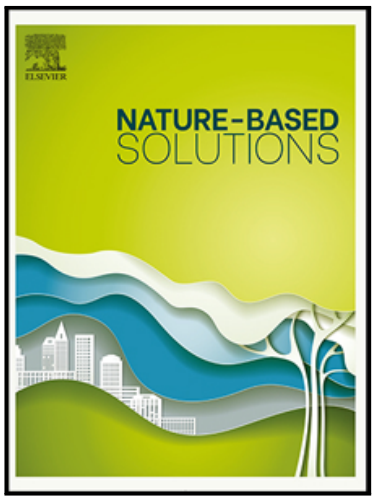
Journal Pre-proof



Unlocking the potential of agroforestry as a Nature-based Solution for localizing Sustainable Development Goals: A case study from a drought-prone region in rural India

Yasmeen Telwala

PII: S2772-4115(22)00037-4
DOI: https://doi.org/10.1016/j.nbsj.2022.100045
Reference: NBSJ 100045

To appear in: *Nature-Based Solutions*

Received date: 14 March 2022
Revised date: 14 November 2022
Accepted date: 30 November 2022

Please cite this article as: Yasmeen Telwala , Unlocking the potential of agroforestry as a Nature-based Solution for localizing Sustainable Development Goals: A case study from a drought-prone region in rural India, *Nature-Based Solutions* (2022), doi: https://doi.org/10.1016/j.nbsj.2022.100045

Unlocking the potential of agroforestry as a Nature-based Solution for localizing Sustainable Development Goals: A case study from a drought-prone region in rural India

Author name: Yasmeen Telwala

Author affiliation: Yasmeen Telwala is a Ph.D. from the University of Delhi in India and has worked with the UN agencies such as UNU, UNCCD, and FAO while supporting developing countries on issues related to land degradation, land tenure, and community-based climate change adaptation. She is currently working as Program Management Officer with the Convention of Migratory Species, UNEP.
Corresponding author: Yasmeen Telwala
E-mail: yasmeentw@gmail.com
Permanent Address: 36 Najampura, Boharwadi, Udaipur, Rajasthan, India 313001

Abstract: Agroforestry enhances farmers' ability to adapt to climate change and delivers multiple ecological, social, and economic benefits. However, scientific evidence linking agroforestry as a Nature-based Solution (NbS) to the achievement of the Sustainable Development Goals (SDGs), and in particular the localization of these goals, is limited. Using a case study from a drought-prone region of southern India, this paper uses a qualitative research methodology to demonstrate how agroforestry offers NbS that localize 10 of the 17 SDG targets. In doing so, it identifies farmers' intrinsic motivations, barriers to the adoption of agroforestry practices as means to adapt to climate hardships, and the role of the carbon market in rewarding environmental stewardship.

This case study focuses on the farmers' narratives, and puts their perspectives at the forefront, emphasizing on basic needs of the poorest of the rural poor, illustrating the "real world" setting of developing countries. The information presented in this paper will be of interest to practitioners, researchers, and policymakers working on community-based NbS in developing countries, as well as those interested in agroforestry as a strategy for advancing the SDGs and its scope under global initiatives as UN Decade for Ecosystem Restoration.

***Keywords*:** Agroforestry, SDGs, Nature-based Solutions (NbS), climate change adaption, small-holding farmers

Introduction

In 2015, the United Nations General Assembly adopted Agenda 2030, with 17 overarching sustainable development goals (SDGs). In 2018, the High-Level Political Forum (HLPF) agreed that for accelerated SDGs implementation, the local dimensions should be prioritized and efforts at the local level should be increased. Based on the concept of localizing SDGs, for developing countries, this will imply identifying and formulating targeted strategies for rural areas that are adapted to cultural context (Oosterhof, 2018).

Based on the Nature-based Solutions (NbS) that are gaining momentum globally to ensure long-term sustainability and their definition adopted by the Fifth Session of the United Nations Environment Assembly (UNEA-5) in March 2022, "actions to protect, conserve, restore, sustainably use and manage natural or modified

terrestrial, freshwater, coastal and marine ecosystems, which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, and resilience and biodiversity benefits.", it is affirmed that interventions at the local level must take into account both ecosystem services and human well-being.

Agroforestry (also known as farm forestry) offers one such cost-effective, long-term strategy practiced in many developing countries (Kumar et al., 2020; van Noordwijk et al., 2020), where societal challenges (such as rural development, poverty alleviation, food security, climate change resilience) and ecosystem needs (such as soil quality, water security, biodiversity) (Magcale-Macandog et al., 2010; Kiptot et al., 2014) converge to create local socio-economic pathways (M Van Noordwijk et al., 2018) while also advancing multiple SDGs (Waldron et al., 2017). The point of action for agroforestry can start from a single farmer's farm and if adopted at a large scale by several farmers, cumulatively it can lead to a landscape transformation (Lasco et al., 2014).

Although agroforestry has been part of the traditional agricultural system, it has seen a decline in recent decades as the focus shifted to the intensification of agriculture for poverty alleviation (Dhyani et al., 2021; Chand et al., 2017; Hazell et al., 2010; Imai et al., 2014). Nonetheless, it is regaining importance as, for example, the United Nations Framework Convention on Climate Change (UNFCCC) and the United Nations Convention to Combat Desertification (UNCCD) have highlighted the importance of agroforestry as a means of reducing the impacts of climate change and achieving land degradation neutrality (Zhongming and Wei, IPCC report, 2019, Gonzalez-Roglich et al., 2019).

Despite the fact that agroforestry creates carbon sinks while improving the environment in agricultural landscapes, it has not received the attention it deserves in local and national policy. For example, the inclusion of agroforestry in India's Nationally Determined Contributions (NDCs) to the UNFCCC can create an additional carbon sink of 2.5 billion to 3 billion tonnes of carbon dioxide equivalent through forest and tree cover by 2030 (Nath et al., 2021). Agroforestry is part of the Green India Mission, one of the eight missions under the National Action Plan on Climate Change (NAPCC). The potential of agroforestry to make a significant contribution to rural livelihoods and the SDGs is not yet sufficiently quantified or appreciated.

For an NbS seeking inclusive rural change, it is crucial to know and understand how to initiate and support community-led change, what works and what makes things work at the local level, but this knowledge is limited (Gosnell et al., 2019; Mbah and East, 2022; Park et al., 2012). This paper is an attempt to fill the knowledge gap

by presenting a micro-level case study from a drought-prone region in India where smallholding farmers are driving landscape change that offers lessons for developing similar strategies at the grassroots level.

The paper is structured as follows. First, there is the socio-economic background of the study area. Second, there is the research design. Third, there are findings along two themes of specific importance, (i) motivation and challenges of farmers, (ii) theoretical construct based on the qualitative synthesis of findings. Finally, there are discussion and conclusion sections capturing lessons for other similar NbS interventions.

1. Socio-economic background of the study area

The twenty villages of Bagepalli and Chintamani taluks in the southern Indian state of Karnataka, where farmers were interviewed for this study, are located in a semi-arid, drought-prone dryland with an average annual rainfall of 598 mm. The majority of families in the villages work as agricultural laborers, while a few own small agricultural plots ranging in size from one to ten hectares. Farmers largely practice rainfed agriculture and generally grow drought-resistant crops such as finger millet, groundnut, pigeon pea, and cowpea. Drip or sprinkler irrigation methods are usually only affordable for relatively wealthy farmers. Farmers are exposed to current climate variability and risk, which is likely to increase due to climate change, as there has been unusually heavy rainfall in 2020-21. The migration of young people to nearby cities is increasing, in part due to the decline of agriculture due to erratic climate patterns.

The village-based self-organization of small farmers is called "Coolie Sangha" with about 30,000 participating families in over 1,000 villages. The innovative idea of guaranteed minimum field labor to prevent seasonal migration of farm workers first emerged in these Coolie Sanghas and was later adopted at the national level in the Mahatma Gandhi National Rural Employment Guarantee Act (MG-NREGA). The locally based NGO called Agricultural Development And Training Society (ADATS) has been working with the Coolie Sangha for forty-four years and has developed an award-winning biogas project, a pro-poor Clean Development Mechanism (CDM) project, and low-carbon emission farming to mitigate climate change.

In the 1990s, the region generally lacked awareness, knowledge, and tools for agroforestry adaptation, as farmers largely focused on growing millet and dryland crops to survive. In 1997, farmers were mobilized by ADATS to convert to agroforestry. More information on the agroforestry project is available in the strategic plan on farm forestry by ADATS[1].

[1] https://adats.com/documents/book5/download/0517.pdf (last accessed in September 2022)

The efforts of farmers, which had begun in 1997, led to the registration of one of the first afforestation/reforestation CDM projects in 2011 with UNFCCC[2]. In 2015, the project was awarded, the Gold Standard. The Gold Standard sets the standard for climate and development interventions to quantify, certify and maximize their impact. All impacts are tracked according to robust monitoring plans, verified by an approved independent third party, and certified by the Gold Standard, which forms the basis of the generation of Verified Emission Reductions (VERs). More recently, ADATS negotiated with private sector organizations for the sale of VERs that wanted to offset their emissions such as FairClimateFund (the Netherlands), PrimaKlima (Germany), NUMERCO (London), Climate Partner. (Germany) and EcoAct (France). A total of 96% of the INR 61.8 million (approx. USD 800,000) received as carbon revenue for the 72,868 gold standards VERs were distributed to the participating farmer families, based on the survival rate of trees on their fields (carbon stock they had sequestrated), as a reward for the environmental service (Source: https://www.fairclimate.com/Projects/Forestry/). The estimates are that 22,800 tCO_2 were sequestered at the end of the 5th year and 5,700 tCO_2 were sequestered per annum (Source: strategic framework). The total number of participating farmers in the program at the beginning of the period of 1997-2000 was 78, and as of December 2021, a total of over 1,352 farmers (33% of which are women) have planted 334,166 trees with around 61% survival rate, in the area spreading across 3,968 acres.

This case study provided a typical success story of how farmers continue agroforestry under dynamic conditions, which would address the research question of how agroforestry supports the localizing of SDGs and the intrinsic motivation for communities to continue. This was considered an interesting case because another researcher (Kattumuri et al. 2017) has already identified agroforestry as one of the possible adaptation strategies to improve climate resilience in the case study region but did not put it in the perspective of NbS and SDGs. The author worked as a program manager for low-carbon emission farming with the Fair Climate Network (a consortium of non-governmental organizations in the region led by ADATS) in 2011-12. This provided additional comparative insights into changes over a decade in the same group of farmers.

2. Research design

The qualitative research was carried out using grounded theory methodology with a focus on understanding the phenomena and potentially creating new knowledge through the construction of theory (Glaser and Strauss, 1967). This methodology consists of flexible strategies to guide qualitative data collection, and, particularly, data analysis

[2] https://cdm.unfccc.int/Projects/DB/DNV-CUK1131002343.1/view?cp=1

tools for studying basic social and social psychological processes in natural settings. The analytical framework used in the paper is summarized in Table 1.

Table 1:Overview of the analytical framework for research.

Step 1	Definition of a research question	Based on a technical review two main research questions were defined: 1. What is farmers' motivation and challenges for the adoption of agroforestry (including the role of the carbon market)? 2. What are the links of agroforestry to SDGs and its localization?
Step 2	Selecting case study	A typical case study was identified that had theoretically useful elements and required scientific references.
Step 3	Data collection	A flexible data collection method using semi-structured interviews was selected to take advantage of emergent themes and unique case features with questions such as: – Who told you to plant trees on your land? – Do you want to have more trees on your land and why? – Will you keep your trees for the long term? – How have these trees changed your life? – How much resource and labor is needed? Forty farmers from twenty villages were interviewed. The experiences of the field staff of ADATS and the four case workers who are directly supporting agroforestry initiatives were noted. Personal interactions were conducted with the senior executive staff of ADATS. All interviews were conducted on-site, and face-to-face in December 2021. This was a perfect year to explore vulnerability because of two additional difficulties, the world faced COVID-19, and farmers in the region faced unusually heavy rains. This provided the author with an additional opportunity to observe and note issues that may be deemed unimportant in the first place or in other regular years. ADATS monitoring database was referred for information such as the year(s) of planting trees, survival rates, the area under agroforestry, land titles of farmers, carbon offset, and carbon credits received by the farmers.

Step 4	Data ordering	Interviews were arrayed chronologically to facilitate data analysis and the examination of processes. Set categories were early adopters (farmers who pioneered agroforestry with their efforts); later adopters (farmers who received augmented support from the afforestation project), and most recent farmers (with access to carbon offset mechanisms) to understand their behavior for adoption.
Step 5	Data analysis	Content analysis of interviews was done and phrases in connection with the motivation and barriers to agroforestry were extracted. Open coding was used to develop categories. The following core categories were formed by selective coding: **Environmental** —Adopted agroforestry as means to fight climate change (droughts in past, recent heavy rain). **Economic** —Agroforestry provided financial security and social respect. —Motivated by additional income from carbon credits. —Limited funds to invest in good seedlings. —Motivated to invest in land improvement. **Attitudinal** —A sense of responsibility for the next generation. —Problem-solving approach. —Willingness to experiment in new ways. —View agroforestry as less labor-intensive.
Step 6	Axial coding	Connections were made between the narratives and the SDG targets. As the data emerged, consistent with grounded theory principles, a theoretical construct was developed to explain stakeholder views from the perspective of the SDGs by organizing a series of short statements linked to the SDGs.
Step 7	Selective coding	A theoretical framework was created by integrating categories. Constructs from the farmer interviews, themes that emerged from the data, aspects of the author's own professional experience with the SDGs, and comparative insights into a decade of change from the author's own field experience working with the same group of farmers in 2010-2011 were extracted as a qualitative synthesis.

Step 8	Links between agroforestry and NbS criteria	To illustrate how agroforestry fits into the concept of NbS, the elements of the case study were compared with the eight IUCN Global Standards for Nature-Based Solutions, 2020 (Andrade et al., 2020) that are: Criterion 1: NbS effectively address societal challenges; Criterion 2: Design of NbS is informed by scale; Criterion 3: NbS result in a net gain to biodiversity and ecosystem integrity; Criterion 4: NbS are economically viable; Criterion 5: NbS are based on inclusive, transparent and empowering governance processes; Criterion 6: NbS equitably balance trade-offs between achievement of their primary goal(s) and the continued provision of multiple benefits; Criterion 7: NbS are managed adaptively, based on evidence; Criterion 8: NbS are sustainable and mainstreamed within an appropriate jurisdictional context.

3. Findings

3.1 Motivation

Security from climate risks is the main motivation for all farmers to plant trees on a piece of land where they otherwise grew only millet. Although all farmers knew about carbon credits, more than 90% of respondents mentioned the non-economic benefits of trees, and only four of the farmers mentioned carbon credits. The intrinsic drive to move to a climate-resilient cropping system is the main factor for success, rather than external factors such as financial support through carbon credits.

The attitudes of the early adopters (champion farmers) and those who consistently sought more trees and acreage for agroforestry over several years demonstrate a high level of environmental stewardship. For the early adopters, their economic concerns were overridden by other concerns and values like protecting the land or the sense of responsibility of the next generation. Early adopters showed a high willingness to change in response to the needs and demands of a changing environment. They strongly believed in their ability to develop response options and to use traditional knowledge and available resources to choose the best course of action in a crisis

The later proponents persevered in their efforts over several years, even though they struggled with water scarcity and soil salinization. Over the years, they did well and helped many trees survive. This is an example of farmers reducing uncertainty over time by gaining experience, modifying the innovation, and becoming more efficient in its application (Mercer et al. 2004). These farmers were more motivated to take on opportunities for

resource gain or protection from resource loss and appreciated the basic support in the form of upfront seedling costs provided by the CDM project.

One of the most salient characteristics is that new farmers are willing to adopt innovative farming practices, such as planting rows of different fruit trees, practicing multi-layer farming methods, introducing new fruit varieties that are in better demand in the market, and integrating existing programs. They are better informed and aware of the benefits and potential of agroforestry. They are more motivated by complementary carbon finance compared to early and later proponents who placed more emphasis on noncarbon benefits of agroforestry, such as fruits for children, fuel for household energy needs and fodder for livestock, income diversification through marketable tree products, erosion control, soil fertility, and improved water and nutrient availability. The early adopters show adaptive behavior and the new farmers show proactive behavior, both of which are key to change and adaptive management to build climate resilience.

Tenure is a critical factor in reaping the long-term benefits of agroforestry systems. Because all farmers in this study operated under secure tenure, they were motivated to make long-term investments. Without exception, all farmers interviewed showed interest in planting more trees if they had more land available, regardless of available resources.

An overview of their perception of resource needs is provided in Table 2.

Table 2: An overview of farmers' perception of the resources needed to grow annual crops and practice agroforestry.

Resource/means	**Grow annual crops**	**Practice agroforestry**
Land	High	Low to high
Labor	High	Low to medium
Inputs	High	Low to medium
Vulnerability to climate change	High	Low to medium
Economic returns	Immediate	Long-term
Most planted trees	With high economic returns (Mango, Tamarind, and Cashew).	
Intercropping	Finger millet or ragi, groundnut, red gram, coriander, and chilies are intercropped to support basic survival.	

3.2. Challenges

In agroforestry, there is a longer time duration after which the economic returns can be obtained as compared to the short return time from agricultural farms, a factor most pertinent to the needs of smallholding farmers who

survive only from agriculture. Limited resources to have irrigation facilities or buy good quality saplings were another constraint for farmers to participate. The small size of the land holdings is another reason why some farmers are unable to spare land for agroforestry establishment even though it promises higher returns in the long term.

Figure 1: Pictures of agricultural fields of some of the farmers interviewed, taken by the author during field visits in December 2021.

In figure 1, pictures of the fields of interviewed farmers are shown. A is the land parcel from a prospective farmer who is willing to plant trees in 2022, B is the land parcel from a farmer who has planted trees in 2019, adopting irrigation technology in the form of drip irrigation and C is the field of a farmer with several mango trees planted as early as 2008. This exemplifies how the transformation of the land use type becomes more multifunctional by consistent efforts in a water-scarce area by smallholder farmers, being supported through carbon initiatives.

3.3. Localization of SDGs

Based on the ideas obtained by the content analysis of interviews and field observations, it has been possible to identify information on 10 of the 17 SDGs. Table 3 summarizes the narratives of selected farmers and interprets how these narratives feed into the goal of localizing the SDGs.

Table 3: Narratives from selected farmers and their interpretation in terms of localization of SDGs

Name/ village/ year (s) of plantation	**Age-group/ Gender (M/F)**	**Selected Farmer's Narrative**	**Interpretation in Terms of Meeting SDGs by Its Localization**
Billur/S. Gangulamma/2009, 2010	60-70yrs (F)	The field is cultivated by an old woman whose son has died, and she is the supporting member of the family including the grandchildren. She has no water source and gets water from a	Carbon credit provides economic security and self-sufficiency to the poorest while contributing to poverty alleviation (**SDG 1 of no**

		nearby lake in the area which is 5 km away from her field. "I will plant more trees this year. The carbon credits bring me economic security."	**poverty and SDG 2 of zero hunger**).
Bommaikal HC /Rathnamma/ 2003	60-70 yrs (F)	"ADATS had advised us at the time to plant trees to combat climate change. Trees would also be a good choice for our old age in case our children can no longer work in the field. My son and husband have passed away. I received carbon credits for planting trees back in 2003 when we had no water and nothing to eat. Today, I feel self-sufficient. I also tell others in the village to plant more trees."	Older women are often at risk of poverty when their household structure changes, especially when their husband dies. Conversion to agroforestry has helped this farmer achieve the SDG goals of healthy aging, gender equality, and women's empowerment **(SDG 1 of no poverty, SDG 3 of good health and well-being, and SDG 5 of gender equality).**
Dodda Kondarahalli/ K.V. Sreenivas/1998, 2008	50-60 yrs (M)	"The mango trees in my field are like an ATM because I can borrow money from other farmers whenever I need it. People easily lend me money because they know I can pay them back by selling my mangoes. These trees have helped me finance my daughter's education, who is now a software engineer. My	An example of how agroforestry helps farmers move from inequality to dignity (**SDG 10 of reduced inequalities and SDG 4 of higher equality education**), especially for a female child. So, the impact is multidimensional and can change generations.

		son works in the village and also works in the field when needed."	
Muddalahalli/Shivshankar reddy/ 2008	40-50yrs (M)	The Chintamani belt was popularly known as "silk and milk". "I had earlier established mulberry plantations for silk cultivation, which could fetch me up to INR 1,00,000-1,200,000 per year. But this was a water-intensive crop and required lots of effort. The well in the field dried up. I have now switched to fruit cultivation. Selling mangoes brings me about INR 1,00,000 per year and the tamarind tree brings me INR 25,000 without any effort."	Farmers are turning away from resource-intensive farming methods. Converting cropland to forests and pastures from open dryland helps achieve land degradation neutrality (**SDG 15 of Life on the Land**).
Muddalahalli/C. Narayanaswamy/2003	40-50yrs (M)	"My son is now a chartered accountant working in Bangalore. With his help, we opened an online platform to sell organic mangoes from our field. Our sales increased during COVID-19, as more people from Bangalore ordered online. We received support from the local mango authority and participated in the organic certification program at the	The next generations of champion farmers are empowered and engaged through education made possible by the economic returns of agroforestry. Youth engagement opens livelihood opportunities and transforms the business model. (**SDG 8 of diversification and innovation, SDG 9 of**

		district level. Online, we sold 3kg boxes between INR 500-700, depending on the mango variety. When we planted the first mango trees in our field, we had no water. You can see the tank provided by ADATS, these first initiatives allowed us to water the trees and let them survive."	**innovation, and SDG 10 of reducing inequality**)
Chinnaganapalli/C.S. Jaganmohan Reddy/2008,2010	40-50yrs (M)	"My father planted over 1000 trees of mango, guava, and mahagony, however, the next year of planting was a severe drought. There was no water for drinking. Under those conditions, we managed to make over 40 mango trees survive. Lots of neem trees and also sandal trees grew on their own after we planted mango trees." There were lots of butterflies and birds in his field. He is a second-generation farmer as his father has pioneered growing trees in 2010. He is pioneering guava cultivation in his village.	The growing number of other trees, after the survival of the mango tree, may have contributed to a better microclimate, and increased biodiversity, which led other trees to grow (**SDG 15, of life on land**). In this process, many trees directly contribute to carbon sequestration (**SDG 13 of climate change**). This is another example of youth engagement is opening opportunities for sustenance, transforming the business model, and preventing migration to cities (**SDG 8 of diversification and innovation, SDG 9 of innovation).**

Iddilavaripalli/ P.S.Reddeppa/2019	30-40 yrs (M)	He is experimenting with papaya and guava as intercrops in conjunction with fish farming. He has planted 6000 papaya trees and about 200 guava trees with his efforts. "I have received the progressive farmer award and would like to present successful examples of agroforestry systems... I am not interested in leaving the village".	Youth is open to innovation and experimentation in agroforestry. New opportunities related to agriculture reconnect youth to the land, prevent youth outmigration, and provide a sense of achievement. **(SDG 8, Diversification and Innovation**). Prevent youth out-migration by promoting sustainable, inclusive, and sustainable economic growth in villages.

Figure 2: Motivated female farmer who joined the agroforestry program in 2019 with young trees, in otherwise saline and degraded soil. She and her sister-in-law, who shares the adjacent plot, put their time and effort into managing these trees.

Figure 3:The motivated young farmer proudly showed his 80 guava trees that he planted for the first time in the village and made a profit of INR 6,000. He is the second generation. His father made the first attempt at agroforestry in 2010. He is motivated to adopt innovative practices and does not want to migrate to a larger city.

4. Theoretical construct based on a qualitative synthesis of findings

The highlights of the synthesis are explained in more detail in this section.

Drivers and pressure of land degradation

The devastating effects of climate change are leading to the failure of conventional subsistence agriculture. This exposes small farmers to disproportionate risk, leading to poverty and out-migration. Some farmers may decide to permanently abandon farming in a drought-affected area leading to overall negative impacts on production, livelihoods, and food security of the most vulnerable populations who rely on agriculture as their main source of livelihood. This "poverty-environment trap" leads to increased environmental degradation to generate more income. The weak or insecure land tenure and property rights could prevent farmers who care about their land from reaping the expected socioeconomic benefits occurring from the land. Limited institutional and policy frameworks at the local level for sustainable land management, especially in response to climate change make things more difficult.

Barriers

Barriers in this case study are considered from two perspectives - barriers to agroforestry adoption and barriers to carbon market access. The main barriers to the adoption of agroforestry include a lack of awareness, knowledge, and tools for the adoption of agroforestry or other climate-smart initiatives. There is a lack of resources to support conversion to agroforestry. For example, farmers lack the money to buy seedlings with good germplasm, build ponds, construct wells to address water scarcity, and protect fields from grazing. Barriers to accessing finance for carbon projects include difficulties in accessing carbon markets due to technical complexity, uncertainty, and cost. High transaction costs make them costly to implement. To achieve spatial scale, it is important to mobilize a large number of smallholders to achieve a sufficient amount of emission reductions to make the project financially viable. The inadequate availability of data and baselines for monitoring is another major challenge to tapping the carbon market.

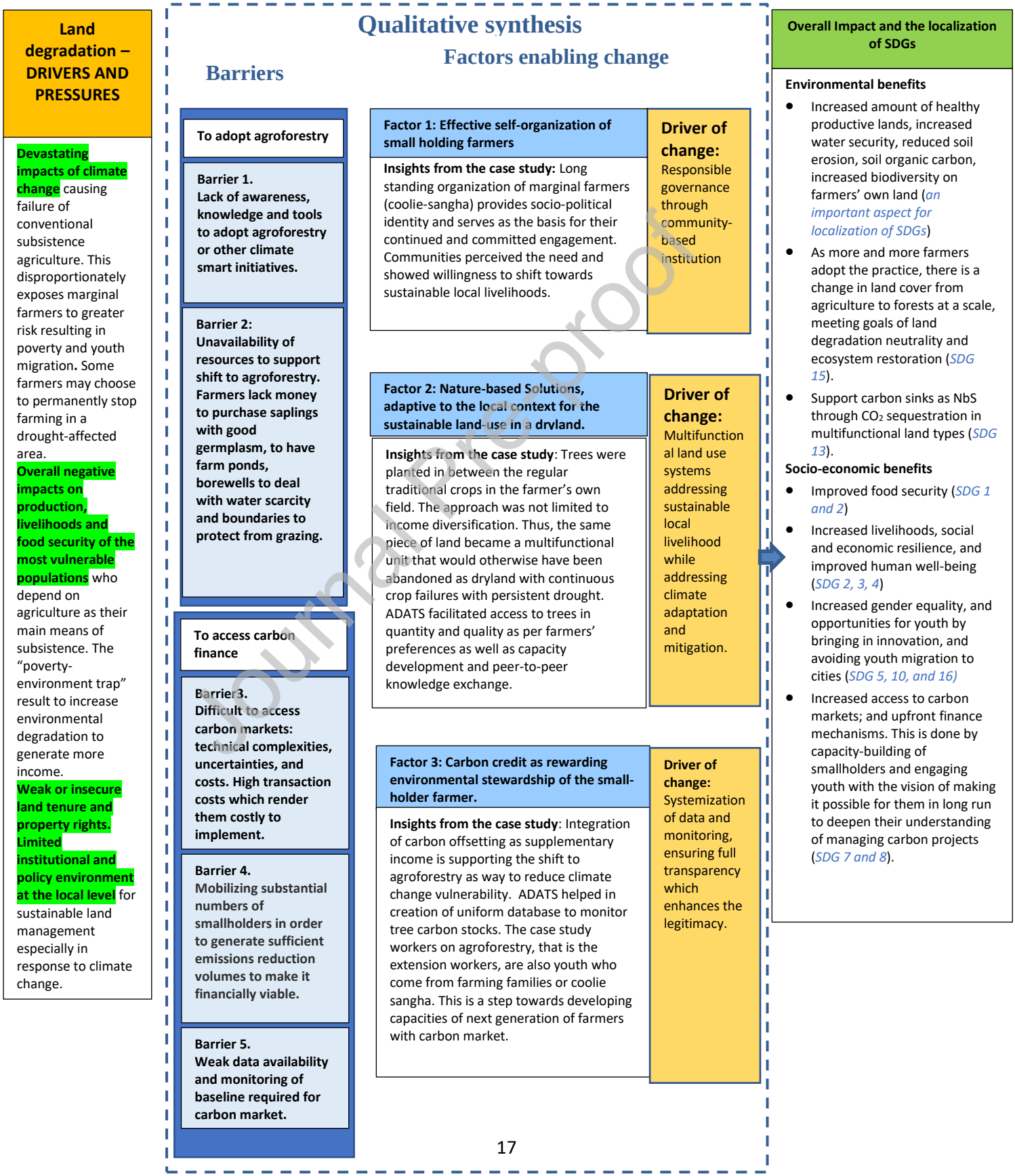
Enabling factors for change

Based on the case study, three factors have been identified that represent a minimum set of critical elements that should be considered in the general planning of similar NbS interventions targeting rural development. First, for community-led initiatives to succeed, governance based on community self-organization has the greatest potential to enable change toward sustainability and inclusiveness. Self-organized institutions provide opportunities for networking and knowledge sharing and help achieve scale. Other stakeholders such as NGOs can provide a support system to strengthen the collective action of these institutions in terms of capacity

building and/or access to finance, e.g., the carbon market. Secondly, flexibility to adapt to the local social and environmental context is needed to take into account the diversity of experiences, traditional knowledge, and changing circumstances. To develop a solution using nature, it is important to have a good understanding of local ecosystems. Conscious efforts to conserve trees on agricultural land are often guided by farmers' traditional knowledge. Third, balance short- and long-term goals. To achieve short-term goals, economic benefits should be considered, and to achieve long-term goals, an integrated, process-oriented model that links motivation and results should be implemented. The systematic technical capacity-building roles performed by NGOs (that are responsive to local needs) for monitoring, and reporting are critical. Enabling the environment through local policies and developing opportunities for community-centered strategies could accelerate the process.

Figure 4 succinctly illustrates the lessons learned from the case study. The comparative assessment of agroforestry with the criteria of the IUCN Global Standard for Nature-Based Solutions (Andrade et al., 2020) is presented in Annex 1.

Figure 4: Qualitative synthesis of lessons learned from case study considering pressure, barriers for land degradation; enabling factors to drive change, and its overall impact on the localization of SDGs



5. Discussion

Why agroforestry as NbS for sustainable and inclusive transformation?

Annex 1 outlines in detail how agroforestry is best suited as NbS. Agroforestry contributes to addressing the most pressing societal challenges in developing countries (such as rural development, poverty alleviation, food security, and climate change), and the interventions are a direct response to the challenges (criterion 1) with significant gains in biodiversity and ecosystems (criterion 3). Community-based approaches to NbS such as agroforestry offer a way to reconcile social development and conservation. Agroforestry is an example of how empowering poor farmers to use their limited resources on their farms in a marginal environment can lead to a transition to a green economy development model. The outcomes for human well-being are aligned with the SDGs and have the potential to lead to transformative change (criteria 6, 8). Actions are based on the traditional knowledge of farmers who demonstrate adaptive management (criterion 7). The use of a community-based governance model helps to achieve spatial scale and address inclusive processes by involving farmers in decision-making processes that affect implementation and policy change (criteria 5, 6, 8). Systematization of data and monitoring is possible, with clearly measurable biodiversity outcomes (criterion 7). Some frameworks can be easily adapted for monitoring purposes. For example, the LDN framework suggests three indicators for monitoring progress: Changes in land cover, changes in soil productivity, and changes in carbon stocks (Cowie et al., 2018). A balance can be struck between farmers' short-term survival and economic benefits from the sale of fruits, timber, and additional income from carbon credits. (criteria 4, 8).

What are the learnings from this case study to inform similar NbS interventions?

The three enabling factors for change presented in Section 4 provide a blueprint for what is critical in the planning, implementation, and success of community-led NbS as agroforestry. The following discussion re-emphasizes important considerations while designing similar NbS interventions at the local level.

According to Feder et al., 1985, the five main determinants that provide a framework for the adoption of agroforestry are preferences, resource endowments, market incentives, biophysical factors, and risk and uncertainty. This case study shows that farmers' problem-solving approach to climate change adaptation is paramount, and their behaviors are driven by their intrinsic drive for change (Jones and Boyd, 2011, van Duinen, 2015). The results suggest that behavioral factors are as important as socioeconomic factors in farmers' adaptive decision-making.

One of the criticisms that agroforestry practices have received over several years is that they are not adopted by poor households, but that higher-income farmers remain the main beneficiaries (Alavalapati et al., 1995). In

contrast, in this case, smallholders show the flexibility and adaptability to evolving with the dynamic resources available to them in the form of policy incentives (some farmers have made the most of the government's MGNREGA program), off-farm opportunities, market situations (e.g., of farmers using the online market to sell mangoes at COVID -19), and carbon payments by finding a balance between their short- and long-term goals. Connections and networks within communities have a significant impact on support, self-organization, knowledge transfer, and resilience in the face of challenges (Sterling et al., 2020). In the case study, the Coolie Sangha was the model of local governance. The social dynamics of the "Coolie Sangha", the demonstrated success of champion farmers, and the adaptability and innovative thinking of the farmers contributed to the adoption of agroforestry throughout the community and transformed the landscape. Although economic factors may play an important role in smallholder decisions, it is the sociocultural processes and internal drive for change in the community that is critical to the continued spread of agroforestry practices across the landscape and cannot be ignored. Based on the value of social learning-oriented approaches, self-governance promises to mobilize other members of the community and achieve scale.

Despite implementation challenges, carbon credits still appear to be a good alternative to reward environmentally conscious actions. Private sector organizations can support farmers through carbon payments, which can help them transition to sustainable and productive practices. Carbon payments can help farmers overcome adoption thresholds caused by market risks. When it comes to the "technical, managerial, and measurable" complexities of the carbon market, the role of trusted local agencies as NGOs becomes critical. It is critical to have trusted liaisons who are responsive to the local context and ensure that revenues reach the true beneficiaries. The model for operating these liaisons should be through institutions managed by farmers, such as the Coolie Sangha in this particular case study. Operation through local institutions that can help achieve scale - another fundamental feature for achieving economically viable carbon offsets.

What is important for localization for SDGs?

Inclusive processes strengthen the legitimacy of the SDGs, which in turn increases the chances of SDG implementation (Jönsson et al., 2021). Our analysis, therefore, suggests that it is possible to fulfill the transformative aspirations of the SDGs by focusing on inclusive localization strategies such as agroforestry. Agroforestry can provide viable utilization and maximization of benefits from otherwise degraded land. However, the ultimate success of localizing the SDGs to achieve national SDGs targets depends on the extent to which local levels of government and other relevant local stakeholders are engaged and more inclusive policies are consistently implemented. The success of localizing the SDGs will depend largely on the extent to which

approaches incorporate both social and environmental dimensions-emphasizing the need for measures of multidimensional well-being (Sterling et al., 2020). Empowering young people through agroforestry provides them with the opportunity to be gainfully employed in their field, rather than migrating to cities or urban centers or working as laborers in the fields of others, which can cause low self-esteem and further marginalization. The adoption of agricultural innovations by youth will lead to long-term equilibrium (Feder et al., 1985). Localizing the SDGs would require transformative development, not a continuation of business as usual. New forms of collaboration among stakeholders (including the private sector and farmers) with long-term commitments should be considered while mainstreaming national green economy strategies.

Agroforestry incorporates pluralistic approaches to land management strategy and has immense potential for restoring ecosystem services (Keesstra et al., 2018). It can be deployed as a strategy to overcome barriers to the inclusive achievement of the SDGs with the principle of "leaving no one behind" by addressing the basic needs of the rural poorest (Gupta et al., 2016; Oosterhof, 2018).

Conclusion

The paper adopts a descriptive and qualitative research approach that is more process-oriented and grounded in a dynamic reality. However, it has its limitations such as subjectivity inherent in the interpretation of interviews, missing perspectives from non-adopters to agroforestry, and limited possibilities to generalize findings. Nevertheless, due to the relative paucity of qualitative research on promoting agroforestry as NbS and its link with the localization of SDGs, this paper aims to enrich our understanding and generate interest, discussion, and refinement by other researchers and practitioners working on NbS for ecosystem restoration.

As NbS aim to address societal challenges with an integrated and sustainable approach, the effective implementation of such an intervention undoubtedly requires dealing with complex human-nature systems. One of the main reasons why agroforestry should be promoted as the NbS approach is that it has immense potential to integrate socio-ecological systems that deal with coupled systems of human adaptation strategy and nature.

It is important to give preference to a process-oriented approach that enables self-organisation, learning and adaptation to increase the chances of success in the dynamic social conditions of developing countries.

The case study provides lessons for other similar community-based NbS as it highlights the underlying factors that led to farmers' transformative adaptation triggered by a crisis (drought) and facilitated by exposure to an alternative pathway (agroforestry). It shows how even in a complex system that requires constant adjustments with limited policy support, smallholder farmers can achieve positive results. The pioneers, as agents of change, set the course, followed by scaling up through the involvement of other community members, which later

includes innovation and its diffusion, with adaptations being iterative. Farmers' adaptive management strategies, based on their wisdom and traditional knowledge, led to systemic change. It is important to empower marginalized and vulnerable communities, especially the youth, to reconnect with traditional knowledge rather than moving away from what they are good at and disconnecting from nature.

Greater collective and coordinated action by smallholder groups through a self-governing institution helped to achieve a spatial dimension required for landscape-scale approaches to integrated natural resource management. The path to conversion was facilitated by the dedicated local NGO that connected farmers to the carbon market and took care of the technical complexities. Economic instruments to reward ecosystem services such as carbon sequestration help sustain enthusiasm and build long-term data capacity. Farmers' intrinsic motivation to pursue more climate-resilient land management had a direct and large impact on their attitude or behavior to shift to agroforestry. This further elucidates links between perceptions of climate change and effective mitigation and adaptation strategies. Local strategies like agroforestry that can lead to long-term sustainable change without depending on the traditional donor development model should be prioritized for true self-sufficiency with a balance between short-term economic benefits and long-term sustainability goals.

Agroforestry should be given higher priority as NbS in policies and programs aimed at ecosystem restoration, land degradation neutrality, and climate change mitigation goals, particularly for developing countries.

Acknowledgement: The author would like to thank all the farmers, field staff and senior management in ADATS for taking the time for interviews, their contributions during the field visits and stimulating discussions for hours. I also gratefully acknowledge the inputs provided by Holger van Gorkum, a volunteer at ADATS, who helped in shaping the document.

Funding: This work was self- financed by the author. ADATS has supported the food and accommodation of author during the month of field visit. The work was undertaken by the researcher during the contract break and the views expressed in this study are those of the author and do not necessarily reflect the views or policies of organization with which the researcher has affiliations as FAO, UNCCD and UNEP.

Disclosure statement: No potential conflict of interest exist to the knowledge of the author.

NBS Impacts and Implications:

This is a case study to support the adoption of agroforestry as a nature-based solution to address climate change adaptation and socio-economic resilience. It discusses the potential of agroforestry in localizing SDGs, inclusive development and throws light on the "real world, which is particularly relevant for developing countries.

References

Alavalapati, J.R.R., Luckert, M.K. & Gill, D.S(1995). Adoption of agroforestry practices: a case study from Andhra Pradesh, India. Agroforest Syst 32, 1–14.

Andrade, A., Cohen-Shacham, E., Dalton, J., Edwards, S., Hessenberger, D., Maginnis, S., ... & Vasseur, L. (2020). IUCN Global Standard for Nature-Based Solutions: a user-friendly framework for the verification, design and scaling up of NbS. *IUCN: Gland, Switzerland*.

Chand, R., Srivastava, S. K., & Singh, J. (2017). Changing the structure of the rural economy of India has implications for employment and growth. *New Delhi, India: National Institution for Transforming India, NITI Aayog*.

Cowie, A. L., Orr, B. J., Sanchez, V. M. C., Chasek, P., Crossman, N. D., Erlewein, A., ... & Welton, S. (2018). Land in balance: The scientific conceptual framework for Land Degradation Neutrality. *Environmental Science & Policy*, *79*, 25-35.

Dhyani, S., Murthy, I. K., Kadaverugu, R., Dasgupta, R., Kumar, M., & Adesh Gadpayle, K. (2021). Agroforestry to achieve global climate adaptation and mitigation targets: Are South Asian countries sufficiently prepared? *Forests*, *12*(3), 303.

Feder, G., Just, R. E., & Zilberman, D. (1985). Adoption of agricultural innovations in developing countries: A survey. *Economic development and cultural change*, *33*(2), 255-298.

Glaser, B., & Strauss, A. L. (1968). The discovery of grounded theory: Strategies for qualitative research. Nursing Research, 17, 377–380.

Gonzalez-Roglich, M., Zvoleff, A., Noon, M., Liniger, H., Fleiner, R., Harari, N., & Garcia, C. (2019). Synergizing global tools to monitor progress towards land degradation neutrality: Trends. Earth and the World Overview of Conservation Approaches and Technologies sustainable land management database. *Environmental Science & Policy*, *93*, 34-42.

Gosnell, H., Gill, N., & Voyer, M. (2019). Transformational adaptation on the farm: Processes of change and persistence in transitions to 'climate-smart'regenerative agriculture. *Global Environmental Change*, *59*, 101965.

Gupta, J., & Vegelin, C. (2016). Sustainable development goals and inclusive development. *International environmental agreements: Politics, law and economics*, *16*(3), 433-448.

Hazell, P., Poulton, C., Wiggins, S., & Dorward, A. (2010). The future of small farms: trajectories and policy priorities. *World development*, *38*(10), 1349-1361.

Imai, K. S., Gaiha, R., & Garbero, A. (2017). Poverty reduction during the rural–urban transformation: Rural development is still more important than urbanisation. *Journal of Policy Modeling*, *39*(6), 963-982.

Jones, L., & Boyd, E. (2011). Exploring social barriers to adaptation: insights from Western Nepal. *Global environmental change*, 21(4), 1262-1274.

Jönsson, K., & Bexell, M. (2021). Localizing the sustainable development goals: the case of Tanzania. *Development Policy Review*, *39*(2), 181-196.

Kattumuri, R., Ravindranath, D., & Esteves, T. (2017). Local adaptation strategies in semi-arid regions: study of two villages in Karnataka, India. Climate and Development, 9(1), 36-49.

Keesstra, S., Nunes, J., Novara, A., Finger, D., Avelar, D., Kalantari, Z., & Cerdà, A. (2018). The superior effect of nature based solutions in land management for enhancing ecosystem services. *Science of the Total Environment*, *610*, 997-1009.

Kiptot, E., Franzel, S., & Degrande, A. (2014). Gender, agroforestry and food security in Africa. *Current Opinion in Environmental Sustainability*, *6*, 104-109.

Kumar, M., & Singh, H. (2020). Agroforestry is a nature-based solution for reducing community dependence on forests to safeguard forests in rainfed areas of India. In *Nature-based Solutions for Resilient Ecosystems and Societies* (pp. 289-306). Springer, Singapore.

Lasco, R. D., Delfino, R. J. P., Catacutan, D. C., Simelton, E. S., & Wilson, D. M. (2014). Climate risk adaptation by smallholder farmers: the roles of trees and agroforestry. *Current Opinion in Environmental Sustainability*, *6*, 83-88.

Magcale-Macandog, D. B., Rañola, F. M., Rañola, R. F., Ani, P. A. B., & Vidal, N. B. (2010). Enhancing the food security of upland farming households through agroforestry in Claveria, Misamis Oriental, Philippines. *Agroforestry systems*, *79*(3), 327-342.

Mbah, M. F., & East, L. A. (2022). How Can "Community Voices" from Qualitative Research Illuminate Our Understanding of the Implementation of the SDGs? A Scoping Review. *Sustainability*, *14*(4), 2136.

Mercer, D. E. (2004). Adoption of agroforestry innovations in the tropics: a review. *Agroforestry systems*, *61*(1), 311-328.

Nath, A. J., Sileshi, G. W., Laskar, S. Y., Pathak, K., Reang, D., Nath, A., & Das, A. K. (2021). Quantifying carbon stocks and sequestration potential in agroforestry systems under divergent management scenarios relevant to India's Nationally Determined Contribution. *Journal of Cleaner Production*, *281*, 124831.

Oosterhof, P. D. (2018). Localizing the sustainable development goals to accelerate the implementation of the 2030 agenda for sustainable development.

Park, S. E., Marshall, N. A., Jakku, E., Dowd, A. M., Howden, S. M., Mendham, E., & Fleming, A. (2012). Informing adaptation responses to climate change through theories of transformation. *Global Environmental Change*, *22*(1), 115-126.

Sterling, E. J., Pascua, P., Sigouin, A., Gazit, N., Mandle, L., Betley, E., ... & McCarter, J. (2020). Creating a space for place and multidimensional well-being: lessons learned from localizing the SDGs. *Sustainability Science*, *15*(4), 1129-1147.

van Duinen, R., Filatova, T., Geurts, P., & van der Veen, A. (2015). Coping with drought risk: empirical analysis of farmers' drought adaptation in the south-west Netherlands. *Regional environmental change*, *15*(6), 1081-1093.

van Noordwijk, M. (2021). Agroforestry-Based ecosystem services: Reconciling values of humans and nature in sustainable development. *Land*, *10*(7), 699.

van Noordwijk, M., Duguma, L. A., Dewi, S., Leimona, B., Catacutan, D. C., Lusiana, B., ... & Minang, P. A. (2018). SDG synergy between agriculture and forestry in the food, energy, water and income nexus: reinventing agroforestry?. *Current opinion in environmental sustainability*, *34*, 33-42.

van Noordwijk, M., Gitz, V., Minang, P. A., Dewi, S., Leimona, B., Duguma, L., ... & Meybeck, A. (2020). People-centric nature-based land restoration through agroforestry: A typology. *Land*, *9*(8), 251.

Waldron, A., Garrity, D., Malhi, Y., Girardin, C., Miller, D. C., & Seddon, N. (2017). Agroforestry can enhance food security while meeting other sustainable development goals. *Tropical Conservation Science*, *10*, 1940082917720667.

Zhongming, Z., & Wei, L. (2019). Climate Change and Land-An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems.