different devices used for harvesting tea in those countries. Since selectivity and efficiency is highly concerned in plucking, mechanization should be oriented in a way to fulfil those requirements.

Justification

During manual plucking, shoots with first two or three leaves and the unopened terminal bud is harvested typically. This is a selective and skillful practice which involves between 140 and 190 individual hand actions per minute. It requires good hand and eye coordination, dexterity, accuracy, focus and speed. Further, non-selective machine harvesting reduces the land productivity, adversely affects the quality due to high percentage of coarse leaves, cut pieces and broken or damaged shoots, causes bush debilitation and poor recovery, needs extra workers for sorting out of coarse leaves, mature foliage, stalks, *etc.*

To maintain the quality of harvested leaves while increasing the efficiency, a selective motorized tea plucking machine with improved ergonomics needs to be introduced. Such a machine has been recently designed and fabricated by the Rajarata University and the performances of the machine have been evaluated at the Tea Research Institute (TRI), Ratnapura (Piyathissa *et al.*, 2015). The machine is easy to operate and can be improved further ergonomically. Therefore, the people may prefer it and could be motivated to shift for machine operated plucking.

PROJECT IMPLEMENTATION

To retrain the quality of the end product, the introduced machine should be able to select shoots at correct maturity stage and to pluck those without crushing. This machine consists of a shoot selector, roller conveyor, cutter, collector, battery and a motor. Shoots selector is the front edge of the machine and it allows shoots that could enter from the gap between the teeth of the selector. It was made from Aluminium as it is light in weight and does not rust. From the motor (500 W), power is transferred to the roller conveyor and the cutter. A stainless steel sharp blade is used as the cutter to shear the shoots selected by the shoot selector. The directing roller is used to convey all the selected shoots to the cutter and to load cut shoots to the collector. This roller consisted of two plywood wheels, four Aluminium connecting tubes, center axel, and a rubber sheet. Aluminium tubes have been used in order to minimize the weight. Center axel has been fabricated from Iron. The function of the collector is to collect the shoots temporarily after cutting. Once filled, the content is unloaded to a bag. A thin Aluminium sheet is used to fabricate the collector to reduce the weight of the machine. As the power source to operate the motor, a 12 V, 7 A lead acid battery is used. The machine weighs 6.5 kg and the total cost of production is about Rs. 12,000, and both could be reduced with further improvements. The efficiency of the machine is promising compared to manual plucking, TRI cutting shear and one of the Japanese non-selective tea harvesters (Kawasaki) (Table 1).

Table 1: Comparison of Performances of Different Plucking Methods

Method	Actual Field Capacity	Theoretical Field Capacity	Field Efficiency
Manual Plucking	0.014 ha/h	0.023 ha/h	60.8%
Newly Constructed Selective Plucking Machine	0.021 ha/h	0.029 ha/h	72.0%
TRI Cutting Shear	0.015 ha/h	0.023 ha/h	65.2%
Japanese Non-Selective Plucking Machine	0.26 ha/h	0.035 ha/h	74.3%

Source: Piyathissa et al., 2015

Project Constraints

Most of the tea plantations are not established to be mechanized. Hence, access and maintaining continuous plucking sessions are difficult in some lands in the presence of shade trees, drains, steep terraces and high plucking table with dense canopy. Efficiency might be low in irregular sloped lands. Capital and wear and tear costs, possible break downs of the machine and requirement of training prior to operate the machine are some other drawbacks.

Project Assumptions

Since the tea leaves are not getting crushed, the final quality of the product will be excellent. With the increased harvesting efficiency, the final yield per day will also be increased. The ergonomically improved machine will enhance the willingness of workers to operate the machine compared to laborious manual plucking. Workers can be motivated with the change of job style and they could earn more income with less effort.

Project Dependencies

The entire project depends on the availability of this machine in the market for an affordable price.

PROJECT SUCCESS CRITERIA

According to the results, the newly constructed selective plucking machine can be effectively used to reduce the labour requirement of tea harvesting activity. The selectivity of the machine is satisfactory and it can be further improved to reach to the selectivity level of manual plucking. By changing or improving the cutting mechanism of the machine and replacing the roller conveyor with a pneumatic conveyor, damaged leaves percentage could be further minimized. The weight of the machine can be reduced using light weight standard materials.

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Author:

Pabasara Manik Rathnasekara: Tea Inspector/Extension Officer at Tea Small Holdings Development Authority. She holds B.Sc. (Plantation Management) from WUSL
(e-Mail: *manikwithk@gmail.com*)

Reviewer:

Priyanwada S. Warakagoda: Senior Lecturer at Department of Biotechnology, FAPM, WUSL. Her teaching and research interests include: Micropropagation/Tissue Culture Techniques, *In vitro* Conservation and Screening Techniques and Yield Improvement Strategies for Secondary Metabolites (e-Mail: *priyanwadawarakagoda@gmail.com*)

COMPOST FROM FARM WASTE: A SYSTEM FOR SUSTAINABLE WASTE MANAGEMENT IN KOULWEWA FARM, NARAMMALA

Shashinda Ashan Sumanarathna

National Livestock Development Board, Koulwewa Farm, Narammala, 60100

INTRODUCTION

Waste management plays a vitally important role in conservation of natural resources in the world. Plantations and animal husbandry farms produce large amounts of waste material all around the world and it is estimated at around 998 million tons. Further, organic waste can be up to 80 percent of the total solid waste generated in any farm (Obi *et al*., 2016). Typically, farms practice several methods to dispose of their waste, such as burning, burying, skip, wheelie bin, dumping into the gully, and composting. Poor waste management on a farm creates serious health, safety, and environmental issues.

Current Status in Koulwewa Farm and Sri Lanka

Koulwewa farm is one of the major farms in Sri Lanka, which produces coconut and dairy products under the National Livestock Development Board (NLDB). There are about 800 acres of land area and around 400 milking cows at the Koulwewa farm. Plant materials, animal waste, and household waste from workers are the major waste generating sources on this farm premises.

Composting is proven to be a viable solution to address solid waste management in the globe and is practiced in Sri Lanka too. Large quantities of solid waste materials are produced by private and public sector farms in the country. Therefore, more than 100 composting plants have been established in the country along with the introduction of the National Solid Waste Management Programme over the past few years. Mostly, the composting sector is managed by the public sector in Sri Lanka. The Ministry of Local Government and Provincial Councils are the main facilitators of waste management activities by implementing composting projects (Jayathilake, 2015).

Justification

An agricultural farm daily generates a large volume of waste which consists mostly of biodegradable materials. Thus, a farm needs to have a good solid waste disposal mechanism. Composting converts the accumulated organic waste or biodegradable materials into a usable product. This compost manure is more stable, hygienic, humus-rich, and high in nutrients thus, used as a slow-release fertilizer for plants. Further, compost is suitable to increase the water retention ability of sandy soil and water infiltration of clay soil. Therefore, farm solid waste can be used to produce compost and it can be used as a fertilizer for plantations within the farm. To ensure sustainable farm waste management, compost production is an important practice within the farm. This study describes the case of implementing a composting project at Koulwewa NLDB farm with the aim of enhancing eco-friendly and sustainable farm waste management.

Composting Process

Composting is a natural process that returns organic material into a usable substance called compost or humus. In this process, organic material of animals and vegetable origin is decomposed with shorter molecular chain. Thus, compost production is termed as the controlled decomposition of organic matter by aerobic microorganisms (bacteria and fungi) into usable product. This compost is a rich source of organic matter and a good source of plant nutrients (Table 1).

Table 1: Nutrient Composition of Compost

Nutrient	Dry Weight (%)
Nitrogen	<1% up to 4.5%
Potassium	0.5% - 1.0%
Phosphorous	0.8% - 1.0%
Calcium	2.0% - 3.0%
Magnesium	2.0% - 3.0%

Source: Food and Agriculture Organization of the United Nations, Rome, 2007

PROJECT IMPLEMENTATION

The proposed composting system will be implemented in February 2021 at Koulwewa NLDB farm, Narammala. The first step is to get permission from the relevant authorities. Then, all the workers and staff of the farm will be made aware of this project and selected staff will be trained to carry on the project successfully. The Windrow Composting Method will be followed in this project (Figure 1). The final project documentation will include a necessary land area for the construction of windrows, a detailed equipment list, and the total budget. It is assumed that the authority will allocate the finance and human resources needed through its Budget 2021 for the implementation of the project.

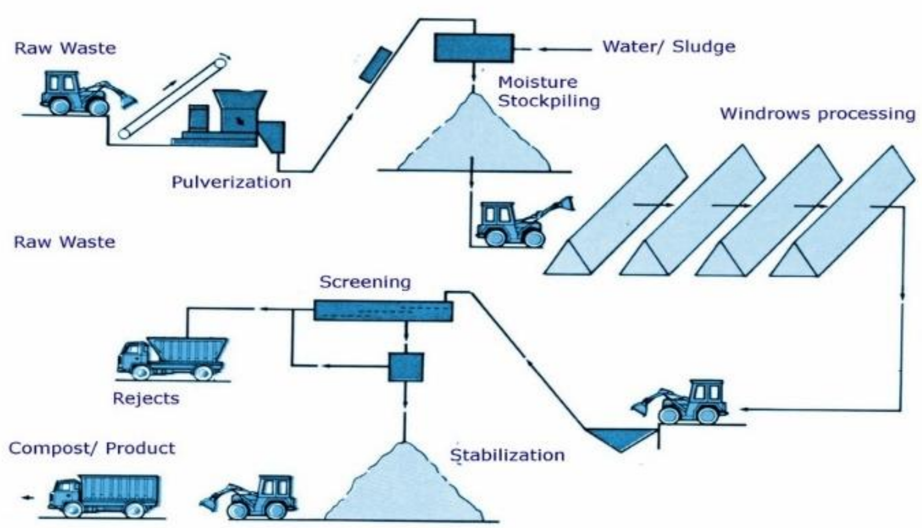

Figure 1: Flow Diagram of Windrow Composting
Source: EuroWaste, 2015 (www.eurowaste.20m.com)

The Windrow Composting Method

Windrow composting is a method of compost production by piling organic waste into long rows that make an elongated pile. This method is suitable to produce a large volume of compost and it is commonly used in farm scale composting. In this method, it is necessary to consider a slightly sloped site with close proximity to other farm operations and 100 m away from the drinking water sources in selecting the composting site. The static windrow pile is produced in the form of a triangle, called a delta windrow, to reach 2.0 m in height and 2.5 – 3.0 m in width. Windrow composting method has become economically and technically attractive due to its relatively simple equipment requirements, good performance results, and environmental profitability (Saad *et al*., 2014).

The project will be monitored throughout the process and a Cost-Benefit Analysis will be done after producing compost in two consecutive times.

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Author:

Shashinda Ashan Sumanarathna; Assistant Farm Manager, attached to the National Livestock Development Board of Sri Lanka. He holds B.Sc. (Specialized in Animal Science) from Uva Wellassa University of Sri Lanka (e-Mail: *shashiashan@gmail.com*)

Reviewer:

Chandana Jayathilake: Senior Lecturer of Information and Communication Technology Centre of WUSL, Makandura. His teaching and research interests include: e-Agriculture, e-Learning, ICT for Development (ICT4D), ICT4AD and Web Technologies
(e –Mail: *jayathilake@wyb.ac.lk/hackjayathilake@gmail.com*)

EFFECT OF THE HARVESTING INTERVAL ON COCONUT YIELD

Asoka Dharmapriya Perera

No.43, Bandarawela Road, Badulla, 90000

INTRODUCTION

Coconut is one of the major plantation crops in Sri Lanka which accounts for approximately 12 percent of all agricultural produce in Sri Lanka. Total land area under cultivation is around 395,000 ha and about 2,500 million nuts are produced per year.

Harvesting frequency of coconut varies in different areas depending upon many factors, including availability of labour. In well maintained and high yielding gardens, bunches are produced regularly and harvesting of coconut is done once a month. Generally, a bunch of coconut becomes mature in about 12 months after the opening of flowers (Mathes and Marikkar, 2004). Nuts which are eleven months old give fibre of good quality and can be harvested in the tracts where green husks are required for the manufacture of coir fibre (Harries and Clement, 2014).

Nut Development

In a bearing palm, every leaf axil can produce an inflorescence. Under normal conditions, the number of inflorescence produced in a year varies from 12 - 15. The inflorescence develops within a strong, tough, pointed tube called spathe, which after full development splits from top to bottom and releases the inflorescences. This usually occurs from 15 - 90 days after the first appearance of its tip in the leaf axil (Figure 1).

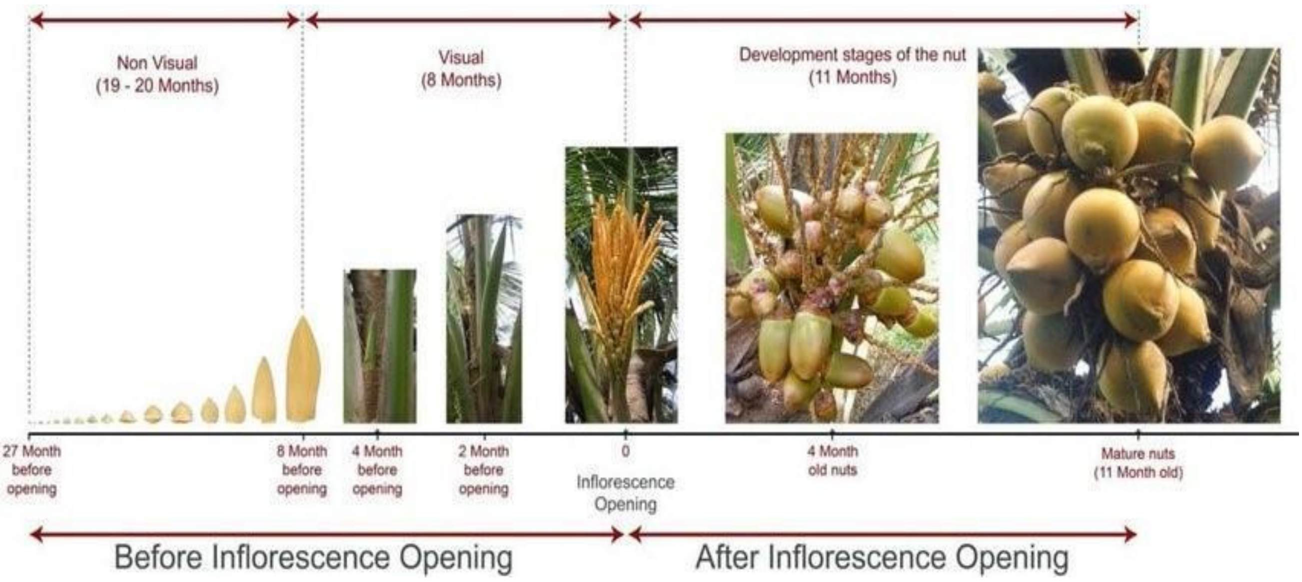

Figure 1: Different Stages of Nut Development in Coconut
Source: Coconut Research Institute of Sri Lanka

Coconut Harvesting Method

Coconut harvesting practices vary in different countries. In most Pacific Islands, ripe fruits are allowed to fall on their own and are collected periodically. Pole-harvesting is adopted in most estates in Sri Lanka. In other countries, man climbs the coconut tree, with or without ankle and waist rings, for harvesting fruits or leaves. In parts of Malaysia and Thailand a sturdy monkey is trained to harvest coconuts. All these practices are followed in different regions of Indonesia. In West Sumatra, macaque monkeys harvest about 70 percent of coconut palms. The harvesting method used makes some differences to harvesting interval as they rely on availability of required skilled human or physical resources.

Coconut Picking Interval System

Coconut becomes mature in about 12 months after the opening of the spathe. Nuts which are eleven months old give fibre and kernel of good quality and can be harvested. In practice, the harvesting cycle varies from 30-day, 60-day and 45-day periods. However, considering the hired labour cost, 45-day cycle is considered to be practical for economic reasons. One to two bunches of coconut could be harvested from each palm if this cycle is followed. This harvesting cycle has been found to yield a good number of mature nuts with high copra and oil recovery.

Effect of the Picking Interval on Coconut Yield

Plantation sector in Sri Lanka has been methodically attempting to increase the extent of land acreage under coconut to increase the national production of coconut. In the meantime it is important to see what kind of impact harvesting interval can make on the yield of coconut. A study conducted in major plantations of coconut to investigate the effect of harvesting interval on yield of coconut shows significant differences. Figure 2 shows the changes in coconut yield with different picking intervals and it shows that, monthly interval of harvesting has given the highest yield in the four consecutive years observed.

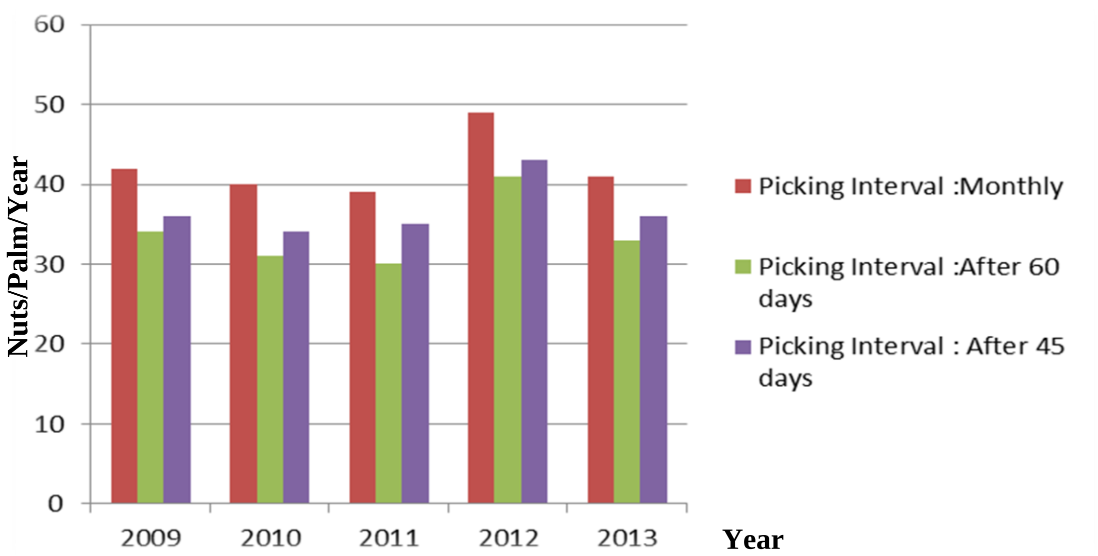

Figure 2: Effect of the Picking Interval on Coconut Yield

CONCLUSIONS

Monthly Picking Interval is the most suitable harvesting interval to achieve the highest yield from coconut plantations. However, cost has to be considered depending on the method of harvesting.

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Author:

Asoka D. Perera: Planter. He holds MBA and B.Sc. (Plantation Management) from WUSL and National Diploma in Plantation Management from National Institute of Plantation Management, Athurugiriya (e –Mail: *dfadperera@gmail.com*)

Reviewer:

Indika K. Herath: Senior Lecturer attached to the Department of Plantation Management, FAPM, WUSL. Her teaching and research interests include: Soil Science & Plant Nutrient Management, and Environmental Impact Assessment (e-Mail: *indikaherath@hotmail.com*)

INTRODUCTION OF LOW INTENSITY HARVESTING (LIH) SYSTEM FOR THE SUSTAINABILITY OF RUBBER PLANTATIONS

Jagath Rohana Ranasinghe

Rubber Development Department, Regional Office, Kegalle, 71000

INTRODUCTION

Natural rubber is an important commodity for the economy of Sri Lanka. This industry makes export earnings, sustains the livelihood of thousands of people, supplies thousands of hectares to the forest cover and provides many other socio-economic and ecological benefits. Harvesting latex from rubber trees (tapping) is considered to be the costliest operation in the industry. Over one third of the cost of production is spent on tapping, particularly in a commercial plantation (Anon, 2020a). Further, tapping requires a greater skill and this, together with poor wage structure has led to the shortage of skilled harvesters in the rubber industry. Low Intensity Harvesting (LIH) is a system that addresses both of the above mentioned issues.

Justification

In harvesting, the rubber tree is generally tapped along a half of the circumference of the trunk (S/2) with the frequency of once in two days (d2), hence each harvester can be given two tapping blocks. As skilled labour and tapping cost are major concerns in the rubber industry, introduction of the LIH system is an effective method that addresses the above issues.

In the LIH system, the time gap between two tappings is extended up to four days (Half spiral based once in four days system - S/2 d4). Therefore, each harvester can be allocated four tapping blocks. Simultaneously, to compensate the yield loss due to a smaller number of tappings, yield stimulants are applied at regular intervals, thereby yield per tree per tapping increases. Due to the lesser number of tapping days per year, bark consumption rate also decreases. In most rubber plantations, including smallholdings, the bark consumption level is high which leads to a shorter economic life span of the rubber tree (Table 1; Anon, 2020b).

The LIH system is also a solution for the problem of the shortage of skilled tappers. With higher efficiency in labour use, LIH system is rather less affected by the increase in labour wages.

Table 1: Bark Consumption Levels in Rubber Plantations

Tapping System	Tapping Days	Bark Consumption		Estimated Years Tapping on Panel B0 & B1			
		Per Tapping (cm)	Per Year (cm/yr)	Panel 1	Panel 2	Panel 3	Panel 4
S/2 d2	165	0.135	22.3	5 ½	11	16	21 ½
S/2 d4	94	0.144	13.5	9	18	27	36

Source: The Low Intensity Harvesting Research Data, The Rubber Research Institute of Sri Lanka

Project Constraints

Although the new harvesting system brings above said benefits, the adoption process of the new LIH system is rather complicated. The present workforce is used to harvest according to the traditional S/2 d2 method. To make them adopt the new LIH system a lot of convincing is necessary. In addition, awareness programmes and demonstrations should be conducted for the workers as well as for the top to bottom management. Traditional tappers are reluctant to adopt the LIH system as it needs a considerable monitoring and record keeping about application of stimulant and GTT (Gram/Tapping/Tree).

Availability of stimulant and skilled labour to apply stimulant on time is necessary. The cost for this is also added to the cost of production (COP). As a stimulant is used in LIH, the tapping panel should be covered with a rain guard. As a result, an initial cost for fixing rain guards should be borne by the management.

Project Assumptions

Success of the project depends upon following assumptions.

- Stimulant is applied on due time and the recommended amount is used
- Rain guards are fixed on time and maintained during the rainy season
- Changes in climatic conditions occur in the regular pattern
- Agronomic practices are maintained properly
- True records of the LIH are maintained

Project Dependencies

The project depends upon the support of the Rubber Research Institute (RRI) and Rubber Development Department (RDD) to conduct demonstrations and training for effective technology transfer and also for initial financial support given to them under the project for the establishment of LIH with rain guards. Further, their support is needed to conduct monitoring on the project for a period of four years to investigate the effectiveness. The estate, Regional Plantation Companies (RPCs) and the smallholders themselves should bear up the cost of agronomic practices.

Project Success Criteria

- Reduction of COP with effective use of labour
- Shortened replanting cycle with reduced bark consumption
- Increased economic life span of rubber trees
- Reduction of the workforce
- Improved livelihood of the workers with higher wages
- Increased income of the industry (Table 2)

Table 2: Comparison of Traditional Rubber Tapping System (S/2 d2) and LIH (S/2 d4) System

Tapping System	Tapping Days	Annual Yield of 300 Trees (kg)	Cost for a Tapping Block per Year (Rs.)				Income at Selling Price Rs.300/kg	Profit (Rs.)	
			Tapping	Stimulant	Other at Rs.60/kg	Total		Total	Increase Over S/2 d2
S/2 d2	165	1153	132,000	0.0	69,192	201,192	345,900	144,708	-
S/2 d4	94	1187	75,200	5,760	74,244	152,204	356,100	203,896	59,188

Source: The Low Intensity Harvesting Research Data, The RRI, Sri Lanka

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Author:

Jagath Rohana Ranasinghe: Divisional Officer attached to The Rubber Development Department of Sri Lanka. He holds B.Sc. (Plantation Management) from WUSL and Diploma in Plantation Extension Management from NIPM (e-Mail: *rajrranasinghe@gmail.com*)

Reviewer:

Thilak Attanayake: Professor in Biotechnology, Department of Biotechnology, FAPM, WUSL. His teaching and research interests include: Plant Molecular Biology, Genetics and Plant Breeding (e-Mail: *dpstga@yahoo.com*)

PROMOTION OF CHEMICAL RESIDUE FREE HOME GARDENING IN BATTICALOA DISTRICT

Paramanathapillai Premendra

Deputy Director of Agriculture–Extension Office, Department of Agriculture, Yard Road, Batticaloa, 30000

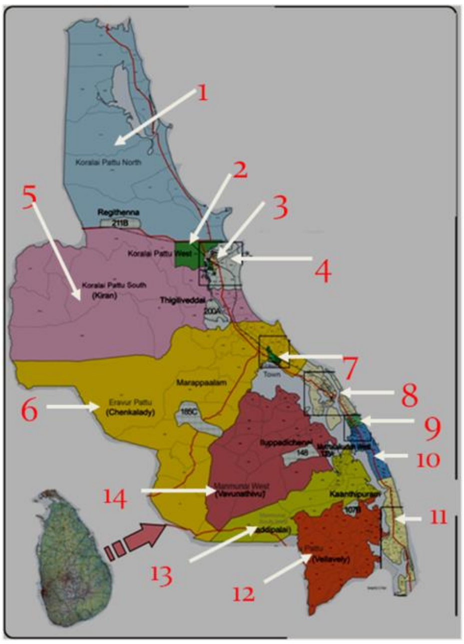
INTRODUCTION

Excessive use of agrochemicals and inorganic fertilizers is a threat to the healthy life of human being and sustainability of the environment. Agricultural pollutants are considered as a major cause for several non-communicable diseases, *e.g.* chronic kidney disease of unknown aetiology, cancer and heart diseases. A study conducted in Batticaloa District revealed that the volume of agrochemical wastage is higher than the volume of utilized pesticides in all sort of cultivations (Prasannath and Prasannath, 2013). Main reason could be the lack of awareness among farmers on the toxicity level of chemicals, their interactions and the effect on human health. Considering those circumstances, importation and usage of certain agrochemicals have been banned in Sri Lanka (Anon, 2015).

Farmers practicing sustainable agriculture have to achieve its main objectives *i.e.*; minimised environmental pollution, increased crop yields, reduced cost of production and mitigation of climate change impact in order to feed the increasing world population. With the establishment of organic agricultural systems where higher amounts of animal and crop wastes are used for soil improvement, integrated pest management (IPM) is practiced with the application of bio-pesticides and bio-fertilizers to nourish the crops and it would be sustainable in long term. Generally, the price of organic food is higher than that of the conventionally produced food. In majority of food crop sectors, availability of organic products is less than 10 percent whereas the rest is supplied from conventional farming systems. Therefore, awareness programmes on chemical-free agricultural production and importance of those products for maintenance of a healthy life should be conducted through effective extension programmes at village level in order to promote shifting from conventional farming to organic cultivation in the district.

Agro-Ecology of Batticaloa District

Batticaloa district which consist of 14 Divisional Secretariat (DS) Divisions with a population of 556,000 is located in the central part of Eastern Province and has a total area of 2,854 km^2, with inland water coverage of 244 km^2 (Figure 1). It belongs to the dry zone and the mean annual temperature is 28.2°C. The annual rainfall is 3,581 mm with a higher intensity in the months of September to January. This district has four major soil groups, namely sandy soil, clay soil, alluvial soil and reddish-brown soil.



No.	DS Division	No.	DS Division
1	Koralai Pattu North	8	Manmunai North
2	Koralai Pattu West	9	Kattankudy
3	Koralai Pattu Central	10	Manmunai Pattu
4	Koralai Pattu	11	Manmunai South Eruvil Pattu
5	Koralai Pattu South	12	Porathevu Pattu
6	Eravur Pattu	13	Manmunai South West
7	Eravur Town	14	Manmunai West

Figure 1: District Map of Batticaloa Showing the Locations of Divisional Secretariat (DS) Divisions
Source: Annual Report, 2016, Department of Agriculture, Sri Lanka

Justification

Agriculture sector of Sri Lanka is the primary source of livelihood where organic cultivations would perform several functions; enhancing green productivity, minimizing environmental pollution, promoting reuse and recycling of organic farm waste and crop residues, improving biodiversity, and improving soil productivity. Demand for food quantity is continuously increasing rather than quality, hence there is a doubt whether it is possible to meet the demand from a limited land area while adopting the organic concept. However, for export market availability of quality products is an essential requirement and thus, the crops grown under hygienic conditions without use of “agrochemicals” especially pesticides, and at premium prices, have attracted attention. A few production units have already been established in Batticaloa district with considerable success and there is an emerging opportunity for further expansion to meet the export demand.

Constraints

Majority of farmers do not have an interest in preparation of natural pesticides because it is an extra work that requires additional labour. On the other hand, they are lacking awareness on IPM. Therefore, continuous production of organic food in Batticaloa district is a challenging task. Unavailability of a proper organic certification mechanism which is affordable for average farmers is another constraint. Furthermore, farmers are not assured of a reasonable price for their organic vegetables.

Dependencies

Success depends on the performance of home garden farmers selected from Batticaloa district and the involvement of the government institutions, such as the Department of Agriculture in Eastern Province. Efficiency of the farmers’ capacity development may also influence the success.

PROJECT IMPLEMENTATION AND SUCCESS CRITERIA

A survey was carried out to collect information on home garden systems in Batticaloa District, including the availability of resources and facilities and present usages of chemicals at the home garden level in order to convert them to chemical-free cultivation.

All organic home gardens established in the district continuously produce chemical-free vegetables and supply commodities to the sales centres within the district. Since consumers have access to those products, consumption of organic food has been increased throughout the year. Home garden cultivation is a secondary income for the farmers in Batticaloa district. Low yield and high water wastage are considered as the constraints of traditional home gardens and that can be overcome by adopting modern home garden technologies. By establishing one model home garden for each DS division and transferring knowledge on preparation and usage of natural pesticides through training programmes conducted in model home gardens will improve the farmers’ skills on this aspect. Furthermore, arrangement of marketing facilities will be an encouragement for farmers to continue organic food production at home garden level in Batticaloa district.

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Author:

Paramanathapillai Premendra: Agriculture Instructor at the Department of Agriculture Batticaloa. He holds B.Sc. (Agriculture) from Alliance International University (AIU) and BA from Eastern University of Sri Lanka (e-Mail: *preme2u@yahoo.com)*

Reviewer:

Bandula Ranaweera: Senior Lecturer, Department of Horticulture and Landscape Gardening, FAPM, WUSL. His teaching and research interests include: Plant Protection, Pest Management, Biorationals, Bio Pesticides & Bio Fertilizers and Toxin-Free Crop Production
(e-Mail: *branaweera@gmail.com/branaweera@wyb.ac.lk*)

FACTORS AFFECTING SUSTAINABLE DAIRY DEVELOPMENT IN SRI LANKA AND ENVISAGING UVA PROVINCE AS A PILOT PROJECT

Chithral Hilarian Munaweera

All Island Dairy Association, The Ceylon Chamber of Commerce, No. 5o, Nawam Mawatha, Colombo 02, 00200

INTRODUCTION

Dairy farming in Sri Lanka plays a key role in the improvement of rural household income and food security. Although these are factors of significance, the country has not been able to achieve self-sufficiency in milk production. The country, in accordance with recent statistics, imports around 100,000 t of milk powder. Sri Lanka is only 40 percent self-sufficient in its requirement of milk and the balance depends on imports (Figure 1; Dairy Industry Statistics, 2018). With the introduction of open economic policies, one can notice a gradual increase in milk importation since 1977, which acts as a crucial factor affecting economic development, given the outflow of foreign exchange of the country is negative, or in other words, "debt-ridden economy" (Livestock Research Centre, 2015).

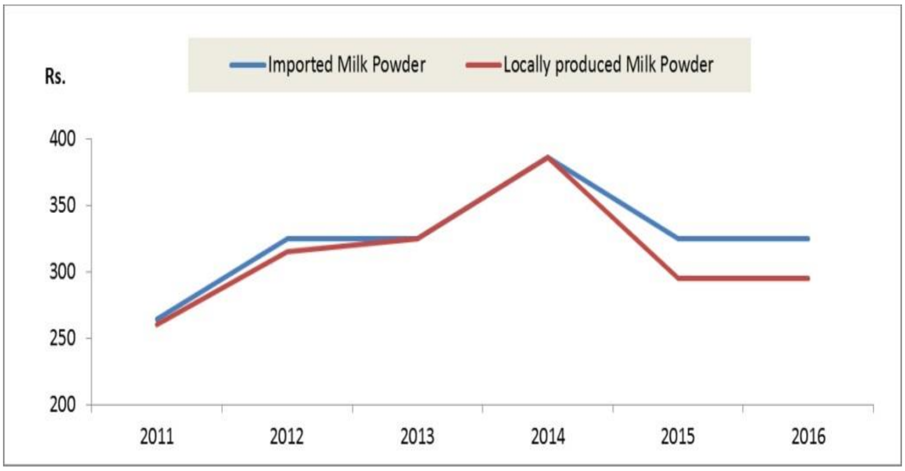

Figure 1: Maximum Retail Price of 400 g Milk Powder Pack in Sri Lanka
Source: Ministry of Finance, News Articles (2018)

Justification

The Uva Province of Sri Lanka includes two districts, namely Badulla and Moneragala. It contributes nearly 8 percent to the Gross Domestic Product and is responsible for 14 percent of milk production of the nation (Central Bank of Sri Lanka, 2018). Further, these two districts hold 7.3 percent of Sri Lanka's cattle population and the land areas are available for both 'intensive' and 'extensive' dairy farming. It is assumed that with the implementation of the project in Uva province, 20 percent increase in milk production could be anticipated within 5 years. The Province has a large-scale commercial dairy processing plant with a capacity to process 200,000 L of milk in a day with the participation of all key value chain actors.

The intention is to categorize the province as per its agro-ecological features and resources available within the province and embark on a phased-out systematic dairy development programme encompassing all dairy value chain actors together with other required components as can be seen from Figure 2.

Project Constraints

The amount and pace of allocation of funds by the respective governments, *i.e.* both National and Provincial, is crucial to expedite the implementation of project. Although the country's policy on dairy development is set to achieve 'self-sufficiency in milk', there are gaps in the existing policy and therefore, it needs to be refined to be more focussed on entire value chain, profits and sustainability. Further, large areas of fallow lands belonging to the marginal tea estates are available, especially in the Badulla district, which are ideal for improved fodder cultivation. It is important to have a proper direction from the side of government so that Regional Plantation Companies (RPCs) can allocate such lands for the development of dairy sector. If it takes place satisfactorily, it would have a significant impact on feed and nutrition resulting in enhanced milk production. Moreover, the guaranteed price paid per litre of milk enforced by the government does not conform to the actual cost of production and hence, the periodic price adjustments have become a necessity.

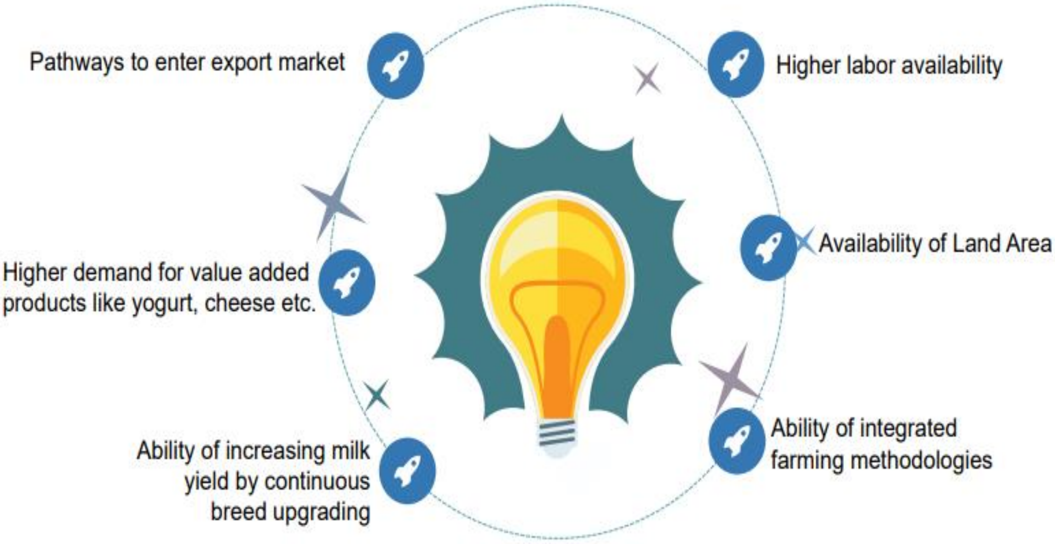

Figure 2: Potentials of Sri Lankan Dairy Industry
Source: Department of Animal Production and Health, Sri Lanka (2017)

PROJECT IMPLEMENTATION

A detailed study should be conducted where information should be gathered in three forms: 1. Questionnaire-based field survey, 2. Key informant interviews and focus group discussions and, 3. Review of published and unpublished data/information. The field survey data should be collected primarily through interviews and at least 300 samples should be obtained from the project area for the analysis. These should be obtained from all supply chain individuals involved, including the key informants, input suppliers, milk collectors, transporters, milk processors, support service providers, and more importantly, the dairy farmers. It is also important to obtain an accurate census of cattle population breed-wise.

The project implementation team should be under the Divisional Secretary of the district. All identified constraints should be carefully evaluated and suitable solutions should be found. The banks can play a vital role as stakeholders in the project's success by way of providing credit facilities and other essential financial services at each level in the supply chain.

The Non-Governmental Organizations (NGOs) also have an important role to play in the support process. The deviations that occur in the project process in achieving the required goals should be promptly corrected so that the required dividends are extended to the beneficiaries. The investment by private entrepreneurs on processing and investing in dairy farming and in its supply chain within the district should be encouraged. The Department of Animal Production and Health who spearheads the extension staff should be supported at all times by the Project Management Committee.

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Author:

Chithral H. Munaweera: Consultant to the All Island Dairy Association, Ex-General Manager of the NLDB and CEO of the Ambewela Dairy Complex of Lanka Milk Foods (CWE) PLC. He holds B.Sc. (Plantation Management) and an MBA from the WUSL (e-Mail: *chmunaweera@gmail.com*).

Reviewer:

Jagath C. Edirisinghe: Professor in Agribusiness Management, Department of Agribusiness Management, FAPM, WUSL. His teaching and research interests include: Agricultural Marketing, Supply Chain Management, International Trade, Environmental Economics and Bayesian Econometrics (e-Mail: *jagath@wyb.ac.lk*)

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DEVELOPMENT AND PROMOTION OF BANANA FLOUR AND RELATED PRODUCTS

Ramani Kumari

Mahaweli Authority of Sri Lanka, Weheragala Block, System C, Dehiattakandiya, 32150

INTRODUCTION

Banana (*Musa* spp.) is one of the major fruits cultivated in Sri Lanka. Currently, nearly 50,000 ha of land is under banana cultivation, and the annual banana production is around 450,000 t. Bananas are subject to post harvest losses of around 40 percent during their reach to market place. In special areas of Mahaweli Authority of Sri Lanka, there are possibilities to introduce various value added products from the banana fruit. The objective of this proposal is to find out the possibility of producing banana flour and related products as a pilot project aiming at launching a large scale production in future and marketing them in the local and international markets.

Banana Flour

Banana flour is being produced by green matured banana through a process consisting of peeling, cutting, drying and milling. This product is mainly available in Africa and Jamaica as a cheaper alternative to wheat flour, as a raw material for the making of products, such as bread, green smoothie, tortillas, banana zucchini loaf, *rotti*, cake and ice-cream. Due to use of green bananas, it has a mild banana flavour. It is mainly included in most diet plans as a good source of resistant starch which is available more than 60% in weight (Banana Improvement, 2020).

Resistant starch can be identified as a starch which is none or partly digestive in small intestine in healthy individuals. Some types of them are digested in large intestine and large intake tends to make more gases in the stomach and lead to flatulent. Due to this reason, it is mostly recommended as a diet food for elders who have been advised to control the intake of starchy meals due to health problems. On the other hand, banana flour contains Magnesium, Zinc and Phosphorus to enhance the general health through supporting to reduce harmful Low Density Lipoprotein (LDL), inhibiting the growth of harmful pathogenic bacteria in the gut, assisting in weight loss, promoting a healthy heart and maintaining a healthy blood sugar level.

PROCESSING METHODOLOGY

Banana flour is mostly produced from mature green bananas. However, there are some countries, such as Chile who are producing it using over ripe fruits through a puree making process. It takes 8 -10 kg of green banana to make 1 kg of banana flour. Main steps of the production process can be identified as cleaning, blanching, chopping, drying, milling and packing of the product (Sandanayake, 2006).

To fulfil this manufacturing procedure, a mechanized system which has been designed to come up with a quality product is shown in Figure 1.

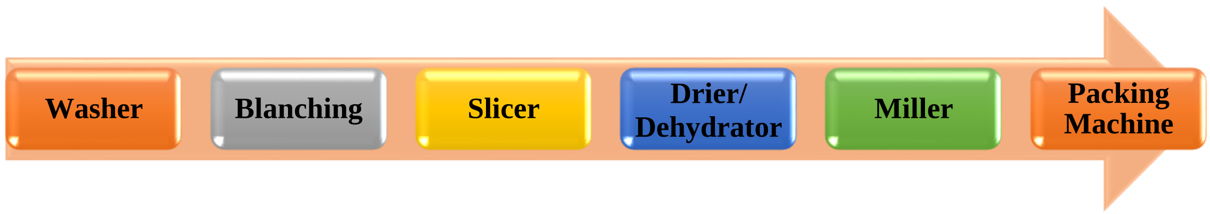

Figure 1: **Processing Procedure for the Making of Banana Flour**

Bio Breeze Pvt. Limited, Yatiyana, Minuwangoda is a company which is exporting this product to the foreign markets. They are making banana flour from matured sour and sweet banana using the machinery produced by Udaya Industries, Gampola. According to their experiences, foreign demand is average and the local market demand is near to zero for this product. The production plant has been established in a farmer organization under the cooperative system. Activities are monitored with close supervision by the Mahaweli Authority.

DEVELOPING A MARKET FOR BANANA FLOUR

Banana flour is a totally new product for the local market. Due to high cost for machinery and high price range of the product it is necessary to carry out a pilot project to ensure whether it is an appropriate product for launching at large scale. It is also essential to make people familiarize for consuming this product and introduce it to the potential markets and places.

People are more concerned about health benefits of their day to day diet. They have some selected food patterns and outlets/places where they prefer to have their meals. In that context, "Hela Bojun", "Govijana Bojun" and "Mahaweli Bojun" centers are highly popular around the country which are managed via the Department of Agriculture, Mahaweli Authority of Sri Lanka and the Department of Agrarian Services. Those centres are selling a variety of highly popularized local food items for the people who search for healthy foods. Therefore, novel products can be developed from banana flour and make available at those popular food outlets (Figure 2).

Products of banana flour are to be developed for introducing to the local market in variety of forms, such as bakery products, chocolate, ice cream, 'murukku', and cake. Technical guidance will be obtained from the Food Research Unit (FRU) of the Department of Agriculture, Gannoruwa, Peradeniya.

Figure 2: Some Value Added Products Made from Banana and Banana Flour (A) Mature Green Banana as the Raw Material, (B) Dry Sliced Banana and Banana Flour, (C, D) Products form Green Banana Flour

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Author:

Ramani Kumari: Agriculture Officer, Weheragala Block, Mahaweli Authority of Sri Lanka. She holds B.Sc. (Plantation Management) from WUSL (e-Mail: *ramanikumari7199@gmail.com*)

Reviewer:

Sarananda K. Hewage: Senior Lecturer, Department of Bio-Systems Engineering, FAPM, WUSL. His teaching and research interests include: Postharvest Technology, Food Processing Technologies and Value Addition and Product Development Technologies
(e-Mail: *sarahewa62@yahoo.com*)

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PRESENT STATUS AND POTENTIALS OF ORNAMENTAL FISH INDUSTRY IN SRI LANKA: A MINI REVIEW

Thiyanka Chaminda Kulawansa

National Livestock Development Board, Beligama Farm, Beligamuwa, 21214

INTRODUCTION

Sri Lanka is home to a total of 111 ornamental fish species living in fresh, brackish and marine water habitats, which makes the country one of the most sought after aquarium fish exporter destinations to the world. The ornamental fish industry in Sri Lanka has become a valuable foreign exchange earner during the past few years, earning Rs. 2.2 billion in 2017 (Export Development Board of Sri Lanka, 2018). The ornamental fish industry in Sri Lanka has a history of nearly 100 years when a group of hobbyists and collectors started exploring and discovering exotic fish varieties in the rivers, lagoons, and marine habitats around the country. Yet, the rise of conservatism and the urge for sustainable breeding and harvesting practices in the global ornamental fish industry as well as the introduction of local laws and regulations to avoid the destruction of habitats and breeding populations of rare and threatened exotic fish species, have driven the ornamental fish industry in Sri Lanka to a new direction compelling them to take steps on sustainable harvesting and breeding (Export Development Board of Sri Lanka, 2018).

Out of the freshwater aquarium fish species exported from Sri Lanka, Guppy (*Poecilia reticulata*) consists of nearly 60 – 70 percent (Table 1) in quantity and they gain high demand and price in the international market for their strength and high diversity in comparison to other aquarium fish exporting countries in the world. Sri Lanka exports Guppy fish and other ornamental species (Goldfish, Mollies, Platy) to the USA, UK and other European countries as well as to western and eastern Asian countries (Export Development Board of Sri Lanka, 2018).

Justification

The ornamental fish industry was commercialized by a few entrepreneurs about 70 years ago and has now developed into a thriving industry with an export market, affording employment to many people. As a result of over-crowding, high labour cost and lack of land for fish grow-out facilities in the Western Province, the large scale growers started to move to rural areas of the dry zone of Sri Lanka. At present, the ornamental fish grow-out systems are distributed in the North-Central, North-Western and Central Provinces of Sri Lanka. With this expansion, a proper analysis of the current status and future opportunities would benefit for a sustainable and profitable industry.

Table 1: Ornamental Fish Species from Sri Lanka for the Export Market

Species	Percentage (%)*
Angels	8
Goldfish	2
Mollies	4
Platy	6
Sword Tales	8
Guppy	67
Others (different types of Tetras)	5

**Percentage values based on numbers of fish per species*
Source: Wijesekara and Yakupitiyage, 2001

CURRENT STATUS OF ORNAMENTAL FISH INDUSTRY

This mini-review on the present status and future trends of the ornamental fish industry in Sri Lanka is prepared based on the available literature. Accordingly, a SWOT Analysis was performed to identify the Strengths, Weaknesses, Opportunities and Threats in the Sri Lankan ornamental fish industry (Figure 1). Although there are numerous positives, weaknesses, such as lack of advanced breeding technology, poor disease management, difficulties in reaching the export market, and lack of production in the off-season could be identified as major drawbacks in the industry.

Strengths

- Strong cooperatives
- Resource availability (land, water)
- Less labour intensive than poultry and cattle farming
- Creates employment opportunities and income generation
- Favourable climatic condition
- Excellent geographical location
- Recognized international reputation
- Government training programmes

Weaknesses

- Lack of advanced breeding technology
- Lack of knowledge on diseases
- Lack of technology transfer
- Difficulties in entering the export market
  Difficulties of maintaining the industry in the off-season
- Export of fish in some cases for low price

Opportunities

- Developing technology (breeding)
- Financial support from local government (loans, subsidies)
- Potential development of a new customer base
- Improving the image of the ornamental fish sector
- Infrastructure development of the country

Threats

- Rapid urbanization and environmental degradation
- Lack of skilled labour
- Lack of rainfall or drought condition in some areas

Figure 1: SWOT Analysis of the Ornamental Fish Industry in Sri Lanka

CONCLUSIONS

With the expansion of the ornamental fish industry to rural areas, it has created employment opportunities. Compared to the status of 20 years back, still this industry is facing problems related to technology transfer. However, with the intervention from government organizations, such as the National Aquaculture Development Authority (NAQDA), farmers are now able to gain well-organized training programmes covering many aspects. Currently, the wild collection of fish for ornamental purposes has been banned by the law. It is a massive ecological gain although it seems like losing an economic gain and it can be compensated by breeding indigenous varieties. The development of infrastructure facilities of the country is advantageous, especially in dealing with the technology and transporting fish in short time duration. The ornamental fish industry in Sri Lanka has a potential to be expanded in catering the increasing international demand, thus sensible laws and legislations need to be strengthened in safeguarding all stakeholders of the industry as well as the sensitive ecosystems of the country.

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Author:

Thiyanka Chaminda Kulawansa: Senior Farm Manager, National Livestock Development Board. He holds B.Sc. (Agric.) from University of Peradeniya and currently works at the Beligama Farm, Beligamuwa (e-Mail: *thikulawansa@gmail.com*)

Reviewer:

Dileepa de Croos: Senior Lecturer attached to the Department of Aquaculture and Fisheries, Faculty of Livestock, Fisheries and Nutrition, WUSL. His teaching and research interests include: Marine Biology, Marine Ecology, Fisheries Management and Population Genetics
(e-Mail: *dileepa_dc@yahoo.com*)

OPTIMAL STEM CUTTING LENGTH AND MEDIUM FOR PROPAGATION OF *Anthurium andraeanum* VARIETY TROPICAL RED

Wajira Thennakoon

Coconut Cultivation Board, Mylambaweli, Batticaloa, 30000

INTRODUCTION

Anthurium andraeanum which belongs to family Araceae is one of the major economically valuable ornamental cut flower plants in the tropical region, including Sri Lanka. It is produced for both exportation and for the local market. It is one of the major export items earning a considerable foreign exchange into the country. Based on the colour and the shape of the spathe, there are many different species and cultivars. The variety 'Tropical Red' has been grown substantially in Sri Lanka during the last few years. Even though *Anthurium* is propagated by seed and tissue cultured plants, vegetative cutting is the most popular propagule for multiplying this plant. Therefore, the present project is aimed to introduce the appropriate length of stem cutting for a higher propagation rate. Furthermore, finding the most appropriate potting medium for vegetative propagation of *Anthurium* (var. Tropical Red) is also an objective of the current study.

Justification

The composition of the potting medium and the length of stem cutting affect the formation and growth of plantlets in *Anthurium* (var. Tropical Red). Therefore, it is important to determine the appropriate length of stem cutting and the composition of growing medium to get a higher number of plantlets with a low cost for enhancing the efficiency of vegetative propagation of the variety. There are high cost methods to increase plantlet formation. However, it is unaffordable to the farmers with a lower income. Therefore, establishing a low cost method for propagating the plant is beneficial for the small scale farmers.

Constraints

It is hard to find well grown healthy mother plants of *Anthurium* to obtain healthy stem cuttings. Mother plants from which the stem cuttings are taken should be free from diseases and pests. However, finding a sufficient quantity of such healthy mother plants to be used in propagation is a challenge. On the other hand, the *Anthurium* var. Tropical Red is available only in specific areas. For a healthy growth, there should be 70 - 80% shade level with 21°C - 32°C temperature (Chen *et al.*, 2015). Net houses are used to control the shade and the temperature which is sometimes unaffordable to the smallholder farmers.

Assumptions

Anthurium does not produce good quality flowers in the open cultivation. However, by providing the recommended shade levels in net houses, the plants produce good quality flowers (Dufour and Guerin, 2003). For providing the shade, coir mesh enclosures and shade nets can be used. The suitable media should have all favourable characteristics, such as retaining of moisture, providing all nutrients for plantlet growth and suitable drainage of water. The potting medium containing coir dust, sand, compost and coconut husk in a suitable ratio will provide an appropriate medium for propagation. The suitable potting media for the expectative propagation of *Anthurium* (var. Tropical Red) using its stem cutting are coir dust and sand at 3:2 ratio with coconut husk chips, coir dust and sand at 2:3 ratio with coconut husk chips and coir dust, sand, compost at 1:1:1 ratio with coconut husk chips.

Dependencies

Success depends on the quality of the mother plants from which the cuttings are taken. It takes about 9 months for flowering for the identification of the characteristics of mother plants.

PROJECT IMPLEMENTATION AND RESULTS

Six different potting media and three size categories of stem length were tested during 5 months to select the most suitable potting medium and the length of stem cutting. Five propagation media were used as depicted in Figure 1. Stem cuttings of different lengths (L1 – 2.5 cm, L2 – 5.0 cm, L3 – 7.5 cm) were used to assess the propagation success. At the end of the period, the potting medium containing coir dust and sand at 3:2 ratio (Figure 1) and the stem cutting with 7.5 cm length (Figure 2) produced the highest number of shoots/leaves.

Therefore, the vegetative propagation of *Anthurium* (var. Tropical Red) by stem cuttings can be introduced to the farming communities through awareness programmes. It can be developed to a smallholder business through better supervision and the market can be arranged to sell their products.

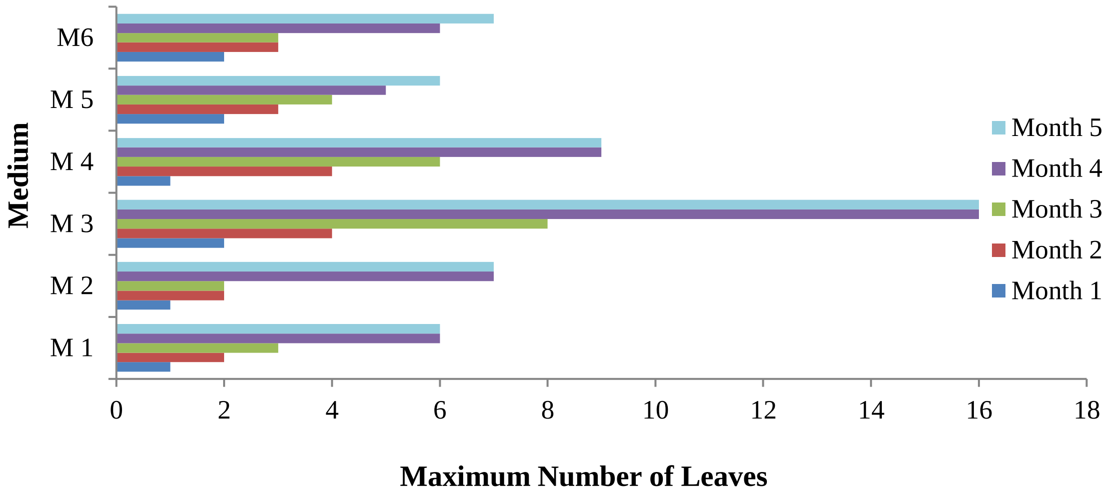

Figure 1: Variation of the Maximum Number of Leaves in Plantlets of *Anthurium* (Var. Tropical Red) in Different Potting Media over the Time

M1- coir dust and sand (4:1), M2- coir dust and sand (1:4), M3- coir dust and sand (3:2), M4- coir dust and sand (2:3), M5- coir dust, compost and sand (1:1:1), M6- coir dust, compost, cow manure and sand (1:1:1:1). Coconut husk chips were added to all above media to fill the constant volume.

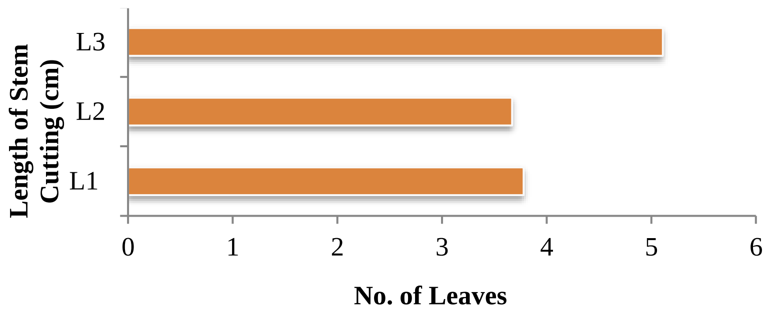

Figure 2: Variation in Number of Leaves Produced by Stem Cuttings of Different Lengths

Length of Stem Cuttings: L1 – 2.5 cm, L2 – 5.0 cm, L3 – 7.5 cm

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Author:

Wajira Thennakoon: Assistant Manager, Coconut Cultivation Board of Sri Lanka. He holds B.Sc. (Plantation Management) from WUSL, Diploma (Plantation Management) from AQUINAS, Diploma (Plantation Extension Management) from NIPM
(e-Mail: *thennakoonwajira1@gmail.com*)

Reviewer:

Kamani Ratnayake: Senior Lecturer, Department of Horticulture & Landscape Gardening, FAPM, WUSL. Her teaching and research interests include: Postharvest Physiology & Technology and Horticultural Science
(e-Mail: *kamani.ratnayake@uqconnect.edu.au/kamani@wyb.ac.lk*)

AN ALTERNATIVE FOR SHORTAGE OF PLUCKING ASSISTANTS IN TEA PLANTATIONS

Harippriya Jayananda Kumara

Digowa Bungalow, Pambegama Estate, Parakaduwa, 70550

INTRODUCTION

Tea plantations of Sri Lanka were commercially started by the British planters from the year 1867 initiating planting in Loolkadura Estate, Hewahata and the planting expanded. Mr. James Taylor was the pioneer in introducing tea to Sri Lanka. Managements of the estates were under the British own companies and later local business persons invested on plantations and became owners. Land requirements were made introducing the Crown Land Act and absorbing lands from the villagers. Many of forest areas were cleared. During this period villagers were highly reluctant to work under the British planters. As result, with the help of rulers during that period, steps were taken to get the workers from India to work in the plantations. Plantations were maintaining in viable and profitable level. Resident workers were provided with the line rooms with water facilities and access roads. Estate workers' payments were on daily payment based.

The government which came into the power during the period of 1970 nationalized the plantations and managed by the Sri Lanka State Plantations Corporation (SLSPC) and Janatha Estate Development Board (JEDB) on behalf of the government and they managed the plantations until those were handed over to Regional Plantation Companies (RPCs) for their management in 1992 as per the decision taken by the then government. There were many projects to fund the plantations to improve the productivity levels of the plantations and to improve the living standard of population of the plantations. Projects were funded for tea new planting and re-planting, to improve the infrastructures facilities and living standard of plantation residence, researches and tea factory improvements and to improve the transport fleets. Funds were allocated also for field diversification and poor tea fields which had low productivity were selected for that purpose.

Justification

After the privatization, many of similar management practices were implemented and attention was paid on managing plantations to achieve the targeted yields and profits to run them as viable properties while looking after the estate workforce by way of strengthening their earnings and living standards. To address all these important factors, there should be sufficient estate workforce. Sufficient workforce in an estate at present is a challenge. It directly affects the quality of end product. Shortage of workers for tea plucking is mainly experienced in the low country tea plantations. In a tea estate, the only revenue is generated from harvested produce and it decides the cost of production level and profitability of the plantations (Chandrabose, 2019).

Retaining the estate workforce within the estate depends on the income that they receive. At present, many of the tea plantations do not have sufficient registered plucking assistants to harvest an appropriate crop. Therefore, plantations are struggling to maintain their viable levels. Tea, as a crop which brings foreign exchange to the country, the quantities produced and provided by the larger plantations are highly important as a considerable component of tea crop is provided by those plantations.

Therefore, proper introduction of Contractual Plucking concept was proposed to the plantations of the low country regions as an alternative for shortage of plucking and sundry assistants. Contractual plucking is a concept that could help improve the earnings of plantation families. It will help maintain their enthusiasm towards estate operations, such as maintenance of appropriate plucking frequency which helps to provide good raw materials for manufacturing. If this is properly implemented, contractual plucking concept will facilitate estate maintenance (Table 1).

Table 1: Projectable Key Performance under Contractual Plucking Concept

Component to Perform	Projectable Performance
Yield/ha	1,100 kg
Profit	Rs. 61 million
Estate Extent	360 ha
Contractual Extent	155 ha
Percentage Vegetative Propagated Tea	35%
Percentage Old Seedling Tea	65%

Source: Tea Plantation Annual Financial Report, 2012

PROJECT IMPLEMENTATION

This method should be applied to plantations where the plucking and sundry assistants are limiting, as there is no need to apply it for the whole extent of the estate. As per the requirement of the estate and considering the workforce, contractual plucking extent could be decided. In carrying out this, tea bush count of the selected fields are important for the purpose of allocating a land area on the basis of bush count. Distribution of contractual plucking area should be only among the registered worker families on a written agreement. There should be separate one or two days for contractual plucking. Tea green leaf taking over and handing over will be taken place according to the estate operations and the payment mode is a percentage from the bought leaf payment rate and it is around 64 percent from the bought leaf rate which is paying for 1 kg of tea green leaf supplied.

Under this method, the cost of agricultural practices should be borne by the contractor and recoveries should be made in installment. The benefit of giving contractual plucking areas to registered worker families is that, in some of the estate families, either husband or wife is working in the estate, but if contractual plucking blocks are given, the whole family would come and work resulting in more plucking hands on the contractual plucking day, and those cannot be extracted for the usual operations in the estate. The tea harvesting operation could be improved. Contractors could draw better income apart from the income receiving from the usual work in the estate. Eventually, it will generate more enthusiasm towards the estate operations. If this method is implemented under proper documentation, monitoring and controlling measures, then there will be numerous benefits for both parties. Transparency is the most important aspect under this method to encourage both the plucking contractor and the management.

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Author:

Harippriya J. Kumara: Assistant Superintendent, Pambegama Estate. He holds B.Sc. (Plantation Management) from WUSL (e-Mail: *jayanandakumara@yahoo.com*)

Reviewer:

Chandana Abeysinghe: Professor in Plantation Management, Department of Plantation Management, FAPM, WUSL. His teaching and research interests include: Tea Agronomy and Processing, Crop Physiology, Bioactive Compounds in Foods, and Antioxidant Properties of Food (e-Mail: *abeysinghedc@yahoo.com*)

REASONS FOR REJECTION OF SEED PADDY LOTS DURING THE SEED CERTIFICATION PROCESS

Rasika Erandathi Jayatilaka

Seed Certification Service, Gannoruwa, Peradeniya, 20400

INTRODUCTION

Rice is the staple food in Sri Lanka and the most important agriculture sub-sector in the country. Seed quality is one of the major factors that determine the rice yield. The Seed Certification Service (SCS) of the Department of Agriculture (DOA) is the main authority in Sri Lanka which is responsible for maintenance of the seed quality. The purpose of seed certification is to maintain and make available to the public, through certification high quality seeds, grown and distributed as to ensure genetic identity and purity. Quality of seed is maintained by keeping freedom from diseases, weeds, other distinguishable varieties, insects and mechanical damage, other crops seeds and by maintaining recommended moisture and germination levels.

In the seed certification process, producers are requested by the SCS to register their field for certification. Initially, officers of SCS conduct field inspections during the cropping period and provide a written document regarding the crop maintenance. Consequently, seed farmers should maintain the quality during the crop production period and during postharvest handling and processing procedures. After processing the harvest, seed samples will be drawn from seed lots and taken to the seed testing laboratory of SCS for testing (Seed Certification Handbook, 2009).

Justification

Estimated annual seed paddy requirement of Sri Lanka is about 90,000 t. Out of that, only about 15 percent is presently supplied as quality certified seed (Senewirathna, 2013). Challenge of the future agriculture is to grow high yielding crops using limited lands and other resources. Quality seed is an important factor that determine increasing yield without increasing land usage. There is a high potential to increase the supply of seed paddy without increasing the registered seed paddy production land extent by minimizing rejections at different stages of the seed certification programme. In laboratory, about 15 percent is rejected due to various reasons. In order to increase the targeted amount of seed production, DOA has to minimize the rejection percentage.

MAJOR REASONS FOR REJECTION OF SEED PADDY DURING CERTIFICATION

When considering the causes of rejection, availability of weed seeds is one of the serious problems (Figure 1). Within the production field itself weed seeds can be mixed with seed paddy. It is therefore, important to implement an efficient weed management programme from initial stage to mature stage of the crop. A higher percentage of rejection due to weed seeds is observed in *Yala* season and that can be attributed to the prolonged dry spell that leads to a higher seed production by weed plants.

Another main reason for rejection is the presence of Other Distinguishable Varieties (ODV). Contamination by ODVs may occur within the production field level as well as during post-harvesting period. It is necessary to pay special attention to remove these other varieties in paddy production field and in addition it is necessary to have special knowledge and skill to identify the ODVs. In the post-harvesting period ODV can be mixed with paddy seeds through numerous ways, such as using processing machines without cleaning, during drying and storing of seed lots.

According to SCS reports, a higher percentage of rejection due to inert matter was identified in the dry zone areas. Lack of clean storage facilities and use of inappropriate processing methods could be the reasons for this increase in inert matter content. Excessive moisture content is a major reason for seed paddy rejection identified in the wet zone. It can be explained by the climatic condition prevailing in wet zone during the harvesting period. Appropriate drying of seeds up to the accepted standard level (Table 1) is difficult without suitable climatic conditions.

In addition to above mentioned reasons, contamination by weedy rice can be observed in some seed paddy production areas.

RECOMMENDATIONS

These laboratory rejections could be avoided by achieving accepted standard levels of quality parameters through adopting recommended crop management practices and following instructions given by the SCS (Table 1). It is necessary to train officers of the SCS, seed laboratory technicians, seed producers of the private sector, seed growers, employees of various seed enterprises and others involved in seed production in order to implement the special seed paddy production programme and to fulfil the seed paddy requirement of Sri Lanka.

Figure 1: Inert Matter and the Seeds of Weeds, Weedy Rice and Other Distinguishable Varieties (ODVs) Found in a Paddy Seed Sample during Testing

Table 1: Summary of Standards for Certified Paddy Seeds

Parameter	Accepted Level for Certified Seeds
Moisture %	13
Germination %	85
Other Distinguishable Varieties (No. of max. per 500 g)	100
Weed Seeds (No. of max. per 500 g)	10
Insect and Mechanically Damaged Seeds (No. of max. per 500 g)	200
Smell	Good
Appearance	Good
Weedy Rice (No. of seed/per 500 g)	0

Source: Seed Certification Handbook, 2009

Regular monitoring of the relevant staff, seed growers, producers and evaluation of the progress of seed certification programmes in their areas are essential for the success of the seed production programme. Selection of suitable farmers who are having knowledge, skills and attitude in quality seed production and the selection of suitable lands for seed production programmes are of paramount importance for quality seed paddy production in Sri Lanka. One of the major constraints to promote quality seed paddy production may be the shortage of seed processing capacity in the country. Seed processing machines are a must to decrease the rejections due to weeds, insect and mechanical damages. Therefore, distribution of seed processing machines for major production areas can be helpful to minimize the rejection of seed lots.

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Author:

Rasika Erandathi Jayatilaka: Agriculture Instructor attached to the Department of Agriculture, Sri Lanka. She holds B.Sc. (Plantation Management) [Second Class] from WUSL.
(e-Mail: *jayatilakarasika@yahoo.com*)

Reviewer:

Bandula Ranaweera: Senior Lecturer, Department of Horticulture and Landscape Gardening, FAPM, WUSL. His teaching and research interests include: Plant Protection, Pest Management, Biorationals, Bio Pesticides & Bio Fertilizers and Toxin-Free Crop Production
(e-Mail: *branaweera@gmail.com/branaweera@wyb.ac.lk*)

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Master of Agri-Enterprise and Technology Management, Wayamba University of Sri Lanka

PRODUCTION OF MEAL, READY-TO-EAT (MRE) FIELD RATION PACKS FOR SRI LANKA ARMED FORCES

Ruvinda Sandapa Rajapaksha

General Sir John Kotelawala Defense University, Southern Campus, Sooriyawewa, 82010

INTRODUCTION

A field ration (also known as combat ration) is a pre-packaged meal, easily prepared and consumed by military troops. They are distinguished from regular military garrison rations by virtue of being designed for minimal preparation in the field, using canned, vacuum-sealed, pre-cooked or freeze-dried foods, powdered beverage mixes and concentrated food bars, ensuring long shelf life. More often field rations contain meat as one of the main courses.

The "Meal, Ready-to-Eat" (MRE) is a self-contained, individual field ration in lightweight packaging often used by the United States Department of Defense for its service members for use in combat or other field conditions where organized food facilities are not available.

Most armed forces in the world today use some form of pre-packaged combat ration, often suitably tailored to meet national, regional or ethnic tastes. While MREs should be kept cool, they do not need to be refrigerated. Each MRE pack provides an average of 1,250 calories (13% protein, 36% fat, and 51% carbohydrates) and 1/3 of the military Recommended Daily Allowance (RDA) of vitamins and minerals. A full day's worth of meals would consist of three MRE packs.

Justification

The data show the expenses for the import of MRE from foreign nations. It shows the large amount of money flown away from the country. The Sri Lanka Special Forces, including Commandos, mainly consume MREs imported from Malaysia (SF 09 PACK; Figure 1A). The Malaysian MRE packs are normally heavy in their sizes that when it is used during jungle exercises, such as long-range patrols (LRP), soldiers claim that the weight of the ration packets are an extra fatigue for them. The other most important factor is the taste of the included materials of the imported MRE packs and it does not match with the Sri Lankan traditional spicy taste. Sri Lanka Special Operations forces found it too bulky, and troops on maneuvers found some menu items were unsuited for easy digestion and for high-temperature/high-humidity environments.

Sri Lanka Army therefore, carried out a research with Wayamba University of Sri Lanka on development of a MRE suitable for 24-hour special operations by using the local food materials (Sri Lanka Army, 2019). After a successful trial cycle SL Army constructed a production facility in late 2019, which had the capacity to produce 900 MRE packs per day. The product, made of processed steamed rice, tempered chickpeas, peanuts, fish, soy, chicken, vegetables, *etc.*, is manufactured under strict health standards with three different packagings for each meal (breakfast- 200 g, lunch- 400 g and dinner- 400 g; Figure 1B).

Figure 1: Meal, Ready-to-Eat (MRE) (A) Packs Imported from Malaysia (B) Packs Produced Locally

Project Constraints

The final product in the initial stage was mainly targeted for the Sri Lanka Army personnel. The raw materials, such as vitamins and dairy products could not be supplied through the supply body of SL Army and therefore, outsource suppliers were needed.

Project Assumption

The production of MRE packs is a combined and complicated process; as an example, the continuous supply of quality raw material is a main factor in the production cycle. Therefore, enough raw material stock should be managed during the production process. The stable government policies should be maintained throughout the period. The price of outsourced production raw materials, such as polythene and packets should be stable.

Project Dependencies

The continuous supply of raw materials to the production facility is highly important that the raw materials mainly come from military farms in surrounding areas. Therefore, the farm management must always communicate with the production facility as the most important task. However, the association with outsourced suppliers is beneficial, especially in adverse climatic situations.

Project Success Criteria

The development of the domestic MRE packets is a landmark of the military field ration industry in Sri Lanka. Sri Lanka armed forces depended upon foreign-made imported MRE ration packets for over 30 years with significant observations. With this new innovative product, the Sri Lanka Army is able to save the government about 60% of expenditure on importation of it from Malaysia for consumption of the tri-services, thereby saving foreign exchange.

ACKNOWLEDGEMENTS

The research support and guidance given by the Faculty of Livestock, Fisheries and Nutrition, Wayamba University of Sri Lanka in developing the MRE ration pack is significant. Major General A.K.A.B. Gunarathne, Former Director of Agriculture and Livestock, Sri Lanka Army has given his valuable leadership to carry out the tasks.

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Author:

Ruvinda Sandapa Rajapaksha: Commissioned Officer in Sri Lanka Army. He is currently working as an Agriculture Officer at Sir John Kotelawala Defense University. He holds B.Sc. (Plantation Management) from WUSL (e-Mail: *ruvindasandapa@gmail.com*)

Reviewer:

Ananda Chandrasekara: Senior Lecturer of Department of Applied Nutrition, Faculty of Livestock, Fisheries and Nutrition, WUSL. His teaching and research interests include: Diet and Diseases, Diet Therapy, Sports Nutrition, Human Physiology and Biochemistry
(e-Mail: *a.chandrasekara@deakin.edu.au*)

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INTRODUCING URBAN AGRICULTURE TO MINIMIZE ADVERSE EFFECTS OF LAND FRAGMENTATION

Janaka Sirilal Dahanayaka

Land Commissioner's Department - Southern Province, 211, Wackwella Road, Galle, 80000

INTRODUCTION

Physical land fragmentation is a common phenomenon in developing countries as the paternal cultural inheritance practices encourage the splitting of land amongst children from generation to generation (Niroula and Thapa, 2005). It is an obstacle to agricultural productivity and development, since decline in land size may couple with an increase of operational costs in farming. Although the agricultural land area is diminishing gradually, the demand for food and agro-commodities is increasing due to the ever-growing population.

Urban agriculture is a practice that involves, growing of agricultural commodities within a limited space, mostly in urban areas. It is a supplemental food production beyond rural farming operations which can improve food security and food safety.

Current Situation

In Sri Lanka, the extent of land used for agriculture is declining due to many factors such as land fragmentation, urbanization, and housing developments. The number of houses has increased along with the population growth, whereas the extent of cultivated land has decreased and statistics for the Divisional Secretariat area of Akuressa is given in (Table 1).

Table 1: Number of Houses *versus* Cultivated Land in Akuressa Area

Year	Number of Houses	Cultivated Land (ha)
2011	12,699	18,232
2013	13,263	16,730
2015	14,499	15,456
2017	14,748	14,041
2019	15,325	13,298

Source: Statistical Data, Divisional Secretariat, Akuressa

As land fragmentation leads to a higher cost of production, lower crop yield and inability to use certain types of agricultural machinery, it could hinder the agricultural modernization which aims for higher crop productivity. In order to find a sustainable solution to increase the land availability for agriculture, it was focused to identify methods for discouraging the land fragmentation while adapting to new methodologies in agriculture.

Project Justification

Use of agro technology management is vital to identify methods to overcome the cultivation space issues in an urban environment. As limited spaces are available for cultivation within urban areas, the concept of "Urban agriculture" could be used. It provides food products from different types of crops, such as vegetables, root crops, mushrooms, fruits, herbs and green leaves which can be grown in pots, hydroponic systems and vertical spaces, and available spaces on flats, such as concrete slabs. The concept is an important contribution for household food security and income generation (Anon., 2020).

As a strategic approach to discourage land fragmentation, the concept of providing flats on easy payment schemes for landowners who are intending to fragment their lands for housing requirements could be implemented with the assistance of government regulatory and monetary bodies. It would be beneficial for both parties as land fragmentation is discouraged which eventually increases the land availability for agriculture while the housing requirements of the target group would also be fulfilled.

Project Constraints

A significant constraint for the execution of the project would be the attitude of landowners and cultural issues as most of the landowners would find it uncomfortable or may refuse to shift to flats. The lack of government policies would be another significant constraint during the execution of the project. Lack of officers who possess technical knowledge on introducing the urban agriculture concept is another limiting factor. Most of the urban people may be reluctant to adapt to new concepts of agriculture due to time limitation. Some would prefer flower gardening instead of agro-consumable plants or crops.

Assumptions

It would be assumed that the government policies would remain unchanged or unaltered. Another assumption is that the climatic conditions would be the same throughout the project. As the economic state of the country would have a direct impact on the decisions made by the government, it is assumed to be in a steady phase. It could be assumed that landowners will not violate the terms and conditions and will not proceed with fragmentation of their respective lands. Further, it would be assumed that full contribution and participation will be received from the urban population for the urban agriculture concept.

Project Dependability Aspects

The project is dependent on the active contribution of the landowners. It also depends on the activation of favourable government policies and regulations that may discourage land fragmentation. Another factor is the market for the agricultural crops and nominated prices for grown commodities. It is also worth to consider that the costs of fertilizer, pesticides, decreasing of labour force, high crop maintenance costs, lack of technical knowledge on agriculture and increasing transportation costs would lead to people moving away from agriculture and hence, the active contributions from relevant authorities to diminish the adverse effects would be a major factor.

MEASUREMENTS OF PROJECT SUCCESS

Systematic analysis of the data on the number of houses which have commenced “Urban Agriculture” could provide a clear indication as the success criteria of the proposed project. While “Urban Agriculture” provides a solution to lesser land availability for agriculture in urban environments, it will provide many advantages, such as food security, domestic level income generation and availability of healthy, safe and fresh produce. Therefore, the project would uphold health and wellbeing of the urban population. Implementation of the proposed measurements to transfer the landowners to flats would discourage land fragmentation, which in turn, would lead to increase in land availability for agriculture. Thus, it will provide a significant contribution to the country’s agro-economic development.

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Author:

Janaka Sirilal Dahanayaka: Land Officer attached to Land Commissioner’s Department – Southern Province. He holds B.Sc. (Plantation Management) from WUSL and Dip. in Agriculture from School of Agriculture, Labuduwa (e-Mail: *dahansyakajkjs@gmail.com*)

Reviewer:

Kapila Yakandawala: Professor and the Chair of Department of Horticulture and Landscape Gardening, FAPM, WUSL. His teaching and research interests include: Landscape Gardening, Environmental Horticulture and Urban Agriculture
(e-Mail: *yakandawalakapila@gmail.com/kapilay@wyb.ac.lk*)

HOUSING LOANS: STRATEGIES TO CATER CUSTOMER DEMAND

Suraj Asanga Rathnayake

Sampath Bank PLC, Marandagahamula, 11260

INTRODUCTION

There is a rising demand for housing loans in Sri Lanka at a compound rate due to the escalation of per capita income, changing patterns of consumption and saving habits in the recent past. The annual demand for housing in Sri Lanka is in the range between 80,000 to 100,000 units and expected to substantially increase in future. In addition, there is a growing demand for condominium units in the Western Province of Sri Lanka from expatriates and Sri Lankans residing abroad. The construction of high-rise apartments has become a lucrative business and the number of such buildings in the city area is rapidly increasing due to the growing demand for those condominium units from expatriates as well as Sri Lankans residing abroad (Figure 1).

Demand and Supply Side of the Housing Loans

There are key factors triggering the progressive growth of demand side of housing loans. Foremost, the declining interest rates over the past years have encouraged investment in properties rather than in low yielding government securities and term deposits. Further, rapid rises in private sector income, tax benefits extended to borrowers, and demand arising from migrant workers is the other key factors triggering the demand for housing loans. Certain factors on the supply side have also supported growth in housing finance, *i.e.* emerging competition in the housing finance sector, increasing number of new entrants to the housing finance market, introduction of several new products by the lending institutions to meet the needs of a wide variety of customers, floating rate mortgages, branded housing loan products and expansion of loan portfolios, and increasing collaboration between lending institutions and housing developers.

FINDING THE BEST REPAYMENT AND LOAN OPTIONS

Home loans are designed to suit a variety of borrower needs and budgets, and thus can come in several forms based on repayment methods. There are three methods;

- Fixed capital installment: a fixed principal component, along with a decreasing interest component calculated on the outstanding debt
- Equated installment repayment: a fixed payment amount made by a borrower to a lender at a specified date in each calendar month. This method is used to pay off both interest and principal so that over a specified number of years, the loan is paid off in full.
- Structured installment repayment**:** There are four types of methods, *i.e.* step up, step down, seasonal and bullet repayment

How to Decide the Loan Amount?

The Bank shall advance only up to 70 percent of the total housing project or 70 percent of the Forced Sale Value (FSV) approved by the Bank. Further, the amount of the loan shall be subjected to the repayment capacity as well as the age of the applicant. Value of the land can be considered as the applicant’s contribution upon ownership but shall not exceed 90 percent of the Bill of Quantity (BOQ) value. Bank shall satisfy themselves of evidence pertaining to financing of customer's contribution. Further, in instances of renovation and extension, an advance up to a maximum of 90 percent of the BOQ value shall be provided.

A COMPARISON OF DOMESTIC AND GLOBAL CONTEXT

In developed economies, housing as an asset makes up from 20 to 50 percent of the reproducible wealth (Figure 2). It is a major motivation for household savings and significantly influences household consumption. In addition, it affects inflation, financial depth, labour mobility, and the balance of payments, as well as budgets through taxes and subsidies. In Sri Lanka, formal financial sector mortgage assets represent 3 percent of GDP, as compared with a world average of 14 percent, and 4 percent in India, 2.5 percent in Bangladesh, 0.6 percent in Pakistan, 22 percent in Malaysia, 16 percent in Thailand, and 12 percent in China (Figure 2).

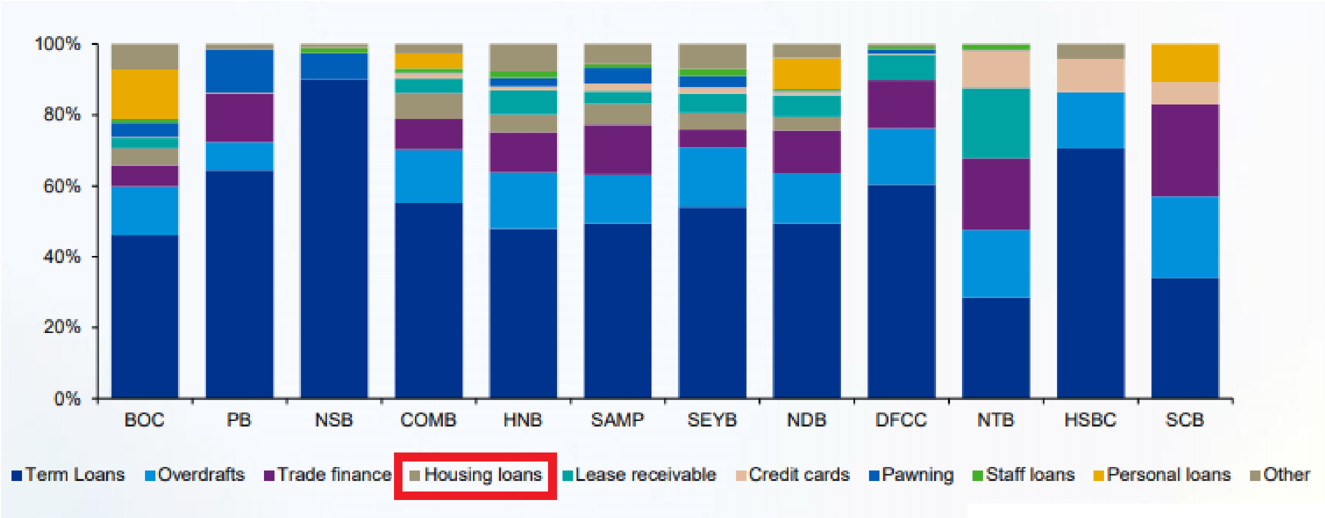

Figure 1: Composition of Gross Loans and Advances from the Banks in Sri Lanka
BOC- Bank of Ceylon, PB – Peoples Bank, NSB - National Savings Bank, COMB – Commercial Bank PLC, HNB - Hatton National Bank, SAMP – Sampath Bank, SEYB – Seylan Bank, NDB – National Development Bank, DFCC – DFCC Bank, NTB – Nation Trust Bank, HSBC – HSBC Bank, SCB – Standard Chartered Bank
Source: CBSL/KMPG-Sri Lanka Banking Report

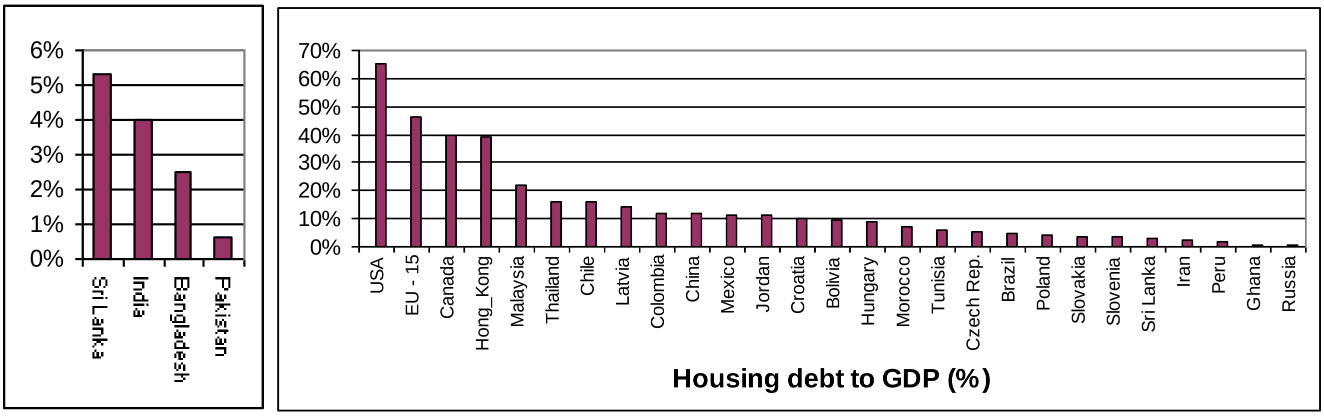

Figure 2: Housing Finance Depth in Sri Lanka, Region and World Comparison
Source: World Bank. 2006; Ahmed et al., 2007

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Author:

Suraj Asanga Rathnayake: Branch Manager - Sampath Bank PLC, Maradagahamula Branch. (e-Mail: *suraj.asanga@yahoo.com*)

Reviewer:

Rupika Abeynayake: Professor in Applied Statistics, Department of Agribusiness Management, FAPM, WUSL. Her teaching and research interests include: Econometrics, Statistical Quality Control, and Time Series Analysis (e-Mail: *rabeynayake@hotmail.com*)

USING DRONES TO SCARE OFF FLYING BATS FROM SYSTEMATIC RAMBUTAN CULTIVATIONS IN SRI LANKA

Gayan Indrajith Weerakoon

Kurunegala Plantations Limited, Attanagalla Area Estates, Dansalawatta Division, Pasyala, 11890

INTRODUCTION

Bats (*Chiroptera* spp.) are present almost all around the world. They usually prefer night and quiet places to survive. They have an acute hearing sense which helps them find their food. The diet of the bat is very different from other mammals. Fruit bats eat all kinds of fresh fruit, including rambutan. Bats are of different sizes and shapes, and their habits depend on the location where they exist (Yapa and Ratnavira, 2013). The prime enemy of rambutan is the bat which is called "Eta Vavula" in Sinhala. Generally, fruit bats are responsible for approximately 42 percent of the total damage of rambutan fruits (Figure 1). Damaging to rambutan fruits by bats has been an on-going and a challenging problem to rambutan cultivation in Sri Lanka.

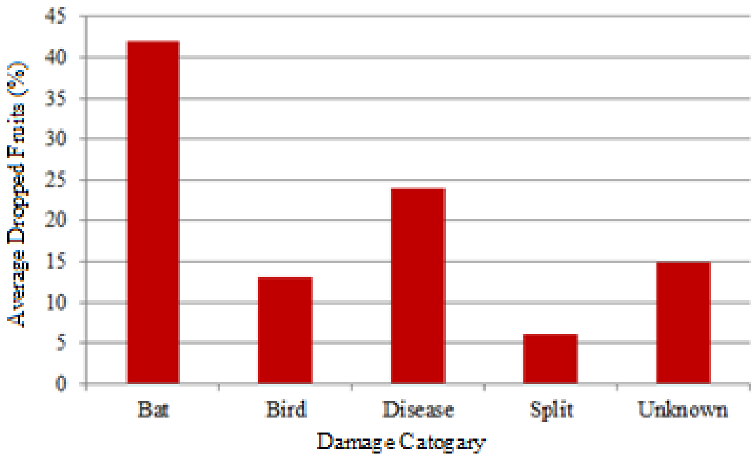

Figure 1: Major Causes of Fruit Drop in Rambutan
Source: doi:10.1371/journal.pone.0220955.g003

Distribution of Rambutan Production in Sri Lanka

Rambutan (*Nephelium lappaceum*) is successfully grown in the districts of Gampaha and Colombo. Potential areas for future expansion are Ratnapura, Galle, Matara, Badulla, Kegalle and Kandy districts. In Sri Lanka, 989 ac of land is confined for systematic rambutan cultivation while 546,935 ac of land contains scattered trees (Department of Census and Statistics, 2019). A Peak harvest could be obtained during the period of July - August and off-seasonal crops during December - February. An average tree may produce 5,000 – 6,000 or more rambutan fruits (250 – 350 kg/tree). Yield begins at 1.2 t/ha (0.5 t/acre) in young cultivations and may reach 20 t/ha (8 t/acre) in mature trees.

MITIGATION OF BATS' DAMAGE USING DRONE TECHNOLOGY

Rambutan growers work on identifying potential solutions for the bat problem. At night, lights are placed on the top branch of the tree to keep the bats away from fruits. In addition, some traditional methods used to scare away bats from rambutan trees include, hanging of the sound-making devices called '*tukkas*' made out of iron on to the branches, canopy netting, tunnel netting, smell from carbide and making sound using crackers. Those methods could be successful at the initial stage, but they do not provide a consistent protection from bats.

Justification

An advanced tool for repelling bats is the unmanned aerial vehicle (UAV) or drone (Figure 2). It can be fitted quickly to any drone with no installation of cables or wires and deployed to the task. It is also a good choice for bat removal as a siren can be fitted to smaller drones avoiding the need to fly large drones through rambutan cultivation areas. The drones are fitted with the hover drone siren which delivers a high multi-pitch sound designed to scare bats.

In drones, one of the major hurdles is detecting the call of bat over the noise of the drone's propellers, which emit loud ultrasonic frequencies. The drone can be flown manually to fly directly to problem areas or programmed to fly predetermined routes utilizing GPS technology, mitigating bat numbers over rambutan crops.

Figure 2: A Drone Hovers over a Lychee Orchard in Australia to Combat Birds and Bats
Source: Rooyen, 2015 (https://www.abc.net.au/news)

Outcomes of Using Drones to Scare off Flying Bats

Drone-based bat control products are always humane and eco-friendly. The drone acts as a bat repellent. When the drone is launched, it patrols the area and lands on its own. Users are also able to set "waypoints" to perfectly customize patrol areas via GPS technology. The terrifying physical presence is heightened by sonic predator sounds. Thus, UAV or drone could be considered as one of the most effective ways to scare bats away. Commercial rambutan plantations can be benefited using bat deterrent drones.

Drones are effective bat control devices, combining sight with a threatening physical presence and natural sounds. Bat deterrent drones are easy to maintain and operate with the latest GPS technology. The autonomous flight feature means less man-hour is required to keep bats away. Bat control drones cover large areas more effectively than other systems.

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Author:

Gayan Indrajith Weerakoon: Assistant Superintendent, Kurunegala Plantations Limited, Attanagalla Area Estates. He holds B.Sc. (Plantation Management) from WUSL and National Diploma in Agriculture from Technical College-Kuliyapitiya
(e-Mail: *indrajit.weerakoon@gmail.com*)

Reviewer:

Wasantha Gunathilaka: Senior Lecturer of Department of Plantation Management, FAPM, WUSL. His teaching and research interests include: Agriculture Engineering, especially Farm Machinery and Irrigation (e-Mail: *haws.gunathilaka@gmail.com*)

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Master of Agri-Enterprise and Technology Management, Wayamba University of Sri Lanka

YIELD PERFORMANCE OF COCONUT IN RESPONSE TO DIFFERENT FERTILIZER PRACTICES

Kasun Chanaka Rathnayaka

Coconut Cultivation Board, Regional Office, Meegahakotuwa, Kuliyapitiya, 60200

INTRODUCTION

Coconut palm (*Cocos nucifera* L.) is the most economically valued palm in the world and it plays a significant role in the daily life of people in over 80 countries of the tropics. The origin and dispersal of coconut was extensively debated until recent DNA analyses provided substantial evidence for its origin as coastal islands in the Far East or Pacific.

Sri Lanka is the fourth largest coconut producing country in the world, occupying a total area of approximately 394,836 ha of land which is about 19 percent of the total arable land. The most important coconut producing area of the country which is referred to as the "Coconut Triangle", comprises the districts of Kurunegala, Gampaha and Puttalam and accounts for 65 - 70 percent of the total area under coconut. The intermediate and dry zones together account for about 65 percent of the existing coconut plantations and the potential for further expansion also lies in these agro-ecological regions. Coconut cultivation is dominated by the smallholders' sector holding less than 8 ha (20 ac) and occupying 75 percent of the area (313,088 ha), while the estate sector accounts for 25 percent of the area and it contributes about 40 percent to the national production (Somasiri *et al.,* 2020).

Justification

Coconut palm regularly removes plant nutrients along with harvested nuts, fallen fronds and other parts of the inflorescences. Previous studies have shown that the harvested nuts, fronds and most of the other residues that are fallen from the palm, remove a considerable quantity of macro and micronutrients. Application of fertilizer containing N, P, K and Mg may compensate for the aforementioned macronutrient depletion.

Nutrient removal studies would provide a basis for understanding the rate and amount of nutrient depletion from the soil. The information on nutrient depletion from those coconut eco-systems, which belong to different potential productivity categories, is useful in formulating fertilizer recommendations. The potential for coconut production of different lands varies depending on the quality of the land. The variations in climate, relief, soils, hydrology and vegetation influence the coconut productivity in varying degrees. Within a region of fairly uniform climate, relief and hydrology, soil is the main cause of differences in the productivity of coconut land suitability classes (Sl: highly suitable and S2: suitable to highly suitable lands, yielding more than 15,000 nuts/ha/year and 12,000 to 15,000 nuts/ha/year, respectively) which are regarded as high potential productivity lands. In those lands there are no severe limitations to sustained coconut production.

Yield Gap

The data presented in Table 1 were collected from Kurunegala and Kuliyapitiya regions in the Coconut Cultivation Board. Ten organic estates, 10 inorganic estates and 10 non-fertilizing estates were taken. From each land, 1 ac area was selected for the study. Coconut yield records were collected for a period of five years from the available data. According to the data, there was a notable yield difference between fertilizing and non-fertilizing fields. To get a higher yield, it is essential to provide removing nutrients by providing fertilizers.

EFFECT OF FERTILIZATION ON GROWTH AND YIELD OF COCONUT

Coconut is a highly exhaustive palm and it is difficult to meet the demand of plants through synthetic fertilizers alone (Table 2). To improve the soil and to sustain yields, locally available organic resources and bio-fertilizers are recommended. Use of these organic manure in combination with an appropriate ratio of fertilizers may be beneficial in increasing the crop yield and maintaining soil health.

Organic materials, such as cattle manure, goat manure, broiler and layer poultry manure, pig manure, farmyard manure, biogas residue, sewage sludge, compost, *Gliricidia, Pueraria, Calopogonium* and *Acacia*, have considerable amounts of macro and micro-nutrients and these materials could be used as a source of plant nutrients for coconut to supply the N requirement in full and P, K and Mg requirements in part (Somasiri *et al.,* 2000).

Table 1: Coconut Yield from Organic (10), Inorganic (10) and None-fertilizing (10) Lands

Land Type	Yield (nuts/ac/year)										
	1	2	3	4	5	6	7	8	9	10	Mean Yield
Organic	2,432	2,349	4,580	1,410	2,053	4,500	4,096	4,140	3,960	3,950	3,347
Inorganic	3,018	3,302	3,110	1,980	2,660	4,600	4,250	4,920	3,900	4,210	3,595
Non-fertilizing	3,000	1,459	1,496	1,449	1,566	1,808	1,717	1,583	1,726	1,829	1,763

1 – 10: The number given for the coconut estate.

Table 2: Fertilizer Recommendation for Coconut

Fertilizer Category	Fertilizer	Quantity per Plant
Mixed	APM-W/APM-D	3.3 kg/2.7 kg
	Dolomite	1 kg
Non-mixed	Urea	800 g
	ERP-W/TSP-D	900 g/400 g
	MOP	1.6 kg
	Dolomite	1 kg

Source: Coconut Research Institute of Sri Lanka (Anon., 2005).

The coconut growers are showing an interest in utilizing organic manure, primarily due to the exorbitant price of imported chemical fertilizers. Organic materials, such as animal manures, green manures, crop residues, kitchen wastes and sewage sludge are often freely available. Organic wastes serve not only as a source of plant nutrients but also it enhances soil quality, thereby improving the chemical, physical and biological properties of soil. The benefits of organic manures for stimulating plant growth, increasing crop yield and developing resistance to pests and diseases have also been reported.

However, there are some limitations as the organic fertilizers are bulky and need to put in large quantities to get the same effect as with inorganic fertilizers. Considering all these factors, it can be recommended that an effective fertilizer combination has to be adopted in order to have long term beneficial effects and organic fertilizers can play a significant role in such formulations.

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Author:

Kasun Chanaka Rathnayaka: Coconut Development Officer, Coconut Cultivation Board. He holds B.Sc. (Plantation Management) Degree from WUSL
(e-Mail: *kckrathnayaka@gmail.com*)

Reviewer:

Indika K. Herath: Senior Lecturer attached to the Department of Plantation Management, FAPM, WUSL. Her teaching and research interests include: Soil Science & Plant Nutrient Management, and Environmental Impact Assessment
(e-Mail: *indikaherath@hotmail.com*)

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Master of Agri-Enterprise and Technology Management, Wayamba University of Sri Lanka

REDUCTION OF FOOD LOSS AND FOOD WASTE: SUPPORTIVE ACTIONS TO FOLLOW AS PART OF THE COMMUNITY

Piyumi Savithri Perera

NWP/Ch/ Galmuruwa Junior School, Galmuruwa, Madampe, 61230

INTRODUCTION

Anually, approximately 30 percent of global food production is either lost or wasted along the food supply chain. This is equivalent to 1.3 billion tons of food and the direct economic consequences to producers of food. Food wastage (excluding fish and seafood) runs to the tune of US$ 750 billion annually [Food and Agriculture Organization (FAO), 2011]. Food loss occurs along the food supply chain from harvest up to, but not including, the retail level where food waste occurs at the retail and consumption levels. Food waste is especially challenging as it is related to a number of factors: the land which is used for agriculture and livestock, excessive water and energy demand, breeding and slaughtering of animals, chemical usage on soil, packaging and transport, climate change impacts and damage to forest and marine habitats along with their biodiversity. With the future of more people, it is not rational to let people throw away the natural resources as garbage.

Project Justification

Food waste is a global challenge. In Sri Lanka, rapid urbanization, expansion of retail chains and changes in life styles and diets are usually identified as the key drivers for food waste generation. Data of food loss and waste in Sri Lanka is still scarce. However, a study from 2016 reports that 63.6 percent of the 700 t/day municipal solid waste in Colombo Municipal Council area is short term biodegradable, and a high proportion of this waste could be food waste (Food and Agriculture Organization, 2019). The Ministry of Megapolis and Western Development, supported by the FAO and the International Water Management Institute (IWMI) has launched a project on innovative approaches to reduce, recycle and reuse food waste that is implemented from June 2019 to February 2021. This project on food waste reduction funded by FAO, in Sri Lanka, brings together key stakeholders, wholesalers, supermarkets, hotels, restaurants, hospitals, schools and consumers to the waste management system.

Project Constraints

Causes for food waste are a combination of consumer behaviour and lack of efficiency in the supply chain. Especially, the developing countries face major food losses due to financial and structural limitations in harvesting techniques, storage and transport infrastructure, combined with challenging climatic conditions. On the other hand, there are many unsustainable consumer practices. Those who can afford, would like to overstock and buy more than needed, take much more food from the buffet than what one person can eat and hook up to “buy one get one free” and other promotions. Moreover, most of the consumers expect products to be cheap, and it is much easier to throw something which is cheap, than a product which is expensive.

POSSIBLE ACTIONS TO PROCEED

There are a number of positive activities already happening in Sri Lanka: there is a culture of sharing food and meals among employees, family members and friends; often the leftover food is given to animals if there is no use anymore within the household; some supermarkets donate their excess products to homes; some households use bio-composters to generate their own fertilizer or even biogas; and there is an increased understanding about food waste challenge. However, in large scale, the Government Ministries concerned with nutrition and agriculture must align their policies to ensure a better situation with many solutions. Food producers can invest on better harvesting and storage technology to avoid food loss; food retailers can reduce prices of imperfectly shaped vegetables and donate unsellable yet edible surplus food to people in need and food not fit for human consumption should be used to feed animals. Awareness programmes to inspire customers to take whatever steps they can to stop food wastage and reduce landfills through conversion of food waste into compost and biogas can be carried out. Further, individual customers can be more careful shoppers to use methods to store and recycle leftovers and request smaller portions in restaurants.

Project Dependencies

The collaborative approach of the project funded by FAO in Sri Lanka is aimed at mainly three actions. They are: increasing awareness in the impact of and solutions for food waste, collaboration and coordination of stakeholders for data collection on food waste, and drafting an evidence-based national strategy on food waste prevention, reduction and management in Sri Lanka, for which consultations with the public/private sectors and civil society are held. Urgent supportive actions to reduce food loss and waste are essential, especially in a global pandemic situation. The world food production and all other aspects attached to it are collapsing fast and more importantly, as Sri Lankans now it is high time to understand the potentials and strengths in food production sector to become a self-sustaining nation. Unless bolder actions are taken soon, humanity is at a high risk of seeing a continued rise in the rates of hunger, obesity and diet related chronic diseases.

FOOD WASTE REDUCTION PROJECT SUCCESS CRITERIA

To fix the food systems, working together is important. Diversification of food systems by growing food in home gardens and in public spaces is a timely need. The school system in Sri Lanka, including Galmuruwa Junior School, has taken a successful approach in this scenario. The vegetable gardens and fruit gardens in schools managed by teachers and students are appreciative examples for every person in the society. Furthermore, the Ministry of Education is conducting the “Food for Education Programme” in which every student in primary section is given a free nutritious breakfast to ensure a balanced diet before school activities are begun. Through this programme, the students are not merely provided with food but they are taught and practiced how to take food to their plates in appropriate portions and advised to eat that portion completely (Figure 1). They are taught how food waste can be reduced by giving the leftovers to animals and birds in the school premises. On the other hand, the students are encouraged to make compost making structures or fertilizer bins using *Gliricidia* for the school garden and also asked to practice it in their homes.

Figure 1: An Awareness Programme on Food Waste Reduction for Primary School Students

The value of homemade fruits and vegetables using no chemicals and taking a fresh and nutritious meal without any chemical preservatives are important facts for the future of a healthy generation. When the above mentioned approaches are successfully maintained among people in the country, the overstocking of food and throwing them away without getting any use, panic buying in supermarkets and lack of food for under privileged people in the society will be no more problems in Sri Lanka.

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Author:

Piyumi Savithri Perera: Teacher at Galmuruwa Junior School, Galmuruwa, Madampe. She holds B.Sc. (Hons.) Agriculture Technology and Management from Faculty of Agriculture, University of Peradeniya. Her professional interests include Agribusiness Management, Agricultural and Food Economics and Project Management
(e-Mail: *saviperadeniya@gmail.com*)

Reviewer:

Geethi K. Pamunuwa: Senior Lecturer, Department of Horticulture and Landscape Gardening, FAPM, WUSL. Her teaching and research interests include: Food Science and Technology, Nutraceuticals and Nanotechnology (e-Mail:*geethipamunuwa16@gmail.com*)

PACLOBUTRAZOL FOR YIELD ENHANCEMENT AND OFF SEASON PRODUCTION OF MANGO

Indika Wasala Bandara Amarakoon

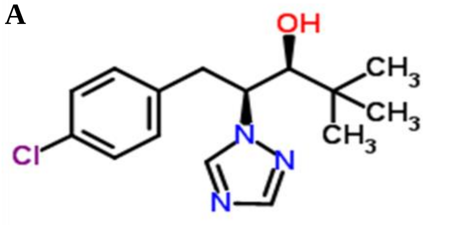
Provincial Agriculture Department (Central Province), Sarasavi Mawatha, Peradeniya, 20400

INTRODUCTION

Mango (*Mangifera indica*) is thought to have evolved in the Indo-Burmese region and although not endemic to Sri Lanka, mango was introduced in ancient times and has been cultivated on the island for a long time. At present, mango trees are a popular plant in many orchards and home gardens in Sri Lanka. Mangoes collected from home gardens are the major contributor in the fruit market as commercial production is very limited. Moreover, there are many reasons for not having the expected yield in mango cultivars. Among them, non-flowering trees, irregular blossoming, occasional flowering, and the small number of clusters negatively affect the expected yield (Department of Agriculture, 2014).

A diverse range of mango cultivars can be grown in various tropical regions which are conducive to year-round vegetative growth, however, production is seasonal. Most of the mangoes come to markets during April–July and October–January, whereas fruits are in short supply during February–March and August–September. Therefore, if mango cultivars can be induced to flowering to continue to fruit maturity during off-season, it can receive a higher demand in the market to fetch higher prices in both local and international markets. Chemical flowering induction methods based on plant growth regulators have more promise for the regulation of mango growth and flowering. Paclobutrazol (PBZ; Figure 1) can be used to regulate growth and the development cycle, thereby enhancing flowering in mango trees. It prevents excessive vegetative growth of mango trees by inhibiting the synthesis of gibberellins. Thus, the mango flower buds occur without any interruption, which leads to early and uniform flowering (Tongumpai *et al.*, 1991). Hence, application of PBZ can be popularised among farmers to increase the yield and also to obtain mango harvest in the off-season.

A



$C_{15}H_{20}ClN_3O$

B

Figure 1: Paclobutrazol (A) Chemical Structure and Molecular Formula (B) Formulation

TECHNIQUE OF USING PACLOBUTRAZOL

Paclobutrazol can be used in any plantation in the island to increase the yield and for getting the harvest in the off-season. It can be done in commercial level as well as at home garden level. PBZ can be applied for, three and half years old budded plants and can also be applied for mature seed trees of five years. It is advised not to use this chemical during the periods of heavy rainfall and drought. The efficient way to use PBZ is when tender leaves start maturation before flowering. After pruning of mango trees PBZ can be applied at maturation stage of tender leaves.

Paclobutrazol can enhance flowering even during the off-season. In addition, this hormone is used as a soil remedy. It is necessary to measure the canopy before the hormone application. The recommended dosage is 10 g of 15% PBZ per one meter of the canopy. The chemical is mixed with water and poured until it reaches 45 cm in the stem and wet the soil around stem. This technology enables consumers to eat quality fruits throughout the year and the producer also receives a uniform income throughout the year (Department of Agriculture, 2012).

PROJECT IMPLEMENTATION

If the hormone is applied according to the correct dosage and if the right methodology is used, blooming will start within 3 - 4 months after application. It is important to maintain soil moisture after applying the hormone.

A mulch can be applied for retaining soil moisture. The flowers which occurred due to the PBZ may drop because of the lack of soil moisture, excessive sunshine, wind, pest and diseases. Therefore, it is important to control the pests and practice irrigation. After the hormone application, the tree may become more stressed. To avoid that it is necessary to apply organic fertilizer and chemical fertilizer as recommended. The Department of Agriculture needs to take necessary actions to provide a good market for farmers to sell their harvest both during the season and off-season. In order to encourage farmers, the relevant authorities should provide PBZ and subsidies.

Although there is a market to purchase paclobutrazol chemical in Sri Lanka, the farmers have a less technical knowledge on the correct dosage and the correct application method. Also, this chemical is not available in every chemical shop. If the PBZ growth inhibitor is applied too much, the new shoots may be deformed. When applying PBZ, it is important to maintain the soil moisture. Therefore, it is a problem for dry areas. Due not adhering to the right procedures when applying this chemical to plants, farmers are not yet achieving the best results. Therefore, it is important to organize training programmes and field demonstrate for farmers to educate them on the correct procedure of applying chemicals to crop.

Project Success Criteria

By introducing this technology among farmers, it can increase the yield of mango even in the off-season. This chemical can also act as a fungicide. It is not a chemical that contributes for environmental pollution and it remains low level of residues. Also, this is a cost-effective method (Rs. 250 per 100 g) for farmers in Sri Lanka. Furthermore, this application does not require heavy labour, and it is not a complicated process to follow. Therefore, this project is user friendly and easily accessible to everyone. Quick results can be obtained within 3 - 4 months. PBZ can be applied for trees at 1 or 2 year intervals. Further, it can be applied to plants of any mango variety in Sri Lanka.

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Author:

Indika Wasala Bandara Amarakoon: Agriculture Instructor, Department of Agriculture - Central Province. He holds B.Sc. (Plantation Management) from WUSL
(e-Mail: *indikawasalabandara@gmail.com*)

Reviewer:

Thilak Attanayake: Professor in Biotechnology, Department of Biotechnology, FAPM, WUSL. His teaching and research interests include: Plant Molecular Biology, Genetics and Plant Breeding
(e-Mail: *dpstga@yahoo.com*)

COCONUT WATER PROCESSING PROJECT BY THE COCONUT CULTIVATION BOARD

Dinushi Nimanthika Bandara

Coconut Cultivation Board, Regional Office, Bandiyamulla, Gampaha, 11000

INTRODUCTION

Coconut water is the liquid inside coconuts, which are the fruits of the coconut palm (*Cocos nucifera*). Natural coconut water is a popular beverage in tropical countries. The consumption of coconut water in Europe is still relatively low compared to Asia and South America, which account for more than 90 percent of world consumption. The United Kingdom, the Netherlands, France, and Germany offer the best opportunities for exports from developing countries. Over 95 percent of the coconut water consists of water (H_2O). On average, 243 mL volume of water is included in a coconut which consists of a pH value of 5.5. Hundred millilitres (100 mL) of coconut water contain 4.5 g total solids, 2.7 g total sugars, 3.0 g sucrose, 1.2 g glucose, 0.8 g fructose, 0.25 g proteins and 0.51 g fats. Mineral composition of mature coconut water per 100 g of coconut water can be given as 259.0 mg potassium, 119.5 mg chloride, 42.0 mg sulphur, 36.6 mg calcium, 28.8 mg sodium, 11.5 mg magnesium, 12.2 mg phosphorus, 0.08 mg manganese, 0.06 mg aluminium and 0.025 mg zinc (Prades *et al.*, 2012). It has natural energy for sports drink having low levels of fat, carbohydrates, calories, and a significant electrolyte content.

Current Status in Sri Lanka

At present, there is no widespread market for coconut water products in Sri Lanka. There is some understanding of the importance of coconut water in the society, but it is not yet prevalent in Sri Lankan society compared to foreign countries. The selected formulae which obtained highly desirable comments as “refreshing thirst quencher”, is not very pleasing to Sri Lankan consumers because they are used to the natural refreshing quality of coconut water which is lacking in any processed coconut water beverages. The coconut water industry in Sri Lanka is mainly driven by the export market. Major supplying countries of the bulk concentrated coconut water to Europe are the Philippines and Indonesia while Silver Mill Beverages, Renuka Agri Foods, Well Organic (Pvt) Ltd. and Jacobi Carbons Lanka (Pvt) Ltd. are the major exporters in Sri Lanka (Table 1).

The production of canned coconut water has two preservation types. The traditionally employed high-temperature/short-time preservation process is one method in commercial production. Cold preservation is another method for extending the shelf life of the product and it has used especially in self-employment situations.

Justification

Coconut industry is one of the main sources in export market which increases foreign exchange and employment day by day. Moreover, coconut is one of the main components in Sri Lankan cuisines. The industry mainly focused on the export market. Entrepreneurs who have the potential to enter the export market can start the production for good profit using coconut water as a by-product from main coconut productions. The production plant must be in the vicinity of the coconut growing area where abundant coconuts are available throughout the year.

Gampaha is one of the best coconut growing areas which belongs to the Coconut Triangle. The Coconut Cultivation Board (CCB) of Gampaha has a planned 5-year Coconut Water Processing Project. It will be driven from November 2020 to 2025. The objectives of this project are to increase the income of coconut growers and provide employment opportunities to the youth while motivating people in the area towards the natural drinks rather than artificial-carbonated drinks. Raw materials will be supplied by “Kapruka Societies” in Gampaha district.

Table 1: Export of Coconut Water From Sri Lanka

Year	Export Volume (t)
2017	3,945
2018	5,047
2019	5,047

Source: Coconut Development Authority, 2019

PROJECT IMPLEMENTATION

Good practices or procedures must be followed by the small processors for the production of high quality coconut water. Growers were selected within 5 km to coconut water processing site. Harvest was collected at 9 months of maturity from the selected coconut growers. It controls the consistency of taste and collects the maximum volume of coconut water. Nuts should not be allowed to come in contact with soil, and must always be in contact with clean surfaces to avoid contamination of the nuts. All field practices are monitored by field officers of the CCB.

Handling and transportation need to be followed by the given food safety guidelines. Transported nuts are checked before entering to the processing area. Suitable nuts must be stored in a clean, well ventilated and shaded environment. Stainless steel cutlasses must be used for cutting the nuts. Furthermore, coconut water should be collected from harvested coconuts within 24 hours. During this process, any high-heat treatment is not applied to preserve the product and good practices need to be adopted to avoid contamination. Further, prevention of temperature abuse at every step of the processing chain is highly recommended. Damage–free, appropriately matured coconuts need to be sanitized with chlorinated water for 15 minutes (300 ppm 5% chlorine bleach). Then, cleaned coconuts need to be allowed to air dry and afterwards it can be cut off. The collected coconut water is passed through a filter and transferred to a cooling tank, to chilled storage and maintained at about 4ºC for 3 - 4 hours. Cooled coconut water is rapidly filled into sanitized bottles and should be immediately cooled in ice or a freezer to the point of delivery. Maintaining the temperature at 4ºC is critical throughtout the whole chain and the coconut water should be away from light (Rolle, 2007) (Figure 1).

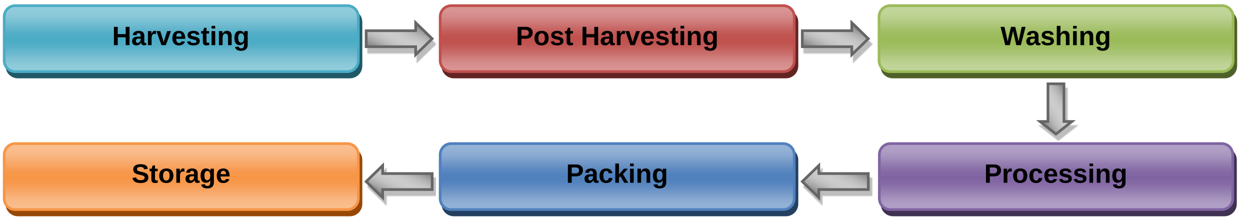

Figure 1: The Coconut Water Processing Chain

The shelf-life and cost of products are highly influenced by the level of processing technology. Finally, processed coconut water must be labelled and sold through the outlets in the area. Cold preserved coconut water has a shelf life of minimum 10 days under refrigerated condition.

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Author:

Dinushi Nimanthika Bandara: Coconut Development Officer attached to the Coconut Cultivation Board in Gamapaha Region. She holds B.Sc. (Plantation Management) from WUSL
(e-Mail: *ruchiralw111@gmail.com*)

Reviewer:

Amani Wijesinghe: Senior Lecturer at the Department of Bio-Systems Engineering, FAPM, WUSL. Her teaching and research interests include: Food Technology, Food Safety & Quality Management and Development of Food Preservation Techniques
(e-Mail: *jaacwijesinghe@wyb.ac.lk*)

IMPORTANCE OF ESTABLISHING SCHOOL GARDENS TO PROMOTE AGRICULTURE ENTERPRISES

Nishani Shaleendri Silva

St. Thomas' Catholic International College, Liyanagemulla, Seeduwa, 11410

INTRODUCTION

Agricultural enterprise is an emerging concept in the modern day world, and also in the present status of the country. The concepts, theories and practises of agriculture are not novel to Sri Lanka, as it has been in practise since the era of traditional agriculture. With the new tools and technologies that has being introduced into the sector, more innovations as well as transformations have taken place regarding many aspects of agriculture, with the main focus on increasing agricultural productivity of crops.

However, when considering the young generation of the country who are presently involved in the agriculture sector, it is clear that their focus and tendency is more towards technology rather than to agriculture. This is a drawback to the society, as the generation of experienced farmers are quietly fading away, without the emergence of new farmers with expertise. This will be a serious problem in future, if this will continue to happen, where there will be no workforce left in the country to bring out the agricultural produce needed for the country and for the relying countries in the world. Therefore, a timely need of inculcating the knowledge of agriculture to the future generation has come into existence. One of the best places to begin this kind of a programme would be the educational institutions such as schools, as the mind-set of the students are already arranged to gain more knowledge during school time. This approach will be highly effective as they are equipped with the knowledge of different aspects and values during their studies.

Justification

The natural resources of the country are seemingly wasted and destroyed in an ever increasing rate, and the space available for agricultural purposes are drastically reducing due to various developmental and infrastructural purposes. These issues can be effectively addressed by making the students aware about this fact, by the simple but profitable method of establishing school gardens. The students not only gain the awareness of protecting the nature around them, but also will be equipped with the knowledge, techniques and hands-on experience on the basics of growing plants in proper manner. This will eventually build up the interest on agriculture and lead the students into gaining more knowledge on agriculture, where they will use their experiences of learning to initiate their own agricultural enterprise in future.

Many students in the school love the nature and are willing to protect the natural resources around them. This is the ideal workforce that can be identified to begin such programmes as they have the enthusiasm of building their own garden with the resources around them.

ESTABLISHING THE SCHOOL GARDEN

The importance of establishing school gardens to inculcate agricultural knowledge to students has been gaining attention. According to the findings of a study conducted in rural Uganda, it was revealed that the students can greatly benefit through the education of agriculture, especially in the case of a rural community, to provide the community with enough food, through the knowledge gained by maintaining the school garden (Snodgrass, 2012). Nevertheless, this knowledge is important not only to the rural community, but to urban communities as well, where the resources such as space and water are lacking to grow food plants. Therefore, the concept of developing school gardens and maintaining them has already been initiated at St. Thomas' Catholic International College, Seeduwa, giving the opportunity to the students to gain the basic knowledge and practical aspects of gardening, while learning to protect and preserve the natural resources around them.

Limitations

Initiating a school garden would bring many benefits to the students. However, the success of this activity depends on many factors, such as the willingness of the administration of the school to initiate such programmes in the school premises, the willingness of teachers to support the activities and many other unknown factors, such as the weather conditions and geographical suitability of establishing school gardens, *etc.*

The major limitations that have been identified so far are the supplying of water (irrigation) for the plants and the geographical suitability. Being a school erected on a marshy land, there were limitations in selecting suitable plant types that could be planted in this area and could be maintained by the students. As the sunlight cannot be controlled in this spacious area, a small plant house was therefore erected by the students to control the excess heat and sunlight.

Assumptions

Assuming that the basic requirements for the plants to grow can be obtained in the school premises, this programme was begun in the school through the school's Nature Club. The students' enthusiasm in maintaining the school garden and gaining knowledge will be a considerable factor in the success of this project initiated at school.

Project Dependencies

The possible beneficiaries of this program would be the members (students) of the Nature Club, as they will be exposed to many areas of learning during their time spent in school, both theoretical and practical. As a generation that is moving forward with technology, while gaining knowledge of different areas, these students who are involved in the Nature Club of the school would pay attention to proper maintenance of the school garden which was established by themselves, and eventually, will enjoy the harvest, learning to grow their own food, and to provide food resources to the country in the future.

Even though the students gain knowledge and expertise of many aspects, they seem to lack the knowledge of how to grow their own food, or at least how to grow any food plant of their choice. This has happened mainly due to the lack of time in their routine to spend for home gardening. Most of the students are engaged in after school activities, such as sports, extra-curricular activities, tuition, *etc*. and have less time even to complete their school home work. In this situation, the school has provided the students with an hour of engaging in their desired club, and the school Nature Club will engage in establishing a proper school garden, as they have already begun with herbs.

Project Success Criteria

The students who were engaged in establishing the school garden were enthusiastic about the activity. Many students were creative in arranging the plant materials, and showed a keen interest in building the school garden together. However, some of them lack the knowledge in preparing the plant materials in a proper manner in order for the plants to grow well. This shows the importance of establishment of school gardens in order to build up their basic skills and knowledge in agriculture.

In a research carried-out in Uganda, Snodgrass (2012) showed that how the students of a school were successful in providing the food needed for the people of their village, by simply encouraging the students to establish school gardens. The basic knowledge that these students will gain by engaging themselves actively in maintaining the school garden will not be a waste, but an investment for the future of the country. If this programme is successful, there will be a generation of youth in future who are keen in improving the path to agricultural enterprise in the country, as they will be well-equipped with the interest, knowledge and expertise to be engaged in agriculture.

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Author:

Nishani Shaleendri Silva: Teacher of St. Thomas' Catholic International College, Seeduwa. She holds B.Sc. (Agri.) Hons. [Second Class Upper Division] from WUSL
(e-Mail: *shaleendrisilva92@gmail.com*)

Reviewer:

Mudith Mewan Kooragodage: Senior Lecturer, Department of Biotechnology, FAPM, WUSL. His teaching and research interests include Molecular Biology and Biotechnology, Tea Biochemistry, Quality, Standards & Value Addition
(e-Mail: *mewankm@gmail.com/mewankm@wyb.ac.lk*)

INTRODUCTION OF RHIZOBIAL INOCULANT TECHNOLOGY FOR BEAN CULTIVATION IN SRI LANKA

Prasad Bandara Nandathilaka

Department of Agriculture - Central Province, No. 25, Labuduwa Sri Damma Mawatha, Peradeniya, 20400

INTRODUCTION

Bean (*Phaseolus vulgaris*) is one of the major vegetable crops cultivated in Sri Lanka. In 2019 a total land extent for bean cultivation was 5,558 ha with 63,527 t of yield (AgStat, 2019). Both bush bean and pole bean are grown across all agro-ecological regions of Sri Lanka. The Department of Agriculture (DOA) indicates an average yield of 6 - 10 t/ha for bush bean and 9 - 12 t/ha for pole bean. According to DOA fertilizer recommendation, 640 kg/ha of synthetic N, P, K fertilizers are required and annually the country spends nearly Rs. 2 billion for importing fertilizer for bean. As other leguminous crops, beans form root nodules in symbiosis with nitrogen (N) fixing rhizobia. Rhizobial inoculants can be used as N bio-fertilizer for bean cultivation. National Institute of Fundamental Studies (NIFS) has introduced a new *Rhizobium* inoculant (Figure 1A) for bean and other leguminous crops in Sri Lanka (Kulasooriya, 2016). This inoculant is capable of resulting 14 – 17 t/ha of bean yield (Figure 1B) which is 30 – 40 percent more than the average yield which can be obtained from DOA recommended fertilizer added bean fields (Kulasooriya, 2016).

BEAN *RHIZOBIUM* INOCULANT TECHNOLOGY

Common bean is a poor symbiotic N-fixer, with a low response to inoculation owing to its promiscuous nodulation with competitive but inefficient resident *Rhizobium*. However, *Rhizobium* inoculants are based on autochthonous strains, they often have superior biological nitrogen fixation performance in the field due to their genetic adaptations to the local environment. During the formation of functional indeterminate nodules, symbiotic bacteria must gain access to the interior of the host root. To get from the outside to the inside, rhizobia grow and divide in tubules called infection threads, which are composite structures derived from the two symbiotic partners.

Justification

Currently, bean cultivating farmers are facing several issues such as high cost of production, low yield, price fluctuations as well as pest and disease problems. Over application of fertilizers and other agrochemicals in vegetable cultivation to obtain a better yield has been identified to contaminate the environment. Presence of chemical residues on fruits and vegetables than the maximum permissible levels in crops exerts a threat to the health of consumers. Usage of agrochemicals has been criticized as a threat for sustainable agriculture (Anon, 2015).

Figure 1: *Rhizobium* – (A) Inoculant, (B) Inoculated Vine of Bean

According to the fertilizer recommendation by the DOA for beans, 220 kg/ha of N should be added as Urea. Sri Lanka imports 476,888 t of Urea annually spending billions of rupees. Therefore, alternative N sources such as bio-fertilizers are needed. The bio-fertilizer consists of rhizobium inoculants and 100 g of the inoculant is sufficient for 1 kg of bean seeds to apply as a seed coating before planting. Addition of Urea can be 100 percent replaced by the locally produced bio-fertilizer, thus saving foreign exchange and reducing the environmental issues and health risks. Currently, selected farmers have adopted this novel technology and obtained good yield. This technology can be adopted for cultivations under "Good Agricultural Practices" (GAP) certification system as well as for organic farming systems in Sri Lanka.

Project Constraints

As this is a novel technology, it is not still popular among bean cultivation community in Sri Lanka. That is the main constraint because farmers do not have an idea about the advantages of using this technology. Furthermore, inoculant production is not sufficient to match with the farmers' requirement and most farmers do not have access to purchase this inoculant. Currently, only a few farmers got the opportunity to adopt this technology in Kandy district as this inoculant production is limited to NIFS. Some farmers did not follow proper cultivation practices as they were not satisfied about the application of inoculants only. They applied synthetic N fertilizer (Urea) and that affected the microbial activity and plant growth negatively.

Project Dependencies

The Department of Agriculture has the mandate to make fertilizer recommendations for crop cultivation in Sri Lanka. Therefore, Research sector of DOA should involve directly for recommending the inoculant technology and develop a subsidy scheme to supply this inoculant to bean growers.

Farmer awareness programmes and field demonstrations by the DOA are required for effective dissemination of this technology. Media publicity through electronic and print media, such as television and radio programmes as well as leaflets can be used.

PROJECT IMPLEMENTATION

The project involves DOA for production of inoculants and dissemination of the inoculant technology. Extension staff will organize farmer awareness programmes and field demonstrations island-wide to enhance the adaptation to this technology by bean cultivating farmers. As many consumers seek safe food free from agro chemicals, the DOA has a responsibility to fulfil the need. Currently, DOA promotes organic farming technologies especially in vegetable cultivation. This project can be implemented under the organic farming programme.

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Author:

Prasad Bandara Nandathilaka: Agriculture Instructor attached to the Department of Agriculture (Central Province). He holds Dip. in Agriculture from School of Agriculture, Kundasale and B.Sc. (Plantation Management) from WUSL and currently engaged in the Extension Division in Kandy district (e-Mail: *prasadky@gmail.com*)

Reviewer:

Wajira K. Balasooriya: Senior Lecturer, Department of Biotechnology, FAPM, WUSL. Her teaching and research interests include: Industrial Microbiology and Biotechnology, Environmental Biotechnology, Agricultural Chemistry and Molecular Techniques
(e-Mail: *wajirab@wyb.ac.lk*)

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Master of Agri-Enterprise and Technology Management, Wayamba University of Sri Lanka

A ROUGHAGE PRODUCTION PLAN FOR INTENSIVE DAIRY FARMS

Florence Sajith Paris

National Livestock Development Board, Horakelly Farm, Kudawewa, 61226

INTRODUCTION

Dairy Farming plays an important role in Sri Lanka's agricultural economy. However at present, the production only amounts to a portion of 45 percent of its aimed self-sufficiency in milk, while the government annually allocates Rs. 55 billion to import milk and dairy products (Annual Report, 2018). Achieving self-sufficiency in milk by 2022 is a priority out of the goals of the Sri Lankan government. The government has taken numerous measures towards the success of this objective. For instance, the provision of imported European pregnant heifers in breeds of Jersey and Jersey-Friesian crossed cattle to the public and private sector farmers at subsidized prices, provision of loan facilities and development of infrastructure facilities are some of the actions initiated.

Project Justification

However, despite these measures, the productivity of cattle is lower than expected. One reason behind this failure is the inadequate and imbalanced feeding of cattle. Due to the lack of sufficient roughage in good quality throughout the year and high prices of concentrate, farmers have impeded in providing a nutritious, balanced diet to the animals. This leads to the productivity of animal remains to be stunted and to the discontinuation of operations of some farmers. Therefore, introducing an appropriate roughage production plan to maintain the available sufficient roughage for cattle is highly important.

HERD STRUCTURE

The number of cows expected to be maintained and the number of followers needed for the replacement which refers to the herd structure is of vital importance when planning a dairy farm. Animals must be disposed every year on culling and surplus for the economic productivity of the herd which will depend on the technical measures and basic management parameters.

Basic Parameters Used

Replacement rate – 20% (15% - 33%)
Age at 1st calving – 26 to 30 months
Calving – 90%
Mortality – Calves 10%, Adults 2%

The information presented in Table 1 are related to a herd structure which consists of 100 cows.

Table 1: Calculation of Livestock Units (LU) for 100 Cows Project

Animal Class	No. of Heads	LU Rate	No. of LU
Cows	100	1.0	100
Heifer Calves – below 12 months	40	0.3	12
Heifers – 12 to 24 months	24	0.5	12
Pregnant Heifers	20	0.7	14
Total	184	-	138 LU

Adapted from: Farm Plan, 1995 (IPC Livestock Oenkerk Friesland - The Netherlands)

Assumptions

The following assumptions were taken into account in relation to the herd structure: all the male calves will be disposed after feeding Colostrum, surplus Heifers will be disposed on age of 12 months and selected creamy pregnant heifers for elite herd and remains will be issued on 24 months.

Stocking Rate

The number of specific kind and classes of animals (or Livestock Units) grazing or using a unit of land for a specific period of time refers to the Stocking Rate.

- If the body weight of the lactating cow was assumed to be 500 kg, then the total Dry Matter (DM) intake requirement of the animal per day is 18.75 kg (DM requirement is 2% - 3.75% of the body weight)

- The norm is that at least 2% of the DM requirement has to be fulfilled through roughages. Then, roughages in feed should provide 10 kg of DM satisfying the animal
- The DM requirement that needs to be fulfilled per livestock unit (LU) through roughages = 3,650 kg/year
- Every 100 cows in the farm maintain 138 LU with followers
- Annual requirement of farm = 138 x 3650 DM kg
- This DM can come from maize, sorghum, CO-3 or pasture grown in the farmland.

The following equation is used to determine the land area needed to obtain the total dry matter requirement that suits the animal count in the farm;

$$Area\ needed\ for\ Dry\ Matter\ requirement = \frac{Total\ Dry\ Matter\ requirement}{Fodder/Pasture\ yield\ DM\ Tons/\ ha/year}$$

RECOMMENDED MAIN FODDER VARIETIES GROWN IN SRI LANKA

Fodder CO-3 (Hybrid Napier)

CO-3 is a high yielding perennial fodder grass. It is recorded that an average green fodder of 30 t/ha/cut can be cut under Sri Lankan conditions. This grass could be maintained as a perennial crop for up to 4 - 5 years, while the first harvest of the crop can be taken in 60 days and repeat in every 35 - 45 days resulting in 180 t/ha/year. CO-3 can be grown in wet zone or in the dry zone under irrigated conditions. Lack of sunlight, low atmospheric temperatures and high acid level in soil are not favourable for the growth of grass (Sarmini and Premarathne, 2017).

Fodder Sorghum

The most commonly grown fodder variety in Sri Lanka is “sugar graze”. It is a hybrid variety developed by crossing sorghum and Sudan grass. The average annual yield of sorghum is 34 t/ha which can be changed base on ratoon crop and water availability. Further, it is a water efficient crop and can be cultivated under irrigated or rain-fed conditions. Sorghum is an annual ratoon crop, which facilitates multiple cuts similar to CO-3. The first harvest can be taken at 60 days and subsequent harvesting at every 45 days.

Fodder Maize

Maize can be grown in different agro-ecological zones. Both, fresh matter and dry matter yield of maize is higher than CO-3 and sorghum. The average yield that can be obtained from maize is 40 - 50 t/ha/cut. This fodder should be harvested at milking stage. However, the disadvantage is that multiple harvesting is not possible with maize. Maize also needs a considerable amount of water for growing. Both maize and sorghum are good for silage.

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Author:

Florence Sajith Paris: Assistant General Manager (Retired), NLDB. He holds B.Sc. (Plantation Management) from WUSL, Diploma in Agriculture from SLSA, Kundasale, and Diploma in Dairy Husbandry & Milk Processing DTC Oenkerk Friesland–The Netherlands
(e-Mail: *parises117@gmail.com*)

Reviewer:

Wishwajith W. Kandegama: Senior Lecturer, Department of Horticulture and Landscape Gardening, FAPM, WUSL. His teaching and research interests include: Food Quality and Safety, Food Processing, Organic Farming and Eco-Friendly Plant Protection Systems
(e-Mail: *wishwajith@wyb.ac.lk*)

MOTIVES FOR EMPLOYEE TURNOVER AND ORGANIZATIONAL PERFORMANCE IN JAINDI EXPORT LANKA

Thushan Randika Senarathna

Coconut Research Institute, Bandirippuwa Estate, Lunuwila, 61150

INTRODUCTION

The employee turnover has now become a major problem for all labour oriented organizations in the world. Therefore, identifying the factors of employee turnover in Jaindi Export Lanka is necessary as it has become a common and major problem to seek factors of employee turnover and take an action to control this problem. This problem is affecting the productivity of the company and its profit (Kelegama, 2004). With this background the study is carried out with the objective of identifying the reasons of employee turnover and to suggest measures.

Current Status

Employee turnover, which is considered to be a challenging issue in business, creates insecurity for organizational workforce. The negative effect of turnover has been the focus of top-level management in almost every organization. It specifies that turnover is one of the most expensive and difficult workforce challenges faced by the organization. The purpose of the study is to examine how the organization is negatively changed by employee turnover and how it affects on other staff members. The project will study to verify the specific reasons for turnover in order to supply supporting information, to identify the clear purpose of turnover, its harmful effects and possible suggestions that could be helpful to the industries for their efficiency, productivity and performance.

Justification

The Jaindi Export Lanka is a well reputed coconut based products company which is providing high quality coconut based products in Dankotuwa area and it has three factories. In the past two years, Jaindi Export Lanka Organization has detected a raise in employee turnover in specific positions. This predicament not only impinges on the organization directly, but also other workers in the workforce. As employees leave the organization, other employees are required to work extra hard to cover the additional essential hours until the hire of a new employee.

Despite the fact that a number of employees welcome the extra hours, others have commitments at home to be with their families and actually do not welcome the extra responsibility. Job satisfaction can be defined as how employees feel about different aspects of the job with regard to employee salary, promotions, co-workers, work itself and supervision. Companies provide various types of concessions to retain their team members through competitive wages, fair treatment, benefits, training and safe working conditions (Price, 2001).

Constraints and Assumptions

There are common constraints due to various situations when implementing this kind of project, for example, the overall production may be reduced. Another limitation is that, employee selection and training to fill up the vacancies. Management has to spend money on selection and training of new workers. It increases the cost of production. The new recruitments may need to learn the work and adjust themselves to the new surrounding which may result in loss of productivity.

In this situation, Company Board mainly assumes that it is necessary to limit or stop the employee turnover. Therefore, following measures may be adopted to minimize the employee turnover in the company. Appointing right man for the right job, fair and equal treatment of all workers throughout the organization, improvement of working conditions, provision of fair wages and allowances and also other monetary benefits. Provision of proper training facilities for new and as well as existing employees, medical facilities to protect employees from sickness and welfare activities.

PROJECT IMPLEMENTATION AND SUCCESS CRITERIA

In Jaindi Export Lanka there are a number of resources to improve and inspect the progress of this method, and such findings will be helpful for other government institutions, private factories and other two branches of Jaindi Export Lanka. Under the factory Human Resource Officers, qualified Senior Directors and other officers will have to inspect the progress of this method and report it to the Board of the Company.

In this project, reducing employee turnover gives numerous advantages to the company. Therefore, employees like to work harder with low pay rates. Less employee turnover and low absenteeism directly affect the company's product output. While employee satisfaction is maintained at a higher level, it is possible to improve organization culture, best relations and customer satisfaction. Moreover, it will decrease the recruiting, interviewing and employee training costs of the company.

Low labour turnover is more profitable to the organization, it is clear that strong corporate reputation leads that to enhance commitment, satisfaction and reduce turnover of employees within the company. Therefore, it is evident that favourable organizational reputation is a strategic resource to an organization which directly contributes to a significant competitive advantage (Table 1). A positive corporate reputation is highly valued since it attracts and retains talented human resources.

Table 1: Causes of Labour Turnover

Causes / Reasons for Labour Turnover	Rank	Percentage (%)
Personal problems	1	41
Domestic problems	2	35
Household problems, Social ceremony	3	25
Unpleasant working conditions	4	17
Long working hours	5	25
Overburden of work	6	29
Unsuitable work	7	20
Inadequate payment and no incentives	8	11
Frequency of accidents and lack of safety	9	26
No suitable conveyance facilities	10	23
Other part-time job	11	23
Other reasons	12	28
Agriculture work	13	28

Source: Kumari, 2018 (Employee Absenteeism in an Apparel Producing Company).

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Author:

Thushan Randika Senarathna: Laboratory and Field Assistant, Coconut Research Institute of Sri Lanka. He holds B.Sc. (Plantation Management) [Second Class Lower] from WUSL
(e-Mail: *randika1208@gamil.com*)

Reviewer:

Kusum Wijesinghe: Senior Lecturer, Department of Agribusiness Management, FAPM, WUSL. Her teaching and research interests include: Organizational Management and Human Resource Management (e-Mail: *kusum_wijesinghe06@yahoo.com*)

DAIRY FARMING AND YOGHURT PRODUCTION FOR SMALL SCALE ENTREPRENEURSHIP

Palitha Asanga Adikari

National Livestock Development Board, No. 40, Nawala Road, Narahenpita, Colombo 05, 00500

INTRODUCTION

Milk is a cash generator for smallholders, converting low value forages and crop residues, and using family labour into valued market commodities. The dairy industry occupies a unique position among other sectors of agriculture as milk is produced every day giving a regular income to the farmers. Furthermore, milk production is highly labour intensive, providing self-employment and entrepreneurship. Integrating dairy production with cropping systems offers great potential as revealed by comparing pastoralists and agro pastoralists. The system plays a major role to reduce climate changes and maintain nutrient recycling that increase overall farm efficiency and reduce vulnerability to market shifts. The small scale dairy farming system has built reliance on reduced methane production rather than larger scale dairy operation commonly found in temperate areas. The demand for milk and milk products are expected to increase driven by the population growth and affluence. Per capita consumption of milk is rising faster in the country where rapid income growth and urbanization result in people adding variety to their diets (Yogurt in Nutrition, 2017).

Justification - Do Current Dairy Farmers Get Fair Return for Fresh Local Milk?

Small scale dairy farmers in Sri Lanka are not receiving adequate return for their milk production. The current milk price is based on milk composition – fat and solids-non-fat (Fat and SNF) – and quality. The current price is Rs. 65 – 85/L of fresh milk. The milk prices are usually set by milk processors. Farmers are unhappy with the milk price and consumers complain about the high cost of milk products. Some dairy farmers are leaving the industry, and due to that reason, temporary downturns in milk supplies have been resulted. Milk production always fluctuates significantly in dry and wet seasons. It is high in the dry season while it declines in the wet season. However, the milk consumption in the country is mostly even throughout the year. Milk and milk products are important components of the human diet. Milk and milk products are used by consumers in the community irrespective of the income level. However, higher income from the milk production increases the quality of life of the dairy farmers. Increasing the efficiency of milk processing, value addition and marketing will enable farmers to achieve this target.

Yoghurt is a milk product obtained by fermentation of milk using specific microorganisms that shall be viable, active and abundant in the product namely, *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus*. Raw cow's milk is a main component of yoghurt. Milk should be obtained from healthy cows following clean milk production techniques (Figure 1). The milk should not contain antibiotic and colostrum. The milk should be transported to the processing plant maintaining the cold chain between 3˚C – 4˚C. Manufacturers produce different types of yoghurt to the market such as creamy yoghurt, non-fat, fruit yogurt, gelatin yogurt, drinking yoghurt, *etc*. according to the costumers' demand coming from the market.

MAJOR QUALITY CONTROL POINTS OF YOGHURT MANUFACTURING

The cow milk that is used as raw material for the process should be within the quality standards, free from antibiotics and at proper temperature. It is important to use high quality safe ingredients and ensure that milk is correctly standardized, and to assure that appropriate pressure is used during the homogenization process. Moreover, making sure to apply correct heat treatment during pasteurization, verifying that the formation proceeds to a predetermined acidity (pH) and ensuring that the product is cooled are important. Avoidance of contaminations while handling, maintaining cold chain and distribution, and adhering to rules and regulations imposed by relevant authorities and public health sector are equally important.

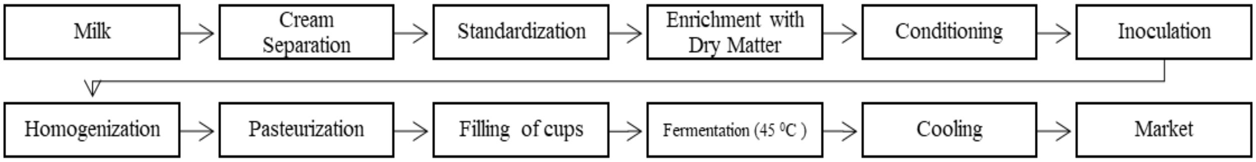

Figure 1: The Flow Chart of Yoghurt Processing

POTENTIAL OUTCOMES OF YOGHURT PROCESSING PROJECT

Yoghurt is an excellent source of protein with high quality advantages linked to high digestibility and richness in essential amino acids, and contains a wide range of fatty acids. Regular consumption of yoghurt is associated with improved bone health in children and teenagers. Yoghurt is advised for elders to prevent osteoporosis and yoghurt consumption improves the gut health (Nutritional Value of Yoghurt, 2016). Considering all the facts, manufacturing of yoghurt enhances the rural dairy farmers' income and double the dairy profit rather than raw milk sales. Yoghurt processing can be started at rural level with less capital investment. In addition, yoghurt industry creates a solution for unemployment and opens doors for new entrepreneurships in rural areas.

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Author:

Palitha Asanga Adikari: General Manager, National Livestock Development Board. He holds B.Sc. (Plantation Management) from WUSL, MBA from WUSL and Diploma in Agriculture
(e-Mail: *palithaadikari@gmail.com*)

Reviewer:

Geethi K. Pamunuwa: Senior Lecturer, Department of Horticulture and Landscape Gardening, FAPM, WUSL. Her teaching and research interests include: Food Science and Technology, Nutraceuticals and Nanotechnology (e-Mail:*geethipamunuwa16@gmail.com*)

VALUE ADDITION OF HERBAL TEA CHAIN: INTRODUCING "PASPANGUWA" HERBAL TEA BAG

Madhushani Ekanayake

Ministry of Public Administration, Home Affairs, Provincial Councils and Local Government, Independence Square, Colombo 07, 00700

INTRODUCTION

The traditional medicines of Sri Lanka have gained an impressive level of acceptance in the world. It is evident that the health benefits of herbal and green teas further drive the growth of the global tea market. Considering the emerging trend for herbal teas, the Sri Lankan tea manufacturers could try to expand their product portfolio by introducing a new herbal tea using a well-respected traditional formula "Paspangawa". This traditional medicine "Paspanguwa" consists of five main ingredients, namely ginger (*Zingiber officinale*), coriander (*Coriandrum sativum*) 'Veniwelgeta' (*Coscinium fenestratum*), 'Pathpadagam' (*Oldenlandia corymbosa)* and 'Katuwelbatu' (*Solanum xanthocarpum*) (De Zoysa *et al*., 2017).

Project Justification

With the advent of many diseases for which the pharmaceutical industry has been unable to find effective remedies, the interest towards complementary and alternative medicines has been on the rise. In addition, Sri Lanka has a high potential for herbal tea production. This is due to the cheaper prices for even high quality herbs. With the right processing and packaging, the export of herbal teas can be profitable. The "Paspanguwa" formula is well known for improving immunity for ailments, such as colds, coughs, headaches, fever, and overall body aches. At present, its capability to boost immunity impresses consumers. However, due to the time-consuming preparation and not having in tea bag size as user friendly manner, some consumers are reluctant to buy the currently available sachet. Therefore, introduction of a value-added product which goes with the timely changes in taste and preferences, will fuel the further market growth of tea industry.

"PASPANGUWA" HERBAL TEA BAG

"Paspanguwa" herbal tea bag is the expected value added product of the current project. In the production process, it will undergo several steps. Firstly, the five raw materials, which are in correct dryness and correct amounts, are crushed into appropriate sizes. Then, those will be blended well and the resultant herbal mixture is directed to a silo which is connected to the tea bagging machine. Tea is filled into tea bags inside the machine and then bagged herbal tea is packed into cartoons (Figure 1).

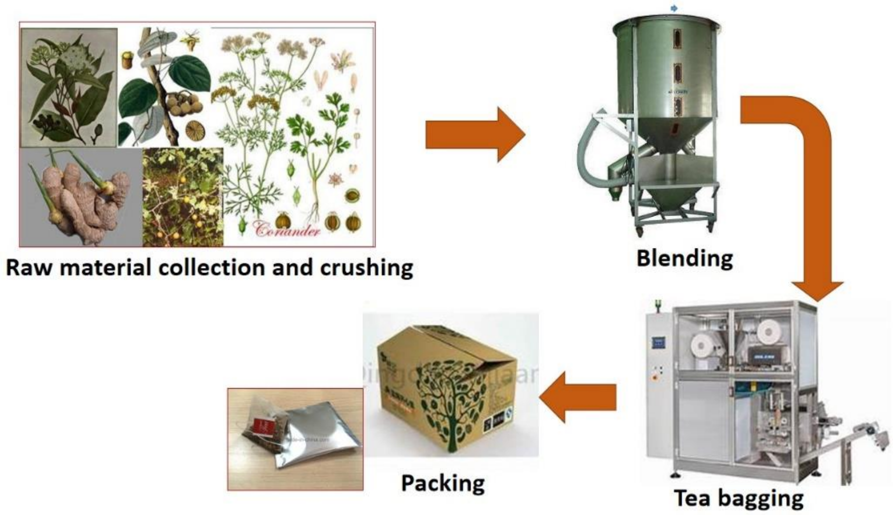

Figure 1: "Paspanguwa" Herbal Tea Production Process

PROJECT IMPLEMENTATION

Production of new herbal tea can be operated inside the existing tea production factory premises. If the factory already has a herbal tea production facility which is producing other herbal teas, such as Chamomile Tea and Mint Tea, it will be an added advantage. It is because that, chamomile powder is similar in appearance to crushed

"Paspanguwa" powder. Therefore, it will be compatible with the available herbal tea bagging machines. After grinding "Paspanguwa" into powder form, it can be directly applied to the blender which will automatically follow the usual herbal tea bagging process. After bagging, it could be packed in two pack sizes as '25 tea bags' and '50 tea bags' packets at the initial stage. The product can be introduced to the international market along with the current herbal tea product portfolio. Special promotion campaigns can be conducted to attract new segments in the local market.

Project Constraints and Dependencies

A few constraints can also be identified regarding this project. In order to stabilize in the international market, this product needs to be congruent with well-recognized quality standards, such as ISO 22000, Food Safety System Certification 22000 (FSSC 22000) and Hazard Analysis and Critical Control Points (HACCP). Therefore, an extra effort should be taken when fine-tuning the product according to those standards. In advance, maintaining the quality of raw materials will add an extra cost to the production operations. As this product is new to the operation staff, it is essential to instruct them to maintain optimum humidity in the storerooms as herbs are more vulnerable to pest and disease attacks than black tea.

Further, temperature conditions in storerooms are assumed to be similar to the temperature required for black tea. For a good measure, it is assumed that raw materials are easily reachable and the supply chain of "Paspanguwa" is running without interruptions. In spite of all the positive effects, this project will depend on some external factors conjointly. Especially, quality certifications like ISO 22000 and HACCP require additional changes to the ongoing production line and to some spots of the overall supply chain. This will alter the estimated cost and lead time depending on the severity of nonconformity for the standard. Furthermore, life-threatening infectious diseases related to respiratory track will also drive people to buy "Paspanguwa" herbal tea bag.

Project Success Criteria

The success of a project can be measured through a Cost-Benefit Analysis (Hwang, 2015). It will be used in this project to measure the fruitfulness of the suggested project quarterly. Furthermore, the timeliness of the project can depict the success of operations. Additionally, Benefit-Cost Ratio (BCR) and Net Present Value (NPV) can also be used as good indicators. Environmental related quality standards, such as ISO 14000, Carbon Footprint and Water Footprint will add extra attractiveness to success measuring criteria.

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Author:

Madhushani Ekanayake: Graduate Trainee at the Ministry of Public Administration, Home Affairs, Provincial Councils and Local Government. She holds B.Sc. (Agriculture) [Second Class Upper] from WUSL. The article was composed based on her industrial experience gained as a Trainee at Sunshine Tea (Pvt) Ltd., Wedamulla, Kalaniya
(e-Mail: *madhuekanayake19@gmail.com*)

Reviewer:

Amani Wijesinghe: Senior Lecturer at the Department of Bio-Systems Engineering, FAPM, WUSL. Her teaching and research interests include: Food Technology, Food Safety & Quality Management and Development of Food Preservation Techniques
(e-Mail: *jaacwijesinghe@wyb.ac.lk*)

SIX SIGMA METHODOLOGY TO IMPROVE THE PRODUCTIVITY OF AGRICULTURAL PRODUCT PROCESS AT CEYCOR NATURE FARM

Shahein Aruna

School of Business, National Institute of Business Management, No. 40, Bauddhaloka Mawatha, Kurunegala, 60000

INTRODUCTION

Many organizations attempt to apply new concepts to improve their business processes, which address the customers' requirements. Six Sigma is a process-driven project approach with the aim of reducing defects in an organizational process, focusing on the customers' requirements (Kwak and Anbari, 2006). Six Sigma methodology, DMAIC ("Define, Measure, Analyze, Improve and Control") process (Figure 1) is a widely used methodology to improve quality that can be extended to Total Quality Management (TQM) (Kumar, 2007) which will ultimately lead to increased productivity (Bhargav, 2015). Manufacturing organizations apply this philosophy to improve productivity by producing non-defective items in their business processes and achieve their organizational goals. Nonetheless, there is low application of this important philosophy to the agricultural production systems in Sri Lanka. This project will attempt to apply the Six Sigma philosophy to improve the productivity of the business process and products of Ceycor Nature Farm at Kurunegala, as a pilot project. Ceycor Nature Farm produces different types of value-added agro products in rice, pineapple, chilli, and banana. Currently, they are facing major quality issues in producing value-added products to compete in the marketplace under competitive prices. Therefore, Six Sigma methodology will be used to overcome the current quality issue and low productivity in their agricultural production process.

Figure 1: The Six Sigma Methodology [Define, Measure, Analyze, Improve and Control (DMAIC) Process]

Define Stage*: What is the best method to improve the productivity by reducing cycle time and non-value added activities in production system*
Measure Stage*: Measure the variables of cycle time of the production, customer satisfaction ideas, total cost and revenues, flow of production and value added productions*
Analyze Stage*: Analysis by using the statistical quality seven tools and non-value added activities to identify the root causes for the low productivity and quality issues in the business*
Improve Stage*: Improve the current business processes by eliminating non-value activities and improve the products by introducing value added products required by customers*
Control Stage*: Make standardize the procedure to improve the capabilities in future and implement the daily monitoring process*
Sources: https://www.sixsigma-institute.org/; https://www.pyzdekinstitute.com/

Justification

The current issue faced by the business is not specific to this organization but a common issue in the industry. Applying this Six Sigma philosophy, will make new directions for Ceycor Nature Farm to think about improving the productivity from a new perspective. It is the need of the hour of all agro-based manufacturing businesses to reduce their costs and cycle time of the process and address the customers' requirement of having a competitive price while improving brand awareness and brand loyalty.

The project will help Ceycor Nature Farm to make value-added products and new product processing methods that bring identity to their business. It will lead to convert their businesses into ventures which promote agro-tourism in the area. After implementing this project, it will make a new path in Sri Lankan agro-businesses to apply the internationally recognized quality methodology to compete in the international market as well.

Project Constraints

The major constraint of implementing this project is the lack of knowledge of Six Sigma Methodology among the employees in this business. Education level and the ability to understand this philosophy are at a low level. Another barrier is the employees' reluctance to make a change to the business process that they are used to for a long time. Therefore, new KPI (Key Performance Indicator) system will be implemented based on their engagement in improvement business and additional revenues generated by them through the new processes.

Project Assumptions

There will be full support from the management to implement the project. Further, the management will be willing to invest on any additional costs that may incur to apply this methodology. It is assumed that all the employees will also provide their full commitment to make this project successful. Due to the process improvement under this project, the employability, salaries and other employee payments will not be deducted. More attention will be paid to improve Technical Productivity and it will lead to Social and Green productivity.

Project Dependencies

The following project dependencies are considered in the form of internal and external factors. Internally, the commitment of the employer and employees will highly affect the project success. The project will be dependable on external forms such as water and fertilizer and other input purchases. Most of the time, the Six Sigma application knowledge and information will be a more external dependable factor in this project.

PROJECT SUCCESS CRITERIA

Under DMAIC methodology following success measures are considered. Cycle time reduction (Minutes in the process) of the food processing of each category is the major success criteria for improving productivity. A number of non-value added activities removed from the production system is another important criteria that can be used to identify the improvement of productivity. New KPI, such as individual processing time savings compared to the standard time, innovation value-added products are considered as other success criteria in the viewpoint of employees.

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Author:

Shahein Aruna: Business Consultant/Lecturer attached to the School of Business, National Institute of Business Management - Kurunegala Campus. He holds B.BA (Operations Management) (Hons.) from University of Peradeniya. Six Sigma Green Belt holder and ISO Internal Auditor. His areas of interest are Operations Management, Business Statistics, Productivity and Quality Management (e-Mail: *shahein.aruna@gmail.com*)

Reviewer:

Jagath C. Edirisinghe: Professor in Agribusiness Management. His teaching and research interests include: Agricultural Marketing, Supply Chain Management, International Trade, Environmental Economics and Bayesian Econometrics (e-Mail: *jagath@wyb.ac.lk*)

ADVANTAGES OF SMALL-HOLD VILLAGE CHICKEN POULTRY REARING FOR RURAL DEVELOPMENT AND FOOD SECURITY

Thilakarathna Widanapathirana

National Livestock Development Board, Galpokuna Farm, Udubaddawa, 60250

INTRODUCTION

Poultry have been domesticated for thousands of years in the world. Archaeological evidence suggests that domesticated chickens existed in China 8,000 years ago. They later spread to the Western Europe, possibly by way of Russia. Domestic chickens appeared in Sri Lanka many centuries ago. Village poultry rearing can be found all over the country and it plays a vital role in many poor rural households (Abeykoon *et al.*, 2013). This paper discusses the major advantages of village or small-hold poultry rearing in terms of poverty alleviation and food security.

ADVANTAGES OF VILLAGE / SMALL-HOLD POULTRY REARING SYSTEMS

Adaptability of flexible rearing systems: Village poultry provide a flexible livestock rearing system that is widespread in most areas of the country, especially in Gampaha, Kurunegala, Puttalam, Vavuniya and Jaffna districts. Village poultry can be reared with existing resources and productivity can be increased with additional inputs (Table 1).

Low input: Village poultry rearing does not require large investments to start or maintain the business. Commercial poultry are found mainly in peri-urban areas. Commercial poultry production needs large capital inputs, considerable technical skill and sophisticated markets. The profit margins of commercial poultry production are likely to drop due to increased costs for better biosecurity, balanced feeds and healthy day-old chicks. Transport costs are increasing, and village poultry rearing is better buffered than the commercial sector to accept any cost increases.

Low labour requirements: Village poultry is highly suitable for female household (women in farming) as they can manage and protect their poultry assets satisfactorily using scavenging feed resource.

Provision of high quality nutrition: Small-hold poultry provide high quality animal protein (eggs and meat) at the source of production and households are not reliant on a cold chain as is required for processed commercial birds, meat and eggs. The size of one bird is sufficient for a family, and a cold chain is not required for preservation of meat. Village poultry may survive where other poultry species would not easily do so.

Income generation: Village/smallholder poultry can provide income for family activities such as education, health and clothes. Village poultry have constantly commanded a price premium over commercial birds and there is a wide market demand for village poultry products. There are a numbers of commercial village chicken farms and hatcheries in Gampaha and Kurunegala districts. The markets for commercial poultry are focused on large markets, a good distribution system and a relatively long supply chain. The supply chain for village poultry is much shorter than commercial poultry; in many cases it is very short.

Low environmental impact: Compared to commercial birds and ruminants, village poultry is more environmentally neutral. It is well suited to remote areas where there are limited markets. Village poultry are better survivors in natural disasters such as floods, tsunamis and fires as they can fly to safety whereas conventional commercial breed birds are generally all lost. In addition, the ability of village poultry to fly and run enables them to be more likely to escape many of their predators (Assefa *et al.,* 2016).

CONCLUSION

Village chicken production in Sri Lanka is characterized by the use of indigenous ecotypes with low input-output levels. It is widely practiced in many parts of the country. Unlike other livestock farming, majority of village chicken are owned by females and children of the family. They require low capital and little supply of commercial feed. A majority of chicken keepers use chicken for sale to cover household expenditure, home consumption, and as means of saving in the rural family. Village chicken production is also used as source of high quality protein food to smallholder farming families. Village chicken production is widely practiced in Gampaha, Kurunegala, Puttalam, Vavuniya and Jaffna districts. Farmers rear chicken in varying number of flock sizes (10 to 50) for the purpose of producing egg and meat. There is a leading trend to rear village chicken as commercial farms in Gampaha and Kurunegala districts. Several commercial hatcheries can be found in same areas owned by the private and government sectors. Increased knowledge and capacity gained by women and children through village poultry can improve village poultry production in the country. When considering development as a whole, village poultry might increase household food security, income generation and improved nutrition. Village poultry numbers were not declining in the country over the past few decades despite rapid growth of the commercial poultry sector.

Table 1: Comparison of Village Chickens and Commercial Chickens

Feature	Village Chickens	Commercial Chickens
Labour inputs	Minimal	Considerable
Housing	Chicken houses using local material; inexpensive	Chicken unit using conventional materials; expensive
Nutrition	Scavenging feed resource base, leftover food, cereals, no supplements; inexpensive	Balanced commercial ration; expensive
Water	Well water, used water, natural sources	Clean water supply essential
Production	Low; could improve with better nutrition, disease control and shelter from predators	High; but requires a high level of inputs
Meat quality	Little fat; pleasant flavour	More fat; less flavour
Adaptability	Good: good flight skills, more likely to escape predators, can scavenge for own food	Limited: easily caught by predators, less skilled at scavenging
Veterinary inputs	None; Newcastle disease vaccination; highly pathogenic avian influenza and fowl cholera vaccination in some households	Control of many viral, bacterial and parasitic diseases essential for efficient production
Environmental impact	Minimal: can be positive through provision of organic fertilizer and pest control	Negative: intensive production of cereals for rations; occasional improper use of antibiotics, excess ammonia production

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Author:

Thilakarathna Widanapathirana: Manager at National Livestock Development Board. He holds B.Sc. (Agric.) from University of Ruhuna (e-Mail: *nldbgalpokunafarm@gmail.com*)

Reviewer:

Dileepa de Croos: Senior Lecturer attached to the Department of Aquaculture and Fisheries, Faculty of Livestock, Fisheries and Nutrition, WUSL. His teaching and research interests include: Marine Biology, Marine Ecology, Fisheries Management and Population Genetics
(e-Mail: *dileepa_dc@yahoo.com*)

IMPROVING THE QUALITY AND EFFICIENCY OF ORGANIC COMPOST BY HEAP METHOD

Hasini Kaushalya Abeysinghe

Sustainable Development and Research Centre, Department of Agriculture, Wayamba, Makandura, Gonawila (NWP), 60170

INTRODUCTİON

At present in Sri Lanka, there is an incresing trend to produce high quality vegetables and fruits without applying inorganic fertilizer. As a result, people have reduced the usage of chemical fertilizers and increased the use of organic fertilizer for their home gardening and other cultivations. In this view, people are moving towards sustainable agriculture practices through using organic inputs in cultivations. Compost plays an important role as an organic input with many benefits. In addition, compost could be considered as a value added product of organic materials, which has a higher commercial value when compared to many other forms of organic materials. However, the problem is lack of sufficient supply of quality compost fertilizer according to the consumer demand. As a solution, large-scale compost producers can be motivated to produce good quality compost with high efficiency by using heap method.

Project Justification

The high amount of foreign expenditure that is spent on importing chemical fertilizer can be saved if good quality compost is produced in large scale by Sri Lankan farmers. In addition, it will be more beneficial towards the environmental friendly farming. Considering these factors, this project is aiming to improve the quality and efficiency of the compost for sale and for the application for cultivations. This technique can be used to effectively manage waste and also to create new job opportunities. It is expected to reduce the cost of importing chemical fertilizer up to 25 percent by 2025 (Census of Agriculture, 2012). The use of compost produced from agricultural waste is gaining popularity in many parts of the world with the current trend towards organic agriculture. By now, many Sri Lankan authorities are involved in producing compost from the organic fraction. If some compost productions are extremely poor in quality, customers may get an impression that all compost are of poor quality. Quality assurance standards (*e.g.* SLS standards) for consistent production of high quality compost is a necessity for compost marketing. However, it has become a challenge to produce compost at a higher scale to meet the specified standard within a shorter processing time. A system that is developed to overcome these challenges would be extremely beneficial.

Project Constraints

Though it is expected to promote the use of organic compost in agriculture to compensate the amount of chemical fertilizer, limited availability and difficulties in producing compost at large scale have been identified as major constraints. In this project, there are a few constraints namely, economic, political, social, technical and environmental. The lack of quality standards for waste composting, finance, new technologies, inadequate partnership between producers of the composting plants and the agricultural experts are major constraints for the successful function of this process.

COMPOST PREPARATION PROCESS (HEAP METHOD)

Composting is a natural process of decomposition of organic materials by microorganisms under controlled conditions. Raw materials such as crop residues, animal wastes, green manures, aquatic plants, industrial and urban wastes are used in the composting process. However, at the end of the process (Figure 1), it needs to be of suitable quality for application to the soil as a fertilizing resource. The end product of the process is compost or humus which is a valuable input for agriculture. In the compost preparation process, the conditions should be controlled to the optimum level to prepare high quality compost (Table 1).

PROJECT IMPLEMENTATION

A suitable institutional arrangement is recommended to check the quality of organic compost regularly before the product goes to the market because a product with government certification would create an assurance to the users. Proper awareness training programmes will be conducted for the large scale compost producers.

Large scale compost preparation by heap method involves machineries. A set of machines namely, compost turner-cum-mixer, chopping machines and automatic compost sieving machine are used for quality compost making, handling and increase the efficiency of compost production. Compost turner-cum-mixer is a trailing and offset type machine used for thoroughly mixing the cow dung, farm residues and biomass for manure preparation. Automatic compost sieving machine is suitable for sieving and separating the finer grade material from the coarse grade ones. The mechanization of the heap compost making process has provided the avenue for large scale production of good quality compost in a more rapid manner without drudgery to labourers. This overcomes the labour problem and accelerates the compost preparation process while imparting dignity to labour. The technology facilitates compost making in 45 - 60 days.

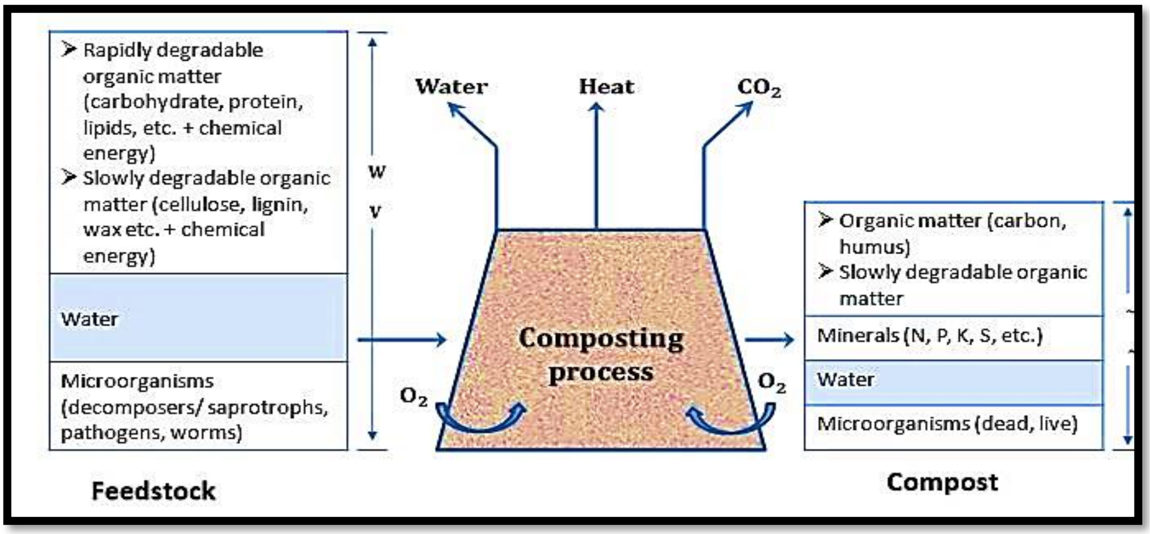

Figure 1: The Composting Process

Table 1: The Factors Affecting Aerobic Composting

Factors	Required Conditions
C:N ratio	The range between 25:1 to 40:1 - efficient process
Surface area and Particle size	The smaller the size the faster the process
Aeration	Air circulation enhances aerobic decomposition
Porosity	Space between particles enable supply of oxygen
Moisture content	Optimum 50% - 60%
Temperature	Optimum 32˚C - 60˚C
pH value	6.5 - 7.5

Source: Ministry of Agriculture, 2015

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Author:

Hasini K. Abeysinghe: Agriculture Instructor at the Department of Agriculture, Sri Lanka. She holds B.Sc. (Plantation Management) degree from WUSL
(e-Mail: *hasinikaushalya199195@gmail.com*)

Reviewer:

Indika K. Herath: Senior Lecturer attached to the Department of Plantation Management, FAPM, WUSL. Her teaching and research interests include: Soil Science & Plant Nutrient Management, and Environmental Impact Assessment (e-Mail: *indikaherath@hotmail.com*)

PRODUCTIVITY IMPROVEMENT OF TEA SMALLHOLDER LANDS BY INTERCROPPING WITH PEPPER

Amila Dayan Premaratna

Kalawana Divisional Secretariat, Kalawana, Rathnapura, 70000

INTRODUCTION

The term "intercropping" refers to cultivation of two or more crops on the same field simultaneously in a mixture or in a regular spatial arrangement. Intercropping in tea serves to maximize land productivity and to minimize the economic and environmental risks involved in growing a mono-crop. Intercropping has become more widespread in the last two decades both in smallholdings and in plantations. In Sri Lanka, tea and black pepper are commercial scale export crops. These crops are grown mainly in the agro-ecological zones under wet and intermediate climatic conditions. Tea and pepper intercropping significantly improves the land productivity.

Current Status in Sri Lanka

Pepper, coffee and cloves have historically been cultivated as intercrops in tea smallholders' lands in the districts of Kandy, Matale and Rathnapura. These crops are, however, economically significant to the country. Black pepper is one of the main export crops in Sri Lanka which is cultivated over 30,931 ha. In year 2010, 12,218 t of pepper was exported earning US $ 42.65 million.

Justification

Sri Lankan black pepper has a high demand like other spices in the export market since it is well known for its superior inherent properties (*i.e.* high Piperine content with strong pungency). It contributes to the Sri Lankan economy by earning foreign currency and government revenue earnings. Limited land availability with suitable conditions has become a crucial issue for increasing the production.

According to the Central Bank Report (Annual Report, 2019), in year 2018, more than 1,462 ha were added through tea replanting and new planting with the majority of small-scale farmers (Table 1). Tea growing is becoming a regular challenge for smallholder farmers because of a variety of problems. Among them, high production costs are substantial due to increasing fertilizer prices and labour wages. Others include shortage of labour, land and family labour involvement in tea cultivation. Crop diversification and intercropping are some of the options available to increase the productivity and sustainability of lands. Further, Gliricidia (*Gliricidia sepium*) is a low shade tree on which the pepper vines are trained. These plants provide a large quantity of biomass through regular lopping and pollarding of branches. It also helps to cut down solar radiation and reduce ambient temperature, thereby creating a micro-climate for the intercropped pepper plants. In addition, Gliricidia increases soil fertility and reduces fertilizer cost. Research studies showed that tea and pepper intercropping system increased the income of tea lands by 33% and land value by 8 - 115% (depending on the locality). It is one of the best solutions for the scarcity of suitable land for pepper cultivation in Sri Lanka (Senavirathne, 2011). Therefore, it provides a good opportunity for tea smallholders to implement intercropping system for tea and pepper to increase their land productivity and income.

Assumptions

Pepper is the most compatible crop with tea in the mid and low elevations. It is assumed that pepper be cultivated by tea smallholders for better land utilization, higher productivity, reduced risk of dependence on a single crop and the generation of additional employment opportunities and finally to increase their income and living standard.

Table 1: Tea Production in Sri Lanka

Category	Units	2017	2018
Production	kg million	307.1	303.8
Total extent	ha '000	201.0	201.0
Replanting	ha '000	944.0	1,027.0
New planting	ha	225.0	435.0
Cost of Production	Rs/kg	466.98	475.29

Source: Central Bank of Sri Lanka, Annual Report 2018

TEA AND PEPPER INTERCROPPING PROJECT

The target group of this project includes tea smallholders who practice replanting and new planting (Figure 1). Firstly, smallholders (farmers) and suitable lands will be selected with the help of field officers in Tea Small Holdings Development Authority (TSHDA) and Department of Export Agriculture (DEA). Thereafter, awareness programmes will be carried out for those growers. Then, recommended pepper planting materials will be supplied for the growers free of charge. Two hundred and fifty pepper plants will be established per one hectare of tea land with the spacing of 6 m × 7 m (20 × 24 ft.) and trained to every other Gliricidia tree established at 3 m × 3.5 m (10 × 12 ft.) spacing. Then, these practices are evaluated by the field officers of TSHDA and DEA and they are assigned to obtain their problems, harvesting details and other details of farmers.

Figure 1: Approach of the Extension Programme

PROJECT IMPLEMENTATION

A 3-year project is implemented by the TSHDA and DEA and they will be allocated with funding for input through their Budget 2021. The project is then executed by the field officers of these organizations. Tea smallholders assigned to the project are expected to complete the project by the end of 2023. The project data will be collected during this period and the project success will be evaluated by year 2023 using a Cost-Benefit Analysis.

The planned outcome of the proposed project is to increase the land productivity and income per unit area. The project also enables smallholders to manage resources efficiently and to reduce the use of external resources (inputs) without depleting the natural resource base. This intercropping project provides insurance against crop failure or against unstable market prices for tea, especially if the areas are subject to extreme weather conditions, such as drought and flood. Finally, it is expected that the proposed intercropping project in tea smallholders' lands with pepper could increase the smallholder income and land productivity.

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Author:

Amila Dayan Premaratna: Colonization Officer, Kalawana Divisional Secretariat, Kalawana. He holds B.Sc. (Plantation Management) degree from WUSL
(e-Mail: *amila87dayan@gmail.com*)

Reviewer:

Kanchana S. Weerasinghe: Senior Lecturer attached to the Information Communication Technology Centre of WUSL. Her teaching and research interests include: Information Systems, Database Management System and ICT in Agriculture & Education (e-Mail:*kanwyb@yahoo.com*)

PRESENT CONTEXT OF DRIP IRRIGATION SYSTEMS INSTALLED AT COCONUT PLANTATIONS IN THE COCONUT TRIANGLE

Priyankara Asoka Thilakarathne

National Livestock Development Board, Narangalla Farm, Kithalawa, 60188

INTRODUCTION

Drip irrigation is a modern, high-tech irrigation method with a very high level of water application as well as water use efficiency. It is sometimes called trickle irrigation, which involves dripping water on to the soil or a very low rate from a system of small diameter pipes fitted with an outlet called emitters or drippers (Wijenayake, 2017). At the same time, the coconut industry is an important source of foreign exchange and employment generation for Sri Lanka, and coconut is an essential component of Sri Lankan cuisine, nutrition and rural livelihood. Sri Lanka is the fifth largest coconut producer in the world with more than 440,000 ha of cultivated extent and current coconut production in the country varies from 2,500 to 3,000 million nuts per year. It is also an important export crop earning foreign exchange of about US$ 550 million annually contributing about 1 percent to the Gross Domestic Product.

The major part of Sri Lankan coconut production comes from the 'Coconut Triangle'. More than half of coconut lands in the coconut triangle are in the dry and intermediate climatic zones, where the productivity is relatively low due to insufficient rainfall (Figure 1). As water is a limited resource in the coconut triangle the application of drip irrigation technology in coconut plantations leads to water conservation while increasing the contribution of coconut to the Gross Domestic Product in the country through yield increase.

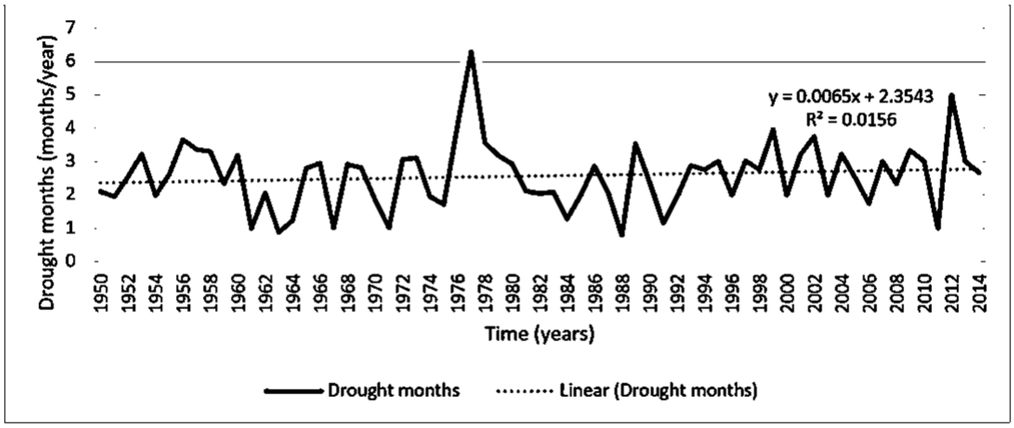

Figure 1: Drought Months Since 1950 to 2014 in Areas of the Coconut Triangle
Source: Vidanage and Jayalath, 2018

Justification

Throughout this study drip-irrigated coconut plantations are investigated (Figure 2). Mainly, the state and conditions of drip-irrigated coconut plantations are expected to be studied. The extent of drip-irrigated coconut plantations at the coconut triangle may provide the picture of the distribution of drip irrigation systems within the coconut triangle. Other than that,

1. Product qualities and standards of drip irrigations systems
2. Irrigation systems' operational status
3. The level of technology obtained by the planters
4. Drip irrigation systems' aftercare and maintenance conditions
5. The level of usage of drip irrigation systems for crop integration within the coconut plantations may bring a strong image to the study

Project Constraints

The project is conducted at the coconut triangle having the dry period from April to September while only in this period the irrigation systems are operated. If the study is conducted only at this period then a better result would be achieved. When carrying out the project, the impression of the planters on drip irrigation systems and attitude of the planters may be barriers for collecting information as the documented information on this sector is scarce. In addition, there may be other general constraints, such as funds, time, sample size and number of samples and other research-based constraints.

Project Assumptions
For the success of the project, mainly it is assumed that the available data and information would be true and correct and the attitude and support of the planters would be positive. Further scientific studies would strengthen the findings because the presently available data and information might not be adequately scientific.

Project Dependencies
Mainly scientific and technical knowledge of both researchers and coconut planters about drip irrigation systems and their functions affect the project. Apart from that, the attitude of the planters and impression made by the product sellers or installers also can impact on the project.

Figure 2: Drip Irrigated Coconut Land

PROJECT SUCCESS CRITERIA
It is expected that the sector of coconut growing would be benefited through the findings of this project. The findings would impact on the enhancement of the yield of coconut plantations as well as on avoiding the money wastage for installations and maintenance of defected irrigation systems. Further, findings of this project provide scientific information for both students and experts in the agriculture sector. Ultimately, these findings would impact on water conservation providing ecological benefits as a whole.

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Author:

Priyankara Asoka Thilakarathne: Farm Manage at National Livestock Development Board, Sri Lanka. He holds B.Sc. (Agriculture) degree from University of Peradeniya.
(e-Mail: *asokanldb@gmail.com*)

Reviewer:

Wasantha Gunathilaka: Senior Lecturer of Department of Plantation Management, FAPM, WUSL. His teaching and research interests include: Agriculture Engineering, especially Farm Machinery and Irrigation (e-Mail: *haws.gunathilaka@gmail.com*)

PROMOTION OF IMPROVED PICKING POLE FOR HARVESTING OF COCONUT IN PLANTATIONS

Sampath Samarathunga

Raddegoda Estate, Thelambugalla Division, Delwita, Rideegama, 60040

INTRODUCTION

The coconut palm (*Cocos nucifera)* is one of the most useful and important trees in Asian countries because there is nothing to throw away from this tree without any usage. Therefore, in Sri Lanka it is known as "*Kapruka*" and it has a long-lasting association with the human being.

Coconut is one of the main plantation crops in Sri Lanka. It is a commercial crop, which earns high foreign exchange (US$ 550 mn) contributing to the Agriculture GNP and National GDP (1.0%). Coconut is also a livelihood crop of Sri Lankans (Livelihood - 700,000 and employees - 135,000). Coconut industrially produces several important export products, such as copra, desiccated coconut, virgin coconut oil, and a variety of other products, such as coconut milk, vinegar, alcoholic drinks, and confectionery (Coconut Research Institute, 2017).

Since the last two decades, coconut industry has been facing many problems, of which the declining profit from coconut cultivation is notable. The declining profit is due to the increased cost of production fuelled by the high cost of inputs, mainly fertilizer and labour. The contribution of labour cost to the cost of production is around 29 percent. Apart from the cost, the labour availability in the coconut cultivation sector has shown a declining trend over the recent years irrespective of skilled or otherwise. The coconut growers complain of the shortage of labour and the rising labour costs. Coconut harvesting needs a large number of skilled labour and it is done using two methods, climbing picking method and pole picking method.

COCONUT HARVESTING BY IMPROVED POLE PICKING METHOD

Pole picking method which is used by 67 percent of the plantations, is cost-effective, easier to harvest, time-saving operation and the safest way to harvest the crop. However, this method encountered higher rejection rates of nuts compared to that in the climbing picking method (Figure 1). The total postharvest losses of coconuts were more than 15 percent. Therefore, improving the pole picking method as an effective harvesting method is a timely important mission to overcome the labour problem in coconut harvesting.

The modified coconut picking pole which supports farmers who are willing to harvest nuts from coconut trees has been developed as a solution for the scarcity of coconut tree climbers in the coconut plantation sector (Figure 2).

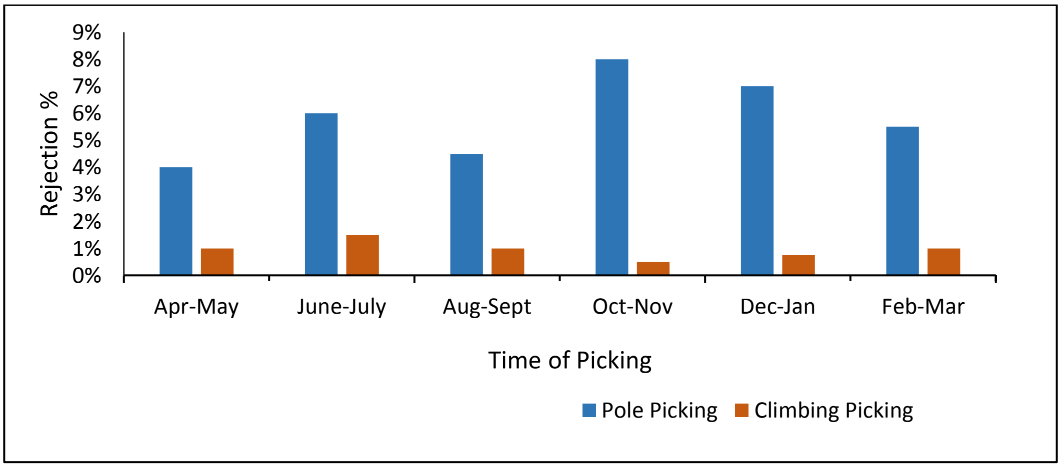

Figure 1: Comparison of Rejection Percentages between Two Picking Methods of the Same Estate
Source: Samarathunga, 2018

Limitation to Promote Pole Picking in Coconut Sector and Suggestions

As one of the main factors, we can identify the misconceptions of the workers. They believe that this job is their inheritable occupation and therefore, they are reluctant to get advice from others. Moreover, lack of skilled labourers is a significant limitation in this sector. On the other hand, the Management has given less attention to the difficulties faced by the picker.

Increasing the skilled labourer capacity is the most important matter because the majority of the climbing pickers (on contract basis) are coming from outside the estate and are highly demanded. Therefore, pole picking gangs should be trained inside the estate in the labour cadre. On the other hand, picking coconut by the pole is not an easy job because they are using long bamboo poles (up to 75 ft.) which are heavy. Therefore, introducing a light pole made of a light metal like Aluminium is important for easy handling. Moreover, simple techniques and knowledge should be given for the identification of the properly mature bunch. If not, the pickers are used to pick one nut from each 2 - 3 bunches to select the mature bunch. Those are dumped as rejections. In addition, the picking people can be motivated by the plantation organizations by giving some special rates and upgrading them as "Picking Technicians" in the labour cadre. In addition, they also have to be given any responsibility for the crop which they have harvested. The modified pole is height adjustable, lightweight, self-controllable, safe to operate, easy to fabricate and economically viable. It consists of two adjustable Aluminium alloy poles, a harvesting knife, nylon hinged clamps and a protective grip. The minimum and maximum harvesting length of the plucking pole are 7 m and 17 m, respectively.

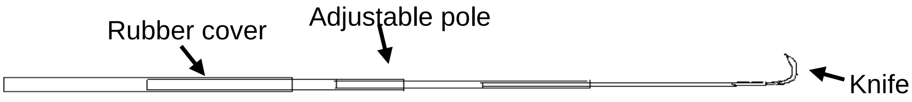

Figure 2: The Proposed Light-Weight Picking Pole

Responsible Institutions to Promote the Technology

Institutes under the Ministry of Plantation Industries, such as Coconut Research Institute (CRI), Coconut Development Board (CDB), Coconut Cultivation Board (CCB), and Regional Plantation Companies related to coconuts are the main organizations to conduct awareness and skills training programmes via extension personnel. Therefore, the Coconut Research Institute can be identified as a key institute that can modify the technology about the pole picking harvesting. In addition, the private sector and smallholders can contribute to these programmes.

Measurable Outcomes of the Promotion

If the improved picking pole can be promoted, it is possible to minimize the wastage that occur in the coconut industry and decrease the rejection rates. Pole picking method can be identified as the most efficient and effective way to harvest. It is a low cost, time-saving faster and a safer harvesting method. Specially, labourer hazards can be minimized. All these outcomes/benefits of the pole picking method are clearly measurable. Table 1 presents an analysis showing the differences in cost of harvesting between pole picking and climbing methods.

Table 1: Comparison of Harvesting Cost

Picking Method	Rate (Rs./Tree)	Nuts per Tree (Assuming 7 nuts/tree)	Cost per nut (Rs.)	As Percentage of COP (18 Rs./nut)
Climbing Picking	65	7	9.30	51.66%
Pole Picking	9.37 (Rs. 600/acre)	7	1.34	7.44%

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Author:

Sampath Samarathunga: Assistant Superintendent, Raddegoda Estate, Raddegoda, Delwita, Rideegama. He holds B.Sc. (Plantation Management) from WUSL
(e-Mail: *samarathunga41@gmail.com*)

Reviewer:

Rupika Abeynayake: Professor in Applied Statistics, Department of Agribusiness Management, FAPM, WUSL. Her teaching and research interests include: Econometrics, Statistical Quality Control, and Time Series Analysis (e-Mail: *rabeynayake@hotmail.com*)

IDENTIFICATION OF TRENDS AND POTENTIALS IN DAIRY MILK PRODUCTION

Harshani Ruwan Pathirana

Kotmale Dairy Products (Pvt) Limited, No. 20, Sri Sumana Mawatha, New Town, Mulleriyawa, 10620

INTRODUCTION

Bovine milk and dairy products have been a part of the human diet, from their birth to old age. Sri Lanka is highly hooked on agricultural sector accounting for 7.8 percent of the Gross Domestic Production in 2015 (Central Bank of Sri Lanka, 2017). The current milk consumption in Sri Lanka is around 700 million litres per annum, which amounts to a per capita consumption of 35 L per annum. The current national milk production of 220 million litres comprises 120 million litres (approx. 300,000 L/day) collected by the formal market and 100 million litres sold through the informal market. The shortfall of 480 million litres is met by imports, mostly in powdered form. Thus, locally produced milk meets only 42 percent of the current national demand. However, Sri Lanka has the potential of being self-sufficient in milk.

Current Status of the Dairy Industry in Sri Lanka

Dairy production in the country has a record of positive growth during the last decade, especially after 2008. Even so, there is a need to import milk products in order to fulfil the local consumption necessities. Most of the dairy farmers are engaged in dairy industry as a source of an extra income. As a result, the domestic milk production has increased by a small proportion.

The land area under agriculture in Sri Lanka is around 2 million hectares, which is 30 percent of the country's total area of 65,610 km^2. Almost 75 percent of the agricultural land is under smallholdings, and the number of such holdings is estimated at 1.8 million, with over 90 percent of them having less than 2 ha. Almost one third of these smallholdings have a mixture of crops and livestock. The area of farm holdings with livestock is around 0.56 million hectares, of which 99 percent are categorised as smallholdings (Perera and Jayasuriya, 2008).

According to the Department of Animal Production and Health (2018), with an average milk production per cow per day of 2 L, Kurunegala district shows the highest number of farms and highest daily average milk production (Figure 1). However, the highest average milk production per cow per day is shown in Nuwara Eliya district, where the animal types are pure exotic animals and crosses. Hence, there can be more positive impresion of investing further on farms in Nuwara Eliya, Kandy, and Badulla districts, where the average milk production per cow per day are 10 L, 5 L, and 3 L, respectively.

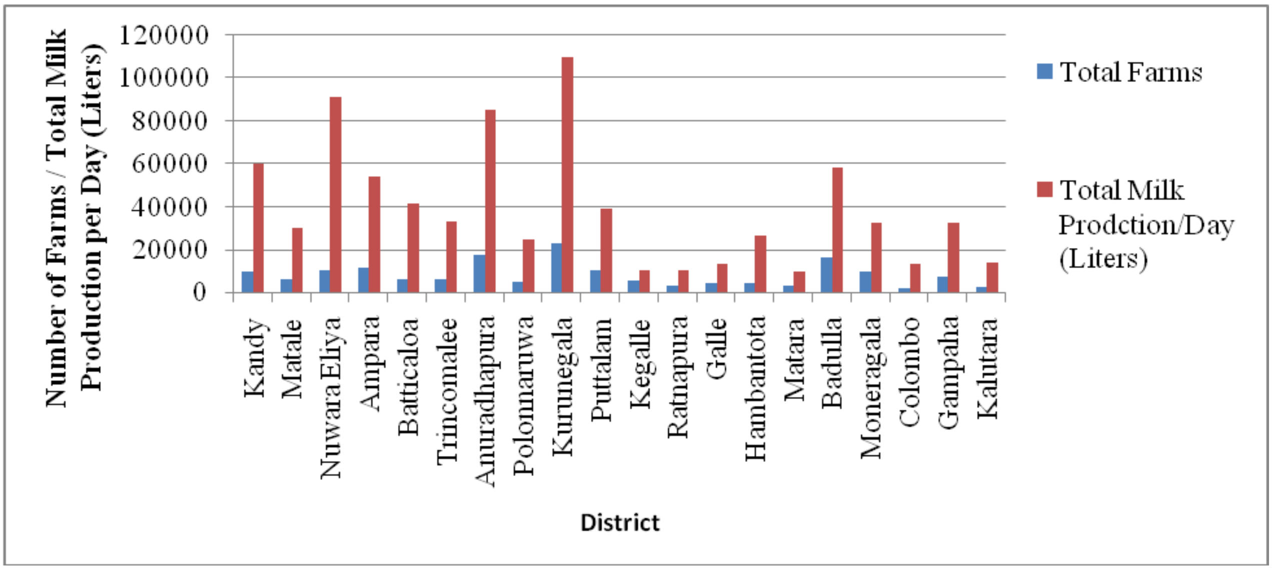

Figure 1: Total Number of Farms and Total Milk Production per Day
Source: Department of Animal Production and Health (Farm Registration Programme-2008)

According to the consumer survey of Hector Kobbekaduwa Agrarian Research and Training Institute, consumer preference is high for fresh milk and local milk powder. This emphasizes that the poor availability and accessibility to safe and high quality local fresh milk based products have compelled consumers to purchase more imported powdered milk and milk based products.

Nonetheless, the dairy sector underwent a turbulent period in 2013, after the detection of dicyanamide (DCD) in imported milk powder. This had a significant impact on consumer behaviour, their attitudes, needs, and demand for dairy products.

Justification

A considerable portion of the foreign exchange is leaked from the country for importation of milk. Importation of milk products can be reduced to a significant extent by developing the dairy sector in Sri Lanka. Yet, the inability of domestic sources of milk production to meet the local demand for milk indicates the inefficiency of the current system.

CONSTRAINTS OF THE DAIRY INDUSTRY

There are limitations which have caused difficulties in rising the domestic daily milk production. Poor farmers find it difficult to access capital and credit facilities to purchase the required breeding stock. Non-availability of good quality dairy animals, inadequate coverage of artificial insemination (AI), high wastage of improved genetic material, inadequate feed resources, unfavourable ratio between farm gate price and cost of milk production, poor extension services and inadequate education on animal health among dairy farmers and limitations of research and development efforts aimed at resolving problems at the producer level have been identified as some of the constraints. Moreover, low investments in the livestock sector primarily due to a lack of state support and financial services, failure to update the technologies, including the development of a proper collection and distribution network in the sector, absence of proper consumer education to appreciate the value of fresh milk and milk products and the lower cost of imported milk powder relative to the cost of local fresh milk, have also been identified as constraints in the dairy industry.

POTENTIALS FOR A SELF SUFFICIENT DAIRY INDUSTRY

Nowadays, the Sri Lankan government has given priority to develop dairy sector through the Ministry of Livestock Development, due to the reason that the country is endowed with required primary resources, including favourable climate. Moreover, both government and industry together should encourage the investment by private investors into large scale commercial farms. There is a need for smallholder farmers to be linked to large scale commercial dairy farms.

By having a long-term strategic plan to increase milk production in the country with the involvement of the government, private sector and the relevant institutions, Sri Lanka can achieve the final goal of self-sufficiency in milk. It will be a sustainable and profitable strategy to uplift Sri Lankan dairy production and livelihood of thousands of dairy farmers.

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Author:

Harshani Ruwan Pathirana: Quality Assurance Executive attached to Kotmale Dairy Products (Pvt) Ltd. She holds Special Degree of Bachelor of Animal Science [Second Class] from Uva Wellassa University of Sri Lanka
(e-Mail: *harshanihasanthi@yahoo.com/harshanihasanthi1963@gmail.com*)

Reviewer:

Nimanthika Lokuge: Lecturer attached to the Department of Agribusiness Management of FAPM, WUSL. Her teaching and research interests include: Agricultural and Food Economics, Applied Econometrics, and Food Marketing and Agribusiness (e-Mail: *nimslkg@gmail.com*)

PREPARATION OF A NUTRITIOUS FOOD BAR USING LOCALLY AVAILABLE RAW MATERIALS

Athma Kithmini Withanage

District Agriculture Training Centre, Gabadawattha, Homagama, 10200

INTRODUCTION

The food bars are snacks of good sensory and nutritional characteristics due to the contents of higher macro and micronutrients. Currently available snack foods, such as extruded products, potato chips, and bakery products in the market do not meet the requirements of a balanced diet and those are unhealthy offerings for the consumers, more particularly to the school children. Increasing consumer demand for nutritious snacks has provoked the food manufacturers to develop nutritious food bars that provide balanced nutrition as well as convenience. School children are in need of more nutritious foods to facilitate their fast growth. Therefore, the food consumed by them should be rich in vitamins, minerals and balanced regarding major nutrients of carbohydrates, proteins and fats. The options available for children to buy wholesome and nourishing food products are limited. The products that are developed by utilizing locally available dried fruits, processed legumes, and cereals along with nuts would be an attractive snack food for school children, as well as for people who are more dependent on snacks for their daily nutritional requirements.

Problem Statement and Justification

More often children and office workers who work in tight schedules consume fast foods at higher prices. They have less concern on the nutritional value of the food they consume. In addition, they regularly skip a few meals. As a result, malnutrition has become a major nutritional problem in Sri Lanka.

This project is designed to prepare a nutrition bar, to fulfil the need of a daily nutritional requirement, by using local raw materials, which will provide the cost advantage for the consumers as well as for the manufacturers. To achieve this objective, economical and underutilized food sources with good nutritional value should be explored, such as moringa leaves, bee honey, rice flakes, legumes and cereals, *etc.* (Selden, 2012).The nutritional compositions of those raw materials were compared with wheat flour and potato (Table 1).

Table 1: Comparison of Nutritional Values of Some Underutilized Food Sources

Ingredient	Carbo Hydrates	Proteins	Lipids	Water	Vitamins	Minerals
	(g / 100 g)					
Bee honey	82.4	0.3	0.0	17.1	B_2, B_3, B_5, B_6, B_9, C	Ca, Mg, Fe, P, K, Na, Zn
Moringa leaves	8.3	9.4	1.4	78.7	A, B_2, B_3, B_5, B_6, B_9, C	Ca, Fe, Mg, Mn, P, K, Na
Cowpea	35.0	13.0	0.9	-	A, D, B_{12}, C, B_6, Mg	Ca, Fe
Rice flacks	86.2	6.7	1.3	-	A, C,	Ca, Fe
Wheat flour	95.0	13.0	1.2	-	A, C, D, B_6, B_{12}	Ca, Fe, Mg
Dried fruits	23.0	0.3	-	-	A, C, D, B_6, B_{12}	Fe, Ca, Mg
Potato	37.0	4.3	0.2	-	A, D, B, C, B_6	Fe, Ca, Mg

Source: Department of Agriculture, 2020

PROJECT IMPLEMENTATION

Raw Material Requirement for 120 g of Nutrition Bar

Cowpea, green gram, rice flakes and soybean were washed, dried and roasted before use. Then, cowpea, green gram, rice flakes and popcorn were finely crushed to reduce the particle size and measured cowpea 12 g, green gram 10 g, rice flakes 5 g, popcorn amount varied as 5 g, 10 g and 15 g and soybean was finely ground. Five grams of soybean were taken. All grains, dehydrated fruits (pineapple) 8 g and peanut 5 g were measured accordingly and properly mixed. Then, 35 g of sugar was dissolved and after that 15 g of glucose syrup was added into the sugar syrup. Then, the mixture was boiled and removed from the flame, added 5 g of butter and vanilla essence. Previously prepared grain mixture was added into sugar syrup and mixed well. The final mixture was added into mould and allowed to dry. Finally, Nutrition Bars were packed in triple laminated pouches and pasteurized. The most preferred sample was selected (Figure 1).

Dehydrated and crushed moringa leaves 4 g, 8 g, or 12 g were added to the above selected Nutrition Bar and the most preferred sample was selected from that. The best sample was used as the control and *Kithul* (*Caryota urens*) treacle was introduced to one bar and bee honey to another, then all the above three bars were subjected to the sensory evaluation to select the most suitable base for the Nutrition Bar. That sample was used to determine the biological quality and nutritional composition of developed nutritional bar. The selected bar was also compared with a commercially available nutrition bar.

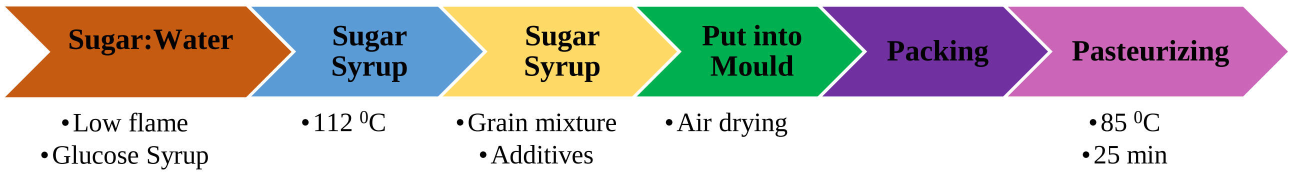

Figure 1: Process of Nutrition Bar Preparation

Sensory Evaluation and Statistical Analysis
Thirty untrained panellists at the District Agriculture Training Centre, Homagama, participated in four sensory evaluations done using a five-point hedonic scale. SPSS 16.0 software was used to analyze the sensory data.

Project Constraints and Assumption
Finding good quality raw materials, keeping a continuous supply with consistent quality, competition from substitute products, effect from pests to the raw material and price fluctuation of raw material, could be identified as the main constraints of the project. In addition, it is assumed that individual nutritional values of raw materials are collectively available in the final product.

Project Dependencies
Quality of product will depend on quality of raw materials, as such the project success will depend on suppliers' ability to produce good quality raw material. Product quantity may vary on seasonal availability of raw materials.

RESULTS AND PROJECT SUCCESS CRITERIA

According to the statistical analysis, the food bar containing 10 g popcorn as base for the 4 g moringa leaves and 5 g bee honey was selected as the best Nutrition Bar formulation. Microbial analysis showed that the bar was safe for consumption. Therefore, the Nutrition Bar will be a popular food for different age groups; most widely recommended to school children and office workers. The proposed Nutrition Bar is a good option for people with busy life style of the modern society.

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Author:

Athma Kithmini Withanage: Agriculture Instructor attached to the District Agriculture Training Centre, Homagama, and Department of Agriculture Sri Lanka (W.P). She holds B. In. (Hons.) Agriculture from Open University of Sri Lanka
(e-Mail: *athmawithanage89@gmail.com*)

Reviewer:

Ananda Chandrasekara: Senior Lecturer of Department of Applied Nutrition, Faculty of Livestock, Fisheries and Nutrition, WUSL. His teaching and research interests include: Diet and Diseases, Diet Therapy, Sports Nutrition, Human Physiology and Biochemistry
(e-Mail: *a.chandrasekara@deakin.edu.au*)

INTRODUCING A STRUCTURED LEASING SYSTEM FOR THE FINANCIAL MARKET OF SRI LANKA

Warnakulasuriya Sajith Fairly

Sampath Bank PLC, No.86/A, Mirigama Road, Marandagahamula, 11260

INTRODUCTION

Business owners seek a variety of financing methods to survive and eventually grow their businesses through acquiring resources. One such method is to lease which is a viable alternative to bank financing and for small businesses as a flexible strategy to preserve cash. Normal lease facilities have equated monthly rentals which need to be repaid over the tenure of lease. Considering the fluctuating net cash inflows of the customers, a structured leasing system can be identified as of paramount importance in the Sri Lankan financial market. This necessity further increases with the changing needs in the leasing industry that are coupled with growing competition to secure a considerable market share.

FRAMEWORK OF THE PROPOSED SYSTEM

Step-up Payment: A step-up lease is a lease with an agreement which stipulates that the rental will be increased by predetermined amounts at various predetermined points in the future.
Step-down Payment: A lease with specified rental amount reductions at certain specific future dates. Opposite of step-up lease.
Bullet Payment: Pre-agreed large payment(s) done within the lease period other than the monthly rental.
Seasonal Payment: Pre-agreed large payments done in a seasonal pattern throughout the lease period other than the monthly rental. These inflated rental payments need to be in regular intervals.
Residual Payment: A lump sum payable other than the monthly rental paid at the end of the term is called residual payment (Table 1).

Table 1: Scheming the Framework through Examples

Method	Period	Payment
Step-up Payment	First 12 Months	Rs. 250,000
	Second 12 Months	Rs. 150,000
	Third 12 Months	Rs. 100,000
Step-down Payment	First 12 Months	Rs. 100,000
	Second 12 Months	Rs. 150,000
	Third 12 Months	Rs. 250,000
Bullet Payment	First 11 Months	Rs. 120,000
	12 Month	Rs. 950,000
	13^{th} to 35^{th} Month	Rs. 120,000
	36^{th} Month	Rs. 970,000
Seasonal Payment	Except December and April	Rs. 100,000
	December and April	Rs. 500,000
Residual Payment	1^{st} to 35^{th} Month	Rs. 125,000
	36^{th} Month	Rs. 2,100,000

Calculated based on Rs. 3.0 million lease facility for 36 months without calculating interest

Project Justification

Net cash inflows of the most Sri Lankan industries fluctuate recurrently throughout the year. The replicable evidence is the hotels with high cash inflows during January, March, May and December while the number declines during February and November. Ready-made garment industry is also another best example with high performance during December and April due to festive seasons. Customers who engage in such business are unable to cater the rentals charged on equated monthly basis throughout the year. Therefore, this study recognizes the importance of implementing a sound structured leasing system to repay the lease in confirmable manner.

PROJECT ASSUMPTIONS AND DEPENDENCIES

In terms of outstanding or portfolios held by each institution, the total amounts to Rs. 800 billion as of 31 March 2018. The contribution from licensed commercial banks and licensed specialised banks through leasing was about Rs. 300 billion and the composition through each bank is given in Figure 1. Industrial future cash inflows are predicted by considering past experience of the market and it will be changed upon unexpected market changes of the industry and to minimize such an external factor's effect to the future cash inflows, provision should be provided when calculating the repayment capacity.

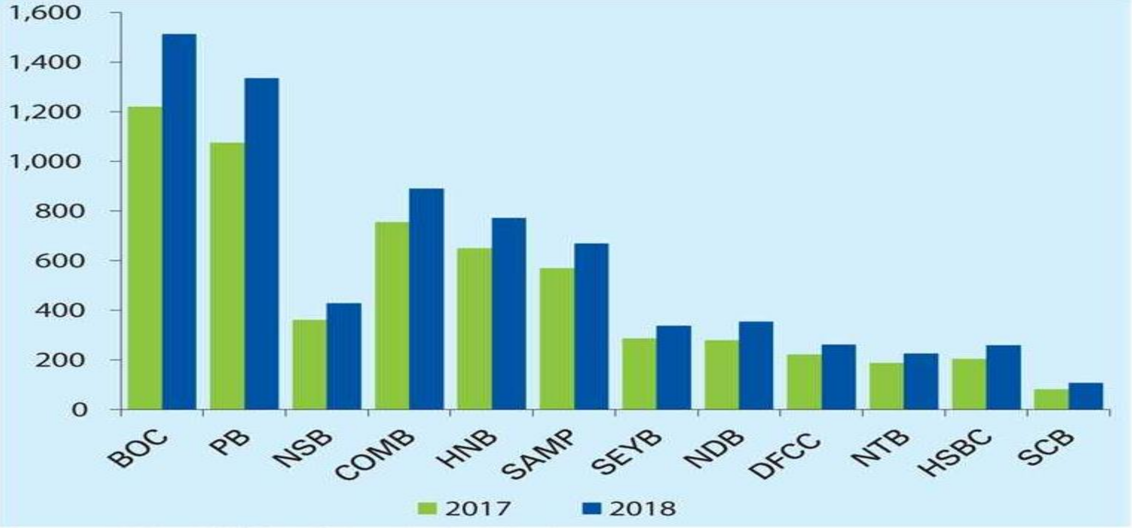

Figure 1: Composition of Gross Loans and Advances from Sri Lankan Banks (Rs. Billion)
BOC- Bank of Ceylon, PB – Peoples Bank, NSB - National Savings Bank, COMB – Commercial Bank PLC, HNB - Hatton National Bank, SAMP – Sampath Bank, SEYB – Seylan Bank, NDB – National Development Bank, DFCC – DFCC Bank, NTB – Nations Trust Bank, HSBC – HSBC Bank, SCB – Standard Chartered Bank
Source: CBSL/ KPMG-Sri Lanka Banking Report

PROJECT CONSTRAINTS AND SUCCESS CRITERIA

Government rules and regulations on some industries and the special provisions on maximum lease values and interest rates are the major constraints to be faced. Success of the leasing is the low risk nature due to absolute ownership of the security. Encompassing a structured leasing system will ensure smooth and profitable repayment and a win-win situation for both the customers and the banks.

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Author:

Warnakulasuruya Sajith Fairly: Junior Executive – Sampath Bank PLC
(e-Mail: *fairlywarnakulas@gmail.com/fairlywarnakula@gmail.com*)

Reviewer:

Sashika R. Guruge: Lecturer, Department of Agribusiness Management, FAPM, WUSL. She is reading for her PhD in Environmental Economics and holds B.Sc. (Agric.), Masters in Business Studies (Colombo), CIM, Diploma in Banking and Finance (IBSL) (e-Mail: *guruge84@yahoo.com*)

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Master of Agri-Enterprise and Technology Management, Wayamba University of Sri Lanka

RAPID PLANT MULTIPLICATION PROCESS FOR PEPPER NURSERIES

Chathura Madusanka

Tissue Culture Research Station and Central Plant Nursery, Department of Export Agriculture, Walpita, 11226

INTRODUCTION

Black pepper (*Piper nigrum*) is mainly cultivated in low and mid country wet and intermediate agro-ecological zones in Sri Lanka. Pepper nurseries managed by the Department of Export Agriculture (DEA) are located in Matale, Kandy, Kegalle, Matara, Gampaha, Nuwara Eliya, Hambanthota and Kurunegala districts. Pepper is the second largest exported spice crop looked over by the DEA, Sri Lanka.

Good nursery management practices are mandatory for obtaining healthy pepper plants and high yield. Thus, good nursery cultivation practices, such as preparation of good growth mixture, rapidly obtaining planting material and quick propagation are important for producing healthy plants (Table 1). The standard pepper growth mixture should consist of four types of materials, such as sand, coir dust, cow dung and top soil. In order to minimize the duration for obtaining planting materials, the recommendation is to obtain planting material from nearby cultivation. However, the pepper cultivation requires a rapid plant multiplication method for the production of plants during difficult times (Department of Export Agriculture, 2020).

Table 1: Pepper Plants Production in Walpita Nursery

	2016	2017	2018	2019
Pepper	110,000	100,000	90,000	100,000
Bush Pepper	6,000	5,000	4,500	5,000
Upright Pepper	2,000	2,000	2,000	3,000

Justification

Usually, pepper is propagated vegetatively using stem cuttings. Commercially, cuttings are obtained from terminal stems or ground runners. If cuttings are taken from lateral branches, bush type pepper plants can be produced. Some characteristics for a suitable mother vines are, it should be high yielding, healthy, vigorous growth, producing lateral branches with short inter-nodal distances, with long spikes, and fully completing the spikes with bold berries.

In Gampaha District, high demand for pepper plants are in *Yala* and *Maha* seasons. In order to cater this demand there is a challenge in supplying mother plant materials from January to May in Gampaha district due to the drought conditions. Therefore, this document presents the case on obtaining planting materials for pepper nursery in Walpita with special reference to rapid plant multiplication method.

IMPLEMENTATION OF THE STUDY

In Walpita nursery, there are five sheds of 18 × 60 feet size for rapid plant multiplication. There are three soil heaps in one shed. These soil heaps are used for rapid plant multiplication and are consisting of 480 pepper plants per shed. The main purpose of establishing this shed was to obtain the required cuttings when they were scarce. A soil heap is developed by making a trench with 45 cm depth, 30 cm width and of convenient length. Then, the trench is filled with growth medium; top soil, sand, cow dung and coir dust in 1:1:1:1 ratio. Soil heaps were formed at 45° angle. The height of the soil heap was 3 ft. and the width was 6 ft. Pepper plants were planted in the trench at the spacing of 9 inch × 9 inch (Figure 1). Following factors that are essential for the quick growth of a pepper vine are maintained; the heap should always be wet, watering the pepper plants daily in the absence of rain and applying the liquid fertilizer twice a month (Urea – 1 kg, Eppawala Rock Phosphate – 0.75 kg, Muriate of Potash – 0.5 kg, Kieserite – 0.25 kg mixed with 250 L of water and applied 250 mL for 1,000 pepper plants). On average, about 15 single node cuttings (8 cm) can be obtained from one black pepper plant. Then the total amount of cuttings which can be obtained at a time is 36,000 from 2,400 plants. It takes about 2 - 3 months for the cuttings to reach the top of the heap in second time whereas it is 3 - 4 months in first time (Figure 2).

The total number of cuttings (36,000 × 3) equals 108,000 annually. Cuttings are obtained from the mother heaps when the annual pepper production target is 100,000. Generally, rooting percentage of pepper cuttings in the nursery was 70 percent. Considering the rooting percentage, approximately 145,000 pepper single node cuttings were needed to reach the relevant production target (100,000). About 108,000 cuttings were obtained from the latest local varieties, “Dingirala”, “Kohukumburerala”, and “Butewerala”.

Figure 1: Rapid Plant Multiplication of Pepper through Soil Heap

Figure 2: Action Plan of the Rapid Plant Multiplication Method

Remaining 37,000 cuttings were obtained from the mother vines of "Panniyur" variety. In order to support the on-going production (Figure 2). Required growth medium items (soil, cow dung, sand and coir pith) must be supplied on time. Normally, upright pepper and bush pepper plants were not in high demand. Therefore, those plants were not produced much. From the mother heaps, cuttings were obtained from the pepper plants. Lateral branches were obtained to produce bush pepper plants, and both cuttings with lateral and vertical branches were used to produce upright pepper plants. These lateral and vertical branches were very fleshy and five-nodal cuttings should be selected. When there are no or not enough cuttings from the mother vines, it is important to get the cuttings by the rapid multiplication methods (heap method) on the correct time.

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Author:

Chathura Madusanka: Farm Manager attached to the Department of Export Agriculture, Sri Lanka. He holds B.Sc. (Plantation Management) from WUSL. He is a Fellow Member of SLIATE (e-Mail: *chakablastmax@gmail.com*)

Reviewer:

Surantha Salgadoe: Senior Lecturer, Department of Horticulture and Landscape Gardening, FAPM, WUSL. His teaching and research interests include: Crop Remote Sensing, Precision Plant Pathology and Crop Production Technology (e-Mail: *surantha@wyb.ac.lk*)

PROMOTION OF ORGANIC AGRICULTURE SECTOR IN SRI LANKA WITH ORGANIC CERTIFICATION

Pamitha Bhadrajith Karunadhipathi

Coconut Collective (Pvt) Limited, Subhasadaka Mawatha, Hokandara South, Hokandara, 10230

INTRODUCTION

It is generally understood that organic agriculture can contribute to socio-economic and ecologically sustainable development, especially in developing countries where agriculture plays a major role in their economy. The market for organic products is growing and offers opportunities to producers and exporters to improve their income and living conditions. Organic agriculture is developing rapidly worldwide and around 70 million hectares of farmlands are organic (IFOAM Organic Agriculture, 2019). As Sri Lanka is rich with full of natural resources with a high degree of biodiversity, there is a great potential to fulfil the considerable portion of the market demand for organic products in the world. Therefore, Sri Lanka has a higher possibility to supply various organic products already grown under well-balanced ecological systems for years within a shorter period of time after practicing efficient management practices adhering to the international standards (Ranaweera, 2008).

Justification

At present, Sri Lanka has a reputation in organic crop production and different varieties of organic products are being exported following international standards. Sri Lanka is considered as the pioneer in the Asian region, to introduce organically certified Ceylon tea and Cinnamon to the world market promoting organic food products. To ensure the trust in the supply chain, consumer and the exporter look for independent third party which verifies compliance to the organic regulatory requirements. This independent third party can be a certification body (CB) or a control authority (CA). CBs verify conformity against organic standards of the operators (farmers, processors) they certify. By complying with these standards, it provides the assurance and confidence to the consumer that the product was made without the use of disallowed materials for organic farming hence considered healthy to them as well as the environment. Organic certification programmes with Fair Trade requirements benefit the entire supply chain by ensuring fairness throughout the process from the farm gate.

Sri Lankan exporters are facing several difficulties in meeting the requirements of the organic export sector. The cost of compliance and the cost of certification are major cost factors farmers/exporters have to incur when applying for international organic certification. Another major constraint faced by the exporters is the insufficiency of good quality certified organic raw materials. Even though the Sri Lankan government introduced many programmes and policies to encourage farmers to adhere to organic standards, lack of monitoring and market support has shown less significant growth in the sector. Comparatively less organic farming research and development activities conducted in the country is another constraint along with the slow dissemination of already available information to the grassroots level where organic agriculture is practiced commercially. In case of residual analysis in the organic products, currently, Sri Lanka Standards Institute (SLSI) performs only a limited number of selected analytical tests while rest of the analytical tests for residual analysis are being done by overseas companies which leads to having a high cost of analysis and courier chargers increasing the cost of certification. Moreover, adaption to organic agriculture is difficult with this current market competition on artificial fertilizers. Inorganic fertilizer subsidies are given to all paddy farmers in every cropping season. Hence, farmers habitually motivate to use inorganic fertilizer for crop cultivations. There is no any large scale involvement introduced to mitigate artificial fertilizer usage and replace the nutrient requirements for the crop from organic fertilizer applications. Unavailability of the skilled workforce for organic farming practices is yet another constraint as organic agriculture only supports physical, biological and cultural practices in the farms which require a more skilled workforce compared to chemical methods. The younger generation is not interested in farming without modern technology where existing policies and benefits are not attractive enough to retain them in organic farming activities. By giving a reputation for farming along with stable income generation could be important to attract a skilled workforce for organic farming practices.

Project Constraints and Assumptions

Farmers who usually do not have a steady income are risk averse and they rely heavily on agrochemicals to protect their crop and increase the yields to secure a good return to their investment. The inertia is greater with farmers who are reluctant to change their conventional method of farming to organic farming.

In order to be successful with this project, certain assumptions are made as; with the current health concerns associated with conventional agriculture, both farmers and consumers will look for healthier alternatives for farming and consumption, respectively, the voice of environmental activists and pressure groups are considered by the developed nations to mitigate climate change, by encouraging and subsidising environmentally friendly approaches, Agriculture based businesses will perform more than other income sectors while concerning the food demand pattern of the global community.

Project Dependencies

As organic labelling requires an international certification for local organic products, the cost of international inspection accounts for extra overhead cost to the cost of production (COP) (Ranaweera, 2008). Therefore, the direct involvement of government is required to minimize COP and to establish a well-streamlined certification process in order to gain the recognition and equivalent status for local certification or to enter into the Third Country Registry enabling local inspection bodies to certify products as organic which will be accepted by any international community.

STRATEGY FOR PROMOTING ORGANIC AGRICULTURE WITH ORGANIC CERTIFICATION

The strategy for the promotion of organic farming needs to identify the potential areas and suitable crops, development of suitable organic farming systems and introduction of suitable practices for different agro-climatic farming systems. There should be region-specific crops and practices particularly in rain-fed areas. Also, significant attention should be given to introduce recent developments in farming technology such as efficient use of crop residue, recycling of residue of dual-purpose legumes, use of biomass of some of non-conventional shrubs and trees, biogas slurry and vermicompost nutrient supply and use of traditional cultivars, bio-agents and predators in pest and disease control.

In order to meet the standards of organic certification, there should be a proper mechanism to perform farming practices adhering to the given standards of organic certification. In view of this, farmer-focused awareness sessions can be organized by identifying clusters that have homogeneity in their farming activities (*i.e.* similar crops, similar resource use and market facilities already available). With this approach it is easy to address common problems and provide solutions with already available resources. Hence, farmers will be less resistant to change their current practices as the information provided to them are more focused towards them and the benefits are more visible. In addition, it is important to perform a market-driven approach to identify products with high demand and increase research and development to address common problems faced by farmers already involved in the production of these products focusing on the organic need of the market. Also it is expected to have significant involvement of the government to increase the efficiency of meeting the supply requirement by adopting new policies for technology development and communication of the available information to the sectors involved in the production. In view of organic certification, with the direct involvement of the government, several activities could be implemented such as setting up local certification procedures under third country registry, policy-making and implementation, registration of Inspection Bodies, registration of exporters and local parties involved in organic sales, issuance of the renewable permit for local sales, penalizing fraudulent sellers, introducing a common seal for certified organic products in Sri Lanka, rendering assistance from media to promote organic export, setting up of Internal Control System for local inspection, registering all training institutes and setting up organic export villages (Ranaweera, 2008). These approaches could be important to safeguard the interest of exporters and farmers/producers in the organic sector and to be competitive in the global organic trade.

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Author:

Pamitha Bhadrajith Karunadhipathi: Operations Manager attached to the Coconut Collective (Pvt) Ltd. He holds B.Sc. (Plantation Management) from WUSL (e-Mail: *kmpamitha@gmail.com*)

Reviewer:

Radhika Gimhani: Senior Lecturer, Department of Biotechnology, FAPM, WUSL. Her teaching and research interests include: Plant Biotechnology, Molecular Plant Breeding and Gene Mapping (e-Mail: *dgimhani@wyb.ac.lk*)

IMPACT OF WELFARE ACTIVITIES ON PLANTATION WORKERS' TURNOVER IN NUWARA ELIYA REGION

Aruna Indika Agalawatte

Meddecombra Estate, Wattagoda, 20134

INTRODUCTION

The objective of this study is to analyze the impact of welfare activities on Estate Sector workers' turnover in plantation sector in the Nuwara Eliya region. Tea plantation industry annually contributes to the country's economy by four billion rupees and employs approximately 23,000 direct workers and one million indirect workers. Therefore, plantation industry plays a significant role in the Sri Lankan economy.

Project Justification

Today in a competitive business world, it is considered to be an important task to manage employee turnover for any organization in order to keep it at the expectable level. Naturally, people need diversity for their everyday life and seek for new and challenging job opportunities. Providing these conditions to employees in an economical way is difficult and time consuming. Nevertheless, it is crucial for any organization to retain its talented employees while maintaining high productivity.

Project Constraints

Managing employee turnover successfully is a must to achieve the above goals. In Sri Lanka it is highly important to manage employee turnover in the plantation sector. Although some fringed benefits, salary and other benefits are given to the employees, they are not satisfied sufficiently as they have less job security.

Project Assumptions

Plantation workers are not satisfied with wages and other welfare benefits that are given by the employers. Therefore, identification of the actual reasons is very important to enhance employee retention. Basically the wage rate of the plantation sector worker is Rs. 850 per day and their monthly income is approximately Rs. 24,000. The purpose of this study is to discern whether welfare activities can make a direct influence on employee turnover (Agalawatte, 2012).

PROJECT IMPLEMENTATION

Today's competitive business world has considered that managing employee turnover is an important task in any organization. There are several factors influencing the employees to leave their jobs. It could be volunteer turnover where they choose to leave because of better career opportunities, interesting compensations and broadening of the current tasks. Voluntary turnover occurs when employees are asked to leave for a reasons including poor performances or inappropriate behaviour. Employee attendance and job performance are the indicators to understand employee turnover. When a company replaces a worker, it will directly or indirectly affect the expenses of the company. Turnover rate also varies from manufacturing to service sector. To identify the turnover, 400 employees were selected randomly from tea plantations in Nuwara Eliya district. Data were collected using a structured questionnaire.

RECOMMENDATIONS

Up country plantation workers are expecting welfare facilities and at the same time expecting more income from the plantation companies. According to the questionnaire survey, it was found that they are expecting daily wages as high as Rs. 1500. To satisfy their expectations, it is recommended to introduce a monthly salary system with a fixed basic salary and also salary increment for workers. It is also suggested to improve the tea productivity using modern technologies and offer additional (overtime) work system.

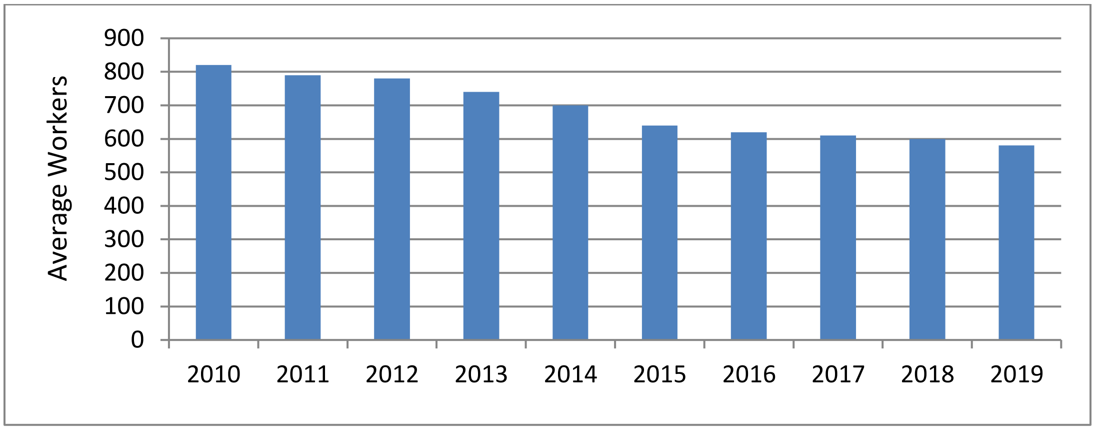

Figure 1: Average Workers in Last 10 Years
Source: Plantation Human Development Trust, 2019

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Author:

Aruna Indika Agalawatte: Deputy Manager, Meddecombra Estate. He has 16 years of experience in plantation sector. He holds B.Sc. (Plantation Management) Degree from WUSL and reading for MBA (e-Mail: *agalawatteaib@gmail.com)*

Reviewer:

Kusum Wijesinghe: Senior Lecturer, Department of Agribusiness Management, FAPM, WUSL. Her teaching and research interests include: Organizational Management and Human Resource Management (e-Mail: *kusum_wijesinghe06@yahoo.com*)

CONCRETE BED NURSERIES FOR PRODUCTION OF COCONUT SEEDLINGS

Lalith Indika Gunawardhana

Bopitiya Coconut Model Garden, Coconut Cultivation Board, Bopitiya (NWP), 60155

INTRODUCTION

Coconut (*Cocos nucifera)* is commonly referred to as the "Tree of Life" which provides livelihood to billions of people across the world. Coconut is one of the major plantation crops in Sri Lanka. The cultivated extent of coconut in Sri Lanka is about 455,000 ha with an annual production of 2,623 million nuts (Central Bank Annual Report, 2018). It is grown in different types of soils with diverse moisture and nutrient regimes in different agro-climatic zones. The annual national production of coconuts varies between 2,300 – 3,000 million nuts. Nearly 70 percent of the total coconut production is being consumed domestically, with a per capita consumption of about 85 nuts/year while the balance is used for industries and export (Senarathne *et al*., 2012).

Constraints in Conventional Type Commercial Coconut Nurseries

Rehabilitation of coconut plantations with quality seedlings needs to be promoted to maintain a proper plantations with profitable yields. Therefore, high quality coconut seedlings must be used as it helps to establish healthy and uniform plantations. Thus, nursery management techniques play an important role in producing high quality planting materials which will ultimately result in an enhanced yield. Standardized nursery techniques help in producing large quantities of quality seedlings at a relatively low cost. However, conventional coconut nurseries (Figure 1) may produce seedlings with poor vigour, which will negatively affect the future yield of plantations. Further, low germination percentage and high mortality rate are the major issues in many conventional nurseries. Less developed root system is one of the main reasons for high mortality rate in coconut seedlings (Senarathne *et al*., 2012). Moreover, conventional commercial nurseries are highly dependent on the water requirement. Prevalence of water shortage across the country has exacerbated the issues of conventional nurseries up to a considerable extent.

Figure 1: A Conventional Coconut Nursery

INTRODUCING CONCRETE BEDS FOR COMMERCIAL COCONUT NURSERIES

Concrete bed nursery method (Figure 2) has been introduced for coconut seedling production in commercial nurseries of the Coconut Cultivation Board (CCB) and private nurseries in Sri Lanka. Concrete bed nurseries have shown numerous fringe advantages over conventional coconut nurseries (Weragoda, 2018). The concrete nursery beds have also demonstrated relatively high water use efficiencies.

Figure 2: Concrete Beds Prepared for Coconut Nursery
Source: Weragoda, 2018

The germination percentage, seedling sprouting percentage, number of rejected seedlings and the percentage of issued seedlings have been compared in the two nursery bed types at Korosduwa and Kandetiya coconut nurseries using a total of 1,000 nuts (Weragoda, 2018).

Table 1: Comparison of Conventional *Vs.* Concrete Bed Nurseries on Producing Coconut Seedlings at Korosduwa and Kandetiya Coconut Nurseries for Laying a Total Number of 1,000 Nuts

Location	Type of Nursery	Number of Coconuts Germinated	Sprouting Percentage (%)	Number of Rejections	Issuing Percentage of Seedlings (%)
Korosduwa	Conventional	932	93.2	98	83.4
	Concrete	935	93.5	22	91.3
Kandetiya	Conventional	906	90.6	115	79.1
	Concrete	946	94.6	29	91.7

Source: Weragoda, 2018

According to previous research, concrete bed nurseries resulted in high sprouting percentage, issuing percentage and high vigour of seedlings compared to conventional bed-raised nursery seedlings (Table 1; Weragoda, 2018). It indicates that, the concrete bed nursery condition was more favourable for the development of coconut seedlings over the conditions of conventional nurseries. Therefore, concrete bed nurseries could be adopted to produce coconut seedlings for the development of sustainable coconut plantations.

Establishment of Concrete Bed Coconut Nurseries

As the initial step, the CCB, in collaboration with Coconut Research Institute (CRI), planned to establish concrete bed nurseries in selected commercial nurseries at Kandetiya, Korosduwa, Ibbagamuwa and Embilipitiya. The project is planned to start by mid-2020.

Constraints for Developing Concrete Bed Nurseries

High initial cost and requirement of skillful technicians have been identified as the main constraints in the process of developing concrete bed nurseries in Sri Lanka. Further, considerable amounts of additional costs incur on coir dust for moisture conservation and on chemicals for termite control.

STRATEGIES FOR PROMOTING CONCRETE BED NURSERIES

The CCB and CRI have taken measures to disseminate knowledge among coconut growers on concrete bed nurseries through awareness programmes. CCB and CRI are also giving financial support for the private coconut nursery owners to develop concrete nursery beds. Further, there is an urgent need to formulate necessary nursery guidelines and methods relevant to concrete coconut bed nurseries.

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Author:

Lalith Indika Gunawardhana: Manager, Bopitiya Coconut Model Garden, Coconut Cultivation Board, Bopitiya (NWP). He holds B.Sc. (Plantation Management) from WUSL
(e-Mail: *indikagunawardana80@gmail.com*)

Reviewer:

Kamani Ratnayake: Senior Lecturer, Department of Horticulture & Landscape Gardening, FAPM, WUSL. Her teaching and research interests include: Postharvest Physiology & Technology and Horticultural Science (e-Mail: *kamani.ratnayake@uqconnect.edu.au/kamani@wyb.ac.lk*)