Rehabilitation of coffee trees in Timor-Leste

Practices

Learning

Recommendations

Market Development Facility

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Executive summary

Coffee is Timor-Leste's primary agricultural export, and 37 per cent of households are involved in coffee production. Coffee is mainly produced by smallholder farmers.

More than half the coffee trees in Timor-Leste have passed their productive life. A lack of replanting and pruning has resulted in Timor-Leste having some of the lowest coffee yields in the world (195kg/ha, versus the global average of 2,000kg/ha). This means the income of coffee-growing households is also very low.

More regular Rehabilitation and Renovation (R&R) is urgently needed to address low coffee yields. Rehabilitation means the pruning and stumping of coffee trees, and renovation means removing old coffee trees and replacing them with new plantings.

R&R can greatly improve productivity in the medium term but can reduce production for 2-4 years. Government, development partners and the private sector will therefore need to provide financial and technical support for R&R to ensure it becomes a regular part of coffee production in Timor-Leste.

The Government of Timor-Leste, selected coffee producers and donors have supported several R&R trials in recent years. Results have varied depending upon agronomic and community engagement methods used. Even when productivity improvements have been demonstrated, it has been hard to ensure farmers continue R&R without ongoing external financial and technical support.

For now, rehabilitation should be prioritised over renovation in Timor-Leste. Whilst there are several stumping and pruning methods used globally, a two-stem management system is recommended for Timor-Leste due to its simplicity. A greater focus on monitoring after R&R will be important for continued productivity improvement.

Glossary

Apical meristem	The growth region in plants that is typically found in the tips of roots, new shoots and leaves.
Axillary roots	Side or lateral roots of trees.
Bearing vertical	The regions of the branches or wood that can produce flowers and subsequently cherries.
Capital root zone	The critical set of roots responsible for absorbing nutrients and determining the health of the tree. It is comprised of different types of key roots.
Certification premium	Extra price the consumer pays to reward the farmers for the additional labour, time and money for maintaining organic, forest garden or fair trade or any other certifications
Critical branches	Flower bearing branches that will later produce cherries.
Date of planting	The date a plant is planted in the soil on the farmland.
Desuckering	The practice of removing the suckers or the water shoots.
Dieback	The progressive death of twigs, branches, shoots, or roots, starting at the tips.
Extension services	Services that deliver information to farmers about farming and related practices.
Feeder roots	Small white roots that absorb water and nutrients from the soil; very sensitive roots that will fall off if the root ball falls apart.
Fruit set formation	Placement of fruit on the branch, and quantities of fruits on each branch.
Growing wood	The branch tissue that widens and elongates as evidence of growth.
Lap time	Pause in growth for the recharging of energy reserves.
Lateral branch	Any secondary branch that grows off the main trunk or **scaffolds**.
Leaf area index	A measure to assess the amount of leaf area that is getting enough sunlight, calculated on the area of one side of the green leaf receiving sunlight per unit of ground surface area in broadleaf canopies.
Meristem	Undifferentiated cells capable of cell division; cells in the meristem develop into all the other tissues and organs that develop in plants.
Nodes	The areas in the stem from which leaves, branches, and aerial roots grow; the intervals between the nodes are referred to as internodes.
Phloem	The tissue of a plant that is responsible for transporting food from production sites to utilisation/storage sites
Plant physiology	Subdiscipline of botany concerned with how plants function. Closely related fields include plant morphology, plant ecology, phytochemistry, cell biology, genetics, biophysics and molecular biology.
Plucking table	The average setting and height of the foliage of a tree where the harvestable units (leaves/fruits) will later emerge and from where they will be harvested.

Pruning	Horticultural practice that involves selectively removing certain parts of a plant, such as branches, buds, or roots.
Rehabilitation	**Stumping** or **pruning** of existing trees to rejuvenate them.
Renovation	Removal of old trees and addition of new trees.
Reproductive growth	Refers to the generation of new offspring in plants, such as growth that produces flowers, fruit and seeds
Scaffold	Lateral branches that were once thin young twigs on the trunk.
Selective picking	For coffee, harvesting ripe cherries only and avoiding picking unripe cherries.
Shade tree	Any tree grown specifically for the shade it provides. This term usually applies to large trees with spreading canopies that control the sunlight landing on the targeted trees.
Shoots/suckers/water shoots	Plant growth from the tree trunk or old branches, growing from latent (dormant or resting) buds.
Smallholder farmer	Farmer who owns a small plot of land where mainly subsistence crops are grown, with one or two cash crops relying almost exclusively on family labour.
Source to sink mechanism	**Phloem** tissue that transports sugar, abiotic (non-living) matter and biotic (living matter) from the source or the storage to the sink (location of the plant where these substances are consumed). Up to 80 per cent of photosynthetic sugars produced by the mature parts of the plant are transported and consumed at the young roots and leaves, which are major sinks during the phase of tissue regrowth (e.g. after **rehabilitation**).
Stumping	The process of removing the upper part and branches from a standing tree trunk.
Sub-lateral branches	Smaller branches growing from **lateral branches**.
Sunlight interception	Amount of sunlight effectively penetrating through the tree canopy relative to the total available sunlight.
Sweat equity	System where labourers are engaged with the promise of sharing the credit from sales. They are paid in shares of the plantation.
Tap root	The large central and dominant root from which other roots sprout laterally. Typically somewhat straight and very thick, growing directly downward and tapering in shape.
Valley of death	After **rehabilitation** or **renovation** it takes the tree a few years to be optimally productive. The period of low productivity and low return following the investment in R&R is called the valley of death. Valley of death is longer for renovation than rehabilitation.
Vegetative growth	Growth that occurs when an individual organism increases in size via cell multiplication.
Vertical	Main stem of a tree that grows vertically.
Vigour	A genetic factor that determines the capacity to resist strain and the ability to survive against threats.
Water shoots	See **shoots**.

Acronyms

ADB	Asian Development Bank
BF	Beaumont – Fukunaga (coffee pruning technique)
CACAO	Coffee and Cocoa Agribusiness Opportunities
CBS	Cafe Brisa Serena
CCT	Cooperativa Café Timor
CQI	Coffee Quality Institute
ETCI	East Timor Coffee Institute
GoTL	Government of Timor-Leste
ha	Hectare
HAT	Mechanical hedged and topped coffee pruning technique
HDT	Hibrido De Timor (coffee cultivar/variety)
kg	Kilogram
MAF	Ministry of Agriculture and Fisheries
MDF	Market Development Facility
MoU	Memorandum of understanding
NCBA	National Cooperative Business Association
NCSDP	National Coffee Sector Development Plan
NGO	Non-Government organisation
PARCIC	Pacific Asia Resource Centre Inter-Peoples Corporation
PARTL	Programa de Apoio ao Desenvolvimento Rural de Timor-Leste
PNG	Papua New Guinea
R&R	Renovation and rehabilitation
SCAA	Specialty Coffee Association of America

Purpose of this study

Market Development Facility (MDF) is an Australian-Government-funded multi-country initiative that promotes sustainable economic development through enabling higher incomes for women and men in Australia's partner countries. MDF connects individuals, businesses, governments and NGOs with each other, and with markets at home and abroad. This enhances investment and coordination and allows partnerships to flourish, strengthening inclusive economic growth. MDF is funded by the Australian Department of Foreign Affairs and Trade (DFAT), and implemented by Palladium in partnership with Swisscontact.

Due to its economic contribution and its relevance to Timorese heritage, coffee is an important sector for Timor-Leste. The country has been growing coffee for over 200 years, and today 37 per cent of Timor-Leste's population is dependent on coffee for their livelihood. Coffee is the primary agricultural export of Timor-Leste and its second biggest export commodity.

MDF has been supporting Timor-Leste's coffee industry since 2015. MDF's objective is to improve the resilience and competitiveness of the coffee industry through building local capacity, improving coffee quality and facilitating greater industry collaboration. The coffee industry of Timor-Leste has made great strides in these areas in recent years.

However, the volume of coffee production in Timor-Leste is declining. Production fluctuates drastically every year. It is clear that coffee from Timor-Leste cannot be globally competitive without improvements in the consistency and volume of production. The main reasons behind low coffee yield are ageing plantations and a lack of maintenance of coffee trees. Therefore, rejuvenating the coffee plantations is the highest priority for Timor-Leste.

Ageing coffee plantations, inconsistent production and declining yields are global challenges for the coffee industry. Different rejuvenation strategies are being trialled worldwide to improve coffee yield in a sustained manner. Rehabilitation and Renovation (R&R) techniques are at the heart of all coffee rejuvenation strategies.

The Government of Timor-Leste, local coffee businesses and the development community have conducted various trials to identify the right R&R strategies for Timor-Leste. Successes have varied based on the agronomic techniques of R&R and strategies for community engagement and implementation. Data collection is not optimal in most cases, making it difficult to assess the effectiveness of many programs.

Despite these challenges, there are relevant learnings from the current programs that can inform decision making on future R&R efforts. But information on these R&R practices is not readily available. This report therefore aims to aggregate information on R&R in the context of Timor-Leste. It is expected to be a public document that all local coffee stakeholders can access and use, and that will provide them with information and knowledge to assist their future decision making on coffee rejuvenation in Timor-Leste.

To achieve its purpose, this report presents some of the current R&R practices in Timor-Leste and analyses the learnings and observations from these programs. This analysis is based on sound agronomic principles and global coffee rehabilitation practices. The results of the analysis are used to make recommendations for optimal R&R practices for Timor-Leste.

Chapter 1

Rehabilitation and renovation: Overview

1. Rehabilitation and renovation: Overview

1.1 Background

Rehabilitation and renovation (R&R) are cultivation management techniques performed on perennial tree crops. Rehabilitation includes pruning, stumping the low-productive coffee trees and renovation includes uprooting or removing old trees, and new planting. R&R is applied when coffee trees surpass their peak production potential and experience declining productivity.

R&R is a collection of activities practised over a period of time, rather than a one-off activity. These are agronomically accepted techniques for better tree management, field management and consequently a better harvest.

Coffee trees in Timor-Leste urgently require extensive R&R. Coffee plantations are old—often 30 to 40 years old—and the harvest is extremely poor. It also fluctuates considerably, making it difficult for exporters to guarantee adequate volume. In most Asian regions, coffee productivity lies around 2,500–3,000kg of green beans/ha, whereas in Timor-Leste it is 195kg of green bean/ha (Coffee Quality Institute, 2017). According to the National Coffee Sector Development Plan (NCSDP), more than half of the coffee farms in Timor-Leste have long passed their productive life. Extensive R&R is the only solution for reversing this declining trend in yield.

R&R affects the key biological process of flowering, which initiates a chain of physiological activities that determine yield (DaMatta et al., 2007). Coffee flowering involves a complex sequence of biochemical, physiological and morphological events that are affected by temperature, light, soil (nutrients), water and genotype, ultimately affecting crop load (number of fruits per cross sectional area of the stem) (DaMatta et al., 2007).

1.2 Difference between rehabilitation and renovation

Renovation includes uprooting old trees and filling gaps with new seedlings. Rehabilitation does not involve uprooting, however. In rehabilitation, old root stock is maintained but unproductive branches are removed by regular stumping and pruning. This allows the productive and critical branches to consume more photosynthate (food reserves or nutrients), which contributes to improving productivity. Rehabilitation also facilitates new root and feeder root development. Figure 1 illustrates the difference between rehabilitation and renovation.

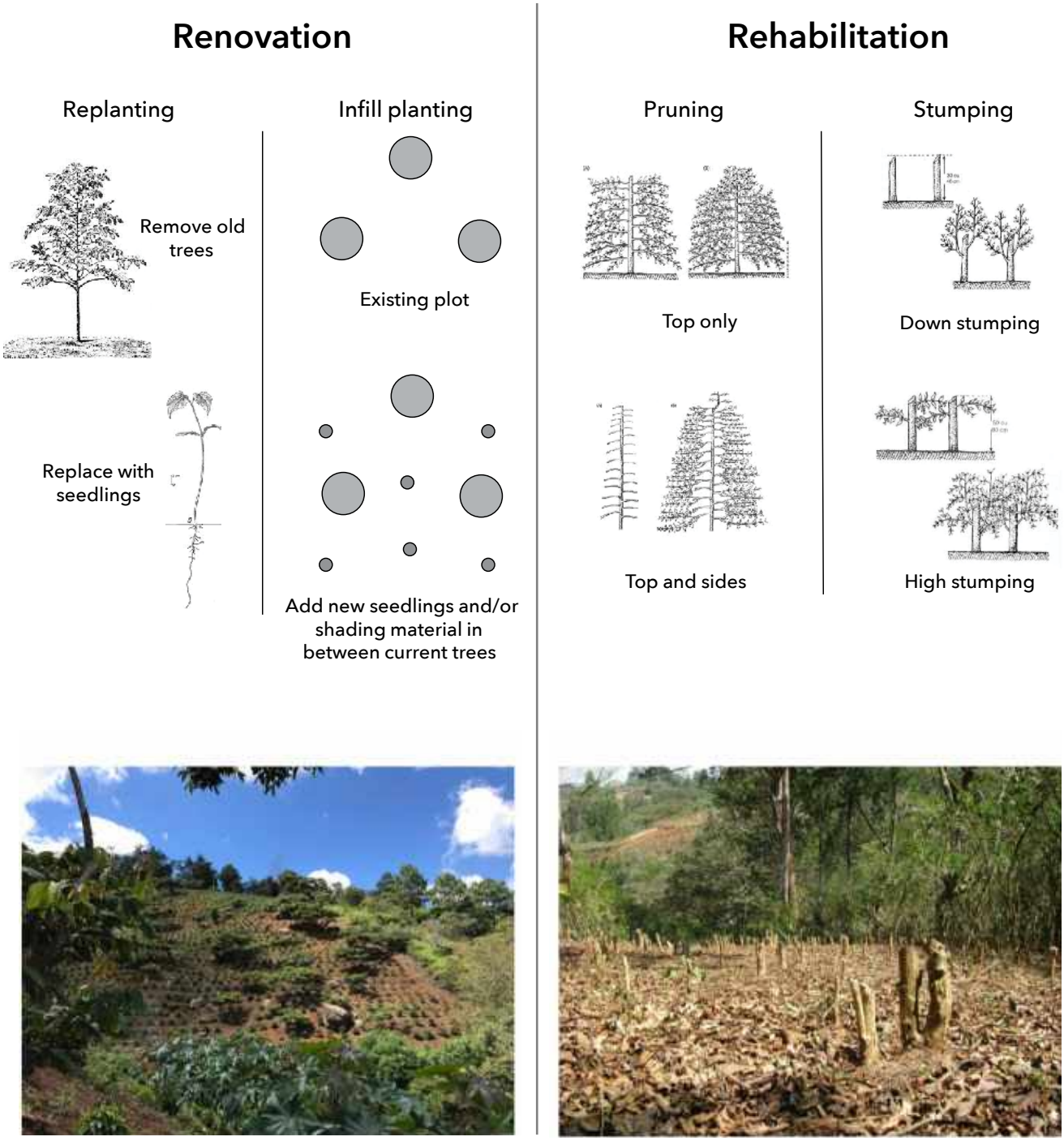


Figure 1: Difference between rehabilitation and renovation (USAID Bureau for Food Security, 2017)

1.3 Global developments in rehabilitation and renovation

Globally, more than 3.4 million hectares of smallholder coffee land require R&R. If R&R were applied to all the land in need, global coffee production would increase by another 5-20 per cent (USAID Bureau for Food Security, 2017). This increase could generate USD 1-3 billion in income for farmers through farmgate sales.

Without the application of R&R, and under current productivity levels, an additional 1–3 million hectares of coffee would need to be farmed in order to gain a similar increase in yield and value. According to the Global Coffee Platform and Technoserve (USAID Bureau for Food Security, 2017), R&R could increase global yield by 88 per cent. R&R programs have a 25 to 100 per cent chance of success (Sustainable Trade Initiative & Dalberg, 2015; FAO, 2019).

According to the Specialty Coffee Association of America (SCAA), R&R is particularly relevant for the specialty coffee market, as the specialty sector wishes to ensure a long-term supply of high-quality arabica coffee produced in a way that empowers farmers and communities.

One of the key developments in the coffee sector globally is the Sustainable Coffee Challenge, a global campaign to collectively address the challenges faced by the coffee industry (Sustainable Coffee Challenge & Conservation International, n.d.; USAID Bureau for Food Security, 2017). Active stakeholders in this initiative include specialty coffee roasters, commodity coffee producers, multinational brands such as Starbucks and Nescafé, research organisations such as the Coffee Quality Institute (CQI) and the SCAA, financial institutions, and various donors with their respective farmer networks. One of the key challenges identified by this program is deteriorating tree stocks, particularly on smallholder land. R&R is one of the most highly recommended approaches to overcoming this challenge. But to be effective R&R design needs to be based on the conditions of a specific farmland, and monitoring needs to be rigorous.

Regional developments: Papua New Guinea case study

PNG has a similar farmer profile to Timor-Leste, with agriculture largely practised by smallholder farmers (SHFs).

Obihaka is a 65ha plantation situated 1,750m above sea level. It is a privately owned farm, but ownership was distributed among members of the community for easy management. Owners of Obihaka plantation bought the cherries and farmers did the harvesting and day-to-day farm management.

Of the total extent of the plantation, 30ha was rehabilitated. Between April 2005 and September 2006, the rehabilitated trees produced almost 37 tonnes of coffee cherry, yielding 1,233kg cherries/ha. The two major components in the rejuvenation of this plantation were rehabilitation of the coffee trees, and pest and disease reduction.

Initially, farmers were using the Training and Visiting extension system. With this system, farmers travel to a farm that is managed optimally. They observe good practices and receive some training on, for example, how to chop the trees at the optimal angle. But for rehabilitation, group training was provided to farmers. Lead farmers discussed the need for rehabilitation with community members, and this helped to mobilise communal labour to do the rehabilitation work. The plantation did not have the capital to pay the labour wage, so 'sweat equity' was used by engaging labourers in a promised credit-share sales system.

It is believed that the principles used in rehabilitating Obihaka plantation have the potential to be replicated in other run-down plantations and on other rural blocks. Furthermore, the plantation at Obihaka is beginning to be used as a centre for coffee extension and farmer training. It also has the potential to be a centralised coffee-processing facility, thereby improving the quality of the coffee produced by surrounding SHFs (Sengere, Susuke & Allen, 2008).

Chapter 2

Analysis of renovation and rehabilitation

2. Analysis of renovation and rehabilitation

2.1 R&R for smallholders

Globally, coffee is primarily grown by smallholders. It is therefore important to understand the nuances of implementing R&R for smallholders. The reasons for declining coffee productivity among smallholders include depleted soil, erratic weather, knowledge limitations, and insufficient access to inputs, technology, markets and financing. Without regular management, coffee trees become highly unproductive, making them vulnerable to pest and disease infections. This results in a downward cycle of low productivity and low income, further reducing farmers' ability to invest in farmland improvement.

The age and productivity of coffee plantations vary widely between countries. In Honduras, 60 per cent of the coffee trees are older than 20 years (Root Capital, 2016). In El Salvador and eastern and central Africa, the average age of a coffee tree is over 50 years. Average yields in Colombia, Nicaragua and Tanzania are 900kg/ha, 600kg/ha and 300kg/ha respectively. In Timor-Leste, the majority of the plantations are 30 to 40 years old and productivity is 195kg/ha (Coffee Quality Institute, 2017).

R&R is crucial for improving productivity and increasing smallholder income. But the design of interventions should be based on the age and productivity of trees as well as the capacity of smallholders.

R&R is not a one-off activity. Irrespective of the R&R technique, ongoing maintenance is mandatory to sustain an improvement in productivity. The need for continued investment is challenging for smallholders. That is why smallholders need to collaborate with financiers and governments to develop and implement a lasting R&R strategy.

2.2 Climate change and R&R

Coffee requires particular climate conditions. Changes in temperature, rainfall patterns, pest and diseases are reducing areas suitable for coffee production globally. The more sensitive, input-consuming high-quality coffee varieties like arabica react negatively to short-term climatic adversities. Increasingly frequent and severe climatic events such as floods, droughts and heat waves reduce yield and quality and increase the incidence of pests and disease. The Center for Tropical Agriculture notes that coffee-growing regions will reduce considerably in area over the coming years as a result of climate change (Inter-American Development Bank, 2021).

2.3 Diseases and R&R

The rehabilitation of coffee trees is known to control rust by removing the infected foliage and improving the vigour of the tree. Countries like PNG have been implementing long-term rehabilitation programs to ensure proper control of rust (Doery, 1987). Many coffee- growing regions are struggling to maintain the quality and supply of their coffee in the face of ageing trees, diseases such as coffee rust, and low market prices that make reinvesting challenging (Sustainable Coffee Challenge & Conservation International, n.d.). Therefore supporting coffee farm R&R has become a critical element in ensuring the longevity of the industry.

The Center for Tropical Agriculture has predicted a decline in coffee production in popular coffee growing regions, starting at 20–30 per cent and increasing to a 50 per cent decline by 2050.

With every 1-degree Celsius rise in night temperature, yield loss in arabica coffee is calculated to be around 140kg/ha. For Timor-Leste, a change of this nature will drastically diminish farmgate productivity levels. Old coffee trees with weakened root systems supporting an overly grown vegetative cover have a lower chance of survival than rehabilitated trees. R&R enhances the vigour and strength of the trees, allowing them to withstand these threats.

2.4 Cost of R&R

Both renovation and rehabilitation incur high upfront investment. Renovation costs more than rehabilitation, as it requires more labour and equipment for activities like removal of existing trees, hole digging, and new plantings. In comparison, rehabilitation mainly requires tools and labour for pruning.

R&R strategy will therefore need to be based on both context and resourcing.

Figure 2 provides a conceptual model of investment and returns related to R&R activities. It shows a timeline for investment and return. The 'valley of death' shown in the figure is the period immediately after rehabilitation or renovation, where return from the field is significantly reduced or even zero. As the figure shows, there is a much longer valley of death for renovation than for rehabilitation.

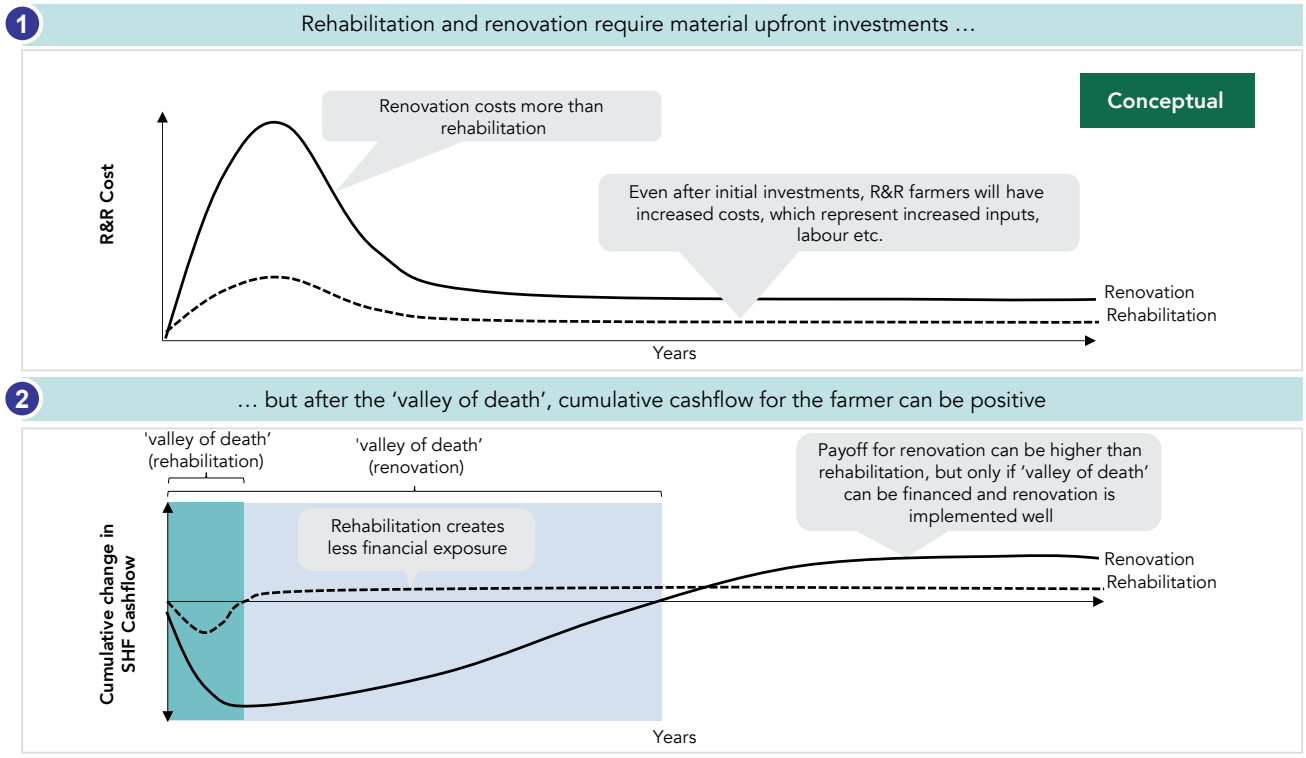


Figure 2: Investment and return related to R&R activities (USAID Bureau for Food Security, 2017)

2.5 Financing models for R&R

Coffee rehabilitation is a costly task. Farmers may have different capacities for funding the selected rehabilitation program, based on where they are placed on the value chain. As is shown in Figure 3, coffee farmers can be grouped in four different categories: i) plantation-based large to medium scale farmers; ii) Commercial SHFs in tightly connected value chains; iii) Commercial SHFs in loosely connected value chains; and iv) Disconnected SHFs.

Farmers in the top two categories are likely to finance, or find support to fund, their own rehabilitation programs, and have the capacity to connect successfully to financial aid mechanisms such as loans. Farmers in the third category are likely to be supported best via grant programs as they lack financial reinforcements. As these farmers are commercial SHFs, they are likely to manage and implement the rehabilitation programs even without technical assistance. The bottom category in Figure 3 shows the disconnected SHFs who are sporadically, rather than consistently, connected to a buyer or a farmers association or group; alarmingly, the majority of the SHFs in coffee growing regions across the world operate within this arrangement. Higher number of disconnected farmers indicate a greater need for rehabilitation. Grants along with technical assistance and capacity building are the most suitable ways to support coffee tree rehabilitation for disconnected farmers (Sustainable Coffee Challenge & Conservation International, n.d.).

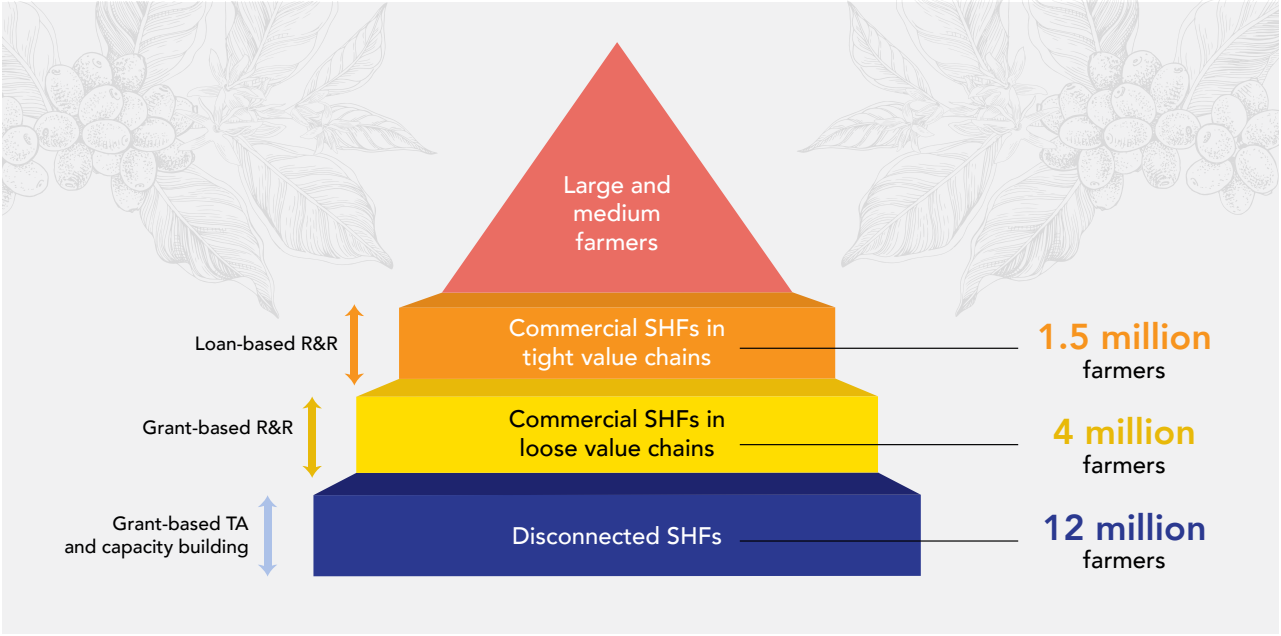


Figure 3: Coffee farmer pyramid in the R&R financing spectrum (Sustainable Coffee Challenge and Conservation International, n.d.)

As the need for R&R grows, so does the need for financial resources. To address this, various organisation types– NGOs, venture capitalists and private financiers – have proposed different financing systems to support R&R operations. These systems rely on funding through farmer cooperatives.

Financing models for SHFs fall into three main categories: i. grant-based financing; ii. loan-based financing (with or without technical assistance); and iii. grant-based finances with technical assistance.

Loan-based finances can be explained using the example in Figure 4.

One of the key organisations funding coffee R&R globally is Root Capital (IDH, 2017). Figure 4 gives an example of one of the Root Capital financing models. In this model, agronomists and loan officers work together on feasibility and monitoring both before and after funding. Agronomists brief loan officers on technical aspects for developing internal control systems. These are essential for tracking performance against land coverage and productivity targets.

A farmer cooperative wishing to secure Root Capital finance needs to submit a loan application that includes an agronomic plan. This plan should contain:

- An overall diagnosis of the coffee farm
- The prescribed treatment based on the percentage of the cultivation that requires renovation or rehabilitation, and the percentage that will be renovated or rehabilitated using the requested funding
- The selection and proposed application of farm inputs
- Projected revenue, and the cost of the renovation or the rehabilitation plan. This forecast should include plant mortality and yield estimations.

Purpose	R&R of permanent/perennial crops
Tenure	Up to seven years, with a grace period on principal payment for up to two years.
Monitoring	Three visits per year to the enterprise, as well as to the farms of 20 per cent of the participating producers/farmers. The sample is identified by the root capital agronomist.
Repayment	Amortised repayment of principal beginning in year three. Interest repayments begin immediately and are paid on a quarterly basis.
Collateral requirement	100 per cent loan-to-value on a fully discounted basis over the life of the loan, offered in land, facilities, hard assets, or through joint guarantee.

Figure 4: R&R Financing model of root capital (USAID Bureau for Food Security, 2017)

The management capacity of the particular farmer cooperative and its effectiveness in functioning as an organised group will determine whether that farmer qualifies for such funding from external parties. But more than 91 per cent of coffee farmers populate the two bottom-most layers of the farmer pyramid (Figure 3). The operation of their rehabilitation program lacks structure and organisational skills, and limits their success with gaining support from loan-based or investment-based financing systems.

Better understanding the farmer profile and structure of the coffee industry will help the funding body to determine whether loan-based or grant-based financing is suitable. This identification will also influence important decisions, such as the ideal R&R technique to apply.

2.6 Decision making on financing smallholders

Both farmers and investors need to assess R&R activities from their own perspectives. The assessment should be based on resource availability, return on investment, risk assessment and operational feasibility. A five-step analysis should be applied:

1. Pre-assessment—assessing short- and long-term viability based on cost, capacity, impact of climate change for the relevant region, and the farmer's willingness to invest
2. Analysis of the program design—this should be based on farmer segmentation (see Figure 3) and a detailed R&R needs analysis of the local area
3. Partner identification—suitable support organisations should be selected as partners
4. Implementation of components—this step involves structuring and implementing financing, verifying that training was done, and distributing tools
5. Follow-up—monitoring results and adapting practices based on feedback.

Steps 1 and 2 vary based on the R&R decision tree (Figure 5). This will help stakeholders to assess the viability of the program based on different farmer segments, grouped by farmer capacity (see Figure 3). Step 3 elements will vary depending on partners' interests. Step 4 requires detailed tailoring and implementation of input, finance and knowledge. Step 5 is essential for learning and for adapting to changing circumstances.

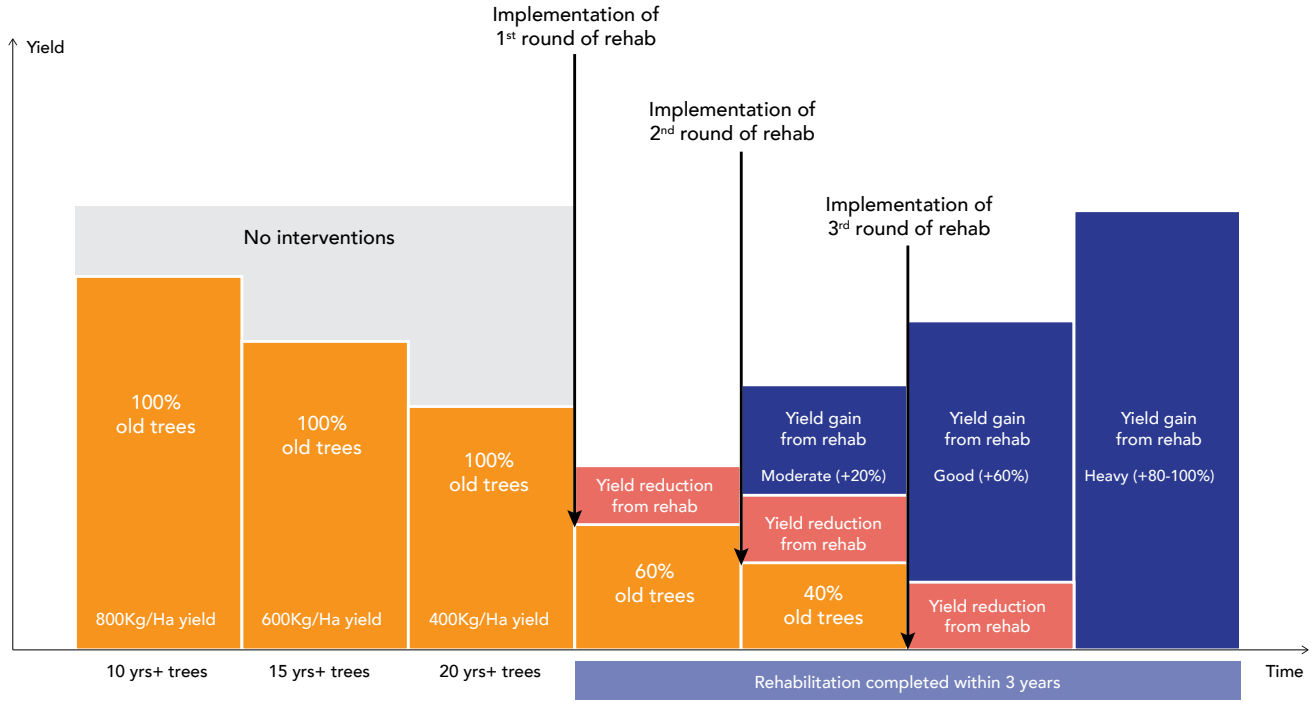


Figure 5: Sectional rehabilitation of coffee cultivations to optimise income

- The far left section of Figure 5 (orange shading, labelled 'no interventions') shows the gradual yield decrease with no interventions.
- Year 1: In the first round of rehabilitation, 40 per cent of the old trees are fully stumped (rehabilitated). Because only a proportion of the plantation is rehabilitated, during the next season the farmer will receive an income from the non-stumped old trees.
- Year 2: In the second round of rehabilitation, another 20 per cent of the old trees are stumped. This season there will be a yield loss from the newly stumped trees, but the farmer will receive improved harvest from the last year's stumped trees and from the remaining 40 per cent of old trees.
- Year 3: In the third round of rehabilitation, the remaining 40 per cent of the old trees are stumped, completing the rehabilitation plan. This season, the farmer will receive a significant change in income due to the improved yield from the trees from the two previous rounds of rehabilitation.
- Year 4: In the fourth year, after starting the rehabilitation activities, the farmer will observe an outstanding improvement in yield and profit as all the stumped or rehabilitated trees are in production. But the farmer will have to conduct the recommended monitoring in order to maintain the gains after every round of rehabilitation.

In Figure 5, hypothetical percentages are used to indicate the proportion of trees to be rehabilitated. The ratio of plantation that will be rehabilitated depends on the farmer's resource availability and ability to absorb income losses in the interim period.

2.7 R&R in Timor-Leste: Rehabilitation or renovation?

In light of the information above, it is more practical for smallholder farms in Timor-Leste to focus on rehabilitation than on renovation. There are three main reasons:

1. Rehabilitation is less resource intensive than renovation. Upfront investment is higher for renovation because it requires significant labour and tools for uprooting old trees, digging holes, and replanting.
2. Income loss for farmers is less severe with rehabilitation. Farmers can continue to earn a small income from the rehabilitated trees during the valley of death (Fig. 2). With renovation, farmers lose their income from renovated plantation completely for at least five years. The recommended strategy is to rehabilitate less than 25 per cent of the farm every year, as opposed to the whole farm. Therefore rehabilitation offers a gradual and less drastic way of rejuvenating coffee trees.
3. There are lower risks with rehabilitation. With renovation, old trees are uprooted and new seedlings are planted. There is a high risk of seedlings drying out or not growing effectively due to lack of input of materials such as water and compost, and due to environmental factors such as rain, sunlight and shade management.

Accordingly, this report focuses on rehabilitation rather than renovation. Most of the R&R trials in Timor-Leste have also been focused on rehabilitation. There have been some efforts to complement rehabilitation with new planting. Figure 5 illustrates one model for how to implement rehabilitation gradually in smallholder farms, and the corresponding change in yield.

Return on the investment for, or the payoffs on, renovation can be higher than for rehabilitation, but only if the financing through the 'valley of death' period is carried out successfully and activities, including monitoring, are implemented effectively.

As an example, after either of the R&R activities are completed, activities such as water shoot removal, lateral branch pruning, and apical meristem removal have to be performed to ensure the success of the original investments in rehabilitation. For most smallholder farmers, cost, commitment and low return during the first phase of renovation can be overwhelming. For example, commitment means monitoring after rehabilitation on an ongoing basis, which requires labour and frequent attention to the plantation. Rehabilitation, which is less resource intensive and results in less income loss, makes less severe demands. It is therefore more suitable for smallholders.

Chapter 3

The status of coffee plantations and rehabilitation efforts in Timor-Leste

3. The status of coffee plantations and rehabilitation efforts in Timor-Leste

3.1 Agronomical issues

Most of the coffee in Timor-Leste is managed by smallholder farmers. Farmers visit the farms during harvest season only. Coffee plants grow in wild settings without any control or management.

The following features are common in smallholder coffee farms in Timor-Leste (also see Appendix 2):

- Coffee trees grow beyond reach of farmers (>1.8m), making selective picking difficult (see Figure 6, which shows how the tree needs to be bent for picking when it grows too tall).
- Farmers do not practise any of the necessary plant management systems, including pruning (of coffee trees and shade trees), fertilisation, disease management, loosening of topsoil and mulching.
- Shade trees grow erratically, with large unmanaged canopies.
- Overgrown coffee trees reduce productivity by limiting sunlight interception in the plantations. Since shade trees and coffee trees compete for sunlight, coffee trees continue to grow tall with few lateral branches, making the cherries unreachable (see Figure 7). This vertical growth limits sunlight interception in the lower branches, which results in reduced flowering. Overgrown trees also reduce sunlight interception for the soil. As a result, soil temperature drops, reducing micro -organism activities. Since farmers do not use any external organic or non-organic fertiliser, organic matter on the soil remains undecomposed, which leads to macro and micro nutrient deficiencies.
- Coffee is grown from self-sown seedlings. Farmers do not uproot wild-grown seedlings. Wild seedlings have less vigour than nursery-grown seedlings because they do not receive homogenous nursery media and space. As a result, new plants have a high mortality rate.
- Coffee is not planted in rows, and trees do not maintain the recommended inter-plant spacing.
- Coffee rust (Hemelia Vesterix) is increasing in Timor-Leste. This is a severe threat to coffee trees: it has decimated coffee plantations in many countries. Because of the ageing trees, even the Hibrido De Timor (HDT) variety, which is highly resistant to rust, is now becoming susceptible.

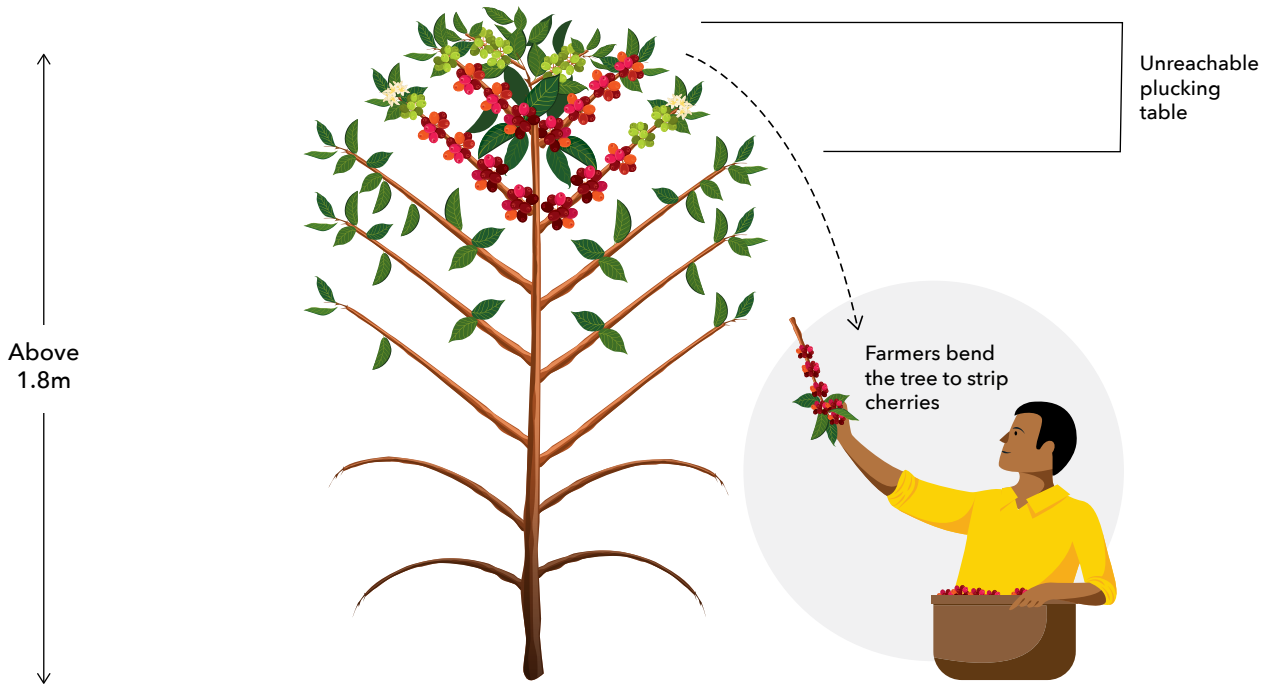


Figure 6: Cherry harvesting/stripping by bending the trees

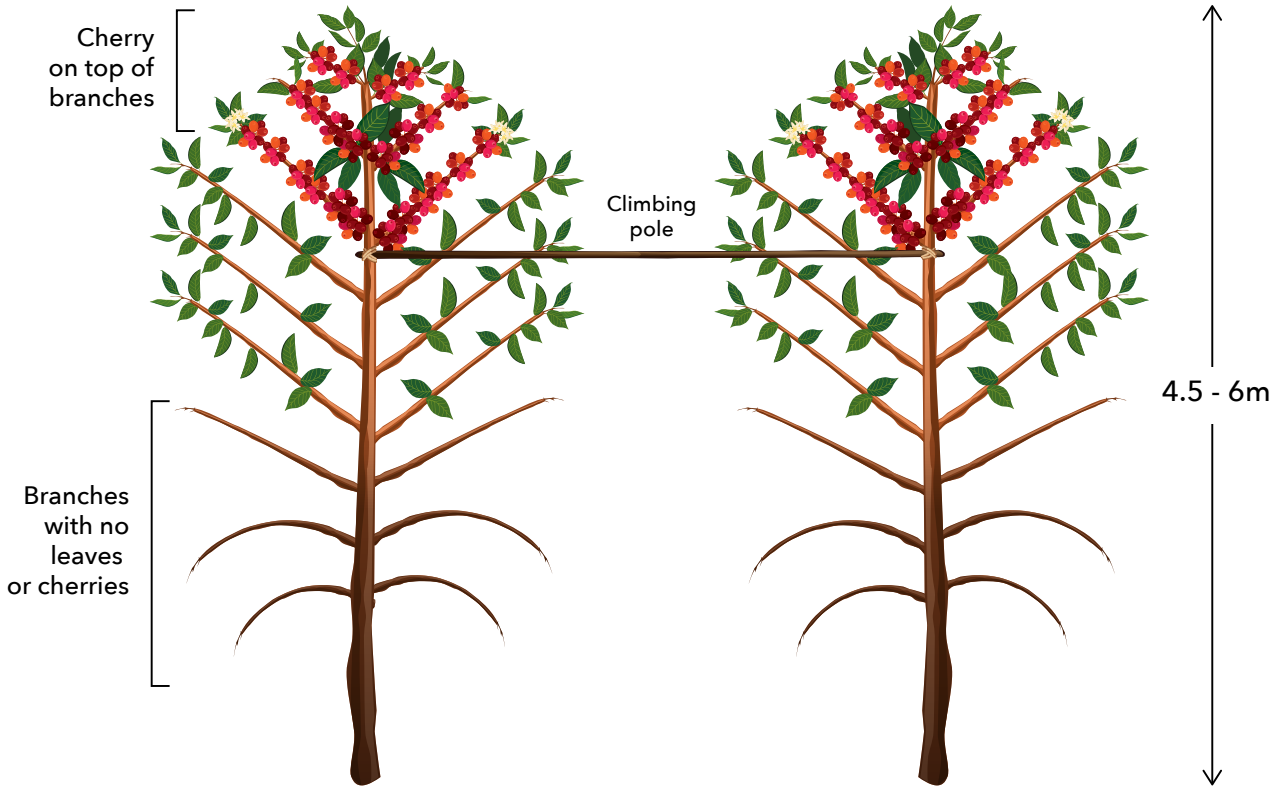


Figure 7: Conventional plucking techniques for overgrown trees

Consequently, productivity per hectare has dropped to 195kg/ha per year, compared to 600kg/ha in Indonesia and 900kg/ha in Colombia. The World Bank (Curnow, 2002) estimates that Timor-Leste's harvests are 21% of the average in other coffee-producing South Asian nations (Inder, 2013). At the peak of coffee production in Timor-Leste during the colonial period, coffee harvest was 600kg per hectare. According to the NCSDP, around half of all coffee farms require intensive rehabilitation because the trees are overgrown or have long passed their productive life. Low productivity and fluctuating quality have reduced the value of coffee export and income for coffee farming households. According to the 2011 Timor-Leste Household Income and Expenditure Survey, average annual income for a coffee-producing household is USD285 (Inder, Brown & Datt, 2014). Securing an adequate price and a suitable market have also become challenging due to supply inconsistencies. It is crucial to identify and scale up successful and cost-effective models for coffee rehabilitation in Timor-Leste.

> *[With] the unmanaged conditions of East Timor, many coffee trees grow out of reach and this poses difficulties for farmers. Much time is spent picking cherries, with little time for local sorting into red, green and over ripe cherries. This, in turn, contributes to the low quality of coffee.*
>
> (Amaral, 2003).

3.2 R&R initiatives

Cooperativa Café Timor

Introduction

Cooperativa Café Timor (CCT) is one of the oldest and largest coffee exporters in Timor-Leste. It exports more than 60 per cent of Timor-Leste's total annual export. CCT has more than 25,000 smallholder members, who have both 'Fairtrade' and 'Organic' international certifications. CCT buys cherries from farmers within 24 to 48 hours after harvest. Wet processing is done at CCT's facilities at the municipality level, and dry processing at its facility in Railaco. The final de-husking, sorting and export processing is carried out at CCT's Akdiru Hun facility in Dili.

Cooperativa Café Timor was established in 2000 with the support of the National Cooperative Business Association (NCBA) and with a grant from USAID (Piedade, 2002). NCBA is a not-for-profit organisation, an umbrella-type organisation for cooperatives in the USA. NCBA started working in Timor-Leste in 1994 together with USAID to support coffee production in the province. Almost all coffee farmers in Timor-Leste sell part or all of their coffee cherry yield to CCT. CCT's cherry price each year is based on the international market price for coffee, and influences the annual market price for coffee in Timor-Leste. CCT farmers are free to sell their coffee to any buyer. CCT's only contract requirement of its farmers is that they are organic farmers.

Rehabilitation

NCBA recognised the need for rehabilitation in the 1990s. It promoted the removal of unproductive branches and the trimming of coffee trees before they reach 7–10m in height to facilitate air circulation, reduce humidity, and provide easier harvesting, not to mention the elimination of unproductive growth. This system was first demonstrated in 1997 after being trialled, and the demonstration involved 1,000 farmers and up to 10ha in the Ermera, Ainaro, Liquica, Aileu and Manufahi districts. The results were impressive, with production increasing from 100 to 300 per cent in over three years. After the observed successes, NCBA and CCT set up demonstration plots of half to one hectare each for coffee rehabilitation in all major coffee producing municipalities, focused on pruning and terracing, for farmers to visit and observe rehabilitation for themselves.

CCT has continued this coffee rehabilitation program with the support of the governments of the USA and New Zealand. It is currently implementing a program called Coffee and Cocoa Agribusiness Opportunities (CACAO) with funding from the Government of New Zealand.

CCT's rehabilitation program has three components: 1) supporting farmers to rehabilitate their coffee farms, 2) establishing demonstration plots, and 3) developing diversification opportunities for farm families to prosper. Under the current program, CCT has rehabilitated about 3,000ha of coffee farmland every year, a total of 15,000ha to date.

Each farm has about 500 to 700 coffee trees. CCT's model is to rehabilitate 25 per cent of each farmland every year, and the rehabilitation model involves stumping and pruning. Together with the farmers, CCT staff do stumping immediately after harvest in September, and follow up with monitoring activities in March/April in the following year.

CCT has also set up 100 demonstration plots, situated close to existing farmlands. After the selection of an area, CCT signs a contract with the farmer of the selected land for three years. This contract allows CCT to rehabilitate the farm and conduct monitoring and management for three years of rehabilitation work. The demonstration plots show best practice and the benefit of coffee rehabilitation to neighbouring farmers.

The main difference between the two programs—farm rehabilitation and demonstration plots—is their implementation. Farm rehabilitation is implemented by farmers using unpaid (family) labour, with support from CCT's extension staff. The demonstration plots, on the contrary, are run directly by CCT.

For farm rehabilitation, CCT provides basic tools such as pruning saws and pruning shears, together with wet weather working garments and boots. CCT's extension staff coordinate the use of the tools and train farmers in rehabilitation and monitoring practices. CCT uses communal labour for rehabilitation, and does not pay wages to farmers.

CCT promotes the following rehabilitation practices:

- Managing tree height at about 1.2-1.5m by removing apical meristem (topping) and encouraging lateral branch growth.
- Maintaining the length of the stem from the ground to the point of stumping at 15–20cm. All unnecessary shoots below the point of stumping should be removed.
- Removing unproductive branches to ensure adequate light and improve circulation within the tree (aeration).
- The two- to three-stem or vertical management technique. Though this technique is recommended, its application may vary depending on farmer capacity. Working with a higher number of stems requires complex management.
- Broadcasting organic manure around the root zone of the trees and using plant debris—organic material—as a mulch around the trees to prevent surface runoff of water. CCT recommends using 4kg of fertiliser for each tree. CCT manufactures its own organic fertiliser from coffee waste materials and other organic additives, and sells it at USD5 per 20kg.

CCT has found its rehabilitation model to be highly successful. Yields have more than doubled after rehabilitation. In the demonstration plots, yield has tripled. This increased yield incentivises farmers to complete the rehabilitation of the remaining 75 per cent of their land. Field observation also confirms that after CCT implemented rehabilitation yield increased significantly. Trees demonstrate better vigour and they are more productive. CCT's demonstration plots set a useful precedence for the coffee industry in terms of good agronomic practices.

However, the currents condition of the rehabilitated farms varies depending on the respective farmers. Recently rehabilitated farms are in better condition because of continued supervision from CCT. Many farms that were rehabilitated more than five years ago show lack of maintenance by farmers. Lack of continued monitoring is a challenge for the industry as a whole, not only for CCT.

CCT considers renovation riskier than rehabilitation. There is a risk of seedlings drying out in the absence of irrigation systems, and it is difficult to convince farmers to adopt a system with significant financial losses in the first three years. However, CCT encourages replanting and replacement planting of trees that have died, since this does not result in any loss of income. CCT distributes some 200,000 seedlings and 100,000 shade trees every year.

In addition to CCT's core business of exporting organic and fair-trade coffee, it is also the largest buyer and exporter in Timor-Leste of vanilla, pepper and cloves.

National Directorate of Coffee and Industrial Plants in Timor-Leste

Introduction

The Ministry of Agriculture and Fisheries (MAF) plays an important role in Timor-Leste's coffee sector. Within the MAF, the Directorate of Coffee and Industrial Crops is the unit that manages the coffee sector. Under this Directorate, the Direção Nacional De Café E Plantas Industriais (DNCPI) manages and monitors coffee cultivation in Timor-Leste.

DNCPI is mandated to provide both extension and research services for the coffee industry. Almost all exporters have private extension staff to support the relevant producers, but exporters do not have the resources or capacity to conduct research. Therefore research is an important area where the DNCPI can support the coffee industry. To date, the DNCPI has not conducted any systematic research on coffee yield; rather, its research has been focused on food crops. But the intention is to start doing focused research on coffee productivity, and the DNCPI has identified land to be used as a research site (Coffee Quality Institute, 2017).

Rehabilitation

In 2003, the DNCPI, noting that 16,000ha of coffee plantation needed urgent rehabilitation (Amaral, 2003), proposed to replant 3,200ha each year using selective replanting. The aim was that in five years all 16,000ha would be replanted.

The DNCPI has implemented various demonstration plots throughout the country. There is little published data or information on these plots, and therefore it is difficult to find information on DNCPI's rehabilitation programs.

However, it is known that the DNCPI began rehabilitation trials in 2012. And, in its annual action plan for 2015–2019, the Directorate proposed the rehabilitation of 500ha per year. Between 2015 and 2019, the total area rehabilitated was 1,528ha (70ha in 2015, 508ha in 2016, 450ha in 2017 and 500ha in 2019). In 2019, the DNCPI carried out a total of 224ha of rehabilitation in the municipalities of Aileu, Ainaro and Manufahi.

When it investigated the condition of Timor-Leste's coffee farms, the DNCPI found there were some plantations with very old, very tall trees, and minimal production. It is therefore focusing on the rehabilitation and rejuvenation of existing plantations, recommending pruning, regeneration and improved fertility practices. Monitoring is also highlighted as an important practice.

The DNCPI recommends that when trees are pruned for rejuvenation there should be continuous replanting of new coffee seedlings between the lines of the older coffee plants and shade trees for coffee. It has also highlighted the importance of cutting shade trees to maintain their height, and has cut older shade trees in some areas as well as introducing new varieties. The DNCPI continues to urge coffee owners to cut planted temporary shading trees before they are too big and difficult to cut, and compete with the coffee trees.

To support rehabilitation financially, the DNCPI has provided remuneration of USD300 per hectare to farmers for rehabilitating their land. It has also supplied equipment support in the form of provided free tools and seedlings to farmers, and technical support through its extension staff. DNCPI considers this remuneration fundamental for incentivising farmers to do rehabilitation.

There have been different levels of success with rehabilitation, as there are challenges with procuring finance, tools and services. But DNCPI is committed to supporting the rejuvenation of coffee trees in Timor-Leste. Despite the various challenges, it is continuing its work on providing access to micro-credit facilities, and improving farmer awareness of good agronomic practices to facilitate rehabilitation. For example, it highlights the following advantages of pruning as a form of rehabilitation:

- It provides space for new shoots and horizontal branches to emerge and grow
- A treetop is created for plants, with dimensions and density that will make it possible to attract light for foliage and promote the production of fruit
- It is easier for farmers to move around the trees as they work, particularly in the harvest season
- It enables the removal of fruitless branches and those infected by pests or diseases.

After rehabilitation, the DNCPI ensures that coffee farmers also carry maintenance of trees in the first and second year after rehabilitation. It advocates that maintenance should not merely be the process of removing coffee buds and pruning the coffee treetops, but should also include clearing wild grasses (turf, lawns, and weeds) and ploughing to loosen the soil around the cut coffee stumps.

The DNCPI advises that rehabilitation results should be monitored on a national level, through collaboration between the Directorate of Municipal Agricultural Services and other entities. A team should be assigned for regular field visits, so that results can be confirmed, new information shared, and the monitoring and evaluation process continually improved.

Renovation

MAF (DNCPI) has a plan to renovate 100ha of coffee farms in Ermera, and has established a nursery to produce seedlings for this renovation effort. This presents a good opportunity for applied coffee research on improving productivity, including the use of new varieties, the renovation of existing trees, coffee nutrition, and the use of shade trees.

Outspan Agro Timor/Olam Timor-Leste

Introduction

Outspan Agro Timor is the second biggest coffee exporter in Timor-Leste, exporting about 15 to 20 per cent of the total annual export. It is a subsidiary of Olam International, which is one of the world's biggest commodity traders. Outspan started operating in Timor-Leste in 2015. It bought the business of a Timorese processor, Timor Corp. Olam acquired Timor Corp's warehouse, milling facility and network of agents.

Olam buys coffee through agents, and direct from 2,000 farmers. It primarily buys dry parchment, which is centrally processed at its facility. It actively practises cupping for grading its coffee. Olam's biggest challenge has been to ensure sufficient volume of coffee due to declining productivity. Increasing its volume of export is crucial to ensuring the long-term viability of its operation in Timor-Leste.

Rehabilitation

In 2018, Olam started implementing a two-year coffee rehabilitation program, funded by the Asian Development Bank (ADB). The funding is for Olam's operations in four countries, to increase the production of smallholders and improve the resilience of Olam's operations. This program is intended to build producers' capacity and incentivise them to adopt continuous rehabilitation.

Olam's agronomical rehabilitation practices are similar to those of MAF and CCT. Olam's focus is on pruning and stumping. It has established a large number of demonstration plots for farmer groups. The land for these demonstration plots belongs to the lead farmer, who is responsible for managing other group members. All farmers in the group receive hands-on training on rehabilitation techniques. Olam supplies pruning saws, pruning shears and hoes to the group. The tools are shared among group members, but the lead farmer manages the tool kit.

Olam recommends two-stem management for arabica coffee and four-stem management for robusta coffee. This way, when farmers need to stump or prune, there is always one productive branch left on the tree.

Communal labour is used to conduct rehabilitation. Olam does not pay wages to the labour. Olam has recruited 10 field coordinators to supervise this program. Each coordinator manages 16 farmer groups in Ermera, Aileu and Liquica. Farmers are encouraged to rehabilitate their farms in stages. To date, Olam has engaged 3,000 farmers, and the target is to engage a further 1,000 in 2021.

Olam recognises that continuity of coffee rehabilitation is the most crucial challenge for R&R in Timor-Leste. It has a threefold strategy to improve continuity of rehabilitation by farmers. First, Olam provides multiple trainings for improved retention. Its contact with farmers is significantly higher than that in other R&R programs in Timor-Leste: it provides eleven training sessions a year, each session scheduled to coincide with a specific time in the production cycle. For example, training is run in February focusing on stem selection, sucker removal and height control.

Olam also provides printed training materials on rehabilitation practices. It believes that increased engagement with farmers will improve farmers' understanding of the need for rehabilitation, and they will better internalise the recommended practices.

Olam also intends to ensure that its farmer groups receive certification premiums. This will give farmers incentive and financial capacity to continue investing in rehabilitation.

In addition, Olam uses an internal traceability system, called the Olam Farmer Information System, to track its engagement in the community. This tool helps track all activities, including initial and final audits, trainings and specific rehabilitation efforts. It is crucial for monitoring progress and return on investment in the short and long term. Olam has identified the limited ability to track the outcome of various investments in rehabilitation as a key gap in the continuity of R&R efforts.

It is too early to determine the success of Olam's program. But closely monitoring its progress can provide important lessons for the industry on the elements of farmer adoption and continuity.

Timor Global

Introduction

Timor Global is one of the oldest coffee companies in Timor-Leste. It is currently the third largest exporter in Timor-Leste, with 10 to 15 per cent of Timor-Leste's total annual exports. It buys from agents and direct from farmers. Wet parchment is purchased and then processed centrally at Timor Global's facility.

Traditionally, Timor Global traded commodity coffee. But between 2018 and 2020 it has been transitioning to specialty coffee. It won the national coffee quality competition in 2020 with the highest ever cupping score in Timor-Leste.

Timor Global is also the only exporter in Timor-Leste with certified coffee quality professionals. Its vision is to grow the volume of its specialty coffee supply, which requires investment in improving quality and increasing yield.

Rehabilitation

Timor Global launched a coffee rejuvenation program in 2019 that combines rehabilitation and new planting. Timor Global's agronomical practices are similar to that of CCT, Olam and the MAF: it focuses on pruning and stumping old trees.

The unique aspect of Timor Global's rehabilitation program is the implementation and funding model. Unlike other rehabilitation programs in Timor-Leste, Timor Global's rehabilitation program is funded by impact investment. Impact investing presents an alternative source of financing for R&R. The impact investor will provide funding and technical support for improving quality and increasing productivity. The aim is to improve the overall return for the business. Timor Global has established demand for its coffee, which makes it lucrative for commercial investors. This can be an important learning for the industry.

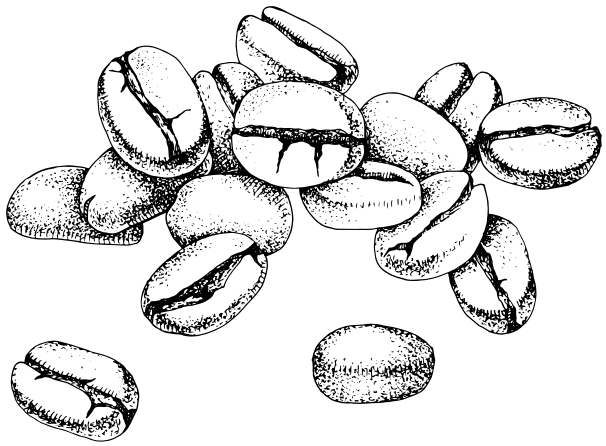
Timor Global is implementing rehabilitation on its own 3,000ha plantation in Ermera. Therefore, unlike other exporters, it is engaging paid labour. The workers are divided into teams of 15 workers with a team leader. Team leaders and workers are paid at different rates. Also, the cost of labour differs for light pruning and stumping. Team leaders receive training and manage the tools. Timor Global provides expandable loppers, clippers and saws. Each team is expected to complete 2ha every week, with 1,600 trees per hectare. The aim is to rehabilitate 600ha to 1,000ha every year. At this rate, it will take three to five years to rehabilitate the full plantation. Timor Global is actively encouraging intercropping with konjac, pepper, ginger and kidney beans. This will minimise income loss for farmers arising from rehabilitation, and the supplemental income will reduce farmers' resistance to doing R&R.

The programs mentioned above are the large-scale coffee rehabilitation programs in Timor-Leste. There are also several other relatively small-scale R&R initiatives, described below.

Quinta Portugal Timor

Projeto Quinta Portugal provides agricultural research and extension services for different agricultural products, particularly agroforestry. Its range of activities include conducting agricultural trials, growing and distributing seedlings and training farmers. But its main focuses are research and capacity building.

Projeto Quinta Portugal is funded by a Portuguese Government body, the Portuguese Institute for Language and Cooperation, Camões I.P. Located in the Aileu district, Camões I.P. is one of the oldest institutions in Timor-Leste conducting research on coffee rehabilitation. Many of the high calibre R&R experts in Timor-Leste originated from programs that were managed and implemented by the Portuguese Cooperation Institute in the last 20 years. These experts have run various R&R trials in the past, but unfortunately data collection was not done suitably, and there was no follow-up after the trials. There is also no published data on their work, so these experts are not able to recommend verified R&R strategies at this point. However, the current project manager at December 2020 is rectifying this and doing better data collection arising from the research on productivity. Quinta Portugal has also started to engage with the coffee industry through the Timor-Leste coffee association. With continued engagement and better follow-up of its trials, Quinta Portugal could become a valuable source of technical expertise on R&R.



East Timor Coffee Institute

East Timor Coffee Institute (ETCI) is a private educational institution specialising in coffee and agricultural diversification. It provides training courses focused on coffee harvesting and processing. It also maintains a nursery that produces seedlings that are distributed to neighbouring farmers. ETCI has four cuttings of the original HDT variety, and this presents interesting research opportunities.

ETCI is eager to contribute to improving the coffee production in Timor-Leste. It has not yet implemented any targeted activities for coffee rehabilitation. But with the right support and partnership(s), it could provide technical support for R&R. ETCI has recently signed an MoU with Timor Global, to support Timor Global's rehabilitation program in Ermera. This program will offer ETCI students the opportunity to be part of Timor Global's rehabilitation program, and ETCI will conduct productivity research at Timor Global's plantation.

PARCIC

Pacific Asia Resource Centre Inter-Peoples Corporation (PARCIC) is an established social enterprise and a medium-scale coffee exporter in Timor-Leste. It exports approximately 100 tonnes of coffee annually, and exports certified coffee, mainly to Japan. Recently PARCIC has been trying to produce and market specialty coffee.

PARCIC trialled its first rehabilitation efforts in 2006. In 2019, it launched a five-year rejuvenation program with one of its partners, the cooperative COCAMAU in Maubisse. This program is funded by the Japan International Cooperation Agency—JICA. Approximately 30 farmers of the 600 member farmers of COCAMAU have opted to join this program. From this group, farmers whose coffee farming performs well as a result of the program will be selected as COCAMAU's extension officers, to ensure that the rehabilitated farms are monitored. Farmers in the program provide free labour, and both PARCIC and COCAMAU supply tools and technical assistance.

PARCIC conducted a survey to assess the current condition of the farms, which included, but was not limited to, information on the age of the trees, distance between plants, terrain and shade. PARCIC shared this information with farmers and also advised farmers on the optimal rejuvenation method for the short term. Farmers used this information as a basis for deciding which R&R method they would adopt.

It has proven difficult to convince farmers to adopt the optimal renovation method for the short term, because they will lose income from the renovated land for five years, and this is frightening for them. Therefore, the farmers are implementing a combination of renovation and rehabilitation, and the models vary widely between farms. For rehabilitation, PARCIC recommends a two-stem management system.

PARCIC has established a simple data collection and management system that can be implemented by the farmers. This program is in its early stages, and valuable learnings are expected from this program in coming years.

Letefoho Specialty Coffee (processed by Café Brisa Serena)

Café Brisa Serena (CBS) is a social enterprise, and the first specialty coffee exporter in Timor-Leste. It is a medium-scale exporter, exporting approximately 150 tonnes of coffee annually. The bulk of the coffee goes to Japan as certified coffee. But CBS has also supplied specialty coffee to the USA, Europe and Australia. CBS's parent body, NGO Peace Winds Japan, began setting up coffee nurseries in 2004 and by 2018 had provided coffee producers with approximately 50,000 shade trees and technical assistance with production. CBS is currently running a crowdfunding program to rehabilitate 60,000 trees belonging to 400 coffee households that supply to it.

3.3 Financing and implementation

Most of the coffee R&R in Timor-Leste is financed by development grants. MAF programs aside, almost all other rejuvenation programs are funded by donors or multilateral development agencies. There are two examples of private investment programs, one financed by impact investment and the other by crowd funding. It is clear that strictly commercial financing may not be feasible for coffee R&R in Timor-Leste in the short or medium term.

Social gain is a key driver for grant financing for R&R. Investments from development partners prioritise farmer benefit over commercial return. Commercial financing is more suited to commercial plantations as opposed to smallholder farms. However, impact investment can present a good alternative for Timor-Leste because it connects commercial and social return.

All R&R efforts have used one of two methods of engaging labour, depending on the type of farming and investor capacity:

- Unpaid community labour, where smallholders do rehabilitation on their own farms without any remuneration. They are incentivised by the gain in yield and resulting income gain. In Timor-Leste, over 90% of R&R programs implemented by private companies or exporters follow this model. This model is likely to be more sustainable. It is less resource intensive and it motivates farmers by demonstrating that R&R efforts result in increased yield, which increases their income. But it is difficult to implement because it requires fundamental change in farmer behaviour.
- The use of daily wage labourers, paying them on the basis of the number of hectares rehabilitated. This is a relatively more expensive model but sees quick results in terms of coffee flowering and then fruiting. It is efficient, and suited to large plantations. The GoTL uses this model, considering it important to pay wages to compensate for labour time

3.4 Results of R&R

On an individual level, most of the R&R initiatives have been successful in terms of yield, with an improvement in yield in two to three years. But scale-up continues to be a challenge. The improvements have been ad hoc and limited to specific producers or communities. On a national level, productivity has not improved. There are three main reasons for this:

Issues with finance

R&R is expensive. It requires tools, equipment, and seedlings. R&R also requires hard manual labour, which is physically challenging and expensive. Smallholder farmers and smaller coffee companies do not have the necessary finance to scale up R&R efforts.

Knowledge of R&R techniques

There is lack of knowledge about appropriate R&R techniques. As a result, there are inconsistencies in different locations. Using unsuitable techniques results in inferior productivity, and this reduces producers' incentive to practise R&R.

Adoption continuity by farmers

This is the biggest challenge for R&R in Timor-Leste. In plantations that have already been rehabilitated, farmers do not continue R&R once supervision is over. Also, despite the presence of a successful demonstration plot, only a limited number of neighbouring farmers adopt R&R. Sustainable R&R requires lasting behaviour change for farmers. Various groups and experts are trying to ascertain the most effective model for ensuring continuity in Timor-Leste.

However, there are some fundamental sector issues that reduce farmer incentive to reinvest in coffee. These issues need to be tackled, along with the productivity challenges, in order to bring about lasting change. Returns from coffee are low. The majority of farmers in Timor-Leste sell to coffee buyers who sell the coffee to commodity markets for a low price, with little or no profit. Therefore coffee is not considered a significantly profitable crop to reinvest in. Also, land ownership is unclear, so farmers are hesitant to make long-term investments.

The Portuguese mission reports success in convincing producers to replace ageing bushes by concentrating on key community members (chefes do suco, chefes aldeia, and priests) and by demonstrating how seedlings can be incorporated into plantations by growing them in the shade of productive bushes. However, they acknowledge that success followed many meetings and the 'smoking of many cigarettes'.

(Laird, World Bank, Lunny, Moreira, cited in Curnow, 2002).

3.5 The National Coffee Sector Development Plan (2019-2030)

With the support of the ADB, the GoTL has launched the National Coffee Sector Development Plan (DCSDP) (NCSDP, 2019), which charts the direction of Timor-Leste's coffee industry from 2019 to 2030. The NCSDP emphasises R&R as a crucial need for the coffee sector. The aim is to double the production from 10,000 tonnes per year to 20,000 tonnes by 2030.

The NCSDP has set a target to rehabilitate 30,000 hectares by 2030 (half of the total of approximately 60,000ha of coffee production) at an estimated cost of USD1,000 per hectare. The estimated cost of this rehabilitation effort would be USD30 million – around USD 2.5 million per year for the 12-year period. This investment will cover the supply of planting material and agricultural inputs for rehabilitation for an average of 2,500ha of coffee farmland per annum. According to the NCSDP, the Government plans to conduct a mapping activity for all current R&R programs in Timor-Leste. The NCSDP highlights the important role of the private sector and producers in R&R capacity building. One of the initiatives under the NCSDP is to develop cash-for-work programs to incentivise coffee farm rehabilitation.

The NCSDP provides a set of instructions regarding R&R. This includes advising farmers with 1ha of coffee to be planted and rehabilitated – 0.25ha each year for four years – to create a continuous production and income stream. In this way, the first-year planting will be already productive when the third and fourth year replanting is undertaken. Coffee planting may be done in empty land as new plantings – these lands may be occupied with other crops. The NCSDP suggests selecting superior seed for replanting which has high yield potential and strong resistance to pests and diseases. The height of the coffee trees needs to be maintained at a manageable level by regularly trimming primary branches. A combination of replanting and better management could increase production from 150–200kg/ha to 260–300kg/ha.

The strategy proposed by the Government is well aligned with R&R principles proposed by international experts on coffee and sustainability.

There are many R&R programs and demonstration plots in Timor-Leste. All of them have reported increased yields. CCT data reveals that after rehabilitation production increased from 500–1,000kg/ha to 2,000–2,500kg/ ha over three years, and CCT used the results to set up more rehabilitation demonstration plots around the country. But the most crucial challenge in Timor-Leste has been continuity and scaling up. Farmers seem to lack sufficient incentives and capacity to continue monitoring and adopting R&R. Therefore, successful and sustainable R&R needs a combination of suitable agronomic practices and the right implementation model. R&R program design needs to ensure access to adequate finance, extensive farmer engagement, and evidence of improved yield. It is important to note that low returns from coffee reduce farmers' incentive to invest in rejuvenation. Lasting improvement in productivity requires improvement in farmers' income from coffee.

Chapter 4

Case studies from Timor-Leste

4. Case studies from Timor-Leste

4.1 Methodology

The contents of this chapter are based on field observations from different coffee regions in Timor-Leste. The MDF team visited multiple plantations where R&R has been implemented. However, because of gaps in data, only two plantations have been included as case studies in this report. The two plantations visited or consulted for the case studies are:

1. A large-scale private plantation run by Programa de Apoio ao Desenvolvimento Rural de Timor-Leste (PARTL, a rural development support program for Timor-Leste/Portuguese Cooperation Agency) in Ermera
2. A medium-scale smallholder plantation in Aileu.

4.2 Macro and micro climatic factor analysis

Rainfall analysis

Both Aileu and Ermera have annual rainfall of over 1,600mm. Rain follows monsoon cycles, which usually start in November and continue until March the following year. There are no systems to store rainwater in catchments. Artesian water through surface irrigation is occasionally directed towards the coffee plantations.

Soil analysis

Aileu and Ermera have a soil type called 'Aileu complex', which is sandy clay soil (see Figure 8, which provides a soil map for Timor-Leste). This soil shows rocky and shallow soil depth characteristics. The top layers of this soil in areas with high slopes are acidic. The underlying parent material of this soil is fractured metamorphic schist (plate splitting rock) with scattered springs that have seasonal high water production potential. In higher altitudes, above 900m, with this soil complex, it is common to find many coffee cultivations (FAO, 2019; ACIAR, 2016).

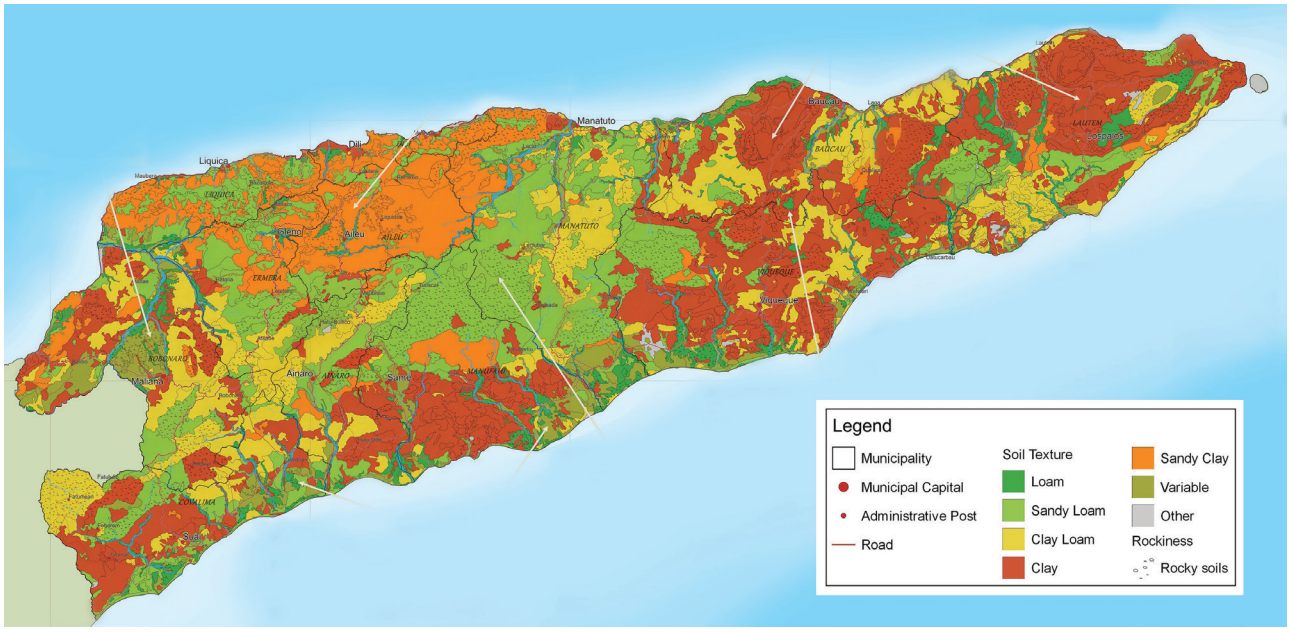


Figure 8: Soil map of Timor-Leste (ACIAR, 2016)

The topsoil layer from Aileu plantation was visually assessed for water retention and texture, porosity and availability of decomposed organic material. The field under observation has been a coffee plantation for over 50 years and had excessive shade tree populations. Due to the poor direct sunlight interception, Ao layer (topsoil) has higher amounts of partially degraded organic matter and soil temperature is less than favourable for the micro organism activities needed for decomposition. The soil, as shown in Figure 9, has moderate humus contents and non-decomposed organic matter.

Figure 9: Organic matter-rich Ao and A layer soil sample from the Aileu plantation

4.3 Case one—Apido, Ermera plantation

Background

This plantation was one of the first demonstration plots implemented in the post-colonial era by a joint program between the Portuguese and Timorese governments. The GoTL owns the plantation, but it is managed by PARTL staff. The first round of rehabilitation was conducted in 2008 along with a coffee new planting program.

PARTL staff and key community members were trained by PARTL agronomists in the full spectrum of coffee plantation management, soil management, seedling and nursery management, pruning, and maintaining the plucking table.

The plantation has Typica, Catimor and HDT cultivars. It spans 5–6ha (varietal differences are shown in Figure 10) and includes well-managed non-rehabilitated and rehabilitated trees. Rehabilitation activities started in 2008 and were managed until 2012 by the Portuguese agronomists, and thereafter by the trained PARTL staff. There are a significant number of trees in this plantation that are yet to be rehabilitated.

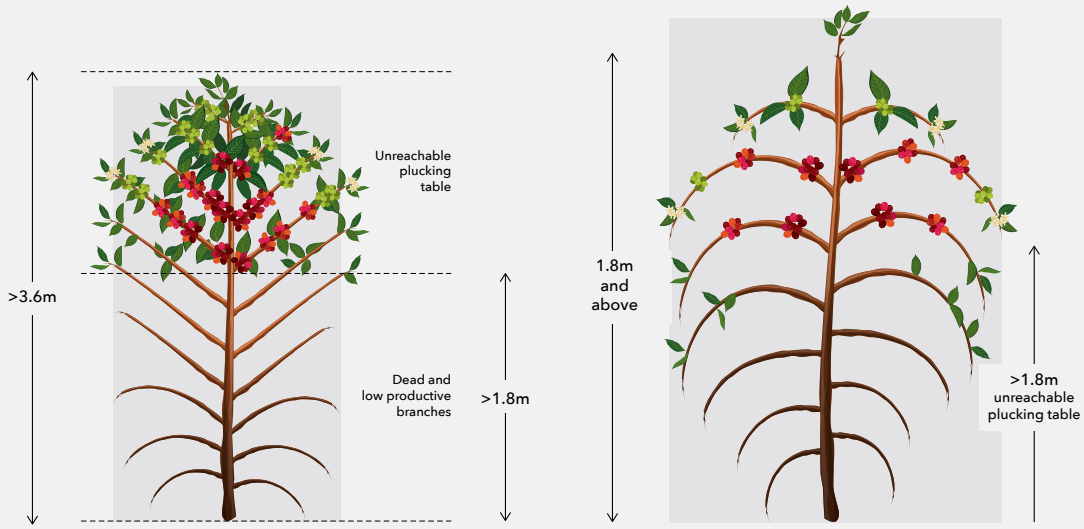


Figure 10: Comparison between HDT and Catimor varieties of poorly managed trees

Observations

- Top pruning was done for all trees by removing the apical meristem. Lateral branches were also pruned and managed.
- Well-managed trees had a minimum 10cm gap between lateral branches. When stem nodes produced branches, workers were advised to remove those shoots to maintain the specific inter-branch spacing.
- Rather than managing too many small branches, a few stronger, highly productive branches were managed to better utilise the photosynthate of the trees.
- Plant spacing was managed at an ideal level, which allowed for easy movement of labour.
- Based on the variety, trees had differences in branch structure and fruit setting (see Figure 10).

Agronomy

Two types of rehabilitation systems or stem management were observed in this plantation.

System A–Timely top pruning and branch pruning only (no stumping)

This system applies to younger trees, trees that are less than 8 years old. Regular top pruning and branch pruning maintains tree productivity and reduces the need for stumping in the next 10 years. Under this system, the following practices were adopted:

- Top pruning was done to make sure the height of the tree did not exceed 1.7m. The observed trees had never been stumped, but were well managed in terms of height and lateral branches.
- Lateral branches were pruned to ensure a 10cm gap between lateral branches.

Figure 11 provides an example of top pruning practices, and Figure 12 shows favourable inter-branch space management.

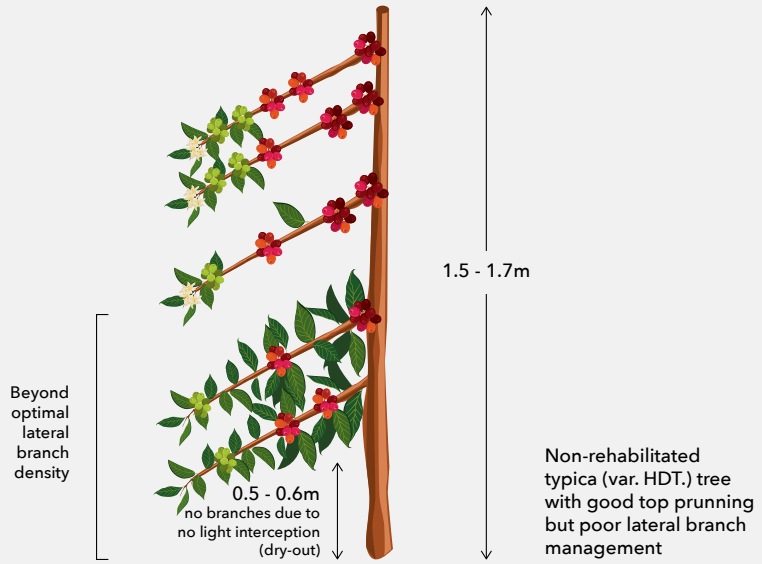


Figure 11: Top pruning practices on non-stumped trees

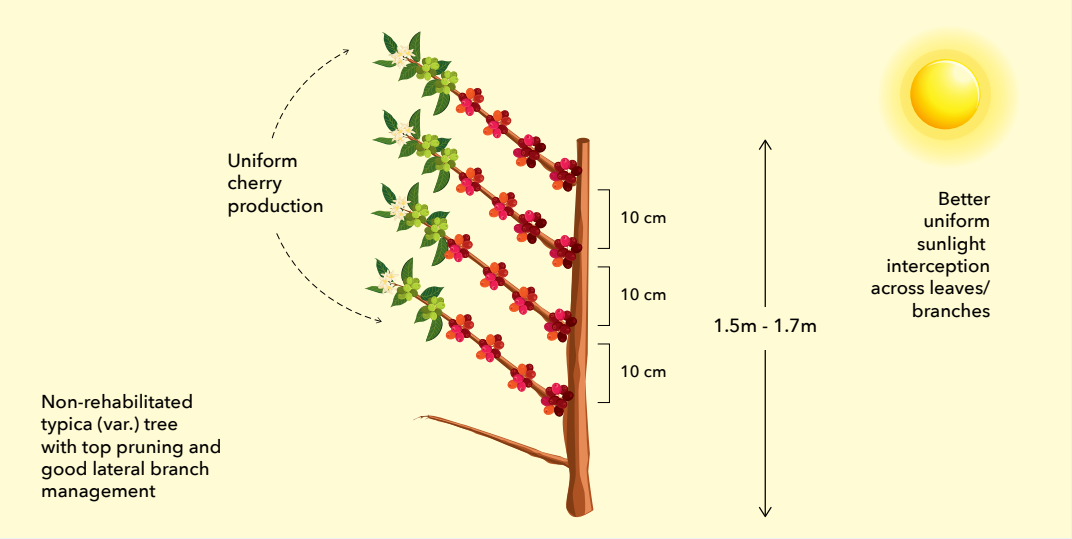


Figure 12: Top pruning and favourable inter-branch space management

Figure 13 shows different sunlight interception on the tree foliage in section A and section B. Section A was treated as the priority for rehabilitation because it had better sunlight interception than section B. Branches in section A were pruned and managed well, and as a result yield was high. Branches in section B were removed because the yield was minimal in this section due to lack of sunlight.

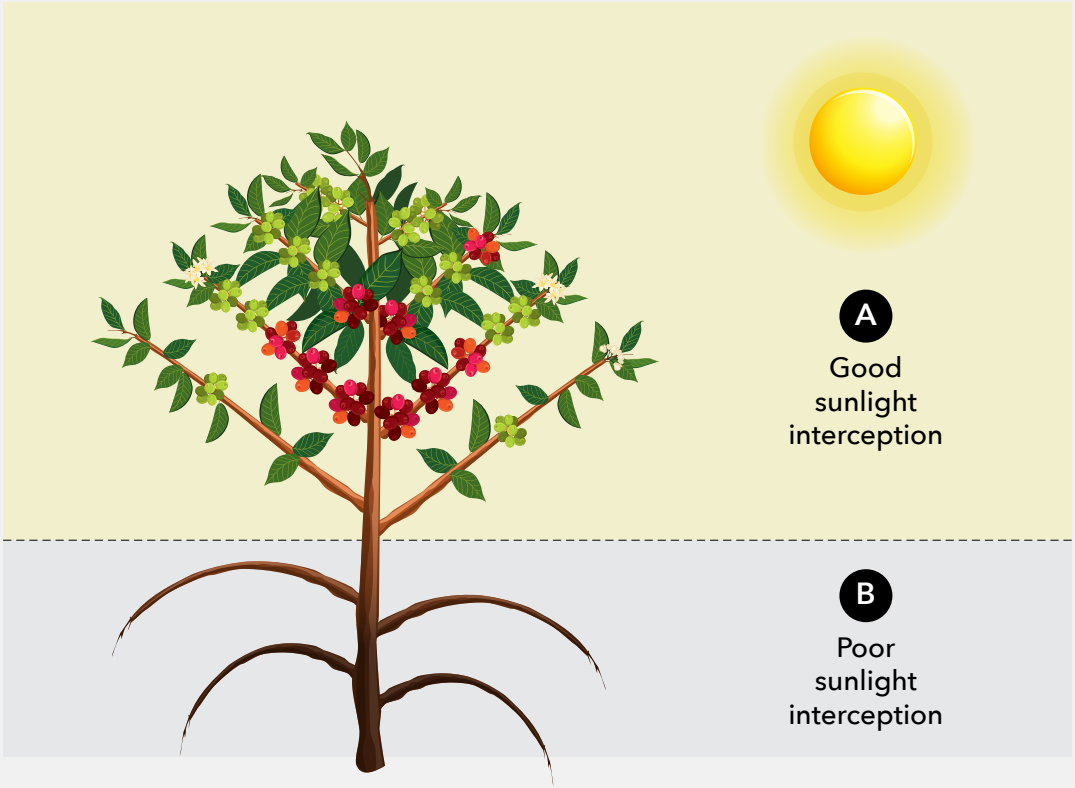


Figure 13: Sunlight interception and cherry distribution

- The canopy was proportionate to the capital root zone, allowing the tree to function better. Overgrown canopy exhausts the roots.
- Pruning of lateral branches and apical meristem was done every year just after the harvest season.
- The canopy of the shade trees was managed with timely branch pruning.

These plantation management practices ensured good sunlight interception to the canopy, maximising leaf area index to increase the rate of photosynthesis. This boosted productivity, and there were higher yields. There were cultivar-specific differences, but fruit set formation and yield were better for pruned trees. The manageable height of the trees also meant farmers could harvest all of the cherries, practise selective picking and minimise fruit drop.

System B–Stumping with timely top pruning and branch pruning

This system applies to older trees that are underperforming due to age or lack of maintenance. A combination of stumping and pruning is essential for old trees to regain optimal productivity.

- Through this system, underperforming trees are stumped and only one stem is allowed to re-grow (see Figure 14). All water shoots below the point of cut or stumping are removed.
- Once the new stem is productive in two to three years, all practices mentioned under system A above for branch management, top pruning, and tree height management are adopted for the new stem.

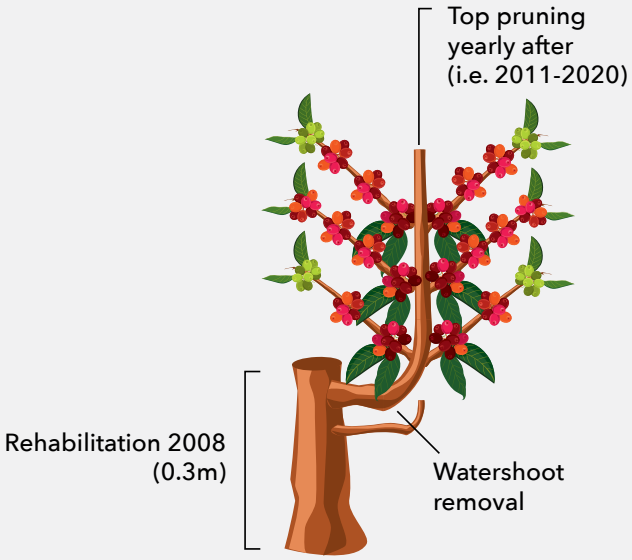


Figure 14: Rehabilitation with one-stem management technique

Financing and labour

Technical resources for training and tools for the rehabilitation were provided by the Portuguese agricultural mission, and labour was funded by the Government of Timor-Leste. Smallholders from the community were hired as daily wage labourers. Farmers were trained in nursery management, planting with consideration of inter- and intra-row management, replanting, stumping, pruning, earthing up and selective picking. The trained farmers, led by a PARTL staff member, have been conducting the rehabilitation practices and the monitoring for the past 8 years.

Results

This farm was very well managed. According to management, the plantation recorded a threefold to fourfold higher yield than a regular, unmanaged coffee plantation. The plantation had no data recorded. The Portuguese agricultural mission stopped managing the farm in 2012. Since then, a PARTL staff member, who operates as a lead farmer, has been maintaining the farm along with the community. Unlike most other rehabilitation programs in Timor-Leste, farmers continued regular pruning and monitoring after project supervision ended. It is difficult to ascertain why these farmers continued monitoring. It is likely that multiple factors contributed to the success. First, in this program, farmers received intensive hands-on training on most aspects of rehabilitation. Second, PARTL staff along with members of the community were trained in good practices. Therefore everyone involved understood well the value of rehabilitation and increased their knowledge about the monitoring practices required. Finally, representatives from the GoTL and the Portuguese mission still visit the farm intermittently to check on its condition.

Key lessons

This case study demonstrates the following key principles for good rehabilitation practice:

Minimising random planting and maintaining row and inter-row spacing.

Planting density should be maintained at 3,000 plants/ha to optimise land usage. Wild plantings should be removed.

New planting through nursery-produced seedlings.

Replanting of wild coffee seedlings will generate new coffee trees because arabica plants are self-pollinating (see an illustration of the anatomy of the arabica plant in Appendix 3). When fallen seeds germinate on the soil as underplantings or wild plantings, the initial feeder roots or tap roots do not have enough media to proliferate. Seedlings therefore suffer from nutrient deficiencies, coupled with poor root growth. To stop poor root zone development from an early age, seedlings should be grown in nurseries for four to six months. As a healthy seedling is one of the key contributors to a healthy plant, managing the seedling quality is a key practice at Apido plantation.

Maintaining the height of the canopy and plucking table through regular monitoring activities.

The plucking table should be maintained within a maximum of 1.7m to promote easy harvesting. To do so, the canopy of the tree also has to be maintained at a similar height. This can be done through removal of the apical meristem via top cutting and maintenance of the lateral branches via side branch pruning. This also ensures easy movement of workers for harvesting and maintenance.

Implementation of rehabilitation practices on a timely basis.

Continuous screening of the plantation is important to identify the need for uprooting and replanting and pruning (top, lateral or stem). Rehabilitation practices need to be undertaken immediately after the harvesting season, and soil management and manuring should be done at the same time.

Managing shade trees.

Pruning the branches of shade trees on a timely basis promotes good sunlight interception on coffee trees, which leads to improved yields.

Maintaining healthy inter-branch spacing.

This promotes healthier canopy management.

4.4 Case two—Kirlelo plantation in Aileu, Timor-Leste

Background

This plantation is owned by an individual farmer. The plantation is 15 to 20 years old and the farmer had observed declining yields over the years before the rehabilitation program. Half a hectare of the total 3ha of this plantation was rehabilitated in 2017 as part of a Government-run rehabilitation program. The GoTL extension team trained lead farmers on basic rehabilitation practices by using demonstration plots, and one of the trained lead farmers in the Kirlelo area led the coordination and management of the rehabilitation activities.

Observations

- Ninety per cent of the trees in the visited plantation were stumped in 2017. Rehabilitated and non-rehabilitated trees displayed clear differences in tree height, fruit formation and canopy size. Figure 15 shows a non-rehabilitated tree in the plantation.

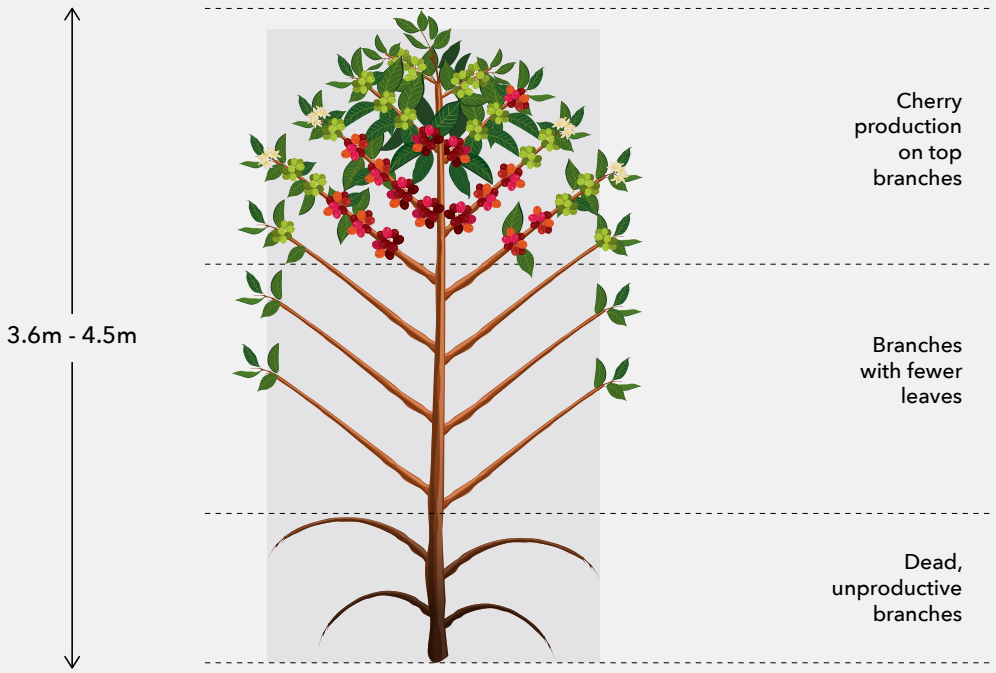


Figure 15: Non-rehabilitated trees

- Stumped trees showed lack of management after the initial rehabilitation in 2017. Critical management practices such as lateral branch pruning or top pruning had not been continued.
- The observed average height of the rehabilitated trees was over 1.8m, and the average plucking table was around 1.4-1.5m, or more.
- The most common rehabilitation practice observed in this plantation was two- and three-stem management.
- Zero management of shade trees has created high competition for light among coffee and shade trees. The relative humidity level is high, with low sunlight interception.

Images from this plantation are provided in Appendix 2.

Agronomy

Rehabilitation followed single-stem and multiple-stem management systems. Using a chainsaw, the trees were stumped at a 45-degree angle by maintaining 0.3m clearance to the collar of the stem (as advised by the MAF extension staff). Most of the multiple ancillary water shoots that emerged were removed manually. A maximum of two or three shoots were allowed to grow beyond the point of stumping (see Figure 16).

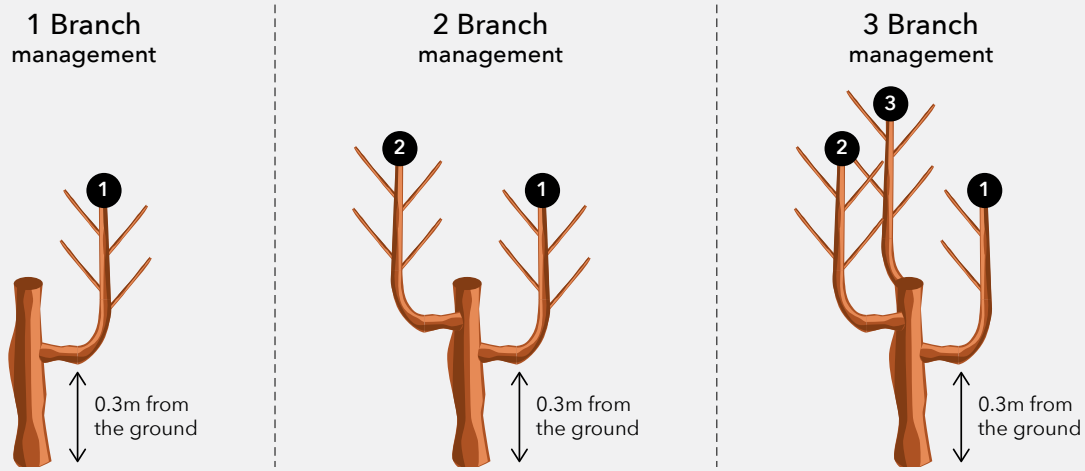


Figure 16: Stem management techniques

Financing and labour

Technical resources and extension knowledge were provided by government extension staff and the trained lead farmer. Chainsaws and machetes were used for rehabilitation. Chainsaws were distributed to lead farmers, who shared them with their respective farmer clusters. Voluntary family labour and community labour were used to implement rehabilitation. Labour was mainly used for stumping. Willing farmers were identified from the community, but only the lead farmer was trained in rehabilitation practices. There is gap in farmer knowledge about replanting, stumping, pruning, earthing up and selective picking.

Results

Flowering and fruiting responses after rehabilitation have varied over the past two seasons. In 2018, around 20 per cent of the trees produced flowers. In 2019, another 40 per cent of trees produced flowers. In 2020, the farmer observed that all the trees had flowered.

The farmer experienced improved yield in 2018/2019 following the rehabilitation because the plucking table was accessible. This enabled easy selective picking and reduced harvesting loss. However, it was observed during the visit that a suitable tree height was not maintained after the initial rehabilitation. As a result, the current plucking table is only marginally accessible, which might lead to reduced yields in the future.

There are few possible reasons behind the lack of continuity. First, this program relied heavily on a lead farmer. Tools and knowledge were provided to the lead farmer only. One chainsaw was provided to the lead farmer, and this had to be shared among other community members. Since other farmers in the community were not trained, they were not able to assist the lead farmer adequately. Second, the lead farmer lacked in-depth of knowledge about rehabilitation. Third, there was limited follow-up and supervision.

Key lessons

This case study demonstrates the following learnings about good rehabilitation practices:

Monitoring/continuation.

Rehabilitation is not a one-off exercise. Without timely and regular monitoring, farmers will lose the benefit gained from rehabilitation. Monitoring practices such as the following are important:

- In a specific stem management system (single, double or triple), removal of excess water shoots emerging below the point of stumping.
- Removal of the apical meristem by breaking the topmost 10-13cm of the tree, to stimulate lateral branch growth
- Removal of unproductive lateral branches via pruning.

Maintaining tree height.

The canopy and plucking table should be maintained within 1.4 and 1.5m so that selective picking can be practised, and wastage reduced. Unreachable cherries encourage stripping: farmers will bend the trees, causing physical damage to plant tissue and resulting in poor tree performance.

Rehabilitation affects fruiting and flowering.

Rate of flowering is affected by the following factors:

- The vigour of the critical root zone that supports the trees in extreme stress during stumping or rehabilitation before the tree re-grows photosynthetic vegetation or leaves
- Availability of phloem storage – source to sink mechanisms (movement of food storage or energy to target parts in need) to support the tree during stem rehabilitation stress
- If the stumping angle is not maintained at 45 degrees and the stumping surface is flat, direct sunlight will cause high water losses via evaporation, and this will result in wilting of tissue. Additionally, rainwater collects easily on a 180° stumped surface, leading to moulds and tissue infections.
- Trees with two-stem or one-stem management may flower more than trees with three-stem management. Higher amounts of photosynthate or food from the tree is spent to maintain the vegetative parts such as additional stems. Trees with a one-stem management system can better utilise the extra energy for reproductive growth, flowering and fruiting.

Controlled planting.

Wild plantings should be removed to maintain the inter- and intra-row distance between coffee plants in the plantation. New planting should be done using nursery-produced seedlings, to enhance the vigour of the tree.

Timely implementation.

Planning of R&R implementation should be based on an analysis of the harvest and tree performance. The best time to prune the trees is just after the harvest. This allows trees to have the resting period to produce new vegetative tissue and store enough photosynthate to re-enter the reproductive or flowering season.

Conclusion

The two case studies present contrasting pictures. Both plantations demonstrate improvement in yields. The increase in yields was short lived for Kirlelo, however, due to lack of monitoring, whereas Apido plantation sustained the yield increase through regular maintenance.

At Apido plantation, farmers have continued the regular pruning and stumping eight years after the program has ended. As a result, the trees show improved vigour and the yield is three to four times higher. Because of regular management, younger trees will not require stumping in the short term. In this program, PARTL staff and community members received extensive training on rehabilitation. Technical experts continued follow-up over an extended period of time. New plantings have been done using nursery-produced seedlings.

At Kirlelo plantations, three years since rehabilitation was implemented, the farm is already showing lack of maintenance, the plucking tables are becoming unreachable and sunlight interception is poor. In this program, only the lead farmer received training on rehabilitation and there was limited follow-up after the initial training.

Chapter 5

Recommendations

5. Recommendations

5.1 Introduction

Previous sections of this paper offered insights into the global and local context of R&R, and lessons from existing rehabilitation programs in Timor-Leste. This chapter makes recommendations on the R&R model most suited to Timor-Leste based on the field observations described in chapters 3 and 4 and the literature review of global R&R practices. These recommendations include information on how to design effective coffee rehabilitation programs, and the correct agronomical practices in the context of Timor-Leste.

5.2 Implementation design

Choose rehabilitation – and do it progressively

This report recommends that in the short to medium term Timor-Leste should focus on rehabilitation as opposed to renovation. Coffee production in Timor-Leste is smallholder led. Smallholder capacity and willingness are important determinants in selecting the model of R&R. Resistance from smallholders is one of the main reasons behind the lack of continued R&R in Timor-Leste.

With renovation, renovated trees are unproductive for five years. With rehabilitation, trees resume production in three to four years. The two-stem rehabilitation technique allows farmers to continue harvesting from the rehabilitated trees even during those three to four years. Furthermore, it is recommended that farmers should rehabilitate less than 25 per cent of their plantation/trees every year, as opposed to all at once. This would ensure some income is earned during the rehabilitation period. Intercropping can further reduce loss of income by creating an additional source of income. Konjac and spices such as ginger and pepper are suitable crops for intercropping with coffee. These crops can be harvested annually, and there is established demand for them.

Rehabilitation is less resource intensive and less risky than renovation. Renovation relies on new planting, and after renovation new seedlings may die due to lack of water, compost and extreme weather.

Regular rehabilitation should become the industry norm. Continuous rehabilitation ensures that annual production is consistent, and yields are higher. Rehabilitation offers a low-cost option for coffee rejuvenation.

In the long term, as farmers better understand the benefits of rejuvenation, they will be willing to take greater risks and implement renovation. In the short to medium term, renovation might be applicable to privately owned plantations only. In such cases, plantation owners may be willing to assume the risk because of the significant gain in yields.

Consider financing and labour models

Commercial financing or loan-based financing is unlikely for R&R in smallholder farms in Timor-Leste. Investing in smallholders is considered high risk due to vulnerability to climate change, lack of good agricultural practices and limited smallholder capacity. Grant-based financing will likely continue to be the main source of funding for coffee rehabilitation in Timor-Leste. The social impact of improving the income of smallholders will be a major driver for these investments. So donors and development partners will continue to play an important role in coffee rehabilitation in Timor-Leste.

For smallholder farms, rehabilitation programs need to be low cost. This will allow local coffee businesses and smallholders to continue them in the long term without requiring continued financing.

These are some important learnings related to financing R&R for smallholders:

- The bulk of the investment should be targeted to training farmers, and improving access to information, tools and extension services.
- Investors and exporters should provide tools in the short to medium term to kickstart the practice of rehabilitation. But reliance on free tools may not be sustainable in the long term. Farmers need to find locally available low-cost tools that can be used for rehabilitation.
- Offering remuneration to farmers for rehabilitating their coffee trees may not be sustainable. This will make rehabilitation expensive. To ensure sustainability, smallholders need to adopt rehabilitation as regular farming practice. It should not be a one-off exercise that is carried out because of external stimuli. Appendix 1 provides the cost structure for one of the current rehabilitation programs in Timor-Leste.
- Impact investing can offer an alternative to grant financing, but is considerably more difficult to manage. Impact investors seek both commercial and social gain. In the context of Timor-Leste, impact financing and commercial financing is more suitable for privately owned plantations. It is easier to implement control systems in private farming.

There are only a handful of commercial plantations remaining in Timor-Leste. Plantations with good infrastructure and management capacity can opt for commercial financing if they can demonstrate clear return on investment.

Irrespective of the source of financing, cost effectiveness and sustainability are key principles to consider for coffee rehabilitation programs.

Focus on capacity building

Capacity building is fundamental for successful and sustainable rehabilitation. Producers, coffee businesses and extension officers in Timor-Leste lack technical knowledge of R&R, in terms of both agronomy and implementation. Based on global best practice and the Timor-Leste case studies referred to in Chapter 4, capacity building for coffee R&R should consider the following factors:

- **Universally provided training**

  Training in rehabilitation practices should not be provided to the lead farmers only, but instead to all farmers in the community who are expected to maintain the coffee trees. In R&R models where only the lead farmer was trained, the quality of R&R practices was poor compared to that for models where a wider group of farmers gained knowledge on R&R practices.

- **Depth of training**

  Training for farmers must be detailed in nature. Trainings need to educate farmers on a wide range of topics related to rehabilitation and monitoring. Producers do not need only to learn the methods, but also to understand the reasoning behind those methods. Further, producers need to internalise the benefit of rehabilitation and the need for continuity.

- **Importance of monitoring**

  Capacity building programs need to place special emphasis on post-rehabilitation monitoring. In almost all rehabilitation programs, farmers have practised the right methods for pruning and stumping. For monitoring, however, practices have been inconsistent and incomplete. Farmers need to gain comprehensive knowledge on specific monitoring practices and when to apply them.

- **Delivery methods**

  Training should be delivered in a way that maximises knowledge retention by farmers. The content of the training and the delivery method should be engaging and easily comprehensible. More importantly, there should be frequent interactions with farmers so that they can fully absorb the information supplied.

- **Continued capacity building**

  Capacity building should not stop after the rehabilitation phase, but should continue throughout the monitoring phase. Rehabilitation programs need to allocate resources for extension services during the monitoring phase.

Ensure good record keeping

One of the biggest challenges in drafting this report was the lack of available data. It is essential for all R&R activities and the corresponding changes in yields to be tracked.

This not only helps in assessing the effectiveness of R&R investment, but is also crucial for securing financing for R&R.

Consider intercropping

Rehabilitating sections of the land as opposed to rehabilitating the whole plot at once is a way to minimise short-term income loss.

Intercropping is another method that can be considered to compensate for the short-term loss in income caused by rehabilitation. For example, rehabilitated coffee plots can be intercropped with root crops such as ginger, turmeric, konjac, or taro. Depending on the location of the farm, intercropping with short-term fruit and vegetable crops may also be effective.

The harvesting of the alternative or intercropped crops is best managed before coffee harvest season. This is because labourer movement during coffee harvesting can cause damage to leafy vegetable crops. Root crops are less susceptible to damage because the crop is below ground, and only the foliar parts above ground may be damaged due to labour movement during coffee harvest.

5.3 Agronomical practices

The key principles of coffee rehabilitation are pruning and stem management through stumping. Pruning is a good agricultural practice that must take place every year after harvest and before flowering. Regular pruning prevents the need for stumping and maintains good productivity levels. Stumping, on the contrary, is a practice that is more radical: when trees are not pruned regularly and productivity levels have dipped, those trees will need to be stumped to grow new vegetative tissues such as stems, bearing branches and leaves. The new vegetative tissues will be more resilient, and energise the tree to produce higher densities of flowers – and, hence, cherries.

Once trees become extremely unproductive, pruning makes little or no change to the yield, and they can be rejuvenated only through stumping. After stumping, regular pruning and monitoring are extremely important to retain the gains.

Pruning

Pruning is the process of regularly removing unproductive branches and maintaining optimal branch density, as well as maintaining tree height by removing the apical meristem. It is vital for keeping trees productive and maximising their productivity and should be done annually, irrespective of the age of the plant. Pruning controls the vegetation in the tree, and influences the reproduction of cherry growth and flowering. The removal of the leaves or meristems of the branches sets off the reaction of a plant hormone (auxin) that induces the tree to flower.

Pruning also regulates the age of the bearing parts of the tree by removing the old cherry-bearing parts; as a result, new cherries are born on new parts of the branch. This keeps the plucking table accessible, which is essential for proper harvesting.

Stumping

Stumping is a more aggressive form of pruning, where the entire tree is cut down to 0.3m above the ground. After stumping, a limited number of stems are allowed to grow. Based on visual inspection and by assessing production data, a first stumping can be performed on underperforming trees after eight to ten years from the date of planting.

Three types of stumping that may be suitable for Timor-Leste are explained below. Smallholders and companies should take their resources and capacity into consideration when deciding on which type to select.

Standard international stem-management systems

Currently the major coffee producing regions of the world use three coffee stumping techniques: (1) Kona style, (2) Beaumont-Fukunaga (BF) style, and (3) mechanical hedged and topped (HAT) style. HAT style is a high-investment mechanised system for large-scale commercial plantations, and as such will not be discussed further in this report. This report discusses the Kona and BF styles, as they are suitable for smallholder management systems.

The Kona and BF styles both propose that a maximum of four to six stems be maintained on one tree. However, the Kona style proposes that one stem be stumped every four years, whereas the BF style proposes that all stems be stumped at the same time every three to five years.

❶ Kona style: Four- to six-stem management

The principle of the Kona style is controlling the number of stems or verticals that are allowed to grow after stumping (Beaumont & Fukunaga, 1958). The Kona style is commonly practised with two variations: 1) four- vertical 1-2-3-4 style; and 2) six-vertical 1-2-3-4 style. Based on the overall farming context in Timor-Leste, the average age of trees, and the vigour of the trees, the four-vertical 1-2-3-4 system is generally more suitable.

Benefits of the Kona style:

- It maintains the bearing surface at approximately the same age over time
- Due to the uniformity of the bearing surface, the size of the annual crop will be uniform
- The trees will be unlikely to suffer from biennial bearing or from dieback

Here are the details of the four-vertical 1-2-3-4 Kona style:

- With this system, only four vertical stems are allowed on the stump, and each vertical stem is allowed to grow for up to four years. The system is managed by cutting the oldest vertical stem each year about 75mm from the trunk and allowing a new one to replace it. The tree may be of any age, even as old as 100 years. The key is to renew the verticals every four years.
- The tree shown in Figure 17 has been stumped, and then managed according to the four-stem four-vertical management method in the Kona style. Labels A, B, C and D on the left show the growth of the verticals from the point of stumping over four years. D is the oldest vertical stem of the tree that was allowed to grow after stumping. A is the youngest vertical, aged only one year.

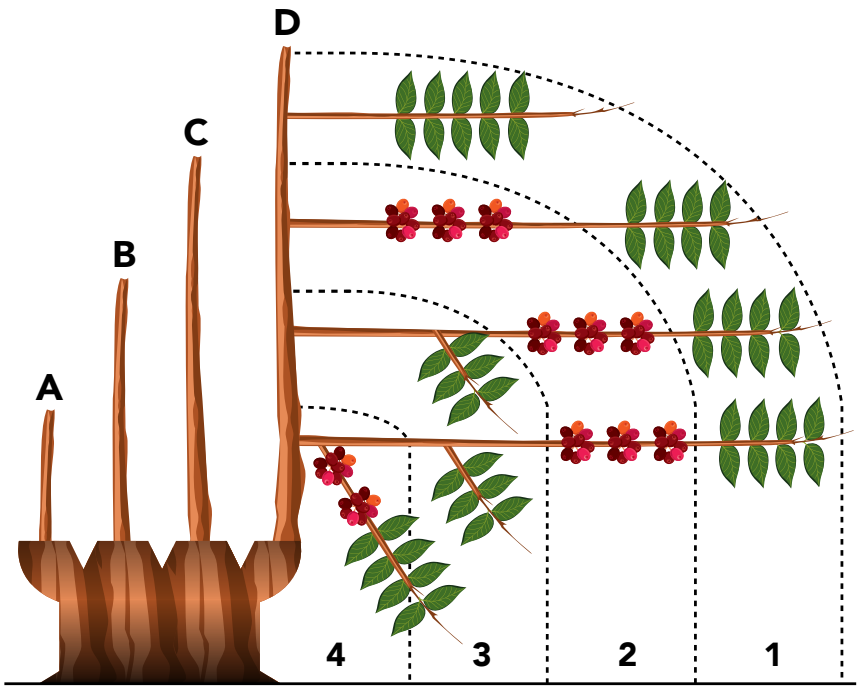


Figure 17: Kona-style rehabilitation—4-year cycle

In Figure 17, the illustrations on the right show the emergence of lateral branches that produce cherry and vegetative growth (i.e. leaves). This figure shows the lateral branch growth, from the D vertical only, but the same process would occur on the A, B and C verticals. Numbers 1 to 4 in the figure illustrate the following:

#1 Growing wood during the first year of growth (no cherry)

#2 Cherry-bearing wood growth during the second year of growth (the tree bears cherry)

#3 Sub-laterals emerging from lateral branches during the third year of growth (no cherry)

#4 Sub-lateral wood-bearing cherry during the fourth year of growth (the tree bears cherry)

If the stem D were stumped in 2020, Figure 17 would illustrate the status of the tree in 2024. This tree would follow the schedule as outlined in Table 1.

Table 1: Schedule for vertical stem removal

Vertical number	First stumping	Next stumping
A	2023	2027
B	2022	2026
C	2021	2025
D (oldest)	2020	2024

Once stumping has been done, water shoots or suckers emerging from the stumps need to be removed before they grow into bearing verticals. Water shoots can be rubbed off with the palm of the hand when they are small, or pulled out when they are about 75-150mm in length. It is especially important to remove suckers during the rainy season, because they proliferate faster during rain. Some countries apply contact weedicides like Postemergent (Gramoxone) to remove suckers, wild plantings and weeds. But this is not advised for Timor-Leste due to the limited capacity for overall plantation management.

❷ Beaumont–Fukunaga (BF) style: three- to six-stem management

With the BF style, three to six verticals grow on each tree (see Figure 18). And then after three to five years all vertical stems of the tree are removed at the same time (Beaumont & Fukunaga, 1958). The tree should be stumped 0.5m above the ground, making it easy for farmers to desucker the tree. The number of new stems can vary from three to six, based on the available space between trees. But too many verticals will reduce yield because of poor sunlight interception.

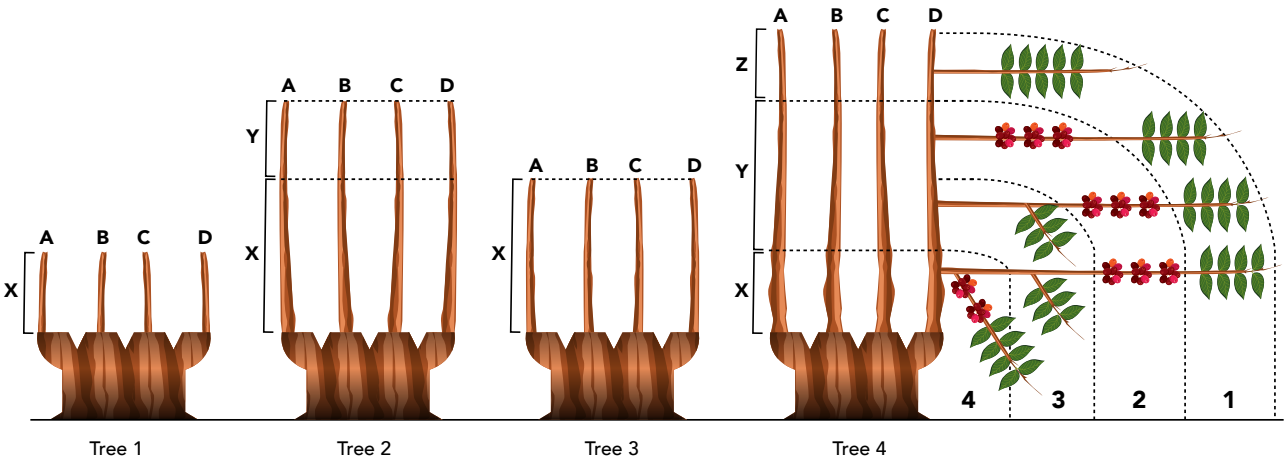


Figure 18: BF-style rehabilitation

Effective pruning and stumping principles

The same principles should be applied for all pruning styles and for all stem removals, irrespective of the number of stems removed:

Degree of rehabilitation

In the current Timor-Leste context, the first stumping will reduce productivity significantly in the first year. This means considerable loss of income for smallholders, and therefore intensive rehabilitation is not recommended at the smallholder level. A gradual approach would be more suitable. It is recommended that stumping of the main trunk be done for 25 per cent of the land every year. Pruning should be implemented in alternate rows for efficient sunlight interception.

Timing of pruning

In principle, pruning should be done in the rainy season after harvest ends. This is the semi-dormant period for the plant. If pruning is done during the flowering or fruiting season, this may cause drastic nitrogen and carbohydrate depletion, affecting the regrowth of the vegetative parts. Pruning at this time also wastes the reproductive phase of the plant, and dieback symptoms are common.

The timing of pruning will depend on the volume of the harvest and the status of vegetative growth in the tree. Each tree has a unique root set, vegetative cover and vigour. Because of this diversity, the method and intensity of rehabilitation should be flexible. It is rare that the same style of pruning will apply uniformly to every tree on a farm. The farmer should understand the rehabilitation requirements of each tree, and apply the most suitable rehabilitation for each case.

Table 2 demonstrates the options for pruning based on the performance of the tree, and a detailed explanation is provided below for each situation shown in the table.

Table 2: Choice of pruning type based on tree performance

Situation	If last year's wood growth was:	And harvest was:	Then this year, pruning should be:	With intensity of fertilisation:	To achieve plant growth that is:	To achieve harvest growth that is:
1	Heavy	Light	Heavy	Heavy	Moderate	Moderate*
2	Light	Heavy	Light	Moderate	Moderate	Moderate
3	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

*For a plant with harvest of 4kg/tree, moderate growth would be 6kg/tree.

Situation 1

If the growing wood (vegetation) is too high and the cherry harvest is low, the intensity of pruning should be higher than for the previous season, with high-volume application of fertiliser. As a result, next year's crop will be moderate, with a moderate amount of vegetative growth.

Situation 2

If the wood growth is light and cherry harvest is heavy, pruning should be light, with moderate fertiliser application. The farmer can expect a moderate yield with moderate vegetative growth in the next season.

Situation 3

If both the vegetative growth and cherry harvest are moderate, pruning and fertilisation should be moderate. The farmer can expect moderate vegetative growth and a moderate cherry harvest in the next season.

It is important to note that consistency – moderate harvest growth – is one of the main aims of rehabilitation. Pruning will ensure a consistent crop every year – a moderate cherry yield, referred to as best annual efficient crop yield. It will prevent heavy yield in one season followed by extremely poor yield in the next season; this inconsistent yield is known as biennial bearing.

A common stem management system—Recommended stem-management system for Timor-Leste

Although the above-mentioned three stem management systems are commonly used in coffee-growing countries, a two-stem management system is recommended for Timor-Leste because of its simplicity.

These are key signs that a coffee tree is unproductive and requires rehabilitation: reduced yield, branches with fewer leaves and fruits, or the tree is tall with cherry production in the top sections only.

For unproductive cherry trees in Timor-Leste, the two-stem management technique is recommended, as it is suitable for smallholders with limited capacity to manage their coffee trees.

In this technique, a maximum of two stems are allowed to grow on a tree at any given time, as illustrated in Figure 19. Stem 1 can be removed or stumped, leaving one old stem or a vertical intact. This will partially reduce the total current tree yield: the loss of yield will depend on the number of stems that were productive prior to stumping (if the tree had two stems prior to rehabilitation and one was removed, the tree will produce at 50% capacity). The stumped stem will gain its full yield potential in an average of four years after stumping. Once the stumped branch regains its full yield, the other stem will be stumped. Therefore, to ensure two productive stems, stumping should be performed every four years.

Between each stumping, the farmer should conduct lateral branch pruning annually to maintain adequate sunlight interception and maximise the number of flowering nodes. As shown in Figure 19, six years after the first stumping both stems have become fully productive. Depending on the quality of the monitoring practices, a farmer can go back to removing each stem alternatively at two-year intervals.

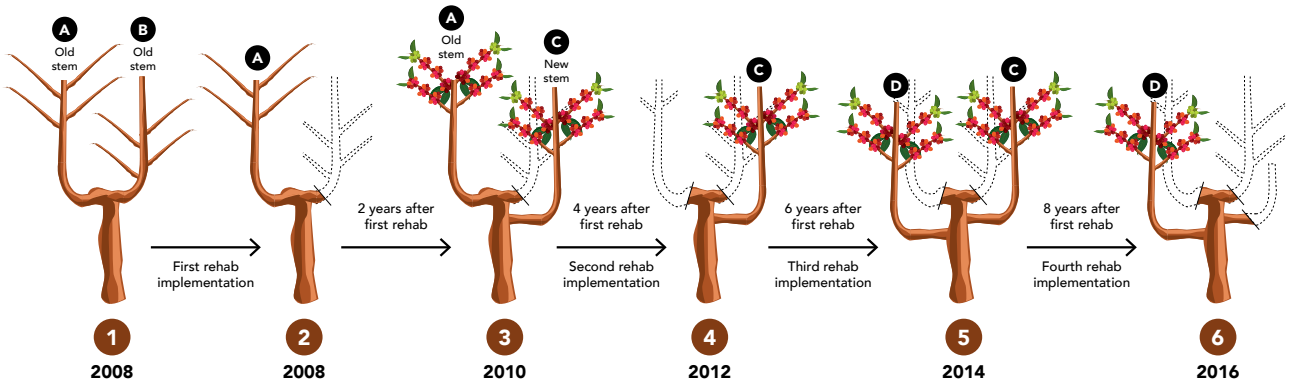


Figure 19: Two-stem management implemented over 8 years

Monitoring

After stumping, monitoring has the greatest influence on the effectiveness of rehabilitation. However, monitoring has been the biggest challenge for R&R efforts in Timor-Leste. In most of the programs, R&R did not continue after the end of the project supervision. Consequently, after a period of moderate increase in yield, productivity dropped to the original low level. Without regular monitoring, there can be no significant long-term change in production.

Regular monitoring actions include:

- Regular removal of water shoots or suckers after stumping
- Ensuring suckers selected to grow as verticals are evenly spaced around the main, stumped stem, to reduce within-tree shading
- Removing unproductive lateral branches
- Regular side pruning of lateral branches to maintain a 10cm gap between branches
- Maintaining the height of the canopy and plucking table to around 1.5m—this depends on average farmer height
- Continuing with subsequent stumping every four years
- Pruning and management of the shade trees to avoid competition for sunlight. Common coffee shade trees in Timor-Leste are Grevillia robusta, Albizia moluccana (common in the Ermera region), Gliricidia sepium, and Casuarina junghuhniana (best grown in regions above 1,300m).

Figure 20 shows the agronomical practices in the two-stem rehabilitation technique, including stumping, removing water shoots, maintaining good branch density and managing the height of the plucking table. This figure also shows optimal planting density where inter- and intra-row spacing is managed at 1.8m*1.8m.

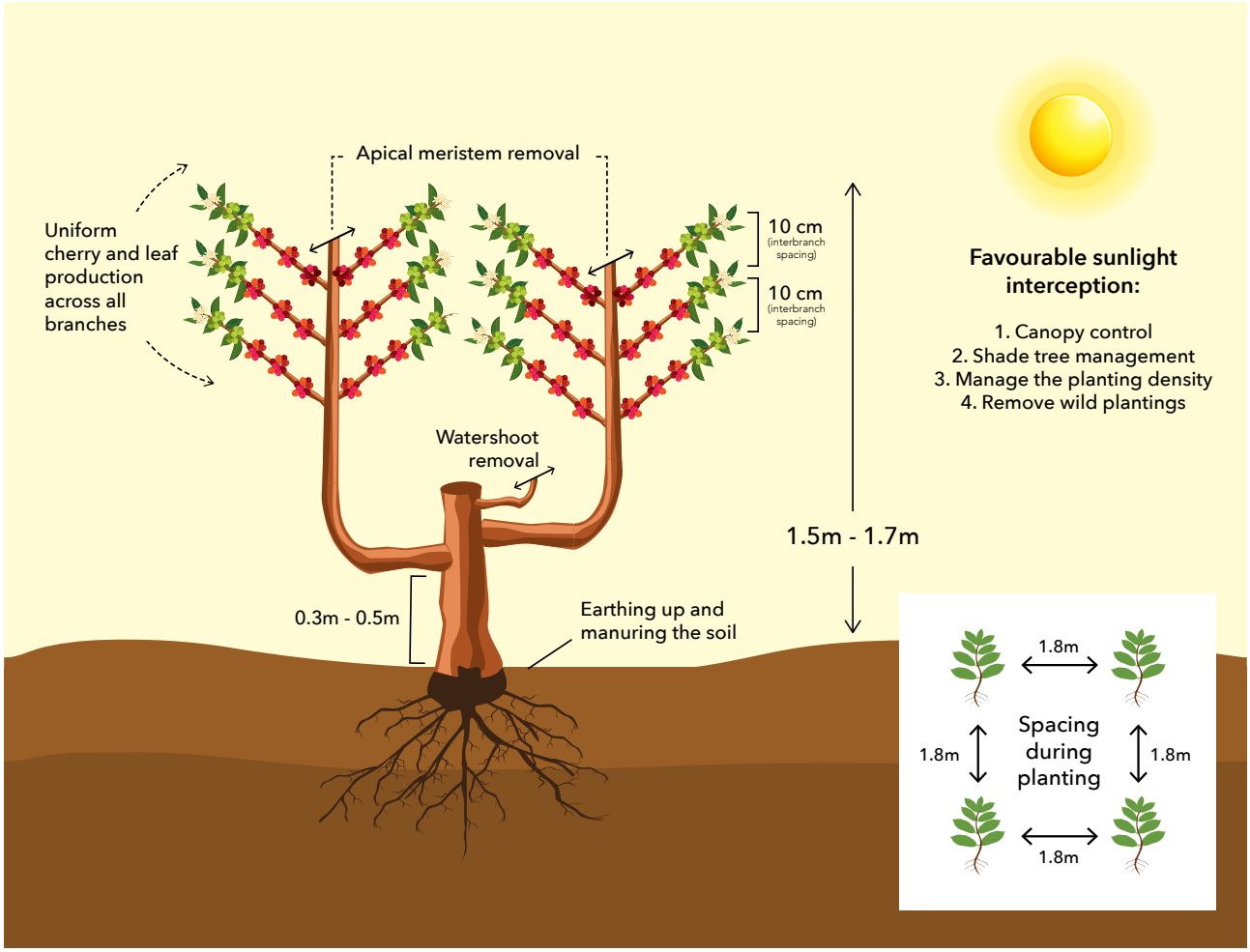


Figure 20: Illustration of an optimally managed coffee plant

New planting

In addition to rehabilitating old trees, filling the empty slots in the field by planting new coffee trees (gap filling) should be continued. In the medium to long term, once the new trees are productive, farmers may be more willing to take the risk of uprooting old trees.

Applying the following principles will ensure new plantings are effective:

- New plantings should be done using seedlings grown in a nursery. Seedlings should be grown in nurseries for four to six months to avoid poor root zone development from an early age. As healthy seedlings are one of the key contributors to a healthy plant, managing the seedling quality is key. Figure 21 shows an optimally potted coffee plant in a nursery.
- Random planting should be minimised, and row and inter-row spacing maintained. Planting density should be maintained at 3,000 plants/ha for arabica and 1,300 plants/ha for robusta to optimise land usage.
- Wild seedlings and underplanting should be removed immediately. This will ensure better utilisation of the macro and micro climate factors in the field, such as nutrients, sunlight, soil and water. This will also help to maintain inter- and intra-row distance between coffee plants.

Soil management

Using inorganic fertiliser is not commonly accepted practice in Timor-Leste. Smallholder farmers are encouraged to use organic fertiliser and avoid chemical fertilisers. Fertiliser should be applied primarily prior to the flowering season. This will not influence productivity immediately, but will release nutrients that will benefit the farms in the long term.

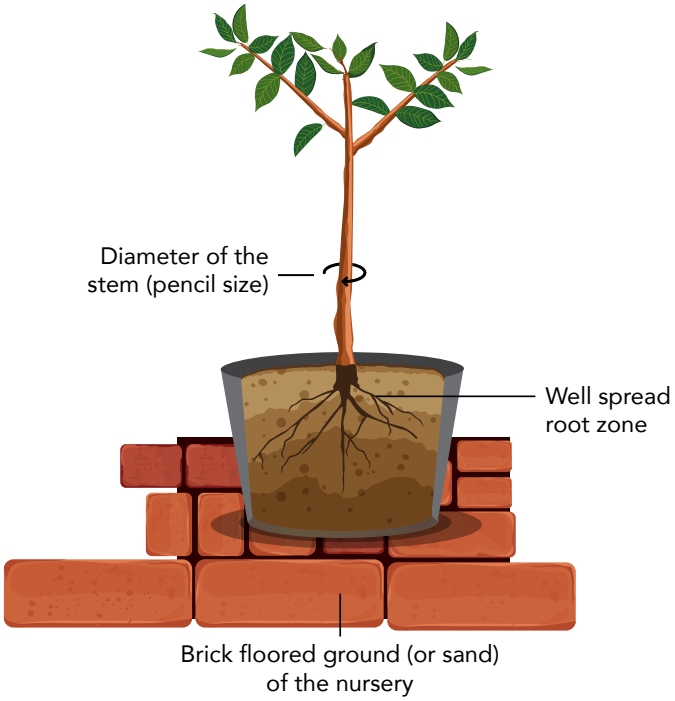


Figure 21: Illustration of an optimally potted coffee plant

Appendices

Appendix 1:
Cost structure per hectare

The cost structure shown in Table A1 is from a 2019 coffee rehabilitation project in Timor-Leste.

Table A1: Cost structure of coffee rehabilitation project (USD)

Costs Item/Ha	Approximate Costs/Ha	Comments
Supervisor Training x 3 days	$2.67	
Field Workers* (25 people)	$183.33	Per trees=$0.15. Per m2 Clearance=$0.08.
Field Team Leader (5 people)	$17.50	Fixed salary + bonus on targets (still to be set)
Plantation Supervisor (1 person)	$15.00	Fixed salary + bonus on targets (still to be set)
Meals & Food Allowance 38 days	$24.32	Food allowance $0.60 per day per person for lunch & 2 coffee breaks
Transport & Fuel	$160.00	$120.00 per day for 1 Truck/Driver & 1 Motorbike
Types of Tools * Incl. Airfreight, Duty & Clearance		Tools are depreciated over 12 months
Hand Saw	$4.50	Imported from Australia & Australian Qlty
Lopper Cyclone Ratchet Bypass Telescope	$4.28	Imported from Australia & Australian Qlty
Pruner Bypass Heavy Duty	$4.33	Imported from Australia & Australian Qlty
Total Costs	**$415.93**	
Misc. costs (10 per cent addition)	**$41.59**	
Total adjusted cost/ha	**$457.52**	

Source: Interview with key informant, June 2020

Appendix 2:

Field observation from Aileu plantation

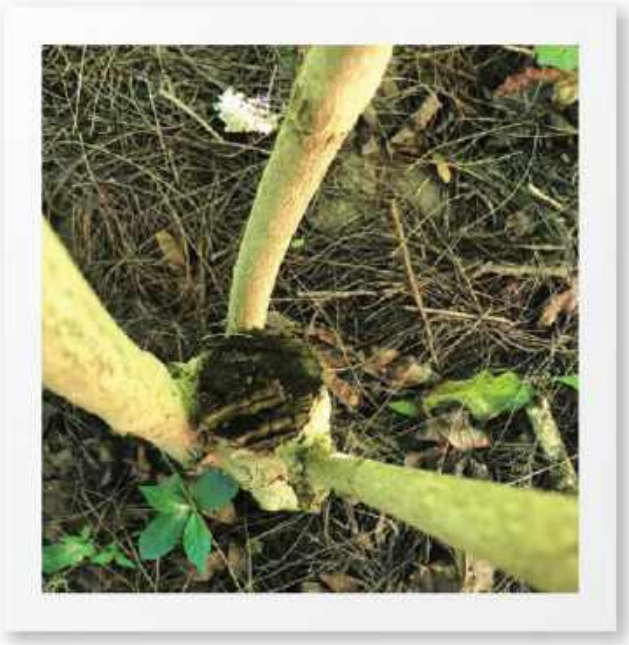


Figure A2.1: Staggered chainsaw cuts

When the pruning is not done as a clean cut, the chances of microbial infections are higher due to water collection on the surface, and the shredded surface provides.

Figure A2.2: Incorrect pruning attempts

These attempts are indicated by extra cut marks, which damage the vegetative tissue, increase the incidence of pests and disease and cause the drying of plant tissue.

Figure A2.3: Stumping clearance at approximately 0.5m from the ground

Figure A2.4: Stumping using a chainsaw at a 45-degree angle

Water shoot removal is observed below the point of stumping.

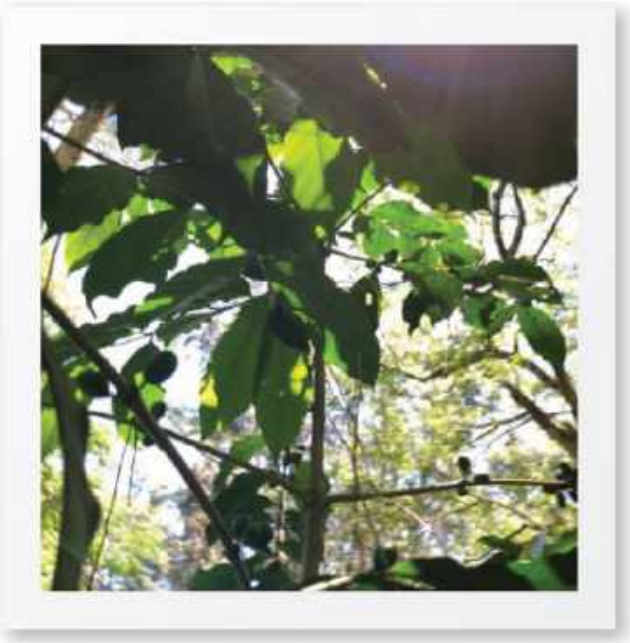


Figure A2.5: The cherry production area of a coffee tree, 1.8-2.4m above the ground

Cherry production is limited to the apex of the tree due to sunlight interception.

Figure A2.6: Strip-picking cherries from the apex of the tree by bending the tree

Stripping causes a low-quality cherry yield and bending the tree causes physical damage to it.

Figure A2.7: The soil preparation tool most commonly used by farmers

When farmers do not have tools for rehabilitation, they tend to use these to stump the mature coffee trees.

Figure A2.8: Machete used by farmers in their daily farming operations

Poor sharpness of the machete causes uneven cuts when stumping the trees.

Appendix 3:

Anatomy of an arabica coffee tree

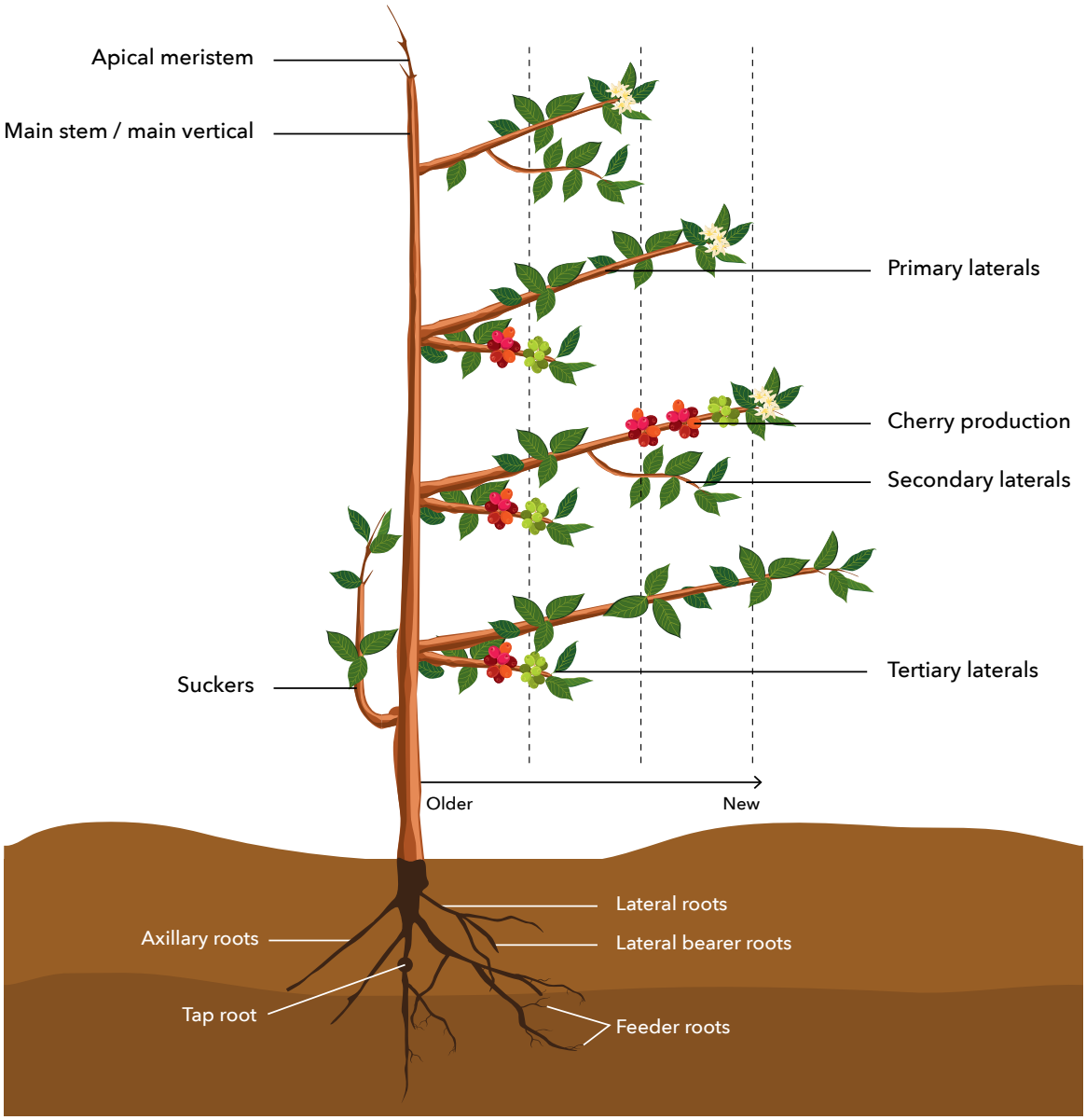


Figure A3.1: Illustration of the anatomy of an arabica coffee tree

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