AGROFORESTRY BEST-PRACTICE GUIDELINE

forestry, fisheries & the environment

Department:
Forestry, Fisheries and the Environment
REPUBLIC OF SOUTH AFRICA

Preamble

The Agroforestry Best Practice Guideline for South Africa has been developed by the Department of Forestry, Fisheries, and the Environment (DFFE) in collaboration with the Institute of Natural Resources (INR) and key stakeholders in response to the challenges faced by small-scale growers in South Africa due to the COVID-19 pandemic. The pandemic severely disrupted rural economies, exacerbating the vulnerabilities of smallholder farmers who rely on agriculture and forestry for their livelihoods. The job losses and limited resources, caused many small-scale farmers to struggle to maintain productive agricultural systems and secure incomes during the crisis.

Recognising the need to build resilience and diversify income sources for these farmers, this guideline focuses on agroforestry as a sustainable and viable solution. Agroforestry systems, which integrate trees, crops, and livestock, offer multiple benefits such as enhancing food security, improving land productivity, restoring soil health, and supporting biodiversity. These systems also contribute to the economic resilience of small-scale growers by providing alternative income streams through cultivating agricultural crops and forest products.

In addition, this guideline addresses the strategic need for South Africa's forestry sector to expand sustainably. With increasing demands for timber and forest products, the sector faces pressure to grow while balancing environmental conservation and community needs. Agroforestry presents a key opportunity for sustainable forestry expansion, allowing for the integration of small-scale farmers into commercial forestry value chains, fostering inclusive economic growth, and contributing to the country's broader environmental goals such as climate change mitigation and biodiversity conservation.

Developed through extensive research, stakeholder consultations, field visits, and focus group discussions, this guideline provides practical, easy-to-use information aimed at capacitating forestry practitioners, extension officers, and the civil society sector with agroforestry knowledge to facilitate knowledge mediation between advisors and small-scale growers and farmers.

By empowering small-scale growers with the knowledge and tools needed to adopt agroforestry practices, this document aims to promote sustainable land-use management, improve livelihoods, and contribute to the overall growth and resilience of South Africa's forestry and agricultural sectors. Through this integration of forestry and agriculture, smallholder farmers will not only enhance their productivity but also contribute to the nation's environmental sustainability goals, making agroforestry a vital component of South Africa's post-pandemic recovery and future development strategy.

How the guideline was developed

The Agroforestry Best Practice Guideline was developed in South Africa through a multi-step process with the DFFE and the INR. It was based on review of local, regional and international literature and enriched through stakeholder consultations, field visits, and focus group discussions, which allowed for a more locally relevant and practical guideline drawing on local practices. Through an iterative process of internal reviews and external reviews by the DFFE-appointed project steering committee, this document was developed.

The literature review provided critical insights into agroforestry classifications, best practices, and challenges associated with different types of agroforestry systems. Important stakeholders provided constructive feedback and information on agroforestry practices in commercial timber plantations. Field visits provided the opportunity to document existing agroforestry practices in different regions of South Africa, providing valuable on-the-ground data to validate the guideline's recommendations. Focus group discussions with small-scale farmers and timber growers in selected areas provided local knowledge and insights into socio-economic factors influencing agroforestry adoption. Internal review processes ensured the content was technically sound, aligned with the latest research, and feasible for practitioners. External review and feedback were provided by the DFFE and external stakeholders in the forestry and agriculture industries to ensure alignment with their strategic objectives. The guideline's practical application and relevance to the South African context are crucial for promoting the adoption of agroforestry practices.

Acknowledgements

Stakeholders: Acknowledgement is due to the stakeholders who gave input and guidance into the guideline development process. The internal stakeholders within the DFFE, the key external stakeholders i.e. Agricultural Research Council (ARC), Sappi, South African Forestry Company SOC Limited (SAFCOL), MTO Forestry, Forestry SA members, and the farmers in KwaZulu-Natal, Limpopo and Mpumalanga; all provided strategic input into the development of this guideline.

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Definitions

Agricultural advisor – a person who advises farmers on farming techniques, feed, equipment, livestock, etc. holds training sessions and demonstrations, and records and manages progress.

Agricultural Extension officer – is someone who communicates with farmers to support decision-making by providing information on sustainable farming practices. Agricultural extension officers propagate new, more effective farming methods based on the latest research. This may include research on how to farm with nature for good results now and in the future.

Annual crops – these crops grow and complete their life cycle in one year. They germinate, grow, bear fruits/grain and die off within a year. Examples of annual crops include wheat, oat, barley, maize, watermelon, peas, leguminous crop, cabbage, and mustard.

Complementary – this refers to the interaction between components of an agroforestry system; therefore, the components are complementary if the presence of one component increases the yield of the other.

Forestry Development Officer – a professional responsible for promoting and managing sustainable forestry practices and initiatives. Their role involves working with local communities, government agencies, and private entities to ensure the sustainable use, conservation, and development of forest resources.

Hectares per animal unit (Ha/AU) – this is a measure of how productive a pasture or veld is. An animal unit is a 450 kg cow with a calf and hectares per animal unit provide guidance on the number of hectares required to feed an animal unit for a year.

Improved fallows – is a practice of resting land by cultivation of vegetation comprising planted and managed species of leguminous trees, shrubs and herbaceous cover crops. These cover crops rapidly replenish soil fertility in one or at most two growing seasons.

Legumes – could be annual, biennial, or perennial plants that bear pods containing one to many seeds. Legumes include alfalfa, lupines, peas, vetches, and lespedezas, some of which fix nitrogen, an important plant nutrient.

Multi-purpose trees and shrubs – defined as all woody perennials that are purposefully grown to provide more than one significant contribution to the production and/or service functions of a land-use system. Examples of these plant species include leguminous fodder shrubs i.e. *Sesbania sesban*.

Nitrogen fixation – Nitrogen fixation is the process whereby atmospheric nitrogen is converted into a form that plants and other organisms can use, such as ammonia, nitrate, or ammonium. Most organisms cannot directly use nitrogen from the air, nitrogen fixation is essential for incorporating nitrogen into the soil.

Perennial plants/crops - these are a multi-annual plant species that are cultivated and live longer than two years without the need of being replanted each year. Naturally perennial crops include many fruit and nut crops; some herbs and vegetables also qualify as perennial. Most trees are perennial crops.

Small-scale farmer – is a farmer whose scale of operation is too small to attract the provision of the services he/she needs to be able to significantly increase his/her productivity.

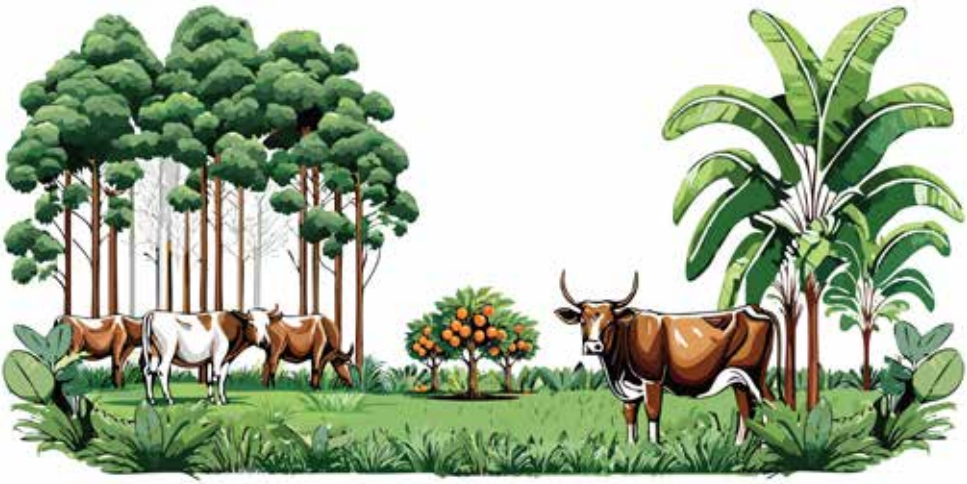
Small-scale growers – this refers to the small-scale timber growers who operate on an area of approximately 1.6 ha and contribute about 3.5% of commercial timber grown in South Africa.

Understory - the layer of vegetation that grows beneath the canopy of trees. This typically includes shrubs, herbs, or shade-tolerant crops, which benefit from the microclimate and protection provided by the taller trees above.

1. INTRODUCTION

1.1 Why the development of this agroforestry guide?

- This guideline is intended to provide easy-to-use information about agroforestry, especially for planning and executing plantation-based agroforestry systems.
- The guideline offers advice to intended users on how to integrate and manage food and fodder crops within plantation-based agroforestry systems.
- The guideline is intended for use by farmer trainers, forestry development officers, agroforestry practitioners, extension officers, institutions of higher learning, and non-governmental organisations (NGOs) involved in forestry, agriculture or agroforestry.
- The steps provided in this guideline will advise users on the management of crops, especially within plantation-based systems, and on how to develop basic business and/or marketing strategies.
- The guideline provides a clear decision-making tool that farmers or small-scale growers, foresters, extension officers can use to select the appropriate agroforestry system that best meets their needs.



1.2 Why the need for extension support related to agroforestry?

The South African Agroforestry Strategy recognises the need to develop and disseminate knowledge about agroforestry to facilitate its adoption.

The government extension service is an effective knowledge disseminator for information created to advance small-scale farmers and small-scale timber growers, offering advice and information to assist farmers as shown in Figure 1.

Small grower extension is a combination of formal and informal educational process directed toward small-scale farmers and small-scale growers.

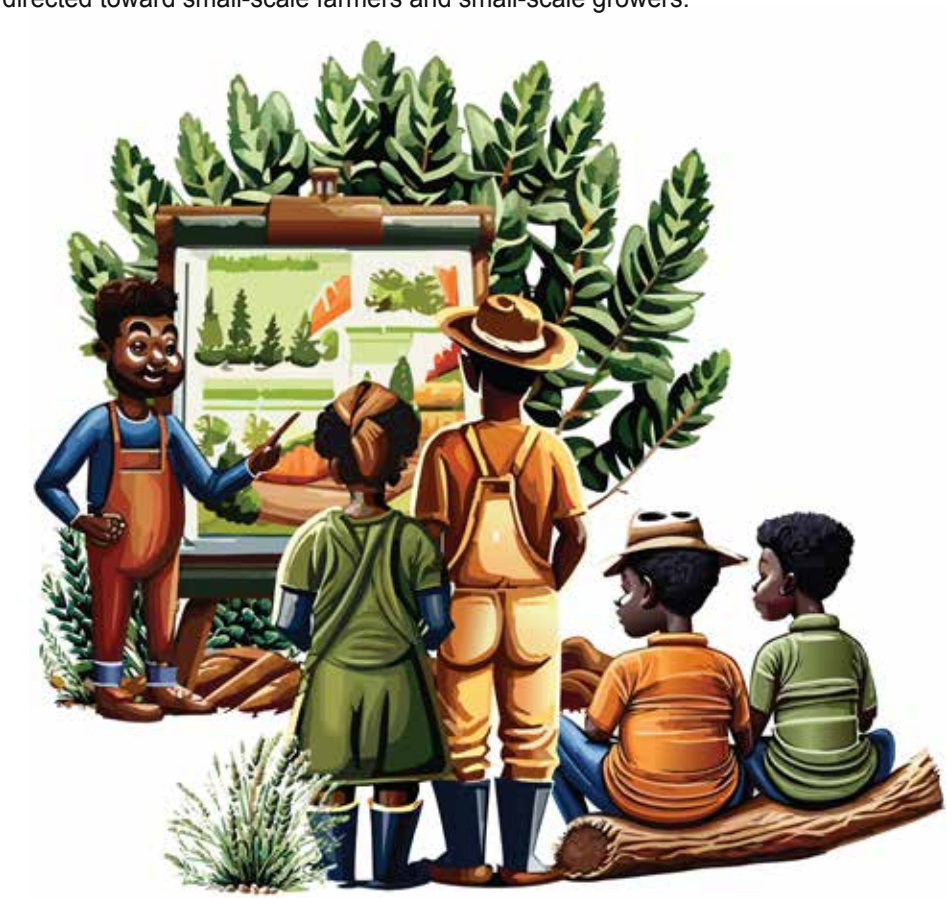


FIGURE 1: *Extension officer delivering agroforestry extension message to small-scale farmers and small-scale growers.*

2. WHAT IS AGROFORESTRY?

In simple terms, agroforestry is any land-use system that integrates different types of trees with agricultural crops as shown in Figure 2.

The term "agroforestry" originates from a combination of the words "agriculture" and "forestry".

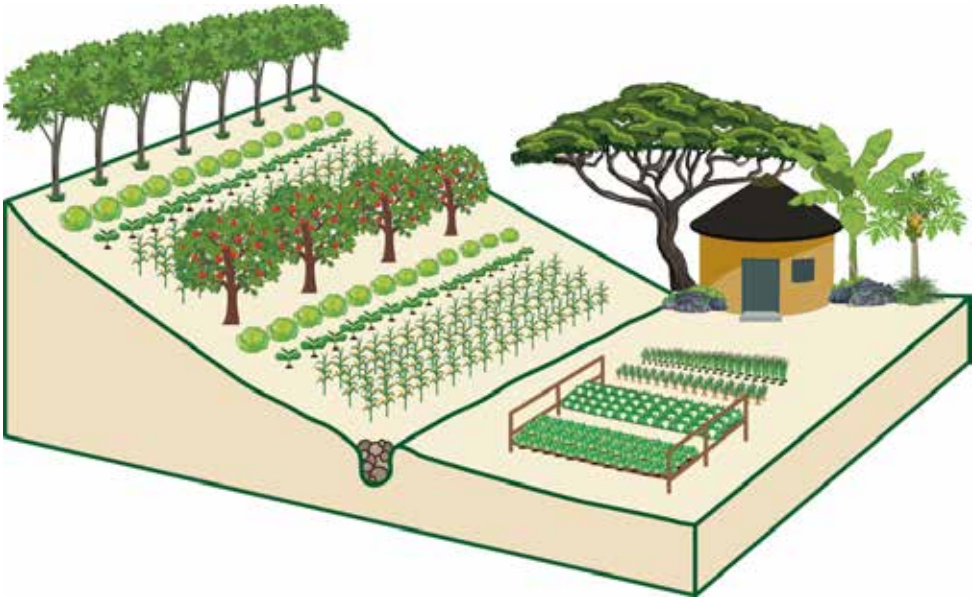


FIGURE 2: *One example of integrating timber trees with vegetables and fruit crops, showing different types of crops and trees being grown together in a diverse agroforestry system (Xu et al., 2013).*

A more detailed definition is that agroforestry is "the practice of deliberately integrating woody vegetation (trees or shrubs) with crop and/or animal systems to benefit from the resulting ecological and economic interactions (Pantera et al. 2021)".

2.1 Production components of agroforestry systems

Agroforestry systems typically comprise of different components whose presence can be complementary if managed in the right way:

Tree component

These may be trees for fruit, fodder, fuel wood, timber and other products.

Leaf litter and other plant residues increase organic matter and replenish soil fertility, and trees can recycle nutrients from deeper soil layers through their root systems.

Annual crops

These crops include grains, tubers, roots, vegetables, mushrooms, and flowers. The rotation for crops is generally much shorter than for trees.

Livestock (including fodder)

This component includes animals for draft power, dairy, meat and egg production, and fish, and other organisms for eating.

Some systems have multi-purpose trees that provide fodder, fruits, grain while others combine trees and pastures that provide grazing.

2.2 Agroforestry systems and practices

Agroforestry systems can be classified in terms of the nature and arrangement of different components as shown in Figure 3.

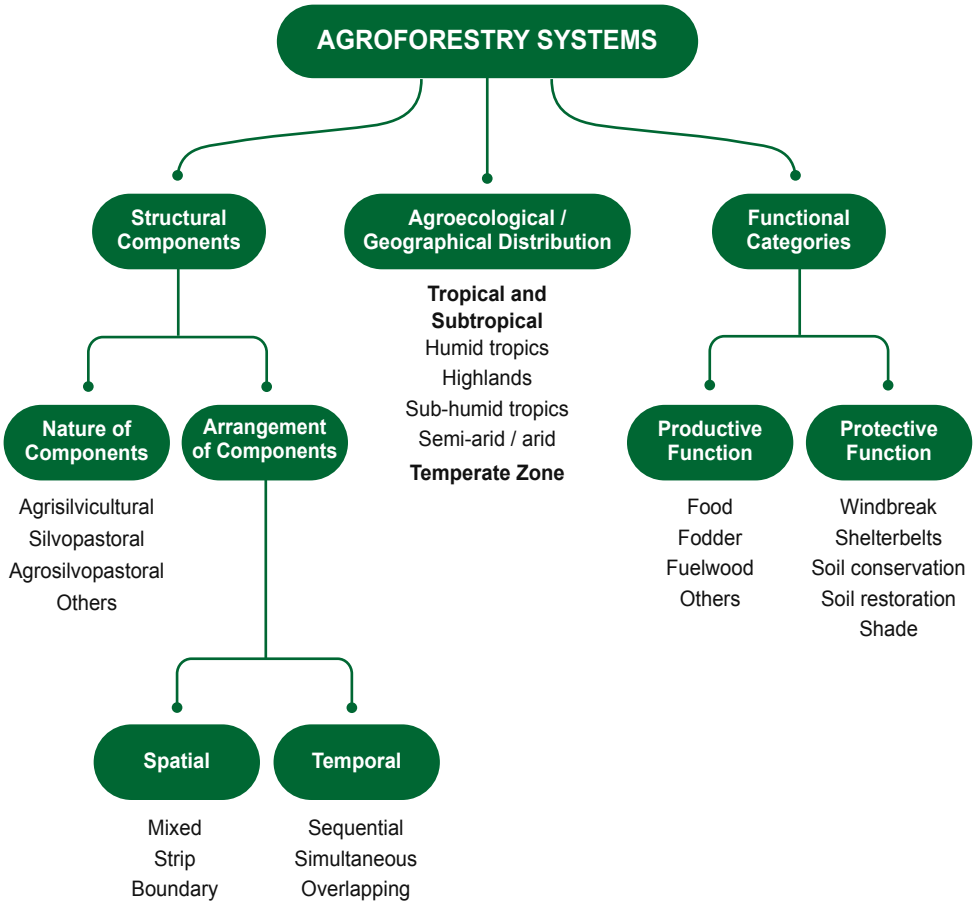


FIGURE 3: *Classification of agroforestry systems (Adapted from Nair et al. 2021).*

There are three main categories of agroforestry systems and practices. Specific practices are assorted to the aggregated categories of agroforestry – agrisilvicultural, silvopastoral, and agrosilvopastoral systems. These systems and associated practices are described in more detail in Table 1.

TABLE 1: Description of different agroforestry systems
Definitions are drawn from (Brown et al. 2018; Köthke et al. 2022).

Agroforestry category	Arrangement of components
Agrisilvicultural: combines crops and trees and/or shrubs	Improved fallows
	Alley cropping
	Timber-based system (modified Taungya)
	Shaded perennial-crop systems, multi-layer agroforestry
	Multipurpose trees, parklands
	Windbreaks, buffers strips, hedgerows
Silvopastoral: combines trees or shrubs, pastures and/or livestock	Protein banks
	Live fence of fodder trees and hedges
	Trees and shrubs on pasture
Agrosilvopastoral: combines the trees, crops and livestock	Home gardens
	Woody hedgerows for browse, mulch, green manure, soil conservation
Other systems	Apiculture
	Aquaforestry
	Mixed woodlots

i. **Agrisilvicultural** – combines crops and trees and/or shrubs.

ii. **Silvopastoral** – combines trees and/or shrubs (especially woody legumes) and pastures for livestock grazing/fodder.

iii. **Agrosilvopastoral** – combines the woody component (trees and/or shrubs), crops and livestock.

	Brief description
	Trees/shrubs (mainly legumes) planted and left to grow during the fallow phase between crop rotations to replenish soil fertility, including shifting cultivation and rotational fallow.
	Planting of rows of trees and/or shrubs to create alleys within which agricultural or horticultural crops are produced.
	A system of planting annual crops within plantations during the early establishment period before the tree canopy closure. Usually the land belongs to the forester who allows the subsistence farmers to raise their crops.
	Perennial crops shaded with trees, e.g. shaded coffee/cocoa, multilayer plant association (short and tall crops).
	Trees scattered on farmland with crops.
	Trees/shrubs around crop land to protect the farmland, e.g. as windbreaks, includes riparian buffers between crop land and water bodies/rivers.
	Various multipurpose trees (protein rich fodder trees) are planted on or around farmlands and range lands for cut and carry fodder production to meet the feed requirement of livestock during the fodder deficit period in winter.
	Various fodder trees and hedges are planted as live fence to protect the property from stray animals or other biotic influences
	Various tree and shrub species are scattered irregularly or arranged according to some systemic pattern to supplement forage production.
	Intimate, multi-story combinations of a variety of trees and crops in homestead gardens; livestock may or may not be present.
	Woody hedges coppiced for multi-purpose, such as fodder/browse, mulch, green manure.
	Trees frequently visited by honeybees are planted on the boundary of the agricultural field.
	Various trees and shrubs preferred by fish are planted on the boundary and around fish ponds. Tree leaves are used as forage for fish.
	Multipurpose trees are grown mixed or separately planted for various purposes such as wood, fodder, soil conservation, soil reclamation etc.

2.3 Why promote agroforestry?

Agroforestry offers a range of environmental, economic, social and ecological benefits that a farmer or grower can take advantage of to achieve a diverse and sustainable farming enterprise.

2.3.1 Benefits of agroforestry

As shown in Figure 4, agroforestry is a diverse system that consists of interlinked components e.g. incorporation of trees into cropping systems can provide microclimatic benefits such as shading, wind protection and moisture regulation, which positively impact crop yields and the nutrition and health of livestock.

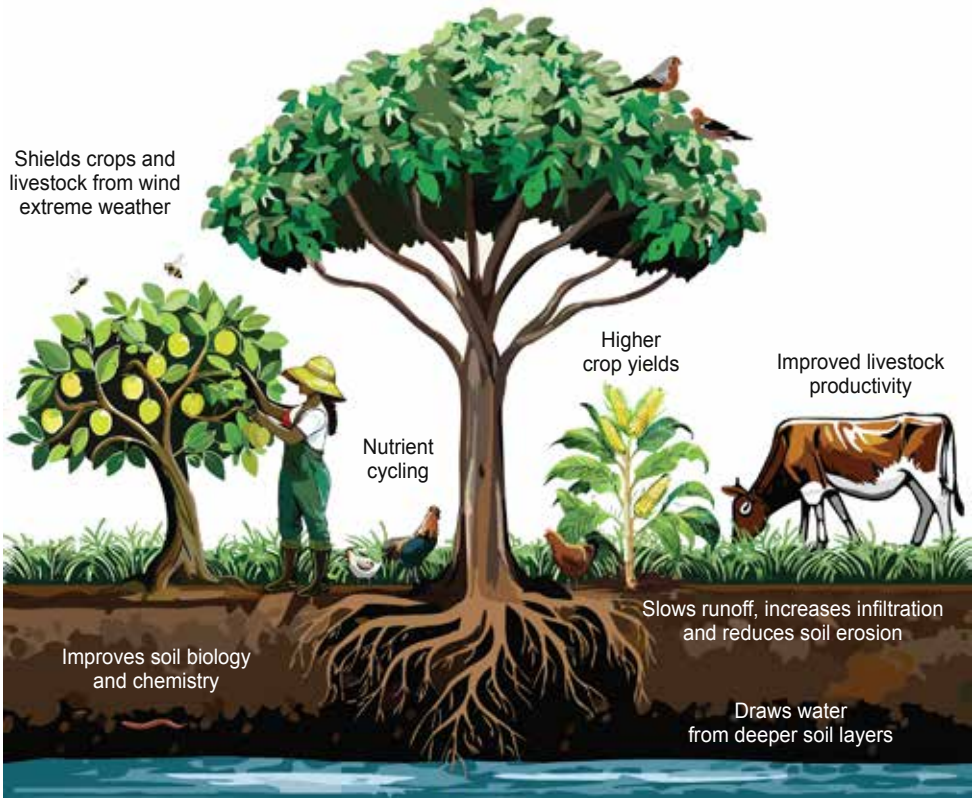


FIGURE 4: *Benefits derived from agroforestry systems.*

2.3.2 Characteristics of good agroforestry systems

Agroforestry systems should have the following characteristics to achieve the benefits mentioned on the previous page:

BOX 1: ENVIRONMENTAL BENEFITS

- **Improved soil health:** incorporating trees and shrubs helps minimise soil erosion, improves soil structure, and increases organic matter content. Their roots stabilise the soil and enhance nutrient cycling.
- **Biodiversity Enhancement:** the diverse nature of Agroforestry systems enables diverse habitats, which support a variety of plants, animals, and microorganisms. This can lead to increased biodiversity on the farm.
- **Climate Regulation:** trees sequester carbon, helping mitigate climate change. They also regulate microclimates, reducing temperature extremes and improving resilience to climate variability.
- **Water Management:** trees can enhance water infiltration and reduce runoff, improving water quality and availability. Their presence can also help recharge groundwater aquifers.

BOX 2: SOCIAL BENEFITS

- **Food and nutrition security:** agroforestry can provide a wide variety of healthy and nutritious food as well as fodder for livestock. This is especially important in rural and subsistence farming communities who depend on locally-produced, low-nutrient grain crops as sources of essential dietary minerals.
- **Reduced production costs:** since agroforestry components interact and benefit from each other, agricultural inputs and subsequent production costs (e.g. purchasing fertilisers) can be reduced.
- **Diversified income:** agroforestry provides farmers an opportunity to generate additional income from timber, fruit, nuts, and other tree products. This diversification reduces economic risk and increases financial stability.
- **Social cohesion:** agroforestry can support community cohesion through shared management and multiple benefits. For instance, some agroforestry trees provide fruits or medicines that are freely shared which contribute to binding people together socially (uBuntu).

2.4 Higher productivity (more production from a given area of land)

The agroforestry system will give multiple products. This will include shorter- and longer-term benefits and will include annual and perennial components. While there may be slight reductions in the production of the individual components due to competition for resources, the overall system should be more productive than if only one crop were produced.

For example, combining maize and pigeon peas may lead to a reduction in the maize yield, but it might be less costly to produce because of the nitrogen contributed by the pigeon peas. In addition, there will be grain and fodder (stover) from the maize crop as well as grain and fodder from the pigeon pea crop.

2.5 Environmental sustainability

In agroforestry systems, the conservation of soil and water is enhanced by the beneficial effects of woody perennials (especially nitrogen-fixing species). Agroforestry systems can recycle nutrients and maintain soil fertility. These systems also enhance biodiversity because there are multiple crops grown within the same area of land.

2.6 Adoptability

Agroforestry systems should be easy for farmers to 'adopt'. Besides being suited to farmers' biophysical conditions, they should also consider:

- Cultural and social factors: If systems require people to eat new crops or engage in activities that are not culturally appropriate, they may not be adopted.
- Affordability: If systems are expensive to establish and manage, this may limit adoption. For example, if planting material for the system has to be purchased and is costly.
- Labour requirements: If labour is limited or expensive, then small-scale farmers/ small-scale growers are unlikely to adopt systems that have high labour requirements (such as regular harvesting of hedgerows to provide fodder or material for mulching).

2.7 If agroforestry is so good, why is it not widely practised?

Factors that influence farmers' decisions and the selection of particular practices include:

2.7.1 Land access and tenure security

Land availability determines whether there is a possibility for farmers to incorporate trees into their farms.

There are various types of tenure insecurity. In many cases, tenant farmers, especially migrants, do not plant or manage trees because tree products belong to the owner. If people do not have title to land, there is a perception that there is no point in investing in trees, which can take a long time for benefits to be realised.

Many agroforestry projects have failed because people have little or no right to the land they occupy.

Unsecured or ambiguous land tenure, common in developing countries, confuses land delineation and rights. Rights to trees may be separate from rights to land, and both land and tree tenure insecurity may discourage people from introducing agroforestry practices.

2.7.2 Unconducive agroecological conditions

Biophysical conditions, including climate, soil type, slope and water availability can impact on the success of an agroforestry system.

For example, in areas that have heavy frosts in winter, many of the multi-purpose tree species used extensively in agroforestry systems in East Africa are unable to survive.

2.7.3 Lack of technical support

There is a lack of technical support (i.e. extension services) to guide small-scale farmers and small-scale growers regarding possible combinations of species, access to planting material and management practices for the tree-crop combinations.

2.7.4 Lack of access to markets

While small-scale growers generally have access to formal markets for their timber, this is more problematic for the other components (crops) of the agroforestry system.

Challenges related to market access include distance to urban centres, poor road infrastructure, lack of market information and failure to meet the requirements of markets in terms of quantity or quality. This is also because small-scale farmers/growers tend to operate individually.

2.7.5 System's suitability to the farmers' aspirations

Agroforestry is extremely context-specific. Extension staff need to be able to provide guidance that is suited to the local conditions without limiting the preferences of small-scale farmers and small-scale growers.

Farmers need to have the capacity to design the system based on factors such as the nature of climate and land, their objectives for the system (i.e. provision of food, fodder, medicine, etc.) and the amount of labour required.

3. AGROFORESTRY IN SOUTH AFRICA

Upon studying the extent and the prevalent types of agroforestry systems in the South African context, this guideline categorises agroforestry into two major systems. The categorisation is based on the type of tree used for the tree component in the system i.e. multi-purpose tree-based and plantation-based agroforestry systems.

3.1 Multi-purpose tree-based agroforestry systems

Multi-purpose tree-based systems are the 'traditional' Agroforestry systems; which involve combining woody tree/shrub species such as legumes, fruit or shade trees with crops and or pastures; for benefits such as soil health, better crop yields and fodder. There are several multi-purpose tree-based agroforestry practices which includes, but are not limited to, silvopastoral, agrosilvopastoral, and agrisilvicultural practices.

3.1.1 Silvopastoral

Silvopastoral systems combine trees or shrubs (woody plants) and pastures. One example combines fodder grass with pigeon peas. The grass can be grazed or harvested and the pigeon peas can provide food in the form of grain, as well as a source of high protein leaf material that can be harvested, and fed fresh or dried to livestock.

FIGURE 5: *Pigeon pea hedgerows cut at 90 cm (left), uncut hedgerows (middle) and vigorous grass growth under the pigeon pea trees (right).*

Another example is protein rich multipurpose trees/shrubs that are planted on or around farmlands and rangelands for cut and carry fodder production (Pigeon pea or *Sesbania sesban*).

3.1.2 Agrosilvopastoral

Homestead gardens that produce food for people and fodder for animals is a popular example of an agrosilvopastoral system practised in South Africa. As shown in Figure 6, the system involves the cultivation of various trees (e.g. for fruit), shrubs, bushes, etc. and agricultural crops, as well as livestock in or around dwellings in rural areas.

In terms of annual crops, preference is often given to nutrient dense vegetables (e.g. root crops, annual legumes, and indigenous leafy vegetables) for household consumption. All plants underneath the trees with high feed value are beneficial to the small and large livestock.

The woody species can be included in the garden in different ways, for example:

- They can be grown as live perimeter fences of the garden to keep livestock out.
- They can be grown as windbreaks.
- Other crops and vegetables can be grown underneath them to utilise the space.

FIGURE 6: *Various woody species such as trees, shrubs, bushes, and understory agricultural crops around dwellings in rural areas.*

3.1.3 Agrisilvicultural

Improved fallows, alley cropping and shelterbelts are the most commonly practiced agrisilvicultural agroforestry systems in South Africa (see text boxes 3, 4 and 5).

BOX 3: IMPROVED FALLOWS

Fallows are a farming technique in which arable land is not used for food production for one or more cropping cycles to allow the land to recover and store organic matter, retaining moisture and disrupting pest life cycles and soil borne pathogens.

Improved fallows are established when land lying fallow is planted with a fast-growing nitrogen-fixing tree species to improve its soil fertility status.

Improved fallows are a short-term substitute for the long traditional fallow. The idea of improved fallow is to use woody legumes that provide some benefits in terms of grain, fodder and while at the same time improving nitrogen / soil health. Normally this type of farming is for small-scale farmers who cannot afford mechanisation or chemical fertilisers.

Pigeon pea and *Sesbania sesban* are two of the woody legumes that have been used as improved fallows in South Africa as shown in Figure 7.

Management considerations:

- The trees are removed after 2 or 3 years, followed by 2 to 3 years of cropping.

Major benefits:

- Improved soil health and fertility
- Increased productivity of subsequent crops
- Carbon sequestration
- Reduced incidences of weeds, pests, and diseases
- Soil and water conservation.

FIGURE 7: *Pigeon pea being grown as an improved fallow in KwaZulu-Natal.*

BOX 4: ALLEY CROPPING

Alley cropping is where trees or shrubs are planted in rows (or hedgerows) and agricultural crops are grown between the trees at the same time, as shown in Figure 8.

Alley cropping is the planting of rows of trees and/or shrubs to create. alleys within which agricultural or horticultural crops are produced.

The relatively large spaces between the rows of trees / shrubs allow for separate management of the trees and the crop. The width of the alleys has an effect on the yield of the crop growing in the alley – known as "alley crops". Crop rows closest to the hedgerows compete for water, light and nutrients. Generally, the yields of the alley crop increase with wider alleys as less of the crop rows have to compete with the hedgerows. Although the woody component causes a slight reduction in the yield of the crop in the alley, the system as a whole is more productive.

Management considerations:

Either the shrubs must be pruned to reduce competition as shown in Figure 8 or they must be replanted every year when land preparation takes place, which is how pigeon peas are managed in Tanzania. Tree prunings are used to enhance nutrient cycling (during the wet season) or as sources of forage for livestock (during the dry season).

Major benefits:

- Diversify farm products
- Improved soil health and fertility
- Higher productivity of subsequent crops
- High quality fodder production during dry periods.

FIGURE 8: *Establishing maize into the mulch from Sesbania prunings.*

BOX 5: SHELTERBELTS

Shelterbelts are groups of trees that are planted to protect the production of agricultural crops and to serve as shelters for livestock.

Sometimes trees are planted in lines around the edge of orchards to provide simultaneous economic, environmental and social benefits that occur when trees are deliberately integrated into an agroecosystem, as shown in figure 9.

Shelterbelts are a line of trees or shrubs planted to protect an area, especially a field of crops, from fierce weather.

Major benefits:

Farmers use windbreaks on agricultural lands for benefits including:

- Soil erosion control
- Protection of crop fields by reducing wind erosion
- Livestock protection
- Reduce moisture loss from soil and plants in summer and autumn
- Reduce the amount of damage caused by strong winds
- Increased crop and livestock production
- Intrinsic values (aesthetics and wildlife habitat)
- Provides shade for livestock during hot weather
- Foliage from shelterbelts can be harvested for livestock feed especially during the dry season
- Help reduce drift of horticultural sprays.

FIGURE 9: *Citrus orchards often have windbreaks to reduce fruit damage.*

3.2 Plantation-based agroforestry systems

Plantation-based agroforestry recognises the unique South African context whereby small-scale farmers or small-scale growers and foresters work collaboratively to add value to timber plantations. This is done by planting cash crops e.g. sugar beans, groundnut, and Bambara groundnut into recently felled timber compartments until the trees grow into full canopy cover.

These systems are described below.

3.2.1 Silvopastoral

Within plantation-based systems, grasses grow naturally below the plantation. As shown in Figure 10, this offers opportunities to integrate grazing livestock, but care must be taken to avoid tree damage. Tree damage can be avoided by ensuring that cattle are only introduced once the trees are strong enough to withstand livestock interference.

FIGURE 10: *Cattle grazing within a timber plantation at Sokhulu village, KwaZulu-Natal.*

In plantation-based systems, the trees provide shade and shelter for the animals, while the livestock contributes to nutrient cycling through their manure, benefiting tree growth and soil fertility.

For communities that have plantations, this is an additional source of income, especially where timber is in the early stages of growing and there is still a lot of grass cover remaining in the understory.

Balancing Land Capacity

In a silvopastoral system, the balance between animal production and land sustainability is crucial. This involves considering the carrying capacity of the system, which includes trees, pastures, forage crops, and livestock.

The stocking rate, tree density, and arrangement of trees must be carefully managed to prevent overgrazing, soil compaction, loss of vegetation, and increased erosion.

Rotational grazing practices allow for periods of rest and recovery for pasture, maintaining forage productivity and the health of both pasture and trees.

Tree spacing is essential to ensure enough sunlight reaches the forage crops beneath them, while providing shade and shelter for animals.

Seasonal variations in forage production should be considered to avoid overstocking during periods of low productivity.

The grazing capacity varies considerably, depending on the condition of the veld or pasture. With good management, a grazing capacity of 2.5 hectares (ha) per animal unit (AU) can be applied. However, considering the silvopastoral system where the same piece of land is shared between trees and pasture, half of this (i.e. 1.25 ha per AU) should be applied.

Water resources are also crucial for the integration of trees and livestock. Proper management of water resources is necessary to prevent the system from becoming overstressed.

Trees can enhance water retention in the soil, improving the system's carrying capacity by making more water available for forage crops. However, it is essential to ensure that water is evenly distributed and not excessively consumed by trees.

3.2.2 Agrosilvopastoral

Small-scale growers (particularly communities living next to plantations) can integrate timber trees, multipurpose species, crops and animals in the same unit of land, usually around or near the house; an agroforestry practice known as home gardens involving animals (see Figure 11).

The system provides subsistence goods and services to households throughout the year, such as food, medicine, wood, poles (building material), fruit, shade and fodder for livestock.

The agroforestry system contributes to improved food access and nutrition, diversified food options, improved livestock production, climate risk reduction and also increased crop yields.

3.2.3 Agrisilvicultural

Taungya is one of the agrisilvicultural agroforestry systems practiced within timber plantations in South Africa (Figure 12). In this system, farmers or small-scale growers cultivate annual crops during the early stages of timber plantation establishment or regrowth.

Because farmers weed their crops, this system allows for foresters to establish plantations at reduced weeding costs.

An important consideration is that farmers can only cultivate agronomic crops for the first year of plantation establishment (or after harvesting the timber).

After canopy closure (6 months), the farmers are allocated new plots within the forest plantation. The timber crop then grows for a period of 7-8 years before it is harvested. After harvest, annual crops can again be established in the alleys.

The system promotes the economic and social development of the small-scale farmers living near timber plantations.

For small-scale growers that have their own woodlots, it also provides a source of short-term income and food while the farmers wait for the timber to grow to maturity.

Some farmers also plant crops in the breaks that are cleared around the plantations to protect them from fire.

FIGURE 11: *An example of an agroforestry system combining timber trees, multipurpose species, crops and animals.*

FIGURE 12: *Agrisilvicultural agroforestry system involving timber trees and annual food crops (Eucalyptus and the common bean).*

Arrangement of tree-crop components in the Taungya system

The arrangements of the different parts of the agroforestry (the woody and non-woody components) relate to:

(1) timing of when the different plants are established, and

(2) the 'spatial' arrangement (how they are placed on the land).

The recommended layout for the system as shown in Figure 13 is as follows:

- Timber species in plantations are usually planted at a spacing of 4 m x 2 m, and agriculture crops must be grown within the alleys.
- Recommended spacing between the timber tree and crop is 0.50 m to minimise the effect of shading.

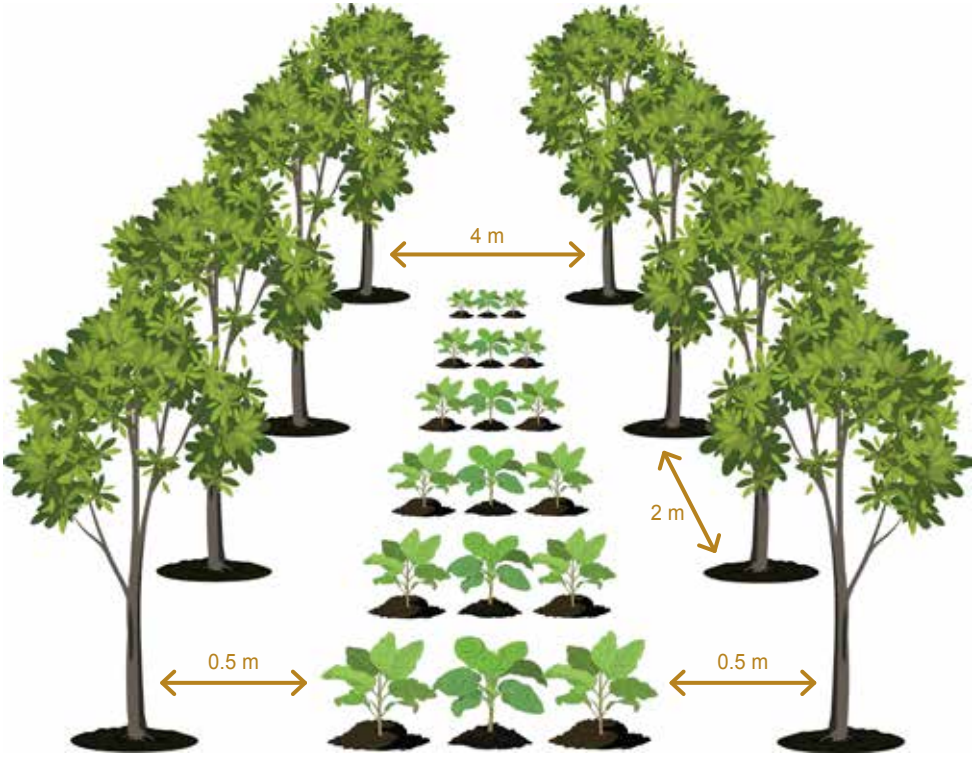


FIGURE 13: *The recommended layout for trees and agronomic crops.*

Considerations for tree species selection

When establishing a plantation, the selection of a suitable tree species is an important step that requires consideration of the intended use (e.g. timber, pulpwood, and bioenergy), desirable traits (such as fast-growing, high tolerance to diseases and high wood yield), compatibility with local climate and soil conditions, and the market.

The grower is advised to get guidance from the local extension forester. The most commonly used species in timber plantations in South Africa are the *Eucalyptus* and *Pinus* genus. In this section *Eucalyptus* will be used as a model species.

Propagation of *Eucalyptus* at nurseries

Eucalyptus propagation can be accomplished in several ways and these include:

- Seeds – the most common and reliable method and takes 7–8 months for planted seeds to reach the appropriate age for planting.
- Cutting – cuttings are grown from coppice and require only 4 months for production.
- Micropropagation – through axillary proliferation, or adventitious shoot proliferation on nodal explants, or both.

Sourcing planting material from a nursery

Before ordering seedlings, the forester or small-scale grower must determine how many seedlings they require based on the size of the area they are planning to plant. An order for seedlings must be placed with the nursery manager well ahead of time to ensure that the nursery produces enough planting material for all the growers.

FIGURE 14: *Eucalyptus planting stock on benches at a nursery.*

Caring for seedlings before they are planted

To ensure healthy seedlings, water them upon arrival, plant them as soon as possible, avoid storing them under shade, water them only in the morning and when wilted, ensure root plugs are soaked through, and thoroughly water them before planting.

Land preparation

Burning of slash

Slash is the waste left in the plantation after harvest. It is critical to manage the slash because it is a fire risk and it makes replanting harder.

Slash should be placed in heaps or rows before burning. Make sure that all neighbours and the fire protection association are aware of the planned burn.

A cool fire is recommended to prevent damage to the soil. A cool fire is achieved when burning takes place during cool, humid weather (10-20 °C); with limited wind, and ideally when it has rained a bit and the soil is a bit moist.

Subsequently if need be, ripping can be performed to prepare a good bed that will allow the trees to grow well.

Site preparation requirements for different types of land

For virgin grassland, all the required authorisations must be obtained first. For site preparation, ploughing along the planting lines is preferable, although pitting with a hoe or pick is another option; however, all vegetation in a 1 m wide ring around the pit must be removed. To prepare land for planting, apply a pre-plant herbicide spray.

If the land was previously used for agriculture, ploughing is recommended, but pitting with a hoe or pick is also an option.

If the land was previously planted to trees, pitting is the preferred approach.

Marking pits

A steel wire marking cable covered with plastic is used to mark tree lines and positions. Special metal markers are attached at the correct distances, indicating where to plant the tree. Two cables with different spaced markers are used, with the baseline cable showing line positions and the marking cable marking tree lines.

Marking positions for planting

Marking positions involves setting up a "baseline" across a slope or dividing it into four parts. The baseline cable has 3 m marks for planting pits, while the 2 m marking cable marks the square line at right angles to the baseline cable. The team moves to the next mark along the baseline cable, holding each end and others marking the pits. A 3 m stick at one end and a 3 m mark on the base line at the other end ensures the marking cable is parallel with the square line.

Plant-to-plant and row-to-row distances

Proper seedling positioning ensures correct plant density. For instance, if the forester or small-scale grower wants to achieve high density plantation then they can select spacing of 1.5 m x 1.5 m (4, 444 plants per hectare (ha)) or 2 m x 2 m (2, 500 plants/ha).

Foresters promoting agroforestry or small-scale growers engaged in agroforestry can choose wider spacing of 4 m x 2 m (1250 plants/ha) or 5 m x 1.5 m (1333 plants/ha).

Crops such as nuts, groundnuts, Bambara groundnuts, beans or medicinal plants can be cultivated in alleys formed by tree rows.

Pitting

Pitting is digging small planting basins for each seedling and preparing the soil for planting. It involves breaking the soil and allowing water to soak in. A well-prepared pit (with well-loosened soil) encourages new roots to develop.

In practice, remove everything in a 1 m ring and use a pick to loosen soil and break up clods to less than 3 cm.

The pit should be 25 cm deep and 50 cm wide for establishment, but 35 cm wide for re-establishment.

Planting timber tree seedlings

Seedlings can be planted with water (water is poured into the hole), hydrogels (allow planting during delayed rains) or dry planting (i.e. planting without water – requires good soaking rain).

Prior to planting, ensure that the pit is free of weeds and dead plant material.

Steps involved in planting seedlings are as follows:

i) dig a 10 cm wide, 20 cm deep planting hole in the centre of the pit using a hand trowel,

ii) hold plants by the stem (when removed from trays) and carefully place next to the planting hole just before being planted,

iii) fingertips and palm of the same hand should be used to support the root plug into the planting hole while the free hand fills in the hole using the planting trowel,

iv) submerge the top of the root plug at least 3 fingers below the soil surface to prevent it from heating or drying, and

v) plant the seedling at an upright position and at the centre of the pit.

After completing these steps, a shallow basin must be formed around the seedling to catch water. Blanking (replacing dead seedlings with new ones to ensure that there are no empty pits) should occur within 2-4 weeks of planting to allow trees to catch up.

Soil management and fertilisation

Soil Testing

Proper soil sampling and testing is essential for monitoring soil pH and nutrient status. This will ensure that fertilisation application rates are aligned with the trees' needs rather than guesswork. Foresters or small-scale growers should send soil samples to the nearest Fertiliser Advisory Services (FAS) to get fertiliser recommendations.

Adjusting Soil pH

Trees such as *Eucalyptus* prefer slightly acidic to neutral soil pH levels. If the FAS soil test results show pH levels above or below this range, amendments such as sulphur (to lower pH) or lime (to raise pH) may be necessary during land preparation.

Fertilisation

To ensure good early growth and quicker canopy cover, apply a small amount of fertiliser at planting, subsequently within 2 weeks after planting. Apply fertiliser during the rainy season or when rainfall is expected. Apply the fertiliser manually or use a specialised tool, making sure to weigh the correct amount per tree and placing it in two slots 15-20 cm on each side of the seedling.

Weeding

Mechanical or chemical weeding is important for ensuring the survival rate of seedlings. Regular weeding for the first 2-3 years, maintaining a 1 m radius around each tree is

necessary. Foresters who grant agroforestry farmers to cultivate food crops within their plantations usually do not spend money on weeding. Weeding is done by the agroforestry farmers during the cropping season for the benefit of both the food crop and the tree.

Pruning

The purpose of pruning is to develop a single straight stem and develop more valuable, knot-free trunks.

When to prune

Pruning to develop a single stem can begin when trees are 2 years old. Young trees 1 to 6 years old are most commonly pruned in late winter, as close to bud break as practical, so that the pruning cuts will be overgrown rapidly with the onset of active growth in the spring. Older trees may be pruned in the summer or when they are dormant.

What to prune

Regardless of tree age, it is important to:

i) remove any dead, broken, diseased, or dying branches,

ii) identify the main stem or leader, any branches that will compete with it, and decide how much of the competing stems should be removed,

iii) suppress or remove lower limbs, or vigorous branches that are growing upward into the canopy, and

iv) either remove or cut back any branch that originates in the bottom half of the tree that has grown into the top third of the canopy.

Tools for pruning

Based on the height and diameter of the branch to be pruned the forester or small-scale grower can use tools such as hand shears or loppers, pole pruners, and power saws and hand saws for pruning trees In agroforestry plantations with widely spaced tree rows (low density plantations) a pruning tower or motorised lift can be used for pruning.

Harvesting

Harvest trees at the right time to maximise timber production. Pine should be harvested after 20-25 years, while *Eucalyptus* should be harvested after 8-10 years. Small-scale foresters may prefer selective harvesting, while clear-cutting is used for replanting. *Eucalyptus* can be coppiced, allowing the stump to regrow for up to three cycles, where poles or firewood are harvested without replanting.

Considerations for crop species selection

- The cultivation of annual grain legumes within alleys is recommended.
- The most popular grain legumes, which are shown in Figure 15, include:
  - Groundnuts/peanuts
  - Bambara groundnut
  - Common bean.
- Climbing crops (such as sweet potato) are not recommended as they affect growth of the tree seedlings.
- Maize is also not recommended as it attracts livestock and wild animals.

FIGURE 15: *Annual grain legumes (from left) Bambara groundnut, groundnut and common bean commonly cultivated understory crops in plantation-based agroforestry systems.*

Criteria for selecting legume varieties

When buying seed, it is important to ask the supplier to advise on the best seed for the area where it is to be planted.

Adaptability

- Farmers should select a seed variety that is adapted to the prevailing conditions.
- A well-adapted variety is likely to give a better yield than one that is not suited to the local environment.

Resistance to drought, pests and diseases

- A wide range of pests and diseases could attack the crops at the different stages of its growth cycle. A farmer therefore should select a variety that can tolerate pest and disease attacks that are common in the local environment.
- Farmers should use varieties that are drought tolerant.

Length of time it takes for the crop to mature

Short duration (fast-growing) crops are best for these agroforestry systems. This is for two reasons:

- Weather is unpredictable and it may be necessary to wait for rain before planting.
- It is best to avoid competition with the tree crop by ensuring that the agronomic crop is harvested as soon as possible.

Managing a plantation-based agrisilvicultural system

Tree - crop interaction

Eucalyptus trees grow relatively fast and can create a dense canopy six months after planting (see Figure 16), thus leading to increased shade levels within alleys. Shading can reduce growth and productivity of alley crops. The effect of shading can be avoided by practising only one cropping cycle, following the harvest of the timber.

FIGURE 16: *Six-month-old Eucalyptus juveniles with a dense canopy, Palm Ridge plantation.*

Site and land preparation

Commercial plantations are divided into areas called compartments.

Crops are grown in the compartments during the re-establishment phase (this is the time between timber harvesting and canopy closure).

The re-establishment phase includes site preparation, slash management, fertilisation and weed management.

Each year, the foresters allocate land to small-scale farmers within their felled compartments for cultivating crops (see Figure 17).

As seen in Figure 17, there is residue from harvested timber that is left on site after burning which is commonly called 'slash'.

The management of slash is one of the most important practices included within site preparation as it can negatively affect both tree and crop performance.

FIGURE 17: *Recently felled compartment within a timber plantation ready for allocating plots to farmers.*

Following the allocation of land within harvested compartments, the remaining slash should be carefully placed along tree rows in a way that prevents damaging new timber seedlings (see Figure 18).

Because timber trees are usually planted at spacing of 4 m x 2 m, mechanical land preparation for the understory crop is not possible as tractors may destroy planted tree seedlings during the process.

Stumps remaining after timber harvest may also not allow for movement of land preparation machinery (see Figure 19).

Manual land preparation using hand hoes is therefore recommended.

FIGURE 18: Eucalyptus *slash carefully placed along the tree rows.*

FIGURE 19: *Cleaned alley with dead stumps of Eucalyptus that remained after timber harvest.*

Crop establishment and management

Alleys should be allocated to farmers just after timber harvesting.

Planting should be done on the onset of rains immediately after the allocation of alleys.

For ease of work, farmers can work in teams comprising of people who are digging holes, placing seed and those who cover the hole and seeds (see Figure 20).

FIGURE 20: *A team of small-scale farmers cultivating food crops within a plantation-based agroforestry system.*

The crops are best planted in straight lines to achieve optimum plant population and to make weeding and harvesting easier.

Use strings with marks (or knots) at specific intervals to ensure that the crop lines are correctly spaced, and that the crop lines are at the correct distance apart.

Table 2 provides a summary of recommended agronomic practices for producing some food crops in alleys formed by rows of trees in a plantation-based agroforestry system.

Table 2: Recommended agronomic practices for producing some food crops within plantation-based agroforestry systems

	Groundnut/ Peanut	Bambara groundnut	Dry bean/ common bean
Days to maturity	160 to 200 depending on cultivar	110 to 150 depending on cultivar	Short duration: 85 to 94 Medium duration: 95 to 104
Suitable temperature for germination	18 °C to 30 °C	30 °C to 35 °C	17.5 °C to 27 °C
Suitable temperature for vegetative growth	20 °C to 35 °C	20 °C to 28 °C	18 to 24 °C
Rainfall requirement per annum	500 to 700 mm	500 to 1200 mm	400 to 500 mm
Recommended planting time	October to end of November	October to early December after good rainfall	Frost areas: November to mid-January Frost-free areas: March and April
Soil pH	5, 5 to 7, 0	5,0 to 6,5	5, 5 to 7, 0
Planting depth	5 to 7.5 cm	Heavy (clay) soils: 2,5 to 3,0 cm Deep sandy soils: 5,0 to 7,5 cm	2,5 to 7 cm
Space between crops	20 to 35 cm within rows 30 to 50 cm between rows	10 to 15 cm within rows 30 to 50 cm between rows	25 cm within rows 45 cm between rows
Space between timber tree and crop	50 cm	50 cm	50 cm
Recommended time of weeding	21 to 28 days after planting	21 to 28 days after planting	14 to 21 days after planting

The rate of seed germination and emergence out of the soil depends on planting depth, soil moisture and temperatures. Therefore:

- Plant after rainfall when the soil is damp.
- Plant during warmer months.
- Plant seeds at a depth approximately twice the size of the seed.
- For uniform plant growth, keep the planting depth uniform.

It is very important to control weeds in the early stages of crop development to avoid competition with crop plants for nutrients, light and water.

Farmers with off-farm income can apply chemical herbicides registered for use on their crops; but must be very careful not to harm the timber trees. This can be achieved by preventing drifts by using a spray hood to control mist coming out of the sprayer.

It is recommended that farmers use hand hoes to weed the alleys 3 to 6 weeks after planting, as shown in Figure 21.

FIGURE 21: *Controlling weeds using hand hoes.*

4. DECISION SUPPORT TOOL FOR AGROFORESTRY

The agroforestry decision support tool was developed to assist farmer trainers, foresters, small-scale growers, agroforestry practitioners, extension officers, institutions of higher learning, and non-governmental organisations to guide farmers and small-scale growers in making informed choices about appropriate agroforestry practices.

The selection of an appropriate agroforestry system depends on the farmer's objectives and available resources.

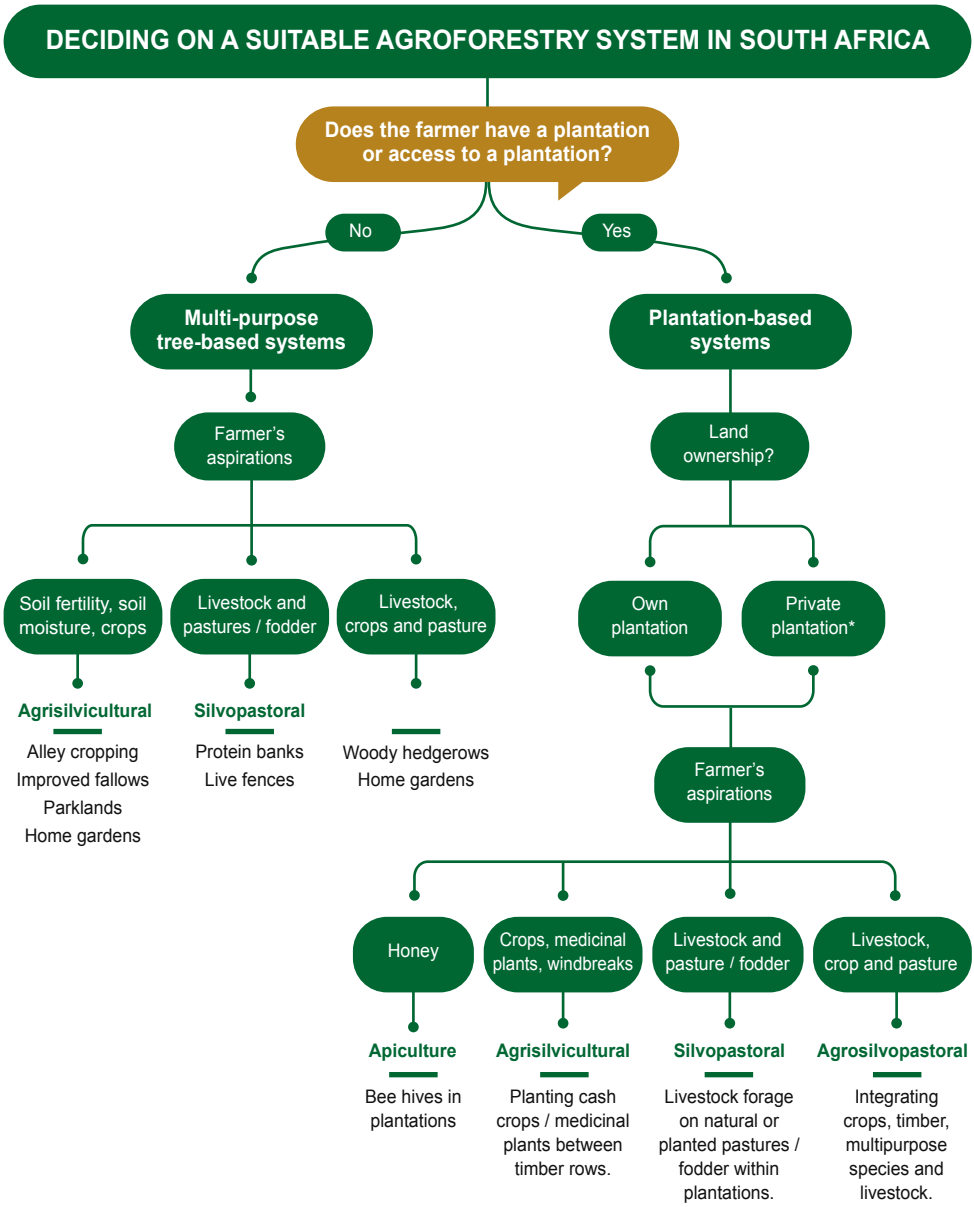
For instance, benefits from plantation-based agroforestry systems usually differ from multipurpose tree-based agroforestry systems. Additionally, some farmers may want to integrate livestock into their systems, while others may not.

Therefore, the agroforestry advisors must engage with farmers and consider the various factors influencing the selection of the most suitable practice.

Figure 22 (Page 40) depicts a pathway that can be taken to select the best agroforestry system based on their specific context and goals. The schematic diagram was created based on the two major agroforestry systems practised in South Africa i.e. multi-purpose tree based and plantation-based agroforestry systems.

The decision support tool starts off by asking an important question; **"what does a farmer want to achieve with agroforestry?"**. This is a fundamental question as it will assist the farmer or grower in determining the best agroforestry system for them to implement.

For example: in a plantation-based system, the grower/farmer might be interested in growing crops for home consumption as well as income generation. The plantation might belong to the farmer/grower himself or to the forestry company. Therefore, the correct agroforestry system to choose in this case would be an agrisilvicultural system (Taungya).



* (Sappi, Mondi, MTO, SAFCOL, KOMATILAND).

FIGURE 22: *Decision support tool for agroforestry advisors and farmers.*

5. ENHANCING LIVELIHOODS THROUGH PLANTATION-BASED AGROFORESTRY

Livelihoods of small-scale farmers and small-scale growers can be improved by introducing agroforestry practices. Benefits can be enhanced by adding value to the crops and by marketing them effectively.

5.1 Value addition

Before selling, the value of non-timber products can be enhanced through proper harvesting and processing, and by using the right packaging.

The processing of crops, especially legumes, includes steps such as drying, shelling, cleaning, sorting and milling.

Groundnuts must be shelled and sorted before they can be processed as shown in Figure 23.

FIGURE 23: *Shelling (left) and sorting (right) the groundnuts before processing.*

In the case of groundnuts, they can be processed and sold in the form of fresh or cooked mature pods, dry grains and as an oil or butter.

FIGURE 24: *Groundnut processing can include shelling and roasting, boiling of pods, and making butter and oil.*

There is a need to design attractive and informative packaging for products. Packaging not only improves the shelf life of the product but also encourages customers to buy the product.

It is important to find out what information is needed on the packaging if the product is to be sold in a supermarket. For instance, the packaging needs to have information about the product such as the name of the product, the manufacturer's name and address, net weight, serving size, list of ingredients, nutrition information per serving and packed and expiry date.

FIGURE 25: *Examples of good packaging for nut products.*

5.2 Market access

Marketing involves all those activities that take the product from the farmer to the consumer.

Effective marketing should ensure that products are supplied according to the demand i.e. on time and of the quantity and quality that consumers want.

Many small-scale farmers and small-scale growers find it costly to transport their products to urban centres where they can potentially get better prices.

Many of them rely on public transport to get the product to towns and formal markets. There are also no guarantees that products will be bought when they reach the market.

5.3 Forming groups

Value addition may be easier if small-scale farmers or small-scale growers work together in groups rather than as individuals:

- They can work together to process and package their products.
- They could also come together to market their products.

FIGURE 26: *Small-scale farmer groups selling products at a farmers' market.*

Establishment of farmer groups can also unlock support from extension officers and other government departments that support enterprise development.

The establishment of farmers' groups could make it easier for them to meet market demands for consistent supply. It might also be easier for them to hire a vehicle together rather than relying on public transport.

Another benefit of forming groups is that the farmers have more bargaining power than when working as individuals. It may allow them to be "price makers" rather than "price takers".

FIGURE 27: *Crops and products being transported to a busy market depot.*

6. CONCLUSION

The Agroforestry Best Practice Guideline for South Africa provides a comprehensive framework to support the successful implementation of agroforestry systems, particularly for small-scale farmers and growers. Agroforestry offers a sustainable approach to improving land productivity, enhancing biodiversity, and promoting economic resilience.

The guideline was developed through a multi-step process that included literature reviews, stakeholder consultations, field visits, and focus group discussions, hence it is grounded in both global best practices and the unique socio-economic and ecological realities of South Africa. Input from key stakeholders, including Sappi, SAFCOL, MTO ARC, and local farmers, ensures that the document is practical, feasible, and aligned with national strategies.

The guideline equips practitioners with knowledge and actionable steps for selecting suitable crops, managing land resources, enhancing market access, and fostering sustainable practices that benefit both the environment and livelihoods. As agroforestry continues to gain importance in addressing climate change, food security, and economic challenges, this document serves as an important tool for guiding the development of robust and adaptable agroforestry systems.

By following the principles and practices provided in this guideline, South African practitioners in forestry, agriculture, NGO sector and academia can drive meaningful progress towards creating more resilient and sustainable farming landscapes for future generations.

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