Agroforestry on tea and coconut plantations in Sri Lanka

Guidelines for design and implementation of agroforestry, based on lessons obtained in two pilot projects



Netherlands Enterprise Agency

WAGENINGEN UNIVERSITY & RESEARCH

IUCN

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Glossary

AERs	AgroEcological Regions
AF	AgroForestry
APMG	Association for Project Management Group
BCR	Benefit-Cost Ratio
CCB	Climate, Community & Biodiversity
CDM	Clean Development Mechanism
CO_2	Carbon dioxide
CRI	Coconut Research Institute
CSR	Corporate Social Responsibility
DEA	Department of Export Agriculture
DOA	Department Of Agriculture
EAC	Export Agricultural Crops
ETS	Emissions Trading System
FGTC	Forest Garden Trainer Certification
GAP	Good Agricultural Practices
GHG	GreenHouse Gas
GPS	Global Positioning System
Ha	Hectares
HR	Human Resources
HRM	Human Resources Management
IPM	Integrated Pest Management
IRR	Internal Rate of Return
IUCN	International Union for Conservation of Nature
KSA	Knowledge, Skills and Attitude
KPL	Kurunegala Plantations Limited
KVPL	Kelani Valley Plantations PLC
NPV	Net Present Value
NRMC	Natural Resources Management Centre
PAC	Project Advisory Committee
PMC	Product-Market Combination
PPE	Personal Protection Equipment
ROC	Regenerative Organic Certification
ROI	Return Of Investment
RVO	Netherlands Enterprise Agency
SDG	Sustainable Development Goal
SOC	Soil Organic Carbon
SWOT	Strengths, Weaknesses, Opportunities, Threats
TRI	Tea Research Institute
USDA	United States Department of Agriculture
UoP	University of Peradeniya
VCS	Verified Carbon Standard
WM1a	Wet Zone MID Country
WU1	Wet Zone Up Country
WUR	Wageningen University & Research

Introduction

The tea and coconut industries are of critical importance for the national economy and rural livelihoods in Sri Lanka. Additionally, these fields cover highly sensitive landscapes in the country in connection with natural ecosystems, biodiversity, watersheds, soil and water conservation. The country has a substantial area of monoculture tea and coconut plantations. Over time, a strong focus on maximizing yields and a simplification of the plantation production systems have created a high dependence on agrochemicals. Nowadays, many plantations face serious challenges in terms of land degradation, aging of the plantations, climate change impacts, price volatility, labour shortages and increasing production costs hence less attention to replanting and soil rehabilitation and improvements. These issues have resulted in declining productivity, reduced market competitiveness and limited capacity to adapt to international quality and sustainability standards.

Low productive tea and coconut lands are being diversified with miscellaneous crops and livestock to ensure increased land use efficiencies and conserving the resources. Diversification of the plantations using agroforestry is seen as a promising strategy to regenerate the productivity and enhance the viability of the plantations, while generating benefits for the environment and rural populations. However, transformation of (degraded) plantations into productive and economically profitable agroecosystems is not straightforward. Agroforestry models require adaptation to the specific agroclimatic and social context and may also require new market linkages and alternative business models demanding right partnerships among various stakeholders.

Therefore, the Government of The Netherlands, through its Netherlands Enterprise Agency, with the active support of the Embassy of the Kingdom of the Netherlands in Colombo, initiated the project “Agroforestry on tea and coconut plantations in Sri Lanka”. The organizations implementing the project were the Netherlands Enterprise Agency (RVO), International Union for Conservation of Nature Sri Lanka (IUCN), the University of Peradeniya (UoP), and Wageningen University & Research (WUR). The project aimed to enhance the environmental as well as socio-economic sustainability of the production systems at one degraded tea plantation and one degraded coconut plantation. To ensure long-term impact, the project developed these guidelines and provided the basis for the creation of an agroforestry network that brings together actors from policy, practice and research to ensure further development and upscaling of agroforestry in Sri Lanka.

Practical examples or guidelines for the transformation of tea and coconut plantations to agroforestry models that integrate ecological, economic and social aspects are not yet available in Sri Lanka. Therefore, this report presents a theoretical framework of agroforestry systems and translates theory into practice considering the specific context of tea and coconut plantations in Sri Lanka, building on the lessons learned during the pilot project. This document contains 3 chapters that are organized as follows: Chapter 1 describes the reasons for implementing agroforestry, the main principles of agroforestry, planning, co-creation and design, building necessary partnerships for implementation and adaptation, and finally monitoring and evaluation. Chapter 2 provides information on relevant policies, laws and regulations, both national and international, including land tenure issues in Sri Lanka. Finally, Chapter 3 looks into the future of agroforestry in Sri Lanka by describing the current research gaps and the need for collaboration between policy, practice and research to further stimulate the development, visualization and adaptation of agroforestry systems in the country.

This guide builds on existing knowledge and experiences present among plantations and seeks to further stimulate and improve agroforestry systems in Sri Lanka in order to support a transition to a more diverse, nature-inclusive, and climate change-resilient form of agriculture.

1. Agroforestry in theory and practice

This chapter provides guidelines for plantations in Sri Lanka that want to start implementing or upscaling agroforestry. It is not a step-by-step description, as no recipe exists for agroforestry systems and adaptation to the local situation is always needed. Rather, this document presents a set of guidelines based on theory and the lessons learned during the "Agroforestry on tea and coconut plantations in Sri Lanka" project. The theoretical framework and the various elements required for the design of an agroforestry system are described on the left side of the pages of this report; the practical aspects of agroforestry implementation are described on the right side of the pages.



Picture 1: Aerial view of Halgolla agroforestry pilot plot

1.1 Why promote agroforestry in tea and coconut plantations?

THEORY **PRACTICE**

Agroforestry is a production system that combines trees with crops, livestock or both, on the same land. Trees are commonly used on farms in other ways as well, including woodlots, fruit trees planted next to a homestead, riparian buffer strips and patches of natural forest. Some authors consider these and other uses of trees on farms to be part of a wider "landscape" concept of agroforestry (Pulleman et al 2023). Agroforestry has the potential to overcome several adverse consequences of input-intensive monoculture production systems, such as loss of biodiversity, degradation of natural resources, high nutrient losses, greenhouse gas emissions, and decline in soil health.

The loss of biodiversity poses a significant threat to ecosystems at local, regional and global scales, particularly under the pressures of high population growth and increasing food demands. Agroforestry counters these threats by enriching biodiversity through diverse habitats that provide crucial breeding, nesting, and resting areas for various species. The integration of diverse plant species, including native flora, ensures a richer biodiversity compared to traditional monoculture systems. Agroforestry systems can also serve as an ecological buffer or green corridor supporting the survival of wildlife in natural forest remnants. This agricultural method not only supports various wildlife but also ecosystem services that depend on those species, including natural pest control and pollination.

Agroforestry also has other environmental benefits such as reduced soil erosion and water retention. In terms of soil health, the strategic use of trees, shrubs and understory companion crops in agroforestry systems plays a critical role in enhancing soil fertility and structure while preventing soil erosion and nutrient removal (runoff and seepage). A vegetation structure composed of species with different rooting depths helps stabilize the soil and pump leached elements back to the surface layers and inclusion of legume cover crops and trees helps to fix "free' nitrogen from the atmosphere and cycle nutrients through decomposing litter and prunings.

Trees help improve the microclimate in the understory, buffering (extreme) temperature fluctuations, regulating humidity and mitigating water stress. Moderate levels of shade, carefully adapted to the local climatic conditions and intensity of solar radiation, can thus enhance plant health and productive capacity of understory plants. Agroforestry also significantly contributes to rain water harvesting, water management by improving groundwater recharge and reducing surface runoff. The root systems of trees and shrubs increase soil permeability, promoting effective water infiltration.

Sri Lanka is the third largest tea producer and the fourth largest coconut producer in the world. Tea and coconut plantations are managed as small, medium and large categories under different crop management systems. The tea and coconut sectors are of critical importance for the national economy and rural livelihoods. However, the sectors and their sustainability are at risk as a substantial part of the large-scale and aged monoculture tea and coconut plantations are degraded.

Diversification of the plantations using an agroforestry approach is seen as a promising strategy to improve or increase the productivity and viability of the plantations, while generating benefits to the environment and rural people. Therefore this project focused on a degraded tea and coconut plantation.

Although agroforestry is not a new concept to Sri Lanka, establishment of agroforestry models requires adaptation to the specific agroclimatic and social context, and requires new market linkages and alternative business models for agroforestry products and services that integrate agroecological, social, and economic aspects as shown in Figure 1.

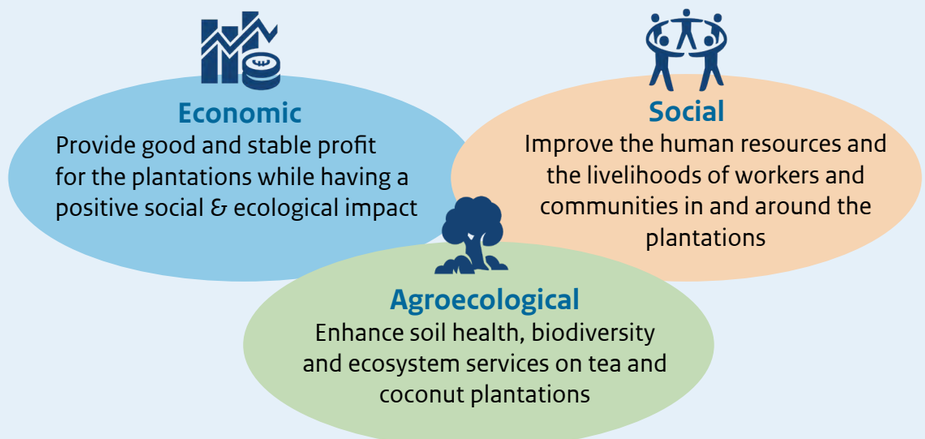


Figure 1. The three main pillars of an integrated agroforestry model that are central to our piloting project

The more buffered microclimate conditions and the diversity of crops and wild species within these systems can provide resilience against climate extremes and variability, including high temperature, drought and (partial) crop failures through averse climate conditions or pest or disease problems. Regarding climate action, agroforestry can also effectively sequester carbon dioxide, thus helping reduce net greenhouse gas emissions and significantly improve micro climatic environments and eco system services.

Economically, agroforestry systems can enhance food and income security by integrating various crop types with different harvesting times, allowing for a continuous and more stable supply. This integration optimizes land and resource use, boosting productivity and sustainability. Furthermore, it offers plantations diversified income streams through the production of fruits, nuts, timber, and fodder, providing a financial cushion against market fluctuations provided there is a market for the products.

Finally, living conditions for livestock are also improved in agroforestry systems by providing shade and shelter, reducing heat stress, feed availability (pasture, fodder, concentrates), and improving overall health and productivity. For humans, the presence of trees reduces air pollutants and provides cooler working conditions, which are more conducive to worker welfare.

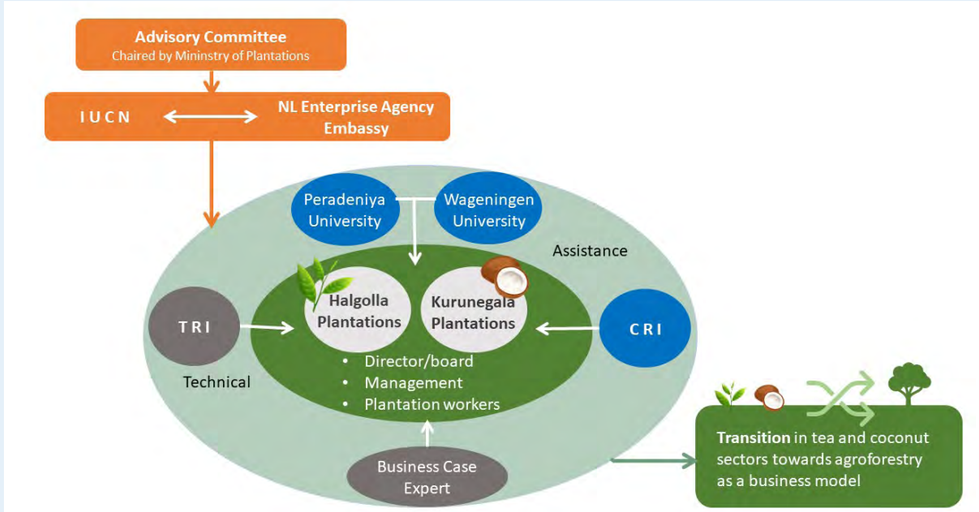


Figure 3: Project setup and stakeholder engagement in building partnerships

1.2 Main principles of agroforestry; agroecological, social and economic

THEORY **PRACTICE**

Agroforestry systems are often considered part of popular sustainable agriculture management concepts like Agroecology or Regenerative Agriculture. Agroforestry is thus set up to provide multiple environmental, social and economic benefits. Being a holistic approach, it considers the integration of components into a complex system rather than just individual components.

Many different agroforestry models exist, depending on the crop type and the producer's objectives and preferences with regard to the specific climatic, ecological and social context and market opportunities. Different models vary in structure, species diversity and composition, and thus in complexity and the different services and products they provide. More detailed explanations and classifications can be found in the inspirational document. Examples of simple and more complex agroforestry systems with either tea (a shade-tolerant shrub) or coconut (a palm tree that leaves sufficient light and space for other crops to grow beneath it) are shown in Figure 2.

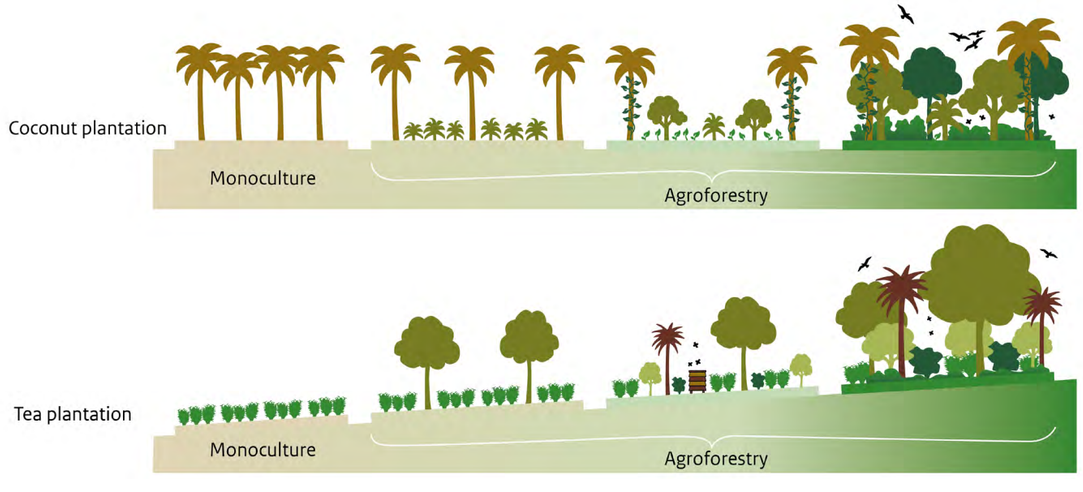


Figure 2: Simple and complex agroforestry systems

The agroforestry systems in this project integrate and carefully align the three main pillars that are critical to successful agroforestry models: the agroecological, the social, and the economic pillars (Figure 1). The project builds on principles of co-creation and adaptation to the specific farming objectives of plantations and the perception of the plantation managers on various components of the agricultural system such as crops, trees and domestic animal species in their prevailing context (e.g. agroclimatic and topographic conditions, markets, policies, infrastructure, technological support, available natural and financial resources and human capital). The agroforestry models were implemented over a time period of three years (the duration of the project), but with a view on long-term impacts and opportunities for upscaling.

To further optimize knowledge integration, the project collaborated with relevant Sri Lankan institutions such as the Ministry of Plantation and Industries, the Tea Research Institute (TRI) and Coconut Research Institute (CRI) alongside UoP. Additionally, WUR worked together with Sri Lankan entities and provided technical support. Part of the project structure was the Project Advisory Committee (PAC), in charge of advising the project partners. Its members were stakeholders from the private and public sectors, and knowledge institutes. The project was funded by the Government of The Netherlands with IUCN Sri Lanka acting as the local coordinating partner (Figure 3, above).

The development and scaling agroforestry interventions requires strong involvement of stakeholders at local and (inter)national level. A participatory approach with active engagement of public and private sector, is essential to achieve positive agroecology, social and economic outcomes and strengthen possibilities to replicate. Important stakeholders in the project were the three positions at the plantations, estate manager, field officer and worker.

1.3 Planning and design

THEORY PRACTICE

Adoption of agroforestry requires long-term planning and investment. Therefore, this phase is very important. Key elements for agroforestry system design are a good understanding of the context (including agroecological conditions, as well as management intensity in terms of input use and mechanisation), clear objectives in terms of agroecological, social and economic benefits and access to the necessary resources.

In terms of agroecological aspects, the interactions between the different woody and non-woody plant species that make up an agroforestry system affecting the availability of resources are key, including space, light, nutrients and water. Agroforestry also affects other aspects of production, such as pests and diseases, natural enemies of pests and pollination. Those interactions can have positive effects (facilitation) or negative effects (competition) on the production of the different species in the system.

Producers are often concerned that shade trees negatively affect the growth of crops growing beneath the canopy. However, even though the potential productivity of crop species may be reduced due to light competition in agroforestry, actual yields obtained may be limited by factors other than light availability, such as water stress, temperature extremes, pests incidence, pollination or nutrient availability. In conditions where agroforestry contributes to alleviating those limiting factors, it can improve productivity. Second, even if crop yields are reduced in agroforestry systems, the total economic and agroecological benefits often outweigh those of monocropping, provided that the right species combinations are selected and the shade density is managed carefully depending on local climate conditions.

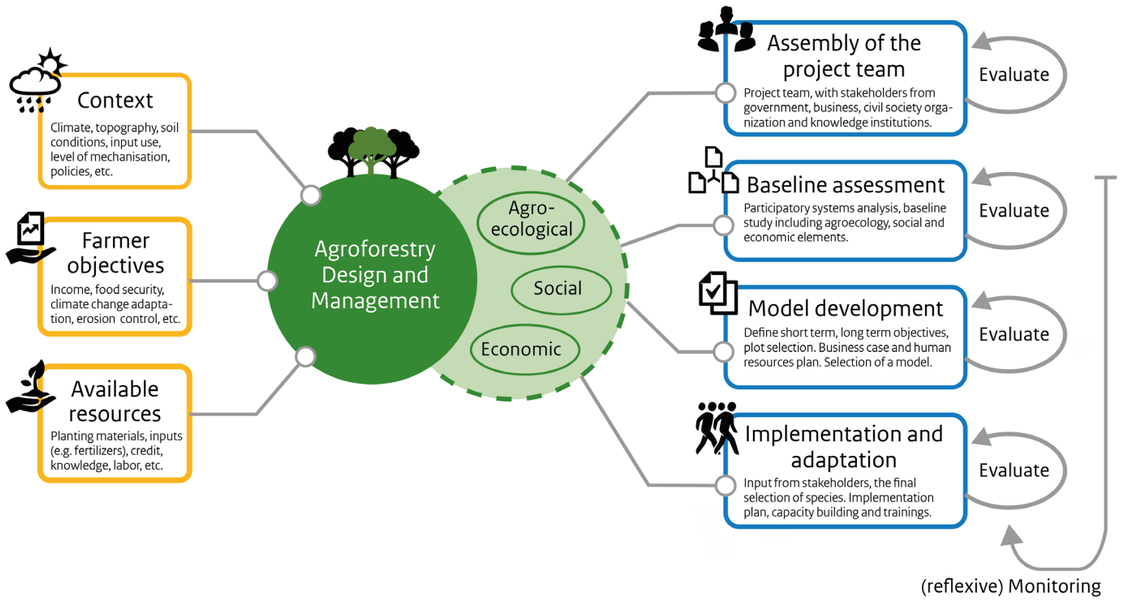


Figure 4: Left - schematic representation of factors and design steps to be considered in the design and implementation of agroforestry systems (Pulleman et al., 2023). Right - the phases of the agroforestry project.

The project consisted of six phases: 1) assembly of the project team; 2) selection of the plantations and involvement of stakeholders (Figure 3 The project setup); 3) baseline assessment; 4) model development and co-creation; 5) practical implementation and adaptation; 6) monitoring, evaluation and reflexive learning (Figure 4).

Phase 1 included the participatory systems and actor analysis, which had the goal of scoping the coconut and tea system in which we are intervening and of identifying the persistent problems and leverage points within this system. Phase 2, the selection of pilot plantations, was based on the following elements: status and ownership, knowledge level, vision, motivation (see Textboxes), representativeness and willingness to invest. Both plantations signed a letter of Intent.

"The main reason for participating in this project is to get better yields and increase effective acreage. Coconut is only 30% of land cover; intercropping allows for higher production per unit of land and creates a better microclimate for coconut trees."
Dr Sam Samarakoon – Managing Director, Kurunegela Plantations Ltd.

"We are the most ethical, responsible and sustainable certified private plantation company in the country and this system will add value to our existing plantation landscape by letting different biological systems cooperate and flourish. This can lead to a rise in productivity, as trees and plants find ways to interact and support each other symbiotically. This will be a definite plus point for us to transform conventional plantation management to a regenerative agribusiness model and to be more competitive in future plantation business operations."
General Manager Corporate Sustainability, Kelani Valley Plantations PLC

Part of Phase 3 was creating a good understanding of the context. Much effort was devoted to conducting the baseline study of each plantation, including agroecological, social and economic indicators. For each plantation a Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis was conducted. The insights obtained were used to guide the interventions on the plantations and also served as a baseline for monitoring progress and impact. The objectives for the pilot plantations were set for the short-medium and long term.

Input was collected from the various stakeholders, with a focus on the selection of species, their varieties and knowledge levels of various stakeholder categories on agroforestry and the management of plants, soil and the environment. More precisely, the tea, coconut, business case and agroforestry experts had discussions with the plantation owners to develop a vision for the pilot for each plantation and a list of selected species for the pilot plots. Expanding upon the latter, the group of experts also gathered input from the Coconut Research Institute (CRI), the Tea Research Institute (TRI) and other coconut and tea producers. Based on this, a production system plan, a business case and a human resources plan were developed for each plantation (Phase 4).

In Phase 5, the implementation of the agroforestry model, co-created by the project team based on the input of key stakeholders, was finalised for each plantation. Both models were validated with various stakeholders and, based on these models, practical plans were made to guide the implementation. The expert team provided the plantations with advice and trainings. The training sessions were conducted on the basis of the needs identified during the baseline assessment. The agroforestry model was continuously adjusted and improved throughout the implementation, so it was not set in stone after writing the implementation plan. This is visualised in Figure 4.

Monitoring and evaluation during the project was an important part of the learning process and resulted in adjustments during Phases 4 and 5.

Introduction to pilot plantations

Kurunegala Plantations Limited (KPL)

Kurunegala Plantations Limited, established in 1992, is a fully government-owned plantation operating under the supervision of the Ministry of Plantation and Community infrastructure in Sri Lanka.

KPL's primary business activities involve cultivating, producing, processing and selling coconut, rubber and other ancillary crops. The company oversees seven estates spread across different agroclimatic zones in four districts of Kurunegala, Gampaha, Anuradhapura and Matale, with a total landholding exceeding 4,950 hectares, of which 3,637 hectares are dedicated to coconut cultivation.



Picture 2: Pilot plot Muruthenge estate with pineapple

Within the premises, a coconut plantation is managed on different levels; an average and a marginal coconut monoculture and underplantation, a functional copra production area, a water tank, a roadside plantation of jackfruit and a perennial well are included.

In close proximity, there is an untouched forest of 30 ha of which 5.1 ha is owned by KPL. In other areas of Kurunegala Plantation, intercropping and agroforestry practices have already been successfully and profitably conducted (Samarakoon et al., 2023).. There, coconut is combined with fruit trees such as mango, cashew, rambutan, dragon fruit, jackfruit, durian and annona, and with spices such as pepper, cinnamon, cloves, ginger and turmeric, and betel as a masticatory crop.

At the start of this project, this plantation had not been properly managed for over five years. Irrigation was not being practised. Weed management was limited due to lack of labour and suitable chemicals. Furthermore, there was a lack of quality fertilisers. Major pest problems of red weevil (Rhynchophorus ferrugineus), black weevil (Oryctes rhinoceros) and mite (Aceriaguerreronis) had been reported. Control of mite problems had been moderately effective using a biological control agent. No serious diseases had been reported at Muruthenge Estate.

Wild boar, porcupine, wild rat, squirrels, grey squirrels and monkeys caused problems, especially for the establishment of coconut and crops and their fruit yield.

Factors such as extreme weather conditions, drought, soil fertility status and poor management over the past several years (including failure to remove unproductive palms and infilling, insufficient land and nutrient management, poor weed, pest and disease control and soil conservation measures, and problems of wild animals) have had a significant impact on the productivity of Muruthenge. Fluctuating market prices for coconut products have also posed a challenge.

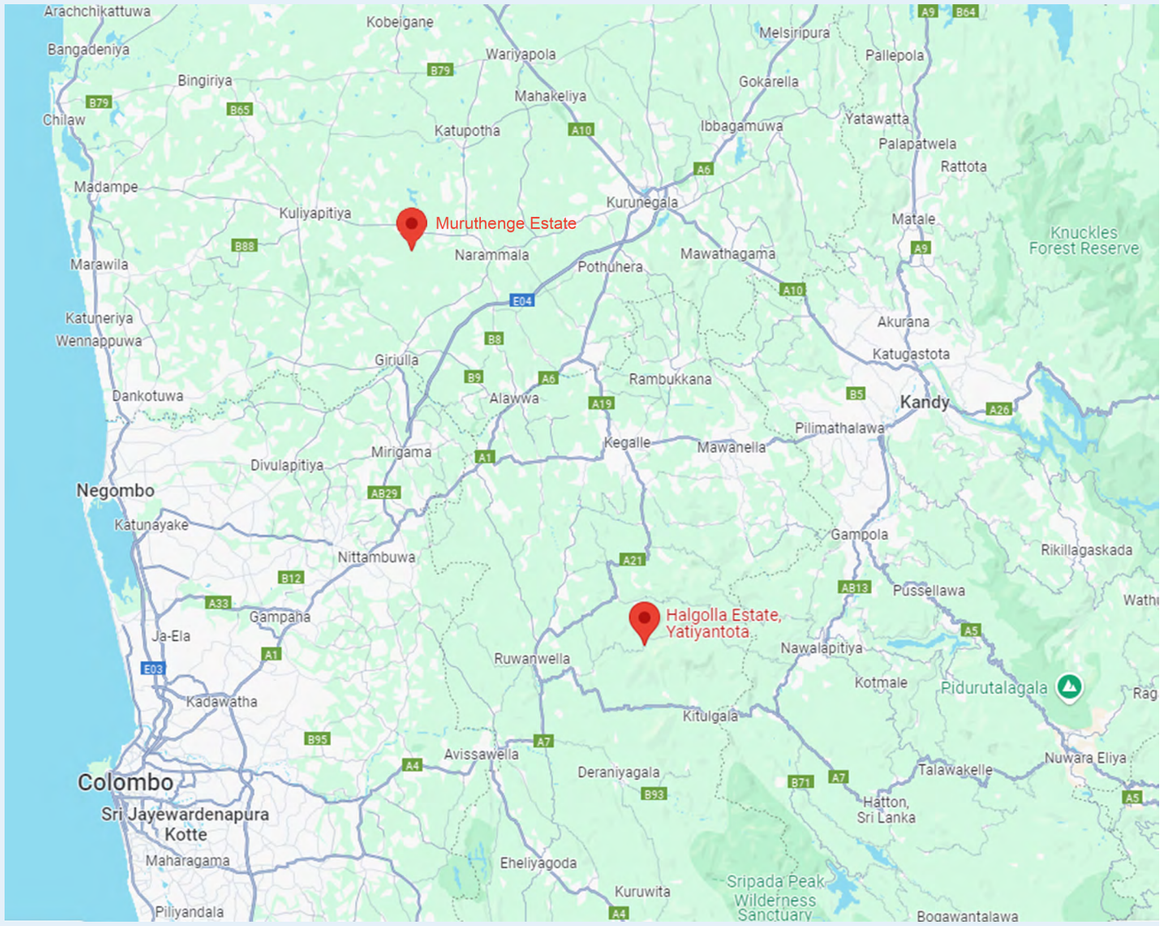


Figure 5: Location of the two pilot plots in Sri Lanka

Introduction to pilot plantations

Kelani Valley Plantations PLC (KVPL)



Picture 3: Pilot plot Halgolla estate after planting coffee plant

Kelani Valley Plantations PLC was established in the late 1920s as a coffee plantation during the British colonial era. Over time, it underwent a transformation into a diverse plantation cultivating tea, rubber and cardamom. In 1972, all privately owned tea, rubber and coconut plantations were nationalised. Currently, the estate is overseen by Kelani Valley Plantation PLC (KVPL).

The total area of the Halgolla Estate is 1,196 ha, of which 403 ha is used for cultivation including tea plantations, areas with rubber plantations, cardamom and naturally regenerating coffee in abandoned tea plantations. The remaining 634 hectares consist of primary and secondary forests hosting a large biodiversity. Tea is predominantly cultivated on the western and southern slopes of the mountain range. At the western edge of the estate, there is a steep precipice that offers a panoramic view resembling the renowned World's End point in Horton Plains National Park and hence referred to as the "Small World's End".

The Kelani river, which comprises numerous tributaries, includes the Wee Oya, a left-bank tributary that flows through the Halgolla and Wee Oya estates. The Olu Ela and Ketagal Oya rivers, flowing through the Halgolla estate, contribute to the watershed of the Wee Oya. The estate is surrounded by notable natural features, including the Olu Ella waterfall, a bat cave and marshes in the Wewalthalava basin.

The cultivation system in the Halgolla primarily consists of tea with scattered shade trees. Common "high shade" species are Grevillea robusta and Albizia moluccana.
"Medium shade" species include Calliandra calothrysus or Dadap (Erythrina spp.). Within the estate, certain areas at higher elevations, specifically the Wewelthalawa Division, are well managed. However, there are degraded and abandoned areas where natural regeneration of coffee and other species has occurred. Several challenges have been identified regarding the management of tea plantations in the Halgolla estate. These challenges include the lack of necessary inputs such as fertiliser and agrochemicals over the past few years, soil erosion and, in some areas, landslides, soil acidification and climate change. These issues pose obstacles to achieving sustainable practices within the tea plantations of the Halgolla estate.

The current management of Halgolla ensures that correct plucking intervals, weeding and nutrient management practices are followed based on the recommendations of the TRI of Sri Lanka. However, there are some areas of concern. Regular pruning and adequate shade management have not been consistently carried out. Several areas of the plantation are either overshaded or undershaded. Although the estate primarily grows tea in shaded monocultures, recently a small portion of tea lands has been diversified through intercropping with coffee. Most of the tea bushes in the proposed degraded site are aged between 60 and 80 years, resulting in low yields. The conversion to VP (vegetatively propagated) teas is necessary but involves a complex and resource-intensive process.
Halgolla, situated at an altitude of over 610 meters, is particularly vulnerable to the impacts of climate change. Frequent climate fluctuations can disrupt tea yields and quality, posing a significant risk to production. Factors such as extreme weather conditions, drought, soil fertility status and poor management over the past several years (including non-compliance with pruning cycles, lack of infilling, inadequate maintenance of bush structure, insufficient fertiliser application and nutrient management, poor weed control and soil conservation measures, and neglect of shade tree management) have had a significant impact on the productivity of Halgolla.

1.3 Planning and design

THEORY PRACTICE

1.3.1 Different agroecological zones

The development and practices of agroforestry in Sri Lanka are intricately linked to environmental factors such as rainfall distribution, elevation, soil types and agroecological regions. Understanding these factors is essential for designing effective and sustainable agroforestry systems.

Considering the different agroecology and zones of Sri Lanka, we can define three major regions that differ in climate and topography: a mountainous region in the south-central part of the island, lowland plains extending radially from the central highlands to the coast and a low-lying coastal fringe that encircles the country.

Nearly three-quarters of the land area lies below 300 m, with the remainder consisting of hilly terrain. The central highland area is characterised by several ranges of mountains, plateaus and peaks. Sri Lanka's tropical location near the equator, along with its unique geographical features, significantly influences the country's climate and drainage patterns (MOE, 2023).

Sri Lanka's topography creates unique rainfall patterns, with notable spatial variations for a country of its size. The country's rainfall regime is divided into three climatic zones: Wet, Intermediate and Dry. The Wet zone receives a mean annual rainfall of over 2,500 mm, primarily due to the south-west monsoon. The Dry zone receives less than 1,750 mm annually. The Intermediate zones receive between 1,750 mm and 2,500 mm, mostly from both south-west and north-east monsoons of varying degrees depending on the location. The south-western slopes of the central hills can experience as much as 5,000 mm of rainfall in a year, with annual variations of 1,000 to 2,000 mm over distances of less than 100 km. All regions receive steady rainfall from October to November during the second inter-monsoon season (WB and ADB, 2020).

The country is further subdivided into 46 agroecological regions (AERs), each defined by specific criteria including monthly rainfall amounts (with a 75% probability) and distribution, elevation and soil types. Figure 6 presents a map outlining these agroecological regions in Sri Lanka.

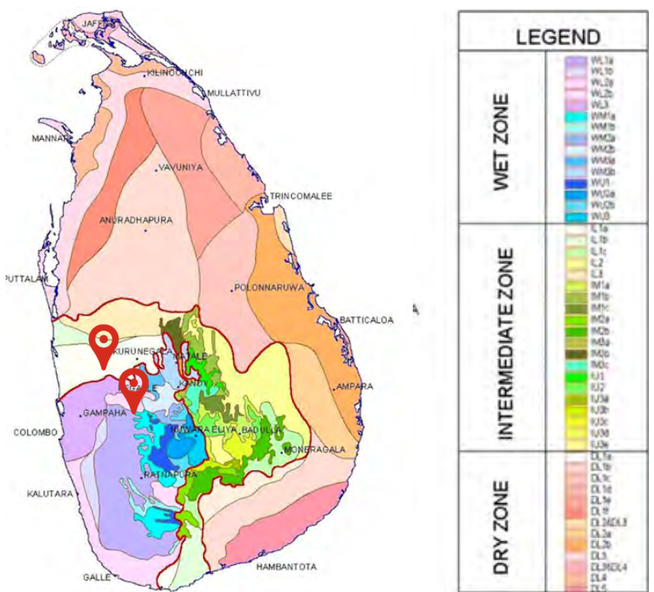


Figure 6: Agroecological regions of Sri Lanka (Source, DOA, 2003)

Muruthenge Estate
Muruthenge spans 60 ha and is located in the Kuliyapitiya East Divisional Secretariat of Kurunegala district of the Northwestern Province of Sri Lanka. The estate is in the Intermediate zone low country (IL1a) agroecological region. The soils are derived from the rocks of the Khondalite series (Cooray, 1984) and consist of red-yellow podzolic and reddish-brown latosolic soils (Punyawardena, 2008). The topography is relatively flat, and slopes range from 4% to 12%.

Soil texture and classification is sandy clay loam in surface soil, clay loam and gravelly clay loam in subsurface soil. Soil pH ranges from 5.0 to 5.6 in both surface and subsurface soil. The soil organic carbon percentage across the plantation is around 1.3% in surface soil (0-20 cm). Due to the nature of the soil, the moisture content of the top 30-60 cm drops to very low levels after 30 days without rain. The coconut root system in most of the soil is confined to 60 cm depth due to the presence of compact gravels in the subsoil. Therefore, the coconut palms are prone to moisture stress during the dry periods.

The area receives a total annual rainfall of 1,400 mm with dry seasons from January to March and from July to August (Punyawardena, 2008). The Maha season is not extended as in other areas, since the north-east monsoon is less impacted in this agroecological region. In addition, the south-west monsoon and first inter-monsoon are also less effective. Therefore, water availability is highly dependent on the availability of rainfall in the area (Punyawardena, 2008).

According to data collected by the Kurunegala plantation, the average annual rainfall over the past five years has been recorded as 1,602 mm, with a total of 76 rainy days out of 365. The rainfall varies from 25 mm in January to 300 mm in November with a bimodal pattern. June to September and January to March are dry period (Mapa et al., 2005).

Halgolla Estate
Halgolla is situated within the Yatiyantota Divisional Secretariat of the Kegalle district in the Sabaragamuwa Province of Sri Lanka. The majority of the plantation is located in the Wet zone Mid Country (WM1a) agroecological region (Punyawardena, 2008), characterised by red-yellow podzolic and lithosol soils. A small portion of the estate is found in the Wet zone Up Country (WU1) agroecological region. The first and second inter-monsoons, as well as the north-east monsoon, influence both agroecological regions, resulting in substantial rainfall from August to November (240-350 mm/month). Conversely, the south-west monsoon has less impact, leading to lower rainfall from December to March (50-100 mm/month), which can be considered a comparatively dry period. The mean annual temperature at Halgolla is approximately 28 °C. The uppermost parts of the Wewalthalava division (WU1) tend to be wetter and cooler in comparison to the middle valley areas of Halgolla (Mapa et al., 1999). Based on data collected by the Kelani Valley plantation, the average annual rainfall over the past five years has been recorded as 5,085 mm, whereas in 2022/23 it reached 5,671 mm, with a total of 214 rainy days out of 365.

1.3.2 Different types of agroforestry systems

Agroforestry systems, which include homegardens, tea, coconut and rubber-based agroforestry, contribute to maintaining the country's green status and ensuring a high level of tree canopy cover. This is especially crucial in areas with limited natural forest landscapes (Premakantha et al., 2023). By integrating a variety of tree species with agricultural crops, these systems enhance biodiversity, improve soil health, provide food, firewood and timber, and thereby provide ecological stability. They also help mitigate the impacts of deforestation and land degradation, thus preserving the natural environment and contributing to the resilience of agricultural practices in Sri Lanka.

Homegarden agroforestry systems in Sri Lanka are a traditional and widespread practice, particularly in rural and suburban areas as shown in Figure 7 (3-4). These systems involve cultivating a diverse mix of trees, shrubs, vegetables, fruits and medicinal plants within household compounds, for instance, with domestic animal components. Homegardens provide a continuous supply of food, medicinal herbs and other essential products, contributing significantly to household food security and nutrition. They also enhance biodiversity, improve soil fertility and offer shade and microclimate regulation. The Kandyan homegardens in the central part of the country are a well-known example of a homegarden system that is well adapted to the mountainous landscape and lowland landscapes (Pushpakumara et al., 2012; Premakantha et al., 2023).

Coconut-based agroforestry systems in Sri Lanka are an essential agricultural practice, especially in the coastal regions and intermediate zones (Figure 7 (2)). These systems involve intercropping coconut palms with a variety of other crops such as cocoa, gliricidia and pepper, cashew nut, banana, mango, rambutan, cinnamon, cashew and pineapple. This multi-layered cropping system maximises land use and provides farmers with diversified sources of income. The presence of multiple crops enhances soil fertility, reduces erosion and improves pest and disease management. By promoting biodiversity and ecological stability, coconut-based agroforestry systems contribute significantly to sustainable agriculture and the resilience of farming communities in Sri Lanka.

Tea-based agroforestry systems are a vital component of sustainable agriculture in the country's highland, mid- and low-country regions. These systems integrate shade trees with tea plantations, creating a biodiverse environment that supports soil health, water conservation and erosion control. In a simpler format, shade trees such as Grevillea, Gliricidia, Dadap, Acacia and Albizia are commonly used, providing not only shade for the tea plants but also additional sources of income through timber and firewood. This intercropping strategy using shade trees enhances the ecological balance, promotes biodiversity and improves the overall resilience of the tea plantations against climatic variations, making it a crucial practice for sustainable tea cultivation, being a shade-loving plant. Tea-based intercropping systems involve a variety of other crops such as coconut, rubber, cocoa, Gliricidia and pepper, cinnamon, arecanut, apple, pear, orange and avocado. The distribution of tea-based agroforestry in Sri Lanka is shown in Figure 7 (1).

Muruthenge Estate

The agroforestry model implemented as part of this project at Muruthenge occupies 5 ha of land and included replenishment of coconut palms and infilling with vigorous seedlings of coconut and king coconut quality planting material to reach the required palm density, which is 145 palms per ha. Available spaces between the palms were used for the establishment of annona (200 plants) as intercrop fruit trees, using quality planting material, and cinnamon (2,500 plants) as blocks. Pepper (390), banana (142), passion fruit vines (50) and pineapple (1,300) were also added to the agroforestry area as blocks. Along the boundary, mahogany (160), kumbuk (Arjun) (70), mee (madhuca) (70) and teak (270) were planted. Along the internal roadside, jackfruit (170 plants) was established to reach maximum ecological and social benefits through synergy and sharing of fruits with workers, respectively. The social block includes Colocasia and Buthsarana. To protect the well and its surrounding environment, Kumbuk and Mee trees are planted, while the boundary of the land is marked with teak and mahogany trees (Figure 8).

The Table 1 below described the interventions that were considered during the process of designing the agroforestry system for Muruthenge.

System components	Proposed intervention and objective/benefit
1. Soil health	• Improve soil structure and aeration: Preparation of land by ploughing and harrowing the area. • Minimise soil erosion: by making contour drains and terraced beds in the experimental field. • Rehabilitate soil and improve soil organic matter and nutrient: Mung bean or crotalaria (for 1-2 seasons) or calopogonium (as a perennial cover crop) green manure crops as blocks. • In order to enhance soil nutrient availability: liming will be performed to raise the soil pH using dolomite at a rate of 1Kg per coconut tree at planting. • Improve soil fertility management: Integrated nutrient management involves the Use of compost (10-15 kg per palm) filling the holes with coconut husks and fertilizer (250 g of urea, 350 g of TSP and 250 g of MOP per palm). Fertilizing using coconut fertilizer as of the CRI recommendation.
2. Water management	• Improve access to water to enhance resilience to drought: Rehabilitation of two water collection wells located in the valley. • Efficient water use: Establishment of water tank and pumping irrigation/fertigation system • Irrigation/fertigation as required during the dry period (February to March and July to August). • Burying of coconut husks as pits for moisture conservation options.

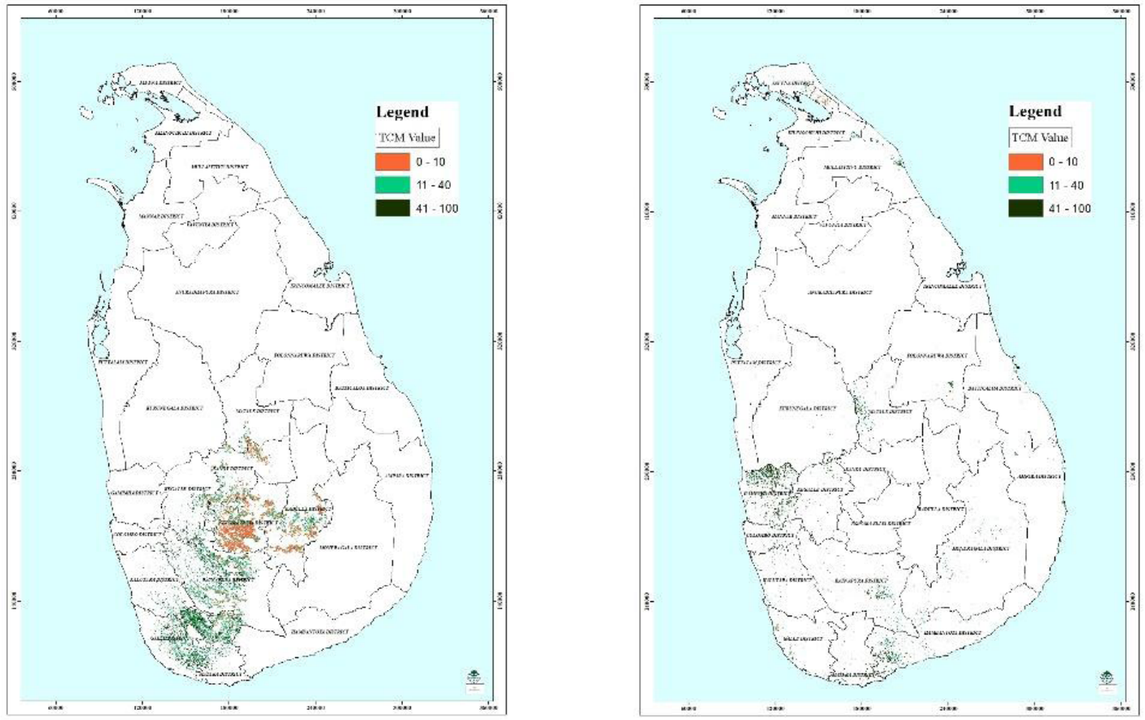


Figure 7: Distribution of different levels of tea-based (1) and coconut-based (2) agroforestry systems (including monoculture systems) in Sri Lanka (Source: Premakantha et al., 2023).

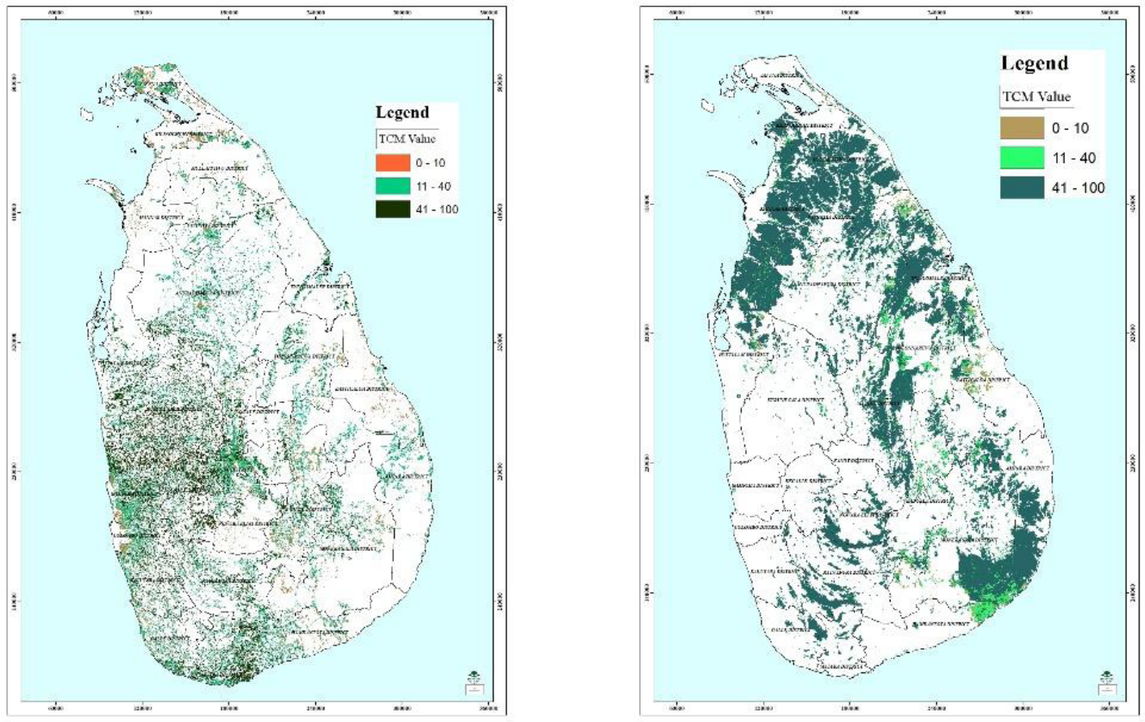


Figure 7: Distribution of homegarden agroforestry systems (3) and natural forest ecosystems (4) in Sri Lanka (Source: Premakantha et al., 2023).

System components	Proposed intervention and objective/benefit
3A. Plant – vegetation structure and agroforestry arrangements - Crops and trees	• Establish coconut/king coconut (90x90x90 cm) to reach desired palm density of 145 palms/ha (Establishment of coconut/king coconut 145-90=55; of which 20 coconut and 35 king coconut palms/ha)). Before implementation phase the King coconut was removed from the list as it was seriously affected by white flies. • Intercropping with cinnamon (30x30x30 cm) and Annona (60x60x60 cm) as block planting (Establishment of cinnamon [variety Sri Wijaya or Sri Gamunu] at spacing of 120x90 cm = 9,000 plants but only 4,500 plants are possible due to available space (10 ha) and Annona at a spacing of 5x5 m = 400 plants per ha but can incorporate only 200 plants due to coconut palms (10 ha). Planting will be done in contour beds as much as possible. Staking and training of plants by attaching them to stakes are required. • Establish and train pepper vines to all coconut/king coconut palms (2x145=390 pepper vines/ha)). Before implementation it was changed and used gliricidia poles to establish pepper. • Establish canna, Colocasia, pineapple and banana blocks in first 3-4 years. • Establish Gliricidia and teak in the boundary and jackfruit along the road network.
3B. Plant - weed management	• Slash and incorporate in soil at the initial stage of the project • Ground cover and mulch will provide necessary weed control status of subsequent time.
3C. Plant - pest management	• Using synergy among plants and also with appropriate chemical treatments to control outbreaks
Bee forage crops and bee colonies	• Honey bee colonies and bee forage crops 5 bee colonies/ha, need 25 bee colonies
4. Landscape - buffers (erosion) - biodiversity strips & strengthening of ES	• Establish a buffer zone using native phytoremediate trees such as kumbuk and mee around two wells • Protection of field from wild boar and other wild animals using a fence around the plantation

Table 1: The interventions that were considered during the process of designing the agroforestry system for Muruthenge

Category	Proposed interventions and objective/benefit
Beverage/Fruit tree species Can be used as a low shade tree for tea while yielding fruits	**Coffea arabica** (coffee) */** variety Lak parakum Spacing 2.5 x 1.8 m, 5 ha need 2,200 plants/ha **Areca catechu** (arecanut) as a soil binder Spacing 3 x 3 m, along contours with the boundary with durian plants. Need minimum of 400 plants per 5 ha. Also along the contour line 2 with coffee plants (need to calculate based on length of contour line) and also along the road structure up to the agroforestry field (at least one side of the road-lower slope of the road). **Persea americana** (avocado) variety Hass or Fuerte Spacing 10 x 10 m, 5 ha needs 500 plants and **Durio zibethinus** (Durian) variety Kasun in the peripheral area. Spacing 10 x 10 m, so a minimum of 120 plants are required. Before implementation replaced with pears. **Caryota urens** (kithul palm)*** Outside but adjacent to agroforestry block. These are already available plants in adjacent areas. In the future, seedlings of kithul palms will be collected from around good mother palms identified and will be established in manageable areas within the close vicinity of the agroforestry plot. Pepper trained to shade trees depends on the availability of shade trees. For the future, shade trees such as Gliricidia will be established in this season and pepper will be established in the next season.
Medium shade trees	**Erythrina lithosperma** (dadap) **
Species suitable for windbreak	**Grevillea robusta**
Firewood species	**Calliandra calothyrsus (caliandra)**
Cover crop/Trap crop/Repellent crop species	**Artemisia** species, **Tithonia diversifolia** or Wild sunflower, **Cymbopogon** spp. (lemongrass)
Species for stream bank protection	**Saccharum spontaneum** (wild sugarcane), **Vetiveria zizanioides** (vetiver grass/savandara), **Cymbopogon** spp. (lemongrass), **Elletaria cardamomum** (cardamom) as a crop (if this matches with the rainforest alliance certificate)
Species for the model community garden	**Artocarpus heterophyllus** (jackfruit) – variety gini waraka, fartherlong Spacing 10 x 10 m, 1 ha need 100 plants, but used as line planting in contours 10 x 20 m, hence need only 50 plants **Artocarpus altilis** (breadfruit) Need around 20 plants **Dioscorea** spp. (yam), need a block planting Year-round producers such as **Musa** spp. (banana) as intercropping **Canavalia gladiata** (avara) along the fence **Psidium guajava** (guava) as line planting at least two lines, 30 plants **Psopocarpus tetragonolobus** (winged bean) **Sechium edule** (cho-chow) along the fence
Bee forage crops and bee colonies	Honey bee colonies and bee forage crops 5 bee colonies/ha, need 25 bee colonies

Table 2: The interventions that were considered during the process of designing the agroforestry system for Halgolla estate

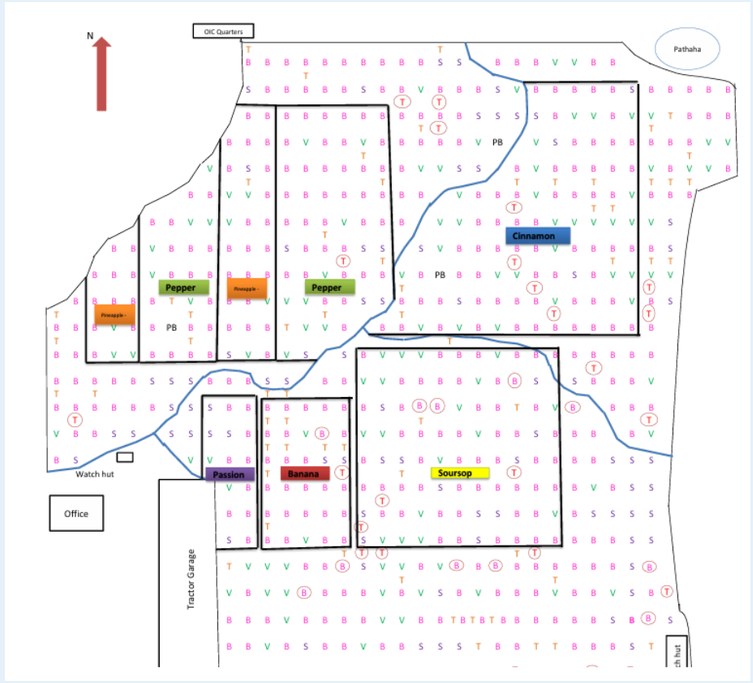


Figure 8: Location of crop combinations at Muruthenge Estate

Halgolla Estate

The agroforestry model for Halgolla consists of 5 ha and includes tea combined with coffee (1,300 plants) as a low shade tree, arecanut (1,400 plants) as a soil binder along the selected contour lines and in boundary with durian plants (500 plants), pepper (350 plants) and pear (350 plants). Shade trees such as Gliricidia were planted and pepper will be planted and trained in the subsequent season once Gliricidia has established or will be trained to already available shade trees.

Adjacent to the agroforestry plot, seedlings of existing kithul (Caryota urens) plants will be collected from around identified good mother palms and will be established in manageable areas in the close vicinity of the agroforestry plot. Additionally, 25 honey bee colonies were placed there. Suitable locations for honey bee colonies were determined in consultation with the Department of Agriculture.

In addition, a social block was planned for workers to provide food and a nutritional garden for estate workers. This will be a designated area, at the beginning of the land to be used as a community nutritional garden. This area will allow workers to collect fruits such as jackfruit, breadfruit and yams, as well as year-round producers such as banana, avara, guava, winged bean and cho-chow for their own consumption. The garden will be managed by the community in collaboration with stakeholders such as the company, shareholders, employees and the plantation community, with the primary goal of meeting their own food and nutritional needs.

The Table 2 demonstrates the interventions that were considered during the process of designing the agroforestry system for Halgolla estate.

THEORY PRACTICE

1.3.3 Selection of trees, crops and varieties

Choosing the right trees, crops and varieties to suit a plantation with a main primary crop involves various factors such as agroclimatic condition, soil type, water availability, adaptability and the specific needs of the primary crop as well as land owners objectives, availability of planting material, availability of labour, the surrounding community and economic aspects such as market opportunities, the strategy of the plantation and processing facilities.

In the case of trees and shrubs, the ideal species are those that provide additional shade, improve soil fertility through nitrogen fixation and form beneficial mycorrhizal associations, as well as offering additional products, such as fruits, foods, fodder, firewood or timber, or services (e.g. nectar and pollen or a habitat for natural enemies of crop pests and diseases), enhancing carbon stocks and the facilitation of micro environments as climate change mitigation avenues and essential eco systems. In this regard, it is preferable to use multipurpose trees that can coexist and companion well with other crops.

Other tree crops and their varieties should be chosen based on their compatibility with the primary tree species, agroecology and their market value, ensuring they do not compete excessively for nutrients or water. Integrating a diverse range of species and their varieties ensures a balanced ecosystem, enhances biodiversity and provides multiple income streams, leading to a more resilient and productive agroforestry system.

It is advisable to perform the selection of trees and crops using a participatory approach to facilitate the co-creation of the model in the plantation or system based on knowledge of tree characteristics (morphology, physiology, coppicing ability, pruning requirements) supported by the technical expertise of the academics, specialists and tea researchers, the requirements of the crops, the preferences of land owners and practitioners, the community and the climate and soil factors ensuring higher performances and benefits.

From a social perspective, it is essential to look at the level of labour intensity for specific trees and crops and whether the workforce can cope with the amount of work needed. Additionally, trees and crops can be selected for the potential nutritional value that they might add to the daily food of the workers. This only applies if workers can take some of the produce home. Choosing trees and crops that improve the quantity and quality of food available to workers increases the food and nutrient security for these workers. It is also a way to increase their in-kind wage, as they spend less money on food.

Furthermore, one might also look at what the workers grow in their homegardens and what they could learn from the agroforestry production, which they could apply in their own homegarden. This would be a way of learning by doing and duplicating it in their homegarden, while also inspiring neighbours. This could be on the level of agroforestry production as a whole but also specifically involve the production of one crop. Developing tree and crop guidelines or protocols and teaching workers how to apply good agricultural practices would provide them with the right knowledge, skills and experience to optimise production sustainably.

Finally, from an economic perspective, to support the financial viability of the agroforestry model, particularly during the initial years when cash flow might be negative, it is essential to explore various crops, products or services that the plantation can offer, ensuring a more stable and predictable cash flow. Agroforestry systems can generate income from various sources, such as timber/non-timber forest products (NTFPs), fruits, nuts and medicinal plants. Diversifying income streams reduces dependency on a single product, thus mitigating risks associated with market fluctuations. This approach can also support product branding by leveraging agroforestry products, particularly those associated with environmental services with adequate tree cover.

The selection of crops, trees and their available varieties for the Muruthenge and Halgolla estates was based on agroecological, social and economic considerations. Table 1 describes the interventions that were considered during the process of co-creation and designing the agroforestry system.

Muruthenge Estate
Pepper was also planted because there was a good market price. Although king coconut was initially selected for infilling vacant and unproductive coconut palms, it was replaced with hybrid coconut palms due to a severe whitefly infestation affecting the king coconut.

Gliricidea was planted with pepper as a support. The original plan to send pepper vines into the coconut was changed, as it might damage the vine during monthly harvestings. In addition, Canna and Colocasia were originally included in the plan, but Colocasia was removed due to wild boar and porcupine attacks. It is also planned to establish honey bee boxes to facilitate pollination and honey bee collection. Banana and passion fruit were also included due to the demand for products.

Halgolla Estate
Coffee plants were introduced as an additional cash crop, as Halgolla's strategy is to diversify the income of the estate. Pear was selected instead of Hass variety of avocado due to the unavailability of quality planting material. Arecanut was introduced both for soil protection and as a masticatory crop. Durian was used to cater the demand and as a boarder crop around the field. The honey bee boxes were placed for honey bee production and also to facilitate the pollination of fruit crops. The crops in the social block were chosen by the workers. The social block was established with jackfruit, breadfruit, green vegetables, winged bean, chaw chaw and yams such as manioc and diascorea to provide year round production of crops.

THEORY PRACTICE

1.3.4 Planting patterns and orientation of trees

Considerations for planting patterns are: (i) species compatibility to ensure that chosen tree and crop species are compatible in terms of light, water and nutrient requirements; (ii) proper spacing and density to minimise competition and maximise benefits. This varies depending on species and system objectives; (iii) tailoring planting patterns to local climatic, soil and topographical conditions to enhance system resilience and productivity; and (iv) regular management, including pruning, thinning and fertilisation, is necessary to maintain the balance between trees and crops. Farmers can create sustainable and productive agroforestry systems that provide multiple environmental, economic and social benefits by carefully selecting and arranging species.

In agroforestry systems, the orientation of trees and crops is crucial to maximise the benefits of this integrated approach. Proper orientation can enhance productivity, reduce erosion, improve rainwater harvesting, improve water management and optimise light distribution. The orientation of trees and crops largely depends on the type of agroforestry system introduced and the existing system and its orientation.

In a coconut-based agroforestry system, the orientation of the trees is strategically planned to maximise the growth and yield of both the coconut palms and the intercrops. Coconut palms are typically spaced at wider intervals (depending on the type of coconut such as all or dwarf and the pattern of planting such as square (7.9 x 7.9 m), rectangular (8.5 x 7.3 m) and triangular at 8.5 m equilateral), with the possibility of intercropping (8.5 x 8.5 or 8 x 8 m) to accommodate their large canopies and allow ample sunlight to reach the ground. Interspersed between these palms, a variety of crops such as fruit trees, legumes and spices are planted in rows or clusters that complement the coconut trees' growth patterns. Trees are also planted along roads. This arrangement ensures optimal light distribution, reduces competition for resources and facilitates efficient water use. The thoughtful orientation of trees and crops in a north-south direction not only enhances biodiversity and soil health but also increases the overall productivity and sustainability of the agroforestry system.

In a tea-based agroforestry system, the orientation of the trees is carefully planned to optimise the benefits for the tea plants. Trees are typically aligned in such a way as to provide adequate shade without overly shading the tea bushes, ensuring they receive the right amount of sunlight for optimal growth. The trees are often planted in contour rows parallel to the tea rows, with sufficient spacing to allow air circulation and reduce competition for nutrients and water. The spacing of trees depends on the type of shade trees (high shade or low shade), the agroclimatic zone (low country wet zone, low country dry zone and up-country wet zone) and the type of management (commercial and subsistence uses). This north-south strategic orientation helps in moderating the microclimate, reducing soil erosion and enhancing biodiversity, ultimately contributing to a more sustainable and productive agroforestry system.

In degraded tea and coconut plantations, where tea, shade trees or coconuts are already established within their respective systems, the planting strategy should be tailored to optimise resource utilisation, minimise excessive competition and enhance synergistic interactions. Competition can be effectively mitigated through well-planned agroforestry tree interventions, such as tree replacement, substitution, increasing tree density and adopting efficient tree management practices (Pushpakumara et al., 2012).

In Table 3 some common planting patterns and their benefits are described.

The way in which the agroforestry models (see Figures 9 and 10) are designed will create synergies among the different crop species and optimise the use of space, sunlight and other resources.

Muruthenge Estate
Although various planting patterns can be used to establish agroforestry systems, Muruthenge adopts block planting of crops in different locations for easier management.

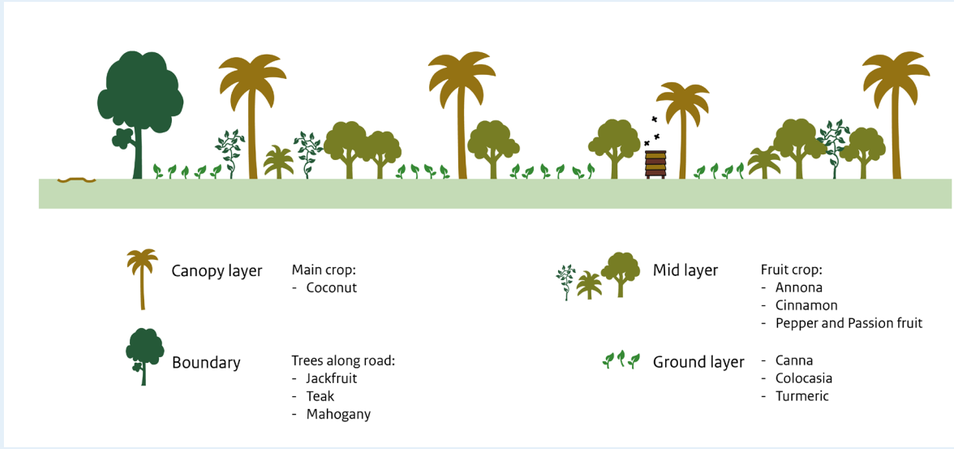


Figure 9: Drawing of the agroforestry model proposed for Muruthenge Estate, , with the placement of species adjusted, but primarily aimed at representing the different layers .

Halgolla Estate
While various planting patterns can be employed to establish agroforestry systems, Halgolla utilizes contour planting along gradients to promote the development of contour bunds, effectively reducing soil erosion.

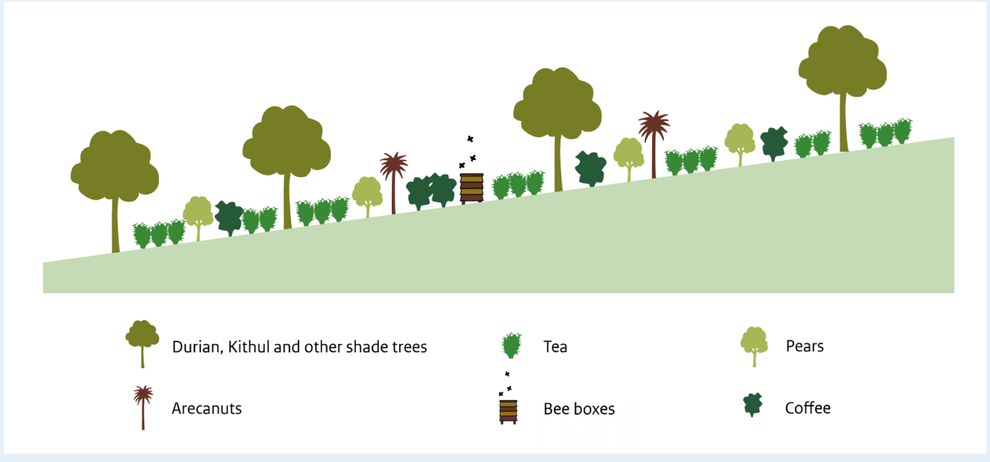


Figure 10: Drawing of the agroforestry model proposed for Halgolla Estate, , with the placement of species adjusted, but primarily aimed at representing the different layers .

Planting patterns	Description	Suitable trees and crops	Benefits
Alley cropping	Trees or shrubs are planted in rows (alleys) with wide spacings, and annual or perennial crops are grown in the inter-row spaces	Nitrogen-fixing trees like Gliricidia or Leucaena; crops such as maize, beans and vegetables	Enhances soil fertility through nitrogen fixation, reduces erosion and provides shade and wind protection for crops
Silvopasture	Integration of trees with pasture and livestock grazing areas	Fast-growing trees like Gliricidia, jackfruit, forage crops like grasses and legumes	Improves livestock health through shade, enhances forage such as fodder and forage quality and provides additional income from timber or fruit
Homegardens	Multilayered planting systems around homes, typically in tropical regions	Fruit trees (mango, jackfruit, bread fruit), vegetables (tomatoes, spinach, winged bean, moringa), herbs and spices (pandan leaves, curry leaves)	Increases biodiversity, provides diverse food and income sources continuously and improves household nutrition
Windbreaks	Rows of trees or shrubs planted to protect crops from wind damage and reduce soil erosion	Hardy trees like Eucalyptus, Gravellia, Dadap; crops such as tea, grains, vegetables or fruit orchards	Protects crops from wind, reduces soil erosion and enhances microclimates for improved crop growth
Riparian buffers	Planting trees and shrubs along waterways to protect water quality and provide habitat for wildlife	Water-tolerant species like kumbuk, mee, bamboo, native species; riparian plants and native grasses	Reduces runoff and erosion, improves water quality and enhances biodiversity
Multistrata agroforestry	A system that mimics natural forests by layering different species vertically	Tall trees (timber species), mid-storey trees (fruit trees) and understorey crops (coffee, cocoa	Maximises space use, increases biodiversity and provides multiple products and ecological benefits

Table 3: Common planting patterns and their benefits

1.3.5 Integrating livestock

Integrating livestock with trees (and crops), known as (agro)silvopastoral systems, offers numerous benefits, such as increased productivity through livestock grazing and reduced need for mowing and weed control. Livestock manure adds nutrients to the soil, improving fertility and nutrient cycling, while some grazing animals naturally loosen the soil, enhancing its structure. Including livestock in the system also boosts resilience, while trees provide shade and windbreaks, creating a more stable microclimate that reduces heat stress and improves animal welfare. Additionally, livestock benefit from a more varied diet through natural foraging. Choosing tree species that are compatible with livestock is crucial, ensuring they provide forage without being toxic.

Effective livestock management includes proper grazing practices, rotation schedules and adequate nutrition and water. Each type of livestock offers distinct advantages and challenges. For example, cattle are efficient at grazing and provide significant manure for soil fertility but require substantial space and water resources. Sheep and goats, on the other hand, are less demanding in terms of space and can control underbrush and invasive species effectively; however, they may be more susceptible to predation and diseases. Poultry can offer pest control and produce high-value products like eggs and meat with minimal land use, but the birds require protection from predators and proper waste management to prevent nutrient overload in the soil. Therefore, choosing the right type of livestock and implementing strategic management practices (housing, watering, fencing etc.) are essential to harness the benefits while mitigating the challenges.

Monitoring and managing pasture growth and health is essential to avoid degradation and maintain productivity. Although initial setup costs can be high, the long-term benefits often outweigh the investment. Successful integration requires knowledge of trees, crops and livestock management, and access to training and technical support can enhance the adoption and success of (agro)silvopastoral systems. Additionally, acceptance by landowners of rearing livestock is crucial for successful integration.

Animal-based agroforestry systems, such as silvopastoral systems, are feasible but heavily dependent on management decisions and site-specific conditions of respective plantations. For example, at Muruthenge, livestock farming between coconut trees is a viable option to establish a silvopastoral system. However, the current management has chosen to focus on a silvoarable system, integrating crops with trees. This decision reflects practical challenges, as livestock can damage saplings and small plants, and combining livestock with certain perennials, such as bananas, proves difficult. Historically, cattle/buffalo belongs to surrounding community were used for weed control in degraded coconut plantations by tethering them to individual trees, but this practice was discontinued under the agroforestry model, necessitating alternative arrangements for cattle in other areas of plantation. Similarly, in Halgolla, livestock is excluded as a policy decision, and free-ranging animals in tea plantations are not viable. However, there is potential to grow pasture species in vacant and common areas of plantations to provide feed sources, highlighting the role of careful management in integrating livestock into agroforestry systems.

THEORY PRACTICE

1.3.6 Social impact of agroforestry

The term 'social' can be perceived as complex and challenging to grasp. Approaching it from a Human Resource (HR) perspective makes it more tangible and easier to implement. An HR vision, strategy and implementation plan is something that every plantation should implement. It is advisable to focus on the following HR components when getting started with agroforestry: (1) the actual and required competency framework for staff involved with agroforestry; (2) the required training; and (3) possible improved working conditions and additional potential benefits for workers. Additional HR aspects can be explored.

Getting started with agroforestry on a small plot provides the plantation with the opportunity to explore these HR aspects and see what impact it has on these social aspects. Questions such as the following can be answered: Is the agroforestry model workable for both employee and employer? How is this valued by both employer and employee? What needs to be adjusted or improved when upscaling agroforestry? Is the current salary model adequate or is a different wage model more suitable for an agroforestry-focused plantation?

Introducing agroforestry on the plantation means that a variety of different labour tasks are needed due to the variety of crops but also different ways of managing and monitoring the land, e.g. more complex and more frequent mulching, weeding and fertilisation. This has both advantages and disadvantages. The positive side is that the work is more dynamic and diverse, which leads to higher motivation and job satisfaction. The downside is that it takes much more time and labour to work on the agroforestry plot; agroforestry is more labour-intensive. This is especially the case at the beginning when plants are still small and the complete ecosystem has not fully evolved and developed. Due to the wide variety of tasks and crops, it is important to rethink the salary model. The plantation also has to rethink its business model, as it is diversifying with multiple (cash) crops. The question is whether the current salary model is sufficient for the tasks/labour on the plantation and whether workers should be paid on the basis of targets, a fixed salary or a revenue sharing model. There is no one correct method for the payment structure, but a key point is that various scenarios should be calculated and tested together with the responsible HR manager.

Agroforestry can potentially result in higher revenue for the plantation, which could trickle down to an increase in salary for workers and even achieving living wages[1] for plantation staff who work on the agroforestry plot. The rationale behind this is that with agroforestry produce a premium can be realised on the end product, e.g. by certifying the plantation against Fairtrade[2] or another certification standard. However, selling agroforestry produce at a premium price takes time and is not always guaranteed: a whole new chain needs to be set up with new buyers and different marketing channels. Also, even if agroforestry results in a more profitable business, it does not always mean that this profit can be shared with the workers. Therefore, it is crucial to manage expectations carefully on this matter. It does not necessarily result in a premium, but more often results in intangible benefits such as market access, long-term contracts and brand image. However, putting 'living wages' as a KPI already can create awareness among plantation management that there is something more than just a subsistence wage. But it should be borne in mind that increasing wages within three years of the implementation of agroforestry is not realistic, as a return on investment will take longer. It is crucial to communicate this correctly to the workers to avoid creating false expectations.

An indirect change in the wage could be realised if workers can benefit from agroforestry by taking the surplus of the produce home and using it for their own consumption. In this way, they save money they would otherwise have to spend buying this food. This can be seen as improved in-kind benefits. The extra produce

1 A living wage is defined as the minimum income necessary for a worker to meet his or her basic needs. This is not the same as a subsistence wage, which refers to a biological minimum, or a solidarity wage, which refers to a minimum wage tracking labour productivity. For further information, go to https://www.rainforest-alliance.org/issues/livelihoods/living-wage/

2 https://www.fairtrade.net/en.html

Plantations have a direct workforce but also operate within a community (indirect workforce) and have, to a certain extent, responsibility for this community. Moreover, there was an important difference between the coconut and the tea plantations; in the case of the tea plantation, workers live on the plantation, whereas in the case of the coconut plantation the workforce (except the guards) lives in the surrounding communities and travels to and from work. Finally, the coconut plantation is state-owned, whereas the tea plantation is privately owned. This has consequences for the management's flexibility with regard to salaries, secondary benefits and other allowances, as these aspects are determined by the state. These variables added to the complexity of the social component within this agroforestry pilot.

The social aspect was initially focused mainly on HR-related items. The underlying assumption here was that a plantation can only function properly and successfully with the right personnel in place. Another reason was to make it more manageable and concrete for the management of the plantations to work on the social aspect. Nevertheless, during the project it became clear that agroforestry would only be implemented on a small plot of the plantation and revising the entire HR strategy would be unrealistic and challenging.

Figure 11 (next page) shows the competency framework that was developed for the two plantations, with three competency profiles: for the estate manager, field officer and worker. For all positions, the knowledge (what), skills (how) and attitude (why) for that specific position are developed. This gives an idea of what is needed for a certain position to comply with the needs. Additionally, it can be used to assess the competence level and the possible need for capacity building. This can involve training, mentoring or support on the job. For this purpose, the competency profiles are translated into a competency framework, with a clear description of each competence, indicating whether it is a knowledge, skills and attitude (KSA) competence, and a scale to assess the level. For the implementation of agroforestry, the competences of staff need to be improved to make them more valuable, both professionally and in their personal lives.

Although agroforestry is not an entirely new concept for the adjacent communities, as they have their homegardens, community members who take the communal road to the agroforestry plot, and who are smallholder tea farmers, have started to integrate crops similar to those used on the agroforestry plot at Halgolla in their own tea blocks. The agroforestry plot is therefore an inspiration for the surrounding communities and at the same time a mode of interaction between the community and the workers and field officers to stimulate cultural cross-pollination.

Additionally, Halgolla started teaching kithul tapping to smallholder farmers living close to the plantation by providing scientific knowledge and explaining to them how to do it. The harvested kithul is collected and bought at a premium price by Halgolla (if it complies with the agreed quality requirements).

Awareness raising among community members took place in two ways: 1) through the Green Clubs at Halgolla, which is an initiative that educates young people about the importance of biodiversity and greening the environment; and 2) by placing a sign that explains what is happening on the agroforestry plot. The plot at Halgolla is located at an intersection of various roads (within the plantation), where villagers also pass by and are inspired by it.

can come from the agroforestry plot or a separate community block where workers can grow their own food and take home what they produce. This can have an improved indirect effect on their wage as well as food security. This is also a strategy to motivate the labour force needed for the agroforestry block.

In general, attracting the younger generation to engage in plantation activities presents a considerable challenge. The prevailing trend among young individuals is to seek employment in fashionable industries such as garments, and many opt for quick income opportunities like three-wheeler ownership/hiring. This trend may result in a shortage of dedicated plantation workers.

Encouraging young people to view tea cultivation as a viable and rewarding long-term career is a formidable challenge. Convincing them to invest time and effort in building a sustainable career within the plantation sector is vital for its future success. During recent presentations, group HR has shown a remarkable improvement in providing a bright future for plantation youth. One potential option is developing tea and coconut-based tourism, where youth can serve as guides or interpreters. This initiative should be planned in conjunction with natural and agro-based systems (i.e. tapping kithul and making juggary, plucking tea, serving young coconut water etc) to attract tourists effectively.

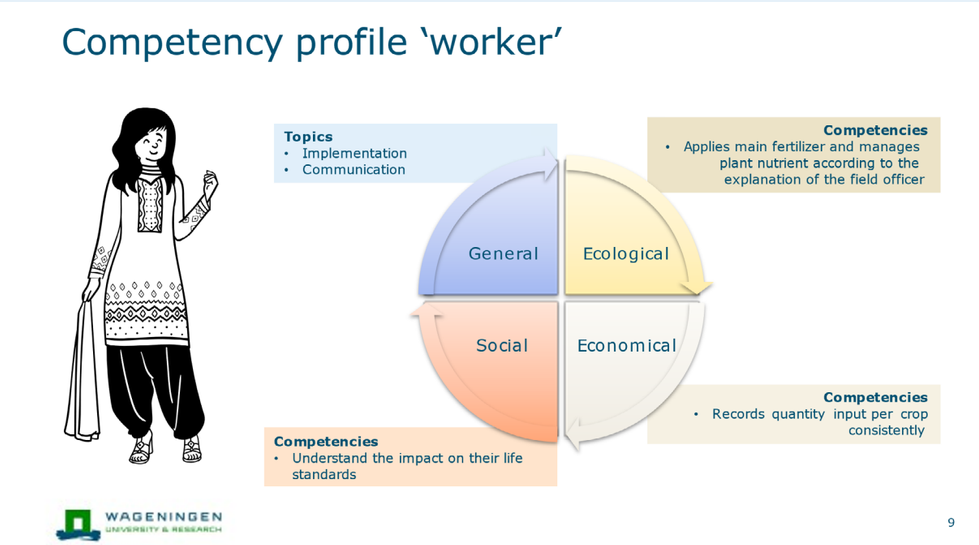
Impact on the surrounding community

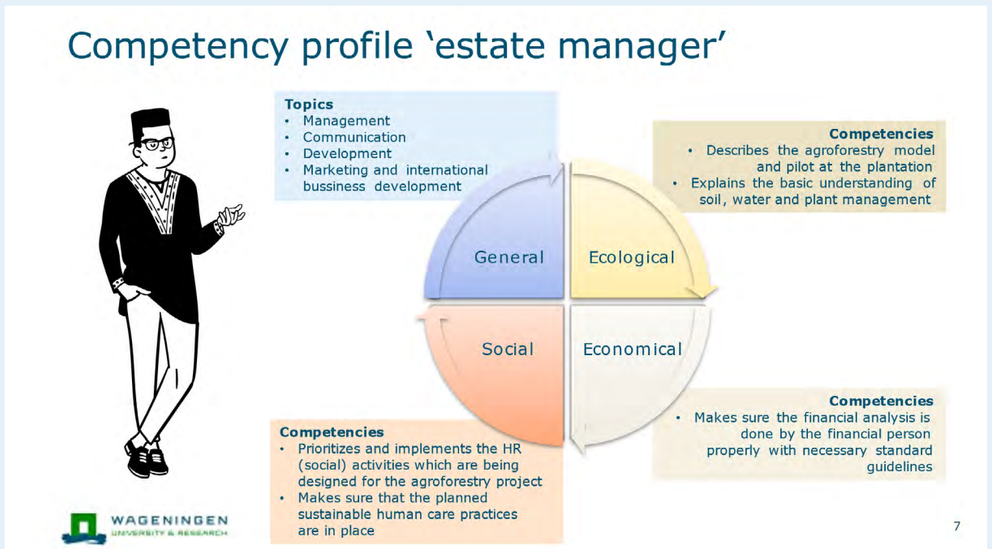
As plantations have a big presence in Sri Lanka in terms of surface area but also in terms of the working population, one should not underestimate the role they could play in inspiring people when implementing a new approach to revitalise the plantation. Either the worker community interacts with surrounding communities or surrounding communities pass the plantations and see what happens there. Field officers play a vital role in inspiring people and raising awareness about agroforestry principles and practices. They can serve as trainers (ToT), facilitating the dissemination of knowledge to the surrounding community. Once systems develop to acceptable level, organizing in situ social events at the agroforestry plot and community block periodically would be an effective way to engage the community and promote these practices.

Muruthenge indicated that next time it implements agroforestry it would also like to have its plot closer to the road so that passers-by could also see what is happening on the plantation.

Building the right partnerships

The sustainability of this initiative largely depends on fostering strong partnerships with all stakeholders through meaningful interactions. This approach is essential to ensure that stakeholders clearly understand their roles and actively participate in all activities.





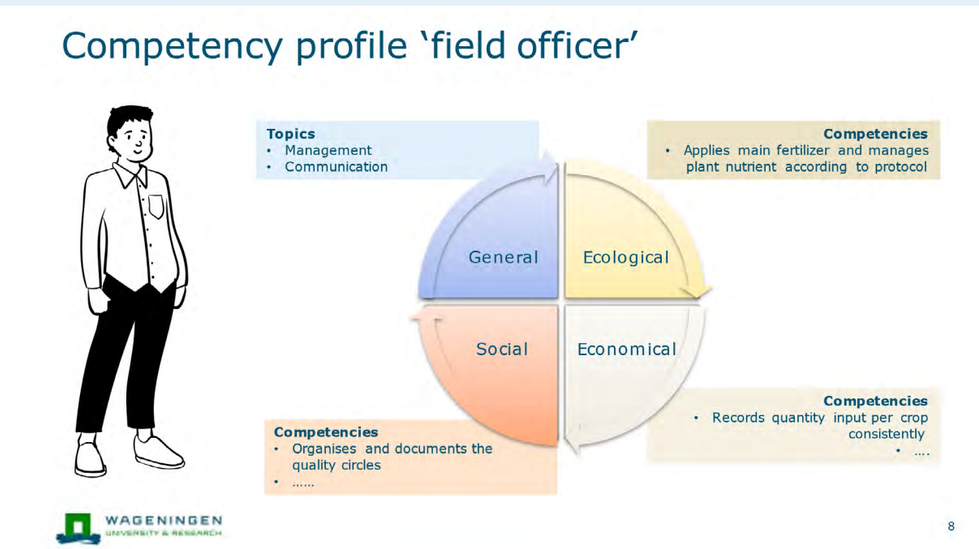


Figure 11: Competency profiles for three positions on the plantation

THEORY PRACTICE

1.3.7 Business models and scenarios

Agroforestry projects typically have long life cycles, so it is important to adopt a long-term perspective when developing the business model. A 10-year forecast is sufficient for making informed initial decisions. This long-term outlook will help in identifying the key phases of the project and aligning resources and efforts accordingly. Critical financial metrics such as return on investment (ROI), cost-benefit ratio, break-even points and net present value (NPV) should be carefully analysed for each crop and product. This analysis will provide insights into the profitability and financial sustainability of the project over time. Adjustments can then be made based on the specific financial goals and circumstances of the company. Initial investments should be carefully planned to minimise costs while ensuring that essential activities are adequately funded. This might involve phasing investments, prioritising high-impact areas and seeking out cost-effective solutions. More examples of a cost-benefit analysis can be found in the Inspirational document[1].

This involves a comprehensive evaluation of all costs associated with the project, including initial setup, ongoing maintenance and projected revenues and should also consider potential risks and uncertainties, allowing for the development of contingency plans. Identifying and mitigating potential risks, such as market volatility and climate change, is essential for maintaining financial stability.

Emphasising sustainable practices, such as the use of organic fertilisers and promoting biodiversity, benefit the environment and ensure the plantation's long-term viability. Sustainable practices can also enhance the plantation's appeal to environmentally conscious consumers. Besides diversifying the crops, incorporating ecotourism or offering educational tours can also provide additional income while raising awareness of sustainable practices. This not only diversifies revenue but also promotes the plantation's commitment to environmental stewardship.

Ensuring that the business model is scalable is crucial for future growth. Processes and systems should be designed to accommodate expansion without requiring disproportionate increases in cost or complexity.

Evaluating the feasibility of manufacturing new products is important. This involves assessing market demand, production costs and potential profitability. By diversifying product offerings, the plantation can tap into different markets and reduce reliance on any single income source. An example is having its own sales outlet, which can bring substantial value in addition to selling raw materials.

Planning also involves creating detailed financial projections, identifying key cost drivers and understanding the revenue potential of various crops and products. A well-structured budget allows for better financial forecasting and resource allocation. Fixed and variable costs must be managed, forecasting expenditures and identifying areas where cost savings can be achieved without compromising the quality or sustainability of the project.

Identifying areas for cost reduction without compromising quality or productivity is critical. This could involve negotiating better terms with suppliers, optimising labour efficiency or investing in technology that enhances productivity and reduces manual work.

For successful implementation of the agroforestry project, it is important to account for various additional costs such as labour, training, planting materials, irrigation systems, fencing and other infrastructure needs. Avoiding excessive upfront costs by prioritising essential investments and phasing in additional expenses as the project progresses is important. In mixed cropping systems, certain costs, such as land preparation, can

1 Pulleman, M. M., Smit, E., & Wintraecken, E. (2022). Agroforestry models and business cases: International experiences. Netherlands Enterprise Agency. https://edepot.wur.nl/566434 Page 19.

Muruthenge Estate
For the Muruthenge agroforestry model, the focus was on a long-term vision, diversifying income sources and conducting thorough cost-benefit analyses.

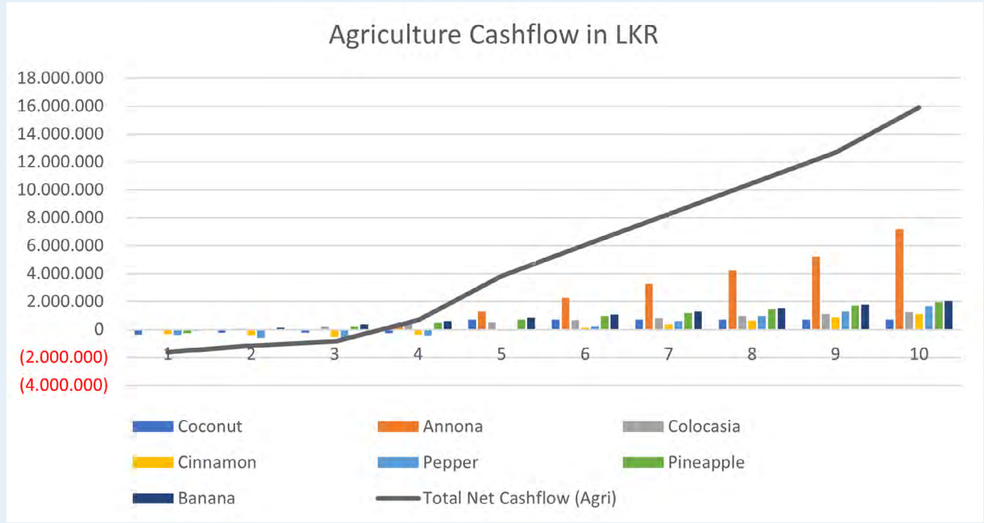


Figure 12: Cash flow analysis of individual crops over 10 years at Muruthenge Estate

The above graph is derived by calculating details for each individual crop. The cash flow forecast covers multiple crops over 10 years and includes labour costs, land utilisation, per hectare metrics and accumulated cash flow per crop. Additionally, it considers ancillary projects and combines these with agricultural cash flow to provide a comprehensive view of financial performance.

The Internal Rate of Return (IRR) varied significantly among the crops, with banana and colocasia standing out at 216% and 183% respectively, as the highest returns, making them highly attractive for investment. In terms of Net Present Value (NPV), annona led with the highest NPV per hectare. Additionally, annona also has the highest Benefit-Cost Ratio (BCR), which reflects its strong profitability compared to other crops.

The yearly accumulated cash flow analysis revealed that in the initial years (1 to 3), all crops except colocasia and banana experienced negative cash flows, reflecting the initial investment and establishment costs. By year 5, however, most crops, with the exception of coconut, cinnamon and pepper, are expected to show positive accumulated cash flows. By year 10, all crops are expected to achieve positive accumulated cash flows, demonstrating the long-term profitability of these agricultural investments.

Focusing on the total net cash flow (AF plot) from agricultural activities only (excluding ancillary income), the cash flow remains negative from year 1 to year 3. By year 4, it turns positive. From this point, the cash flow is expected to increase steadily. The first three years will require substantial investment, resulting in negative cash flows. Therefore, proper funding or financial planning is essential in order to navigate these early stages.

be shared between multiple crops. This cost-sharing strategy can significantly reduce the financial burden on the project, making it more economically viable.
Ongoing maintenance costs, such as pruning, fertilisation, irrigation, pest and disease management and training should also be factored into the budget. Investing in training is particularly important, as it enhances labour efficiency and ensures that crops are managed and cared for properly. Optimising irrigation systems can also help reduce costs and promote sustainability.

Ancillary projects

Ancillary projects are secondary or supporting activities that complement the main agricultural or forestry operations. These projects are designed to generate additional income streams, optimise resource use and reduce risks associated with relying solely on primary agricultural activities. They can also contribute to environmental sustainability and community development.
Benefits of ancillary projects are:

- Supportive role: these projects supplement the primary agricultural activities and help stabilise cash flows, especially during periods when the main crops may not be profitable (e.g., initial plantation years).
- Revenue diversification: ancillary projects provide alternative income sources, reducing dependence on a single crop or product.
- Utilisation of by-products: ancillary projects often involve the use of agricultural by-products or resources that would otherwise go unused.
- Alignment with Sustainability Goals: many ancillary projects promote environmental and social sustainability, aligning with broader goals such as carbon sequestration, waste reduction and community development.

The ancillary projects (picture 4 and 5) are expected to generate a consistent cash flow, significantly enhancing the overall cash flow when combined with the agricultural cash flow. Due to these ancillary projects, the initial cash flow is positive and continues to grow steadily over time.

Eventually the estate's diversification across multiple crops is expected to reduce risk and ensure a more stable cash flow over time, providing resilience against market fluctuations.



Picture 4: Biochar produced from coconut shells

Halgolla Estate
The proposed business case for Halgolla has been developed by considering seven crop varieties to be used on various levels within the five-hectare agroforestry model. The model is expected to deliver a number of raw and value-added products such as tea, coffee, durian and pepper-based products. The community garden will not bring revenue to the agroforestry model, as it is meant for workers' own consumption. The proposed business model for Halgolla also includes ancillary projects such as kithul and ecotourism. However, only kithul is executed during the project period.

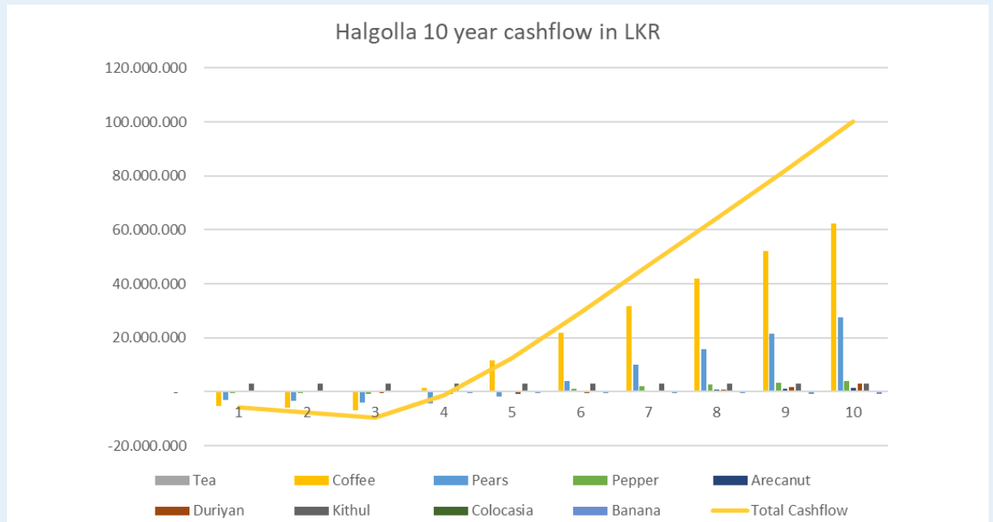


Figure 13: Cash flow analysis of individual crops over 10 years at Halgolla Estate

The tea serves as the primary crop species in the plantation, and the yield is expected to come only from the existing bushes, as no new plantings are planned within the project. However, it is important to note that revenue from tea will not significantly contribute to the cash flow over time due to the absence of new plantings. Coffee is proposed as an intercrop for the model alongside tea. Since there are no yield-producing coffee plants at the time of initiation, there will be no yield during the project period. However, it is anticipated that the field will show a net positive gain after six years of cultivation. Durian is proposed as a fruit crop that takes more than the project period to produce yield. Areca nut, pepper and pears will also start contributing positively to the cash flow with effect from year 6.

The Internal Rate of Return (IRR) varied slightly among the crops, with coffee having the highest IRR at 59% followed by durian at 78%, indicating strong profitability. Durian has the highest NPV at 3,804,946 LKR, making it the most economically promising crop. Coffee and durian have the highest BCR of 2.69 and 2.78 respectively, indicating high returns relative to costs. Pear has a lower BCR of 0.56, which suggests lower profitability compared to other crops.

The yearly accumulated cash flow analysis revealed that in the first three years most crops show negative cash flows due to establishment costs and delayed yield realisation. Coffee experiences significant early losses (-6,853,611 LKR by Year 3), likely due to high initial investment and long gestation periods. By Year 5, total cash flows turn positive (12,587,114 LKR) driven by yields from coffee, durian, pears and pepper. Positive net cash flows grow significantly from Year 5 onwards, reaching 97,513,474 LKR by Year 10. Coffee becomes the primary driver of cash flow after Year 4, contributing 62,251,322 LKR by Year 10. Durian starts with negative cash flows but contributes significantly from Year 7 onwards, reaching 3,091, 812 LKR in Year 10. Kithul, ancillary project, consistently provides 2,900,964 LKR annually, offering stable revenue throughout the period. The crops planted on the community plot remain loss-making, as they are not meant for sales, contributing negative cash flows throughout the period.



Picture 5: The Kithul Palm Sap Extraction Project (ancillary project).

1.3.8 Options for financing

Exploring financial incentives offered by the private sector, governments or international organisations can provide crucial funding for the initial stages of the project or for the scaling of integrated agroforestry models / regenerative agriculture in small farms or large plantations. For example, attracting investors interested in sustainable, climate-smart and ethical investments can provide the necessary capital for expansion and innovation of agroforestry within the plantation. Building a compelling business case that highlights sustainability can attract such investors.

Investigating carbon credits and other financing schemes can also provide additional revenue streams. Carbon credits in particular are increasingly becoming a valuable financial tool for agroforestry projects that contribute to carbon sequestration in trees or in the soil organic matter. However, the implementation of robust MRV systems is crucial, according to the requirements of the certifier.

Carbon credits

Carbon credits are tradeable certificates or permits representing the right to emit one metric ton of carbon dioxide (CO_2) or an equivalent amount of greenhouse gases. They are a tool to help countries, companies and organisations meet their emission reduction goals and comply with international climate agreements. There are two main types of carbon credits:

1. Compliance carbon credits: used by companies or countries to comply with mandatory emission caps under regulations like the Kyoto Protocol or the EU Emissions Trading System (ETS).
2. Voluntary carbon credits: purchased by entities that want to offset their carbon footprint voluntarily, often as part of corporate social responsibility (CSR) programmes. The best-known standards are Verified Carbon Standard (VCS) , the Gold Standard and the UN-backed Clean Development Mechanism (CDM) .

Trees in agroforestry systems absorb CO_2 through photosynthesis and store it as biomass in trunks, branches, roots and soil. This reduces atmospheric greenhouse gas concentrations. Agroforestry programmes can sell carbon credits in voluntary or compliance markets, creating an additional revenue stream for farmers or landowners. By participating in carbon credit markets, agroforestry programmes align with global sustainability goals, enhancing their reputation and opening doors to funding and partnerships. Revenue from carbon credits can fund the expansion of agroforestry programmes, including planting more trees, training farmers and investing in technology for monitoring carbon sequestration.

Acorn programme for smallholders

Rabobank has launched the Acorn programme, which supports smallholder farmers as they transition to sustainable agroforestry practices by measuring the resulting biomass increase and issuing carbon credits accordingly. These are then sold to responsible corporates, with 80% of the total revenue flowing back directly to the farmers.

Amazon Tea, a company sourcing tea and botanicals from farmers in Sri Lanka, has secured funding to support the expansion of organic tea production and the implementation of multi-layer agroforestry systems within coconut monocropping with various botanicals, such as black pepper, ginger, hibiscus, lemongrass and others, promoting diversified and sustainable farming practices. The funding is part of a collaborative effort between responsAbility and the CGIAR for Sustainable Finance, working together through the Climate Smart Food System Fund to support smallholder production systems across the globe, fostering sustainable and climate-resilient agricultural practices.

One of the institutions committed to the Climate Smart Food System Fund is the Dutch Entrepreneurial Development Bank (FMO). Another example is the Sri Lanka Climate Fund, under the Ministry of Environment, which offers a scheme for voluntary carbon trading through carbon removal projects.

1.4 Implementation and adaptation

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The implementation of an agroforestry model generally consist of 4 steps:

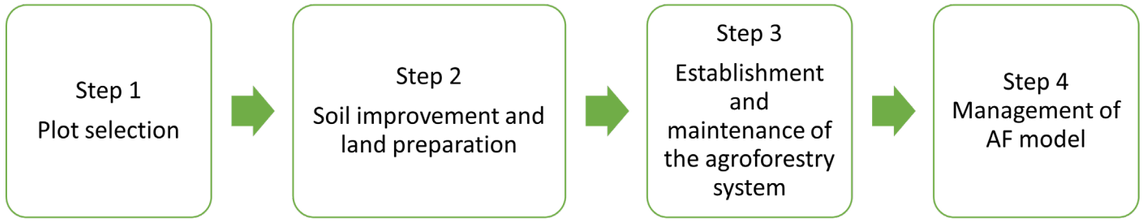


Figure 14: Steps in implementation phase of an agroforestry (AF) model

1.4.1 Selection of plots - Step 1

Agroforestry systems can be implemented during crop establishment or renovation or within mature established plantations. Agroforests can also be established by planting crops (e.g. tea, coffee or cocoa) in naturally regenerated vegetation after a fallow period.

Before establishing agroforestry systems on degraded lands, comprehensive land preparation and soil conservation measures are essential to control further degradation of soil health and ensure restoration and long-term sustainability. Proper land preparation involves clearing the land of weeds and debris, tilling the soil to improve aeration, levelling and incorporating organic amendments to enhance fertility. The addition of organic matter such as compost or manure or the establishment of green manure crops such as sun hemp and greengram improves soil structure, fertility and microbial activity, creating a more conducive environment for plant growth.

Soil conservation practices, such as constructing terraces, contour ploughing, establishing contour bunds with plant debris, sloping agricultural land technology (SALT) and planting cover crops, will help to stabilise the soil and control soil erosion, further reducing land degradation. Mulching with organic materials reduces soil erosion, conserves moisture and suppresses weed growth. Additionally, establishing windbreaks or shelterbelts with fast-growing trees can protect the soil from wind erosion and create a microclimate favourable for crop and tree establishment. Implementing these soil preparation and conservation practices not only rehabilitates degraded lands but also sets a strong foundation for successful agroforestry systems, promoting long-term productivity and ecological balance.

At the outset, it is advisable to use drones or satellite imagery to create orthogonal maps to assess land suitability. This approach provides accurate data and reduces the need for extensive manual work, including ground-level testing.

Social aspects should also be considered when selecting plots. The agroforestry plot should not be too far away from the workers' other activities, so as to prevent workers travelling far between the plots.
Ideally, a community plot / homegarden should be close to the workers' homes, as it is intended to provide fruits and vegetables for their own consumption.

Based on the implementation plans, the plantations finalised the planting of the additional crops in between the main tea and coconut cash crops. Due to a later start, the tea plantation finalised the implementation of the agroforestry model one year later than the coconut plantation.

Muruthenge Estate
The reason for selecting these plots was that the productivity level of the proposed agroforestry area and control plot at the start of this project were below the national average of coconut yield. Therefore, these plots were considered degraded land.

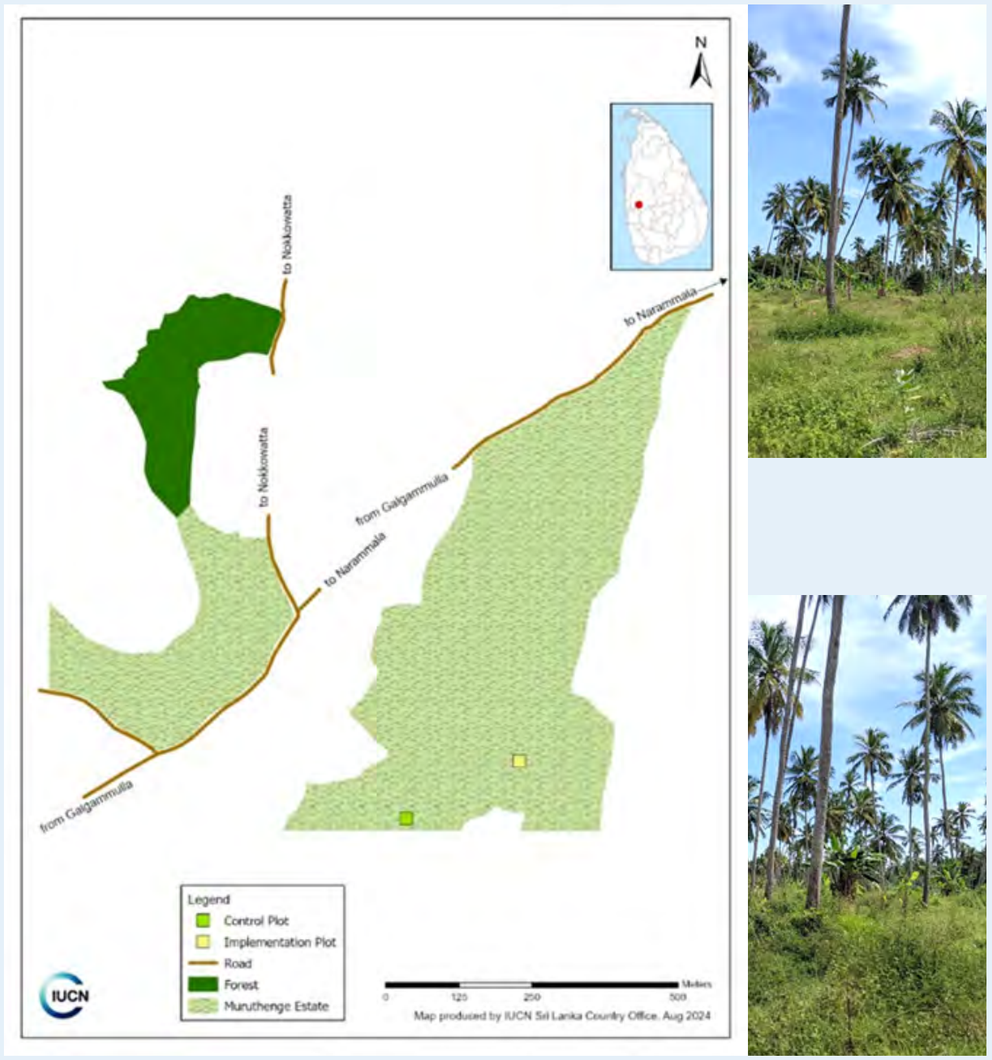


Figure 15: Layout of plantation and location of the control and experimental plots at Muruthenge Estate

Halgolla Estate
The pilot plot for the project and the selected control plot represent different baseline conditions. Whereas the agroforestry pilot plot is located in a somewhat neglected area of the estate with a low bush count, the control plot has a dense cover of tea bushes (over 75%). The control plot is located close to a forest area and has a relatively high shade density due to large trees, particularly with Albizia spp. In summary, the tea bush count, the number of plucking points and the shade tree density on the pilot plot were low as compared to the control plot.

The yield of the agroforestry pilot plot was also significantly below the yields of the control plot, as well as the plantation average. The age of the control and pilot plots of the estate are 37 and 47 years respectively.

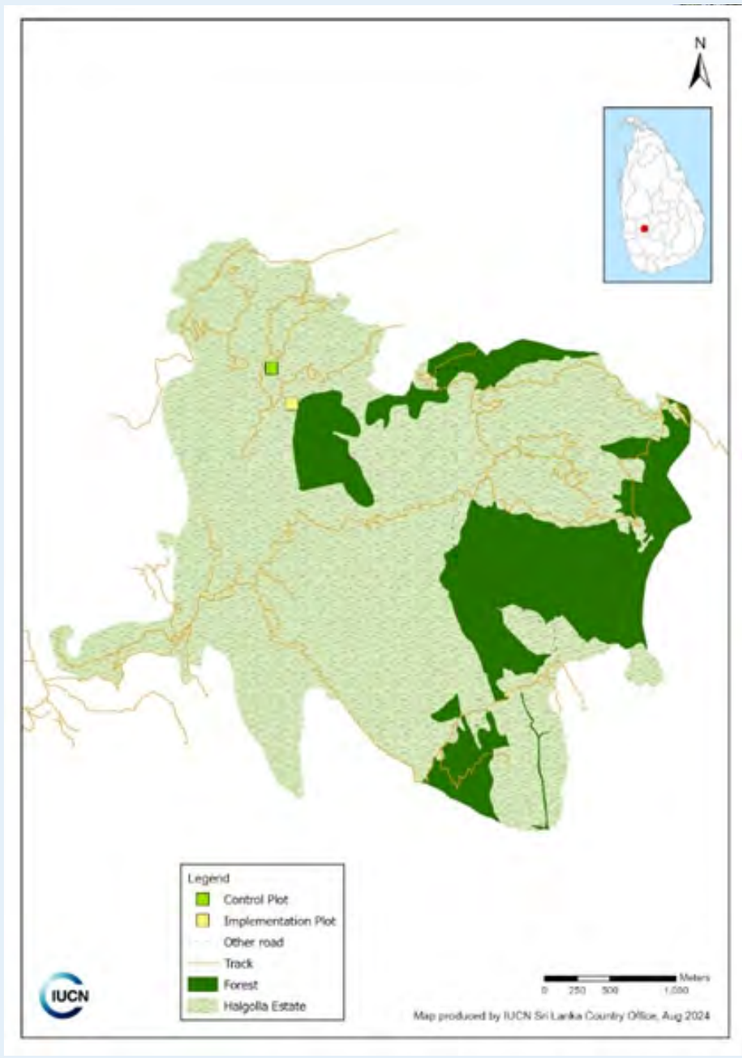


Figure 16: Halgolla Estate field layout map, implementation and control plots

THEORY PRACTICE

1.4.2 Soil sampling, preparation and conservation - Step 2

Regular soil testing is recommended to diagnose the baseline soil health conditions, inform fertilisation strategies and allow for monitoring of soil health over time. The determination of soil quality parameters such as texture, soil organic matter content, nutrient availability and soil pH will guide the application of necessary nutrient inputs (fertilisers) and amendments like lime or compost.



Picture 6: Soil sampling

Soil samples were systematically collected from multiple (16) points within each plot to ensure a representative analysis. Typically, samples were taken from a consistent depth of 10-20 cm to capture the root zone's characteristics. These samples were then bulked together to form a composite sample, which was sent to the laboratory of the Department of Soil Science at the University of Peradeniya for detailed analysis. The laboratory examined the samples for various parameters, including nutrient content (N, P, K and heavy metals), pH and organic matter. This information helped researchers to understand the level of soil fertility and degradation level, identify any deficiencies or imbalances and make data-driven decisions to enhance crop production and soil health.

Step 2 at **Muruthenge** involved preparation of the field by planting, establishing a water distribution system and seeding green manure cover crops such as mung bean, crotalaria and calapogonium. Ploughing and harrowing were carried out before seeding to allow proper establishment of the green manure cover crops. Additional mineral fertilisation was applied to stimulate early growth in the early stage of crops. This phase lasted for five months and resulted in the required soil improvement.

Step 2 at **Halgolla** involved land improvement and preparation by clearing weeds in vacant areas, renovating drainage channels and identifying contour lines with Gliricidia poles, as well as by making soil erosion barriers. This phase included soil testing. Soil was not prepared by ploughing due to the existing tea plants in the area. In identified locations, plating holes were established using a soil digger (auger). This phase lasted for two months.

1.4.3 Establishing and maintaining the agroforestry system - Step 3

As with natural forests, agroforests develop over time from a newly established (low successional) system into a more stable and mature one. Ideally, a year before introducing the targeted main crop, plantations should plant pioneer tree species adapted to full-light conditions, such as N-fixing trees (e.g., Gliricidia sepium and wild sunflower (Tithonia)). These trees will protect young seedlings of understorey crop species intended for intercrop, guard the soil against radiation and other climatic pressures and provide organic residues for soil improvement and nutrient enrichment.

In the early years of the system, the integration of short-cycle, small leguminous trees (e.g., Tephrosia and Crotalaria) or intercropping with food or cash crops, such as maize or bananas, can also provide ground cover and organic residues to improve the soil condition. Slow-growing trees that provide permanent shade (such as high-quality timber species) can be introduced in parallel. With time, management of trees such as thinning thinning or pruning will be needed to regulate shade and avoid resource competition with understorey crops.

The situation may be different in coconut agroforestry systems, as the coconut palms provide the tall canopy layer and there is a lot of space in between coconut palms where somewhat shade-tolerant harvestable crops can be planted. In the initial establishment phase, seeding of (N-fixing) cover crops is recommended for soil protection and improvement, especially in low-fertility, degraded soils.

Capacity building
Applying agroforestry on existing plantations requires different and new competences. First of all, different management, planning and communication skills are needed because more crops are involved, all of which need attention at different times.

Step 3 at **Muruthenge** involved the establishment of the agroforestry model as described in 1.3 and lasted for six months. This phase included soil testing, land preparation, removing unproductive palms and replacing them with hybrid palms (CRIC 65, CRISL 98), the planting of new crops and trees, fertilisation, weed control, pest and disease control and harvesting of coconuts.

Step 3 at **Halgolla** involved the establishment of the agroforestry model as described in 1.3 and lasted for over six months. This phase included the establishment of coffee, durian, shade trees, arecanut, pears, bee boxes, fertilisation, weed control, pest and disease control and the harvesting of tea. In addition, a census of kithul palm and potential tappers was also carried out during this period.

In addition to the agroforestry model and the social block, the stream bank protection programme was implemented, identifying the areas adjacent to the agroforestry plot and establishing a stream bank buffer zone. This area also includes the identification of available kithul palms for tapping. The management of this zone aims to promote the natural regeneration of kithul palms through proper management practices.

Capacity building
To ensure successful implementation of the agroforestry model and build the capacities of the staff of all categories, the following training sessions were and will be conducted:

"The Importance of Agroforestry for degraded coconut and tea plantations and the Agroforestry

The field officers and workers need other technical skills and more technical skills during the various phases of growth (fertilisation and harvesting), but also specialised skills for certain crops. Furthermore, a positive and understanding attitude towards agroforestry and developing leadership qualities needs to be stimulated and fostered. Therefore, it is important to develop a competency framework (in class and in field) for various levels within the plantation. This framework can be used for assessment and training purposes.



Picture 7: Training given by Prof. Pushpakumara at Dewalakanda Estate for Halgolla estate and Kalaniwaly Plantation Ltd officers

Model in Muruthenge Estate and Halgolla Estate", delivered by a researcher from UoP. This programme aimed to equip participants with knowledge and hands-on experience in agroforestry and its diverse systems. It provided a comprehensive understanding of land use systems that integrate trees with crops and/or animals on the same land unit, combining the production of multiple outputs with the protection of the resource base while incorporating sociocultural values into ecosystems. The session highlighted agroforestry's role in rejuvenating degraded coconut-tea plantations and detailed the contributions that various staff categories can make to its adoption. Participants also learned about the potential benefits – individual, collective, plantation-wide and national – of successfully implementing agroforestry practices.

"*The Importance of Land (and Soil) and Water Management in degraded coconut and tea-based Agroforestry*" was conducted by experts in land and water management from the Natural Resources Management Centre (NRMC) of the Department of Agriculture (DOA). This training provided education and practical experience in soil and water management principles within coconut and tea-based agroforestry systems and the need to integrate soil and water management in the system. It highlighted the importance of effective land and water management and detailed the roles of both staff categories in sustaining land productivity. The programme also emphasised efficient land and water management techniques and their integration into agroforestry practices.

"*Leadership and Modern Management Techniques for Successful Agroforestry Model Implementation*" was conducted at Halgolla by a human resource development expert. It will also be conducted at Muruthange and the Head Office of KPL. These sessions focused on embedding interpersonal and leadership qualities into the organisational value system. Participants learned how to foster a mutually consensual, employee-driven culture that supports the adoption of agroforestry as a regenerative agricultural system. This leadership-oriented training aimed to enhance the estate's organisational culture to drive the success of the agroforestry model.

"*Social skills training*" was conducted for key managers on various aspects of communication, such as the basics of communication and an introduction to various models, the competencies needed for effective communication on different levels, reflection on one's own communication style and a specific focus on agroforestry and how to tailor your agroforestry message to a specific target group.

"*Beekeeping training sessions*" to facilitate and popularise the area and raise stakeholder awareness at Halgolla were conducted in collaboration with the University of Moratuwa.

"*Kithul tapping awareness sessions*" aimed at providing an additional income source were launched at Halgolla in partnership with the Divisional Secretariat Office of Yatiyanthota and the VIDATHA Center of Yatiyantota. This will repeat at Muruthenge.

"*Principles and practices of plant and tree management (other than tea) for optimum yield under agroforestry*" will be conducted at both Halgolla and Muruthenge by experts from DOA and UoP. This programme aims to provide guidance on the selection of appropriate plants and trees, the use of quality planting materials and the application of pruning and training techniques aligned with agroforestry standards. It will emphasise sustainable production and productivity through agroforestry interventions, including tree replacement, substitution, increasing tree density and effective management of trees and crops.

The Importance of Agroforestry for degraded coconut and tea plantations and the Agroforestry Model in Muruthenge Estate and Halgolla Estate	*The Importance of Land (and Soil) and Water Management in degraded coconut and tea-based Agroforestry*	*Leadership and Modern Management Techniques for Successful Agroforestry Model Implementation*
Social skills training	*Beekeeping training sessions*	*Kithul tapping awareness sessions*
Principles and practices of plant and tree management (other than tea) for optimum yield under agroforestry	*Principles and practices of sustainable tea and coconut plantation management through an integrated approach of P & D and weed control and nutrient management*	*Effective Communication Skills Development for Agroforestry*
Importance of IT Skills and Sustainable Knowledge/data management for successful Agroforestry and way forward	*Application of ESG/ Sustainability Framework For Agroforestry Way forward And Innovative Marketing Approaches For Agroforestry Product Development, Branding And International/ Potential Marketing Approaches*	*System thinking and natural resource conservation and management in tea and coconut-based agroforestry systems for sustainability*
Good Agricultural Practices (GAP) in tea and coconut plantations		

Figure 17: Overview conducted training sessions

"*Principles and practices of sustainable tea and coconut plantation management through an integrated approach of P & D and weed control and nutrient management*" will be conducted at Halgolla and Muruthenge by an expert from TRI and CRI. This programme aims to deliver comprehensive guidance on managing tea and coconut plantations by integrating pest and disease control, weed management and nutrient optimisation. The focus will be on achieving sustainable production within the tea and coconut agroforestry model by fostering synergy among its components.

"*Effective Communication Skills Development for Agroforestry*" will be conducted by an expert on communication from UoP. This programme aims to equip participants with the communication skills necessary to effectively translate agroforestry knowledge into practical applications at the estate level, bridging communication gaps. Furthermore, it focuses on enhancing participants' communication abilities as part of a broader effort to develop soft skills, enabling more informed and effective decision-making in plantation management.

"*Importance of IT Skills and Sustainable Knowledge/data management for successful Agroforestry and way forward*" will be conducted by an expert from IT field from UoP/Private Sector in both estates. The program aims to explore the applications of necessary IT/ MIS skills for proper implementation and management of Agroforestry related data/ information and to introduce sustainable knowledge management strategies and big-data management for effective decision-making process in relation to sustainability of Agroforestry models in plantation landscape.

"*Good Agricultural Practices (GAP) in tea and coconut plantations*" will be carried out by expert in the DOA for both plantations. GAP training promotes the adoption of environmentally friendly practices, enhancing soil health, water management, and biodiversity conservation. It also helps in improving yield quality and quantity while reducing input costs through optimized use of resources. GAP compliance ensures food safety, meeting international standards and market requirements, which is vital for accessing premium markets. It also improves worker safety and welfare by promoting safe handling of agrochemicals and efficient management systems. By integrating GAP into daily operations, plantations can achieve long-term productivity, reduce environmental impacts, and strengthen their competitive advantage in both domestic and global markets. Training is the foundation for this transformation, equipping workers and managers with the knowledge and skills to implement GAP effectively.

"*Application of ESG/ Sustainability Framework For Agroforestry Way forward And Innovative Marketing Approaches For Agroforestry Product Development, Branding And International/ Potential Marketing Approaches*" will be conducted by and expert on sustainability and branding from private sector. The program aims to explore the new knowledge on emerging trends, needs and opportunities in application of ESG/ Sustainability strategies, reporting and global guidelines on sustainability framework related to the concepts such as Agroforestry and to introduce sustainable market opportunities, brand development, certifications and concept of marketing approaches for Agroforestry based products, potential market approaches.

Finally, "*System thinking and natural resource conservation and management in tea and coconut-based agroforestry systems for sustainability*" will be conducted by an experts from UoP, Government and Private Sector in both plantations. The program aims to explore the applications of systems thinking and how the conservation and management of natural resources within tea and coconut estates can bolster agroforestry practices and contribute to the sustainability of tea and coconut plantations.

THEORY PRACTICE

1.4.4 Management of the agroforestry model - Step 4

Management of trees and water

Although agroforestry can help to improve water management by enhancing soil moisture retention, reducing soil erosion and runoff, complementary measures may be needed to optimise the efficient use of water and minimise water-related stress. Different complementary techniques offer varying benefits and drawbacks. For instance, drip irrigation provides precise water delivery to the root zones of plants, reducing water waste and evaporation losses, but it can be expensive to install and maintain. Rainwater harvesting by means of building mini check dams, contour drains, deep locks and spills, tanks and reservoirs captures and stores rainwater for later use, which is cost-effective and sustainable, but its efficiency depends on local rainfall patterns and storage capacity. Mulching helps to retain soil moisture and reduce weed growth, but it requires regular replenishment and can attract pests if not managed properly. Contour farming and terracing slow down water runoff, enhancing water infiltration and reducing soil erosion, but these methods may involve significant labour and initial setup costs. Effective water management in agroforestry systems ensures a reliable water supply for diverse plant and animal species and enhances the system's resilience to drought and climate variability, promoting long-term sustainability and productivity.

Managing trees in an agroforestry system is crucial for maintaining a balanced and productive environment. Training of the plants and regular pruning and thinning are essential practices to control the growth of trees, ensuring they do not overshadow crops or compete excessively for nutrients and water. Appropriate combination and management of trees is possible with tree replacement, substitution, increasing numbers and management of trees. Weeding is also essential in the early stage of trees. These practices also help maintain the desired shape and structure of the plants, promoting better air circulation and reducing the risk of disease and stimulating flowering in fruit trees. Additionally, periodic fertilisation and pest management are necessary to maintain plant health and productivity. By carefully managing trees, plantations can optimise the benefits of agroforestry, including improved soil fertility, enhanced biodiversity and increased crop yields. Coconut trees are not managed, as they are a monocotyledon plant, but tea bushes need pruning to maintain the plucking table and maintain plants in the continuous vegetative phase.

Muruthenge Estate

Step 4 at Muruthenge comprised the management of the agroforestry model and the harvesting of products, which lasted for 13-36 months. This involved establishing drip irrigation (only for pepper) and fertigation of coconut, pruning of cinnamon and annona, weed control, pest and disease management, management of jackfruit plants, harvesting (coconut, cinnamon, annona fruit, pepper, passion fruit and banana and buthsarana from the social block) and soil testing.

The rainfall pattern is biomodal. In the rainy season, a recharge of the well occurs so that water is available for supplementary irrigation during the dry season. The March-April and July-August periods can have serious drought conditions and seasons are becoming increasingly unpredictable. Although the tall variety of coconut is quite resistant to water stress, drought does reduce the yields that will be expressed eight to 12 months later (coconut takes about 12 months to mature after fertilisation). Supplementary irrigation is therefore important, but the availability of irrigation water (from the well) is diminishing. Moreover, energy use for irrigation represents a cost. Energy could be replaced by solar system to reduce costs and carbon footprint. Weeds were removed manually, incurring extra labour costs. In the case of cinnamon, the complete clearing of vegetation resulted in increased soil erosion and the emergence of weed infestations. Therefore, these blocks have been thatched with coconut leaf mulch to stop soil erosion when the ground is exposed. Other areas are being slashed with bush cutters and tractors and there is no exposure of bare land to erosion. The only erosion is water runoff on the land due to unexpected excessive rains.

The survival of infilling was 100% due to the addition of new genetic resources of CRIC 65, CRISL 2020, Kapruwana and Kapsetha varieties. The survival of cinnamon plants was 91% with a mixture of genetic resources, and the survival of annona was 80%, whereas pepper, pineapple, banana and passion fruit survival rates were 45%, 57%, 94% and 90% respectively. Jackfruit survival was 76% with varieties of gini waraka and local varieties. The survival rates of kumbuk, teak and mahogany are also substantial. In the social block, canna survived well, but colocasia was damaged by wild boar.

White cloth barriers were deployed as a deterrent to prevent wild boars from damaging yam and pineapple crops (see pictures below). Some of the newly planted crops were protected from animals by wooden poles. Plants that did not survive needed to be resupplied. Dry coconut fronds and husks were used to keep the soil around coconut plants and in cinnamon blocks covered and reduce evaporation.



Picture 8: White cloth next to pineapple and drip irrigation for pepper



Picture 9: Passion fruit



Picture 10: Cinnamon in between coconut with dry coconut leaves protecting the soil as a mulch



Picture 11: Jackfruit plant with protection



Picture 12: Coconut plantation

Mechanisation

Mechanisation in an agroforestry model involves integrating machinery and technological tools to enhance efficiency, productivity and scalability. By employing machinery for tasks such as planting, pruning, harvesting and soil preparation, farmers can manage larger areas with greater precision and less labour. Mechanised equipment reduces the time and effort required for manual labour, allowing timely operations and better crop and tree management. For example, mechanised tools like tree pruners, mulches, hole diggers and intercropping planters can significantly reduce labour intensity and increase precision in farm operations. Additionally, modern machinery can incorporate advanced technologies such as AI, GPS, sprinkler or drip irrigation systems and sensors to measure and apply irrigation or sensors to keep wild animals away, improving resource management by optimising inputs like water and fertilisers. This precision agriculture approach minimises waste and environmental impact while maximising yields. Mechanisation also facilitates the integration of multiple components in agroforestry systems, such as trees, crops and livestock, by streamlining their management and ensuring the sustainability and profitability of the system. However, the unique layout of mixed agroforestry systems, which includes a mix of trees and crops with a multistoreyed nature, requires specialised equipment for different tasks. In addition, in some instances mechanisation is limited due to the sloppy nature of the landscape and the complex structure of the system.

Halgolla Estate

Step 4 at Halgolla was the completion of planting and management of the agroforestry model by manual watering, fertiliser application, weeding and pest and disease control.

The coffee plants were still small with a height below 60 cm. In durian and pepper, the survival rate was around 70%. Arecanut and pears had a survival rate of over 90%. Six established bee boxes were performing well. A single application of inorganic fertiliser for the coffee and three cycles of manual weeding had been completed in the experimental area. The social block consisted of food, spice and masticatory items and was performing well.

The coffee plants were protected from wild animals by using a low mesh (see picture below). However, approximately 30% of the plants needed to be replaced due to an unexpected prolonged drought.



Picture 13: Coffee plants protected with white mesh



Picture 14: Honey bee box

Mechanisation

At **Muruthenge**, the plucking (harvesting) of coconut on the plantation was carried out by manual labour using long poles. Land preparation and weed management were carried out by backhoe, tractor and sprayers. Fertilizer application was done manually. The plantation also used cattle/buffalo rearing by villagers as a system of weed control. This provided a partnership with local people based on an agreement, but it proved unsuccessful due to the agroforestry model, as cattle can damage crops. Drip, sprinkler and gravity irrigation using well water was used for pepper but facilitated other crops as well.

At **Halgolla**, tea harvesting takes place manually and is primarily carried out by female workers as is conventional on tea plantations. Male workers are predominantly deployed for miscellaneous field work using equipment such as sprayers, handling tasks for land preparation, including drain and planting hole preparation using hole digger, as well as manure and input applications. Fertilizer application was done manually for all crops. Tea harvesting machines can be introduced to harvest tea and hose irrigation can be practised for coffee during the dry season. However, options for mechanization in tea are limited due to its nature and mixture of crops.

Integrated Pest Management
Integrated Pest Management (IPM) can be supported by agroforestry systems, promoting sustainability, productivity and resilience. By minimising chemical pesticide and herbicide use, IPM protects the environment and preserves soil health, fostering beneficial organisms that support plant growth. Diverse plant species in agroforestry create habitats for natural predators and beneficial insects, reducing pest populations and disease spread. Cultural practices like crop rotation and intercropping disrupt pest cycles, while biological controls leverage natural predators and biopesticides. Mechanical methods such as mulching and manual weeding suppress weeds without chemicals, and regular monitoring ensures early detection and targeted interventions. These strategies collectively enhance the health and productivity of crops and trees, reduce costs and enable access to premium markets, ultimately creating a more balanced and sustainable agroforestry system. The choice of tree vegetation introduced into the agroforestry/intercropping model must ensure that new pests and diseases are not introduced and will not be invasive and must provide nature-based solutions (NBSs) by facilitating natural enemy populations, activating a natural pest balance and pest/disease triangle and providing natural pesticides/botanicals for pest management.

1.4.5 Marketing and markt development

Conducting thorough market research is essential to identify trends, consumer preferences, pricing dynamics, and competitor activities for agroforestry products. This helps pinpoint high-potential crops and effectively position them in the market, both locally and internationally. Widely used model is the Porter's value chain model.
Marketing planning, a critical part of the business process, involves defining key choices: what to sell, where, how, and at what price. Tools like SWOT analysis can aid in this process. Successful strategies integrate branding, market positioning, and promotional activities to establish a strong market presence and differentiate products, fostering customer loyalty.
Effective marketing channels, including digital marketing, trade fairs, and efficient distribution networks, ensure products reach customers in a timely and cost-effective manner. Tailored strategies should also explore national and international opportunities, leveraging certifications, tapping into niche markets, and forming partnerships with distributors and retailers.
Depending on the target markets, the marketing strategy should be tailored to address both national and international opportunities. This might involve leveraging certifications, tapping into niche markets or developing partnerships with distributors and retailers.
To maximise income, adding value to each crop before it leaves the farm gate is advisable. This can be done through processing and packaging or branding and marketing, for example by processing raw agroforestry products into value-added goods, such as converting fruits into jams or syrups, or processing nuts into oils or butters. Quality packaging that preserves the product's quality and enhances its market appeal is also important.
Building a strong brand and highlighting the unique characteristics of your agroforestry products can also help command premium prices and gain access to specific market segments. Emphasising sustainability, quality and uniqueness will help differentiate products in the market. Targeted marketing strategies focusing on premium market segments can maximise revenue.

Certification for agroforestry
Certifications play a crucial role in ensuring that agroforestry products meet sustainability goals, enhance market access and provide consumers with confidence in the sustainability and ethical production of these goods.

Integrated Pest Management
Integrated Pest Management (IPM) on tea and coconut plantations in Sri Lanka is a sustainable approach to pest control, emphasising ecological balance and minimising chemical usage. On tea plantations, IPM strategies include regular monitoring of pest populations, biological control using natural predators and cultural practices such as shade management and pruning to reduce pest habitats. Pesticides are rarely used to control pests.

Similarly, on coconut plantations, IPM incorporates the use of pheromone traps for early pest detection, promoting natural enemies like parasitic wasps and maintaining proper sanitation to eliminate breeding sites for pests like rhinoceros beetles and black beetles. Both tea and coconut based systems prioritise ecofriendly interventions, combining biological, cultural, mechanical and minimal chemical controls to enhance productivity while preserving environmental health and ensuring long-term sustainability. Except for weed management, pesticides are rarely used to control pests on coconut plantations.

Muruthenge Estate
Kurunegala Plantations is a renowned agricultural company based in Sri Lanka, dedicated to sustainable farming through agroforestry and product diversification and producing high-quality, ecofriendly food products. Its marketing strategy focuses on targeting local markets with a strong emphasis on sustainability, quality and environmental responsibility. It aims to attract health-conscious and eco-aware consumers by highlighting its unique selling propositions, such as organic cultivation, adherence to fair trade practices and premium product quality.

The company plans to position its products as premium and sustainable, using clear branding and messaging that aligns with these core values. It is also considering obtaining relevant certifications, such as organic and fair trade, to enhance credibility and attract eco-conscious consumers.

Kurunegala Plantation's sales and distribution strategy focuses on enhancing an online presence through an updated website and partnerships with e-commerce platforms. It leverages digital marketing, content marketing and social media to engage consumers, share stories of sustainability and promote its products. Furthermore, the company aims to form strategic partnerships with complementary brands and establish offline sales channels through local cafes, restaurants and specialty food stores.

To support customer retention and satisfaction, Kurunegala Plantations focuses on delivering excellent customer service, implementing sustainable packaging and tracking customer feedback to continuously improve its offerings. This strategy reflects its commitment to quality, sustainability and community well-being, aiming to attract a loyal customer base that values these principles.

KPL aims to leverage the international market by introducing Ceylon cinnamon from its own plantations and innovative coconut ice cream in powdered form. This strategy overcomes the challenges of shipping frozen ice cream while capitalising on the global demand for

Here are some of the most recognised certifications applicable to agroforestry products:

- Rainforest Alliance Certification: this certification focuses on sustainable agriculture, forestry and tourism. It ensures that products are produced in ways that protect forests, improve livelihoods and promote the rights and well-being of workers and local communities. The Rainforest Alliance Certified seal is widely recognised and applies to various products, including coffee, tea, cocoa and bananas.
- Forest Garden Trainer Certification (FGTC): offered by APMG International, this certification validates an agroforestry practitioner's ability to train others in implementing Forest Garden programmes. It aims to end poverty and deforestation by promoting sustainable agroforestry practices.
- Regenerative Organic Certification (ROC): ROC encompasses farming practices that improve soil health, animal welfare and social fairness. It is applicable to various agricultural products and emphasises regenerative practices that can be integrated into agroforestry systems.
- Climate, Community & Biodiversity (CCB) Standards: managed by the Climate, Community & Biodiversity Alliance, these standards evaluate land-based climate change mitigation projects, including agroforestry, based on their benefits for the climate, local communities and biodiversity. Projects meeting these standards demonstrate significant positive impacts in these areas.
- Fair Trade certification: this certification ensures that products are produced under fair labour conditions, with equitable trade practices and fair wages. It applies to various agroforestry products, including coffee, cocoa and spices, promoting sustainable livelihoods for farmers.
- Organic certification: organic certifications, such as those provided by the USDA or the EU, ensure that products are grown without synthetic pesticides or fertilisers. Agroforestry systems often align with organic principles, making this certification relevant for such products.
- Regenagri: is a regenerative agriculture initiative aimed at securing the health of the land and the wealth of those who live on it. Agroforestry is recognized as a form of regenerative agriculture.

When selecting a certification, it is essential to consider the specific goals of the agroforestry project, the target market and the standards required by each market. Aligning with recognised certifications can enhance market access and consumer trust in agroforestry products.



Picture 16: Halgolla new agroforestry products

unique, tropical flavours. Powdered ice cream offers convenience, longer shelf life, and reduced logistical challenges. Powdered form also reduces costs associated with refrigeration during shipping. This strategy combines Sri Lanka's iconic cinnamon and coconut flavors, targeting health-conscious consumers and premium dessert markets. Certifications for these products will depend on market requirements.



Picture 15: KPL farm gate outlet store

Halgolla Estate

Halgolla, recognised as the world's first tea estate to receive the regenagri certification, is part of Hayleys Plantations. This prestigious certification signifies a commitment to agricultural sustainability, acknowledging estates that implement regenerative farming practices aimed at enhancing soil health, fostering biodiversity and promoting overall environmental sustainability. With the regenagri certification, in addition to other prominent sustainability certifications like Fair Trade, Organic and Rainforest Alliance, Halgolla and Hayleys Plantations have a distinctive opportunity to market their products at premium prices. To fully capitalise on these certifications, Halgolla Estate can effectively showcase its regenerative farming practices by positioning the regenagri certification as a compelling unique selling proposition (USP). By focusing on eco-conscious consumers and penetrating specialty markets – particularly within the premium food and beverage sector – the estate can attract higher-value customers. Furthermore, employing premium branding and eco-labelling that prominently features the regenagri certification along with other sustainability seals will help build consumer trust and highlight the value of sustainably produced goods .

In the context of evolving consumer habits, particularly the growing shift towards healthier lifestyles, there is a significant opportunity to promote agroforestry products like Kithul jaggery or treacle as part of this trend. As more individuals embrace health-conscious choices, Kithul products offer a unique selling point due to their natural, nutrient-rich properties and low glycemic index. These products are not only human-friendly but also provide a healthier alternative to refined sugars commonly used in beverages. Promoting Kithul jaggery as a healthier option for sweetening tea can, therefore, align perfectly with the shift towards healthier eating and drinking habits. By leveraging the rising interest in sustainable and health-oriented products, Kithul products can be positioned as a new, trendy habit—encouraging consumers to "Drink Tea with Kithul Jaggery" for a refreshing, healthier lifestyle choice.

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1.4.6 International market and exports

Even though commodity markets are structured globally, not every participant needs to engage directly in export or imports. The export and import functions are performed by specialised firms bridging supply and demand across borders. Important assets of such companies are trading skills, cultural awareness, market knowledge and finance. Tea and coconut plantations in this pilot, for example, do not act as exporters, but they do participate in export value chains as producers and processors.

Differentiated markets

Agricultural products may be commodities, but they are not all the same. Buyers value some types, flavours or specifications more than others, leading to a differentiation of these markets (and a premium for small products compared to a baseline). Tea and coffee are prime examples of highly differentiated (commodity) markets, whereas edible oils show far less differentiation, partly because they undergo further processing (refining, separating, blending) and partly because they are used as ingredients in composite products. Spices are also primarily used as ingredients in composite products, where they become 'anonymous', which limits market differentiation. Which specific aspects of the product and production process define the differentiation depends on the specific market, buyer and consumer preferences. In general terms, these aspects can be grouped as product quality, food safety and, increasingly, 'sustainability'. The claim 'products from agroforestry' can theoretically also be a differentiating aspect, but only if buyers are willing to pay extra for it. In practice, commodity buyers will be likely to request certification based on established standards rather than accepting individual claims from companies. Such individual claims will be hard to evaluate and then further promote in their markets, which is why standards are being developed.

The export marketing process

When marketing planning is concluded, the implementation of the export marketing effort comprises two steps:

1. Export capacity building. This means preparing all aspects of the marketing mix: product (presentation, quality, packaging, food safety certification), pricing (as price taker, sellers need to know the market price and how to relate to it), distribution (being able to contract domestic and international transport services and knowing their prices and options) and promotion (brochure, price lists, product specifications). Obviously, sales and marketing staff need to be hired and trading skills need to be learned as well.
2. The actual selling and marketing. This includes engaging with customers, giving out orders, solving problems and complaints, organising logistics, participating in trade fairs, sending out marketing mailings, updating the website and social media.

Specialised consultants and platforms are available to help new exporters, or experienced exporters entering new markets. Useful hubs include the Dutch CBI's market information portal for SME exporters in developing countries, the UN's International Trade Centre statistics database ITC Trade map and the EU access to markets helpdesk.

In the advisory talks with KPL and KVPL, opportunities have been identified, although the extent of the opportunities requires further research. Opportunities for consumer-packed agroforestry products were:

- Gift market in Sri Lanka: domestic (foreign and national tourists, expats and other persons looking for gifts). Points of sale include boutique shops, hotels, restaurants, tourist venues, airports, embassies and airlines.
- Gift/gourmet market abroad, with a focus on Sri Lankan heritage and special product taste and flavour. Factors to consider when choosing the most promising markets are: countries with most tourists visiting Sri Lanka; countries with close links to Sri Lanka and countries with the largest Sri Lankan community. Points of sale include shops and web shops used by the target group (with link to Sri Lanka). A specialised gift web shop is Etsy.com. The main overall web shop in Western countries is Amazon.

Success in e-commerce requires an attractive brand and active promotion using social media.

Export opportunities for the agroforestry products of KPL and KVPL offered as raw materials:

- Specialty coffees (green beans of commerce). Quantities range from micro lots (up to several hundred kg) to full container loads (about 20 tons). It is important to know how to position the coffee (based on the quality cupping score). Find buyers accordingly. Probably a minimum quantity is needed to pay for the marketing efforts.
- Spices have a ready market. Production, processing and export marketing each require investments. To compensate for the export marketing effort, sufficient export quality is needed. Requirements in terms of quality and food safety are constantly increasing in export markets. Western buyers tend to work with fewer exporters who can properly manage these requirements and their supply chains. If the quantities are small or investing in export marketing is not possible, the plantations should consider selling to local consolidators or exporters (indirect export).
- Coconut products. Sri Lanka is one of the global hubs for these products. There are many options for indirect exports. As for direct exports, many export companies are already competing abroad. Consider whether the plantations wants to participate in that game. Also consider that the markets for edible oils, desiccated coconut and canned coconut products are different (with different buyers abroad).
- Others: fresh fruit exports are worth considering, and they come with specific requirements with regard to volume, quality and logistics (cold chain). Dried fruit exports could also be considered, and they have their own requirements. In both cases, there is competition with similar producers globally.

When setting the strategy, it is important to note that every product group mentioned above is traded in a different market (constitutes a different product-market combination). For each PMC, a specific marketing effort will need to be made. This means that the exporter will need to engage with different buyers and get acquainted with different standards and practices. That is a substantial effort; for most export markets it will take several years before a newcomer is up to speed.

Once the tea and coconut-based agroforestry models are developed to a substantial level, and the proportion of their plantations identified as agroforestry-based systems, both KPL and KVPL can leverage this classification to brand their products as agroforestry products, presenting a promising opportunity for future marketing strategies.

1.5 Monitoring and evaluation

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As the effects of an agroforestry system can only be fully observed in the long term, it is important that plantations determine short-, medium-, and long-term goals. Developing a monitoring framework helps keep track of progress and enables plantations to monitor both qualitative and quantitative outcomes. In order to monitor specific indicators, record keeping is crucial. The goals will most likely be adjusted over time during the implementation of the agroforestry model as lessons are learned, enabling plantations to define more realistic goals.

This chapter provides a description of the qualitative and quantitative results of the pilot projects with regard to the agroecological, social and economic aspects. In general, it can be concluded that the project was too short to show extensive quantitative effects on these three aspects. Nevertheless, the project did already achieve important qualitative effects on all three aspects. At the beginning of the project, both plantations developed short-, medium-, and long-term goals, outcomes and indicators for agroecological, social and economic aspects. The short term was considered to be within three years (the duration of the project), the medium term was three to seven years and the long term was more than seven years. These goals, outcomes and indicators were developed in a participatory process (discussions within the project team and pilot plantations) and adjusted along the way.

1.5.1 Agroecological: Potential for improved biodiversity and soil health

An indicator framework was developed by the project team to guide the monitoring of progress and outcomes with regard to agroecological aspects of the implemented agroforestry model (Table 3).

The short-term goal for agroecology was to achieve "*a measurable effect on biodiversity (crop, tree and wild biodiversity) and soil health (especially soil cover, OM inputs, nutrient cycling) and to use water and agrochemical inputs more efficiently.*" [1] Several measurable indicators were achieved by the plantations during the project such as increased diversity of crops and woody species, and planting of cover crops. The project was too short to measure the desired outcomes of these practices such as biodiversity, carbon storage in the soil, and improved soil health. Additionally, more efficient use of inputs will take more time to be realised. However, due to the successful implementation of the agroforestry projects on both plantations, these effects are expected to materialise in the coming years.

Most of these agroecological indicators were assessed before and after implementation of the agroforestry models, and additionally through comparison of the pilot plot with a control plot on the same plantation. Ideally, the control and pilot plots were selected for their comparable crop, soil and terrain conditions, as was the case on Muruthenge, but this was more difficult to achieve in Halgolla. On the control plot, existing management practices were continued. Each plot measured 20 m x 20 m. Within each plot, two sub-plots of 5 m x 5 m were designated for seedling data collection, and four sub-sub plots of 1m x 1m were designated for data collection on grasses (Figure 18). Soil samples were collected from the four corners and the center of the area, each taken at a depth of 15 cm. These samples were combined into a composite sample for analysis.

1 The medium-term goal is: The plantation continues to show further improvements in soil health including soil carbon storage. Above and belowground carbon stocks will have increased and net GHG emissions reduced. The use of external inputs (fertilizers, biocides) will be decreased. Abundance and biodiversity insects, birds and small mammals including pollinators and natural pest control species have improved. The long-term goal is: Doubling or tripling of the area with agroforestry systems. This leads to further improvements in above and belowground carbon storage and biodiversity at plantation level and positively affects water use and water quality.

Short-term goal	
Implementation of the AF model leads to a measurable effect on biodiversity (crop, tree and wild biodiversity) and soil health (especially soil cover, OM inputs, nutrient cycling). Water and agrochemical inputs will be used more efficiently.	
Outcomes (out of Theory of Change)	**Indicator**
1.1 Improved biodiversity (crops, trees and wild biodiversity)	1.1.1 Nr of crops and varieties succesfully established/introduced 1.1.2 Abundance and diversity of woody species succesfully established/introduced 1.1.3 Canopy layer 1.1.4 Abundance and diversity of (beneficial/harmful) wild floral and animal species
1.2 Carbon storage	1.2.1 Carbon storage in trees (including belowground storage) 1.2.2 Soil carbon stocks
1.3 Improved soil health (soil cover, soil macrofauna, OM inuts and nutrient cycling)	1.3.1 Proportion of area with permanent soil cover/cover crops 1.3.2 Organic C content of the top soil layer 1.3.3 Chemical soil properties (pH,EC,CEC,nutrients,metals) 1.3.4 Biologiscal soil properties (soil macrofauna) 1.3.5 Physical soil properties
1.4 More efficient use of inputs (water, fertilizers, pesticides)	1.4.1 Crop yields 1.4.2 Use and type of fertilizers and pesticides 1.4.3 Incidence of pests and diseases (including damage by wild animals) and natural enemies of crop pests 1.4.4 Irrigation water use and water productivity (not aplicable to tea plantation)

Table 4: Monitoring framework for agroecological component

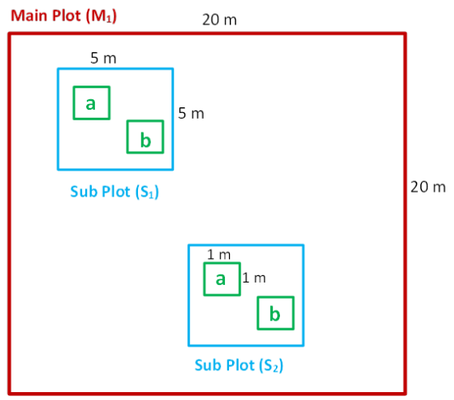


Figure 18: Layout of the experimental plot established on the two pilot plantations

Muruthenge Estate

The findings of the present study in Muruthenge indicate that the agroforestry pilot area (112 palms/ha) and the control plot (110 palms/ha) have similar palm density, with the soil pH of the control plot being more acidic (4.96) than the pilot plot (5.80). The soil organic carbon percentage is higher on the control plot (1.82%) than on the pilot plot (1.42%). Both sites are poor in terms of total nitrogen (0.26-0.27%). Available phosphorus, potassium and magnesium are higher on the pilot plot than on the control plot, possibly due to accumulation of nutrients in a valley area. Although heavy metals such as cadmium have not been detected on either site, lead has been detected on the control site. The entire area of the KPL-Muruthenge Division DAE was previously managed as an organic field and abandoned about five or six years ago. During that period, poultry manure and other compost was used to an adequate extent. The growing of cover crops improved the soil organic matter and nutrient contents, especially nitrogen, by 25% and 12% respectively.

The diversity of crop species in the pilot plot has increased from a single species (coconut) to eight species, including four tree species. The genetic diversity of coconut has expanded from two to four varieties. While measured soil properties have not shown significant changes yet, slight improvements in organic carbon and nitrogen levels have been detected. Crop yields have shown an increasing trend, though not statistically significant at this stage. Fertilizer use has increased due to the establishment of new crops; however, no pesticide usage has been observed. Pest and disease incidences remain insignificant in both the pilot and control plots. In the community block, species diversity has increased from none to two species.

Biodiversity

A total of 18 plant species were recorded at the agroforestry implementation site and 11 plant species at the control plot at Muruthenge during the 2022 baseline survey. A total of 71 plant species were recorded at the agroforestry implementation site and 53 plant species at the control plot at Muruthenge during the 2025 biodiversity monitoring survey.

A total of 23 animal species were recorded at Muruthenge during the 2022 baseline survey. A total of 70 animal species were recorded at the agroforestry implementation site and 64 animal species at the control plot at Muruthenge during the 2025 biodiversity monitoring survey.

Halgolla Estate

The findings of the present study indicate that the agroforestry pilot plot has acidic soil (pH 5.16), although it is less acidic compared to the control plot (pH 4.80). Soil organic carbon levels are higher on the control plot (1.67%) than on the pilot plot (1.49%), probably due to the presence of more shade trees on the control plot and its proximity to the forest area. Total nitrogen (0.17%) and available phosphorus (6.81%) levels are lower on the pilot plot compared to the control plot (0.20% and 7.23% respectively), possibly due to fertiliser application and the higher organic matter content on the control plot. No heavy metals were detected on either the control or pilot plot.

The diversity of crop species in the pilot plot has increased from two species (tea and shade trees) to six species, all of which are tree species. The genetic diversity of tea has remained unchanged. Now, the pilot area also present with honey bee colonies. While measured soil properties have not shown significant changes so far, better improvements in organic carbon and nitrogen levels have been observed. Tea crop yields have exhibited an upward trend, though not yet statistically significant. Fertilizer use has increased due to the establishment of new crops, but no pesticide usage has been recorded. Pest and disease incidences have remained insignificant in both the pilot and control plots. In the community block, species diversity has grown significantly, increasing from none to ten species.

Biodiversity

A total of 26 plant species were recorded from the agroforestry implementation plot and 24 plant species from the control plot at Halgolla during the 2023 baseline survey. A total of 86 plant species were recorded from the implementation plot and 85 from the control plot at Halgolla during the 2025 biodiversity monitoring survey.

A total of 59 animal species were recorded from the agroforestry implementation site and 42 species from the control plots at Halgolla during the 2023 baseline survey. A total of 66 animal species were recorded from the agroforestry implementation site and 52 species from the control plot at Halgolla during the 2025 biodiversity monitoring survey.

The total species counts have increased at both Muruthenge Estate (from 2022 to 2025) and Halgolla Estate (from 2023 to 2025) in the agroforestry implementation and control sites. However, these changes may not be directly attributable to the agroforestry implementation. The increase in species in the control sites could also be influenced by climate and physical factors. For example, weeding did not occur in the control sites, but it did in the implementation sites due to planting activities. Therefore, long-term monitoring is essential to accurately assess the impact of the agroforestry project on biodiversity.

1.5.2 Social: Potential for improved wages, living conditions and capacity building

The short-term goal for social component was to "*bring living wages to plantation workers and sustainable human care practices to the workers and their families in the neighbouring communities where they live, implement capacity building through training to increase the competences of the workers and their value to the plantation.*"[2] It can be concluded that this goal was partially achieved, as providing living wages was not feasible during the project, but human care practices were improved and the competences of workers and their value to the plantation were increased through capacity building on various topics, both technical as well as behavioural, and for various staff categories. These trainings were of real added value in increasing awareness of agroforestry in terms of 'why' and 'how'.

In relation to the financial position of the workers (indicator 1.1), throughout the project period it became clear that living wages or salary increases were not feasible within the duration of this project for several reasons. First, the size of the plot was too small and the labour too limited, so increasing salaries was not realistic. Second, the number of hours spent on the agroforestry plot were not monitored separately, so no analysis could be made of the workload of the agroforestry plot versus the control plot. Finally, a better rationale should be developed as to why the financial position of workers should be improved solely as part of agroforestry.

At the beginning of the project, the project team expected that an increase in income for the plantation would automatically result in an increase in the income of workers. However, despite the additional complementary revenue streams, no increase in income for the plantation has yet been demonstrated. At Muruthenge, salaries did increase, as this was decided upon by the national government, since the salaries were found to be too low. Muruthange has already implemented this increase, even though the increase was not due to take place until the next year. Furthermore, on both plantations, in-kind benefits were provided (coconut and community plot), which did influence the buying power of the workers positively. Finally, in terms of income, Halgolla started experimenting with different ways of contracting, such as the revenue sharing model[3] , direct contracting[4] and target-fee models[5] to see what would work best for the agroforestry plot.

Besides salaries, non-monetary benefits should not be forgotten. Aspects such as happiness level, safety, dignity, collaboration and sense of belonging are at least as important for workers. Dignity was particularly important for tea workers. For example, the tea plantation has been their source of livelihood for generations. It is their identity. At the same time, some workers found that being a tea plucker has a low status, that there is no pride in it. Agroforestry could be used to 'rebrand' the value of being a tea worker. The older generation is generally very loyal to the plantations. Even though they might not be happy with the salary, they will still work, as they see it as their duty. At the same time, some managers or field officers seemed to regard the older generation as unwilling to learn new skills such as cinnamon carving or financial literacy. Investing in the older generation and attracting young workers to the plantation could be a way to diversify the labour force.

With regard to the working and living conditions of workers and their families (indicator 1.2), a welfare team is present at Halgolla with a specific female welfare worker who advises workers (especially women) on health and wellbeing and is also closely connected to the surrounding communities. She noticed the

Short-term goal	
Agroforestry pilot initiative brings living wages to plantation workers and sustainable human care practices to the workers and their families in the neighbouring communities where they live. Furthermore, capacity development through training is implemented to increase the competences of the workers and their value to the plantation.	
Outcomes (out of Theory of Change)	**Indicator**
1.1 Improved financial position of workers	1.1.1 No. of workers (%) with a living wage or higher 1.1.2 Increased income for workers through carbon credit scheme 1.1.3 Increased animal fodder for worker community through CO_3 production
1.2 Improved working and living conditions of workers and their families (quality of life and of work life)	1.2.1 Sustainable human care practices for workers are present and implemented 1.2.2 Sustainable human care practices for worker families are present and implemented
1.3 Improved capacities of the workers (includes knowledge, skills and attitude)	1.3.1 Capacity development activities (both workers and other actors) are in line with the HR plan 1.3.2 Sustainable knowledge management practices are in place 1.3.3 Revised HR plan and approach

Table 5: Monitoring framework for social component

2 The medium-term goal is: The availability of jobs and positions on the plantation have increased. At the same time management continues to safeguard and improve the labor, welfare and learning conditions of the employees on the plantation. So that working at a plantation has become very attractive for non-plantation workers. The long-term goal is: Plantation employees engage in well paid positions on the plantation whereas sustainable human care practices and knowledge management practices are applied. Working at a plantation is rightfully appreciated by society as a means for sustainable economic growth for the nation

3 Revenue sharing model: workers receive a certain percentage of the profit from what they produce and have a fixed plot of land to work on. The estate provides all the inputs they need. This model is still in a pilot phase.

4 Direct contracting: mainly used for workers outside the estate who have special skills and are hired for a fixed salary per day with a clear target.

5 Target-fee model: workers get a daily wage and have a target per day in terms of workload. They are paid a monthly salary. For the tea plantation, the target is 20 kg tea/day and for the coconut estate the targets are more flexible.

agroforestry practices in the surrounding communities. At Muruthenge, there is no welfare worker nor any HR person who could explain changes in HR conditions or salary slips, despite the importance of having such a person on the estate. Other items relating to working conditions such as the use of Personal Protection Equipment (PPE), appropriate sanitation facilities, access to medical aid or support, access to water and proper facilities for taking breaks did not change as a result of the agroforestry model. During the project period, a new restroom building was constructed at Muruthenge that better meets the needs of the workers.

Finally, regarding the capacities of the workers (indicator 1.3), various capacity-building activities were executed for various staff levels in relation to agroforestry to ensure that they had the right skills to implement and manage the agroforestry model (Section 1.3). Additionally, a competency framework was developed for three positions within the plantation (Section 1.3.6) to help monitor the capacity development of employees. Workers represent 93% of the workforce, so capacity building for this group is key. However, the potential of the workers is underestimated by the management, field officers and the workers, so it is important to change this perception and use the competency framework to improve and monitor workers' capacities.

1.5.3 Economic: potential for improved land productivity and income diversification

The short-term goal for the economic aspect was that the "*Plantation implements the concept of agroforestry in the pilot site as a mechanism to improve land productivity and income diversification.*"[6] which was partly achieved. The plantation has established an agroforestry plot, and the first products have been harvested and sold. The income diversification during the project period could not be accurately measured due to adverse weather conditions in previous years, which significantly hampered plant growth. However, based on the current crop growth and available data, there is a strong likelihood that the goals will be achieved in the future. Regarding the improvement of land productivity, it is still too early to provide concrete figures, but there is a strong expectation that this effect will materialize in the coming years.

The actual on-ground analysis of expenditure is given in Figure 19 for the **Muruthenge Estate** for the year 2023. This document is updated on a monthly basis and the format currently used by the estate is sufficiently detailed for analysis. The estate has a detailed expenditure and activity breakdown for different agricultural and plantation activities from December 2022 to December 2023. Based on this table, it has records for various tasks and costs associated with the planting, maintaining and harvesting of multiple crops such as cinnamon, banana, passion fruit and jackfruit. The main expense categories include:

- Planting & Land Preparation: this involved costs for seeds, seedlings, fertilisers and labour for planting. Expenditures peak during significant planting periods, such as in June 2023.
- Weeding & Irrigation: regular maintenance costs, including man-days for weeding and irrigation, which are consistently high in active months like June and August 2023.
- Pest & Disease Control: periodic spending on pesticides, such as carbosulfan and profenofos, with notable expenses in September and December 2023.
- Materials for infrastructure: this includes water pipes, fittings, fuel for transport and construction materials for sheds and boundary structures.

Some preliminary conclusions:

- Coconut seedlings (C-Seedling) shows high costs for land preparation and mulching.
- Cinnamon has significant expenses in land preparation and planting.
- Banana has notable land preparation and planting costs.
- Pepper incurs high expenses in irrigation and weeding.

6 The medium-term goal is: Plantation reaches a sustainable and additional but resilient income source through the introduction of agroforestry. The long-term goals are: 1. The plantation management is encouraged to make further investments in future business and other plantations implementing the piloted agroforestry model as a sustainable and resilient business model. 2. Plantations to identify and utilize untapped income-generating resources to enhance productivity and drive economic upliftment. 3. Increase in land and labour productivity in the coconut based agroforestry systems.

Short-term goal	
Plantation implements the concept of agroforestry in the pilot site as a mechanism to improve land productivity and income diversification.	
Outcomes (out of Theory of Change)	**Indicator**
1.1 Diversified income streams for plantations through high-value intercropping	1.1.1 Percentage increase in revenue attributed to high-value intercrops (e.g., spices, fruits, timber). 1.1.2 Number of diversified crop varieties cultivated successfully within the agroforestry system 1.1.3 Net present value (NPV) and internal rate of return (IRR) of pilot agroforestry projects.
1.2 Enhanced financial sustainability through ancillary projects	1.2.1 Revenue generated from ancillary projects (e.g., biochar production, kithul tapping). 1.2.2 Percentage reduction in operating costs due to ancillary income sources.
1.3 Improved access to markets for diversified products	1.3.1 Number of new market linkages established for agroforestry products. 1.3.2 Percentage of products sold at premium prices due to certifications (e.g., regenagri). 1.3.3 Volume of value-added agroforestry products

Table 6: Monitoring framework economic component short-term

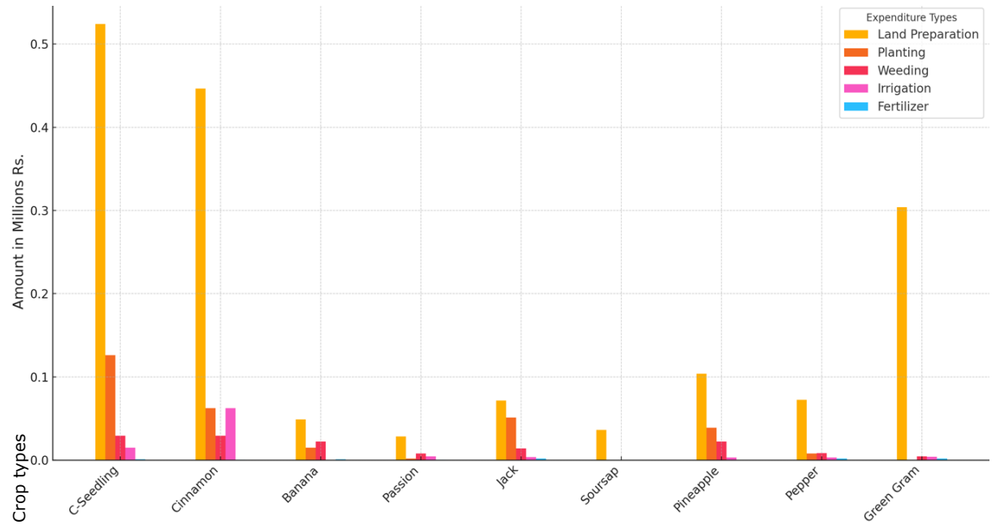


Figure 19: Expenditure patterns for different crops at Muruthenge Estate 2023 in LKR

The volatility of market prices (pepper, turmeric) reinforces the importance of agroforestry, as plantations can better spread the risks of depending on one crop by diversifying their income over several different crops.

Although revenue data was not currently available, comparing each crop's costs with its corresponding revenue will help in assessing profitability. Identifying the crops yielding the highest ROI will inform future planning and investments. Revenue figures, particularly from passion fruit starting in 2024, will be included in future reports.

Regarding **Halgolla Estate**, it can be concluded that plant procurement and transport were the largest costs. Efficiency in sourcing and logistics could reduce expenses. Weeding and preparation (holling & pegging) also consume a significant portion; exploring mechanization or alternative methods could improve cost-efficiency. Training workers to use tools effectively or optimizing task allocation may also help reduce time and labour costs. Categories such as roads, shading materials transport, and small-scale plant purchases appear to be optimized for costs. General charges account for 8.8% of the total costs which may include overhead or administrative expenses. Detailed tracking could identify savings opportunities.

Some preliminary conclusions:
- Durian has the highest plant and transport cost.
- Coffee follows with the second highest plant and transport cost.
- Land Preparation: uniform cost for each crop block.
- Weeding: highest costs for coffee, followed by durian.
- Bee-keeping incurs specialized costs for equipment and colony setup.
- Irrigation costs vary; the highest for coffee and minimal costs for others.

In general, the expenditure pattern reflects a balanced investment between planting, preparation, and maintenance. While the plant costs dominate the budget, strategic planning and cost optimization in preparation and logistics could reduce overall expenses.

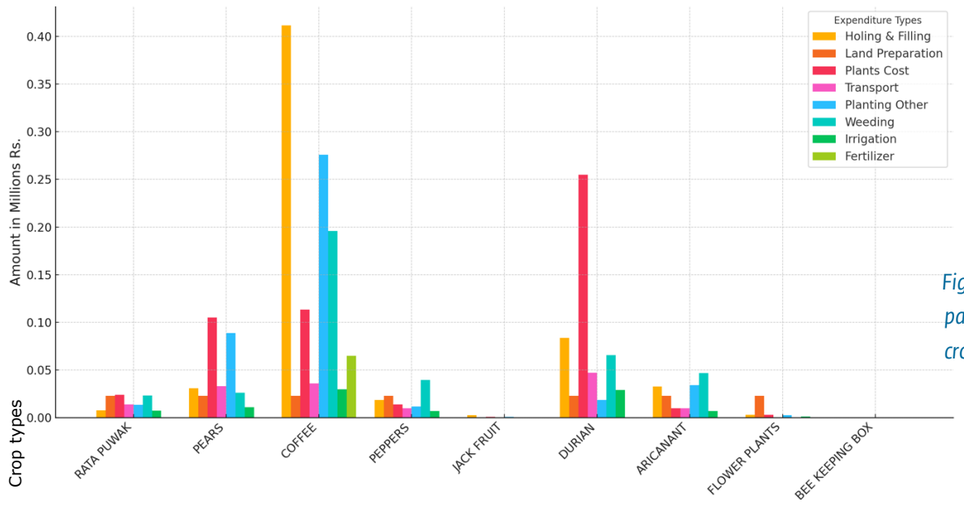


Figure 20: Expenditure patterns for different crops at Halgolla Estate

1.5.4 General lessons learned

An adaptive project management approach, designed as a learning method, was adopted in this study. This approach was particularly suitable, as it involved continuously evaluating outcomes and processes. Taking time to reflect on progress and making any necessary adjustments to the implementation process resulted in more consciousness of the lessons learned. In practice, this meant that the project team met at least semi-annually to reflect systematically on the goals and expectations set at the start of the project across various dimensions (agroecological, social, economic) and the interconnection between these dimensions. During field visits, explicit and structured attention was paid to both successes and points for improvement. This allowed the team to respond quickly to specific needs (e.g. a session on international markets) and make adjustments when necessary (e.g. broadening the social scope beyond HR).

Joint reflection was also an invaluable opportunity to exchange ideas and experiences, which greatly enriched the process. The lessons from these various evaluation sessions have been integrated into this document. The overall lessons learned are:
- Success in co-creation: listen to stakeholders and avoid imposing ideas. It was important to act as a mediator between workers' needs and management (needs).
- Realistic targets: set achievable short-, medium- and long-term goals, as agroforestry outcomes take time to realise. For example, the business case forecast was adjusted from five to 10 years, to create the longer timeframe needed for agroforestry outcomes to solidify. Additionally, several targets that were expected for the short term (e.g. decrease in fertiliser and living wages) were found to be more realistic over the medium to long term. A long-term approach is required.
- Agroforestry is not new to Sri Lanka and has been a practice on plantations and homegardens for a long time. The biggest value of the approach described in this guideline lies in the scientific, technical, holistic, and structured approach. By looking at the entire plantation rather than just the agroforestry plot, new opportunities were identified, such as biochar and kithul. These ancillary projects are beneficial for achieving a quicker return on investment. Additionally, the notion grew that agroforestry can be used as a new marketing strategy to penetrate new markets (including ecotourism).
- The biggest impact of the project is creating the awareness, inspiration and momentum to catalyse the agroforestry concept among different stakeholders: government, plantation management and other important stakeholders. Resulting in the start of partnerships.
- Initially, plantations were concerned about economic risks due to costs of implementing agroforestry, but later in the project plantations perceived the benefits and believed in agroforestry as the only viable business model for degraded estates. Both plantations concluded that diversification through agroforestry is the solution for increasing income security.
- Sustainable private-public partnerships have been successfully established, which is crucial for transitioning towards more sustainable agriculture in Sri Lanka.
- Involving the right people (decision-makers) on the plantation from the outset to ensure there is a shared vision regarding the commitment and responsibility of the involved parties was crucial for the success of the project.
- Discussions on the application of agroforestry and its benefits to the country, including its economic, social and agroecological advantages, have been recognised. However, further study is needed on the extent of agroforestry implementation.
- Effective communication between staff and workers on agroforestry and what it is really about, and what it could mean in the long term, is crucial. It is important to manage expectations with regard to the (possible) impact of agroforestry.
- There was a positive attitudinal change among agroforestry implementers (change agents). A pusher/motivator is needed to create change agents.

2. Laws and regulations relevant to agroforestry

2.1 National laws & regulations

THEORY THEORY

Agroforestry in Sri Lanka is guided and supported by a framework of national laws and regulations aimed at promoting sustainable land use, conserving natural resources and enhancing rural livelihoods and food security. The integration of trees and agricultural crops in farming systems is recognised for its potential to address environmental challenges, improve food security and support economic development.

Key legislation that influences agroforestry practices in Sri Lanka includes:

1. Forest Ordinance (1907, amended in 2009), which is the primary legislation governing the management and protection of forest resources in Sri Lanka. It emphasises the conservation of forest biodiversity, the prevention of deforestation and the promotion of sustainable forest management practices. The amendments in 2009 strengthened regulations against illegal logging and encroachment, encouraging the incorporation of agroforestry practices in forest buffer zones to enhance ecological stability;
2. Soil Conservation Act (1951), which aims to prevent soil erosion and degradation, these being critical concerns in Sri Lanka's hilly and mountainous regions. It supports the adoption of soil conservation measures, including agroforestry practices such as alley cropping contour planting, terracing and the integration of perennial trees and shrubs to stabilise soils and reduce runoff;
3. Agrarian Development Act (2000), which focuses on the sustainable development of agricultural lands and the welfare of farming communities. It encourages the diversification of agricultural practices, including the integration of agroforestry systems, to improve land productivity and resilience against climate change. The Act provides a legal framework for the formation of farmer organisations and supports capacity-building initiatives related to agroforestry;
4. National Environmental Act (1980, amended in 1988), which establishes guidelines for environmental protection and sustainable natural resource management. It mandates environmental impact assessments (EIAs) for significant agricultural and forestry projects, including large-scale agroforestry initiatives. The Act promotes practices that enhance environmental sustainability, such as the use of multipurpose trees and sustainable land management techniques;
5. Sri Lanka State Plantations Corporation Act (No. 4 of 1958, amended in 1985) has provisions on managing agricultural crops by rehabilitating existing crops or diversifying crops. Relevant to tea- and coconut-related agroforestry implementation on state plantations including comprehensive management service in respect of plantation business.
6. Promotion of Export Agriculture Act (No. 46 of 1992) provides legal protection, government level promotion for some important agroforestry crop species. The Department of Export Agriculture (DEA) is the main government institution within the purview of the Ministry of Plantation Industries. It is responsible for research and development by means of productivity, production and quality improvements of a group of perennial, export agricultural crops (EAC), namely Cinnamon, Pepper, Cardamom, Clove, Nutmeg, Coffee, Cocoa, Vanilla, Betel, Citronella, Lemongrass, Ginger, Turmeric, Goraka and Arecanut traditionally grown in Sri Lanka.
7. Felling of Trees (control) Act (2000) provides for the prohibition and control of the felling of selected tree species. So far, only three species are protected: Jack (Artocarpus heterophyllus); breadfruit (Artocarpus altilis) and female plants of palmyrah (Borassus flabellifer). This act will support the preservation of such trees in agroforestry systems. Companies and communities will therefore hesitate to introduce such trees into agroforestry systems due to restrictions.
8. Tea Research Institute Hand Book on Tea (2008) provides directives on tea land classification for the selection of land categories for diversification / intercropping, including setting up agroforestry units and recommended crops and varieties for this purpose.

Policies relevant to agroforestry:

1. National Agricultural Policy (2007), which outlines the strategic direction for the agricultural sector, emphasising sustainable agricultural practices and the conservation of natural resources. It highlights the role of agroforestry in enhancing farm productivity, improving soil fertility and providing ecosystem services. The policy encourages research and development in agroforestry and supports the dissemination of knowledge and best practices to farmers;
2. National Policy on Climate Change (2012 updated in 2023), which addresses the impacts of climate change and promotes adaptation and mitigation strategies. Agroforestry is identified as a key approach for enhancing climate resilience, sequestering carbon and reducing greenhouse gas emissions. The policy supports the expansion of agroforestry practices to improve ecosystem services and enhance the adaptive capacity of farming communities.
3. National Environmental Policy (2003) aims to promote the sound management of Sri Lanka's environment, balancing the needs of social and economic development and environmental integrity.
4. The National Policy on Wildlife Conservation (2000) is committed to the conservation of wildlife resources by promoting conservation, maintaining ecological processes and life sustaining systems, managing genetic diversity and ensuring sustainable utilisation and sharing of equitable benefits arising from biodiversity. This may affect agroforestry initiatives planned near Wildlife Protected Area boundaries and the control of large pest animals such as wild boar, monkeys and elephants.
5. National Forestry Policy (1995). One of the main objectives of this policy is to enhance the contribution of forestry to the welfare of the rural population and strengthen the national economy, paying particular attention to equity in economic development. One section details the use of trees outside forests and agroforestry for timber production and other environmental services.
6. Biodiversity Conservation Action Plan (BCAP), which outlines strategies for conserving biodiversity and promoting sustainable land use practices, including agroforestry. It recognises the importance of integrating biodiversity conservation with agricultural production systems to create multifunctional landscapes that support both environmental and

economic goals.

7. National Adaptation Plan for Climate Change Impacts in Sri Lanka (2016-2025) emphasises the critical role of trees outside forests and agroforestry systems in mitigating and adapting to climate change impacts. These systems contribute to carbon sequestration, enhance biodiversity and improve soil health, making them vital components of climate-resilient landscapes. The plan promotes the integration of trees and agroforestry practices into agricultural systems and degraded lands to enhance ecosystem services, reduce vulnerability to extreme weather events and ensure sustainable livelihoods. By encouraging sustainable tree management and agroforestry interventions, the plan aims to strengthen the resilience of rural communities while addressing national climate adaptation priorities.
8. National REDD+ Investment Framework and Action Plan (NRIFAP) (2017) provides a strategic approach to reducing emissions from deforestation and forest degradation while enhancing sustainable forest management and conservation in Sri Lanka. It emphasises the importance of integrating trees outside forests and agroforestry systems into the national REDD+ strategy as a means to achieve both emission reduction and livelihood improvement goals. By promoting agroforestry and sustainable land-use practices, NRIFAP supports carbon sequestration, biodiversity conservation and the reduction of pressures on natural forests. Additionally, it encourages community engagement and capacity building to ensure that these practices contribute to national climate change mitigation efforts and sustainable development objectives.
9. Nationally Determined Contributions Implementation Plan (NDC) (2021-2030) outlines Sri Lanka's strategic actions to meet its commitments under the Paris Agreement, focusing on reducing greenhouse gas emissions and enhancing climate resilience. It highlights the integration of agroforestry and trees outside forests as key strategies for achieving carbon sequestration, restoring degraded landscapes and enhancing ecosystem services. The plan supports sustainable land management practices that align with national climate goals, emphasising the role of agroforestry in reducing vulnerability to climate impacts, improving rural livelihoods and contributing to biodiversity conservation. By fostering collaboration among stakeholders, the NDC Implementation Plan provides a framework for aligning sectoral actions with Sri Lanka's long-term sustainable development and climate mitigation objectives.

It is clear that Sri Lanka's existing national laws and regulations related to agroforestry and trees outside forests reflect a commitment to sustainable land use and environmental conservation. By promoting agroforestry practices, these legal frameworks aim to enhance biodiversity, improve soil and water conservation and support the livelihoods of rural communities. However, continued efforts to implement and strengthen these policies through coordination among various government agencies, non-governmental organisations and local communities will be crucial for realising the full potential of agroforestry in contributing to the country's sustainable development goals.

In practice, agroforestry initiatives, whether integrated into existing or new agricultural landscapes, hold significant potential for enhancing biodiversity, improving soil health and increasing agricultural productivity while harmonising with the environment. Given the pressing challenges of global environmental changes, population pressure and the need for sustainable food production, the development of comprehensive policies for agroforestry is crucial in all socioeconomic and environmental aspects.

2.2 Land tenure issues

THEORY THEORY

Land tenure is a critical factor influencing the adoption and success of agroforestry practices in Sri Lanka. Secure land tenure provides farmers with the confidence to invest in long-term land management practices, including agroforestry. However, various land tenure issues in Sri Lanka present challenges to the widespread implementation of agroforestry systems. Understanding these issues is essential for developing policies and programmes that promote sustainable land use and agroforestry.

Farmers with freehold land under private land ownership have the highest level of tenure security, allowing them to make long-term investments in their land, such as planting trees and implementing agroforestry practices. A good example is Kandyan homegardens, which are owned by farmers and well adapted with perennial crop-based systems. However, not all farmers own their land, limiting the scope of agroforestry adoption.

Large tracts of land in Sri Lanka are state-owned and managed under the *Crown Lands Ordinance* (1947). These lands are often leased to individuals or communities for agricultural purposes. The terms and conditions of these leases can vary, and sometimes they do not provide sufficient tenure security for long-term agroforestry investments. In many rural areas, farmers cultivate state land without formal rights or leases, a practice known as encroachment. These farmers face significant uncertainty and are less likely to invest in agroforestry due to the risk of eviction.

The Land Reform Laws (1972, 1975) aimed to redistribute land to the landless and smallholders. While these reforms have increased access to land for many, the resulting small landholdings can be insufficient for large-scale agroforestry projects. Additionally, the redistribution process has sometimes resulted in unclear or disputed land titles.

Land tenure rights are critical for tea and coconut plantation companies in Sri Lanka, as secure and clearly defined land tenure ensures stability and long-term investment in sustainable practices. These companies often operate on large estates, which may include both privately owned land and state land leased for 30 years. Clear tenure rights allow plantation companies to make significant investments in infrastructure, technology and sustainable farming practices, including agroforestry systems. However, land tenure disputes, unclear boundaries and bureaucratic delays in lease renewals or land title registrations can pose challenges.

Farmers with insecure land tenure, such as those farming state land without formal leases or those on communal land with ambiguous rights, are less likely to adopt agroforestry. Secure tenure is crucial for the long-term nature of agroforestry investments. Land fragmentation is a significant issue in Sri Lanka, with many farmers owning small and scattered plots. Fragmented landholdings make it challenging to implement cohesive agroforestry systems and reduce economies of scale. The process of securing land titles or leases can be cumbersome and time-consuming, involving multiple government agencies. These bureaucratic hurdles can discourage farmers from formalising their land rights and adopting agroforestry practices. Conflicts over land ownership and use are common, particularly in areas with communal or state land. These conflicts can arise from overlapping claims, unclear boundaries and competing land uses, all of which impede agroforestry implementation.

Addressing land tenure issues is essential for the successful implementation and scaling of agroforestry in Sri Lanka. By ensuring secure land tenure, reducing fragmentation, resolving conflicts and integrating customary rights, Sri Lanka can create an enabling environment for agroforestry. Such measures will not only enhance agricultural productivity and environmental sustainability, but also improve the livelihoods of rural communities, contributing to the country's long-term development goals.

2.3 International laws & regulations

THEORY THEORY

The imperative of reducing human impacts on the Earth's natural systems has wide political recognition. The agriculture sector contributes to the food security and well-being of humankind by providing the most fundamental resources in society. However, it is recognised as one of the major reasons for global environmental changes. In view of these changes due to increasing population pressure, the global community is addressing this concern through a series of conventions and treaties. In compliance with these international agreements, the world community has taken measures to ensure that crop diversity is properly conserved and used sustainably. Apart from these conventions, the international commissions and advisory bodies also play a crucial role in international cooperation for plant production and protection (Paroda, 2009, FAO, 2024).

In the last five decades, agroforestry has been widely promoted in the tropics as a natural resource management strategy that attempts to balance the goal of agricultural development with the conservation of soils, water, local and regional climates and, more recently, biodiversity (Izac and Sanchez, 2001). In fact, the potential of agroforestry to contribute to sustainable development has been recognised in international dialogues and policy meetings, including the Convention on Biological Diversity (CBD) and the United Nations Framework Convention on Climate Change (UNFCCC), justifying increased investment in its development (Foresta, 2013). Agroforestry is now seen to be at the 'heart' of the three environmental conventions (climate change, carbon sequestration, on-farm adaptation; combating desertification, landscape restoration, reversing land degradation; and biological diversity, species and habitat conservation, landscape connectivity).

The United Nations Convention on Biological Diversity (UNCBD), agreed at the 1992 UN Conference on Environment and Development, is one of the most widely ratified treaties in the world. Since 2002, 193 parties to the CBD have committed themselves to agriculture that substantially reduces rates of biodiversity loss; this initiative was later endorsed by the World Summit on Sustainable Development and incorporated into the UN Millennium Development Goals in 2005 (Moran et al., 2008) and the Sustainable Development Goals (SDGs) that came into the global arena. There is an increasing array of national, regional and international policy mechanisms aimed at biodiversity conservation (Rands et al., 2010).

Besides the Convention on Biological Diversity, Sri Lanka is a signatory to several international treaties and conventions related to sustainable agricultural practices, including the International Plant Protection Convention (IPPC), the Rotterdam Convention, the Joint Meeting on Pesticide Residues and the International Treaty on Plant Genetic Resources for Food and Agriculture.

Based on the aforementioned globally accepted agreements, several international rules and regulations have been established to ensure that the parties comply with these agreements. If plantations have the ambition to set up international supply chains to sell their agroforestry products abroad, especially to the EU, these rules and regulations will affect their business and should be considered.

The European Green Deal conveys the EU's ambition to adjust and "green" its economic growth trajectory and become climate-neutral by 2050, as part of its contribution to the Paris Agreement and the Sustainable Development Goals. While being ambitiously pursued within the Union's own borders, the Green Deal also has strong external ramifications, as the EU leaves a tremendous ecological footprint in other parts of the world. The EU has referred to this "external dimension" of the Green Deal without further defining it and appears to primarily understand it as a reflection of the internal strategies and as a call for the EU's partner countries to follow a sustainable recovery trajectory similar to its own.

The *Corporate Sustainability Reporting Directive* (CSRD) is a European Union Directive dated 14 December 2022 that represents a fundamental step towards promoting transparency, accountability and sustainability in the corporate sector. The Directive came into force on 5 January 2023. The CSRD will drastically change the sustainability reporting landscape in the EU by requiring a large number of companies to make extensive disclosures on a broad range of environmental, social and governance matters.

On 23 February 2022, the European Commission adopted a proposal for a Directive on Corporate Sustainability Due Diligence (CSDD). On 24 May 2024 the Council of the European Union approved the political agreement, thereby completing the adoption process. This Directive aims to foster sustainable and responsible corporate behaviour in companies' operations and across their global value chains. The new rules will ensure that companies in scope identify and address adverse human rights and environmental impacts of their actions inside and outside Europe.

Responsible business conduct (RBC) sets out an expectation that all businesses – regardless of their legal status, size, ownership or sector – will avoid and address negative impacts of their operations, while contributing to sustainable development in the countries where they operate. The European Union for Responsible Business Conduct uses RBC standards and recommendations to shape government policies and help businesses minimise the adverse impacts of their operations and supply chains, while providing a venue for the resolution of alleged corporate, social, environmental, labour or human rights abuses. Through RBC, businesses can positively contribute to economic growth and development and become a powerful driver for achieving the SDGs.

European Union Deforestation Regulation (EUDR) is designed to reduce the impact of EU consumption on global deforestation and forest degradation. This initiative encourages the use of products that do not contribute to deforestation, helping to lower greenhouse gas emissions and preserve biodiversity. It is due to come into force on 30 December 2024.

3. Future of agroforestry in Sri Lanka

3.1 Research (gaps) in agroforestry with tea and coconut

THEORY THEORY

Research on traditional Kandyan, permaculture and other homegarden agroforestry systems in Sri Lanka has highlighted several equally pertinent benefits to tea- and coconut-based agroforestry systems (e.g., Dissanayaka et al. 2023), but has also highlighted a number of knowledge gaps that require further work. Among those are studies that comprehensively assess the multiple environmental services provided by tea- and coconut-based agroforestry systems across different scales, from the farm to the landscape (or catchment level) (Peng, Y et al. 2024). The potential of agroforestry systems to store soil organic carbon (SOC) and nutrients in deeper soil layers is also poorly understood despite the potential for carbon removal, improved nutrient cycling and fewer losses to the environment (Bania, J. K et al. 2024).

Other research gaps, particularly for tea- and coconut-based systems, relate to the optimisation of diversified production systems from an agronomic and economic viewpoint, based on a good knowledge of interspecific interactions between the targeted cash crops and other crop and shade tree species (Zhao, F et al. 2023). Such knowledge is required to optimise diversified production systems in terms of species composition, suitable varieties and planting designs, thus ensuring high crop yields and system productivity and profitability, while enhancing resilience to prolonged droughts and climate change. Specifically for tea and coconut, TRI and CRI have already done a lot of research evaluating different intercropping arrangements that the country can draw on, and that are directly relevant to the Sri Lankan plantation cropping context and climatic conditions. (Dissanayake et al., 2023; Mohotti et al., 2020; Pushpakumara et al., 2011; Samarakoon et al., 2023).

Significant remaining gaps include the lack of comprehensive studies on the long-term impacts of promising tree-crop interactions on soil health, pest and disease dynamics, crop yields and overall system productivity, particularly under varying soil and climatic conditions. Additionally, there is limited research on the best tree species and management practices (pruning, spacing and fertilisation) for providing shade while minimising competition for resources, especially under resource-poor conditions. Compared to traditional monocultures, the economic viability and market potential of diverse products from these systems are also underexplored, which limits the capacity of farmers and plantation managers to make informed decisions. Furthermore, studies on integrating livestock into these agroforestry models are scarce, despite their potential benefits for nutrient cycling and weed control, as part of a regenerative farming approach. In short, our knowledge on crop-soil-animal-environment interactions, including synergistic and antagonistic effects of crop combinations and undesired levels of resource competition, needs improvement to support scaling of agroforestry systems (Zhao, F et al. 2023).

Last but not least, the social aspect of agroforestry is another undervalued and understudied outcome of agroforestry. Major research gaps are identified for systematic analysis of social outcomes of all agroforestry types (Köthke, 2022). The lack of clear goals with regard to the desired social outcomes of agroforestry adoption does not help in achieving clarity on positive social outcomes and how to achieve those.

In various literature, social and human capital is being addressed (Quandt, 2019) in intertwining terms: health, human well-being, safety, labour availability, development of skills and knowledge, social inclusion, gender participation, political influence, decision-making power etc.

Addressing these research gaps through interdisciplinary and long-term studies can provide valuable insights into developing sustainable, productive and resilient tea- and coconut-based agroforestry systems.

3.2 Need for Policy-Practice-Research collaboration

THEORY THEORY

Despite the massive potential, the available traditional and local experiences and widespread presence of a wide array of agroforestry systems across significant portions of its land, Sri Lanka has not yet fully integrated these systems into its policy frameworks or public consciousness. This oversight is particularly significant given the pivotal role of agriculture in both the economy and the environmental stewardship of the country. To fully leverage the benefits of agroforestry for sustainable agriculture and ecological conservation, it is crucial to promote these practices through enlightened policies, innovative recognition methods for existing systems and their contributions and comprehensive educational initiatives. At the same time, the ongoing economic crisis in Sri Lanka poses a significant risk to the successful implementation and continuation of agroforestry. This crisis may limit the financial resources available for other projects and affect the overall economic stability of the plantations. On the other hand, proper recognition of agroforestry within Sri Lanka's landscape could create opportunities to expand business ventures of tea and coconut based products, particularly in response to the challenges posed by a changing climate .

This project has resulted in an invaluable partnership between plantations, researchers, and policymakers. This partnership should now further develop into a robust and permanent Policy-Practice-Research collaboration and partnerships to ensure the structural promotion of agroforestry in Sri Lanka, transforming degraded lands and enhancing climate resilience. Establishing a dedicated network that brings together all stakeholders including policymakers, practitioners and researchers, can create a cohesive strategy for agroforestry development. Policymakers can provide the necessary regulatory support and incentives, while practitioners bring practical insights and on-the-ground expertise. Researchers can contribute evidence-based recommendations and innovative solutions. This collaborative approach can ensure that agroforestry initiatives are technically sound, well-coordinated, effectively implemented and continuously improved based on real-world feedback and scientific advances. Additionally, one important task of this network is to develop an approach for recognizing the ecosystem services (both social and environmental) that are being provided by the plantations implementing agroforestry so that they are rewarded for their efforts and can further upscale agroforestry. By fostering such a network, Sri Lanka can systematically rehabilitate degraded lands, enhance biodiversity, improve soil health, harness potential lands, bring in local and foreign earnings and increase the livelihoods of local communities, ultimately building a more sustainable and climate-resilient future.

The future of agroforestry in Sri Lanka holds significant promise for sustainable agriculture, environmental conservation and climate resilience. As the country grapples with the challenges of land degradation, deforestation and climate change, agroforestry presents a viable solution by integrating trees with crops and livestock. This approach enhances biodiversity, improves soil health and boosts crop productivity. Building on existing agroforestry systems and upgrading and scaling them to proven models will benefit the entire country, especially given that forest cover is limited to 29% and that the majority of the tree canopy cover, which exceeds 65%, is primarily due to trees outside of forests. Hence, government initiatives, coupled with increasing awareness among farmers about the benefits of agroforestry, are driving its adoption. Research and development efforts are focusing on identifying optimal tree-crop combinations and innovative farming practices tailored to local conditions. Moreover, policy support and international partnerships are essential to scale up these practices. With a concerted effort from policymakers, researchers and practitioners, Sri Lanka can leverage agroforestry to restore degraded lands, sequester carbon and secure the livelihoods of rural communities, thereby paving the way for a more resilient and sustainable agricultural future while fulfilling government and plantation sector requisites such as carbon neutrality and the promotion of nature-based solutions to minimise external input dependence and to improve land use efficiency, add value and achieve a unique proposition for Sri Lankan produce in the international market arena.

Reflection by stakeholders

"The guidelines provide a comprehensive framework for transforming monoculture tea and coconut plantations into sustainable agroforestry systems. Documents with a well-rounded framework, blending ecological, social and economic principles for agroforestry in Sri Lanka. It provides practical insights into agroforestry systems' design, implementation and scaling, addressing local conditions and future opportunities."
Anjana J. Atapattu - Acting Head of the Agronomy Division and Senior Agronomist at the Coconut Research Institute of Sri Lanka

"The Agroforestry Guidelines document is a robust initiative aimed at advancing agroforestry concept within the plantation sector, providing synergies with the paradigm shift toward the next level of agroforestry initiative, known as regenerative agriculture, in Sri Lanka".
Tharangani Wickramasinghe - Additional Secretary, Ministry of Plantation and Community Infrastructure

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Closing remarks

The future of agroforestry in Sri Lanka holds significant promise for sustainable agriculture, environmental conservation and climate resilience. As the country grapples with the challenges of land degradation, deforestation, resource limitations and climate change, agroforestry presents a viable solution by integrating trees with crops and livestock. This approach enhances biodiversity, improves soil health and boosts crop productivity. Building on existing agroforestry systems and upgrading and scaling them to proven models will benefit the entire country, especially given that forest cover is limited to 29% and that the majority of the tree canopy cover, which exceeds 65%, is primarily due to trees outside of forests.

Hence, government initiatives, coupled with increasing awareness among farmers about the benefits of agroforestry, are driving its adoption. Research and development efforts are focusing on identifying optimal tree-crop combinations and innovative farming practices tailored to local conditions. Moreover, policy support and international collaborations are essential to scale up these practices. While laws and policies provide a supportive framework for agroforestry, their effective implementation requires coordination among various government agencies, non-governmental organisations and local communities. Challenges in agroforestry expansion also include the need for greater awareness and education about the benefits of agroforestry, access to technical assistance and financial resources and the development of market opportunities for agroforestry products. With a concerted effort from policymakers, researchers and practitioners, Sri Lanka can leverage agroforestry to restore degraded lands, sequester carbon and secure the livelihoods of rural communities, thereby paving the way for a more resilient and sustainable agricultural future.

Among agriculture and livestock, Sri Lanka holds a significant reputation and relevance with the plantation industry more particularly with tea, rubber and coconut with respect to coverage of sensitive landscapes, land occupation on exchange oriented products, world renowned value added products, provision of decent job opportunities and guaranteed livelihood income to the entire value chain. Given the current issues and challenges and foreseeable future developments in tea and coconut industries, new interventions and applications are of paramount importance. Additionally, partnerships should be created to market agroforestry products as such so that plantations can do the required investments for producing agroforestry products. In this connection, this project provides two concrete examples of plantations that have started implementing agroforestry. We hope that these examples will inspire other plantations to start with agroforestry and that the guidelines provided in this document help them taking the first steps.

For more information about agroforestry, such as monitoring data, training material, templates, or HR checklists, please contact:
IUCN: Naalin Perera, email: Naalin.PERERA@iucn.org
University of Peradeniya: Gamini Pushpakumara, email (official): ngpkumara@agri.pdn.ac.lk, ngpkumara@pdn.ac.lk; (personal): ngpkumara63@gmail.com

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