



CONVERSION OF A COFFEE PLANTATION INTO A SUCCESSFUL AGROFORESTRY SYSTEM

Guidelines to support grower groups, extension workers and ICS managers during the implementation of agroforestry systems into existing perennial crop systems.



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Agroforestry represents a harmonious combination of trees and agricultural practices, fostering sustainable land use, biodiversity, diversification of income, and resilient food production systems. Before you start implementing agroforestry systems, the following topics and aspects need to be considered.



1. Site assessment

- Conduct a thorough assessment of the current coffee plantation, considering soil health, climate, and topography.
- Identify wind and water erosion areas and consider the outcome when developing the agroforestry implementation plan (where to plant windbreaker trees, where to implement erosion measures and so on).



Figure 1 & 2:
Soil erosion
examples in
Burundi

- Identify existing flora and fauna, including native species of trees, hedges, and ground cover plants suitable for the environment and conditions of the site.
- Identify existing planting systems: Are there some shade trees already? Is some intercropping done already? If yes, are the species suitable and how is it integrated with the main crops?

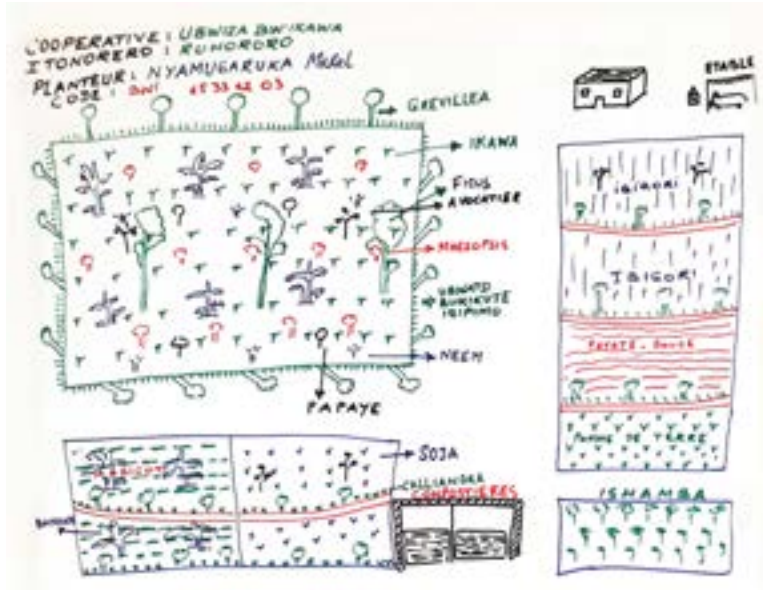


Figure 3: Presentation of farm maps of lead/model farmers with existing agroforestry coffee farming systems including all subsistence crops

sion of coffee farming to agroforestry systems fosters a sense of ownership, encourages collaboration, and leverages the diverse strengths of each group, ultimately leading to more resilient and successful agricultural transformations. Stakeholder engagement must be maintained and fed through the whole conversion process. You need to grow a sense of community ownership and participation in the agroforestry transition, promoting shared responsibility for its success. Plan annual workshops (e.g. with the model farmers) to discuss challenges, achievements, innovations (new tree species).

Stakeholder 1: farmers

Firstly, farmers are the backbone of any agricultural initiative. Their firsthand knowledge of the land, climate, and existing practices is invaluable. By involving them early, we ensure that the agroforestry system is tailored to their needs, conditions and aspirations. It is of high importance to listen to doubts and fears, and to take them seriously. If there is scepticism, ask for their reasons and try to find answers and solutions to overcome concerns.

Stakeholder 2: extension staff

Extension staff play a critical role in bridging the gap between research and practice. Their experience in education and communication can help translate complex agroforestry concepts into practical, actionable steps for farmers. Early engagement ensures that they are well prepared to support and train farmers throughout the transition.

Stakeholder 3: technical experts

Technical experts provide essential insights into the scientific and technological aspects of agroforestry. Their involvement from the beginning helps in designing systems tailored to local environmental conditions, soil types, climate, and existing agricultural practices, but also economically viable. By integrating their expertise early on, we can avoid potential pitfalls and optimize the system for better productivity and sustainability.

2. Stakeholder engagement

Stakeholder engagement makes change processes more resilient. Implementing agroforestry relies on more than having good technical knowledge of growing coffee or forestry. A successful coffee-growing community relies on cohesiveness and constructive input from all members. The community as a whole needs to engage.

Early and active engagement of all stakeholders in the conver-

Stakeholder 4: managers of cooperatives

Managers of cooperatives bring a strategic perspective to the table. Their understanding of market dynamics, supply chains, and collective organization can help in creating robust business models that benefit all members. Early involvement of cooperative managers ensures that the new agroforestry systems are economically sustainable and can compete effectively in the marketplace.

2.1 Initial assessment and planning

The suitability for a particular site depends on the needs of the family or community and the potential benefits of the system. Farmers and other land users must be involved at an early stage in identifying what is most appropriate for their needs and resources. Their involvement in the assessment ensures that the project addresses real issues and is aligned with their expectations. It helps to build trust, create a shared vision and enhance collaboration throughout the project lifecycle.

2.2 Show examples or calculate the economic benefits

Often farmers have concerns of income, because yield of the cash crop might be less than in monoculture. But there are ways to explore other findings:

- Evaluate the economic benefits of the agroforestry system, considering diversified income sources and long-term sustainability (also as a motivation tool for farmers to join).
- Involve cooperative managers and extension staff to determine the allocation of resources such as seeds, equipment, and funding.
- Establish a calculation sheet showing the expenses and revenues of all the agroforestry systems of each farmer to have a realistic financial picture.



Figure 4 & 5: Planning workshop at UNAMAFCOOP, Muyuka, Cameroon



3. Agroforestry design

3.1 Selection of trees

Stakeholder should develop a shade tree list suitable for the sites where the agroforestry system should be developed. The following factors should also be considered: banana and other fruit-giving trees, fertilizing trees, and money-generating trees (like timber trees). Explore complementary crops like fruits, nuts, or spices to enhance biodiversity and income streams.



Figure 6: workshop on shade tree, COCOCA, Burundi, 2023

It might be helpful to create a table, with all relevant information to compare before choosing your favorites:

- origin (native or invasive),
- storey (height or canopy layer),
- function (fertilizing tree, providing high amount of organic matter, animal fodder, food, etc.),
- marketing option or income generating (timber, fruit, etc.),
- information about intercropping characteristics (ccc).
- availability of planting material,
- the environmental suitability of species for the site

Scientific name	Local name	Benefits	Origin
<i>Acacia mearnsii</i>	Barakatsi (Kinyarwanda)	" Fodder, Firewood, Timber, Apiculture, Erosion control, Nitrogen Fixation, Soil Improvement, Ornamental"	Exotic
<i>Acacia sieberana</i>	Umunyinya (Kinyarwanda)	Food, Fodder, Apiculture, Fibre, Timber, Medicine, Windbreak, Nitrogen Fixation	Native
<i>Albizia adianthifolia</i>		Food, Timber, Medicine, Erosion Control, Ornamental	Native
<i>Albizia lebbekii</i>	Bois noir (French)	Fodder, Apiculture, Firewood, Timber, Medicine, Nitrogen Fixation, Soil Improvement, Ornamental	Exotic
<i>Albizia versicolor</i>	Umububa (Kinyarwanda)	" Firewood, Timber, Medicine, Nitrogen Fixation, Soil Improvement"	Native
<i>Artocarpus heterophyllus</i>	Igifenesi (Kinyarwanda)	Food, Fodder, Medicine, Soil Improvement, Timber	Exotic
<i>Azadirachta indica</i>	Neem (Kinyarwanda)	Fodder, Firewood, Timber, Biological Pesticide, Medicine, Erosion Control, Soil Improvement	Exotic
<i>Blighia unijugata</i>	Umuturamugina (Kinyarwanda)	Food, Firewood, Timber, Medicine,	Native

Figure 7: Example of a shade tree list

If you need further information on suitable shade trees, take a look at the World Agroforestry Database:

The World Agroforestry Centre provides a database and multiple criteria search on trees worldwide. It includes information about function, needs, and origin to help in selecting appropriate species for agroforestry systems: worldagroforestry.org.

Having your cash crop in mind, you develop a customized agroforestry layout incorporating native trees, shrubs, and other crops to promote ecological balance - and considering the Naturland standards for coffee.

Here a few more information

- Consider fruit trees and heavy feeders (e.g. Mango, Avocado) more as boundary trees. Other fruit trees like bananas, papaya and jackfruit can be planted on the coffee farm
- Furthermore, consider fast-growing trees and shrubs during the first implementation years, which will protect the coffee and the growing shade trees. These trees/shrubs can also be removed after 3 or 4 years.
- Plan for varying canopy layers to optimize sunlight distribution.
- Yet, the coffee must be pruned properly, e.g. (Arabica no longer/higher than 1,85m), so, e.g. the banana tree can work as a shade tree. Robusta can be grown higher but must be bent down at one point to make harvest and shade possible.
- Diversity plays a crucial role in enhancing resilience. A diverse range of species ensures that if one species is affected by a disturbance, others can step in to maintain ecosystem functions. If a particular tree species is vulnerable to a disease, a diverse forest with many different species is more likely to withstand the impact. In a forest system with a limited diversity of tree species that shed their leaves simultaneously, there is a risk of creating periods without shade.
- Introduce shade-tolerant crops and additional coffee varieties suitable for agroforestry.

3.2 Selection of cover trees

In this process, suitable cover crops for ground cover need to be discussed. Cover crops differ in a newly planted coffee farm and a developed coffee farm. Climbing bean varieties are only suitable if managed well, as they can climb up the coffee tree and weaken the tree.



Figure 8: Pumpkin used as ground cover in a coffee agroforestry system, Uganda, ACPCU

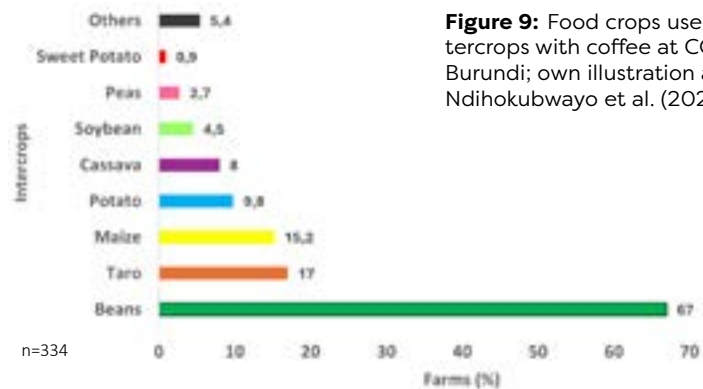


Figure 9: Food crops used as intercropped with coffee at COCOCA, Burundi; own illustration according to Ndiokubwayo et al. (2021)

Important for intercropping: when planting new crops: Do not dig up the soil, as the roots of the coffee trees could be damaged, and it can lead to even more soil erosion! Seeds must be planted carefully with, for example, a stick creating a small hole. Only slashing should be practiced when harvesting the cover crops or performing weeding, keeping the roots in the soil.

Find here some more reflection on the matching of challenges and measures from above:

- Size of land vs. attractive uses: Smallholders have limited land holdings, so very competitive trees (e.g. Eucalyptus spp., Acacia mearnsii) may not be considered even if they are fast-growing and have varied uses.
- Protection of soil erosion vs. competitive root systems: Trees with a deep root system (e.g. Acacia spp., Albizia spp. or Grevillea) are usually less competitive with crops than those with many shallow roots. However, when the main goal is to stabilise the soil, shallow root systems may be desirable.

Sometimes different purposes do not correspond well or contradict. Then you have to prioritize and balance your needs.

3.3 Policy alignment

You did a thorough exploration of your shade trees and crops. Before putting down your final planning, please consider all relevant local regulations and national agricultural policies that support sustainable and diversified farming practices. Study and align your implementation ideas and selection with Naturland requirements and standards before you finalise your choice and spatial arrangement.

3.4 Alignment to Naturland standards

Align the conversion plan with the Naturland regulations.



4. Implementation development

Develop a realistic implementation plan for how to reach 12 shade tree species in a farm of 1 ha or 6 species in 0.5 ha. Less than 6 species are not recommended, even if the farm is smaller than 0.5 ha. If you do long-term planning, include a harvest plan for the timber trees and how to replace them in time (if you harvest a timber tree, the new tree must be already at least 2 - 3 years old).

Establish how many farms will be converted and calculate the number of shade trees that must be distributed to implement a successful agroforestry system.

Calculate total costs for the nursery and distribution of the shade trees.

Establish a calculation sheet showing the expenses and revenues of all the agroforestry systems of each farmer to have a realistic financial picture.

Evaluate the economic benefits of the agroforestry system, considering diversified income sources and long-term sustainability (also as a motivation tool for farmers to join).



Figure 10 & 11: The tree nursery of COCOCA, Burundi



5. Tree nurseries and planting

Nurseries must be appropriately planned. This means a work on these questions is necessary:

- How long will the seedlings take to grow? And in which month should the seedlings be ready to plant in the plantation (consider rainy season for lower mortality rate)
- Which species to start with? (Fast-growing shrubs and trees. Bananas, for example, grow fast and will give shade, mulching material, fodder, new seedlings, and fruits soon)
- Which species are suitable for which regions (not all species will be ideal for all altitudes and areas).
- Can degradable materials be used (e.g., bags made of banana leaves instead of black plastic bags for seedlings, reusable flower pots, etc.)?
- Gradually introduce native trees within the plantation to create a balanced ecosystem and enhance biodiversity.
- Consider nitrogen-fixing trees to improve soil fertility naturally.
- Some trees will not need a nursery as they can be propagated by using branches (e.g. Ficus (nitrogen-fixing tree))



6. Implement organic practices

Organic farming means to protect nature, climate and biodiversity. It means to preserve and maintain soils and water resources, as well as to ensure consumer protection and social responsibility.

For Naturland organic production of coffee, organic practices regarding soil management, water management or pest- and disease management have to be implemented in your agroforestry system. All farmers' practices must comply with the overall principles and standards of organic agriculture!

6.1 Soil management

- Implement erosion control measures, such as cover crops and contour planting and mulching, to protect the soil during and after the transition (trenches are not suitable for every field and can also damage the coffee roots. Also think about planting grass like elephant grass (fodder/mulching material) or lemon grass (home use/extra income)
- If necessary, mulching material must be purchased in the beginning. If the agroforestry system is implemented correctly, the fallen leaves, twigs, and other organic materials will be used as mulch. If there is no ground cover, mulching material hardly decomposes! Hence, mix the ground cover with mulching material.



Figure 12 & 13: Examples of mulching



6.2 Water management

- If irrigation is needed, design water-efficient systems, like rain-water harvesting and drip irrigation, to sustain diverse crops and maintain soil moisture.
- In the long run, the agroforestry system should lead to a reduction of the irrigation needed. Many existing coffee farms with integrated agroforestry systems do not use irrigation.
- Mulching significantly reduces water loss through evaporation and regulates the water balance

6.3 Pest and disease management

- Implementing agroforestry and good agricultural practices in coffee plantations helps to reduce the incidence of pests and diseases.
- Promoting recommended species that can be a source of bio pesticides (e.g. neem variety *Azadirachta indica* to fight *Antestia* bug and many other pests)
- Agroforestry systems will make farmers monitor the farm much better, as they spend more time on the plantation to harvest other crops. Hence, pests and diseases are detected earlier.



Figure 14: Antestia bug



Figure 15: Coffee Berry borer, Source: Walker, K. (2007)



Figure 16: Coffee species leaf infected with coffee rust.



7. Training and capacity building

- Provide training to farmers on agroforestry techniques, diversified crop management, and sustainable agricultural practices.
- Pilot projects and demo plots: Implement pilot projects with a select group of farmers to test and refine the system before wider rollout.



Figure 17 & 18: Training in Rwanda, 2023.

- foster knowledge exchange among farmers to encourage collective learning.
- Introduce model farmers, model farms and farmer field schools to hold training on-site and have farmers the other farmers can go to in case of challenges and questions

- Develop a plan to maintaining the canopy the shade cover required by Naturland but not having too much shade (40 % of shade). Here are some effects, that missing shade risks:
 - Without adequate shade cover, the diversity of plant species within the forest may decline, leading to shifts in species composition and potential loss of biodiversity.
 - Fluctuations in temperature and humidity levels may negatively affect the plants, animals, and microorganisms dependent on the forest environment.
 - Without shade cover, soil moisture levels may decrease, leading to increased soil erosion and reduced water availability for plants and organisms.

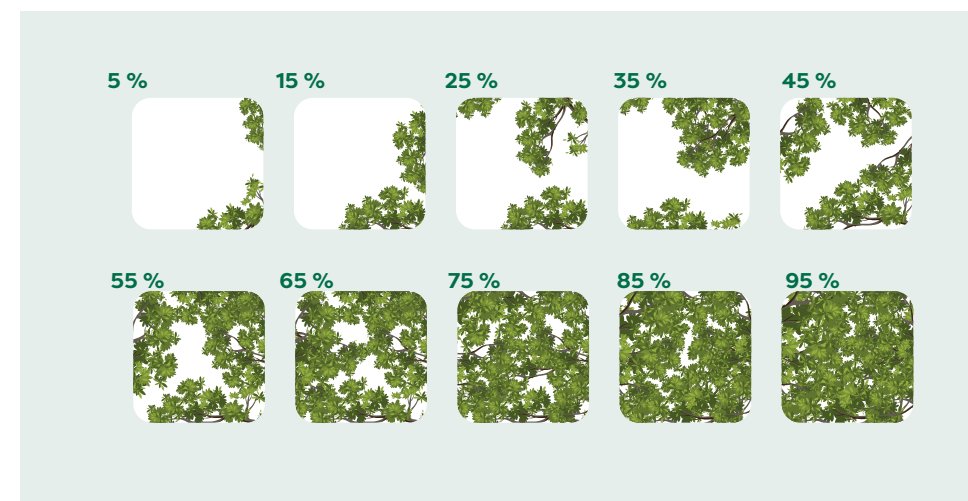


Figure 19: Different levels of shading; illustration adapted from La Disciplina de Fitotecnia en Cenicafé

8. Monitoring and evaluation

- Establish a monitoring system to track the progress of the agroforestry transition.
- assess the health of crops, soil quality, survival rate of shade trees and overall ecosystem resilience regularly.
- Find reasons for shade tree mortality (up to 30 % is in a normal range)
- develop a management plan for the shade trees (pruning/ harvesting/ planting new ones)





Figure 23 & 24: The same coffee plantation. COCOCA, Burundi, 2022.



Figure 20 & 21 (above): Coffee plantation at the start of their conversion to agroforestry: mulching, but there is no intercropping and no shade trees. COCOCA, Burundi, 2014.

Figure 22 (left): The same coffee plantation. COCOCA, Burundi, 2018.

Picture sources:

- Figure 9: own illustration modified according to Ndiokubwayo, Soter & Hav-yarimana, Tharcisse & Windbuehler, Sarah & Niragira, Sanctus & Habonimana, Bernadette & Kaboneka, Salvator & Megerle, Heidi. (2021). Farmers' Perception of Coffee Agroforestry Systems in an Area Targeted for Organic Certification in Burundi. *East African Journal of Forestry and Agroforestry*. 3. 40-53. 10.37284/eajfa.3.1.352.
- Figure 12 & 13: Shutterstock
- Figure 14: Kaldari, CCO, https://commons.wikimedia.org/wiki/File:Antestiopsis_thunbergii_2.jpg
- Figure 15: Ken Walker (2005) coffee beans det. A. Broadley. Updated on 1/25/2023, Available online: PaDIL - <http://www.padil.gov.au> (Accessed 27 May 2024).
- all others: © Naturland - Verband für ökologischen Landbau e.V.



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