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**Harnessing benefits for
climate change mitigation
through irrigation-free
indigenous tree restoration:
sharing knowledge and
building capacity**

**BEST PRACTICE
GUIDELINES MANUAL**
Version for institutional
stakeholders

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Project background and funding

This best practice training manual was produced as part of an international collaboration between Bayero University Kano (BUK), Nigeria, and Universities of Leeds and York, UK. The collaboration, funded by the UK PACT Green Recovery Challenge Fund, aims to develop innovative training to support cost-effective irrigation-free indigenous tree restoration within smallholder farms in northern Nigeria, accelerating emissions reductions. By working with stakeholders at all levels, the collaboration will facilitate Nigeria's progress towards its Nationally Determined Contributions and the Sustainable Development Goals. The success of achieving international commitments that are linked to land, food production and climate change mitigation, depends on strategies that directly involve local participation. UK PACT (Partnering for Accelerated Climate Transitions) is a £60m flagship programme under the International Climate Finance (ICF) portfolio. It is part of the UK's £5.8bn commitment to International Climate Finance by 2021 to tackle climate change. The programme is funded by the Department for Business, Energy and Industrial Strategy (BEIS).

Table of contents

Preface.....	7
1 Introduction.....	9
2. Silvicultural and management practices for irrigation-free indigenous tree restoration.....	11
Step 1. Selection of indigenous tree species and stumps	12
Survey and identification.....	13
Setting community goals, integrating women's perspectives and generating a preferred species list.....	20
Selection and marking of individual trees and stumps.....	22
Step 2. Thinning and pruning	23
Step 3. Protecting and utilising	26
3. The multiple benefits of indigenous tree species in agroforestry	32

ANNEXES

Annex I. Costs and benefits of selected practices..... 41

Annex II. Financing mechanisms to support
implementation and upscaling of selected practices . 50

Preface

Northern Nigeria is subject to land degradation, driven by climate change and unsustainable land use practices. Poverty in the region is high, with land degradation exacerbated by migration, conflict and low recognition of the rights of women. Indeed, women are disproportionately impacted by poverty and land degradation partly because they are largely engaged in unskilled, labour-intensive agricultural work, lack access to finance, training and decision-making. The Nigerian government prioritises uptake of farmer managed natural regeneration of vegetation and irrigation-free indigenous tree restoration to mitigate climate change and deliver livelihood and poverty reduction benefits to smallholder farming communities.

To inform indigenous tree restoration, this training manual collates best practice guidelines covering the most appropriate approaches to irrigation-free indigenous tree species regeneration across northern Nigeria. It draws on desk-based literature review of material from peer-reviewed literature, alongside reports and experiences from northern Nigeria. The manual was developed during two co-creation workshops held in Kano and Jigawa states in August 2021. Workshops were attended by different stakeholder groups including smallholder farmer and

women's associations, traditional leaders, herbalists, extension workers and policy-makers. The manual was finalised after an expert review workshop held in September 2021, in which the manual's guidelines were reviewed and further validated across stakeholder groups.

Two versions of this manual were produced. This version targets the institutional stakeholders, including donors and international organisations, policy and decision makers, NGOs, universities and research organisations. It includes Annexes summarising the costs and benefits of selected tree restoration practices (Annex I) and the financing mechanisms to support implementation and upscaling of selected practices (Annex II). A shorter, practice-oriented version targeting smallholder farmers, women's groups and extension officers is also available.

1 Introduction

Climate change poses an unprecedented risk to the environment, economy and society, hindering progress towards multiple Sustainable Development Goals (SDGs). Lack of evidence, capacity and awareness of sustainable land management practices limits progress for countries to achieve their Nationally Determined Contributions (NDCs) as well as hampering smallholder and subsistence farmers from growing sufficient, nutritious food.

Northern Nigeria, which includes the states of Kano and Jigawa, is subject to land degradation and desertification, driven by both climate change and unsustainable land use practices. Almost 70% of the population is involved in agriculture, which is the backbone of the regional economy, making this a key barrier to sustainable development. Poverty in the region is the highest in Nigeria, with land degradation exacerbated by migration, conflict and low recognition of the rights and roles of women. Women are disproportionately impacted by poverty and land degradation, given their prominent roles in farming households and the fact that they largely engage in unskilled, labour-intensive agricultural work, lacking access to finance, training and decision-making.

State and national government ministries have identified improved uptake of Farmer Managed Natural Regeneration of Vegetation (FMNR) and irrigation-free indigenous tree restoration, as priorities that will mitigate climate change, accelerate progress towards emissions reduction, and deliver substantial benefits to farming communities: improving yields, diversifying livelihoods, enhancing food security and reducing poverty. Irrigation-free indigenous tree restoration is a novel approach, with substantial additional benefits compared to FMNR. When well-managed, it can help maximise climate change mitigation by, for example, increased tree establishment, improved soil health, enhanced vegetation and soil carbon sequestration. It also offers wider socio-economic and environmental conservation benefits, such as increased yields from food and fodder production, livelihood diversification to smallholders (providing new enterprise opportunities to farmers and marginalised groups, particularly women), provision of habitat and food for wildlife, increased biodiversity and ecosystem function, and increased access to traditional medicines.

This manual presents key steps followed in silvicultural and technical practices for irrigation-free indigenous tree restoration (Section 2), and the opportunities for livelihood diversification and empowerment of

marginalised groups through new products and markets linked to the showcased practices (Section 3). The costs and benefits of selected tree restoration practices, and the financing mechanisms to support implementation and upscaling are presented in Annexes I and II.

2. Silvicultural and management practices for irrigation-free indigenous tree restoration

This section outlines three key steps for irrigation-free indigenous tree restoration in Northern Nigeria (summarised in Figure 1), which can be adapted across local contexts and tailored to the needs of diverse communities managing the trees.

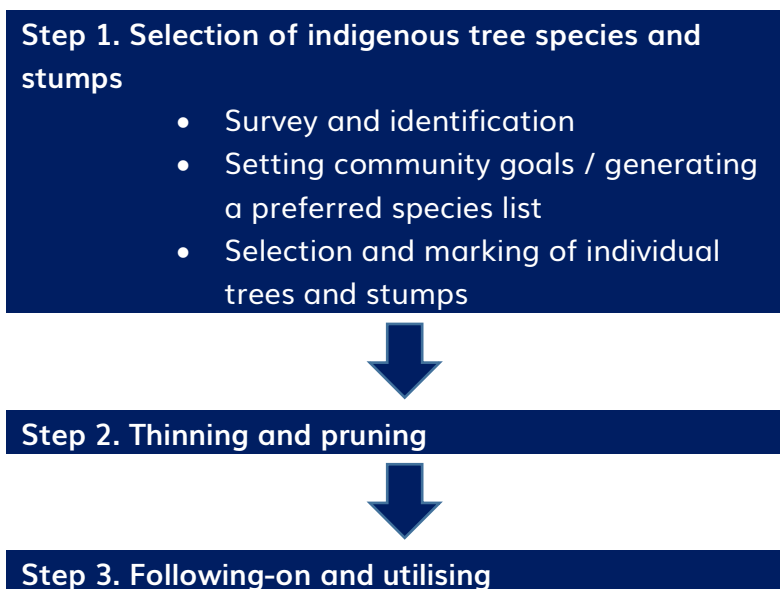


Figure 1. Key steps for irrigation-free indigenous tree restoration in Northern Nigeria.

Step 1. Selection of indigenous tree species and stumps

This first step is undertaken by the smallholder farmer is to decide which and how many tree species and stumps should be regenerated within a site. This is done taking into account the perspectives and needs of the community and disadvantaged groups. Considerations for selection of trees and stumps for restoration include: use values of species (single or multipurpose), quality of

the sprout and other existing growth, crown size of the adult species, conservation status (threatened or endangered), as well as the farm size. It involves the three following sub-steps.

Survey and identification

The farmer starts with a reconnaissance survey of the site to appreciate the tree features of the area (Figure 2). The goal is to determine what and how many tree species are present. Depending on the season, the site might look bare of indigenous trees. However, with advent of the rainy season, the mass of any underground roots will start to sprout.



Figure 2. Surveying for candidate trees at a farm near Bayero University, Kano.

To guide the survey process Table 1 provides a list of the main species found in Kano and Jigawa states from which farmers may select based on their knowledge, preferences, community goals and availability. Knowledge of the names and uses of specific indigenous trees may vary across the community. Consultation with women (who are the repository of extensive botanical knowledge), elders and local experts will be key in surveying the site and identifying the uses to each tree.

Table 1. List of indigenous tree species for regeneration across Kano and Jigawa states, Nigeria, including their geographical presence on the sites, primary uses, and access by women and marginalised groups. Tree species were identified in two co-creation workshops and validated via an expert review workshop.

Botanical names of trees	Tree name in Hausa	Location	Primary uses	Access to trees and products by women and marginalised groups
<i>Acacia nilotica</i>	Bagaruwa	Kano and Jigawa	Land stabilisation/erosion control, gum Arabic, fodder, firewood.	Women are major users of firewood and fodder for livestock.

<i>Adansonia digitata</i>	Kuka	Kano and Jigawa	Food (leaf, pod, seed), medicinal (bark for treatment of pile), root for dyeing, pod used as fuel in rural areas, building material. Aesthetic value.	Women and children are the major users of leaf, pod and bark.
<i>Anogeissus leiocarpus</i>	Marke	Kano and Jigawa	Fuelwood, chewing stick, medicinal.	Women are major users of firewood.
<i>Balanites aegyptiaca</i>	Aduwa	Kano and Jigawa	Medicinal, fruit, firewood, soil stabilisation, soil stabilization, habitat restoration, charcoal, gum and oil.	Firewood is collected by women while fruits are picked by children.

<i>Butyresper mum parkii</i>	Kadanya	Kano and Jigawa	Shea butter, firewood, medicinal, timber and fruits.	Women use firewood and butter for cooking, timber and fodder.
<i>Cassia singuena</i>	Runhu	Jigawa	Medicinal (use by nursing mothers).	Women are major users for traditional child birth.
<i>Ceiba pentendra</i>	Rimi	Jigawa	Fibre and timber, cultural value, medicinal (leaf as aphrodisiac).	Women are major users of fibre to make mattress and pillows.
<i>Faidherbia albida</i>	Gawo	Kano and Jigawa	Land stabilisation / erosion control, fodder, intercropping with food or cash crops.	Women engage in collection and sell of fruits in local markets.

<i>Parkia biglobosa</i>	Dorawa	Kano and Jigawa	Land stabilisation / erosion control, fodder, condiments, firewood, medicinal (bark used for treatment of burns and diarrhoea), nectar and construction.	Women engage in firewood collection and use the seeds to prepare local condiments (Dawadawa in Hausa).
<i>Piliostigma reticulatum</i>	Kalgo	Kano and Jigawa	Food (leaf used for drink), medicinal, erosion control and fodder.	Leaf used by women for the preparation of local drink, seeds for livestock feeds.
<i>Prosopis africana</i>	Kirya	Kano and Jigawa	Erosion control, firewood.	Women fetch firewood for cooking and for craft-making by men.

<i>Tamarindus indica</i>	Tsamiya	Kano and Jigawa	Fruit, fodder, erosion control, nectar, medicinal.	Women are major users of fruits in food preparation.
<i>Ziziphus spina-christii</i>	Kurna	Kano and Jigawa	Fruit, medicinal, construction and fencing material, habitat restoration, livestock feed, fencing material, provide sanctuary for birds.	Children engage in collection and sell of fruits in local markets.

Setting community goals, integrating women's perspectives and generating a preferred species list

After the tree species available on-site have been surveyed, tree selection must be undertaken through consultation between private land owners and the various groups in the community, to ensure that the diversity of local perspectives and needs is taken into account (Figure 3). The restoration of indigenous trees will result in the establishment of alternative livelihoods and increased availability of valuable products, such as fruits and traditional medicines. As noted in the workshops these products are mostly harvested and processed by women. It will therefore be essential that women and marginalised groups are encouraged to take an active role in the consultations, so that they are enabled to influence the selection and make their own choices. For example, according to women's opinions gathered in the Jigawa workshop, it was generally agreed that more of leguminous trees need to be encouraged. The consultation process should lead to the generation of a preferred tree species list, which details the preferred uses of the trees to be regenerated, based on their availability and possible restrictions. As noted in the expert review workshop, after assessing the community preferences, selection of species should also target long-term advantages

related to the trends observed in the markets of specific products derived by each tree. For instance, protecting and restoring shea butter trees (*Butyrespermum parkii*) may generate promising rewards given the current expansion of the global shea butter market.

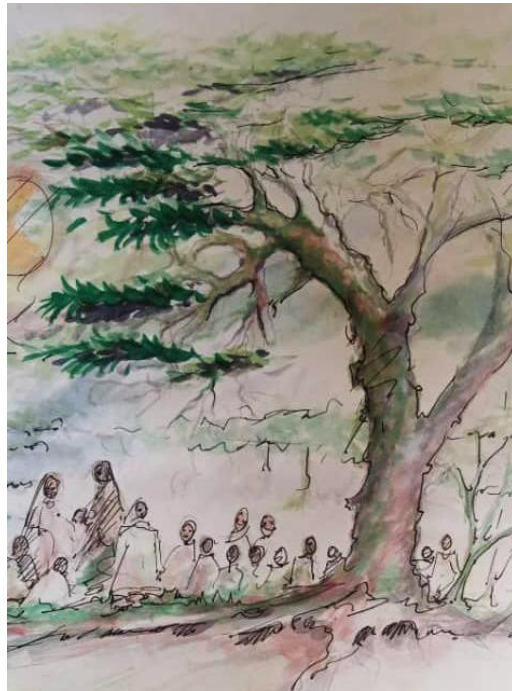


Figure 3. Generating a preferred species list through community consultation in Jigawa. Drawing created by Ms Kaltume Gana: artist, farmer and workshop participant.

Selection and marking of individual trees and stumps

Following the preferred tree species identified by the land owner and community, a number of the tallest and straightest individual stumps to be regenerated and managed should be selected and marked, while the rest should be cut out by pruning. The number of selected tree stumps generally is approximately six to ten per hectare. However, this should be considered as indicative, as the varied cropping systems of individual farmers may allow or higher numbers (Figure 4).



Figure 4. Selecting stands to be thinned at Doka in Tofa Local Government Area, Kano.

Step 2. Thinning and pruning

After the individual stumps have been selected, this step involves cleaning the area around the tree (Figure 5) selecting the unwanted stems and side branches (Figure 6) and remove them to roughly half the height of the stem (Figures 7 and 8).



Figure 5: A farmer clearing the immediate area surrounding a *Pilostigma thoningii* for thinning at a farm in Tofa Local Government Area, Kano.



Figure 6: A farmer selecting the branches to be pruned at his farm in Gwale Local Government Area, Kano.



Figure 1: A farmer removing the unwanted stems from *Acacia nilotica* at Tofa Local Government Area, Kano.



Figure 8. A pruned *Acacia nilotica* at a farm in Tofa Local Government Area, Kano.

A decision is made as to how many stems will be chosen for growth in each stump. As agreed in the workshops, approximately three stems should be kept, while the remaining ones should be culled. This is however a flexible technique, which can be adapted by farmers and communities to meet their own needs. The land users should be free to choose the number of sprouts per stump and per hectare and the method of pruning. For example, in the case of *Piliostigma thoninngii*, in the Jigawa workshop it was noted that only one sprout should be kept. Relying on local knowledge on each

individual tree species is key in ensuring that the adequate approach is undertaken. It is advised to use sharp tools and, preferably, to cut upwards (instead of downward) to minimise damage to the bark and achieve faster recovery.

Step 3. Protecting and utilising

It is noteworthy that in Kano and Jigawa States most indigenous trees are palatable to livestock, and grazing livestock poses the greatest threats to tree regrowth (as well as to mature trees). Communities are first and foremost advised to enact the bylaws and codes of conduct to regulate grazing activities and to control lopping and felling of trees for fodder and/or wood. They are also urged to find means for securing the support and cooperation of migrant (as well as local) pastoralists to facilitate enforcement of the said bylaws.

Stems must be protected while they are growing, and any threats to remaining branches from livestock, fire and competing vegetation should be carefully managed. This can be done by activities such as making fire belts around the site to prevent burning of trees from adjacent wildfires or creating barriers of thorny prunings or live fences around the stems to block livestock. As suggested in both workshops, the use of

cactus and *Jatropha* species is particularly suited for live fencing.

It is important to return regularly, at around every two to six months, to prune sprouts and side branches, so that the selected stumps grow faster and straighter (Figure 9).



Figure 9. New sprouts from a *Pilostigma thoningii* stump at Chai Chai in Ringim Local Government Area, Jigawa.

Side branches can be pruned up to two thirds of the way up the stem once regrowth reaches more than two metres. Depending on the agreed community needs and

management approaches, these practices should be adapted based on what the land users want to achieve. For example, when the trees are grown in conjunction with other agricultural practices (such as agroforestry - see Section 3) more regular pruning might be needed to avoid shading. The Jigawa workshop suggested that it is important to ensure that women are able to make use of non-timber forest products. For example, in addition to utilising the trees for animal fodder, women are typically engaged in a range of livelihood diversification activities through gathering of leaves, fruits and nuts for the uses listed in Table 1 under each tree species.

Based on the planned uses of the trees agreed by the community, trees can be used in the following ways: (i) maintained through pruning, with the trimmings used for fuel wood, fertiliser or fodder, or harvested for fruits, nuts and medicinal products (Figure 10) (ii) harvested entirely and then regenerated from the remaining stumps, or (iii) entirely preserved, without further pruning, if used for forest regeneration.



Figure 10. Tree pruning can be a sustainable way of harvesting fuel wood at Sugungun in Garki Local Government Area, Jigawa.

Each approach and use will generate varied benefits and opportunities to create value and diversify the livelihoods of the private land users and their communities (see Section 3).

BOX 1. Key readings: silvicultural and management practices

Baba Yakubu I. 2020. Training manual on Sustainable Land and Water Management (SLWM) Practices. The Nigeria Erosion and Watershed Management Project (NEWMAP), Kano State office. [Download](#).

Baba Yakubu I. 2020. Promotion of Sustainable Land and Water Management (SLWM) Practices in Tofa, Shanono, Kiru, Takai and Makoda. Kano state Nigeria Erosion and Watershed Management Project (KN-NEWMAP). Final technical report. [Download](#).

Rinaudo T, Muller A, Morris M. 2019. Farmer Managed Natural Regeneration (FMNR) Manual: A resource for project managers, practitioners and all who are interested in better understanding and supporting the FMNR movement. World Vision Australia. [Download](#).

Tukur et al 2013. Indigenous trees inventory and their multipurpose uses in Dutsin-ma area Katsina state. European Scientific Journal 9. [Download](#).

Westerberg V, Doku A, Damnyag L, Kranjac-Berisavljevic G, Owusu S, Jasaw G, Yaboah E, Di Falco S. 2019. Reversing land degradation in drylands: The case for Farmer Managed Natural Regeneration (FMNR) in the Upper West Region of Ghana. Report for the Economics of Land Degradation Initiative in the framework of the "Reversing Land Degradation in Africa by Scaling-up Evergreen Agriculture" project. [Download](#).

3. The multiple benefits of indigenous tree species in agroforestry

Increased tree establishment reduces smallholder farmers' vulnerability to climate-induced risks, as it provides greater resiliency in farming systems, so that the farmers can meet their production needs when faced with extreme weather such as drought or floods. When carefully managed, indigenous tree restoration offers wide socio-economic and environmental conservation benefits. These include increased yields from food and fodder production, livelihood diversification to smallholders by underpinning new enterprise opportunities, provision of habitat and food for wildlife, increased biodiversity and ecosystem function, and increased access to traditional medicines.

The workshops particularly stressed the potential of tree regeneration for income generation and the economic empowerment of women, such as through direct harvesting of non-timber forest products, and the processing of edible fruits, seeds and leaves to produce condiments, beverages and other packaged foods, as well as the production of mats, baskets and twines from tree leaves, (Figure 11). As further noted in the workshops, irrigation-free tree restoration also generates important spiritual co-benefits. According to the Islamic belief, tree nurturing is considered as "Sadaqatul Jariya" (a running charity), meaning that it continuously earns a Muslim heavenly reward as long as he or she lives.



Figure 11. Women transporting the edible fruits harvested from regenerated indigenous trees in Kano. Drawing created by Ms Kaltume Gana: artist, farmer, and workshop participant.

From a mitigation point of view, the workshops noted that the silvicultural practices outlined in Section 2 can help mitigate the effects of climate change in various ways. Trees develop deep roots, reduce surface water flow during the rainy season, and increase groundwater release during the dry season. Compared to annual crops and pastures, trees have higher evapotranspiration rates and are more resistant to droughts and floods. Improved soil health driven by increased indigenous tree establishment contributes to water retention and enhanced soil carbon

sequestration. The approaches described in this manual can therefore be used as valuable tools to help meet future greenhouse gas reduction goals.

The key additional benefits of indigenous tree restoration include the following:

- Aesthetic value / tourism. Establishing plantations of indigenous tree species with an aesthetic value (such as *Adansonia digitata*) may attract tourists;
- Maximising land use values;
- Preventing extinction of indigenous species;
- Boundary line planting land demarcation reduces conflicts about land;
- Improves nitrogen fixation;
- Particularly adapted to farming in extremely desertified settings.

In pursuing socio-economic development goals to achieve the above-mentioned multiple benefits, the silvicultural practices presented in this manual can be successfully combined with other sustainable agricultural practices that go beyond the tree care itself, such as agroforestry, to provide a range of livelihood diversification opportunities and food security for smallholder farmers in Nigeria. Inclusion and equality of women are key components of these

approaches, as rural women will be able to re-establish traditional food systems and diversify their livelihood options, for example by increasing their access to resources such as fuelwood and value products. By enhancing the benefits women, and more broadly the smallholder farming community, get from their labour, and by increasing opportunities to strengthen their control over assets and income-making activities, irrigation-free indigenous tree restoration and other sustainable agricultural practices are valuable empowerment tools.

Agroforestry integrates tree regeneration and management with the development of agricultural systems to diversify production and maximise socio-economic and environmental benefits, such as soil water retention, erosion control, climate change mitigation and adaptation, and biodiversity conservation. The intercropped systems may include annual food crops for household consumption and sale, fodder and livestock breeding, and the production of a range of additional products and services such as timber, construction material, spices, medicinal plants and renewable wood energy. It allows to grow crops that can thrive and yield relatively well even with high water scarcity, for example by planting crops further apart so that more moisture is available for each row,

thereby increasing the likelihood that they will survive a period of drought (Figure 12).



Figure 12. Agronomic crops under *Tamarindus indica* - at Bebeji in Bebeji Local Government Area of Kano

While integrated agroforestry practices can help smallholder farmers, including women and marginalised

groups, to diversify their products, markets and farm income, it must be noted that the impact of agroforestry on such outcomes widely depends on the practices implemented and their interaction with the biophysical and socioeconomic local contexts. The range of sustainable agricultural practices that can be combined with irrigation-free indigenous tree restoration to foster livelihood diversification and value chain development are highly dependent on the site-specific characteristics and the preferences of the land users and their communities. The main steps that need to be considered in the development of an agroforestry system are summarised in Figure 13, while for a detailed description we refer to the key readings listed in Box 2:



Figure 13. Key steps in the development of an agroforestry system coupled with indigenous tree restoration.

BOX 2. Key readings: agroforestry

Hughes K, Morgan S, Baylis K, Oduol J, Smith-Dumont E, Vågen TG, Kegode H. 2020. Assessing the downstream socioeconomic impacts of agroforestry in Kenya. *World Development* 128: 104835. [Download](#).

Pineau W, Adogla-Bessa T, Bakewell-Stone P, Reynolds Barnes A, Tegbe R, Budu-Biney E, Sarkwa F, Amanor I, Amoah J. 2010. *Agroforestry guide. Experiences from farmer trainings in Ghana*. Pro-Natura International. [Download](#).

Smith E, Kuria A, Muthuri C, Kindt R, Sinclair F. 2012. *Agroforestry interventions to reduce sedimentation and improve livelihoods in the Zambian catchment demonstration sites of the Lake Tanganyika*. Kenya: the World Agroforestry Centre. [Download](#).

van Noordwijk M, ed. 2019. *Sustainable development through trees on farms: Agroforestry in its fifth decade*. Indonesia: World Agroforestry (ICRAF). [Download](#).

Annex I. Costs and benefits of selected practices

Monetary considerations are critical in the establishment of indigenous tree restoration and agroforestry systems, as they affect people's motivation to act. In setting the community goals, generating a preferred species list and defining the multiple uses of the selected trees, the smallholder land users should consider whether the species present are of economic value.

The quantification of their economic value, with a view to inform land-use and management decisions, is commonly pursued through application of the Total Economic Value (TEV) approach. This provides the total value of land and land-based ecosystem services as the sum of their use and non-use values. Use values are derived from using land for economic profit and include direct and indirect use. Non-use benefits are not associated with consumption or profit. A summary of the TEV values is provided in Figure 14. For an in-depth understating see the reading list below.

Total Economic Value (TEV) of land and its ecosystems

TEV	USE-VALUE		USE or NON-USE VALUE	NON-USE VALUE		
	Direct	Indirect	Option	Existence	Bequest	Stewardship
	Agricultural production (provisioning); platform for human activities (cultural)	Carbon storage and flood regulation (regulating); nutrient cycling (supporting)	Premium for biodiverse soil as a source of future pharmaceuticals and biochemical (provisioning)	Biodiversity hotspot, symbolic species (cultural)	Land passed onto our children (cultural)	Land maintained in good working conditions for both humans and their surrounding ecosystems

Figure 14. The Total Economic Value (TEV) of land and its ecosystems.

Workshop discussions stressed that there is a high cost-saving potential derived from irrigation-free indigenous tree restoration. The participants unanimously agreed that the irrigation-free approach, when compared to the conventional approach to reforestation and tree restoration, eliminates the need for nursery establishment and maintenance. This results in considerable cost savings for irrigation-free indigenous tree restoration (Table 2 Kano; Table 3: Jigawa).

Table 2. Comparison between the estimated costs of implementing conventional nursery-based restoration and irrigation-free indigenous tree restoration, as identified by workshop participants in Kano.

Restoration task	Estimated cost of conventional nursery-based restoration	Estimated cost of irrigation-free indigenous tree restoration
• Sand provision	₦ 25,000	None
• Manuring	₦ 60,000	None
• Polythene bags	₦ 14,000	None
• Chemicals	₦ 50,000	None
• Watering	₦ 60,000	None
• Management cost	₦ 50,000	₦ 16,000
• Transplanting	₦ 50,000	None
• Ploughing/harrowing	₦ 38,000	None
• Weeding	₦ 30,000	2,500
• Protection	₦ 125,000	₦ 125,000
Total ₦	₦ 502,000	₦ 143,500

Table 3. Comparison between the estimated costs of implementing conventional nursery-based restoration and irrigation-free indigenous tree restoration, as identified by workshop participants in Jigawa.

Restoration task	Estimated cost of conventional nursery-based restoration	Estimated cost of irrigation-free indigenous tree restoration
• Sand provision	₦ 40,000	None
• Manuring	₦ 40,000	None
• Polythene bags	₦ 14,000	None
• Chemicals	₦ 50,000	None
• Watering	₦ 55,000	None
• Management cost	₦ 30,000	₦ 13,000
• Transplanting	₦ 50,000	None
• Ploughing/harrowing	₦ 38,000	None
• Weeding	₦ 25,000	2,000
• Protection	₦ 125,000	₦ 125,000
Total ₦	₦ 467,000	₦ 140,000

Broader studies across sub-Saharan Africa show a clear potential for tree restoration coupled with sustainable farming to generate positive long-term economic

returns. Different plants offer multiple harvests at different times of the year. It was shown that the planting and use of indigenous fruit trees in southern Africa generates economic and livelihood benefits that reduce household vulnerability and widen income generation opportunities. According to the Agroforestry Strategy Framework of South Africa 2017, the use of alley cropping (i.e. the cultivation of food or forage between rows of trees in agroforestry systems) generates an average farm income 12 times superior to the income generated in sole millet systems. It is noted that a 50-80% yield reduction of millet can be derived from the shading from the trees, however the economic yields obtained from the tree products largely outweigh the millet yields penalty.

A study of the downstream socioeconomic impacts of agroforestry in Kenya reports gains in asset accumulation and income from the sale of agroforestry products, with important implications for women empowerment. The increased availability of fuelwood on farm results in reduced time spent by women collecting firewood. It was also found that the agroforestry programme implemented in the country increases asset holdings, particularly among households represented by female participants.

Another study in Ghana on the use of tree restoration techniques aligned with the ones outlined in Section 2 of this manual shows that, when coupled with crop rotation (e.g. in agroforestry systems) the use of these techniques raises smallholder farmers' cropland productivity by 83% in a 5-year timeframe – with crop yields increasing as tree density increases. The payoff period is estimated to 3.3 years, meaning that in the third year the farmers have recovered their additional expense to implement the new practice and can then benefit of higher annual incomes, compared to the income achieved by the farmers who do not implement tree restoration. The study also shows that the implementing farming communities are substantially more food secure and climate resilient as they can harvest a wider range of tree products during the dry season (during which they otherwise would face food shortages). Income diversification helps reducing food insecurity and vulnerability under a changing climate. Finally, the study indicates that substantial improvements in crop revenues are generated when the farmers intercrop with legumes for higher agricultural productivity.

BOX 3. Key readings: costs and benefits of tree restoration and agroforestry, Annex I

- ELD Initiative. 2015. The value of land: Prosperous lands and positive rewards through sustainable land management. Bonn: Gesellschaft für Internationale Zusammenarbeit. [Download](#).
- Emerton L. 2017. Valuing the benefits, costs and impacts of ecosystem-based adaptation measures: A sourcebook of methods for decision-making. Bonn: Gesellschaft für Internationale Zusammenarbeit. [Download](#).
- Hughes K, Morgan S, Baylis K, Oduol J, Smith-Dumont E, Vågen TG, Kegode H. 2020. Assessing the downstream socioeconomic impacts of agroforestry in Kenya. World Development 128: 104835 [Download](#).
- South Africa's Department of Agriculture, Fisheries and Forestry. 2017. Agroforestry strategy framework for South Africa. Scottsville: Institute of Natural Resources NPC. [Download](#).

Westerberg V, Doku A, Damnyag L, Kranjac-Berisavljevic G, Owusu S, Jasaw G, Yaboah E, Di Falco S. 2019. Reversing land degradation in drylands: The case for Farmer Managed Natural Regeneration (FMNR) in the Upper West Region of Ghana. Report for the Economics of Land Degradation Initiative in the framework of the "Reversing Land Degradation in Africa by Scaling-up Evergreen Agriculture" project. [Download](#).

Annex II. Financing mechanisms to support implementation and upscaling of selected practices

The identification of suitable financing mechanisms is key to support implementation and upscaling of irrigation-free tree restoration. A starting point is to link the restoration activities to ongoing global restoration initiatives such as the G20 Global Initiative on Reducing Land Degradation and Enhancing Conservation of Terrestrial Habitats, Bonn Challenge, Global Restoration Initiative, or AFR100 (the African Forest Landscape Restoration Initiative), which can sustain collaborations between donors and the national government to help meet international commitments. Similarly, financing opportunities can be sought by the local land owners to meet global carbon and land restoration goals. However, as noted by workshop participants, the technical capacity to access funding, especially from international sources, is generally lacking. Specialised support is needed to design and submit innovative funding proposal that can meet the donors' criteria.

The list of potential funding sources and mechanisms identified in the workshops is summarised as follows:

- Internal Mechanisms via the Federal Ministry of Environment (e.g. Green Bonds and Ecological Fund);
- National governmental organisations and agencies (e.g. FRIN, NGGW, ADP);
- The Great Green Wall, through NAGGW (Great Green Wall Multi-Actor Accelerator)
- International governmental programmes (e.g. UKPACT, CIDA, USAID);
- Funds operated by the Global Environment Facility (GEF) Under the United Nations Framework Convention on Climate Change (UNFCCC) - including the GEF Trust Fund, the Least Developed Countries Trust Fund (LDCF) and the Special Climate Change Trust Fund (SCCF);
- World Bank Group via the International Finance Corporation (IFC);
- African Development Bank (AfDB);
- United Nations Environment Programme (UNEP);
- International Centre for Research in Agroforestry (ICRAF);
- Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) and Economics of Land Degradation (ELD) initiative;
- Adaptation Fund under the Kyoto Protocol via the UNFCCC;

- Foreign governments – bilateral and multilateral agreements (including economic schemes such as PES, REDD+, subsidy schemes, agro-environmental schemes, and carbon accounting and offsetting)
- National NGOs, farmers associations and youth associations;
- Tax collection: multiple trade organisations and businesses which make use of marketable forest and tree-derived products, i.e.:
 - Wood Cutters Association;
 - Native Doctors Association;
 - Site Renting for Agro Forestry Cultivation;
 - Firewood Sellers Association;
 - Recreational/Event Centres;
 - Forestry Pensioners Association;
 - Seed Multiplication Companies;
 - Agro Products Processing Companies;
 - Food Stuffs Marketers Association e.g. 'Dawanau' Market, Yankaba Market;
 - Commercial Marketers Association e.g. Singer;
 - Zoological Gardens;
 - Forestry Staffs Association;
 - Forestry Student Association;
 - Pharmaceutical Society Of Nigeria;
 - Medical Doctors Association;

- Hunters Association;
- Saw Mills Association;
- Bakeries Association;
- Barbeque (SUYA) Spots;
- Self-Help Groups;
- Philanthropists;
- Tax collection: corporations and government-affiliated entities:
 - Corporations (e.g. banks, telecommunication companies);
 - Oil Companies/ fillings stations;
 - National Union of Road Transport Workers (NURTW), National Association of Road Transport Owners (NATO), Association of Tricycle Operators;
 - Sand, Rock and Coal Miners;
 - Oil Tanker Drivers and other heavy truck drivers associations;
 - Political Office Holders;