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ABSTRACT

Restoring degraded landscapes is critical for achieving global environmental and development goals, and agroforestry is increasingly promoted as a nature-based solution to land degradation. Farmer-managed natural regeneration (FMNR) is an agroforestry-based approach for restoring degraded agricultural land and it has been widely implemented in African drylands. However, a recent systematic review found significant gaps in the evidence base for FMNR, including that its upscaling has been based on inadequate understandings of local contexts. Furthermore, studies reporting on farmer adoption of FMNR have mainly relied on quantitative data from household surveys, resulting in limited understandings of what motivates farmers who practice FMNR. This paper draws on the results of a qualitative study in northeastern Ghana to address two questions: 1) How and why do farmers practice FMNR? And 2) How does context influence farmers' rationales for practicing FMNR? We found that farmers grounded their perspectives on the utility of FMNR in nuanced understandings of the local farming and land and tree tenure systems. The results of our study also demonstrate how farmers' decision-making was situated within socially and agroecologically differentiated contexts, which were conditioned by long-term, multifaceted change in the region. We conclude that in spite of the rush to scale up FMNR, more attention should be directed to assessing where, when, and for whom FMNR might be appropriate. Such assessments should be grounded in resource managers' preferences, local agricultural and land and tree tenure systems, and the requisite biophysical conditions for FMNR. To support these efforts, we propose an FMNR suitability assessment framework, based on our findings and those from related studies. As landscape restoration is scaled up globally, initiatives should be informed by evidence demonstrating how and why resource managers might practice a restoration activity as well as how context influences their choices.

1. Introduction

Restoring degraded landscapes is critical for achieving climate change mitigation, biodiversity and poverty alleviation goals, and is supported by major international initiatives, such as the UN Decade on Ecosystem Restoration (2021–30). Agroforestry is increasingly promoted as a nature-based solution to land degradation, particularly given its capacity to reconcile agricultural, conservation, and development objectives (IPCC 2019; Plieninger,

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Muñoz-Rojas, Buck, & Scherr, 2020; van Noordwijk et al., 2020). What has been coined "farmer-managed natural regeneration" (FMNR) is a type of agroforestry based on the traditional land management practices of farmers in dryland West Africa. FMNR aims to increase woody vegetation in active agricultural land, inclusive of crop growing and livestock grazing (Chomba, Sinclair, Savadogo, Bourne, & Lohbeck, 2020), through the managed regrowth of trees and shrubs (Haglund, Ndjeunga, Snook, & Pasternak, 2011). It has been widely implemented by NGOs in African drylands (Chomba et al., 2020), which is largely due to its purported role in restoring seven million hectares of agricultural land in semi-arid Niger (Smale, Tappan, & Reij, 2018).

Scaling up landscape restoration requires empirically-based understandings of local contexts (Buck, Scherr, Chami, Goldman, Lawrence, Mecham, Nevers, & Thomas, 2019; Plieninger et al., 2020; Reed et al., 2020), including their social and political dimensions (Chazdon, Wilson, Brondizio, Guariguata, & Herbohn, 2020; Elias et al., 2021, 2022). However, studies on farmer adoption of FMNR have mainly relied on quantitative data from household surveys (e.g. Binam et al., 2015, Iiyama et al., 2017, Moore et al., 2020, Kibru, Husseini, Birhane, Haggar, & Solomon, 2020). This has limited the ability of researchers to understand what motivates farmers who practice FMNR, which perhaps also explains the lack of attention to whether farmers might prefer resource management strategies different from those of NGOs. Furthermore, while there is a strong focus on using FMNR to regreen landscapes (Reij & Winterbottom, 2015), a recent systematic review found that its upscaling has been based on inadequate understandings of local contexts (Chomba et al., 2020), including how land and tree tenure systems influence whether and where farmers practice the technique.

This paper presents the results of a 2019–20 study in northeastern Ghana that sought to address these gaps. Based on the results of our study, which employed qualitative interviews, participant observation, and participatory rural appraisal methods, this paper addresses two questions: 1) How and why do farmers practice FMNR? And 2) How does context influence farmers' rationales for practicing FMNR? The next section reviews the benefits and challenges of FMNR, along with the factors influencing adoption, as identified in the secondary literature. We then describe our study area, focusing on the farming and land and tree tenure systems, before explaining our research methodology. This is followed by a presentation and discussion of our results, which includes consideration of learning outcomes that farmers attributed to the NGO-initiated FMNR intervention. We address where and when, based on the results of our study, FMNR was most suitable in the landscape. We then propose an FMNR suitability assessment framework, based on our findings and those from related studies, which we designed to support project teams in assessing whether FMNR might be effective and scalable in an agricultural landscape. As landscape restoration is scaled up globally, initiatives should be informed by evidence demonstrating how and why local resource managers might practice a restoration activity as well as how context influences their choices.

2. FMNR: history, benefits, and challenges

In the 1980s, an NGO practitioner based in semi-arid Niger formally developed what became termed FMNR into an approach for restoring degraded agricultural land (Tougiani, Guero, & Rinaudo, 2009). FMNR involves selecting, pruning, and protecting plants from re-sprouting rootstock and germinating seeds in the soil (Chomba et al., 2020), with the aim of increasing woody vegetation in active agricultural land (Haglund et al., 2011). Chomba et al. (2020) further add that agricultural land "may be used for growing crops or livestock grazing or both, as often occurs in agropastoral landscapes where livestock roam across crop fields in the off-season" (p. 2). FMNR is promoted as low-cost, easily replicable, and especially suitable for growing indigenous trees in drylands given the low survival rates of planted trees (especially exotic species) in these environments (Duguma, Minang, Aynekulu, Carsan, Nzyoka, Bah, & Jamnadass, 2019; Reij & Garrity, 2016). Like many other types of agroforestry (Nair, Viswanath, & Lubina, 2017), FMNR is based on traditional tree management and farming practices (Rinaudo, 2007; Tougiani et al., 2009), including those in the West African agroforestry parklands (Binam, Place, Djalal, & Kalinganire, 2017; Hansen, Ræbild, & Hansen, 2012), a dryland farming system based on the deliberate retention of scattered trees in continuously cropped fields and long-term fallows (Boffa, 1999; Champion, Fuller, Ozainne, Huysecom, & Mayor, 2021). FMNR therefore shares similarities with other "sustainable land management" approaches such as soil and water conservation practices. These approaches have been modeled on traditional African agricultural practices, many evolving over the course of millenia to address contemporary agroecological and climate-related challenges (Reij, Scoones, & Toulmin, 1996; Richards, 1983; West, Benecky, Karlsson, Reiss, & Moody, 2020).

However, a recent systematic review raises important questions regarding the validity and generalizability of the evidence base for FMNR, highlighting that studies skew towards the Sahelian zone and Niger in particular, and that its scaling up has been inadequately supported by local-level data (Chomba et al., 2020). Alluding to the overwhelmingly positive narrative surrounding FMNR, Chomba et al. (2020) caution against seeing it as a "panacea" for degraded landscapes, underscoring in particular the need for research on how land and tree tenure influence farmers' FMNR decision-making (p. 3). Nonetheless, most research attributes to FMNR an array of environmental, social, and economic benefits, including improved crop yields (Weston, Hong, Kaboré, & Kull, 2015). Several studies link FMNR to on-farm improvements in soil carbon content, reduced soil evapotranspiration, and tree species diversity (Bayala et al., 2020; Larwanou & Saadou, 2011). In Ethiopia and Ghana, where FMNR is implemented to restore degraded woodlands and pasture, researchers identify marked gains in vegetative cover, biodiversity, and poverty alleviation (Brown, Dettmann, Rinaudo, Tefera, & Tofu, 2011; Hagazi, Birhane, & Rinaudo, 2019; Weston, Hong, & Morrison, 2013).

There are some disagreements in the literature regarding how farmers most benefit from FMNR and how best to characterize FMNR adoption. For example, multiple studies report that FMNR leads to higher incomes for farmers due to the increased sales of surplus crops, wood-fuel, and other non-timber forest products (NTFPs) (Binam et al., 2015; Haglund et al., 2011; Weston et al., 2013). However, Weston et al. (2015), based on their social return on investment analysis, report that rather than income or agricultural yields, benefits such as the increased consumption of wild resources and health improvements create the most value for farmers in northeastern Ghana. While most studies report high adoption rates of FMNR by farmers (Ouédraogo, Houessionon, Zougmoré, & Partey, 2019; Westerberg, Doku, Damnyag, Kranjac-Berisavljevic, Owusu, Jasaw, & Di Falco, 2019; Weston et al., 2013), a few point out that testing for adoption is problematic since in many of these study areas farmers have for generations practiced a type of agroforestry that is similar to FMNR (Binam et al., 2017; Hansen et al., 2012). Therefore, Binam et al. (2017), reporting on their multi-country study in the West African Sahel, favor focusing on the degree to which farmers practice the technique; Hansen et al. (2012), based on their findings in northeastern Ghana, suggest considering how to use FMNR to build on the traditional agroforestry practices of farming communities.

A number of studies identify obstacles to FMNR adoption, including the lack of rootstock in farmers' fields (Binam et al., 2017). Iiyama et al. (2017) report on the only study to test for associations between adoption of FMNR and climate, concluding that farmers are probably less likely to use the technique in more temperate climates since growing planted trees is easier in these environments. Several cite the need for changes in statutory policies and institutional arrangements, such as forestry codes and natural resource governance, in order to upscale FMNR (Binam et al., 2017; Iiyama et al., 2017; Reij & Garrity, 2016). Fire is cited as a key obstacle (Chomba et al., 2020), along with traditional land management practices in agropastoral systems, which, due to free range livestock grazing, lead to browsing pressures that inhibit the natural regeneration of woody vegetation (Lohbeck et al., 2020; Sida, Baudron, Deme, Tolera, & Giller, 2018). One study reports that pastoralists inhibit assisted natural regeneration, although it is unclear from the publication whether they interviewed pastoralists or observed their livestock damaging shrubs or trees (Moustapha, Baggnian, Yahaya, & Adam, 2014). While unaddressed in the Chomba et al. (2020) review, certain gaps in knowledge such as why and how farmers might practice FMNR and how context influences FMNR decision-making, reflects the lack of in-depth qualitative case studies.

3. Study context

3.1. The West African agroforestry parklands and northeastern Ghana

For centuries farmers in the West African agroforestry parklands have deliberately retained and managed multi-purpose tree and shrub species in agricultural fields (Boffa 1999, 2015; Lovett & Haq, 2000; Neumann, Kahlheber, & Uebel, 1998). While shifting cultivation was once common, agriculture based on farm-fallow rotations became more prevalent with the decline in availability of unmanaged woodland (Blench, 1999; Shepherd, 1992). Fallows are formerly cultivated plots of land (within or outside of settlements) that farmers deliberately leave uncultivated, primarily for tree crop regeneration, improved soil fertility, and livestock grazing. They are managed for NTFPs such as wood-fuel, construction materials and medicinals, and most natural regeneration of trees and shrubs in the parklands occurs in fallows (Ræbild, Hansen, & Kambou, 2012; Schreckenberg, 1999). Farmers often use fire to clear fallowed land, deliberately retaining the rootstock of preferred species in order to promote the regeneration of shoots (Boffa, 1999). Rather than animal draught or mechanized traction, the handheld hoe—which supports higher on-farm tree density, natural regeneration, and intercropping (Boffa, 1999; Richards, 1983)—was historically relied on for field preparation and maintenance (Boffa, 1999). While pastoralists typically graze livestock in the dry forest and on post-harvest crop residues (Shepherd, 1992), cropland expansion and the decline in fallowing, along with politically mediated decisions resulting in the marginalization of pastoralists—such as state supported large-scale land acquisitions in rangelands—continue to reduce grazing areas across West Africa, leading to tensions between farmers and herders (Brottem & McDonnell, 2020; Krätli & Toulmin, 2020).

Talensi district is part of the Upper East Region, which is located in the dry sub-humid and semi-arid northeast of Ghana (see Fig. 1). The northeast lies within the Guinea and Sudanian savanna zones, where soils are largely shallow and contain low levels of organic matter (Callo-Concha, Gaiser, & Ewert, 2012). Rainfall is unimodal, generally occurring in the May to October period and averaging between 600 and 1200 mm/annum (Callo-Concha et al., 2012). The population in Talensi district is comprised mainly of the Talensi but also the Gurunsi and Nabdam. Together, these three ethnic groups are often called *Frafra*, a referent to their shared ethno-linguistic heritage (Hart, 1971). In contrast to other parts of northern Ghana, population densities in the northeast have been high since at least the 1930s, and the current population of Talensi is 81,194 (Ghana Statistical Service. (2014), 2014). Settlements in the northeast were historically concentrated in upland areas, as endemic *onchocerciasis* (river blindness) in the lowlands meant that alluvial farming practices were based on cycles of settled farming and land abandonment (Hunter, 1966). However, the eradication of *onchocerciasis* from the lowlands in the 1980s led to the expansion of permanent farming as well as artisanal mining, which has rapidly increased as an income generating activity since the 1990s (Wardell, 2005).

Along with artisanal mining, contemporary rural livelihoods in the northeast largely revolve around crop-livestock production, NTFPs, and labor migration to the south of Ghana (Lovett & Phillips, 2018; Wardell, Reenberg, & Tøttrup, 2003). Crop farming in Talensi is mainly rainfed and based on the annual wet-dry season cycle. Planting generally occurs around April-May and harvesting in October, although late season floods around September (including as a result of the annual release of the Bagre Dam in Burkina Faso) can lead to extensive crop damage (Kassim & Alhassan, 2020). Subsistence food crops include millet, sorghum, and maize (Kansanga, Andersen, Atuoye, & Mason-Renton, 2018), and intercropping cereals with legumes such as ground nuts is common (Callo-Concha et al., 2012). Livestock, which are tethered during the wet season to prevent crop damage, range freely during the dry season. During this time farmers harvest manure from their compound fields, which are permanently cultivated lands located around farmers' homesteads (and therefore within settlements), storing the manure inside their compounds in preparation for the next planting season. Pastoralists, who are largely comprised of the Fulani ethnic group, mainly herd the cattle of town-based elites and rural chiefs, accessing pasture in fallows, riparian woodlands, and grasslands which are unsuitable for cultivation (Tonah, 2002; Yembilah & Grant, 2014). Crop farming in Talensi is characterized by the "ring-fenced" system of parkland agriculture, where compound fields are continuously cropped and manured, and "bush fields", which are lands cultivated outside of settlements, receive little to no manure. Bush fields are actively cropped fields but they are managed on a farm-fallow rotational basis, meaning they revert to fallows when farmers decide to temporarily let them rest (Boffa, 1999; Hansen et al., 2012). Farmers also grow crops on riparian plots, along both permanent and dry season river courses, which are irrigated and commonly cultivated in the dry season for vegetables (Callo-Concha et al., 2012; Hansen et al., 2012). While nominally "sedentary", Talensi farmers, somewhat like pastoralists (Scoones, 2020), employ mobility as a livelihood strategy by crop farming one or two bush or riparian fields in addition to their compound fields during the wet season. As farmers often retain cultivation rights to multiple bush fields, they can choose which to farm and which to fallow at the beginning of each cropping season. Mature, natural stands of trees such as *Vitellaria paradoxa* (shea) predominate in compound fields, serving as a demonstration of farmers' historic tree selection preferences (see Table 1) (Boffa, 1999). Bush fields are typified by greater tree density and diversity in species and age (Hansen et al., 2012; Lovett & Haq, 2000).

Like elsewhere in the West African drylands (Toulmin, 2020), agricultural practices in northeastern Ghana have changed significantly in recent decades and many of these changes carry implications for landscape restoration. Fallow periods have declined (Hansen et al., 2012), and many bush fields have been converted to continuously cropped fields (Dietz, Millar, Dittoh, Obeng, & Ofori-Sarpong, 2004), which are increasingly farmed with tractors (Kansanga, Andersen, Kpienbaareh, Mason-Renton, Atuoye, Sano, Antabe, & Luginaah, 2019). Reduced fallowing and NTFP commodi-

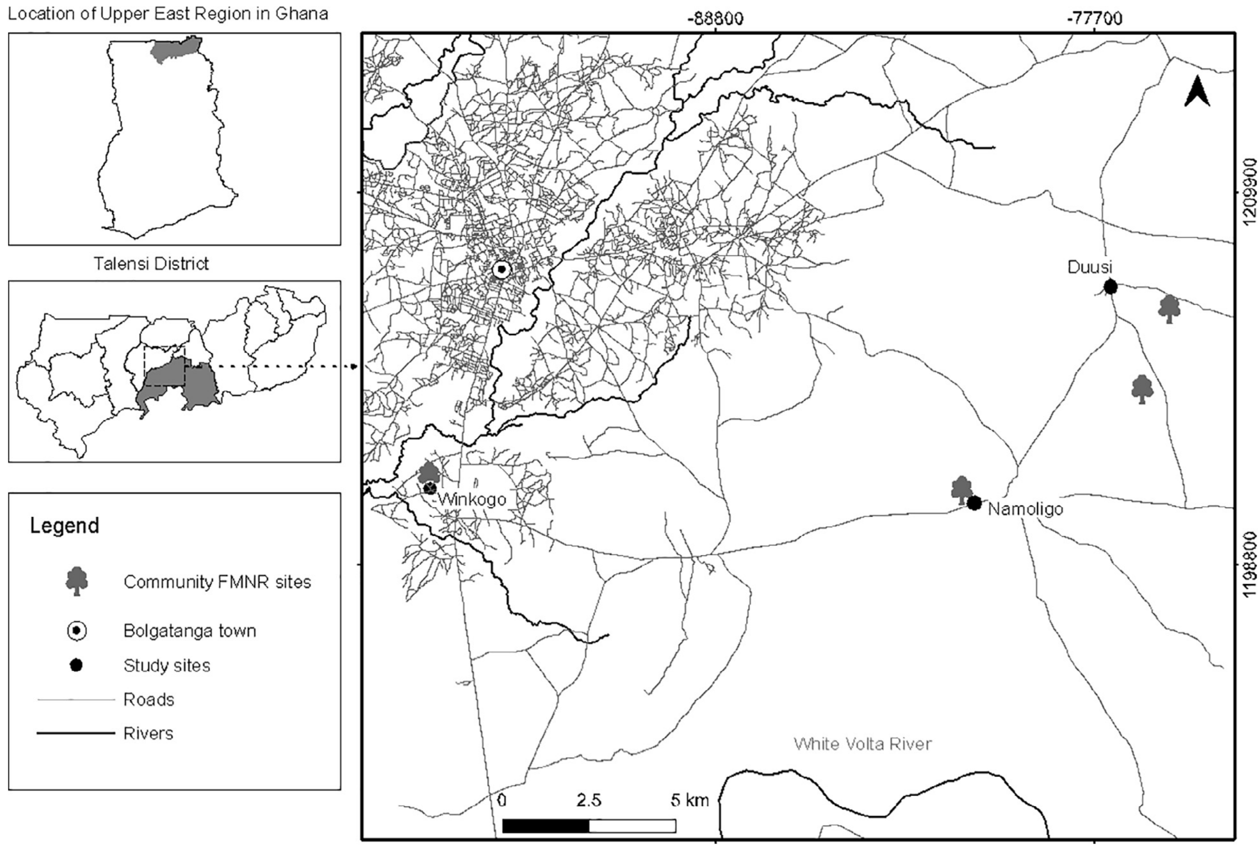

Fig. 1. Map of study site in Talensi district, Upper East Region, Ghana.

tization have especially impacted women given their historic reliance on harvesting shea in fallows, which are generally managed as a common pool resource (Kansanga et al., 2019; Kent, 2018). Once prominent social taboos against planting trees are generally no longer observed and farmers regularly plant exotics such as *Mangifera indica* (mango) around their homestead (Blench, 1999). The cutting of shea and *Pterocarpus erinaceus* (rosewood) for commercial charcoal and timber production, respectively, reflects the rising commoditization of NTFPs in the region (Boffa, 2015; Lovett & Phillips, 2018).

3.2. Land and natural resource governance in the parklands and northeastern Ghana

Rights to trees are often separate from rights to land in customary tenure systems in Africa (Fortmann, 1985), and this influences agricultural land management decision-making. The distribution of tree species within parklands therefore reflects the cumulative land management decision-making of resource managers, as well as how agroecosystems are socially and politically constituted. For instance, local tree tenure systems influence which social groups retain control over specific tree products (Pehou, Djoudi, Vinceti, & Elias, 2020; Rousseau, Gautier, & Wardell, 2017), which in turn may influence whether farmers deliberately retain rootstock and seedlings in their fields (Boffa, 1999; Brottem, 2011; Poudyal, 2011; Schreckenberg, 1999). Tenure systems also condition intra-household decision-making differences between women and men regarding the management of trees on-farm (Elias, 2015; Rousseau et al., 2017).

In rural northeastern Ghana, land is largely governed under customary arrangements, although statutory land laws co-exist with customary tenure (Akaateba, 2019). This legal pluralism, supported by the 1992 Constitution of Ghana, reflects the history of precolonial, colonial, and postcolonial land uses and state processes. For instance, the forest reserves, which the colonial state largely superimposed onto abandoned agricultural lands that had naturally regenerated into savanna woodlands, are often still cultivated by local farmers who negotiate access agreements with forestry officials (Wardell et al., 2003). Similar to its colonial predecessor, the Ghanaian state largely supports the chieftaincy as the customary land authority in Ghana (Boamah, 2014), even though the political systems of many ethnic groups in the north, such as the Talensi, were decentralized and authority over land was based on first clearance and settlement (Millar, 2003). In these acephalous systems, the politico-cultural institution known as the *Tindana*, which is mediated exclusively by the firstcomer lineage of a settlement, is most closely associated with a traditional land authority (Fortes, 1949; Lund, 2008). Since changes to the Constitution of Ghana in 1979 resulted in the transfer of land ownership from the state to traditional authorities, there has been increased conflict between the chieftaincy and *Tindana* over which institution mediates the allodial land title, as the allodial titleholder holds ("owns") the land in trust on behalf of communities (Lund, 2008). Primary usufruct land rights are inherited by men through their patrilineage. Women, who move from their natal area to their husband's homestead upon marriage, acquire secondary rights to land through their husband. Other secondary rightsholders to land include farming migrants, or "latecomers", as well as tenant farmers and sedentarized pastoralists, the latter of whom normally acquire land rights directly from chiefs (Soeters, Weesie, & Zoomers, 2017). Tenant farmers negotiate for cultivation rights to land with the primary usufructuary or allodial rightsholder, and they are generally expected to demonstrate their gratitude by delivering a portion of the harvest to the lessor at the end of the farming season.

Table 1
Common species found in the parkland landscape of the study area.

Family	Scientific (common name)*	Mature life form	Status & Utilization	Regeneration
Malvaceae	*Adansonia digitata* (baobab)	Huge trunk, spreading deciduous tree	High commercial value. Edible leaf, fruit powder, cosmetic seed oil, bark fiber, bee fodder	Seed, transplant wildings
Combretaceae	*Combretum molle* (velvet bushwillow)	Small multi-single stem deciduous tree-shrub	Low commercial value, fire-fuel, poles, bee fodder & medicinal	Seed, coppicing regeneration
Ebenaceae	*Diospyros mespiliformis* (West African ebony)	Med-large multi-single stem evergreen tree	High commercial value. Edible fruit, charcoal, poles, bee fodder & medicinal. Sacred (home of dwarves)	Seed, transplant wildings
Fabaceae	*Faidherbia albida* (apple-ring acacia)	Med-large multi-single stem deciduous tree	High commercial value. Soil improver, animal fodder (leaf & fruit), charcoal, poles, bee fodder & medicinal. Reverse phenology with no leaves in rainy season	Seed, transplant wildings
Moraceae	*Ficus gnaphalocarpa* (sycamore fig)	Med-large trunk evergreen tree	Low commercial value. Animal fodder (leaf & fruit), charcoal, poles & medicinal	Cuttings, transplant wildings
Anacardiaceae	*Lannea microcarpa* (African grape)	Small-med multi-single stem deciduous tree	Medium commercial value. Edible fruit, medicinal, animal fodder (leaf), poles, wood-fuel, bark fiber, bee fodder	Seed (recalcitrant), transplant wildings
Fabaceae	*Parkia biglobosa* (African locust bean)	Med-large multi-single stem deciduous tree	High commercial value. Protein-rich condiment, fruit powder, wood-fuel, soil-improver, medicinal, wall-hardener, bee fodder	Seed, transplant wildings
Fabaceae	*Piliostigma thonningii* (camel's foot)	Small multi-stem evergreen tree-shrub	Low commercial value, food flavoring & packaging, firewood, dyes, apiculture & medicinal	Seed, coppicing regeneration
Sapotaceae	*Vitellaria paradoxa* (shea)	Med-Large multi-single stem deciduous tree	High commercial value. Edible fruit & seed oil (cosmetic), medicinal, wood-fuel, bee fodder	Seed (recalcitrant), transplant wildings

*(Arbonnier, 2004; Boffa, 1999; Hall, O'Brien, & Sinclair, 2002; Sidibe & Williams, 2001).

Aside from specific laws pertaining to the governance of timber trees, statutory law in Ghana has historically been ambiguous on tree tenure and the governance of NTFPs (Ministry of Lands & Resources, 2016), although recently passed legislation, resulting in the formation of a Tree Crops Development Authority, indicates this is changing (Wardell et al., 2019; (Act 1010, 2019)). The very recent commercial interest in rosewood notwithstanding, the northern savanna, in contrast to the temperate forests of the south, was never valued for its timber. Trees remain largely governed–at least in practice–under customary tenure in the northeast. However, the regional changes highlighted above carry specific implications for FMNR.

3.3. FMNR intervention

Since 2009, the international NGO, World Vision, has implemented FMNR in Talensi district. The FMNR projects, which were implemented over a three-year period, supported World Vision's efforts to address land degradation, deforestation, and climate change effects in northern Ghana (World Vision Australia. (2019), 2019). In each FMNR project community, the NGO, in collaboration with lead farmers, selected 20 farmers to serve as volunteers in a Community FMNR group and another 20 to serve in a Fire Volunteer group, which was also tasked with preventing and extinguishing fires in their community (Weston et al., 2013). While sedentary pastoralists lived within or near farming communities, they were not included in the intervention (Weston et al., 2013). A key component of the intervention was establishing community FMNR sites. These were created following an agreement between the NGO and local authorities, including the chief and district assemblyperson, as well as the senior men of a usufructuary household(s) who consented to their household land being converted into a community FMNR site and henceforth governed as a common resource. Based on our observations and the accounts of key informants, the community FMNR sites were generally marginal lands and ranged between 0.4 and 50 ha. Community FMNR and Fire Volunteer group members, who were provided training by the NGO in FMNR techniques such as tree pruning, thinning, weeding, and protection, were instructed to use FMNR on a weekly basis at the community sites in order to promote the regrowth of shrubs and trees, with the aim of transforming them into community forests (Weston et al., 2013). Farmers were expected to replicate these FMNR practices on their cropped fields. All local residents were meant to be allowed to harvest NTFPs from the community FMNR sites and cutting wet or dried trees was prohibited. Additional by-laws in the community, which were created as a result of the NGO intervention, included prohibitions against using fire for any purpose, and fire breaks were created around the community FMNR sites to mitigate dry season fire damage.

4. Methodology

4.1. Study design

The study consisted of three phases of data collection and analysis (see Fig. 2). Results of data analysis from each phase led to strategic refinements in sampling parameters, data collection tools, and lines of enquiry. This iterative, qualitative design supported our aim of addressing gaps in the research literature regarding why and how farmers practice FMNR and how context influences

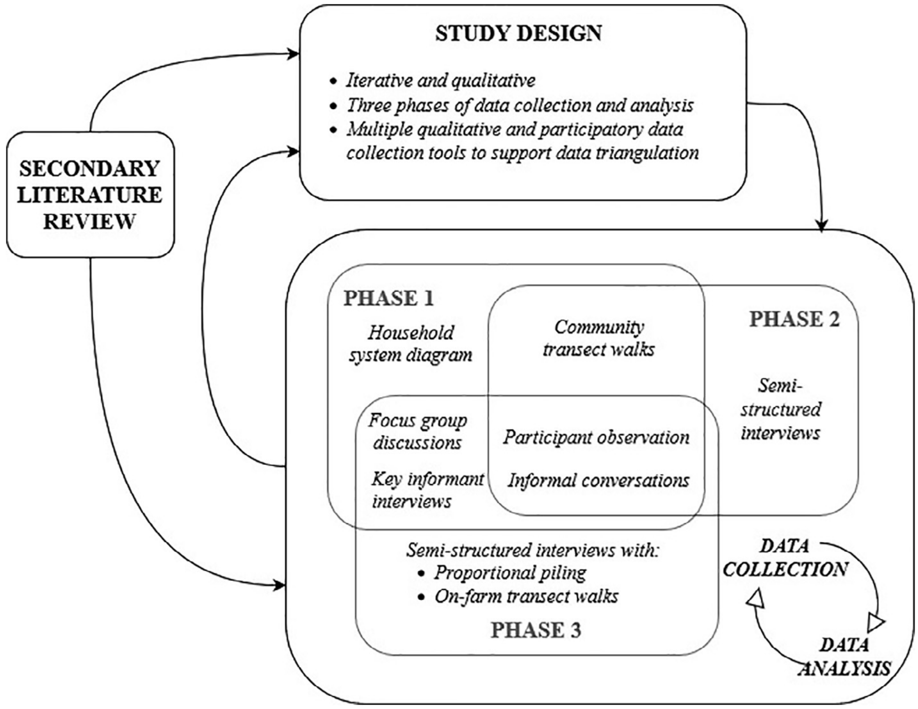

Fig. 2. Schematic representation of our study methodology.

farmers' rationales for using the technique. Our use of multiple qualitative and participatory data collection tools supported data triangulation, which is especially important for qualitative case studies, as this strengthens the internal validity of the evidence base and provides a more robust case for transferability (Pretty, Guijt, Thompson, & Scoones, 1995).

4.2. Site selection

We selected Talensi as the study site because it was the district with the longest history of an FMNR intervention in Ghana. We selected our study communities—Duusi, Namoligo, and Winkogo—based on a) whether an FMNR project was active or had previously been implemented and b) economic and geographic variation in order to ensure that a wide range of farming communities were represented (see Fig. 1). Entry into each community, which were approved by the appropriate traditional authorities, began with a transect walk involving anywhere between 2 and 12 residents. We used the transects as a way to introduce ourselves and the objectives of the study, and to learn from participants about their land and natural resource management practices, local ecological knowledge, livelihoods, and perceptions of land cover and land use change. Each transect included visiting the community FMNR site and, when possible, reaching the highest point of elevation in the community in order to enable unimpeded observations of the landscape.

4.3. Overall sampling strategies and data collection and analysis

Throughout the study we tried to maintain an equal balance between female and male participants. We also tried to ensure representation of young men and women, based on the African Union category of <35 years of age. All focus group discussions in the study were separated into male-only, female-only, and youth-only groups. Community data collection occurred at farmers' and pastoralists' homesteads, in cultivated fields, in fallows, and at community FMNR sites. Given that our methodology involved multiple follow-up engagements with research participants, we made a conscious effort to respect participants' time and obligations, adjusting the length of research protocols when necessary. Throughout the fieldwork each researcher practiced participant observation, based on an ethnographic research approach (Bernard, 2000), which consisted of daily observations and notes on informal conversations held with participants. In addition to being useful for facilitating daily reflection, observations allowed for cross-checking certain data. All data were cumulatively analyzed upon completion of fieldwork, using inductive and deductive approaches, including for assessing how and why farmers practiced FMNR. NVivo 12 was used for analysis of all qualitative data from the study.

4.4. Phase one: Background information and scoping study in one community

In May 2019 we conducted interviews with key informants (n = 23), selected based on their knowledge about landscape restoration initiatives, livelihoods, the local farming system, and land and natural resource management and tenure systems in northern Ghana. Key informants were development practitioners, researchers, and elected officials and civil servants based in Talensi district or the broader area of northern Ghana. We also held a meeting with World Vision at their office in Talensi in order to learn about the aims and scope of the FMNR intervention. We acquired entry into Duusi and conducted focus group discussions (n = 3) using a natural resource mapping protocol, as well as semi-structured interviews with farmers (n = 3) using a household system diagram protocol. We conducted these interviews to develop understandings of land and natural resource management practices, local ecological knowledge, and livelihoods. These data were analyzed inductively to allow for emergent insights. Combined with secondary literature review, the data informed the development of our semi-structured interview protocol, implemented in the second phase of data collection in all three communities.

4.5. Phase two: Semi-structured interviews in three communities

In June-July 2019 we used the semi-structured interview protocol to conduct interviews (n = 78; 42 men and 36 women, of which 13 were youth) with farmers in Duusi, Namoligo, and Winkogo. We included in our sample farmers who were members of their community NGO FMNR and Fire Volunteer groups (n = 47). This included four senior men who allocated household land for the establishment of the community FMNR sites. We also sampled farmers (n = 31) who were not part of their NGO community groups. Given the local farming system (Hansen et al., 2012; Lovett & Phillips, 2018), we assumed it was likely that these farmers, to some degree, engaged in practices similar to FMNR, and we also thought their perspectives on the practice would be less likely influenced by the NGO intervention. These non-members were sampled using a snowballing approach, whereby NGO group members identified non-members in the community. We avoided a clustering bias by ensuring that this sample included people from different areas of communities, including those further removed from primary roads (Catley, Burns, Adebe, & Suji, 2014).

The interviews collected open-ended interview data on topics including agricultural practices, land and tree tenure, and learning outcomes (what farmers felt they had learned) from the FMNR intervention. We asked participants to list, if applicable, any benefits and challenges they experienced from practicing FMNR. We engaged participants in open-ended discussion about what a "restored" environment or landscape might look like to them. We also observed the NGO community groups managing a Duusi community FMNR site in order to learn more about the community FMNR approach employed by the NGO.

These interview data were first analyzed inductively and then deductively for all experienced benefits and challenges. The open-ended benefits and challenges free listed by farmers were counted, ranked, and organized into higher-level conceptual categories in order to facilitate analysis and comparison. These data formed the basis of our proportional piling protocol in phase three.

4.6. Phase three: Participatory rural appraisal exercises and key informant interviews

In January 2020 we collected data using proportional piling, on-farm transect walks, participatory mapping focus groups, and key informant interviews. Proportional piling is based on participants assessing the relative importance of categories by assigning numerical values to each one and then explaining their reasoning behind their choices (Catley et al., 2014). We used the proportional piling method to allow for more in-depth exploration of the motives and decision-making of farmers who practiced FMNR. We used 11 categories in our protocol, of which 10 were the most frequently mentioned benefits by farmers during first round interviews. Using these focal categories supported our aim of grounding our data in farmers' perceptions. We used laminated A4 index cards with images that most closely represented each benefit, and each benefit was translated into Talen, Gurune, and English. The exercise began with the interpreter explaining its purpose and reviewing each benefit, ensuring that participants understood the meaning behind each image. Participants were given 110 beans, 10 for each benefit, and then instructed to distribute beans on the index cards according to their views on the relative value of each benefit. The more beans assigned, the higher the perceived relative value of a benefit (0 was a possible score). Participants were also allowed to propose additional benefits, assigning appropriate values accordingly (but the total allotment of 110 beans did not change). During the exercise, the facilitator engaged participants in open discussion about why they assigned specific values to the respective benefits and challenges. The proportional piling sample (n = 21; 12 men and 9 women, of which 4 were youth) was conducted with 19 participants from phase two and involved two new participants. The sample was evenly distributed across all three communities.

The on-farm transects and participatory mapping focus groups were implemented to validate and enrich our understandings of a) why and how farmers practiced FMNR b) local land and natural resource tenure and management, and c) where within the landscape farmers thought using FMNR to restore agricultural land was most viable. The on-farm transect sample consisted of additional follow-ups with some of the participants (n = 9) from the proportional piling exercise, excluding any informal conversations that were also held with them over the course of fieldwork. We limited the on-farm transects to areas that participants actively cropped and (if applicable) intended to crop in the following farming season. A key finding from the proportional piling exercise was that participants more often practiced FMNR in their bush fields than in their compound fields. Consequently, given its salience as an agroecological setting, "bush field" emerged as a new sampling frame, which led to our decision to conduct three of the transect walks in bush fields. This decision cohered with our qualitative methodology, as social settings are often sampled in order to understand how they might lead to variations in experiences (Crouch & McKenzie, 2006). The participatory mapping focus group discussions (n = 9) were equally distributed across each community. They included some participants from previous data collection exercises but also involved new ones. The key informant interviews (n = 4) were conducted to develop a more in-depth understanding of local land and tree tenure systems and involved the Chief of Winkogo and three senior men, one of whom was from a *Tindana* lineage.

Qualitative data from the proportional piling exercise, on-farm transects, participatory mapping focus groups, and key informant interviews were analyzed inductively to allow for emergent insights as well as to facilitate reflection vis-à-vis previous data collected. Quantitative data from the proportional piling exercise were entered into an MS Excel spreadsheet and first analyzed in pivot tables, later in radar charts, both at aggregate level and then disaggregated by community, gender, generation (youth/adult) and FMNR NGO group member/non-group member.

5. Results and discussion

5.1. How did farmers practice FMNR and were there any learning outcomes from the NGO intervention?

In this section we analyze how farmers practiced FMNR, first considering learning outcomes that farmers attributed to the NGO intervention. We then discuss our findings on community FMNR before addressing how farmers practiced FMNR in their cropped fields. Our results demonstrate that farmers' FMNR practices were socially and agroecologically differentiated and strongly influenced by land and tree tenure and long-term change in the region.

5.1.1. FMNR learning outcomes were differentiated

Since farmers in the agroforestry parklands of West Africa have for generations managed naturally regenerating trees and shrubs in ways that are similar to FMNR (Binam et al., 2017; Hansen et al., 2012), Chomba et al. (2020) conclude that we need to learn more about FMNR adoption outside these countries—a position informing recent research in Tanzania (Moore et al., 2020). However, our results present a more complex picture, with some farmers indicating that they acquired no new knowledge from the intervention, describing traditional tree management techniques which can be classified as FMNR. For example, an older male farmer explained during an on-farm transect how they traditionally pruned branches from species such as *Ficus gnaphalocarpa* (sycamore fig) for fodder. *Combretum molle* (velvet bushwillow) and *Piliostigma thonningii* (camel's foot), which we also observed during on-farm transects, were generally coppiced, with farmers indicating that they used the branches for wood-fuel and the leaves in cooking (see also Boffa, 1999). During an on-farm transect, an older male farmer explained how he transplanted a *Lannea microcarpa* (African grape) seedling (a wilding) to just in front of his home after finding it germinating underneath the crown of a mature *L. microcarpa* located in his compound field. Some farmers also cited preexisting knowledge regarding thinning, weeding, and protecting *in situ* rootstock and germinating seedlings, with an older female farmer explaining that the pruning techniques she used for trees in her bush field prevented livestock damage.

However, other farmers, with variation in age and gender, attributed specific learning outcomes to the NGO intervention, including the following: 1) Enhanced knowledge about the value of integrating non-fruit bearing trees into cropped fields 2) Pruning shoots from re-sprouting rootstock with an upward rather than downward motion in order to prevent damage to the preferred shoot 3) Understanding and experiencing how a higher density of trees can be maintained on farms without resulting in reduced crop yield, and 4) Observations that *Faidherbia albida* (apple-ring acacia), along with other thorny trees, should be retained in fields for their fertilizing benefit (in the past some farmers intentionally cleared all thorny trees when preparing the land). Learning outcomes were not limited to Community FMNR and Fire Volunteer group members. For instance, a young woman in Duusi, who was not a member of either group, reported learning about techniques for pruning by observing group members at a community FMNR site.

Differences in learning demonstrate that farmers possessed varying levels of preexisting knowledge regarding FMNR (or tree management techniques that can be classified as FMNR), suggesting that there was a basis for strengthening the capacity of farmers in how to manage re-sprouting rootstock and germinating seedlings in agricultural fields. However, we also found that differences in learning outcomes were conditioned by local-level power relations and that this led to an inequitable distribution in the benefits of the intervention (see Kandel et al., 2021 for an in-depth assessment of the social equity of FMNR in northeastern Ghana). For instance, in one of our study communities, three adult male research participants, none of whom were Community FMNR or Fire Volunteer group members, felt they were excluded from benefiting from the intervention because they resided in another section of the community. In their views, the section of the community with the community FMNR site tended to capture development resources, despite the fact that they were of the same (firstcomer) lineage as this other section and that natural resources on the community FMNR site were supposed to be accessible to all residents. One of the men attributed this inequity to the chieftaincy being mediated by the other section, suggesting that the chief monopolized development resources to the exclusion of their section, while another man simply cited stronger networks to NGOs and government officials in the other section. This shows how power relations mediate access to development resources (Leach, Mearns, & Scoones, 1999; Mansuri & Rao, 2013), including in landscape restoration contexts (Crossland, Winowiecki, Pagella, Hadgu, & Sinclair, 2018; Elias, Joshi, & Meinzen-Dick, 2021; Reed et al., 2020).

5.1.2. Community FMNR did not align with farmers' perspectives on local resource tenure and management

We found that the NGO's community FMNR model did not fully align with farmers' preferences and the local land and tree tenure system, consequently leading to post-project sustainability issues. In Talensi, traditional land and natural resource governance supported two types of commons: 1) *De jure* commons, which referred to an area of the landscape that was governed, based on customary law (and possibly also with the support of statutory law), for a specific land use, such as grassland within settlements managed exclusively for pasture, and 2) *De facto* commons, which were areas of the landscape that, while not formally governed as a commons, were in practice managed as one, such as in the case of fallows. However, in the case of *de facto* commons, a lineage still maintained customary rights to the land and if a household from the lineage decided to (re)assert their authority and control over the land (such as by cultivating it), the land would then be removed from common resource management. The community FMNR site, though a *de jure* commons according to the agreement between the NGO and community authorities, was still in certain respects managed as lineage land. For example, we found that the households that allocated land for community FMNR retained exclusive rights over the harvesting of shea nuts from their land. Also, some research participants felt they were prohibited from accessing resources on the community FMNR sites because they were not members of the NGO's groups in their community. An evaluation identifies numerous benefits of community FMNR (Weston et al., 2013), and our second phase interviews demonstrated that some farmers perceived benefits of community FMNR, including increased access to fodder for livestock. However, our observational and interview data also demonstrated that the Community FMNR and Fire Volunteer groups were not using FMNR to manage the sites upon completion of the FMNR project, suggesting that participants did not perceive the benefits as outweighing the challenges. The main disincentives to community FMNR cited by participants in second phase interviews were distance to travel to the community FMNR site, time commitment, and not being financially compensated by the NGO for their labor. A young female member of a Community FMNR group specifically cited pressure from her husband (a non-member) to stop participating in community FMNR, as he felt the time commitment was detracting from her household work; he also resented that she was not being financially compensated for her participation.

There is a long history of NGO- and government-supported community woodlots and wood-fuel plantations in northern Ghana, including those which relied on unpaid community labor (Wardell, 2020), and national-level government policies such as the Ghana Forest and Wildlife Policy promote them as ecologically and commercially beneficial (Ministry of Lands & Resources, 2012). However, community woodlots based largely on top-down designs run the risk of creating tensions with local land and tree tenure and natural resource management systems. As explained by a young man from Namoligo and an older man from Duusi (neither of whom were members of their Community FMNR groups), farmers only practiced FMNR if there was an individual incentive to do so. This was lacking in both *de jure* and *de facto* commons due to the perceived risk that one would not be able to ultimately benefit from the investment of their labor in FMNR. This was why FMNR, in their view, was only suitable on household-controlled land under active utilization, a rationale that ran counter to the community FMNR model. This finding illustrates the importance of assessing rights to land and trees in practice rather than simply rights in law (be it customary, statutory, or NGO law—see Meinzen-Dick and Pradhan (2002)), as McLain, Lawry, Guariguata, and Reed (2021) recommend within the context of forest landscape restoration (FLR), an integrated approach to landscape restoration.

5.1.3. Multi-faceted regional change influenced farmers' use of FMNR in cropped fields

While FMNR was inspired by farmers' traditional field-level practices in the West African parklands, we found that long-term agroecological, social, cultural, political, economic, and land use change in the region narrowed the scope for FMNR as a land restoration approach. We also found that how and where farmers used FMNR was socially differentiated, which reflected the autonomy of farmer decision-making—something supported by the NGO and recognized as a fundamental principle of FMNR (Moore et al., 2020; Tougiani et al., 2009)—but also how gender, class, and generation influenced on-farm tree management. For instance, female participants in women- and youth-only focus groups more often underscored the importance of managing the regrowth of shea, specifically, confirming its relatively greater importance to the livelihoods of women in northern Ghana (Kent, 2018). However, we learned from women in Winkogo that they were also interested in planting shea, in addition to *Parkia biglobosa* (African locust bean) and exotics such as mango and *Anacardium occidentale* (cashew). In Talensi, planting indigenous species was historically even less common than planting exotics, and a once influential superstition stipulated that one who plants a tree will die (Hansen et al., 2012). Changing preferences of farmers regarding how to grow trees reflects agroecological and cultural change. Given that the regeneration of shea occurs mainly in fallows (Ræbild et al., 2012; Schreckenberg, 1999), cropland expansion and shortening farm-fallow rotations (Kleemann, Baysal, Bulley, & Fürst, 2017), while not necessarily altering the selection preferences of women, might be creating a context where the growth and management of shea is based on a combination of (assisted) natural regeneration and tree planting, as suggested by Boffa (2015) and Lovett and Phillips (2018).

In contrast to planted trees, selecting and managing naturally regenerating trees and shrubs is contingent upon the presence of rootstock or germinating seeds in the soil (Lohbeck et al., 2020). In open-ended discussions, 13 participants from our community sample cited the absence of rootstock in their compound fields as the main reason why FMNR could not be practiced there. Participants cited more opportunities for practicing FMNR in bush fields, corroborating evidence that natural regeneration is more abundant within a farm-fallow context (Schreckenberg, 1999; Ræbild et al., 2012). The exception to this were large landholders, who, based on our observations, maintained fallows and woodlands around their homestead, creating biophysical scope for FMNR. However, our findings, in contrast to the tentative conclusions drawn by others (Binam et al., 2017; Haglund et al., 2011; Iiyama et al., 2017; Ouédraogo et al., 2019), suggest that these farmers were not necessarily more motivated to practice FMNR than poorer farmers. For example, these relatively wealthier, large landholders were also more likely to possess greater access to capital, making it easier for them to invest in materials and labor for tree planting. This was evidenced by a senior male who had hired laborers—something uncommon for poor farmers in Talensi—to assist him with planting mango trees in a compound field. Also, our interviews with three male large landholders who allocated land for community FMNR suggest that their decisions should be contextualized within their long-term land investment strategies rather than simply as a demonstration of their commitment to the project. For instance, one of the men was also leasing out land to a tree planting project, another was informally leasing out land to artisanal small-scale miners, and another had allocated household land to the government for the construction of a dam, which was located adjacent to bush fields controlled by a lineage from his settlement. These landholders might also have allocated land to acquire social prestige or additional benefits from associating with an intervention—as Kiptot, Hebink, Franzel, and Richards (2007) observe in their study of an agroforestry project in Kenya.

Based on our observations and the perspectives of participants, opportunities for smaller-scale farmers to use FMNR in compound fields were mainly limited to managing germinating seedlings in the soil. However, growing trees from seedlings typically takes longer than from rootstock (Binam et al., 2015), and livestock browsing pressures were cited as a challenge by some participants, specifically with respect to *F. albida*, which provided good fodder for livestock. We observed farmers using three types of protection for seedlings in their compound fields: metal wire fencing, mosquito nets supported by poles, and cement blocks stacked on top of one another in the shape of a ring. However, we only observed these protective measures for trees that farmers had planted, whereas germinating seedlings—such as *F. albida*—were left unprotected. We also more often observed metal wire fencing in the fields of farmers who were beneficiaries of a government-implemented payment for ecosystem services scheme, indicating socially differentiated access to protective materials. Therefore, while there was scope—albeit limited—for FMNR on compound fields, farmers preferred managing the growth of planted trees.

Farmers' use of protective material for trees has possibly increased in recent years but the salience of culturally mediated protection of trees has declined across northern Ghana (Blench, 1999; Hansen et al., 2012), and this has been hastened by the rising commoditization of NTFPs (Boffa, 2015; Lovett & Phillips, 2018). For example, while it was once taboo to cut shea, the cutting and processing of shea for commercial charcoal production threatens its natural regeneration in contemporary northern Ghana (Lovett & Phillips, 2018). We learned that members of a lineage in Duusi once believed they should also never cut *Diospyros mespiliformis* (West African ebony), wet or dried, because of its cultural significance, which derived from its abundance in the landscape at the time of their founding ancestor's settlement. In the view of a senior male from Duusi, those who still observed customary protections of trees, which included the observance of traditional taboos against the use of certain tree products, skewed to older generations as they had largely lost meaning for younger people.

Changes in cultural beliefs regarding trees also facilitated or intersected with political and agroecological changes. This was illustrated by the case of *P. biglobosa*, which farmers and key informants generally identified as disappearing from the landscape. Similar to elsewhere in West Africa (Pehou et al., 2020; Poudyal, 2011; Schreckenberg, 1999), *P. biglobosa*, or specifically its commercially valuable pod, was traditionally controlled by the chieftaincy or *Tindana*. In northern Ghana this has disincentivized farmers from retaining *P. biglobosa* seedlings in their fields, hastening its decline in the landscape (Poudyal, 2011). A male elder of a *Tindana* lineage directly attributed the reduced prevalence of *P. biglobosa* to the decline in the political power of the *Tindana*, a development which he discussed within the context of the rising power of the chieftaincy—an institution he did not consider to be endogenous to the Talensi socio-political system. He also indicated that cropland expansion facilitated the declining numbers of *P. biglobosa* in Talensi, for when he was young, the pods from *P. biglobosa* were mainly harvested in woodlands—areas now largely converted to permanent crop farming.

5.2. Why did farmers practice FMNR?

In this section we analyze why farmers practiced FMNR. Similar to what our research revealed about how farmers practiced FMNR, we found that farmers' motivations for practicing FMNR were socially differentiated. We also learned that farmers rationalized their use of FMNR within the context of the local farming system. We found that farmers considered FMNR most useful during crop field preparation, which underscored the temporal dimension of the land restoration approach.

5.2.1. Farmers' perceptions of the benefits of FMNR were socially differentiated

Similar to many other studies (e.g. Haglund et al., 2011, Weston et al., 2015), we found that farmers identified numerous benefits from practicing FMNR. As shown in the radar chart (Fig. 3), which presents aggregated and gender-disaggregated results from second round interviews using the proportional piling exercise, most of these benefits, such as improved soil fertility and access to fruits, are promoted as reasons for practicing agroforestry. Several of these benefits reflect the participation of farmers in their community NGO groups. Specifically, the categories of "learning outcomes" (see section 5.1.1), "transactional development", and "reduced bush fire" were closely linked to those participants who associated benefits with the NGO intervention. As mentioned above, a key focus of the intervention was the prevention and suppression of fire—natural or anthropogenic. We found that people in Talensi historically used fire for practices such as hunting, harvesting honey, and managing vegetation. Fire was also culturally significant as it featured prominently in at least two of the origin stories of lineages in our study communities. However, farmers in our study generally described fire as less useful for contemporary livelihoods. This in part likely reflects the regional trends of cropland expansion and urbanization (Amanor, 2002), which tend to reduce biomass in landscapes and therefore lead to changes in savanna fire regimes (Laris, Jo, & Wechsler, 2018).

We found that farmers' perceptions regarding the benefits of FMNR were socially differentiated. For example, there were differences between women and men regarding their perceptions of some of the benefits of FMNR (Fig. 3). These differences are consistent with research findings within the ecosystem services literature, which generally finds agreement between men and women regarding "regulating" services (such as "improved rainfall", as represented in Fig. 3) but then divergences regarding "provisioning services", which, as seen in Fig. 3, include improved access to fruit, medicinals, and wood-fuel (Paudyal, Baral, Burkhard, Bhandari, & Keenan, 2015). These differences reflect the gendered division of labor within Talensi, where women were largely responsible for household wood-fuel collection and were also more reliant on generating income from the sale of shea products and other fruits. While men dominated the commercial wood-fuel value chain, they sourced wood-fuel from cut trees such as shea rather than through a managed system of rotational coppicing, as we observed with *C. molle* and *P. thonningii* during on-farm transects. While the gender-disaggregated results in Fig. 3 show a divergence between women and men regarding learning benefits from the intervention, open-ended discussions with female and male participants did not yield data which explained this difference. As there was approximate gender parity in the NGO community groups, and we did not collect data through other protocols showing that women were excluded from accessing capacity strengthening resources from the NGO, this divergence might reflect how the value assigned to learning is gendered due to historical asymmetries in educational resource access.

5.2.2. Farmers decide why and when to use FMNR based on a systems thinking approach

While farmers recognized numerous benefits of FMNR, the proportional piling data analyzed in the radar charts do not fully capture why farmers practiced FMNR. In-depth, open-ended discussion with farmers, on the other hand, which occurred during interviews, focus groups and informal conversations, yielded more robust data on the motivations and aspirations of farmers who practiced FMNR. We found that farmers contextualized their reasons for practicing FMNR within the local farming system. This indicated that farmers adopted a systems thinking approach for assessing why, when, where and how to use FMNR. For example, one of the observations made by the lead author, who facilitated the proportional piling exercise, was that farmers were struggling with individually scoring benefits and then explaining why they assigned these scores without also referencing other perceived benefits. A senior male from Namoligo attempted to resolve this tension by proposing another benefit which we coded as "interrelated benefits", as he highlighted how improved soil fertility, rainfall, and access to medicinals and fodder for livestock needed to be understood as integrated. A young woman from Namoligo underscored the temporal and spatial dimensions of FMNR when explaining that the practice, though time consuming, was most relevant in the bush fields. She considered FMNR, as a practice, to be most applicable when preparing the field for cropping, underscoring the time it took to select and manage woody vegetation in the field prior to planting. A young male farmer from Duusi similarly classified FMNR as most applicable during crop field preparation, indicating that this was when he decided which shrubs to manage, pruning those he selectively retained in his field. Open-ended discussions with farmers on how they visualized a "restored" environment also often circled back to crop farming, which provided the context through which participants understood restoration benefits such as increased tree coverage.

The holistic systems thinking approach employed by farmers in our study has been widely observed elsewhere (Agrawal, 2002; Carney, 1991; Duvall, 2008; Sinclair & Walker, 1998). Narrowly concentrating on the specific benefits of FMNR for farmers—as is the case with most studies on FMNR— or abstract narratives around restoring trees to a landscape, demonstrates an underappreciation of the place-based, culturally-situated, experiential learning of farmers (Flachs & Richards, 2018; Netting, 1993; Vanclay, 2004). Such narrow or abstract concentrations also risk disempowering farmers engaged in restoration by fundamentally prioritizing scientific rationales (Reed et al., 2020; Ros-Tonen, Van Leynseele, Laven, & Sunderland, 2018)—a risk underscored in climate change adaptation research as well (Eriksen et al., 2021; Klenk, Fiume, Meehan, & Gibbes, 2017; Nightingale et al., 2020). In many African smallholder communities, farming practices carry meaning beyond the strictly agricultural context since they (re)affirm sociocultural and political institutions—such as marriage and kinship—over the course of decades (Peters, 2019; Richards, 2018). Employing ethnographic approaches (Flachs & Richards, 2018; Kiptot et al., 2007), including when triangulated with methods such as participatory research techniques (Apgar, Allen, Moore, & Ataria, 2015), provides greater scope for learning about why and how different farmers, in different contexts, may decide to engage in restoration practices such as FMNR.

5.2.3. Where and when was FMNR most suitable in the landscape?

The diagrams in Figs. 4 and 5 visualize where and when, based on the results of our study, FMNR was most suitable in the landscape. Fig. 4, which represents the spatial dynamics of FMNR, demonstrates that FMNR was most suitable on bush fields, where it could be used by farmers to manage shoots from re-sprouting rootstock or germinating seedlings. Due to the local land and tree tenure system, we found that farmers were most likely to use FMNR on household-controlled bush fields, where they generally retained control over land use decision-making and commercially valuable NTFPs. Fig. 5, which represents the temporal dimensions of FMNR, illustrates that farmers make their most important FMNR decisions when preparing their bush fields for cropping. The figure also shows how FMNR depends on the fallowing component of the local farming system, as there must be *in situ* re-sprouting rootstock or germinating seedlings for farmers to manage. Although fallow periods have declined in Talensi, fallowing is still widely practiced, including for periods over 10 years (see also Hansen et al., 2012), and it is fallowing which allows for natural regenera-

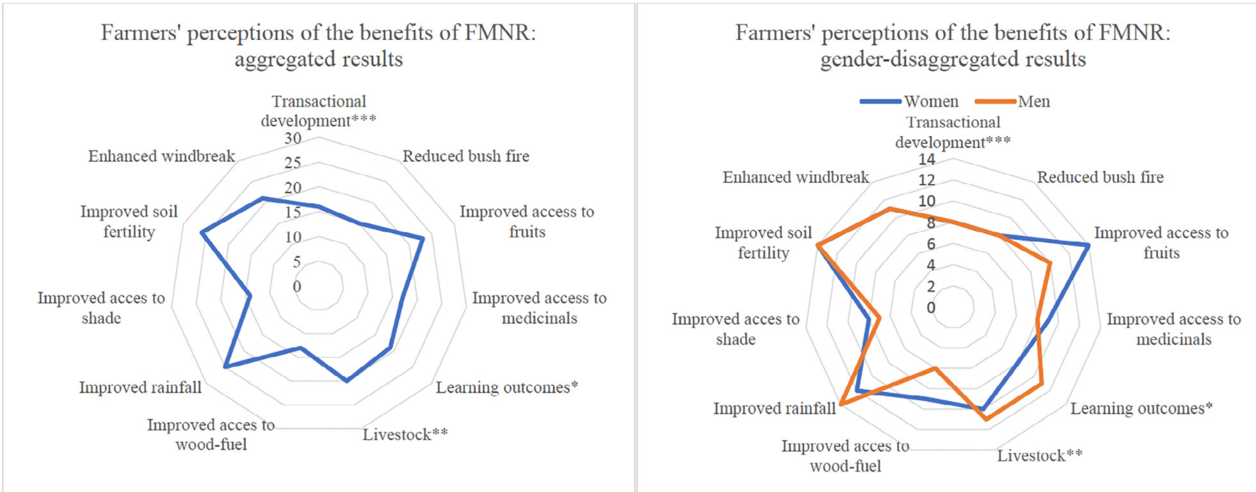

Fig. 3. Aggregated and gender-disaggregated results of farmers' perceptions of the benefits of FMNR, based on their scoring of 11 focal categories during third-phase proportional piling interviews. Each of these categories of benefits derived from second phase interviews, which asked participants to list any benefits they perceived of FMNR. *Learning outcomes: Learning outcomes attributed to the FMNR intervention. See section 5.1.1. **Livestock: This included improved access to fodder and shade for livestock; improved conditions of sites where livestock reproduce; and reduced theft of and attacks against livestock. ***Transactional development: Benefits mentioned by farmers that were directly tied to subsidies or training provided by the NGO but were unrelated to the assisted natural regeneration of trees and shrubs. These included, for instance, the provisioning of livestock, seeds, and waterproof boots. Kiptot et al. (2007) use the term "pseudo-adopters" to classify farmers who adopt a practice mainly to acquire inputs, financial benefits, credit or social prestige.

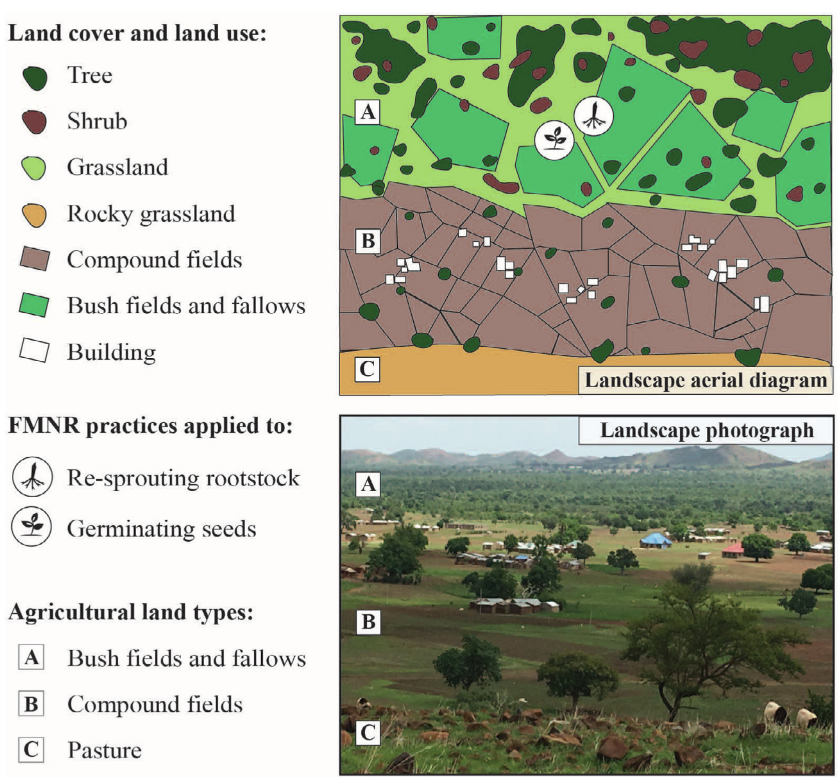

Fig. 4. The landscape of our study area, including dominant agricultural land types and identification of where FMNR, based on the results of our study, was most suitable (bush fields). See Section 3.1 for a full characterization of agricultural land types and practices, but, in brief: compound fields are permanently cultivated fields located around farmers' homesteads (and within settlements); bush fields are fields cultivated outside settlements; fallows are temporarily uncultivated fields, located within or outside settlements, supporting tree crop regeneration, improved soil fertility, and livestock grazing; and pasture are fallow lands and lands deemed unsuitable for crop farming, which are located within or outside settlements.

tion and, consequently, the possibility of FMNR. Viewed together, Figs. 4 and 5 underscore the mosaic of spatially and temporally differentiated land uses in our study area, including crop-livestock interactions and NTFP harvesting, demonstrating how the utility of FMNR, in the views of farmers, were grounded in the local farming and land and tree tenure systems.

Our findings align us most closely with Hansen et al. (2012) and Binam et al. (2017), who highlight the importance of bush fields and fallows for FMNR, and frame FMNR as an opportunity to build on the traditional agroforestry practices of farmers. We found that farmers were either not motivated to use FMNR in their compound fields or they preferred investing their limited capital in protective

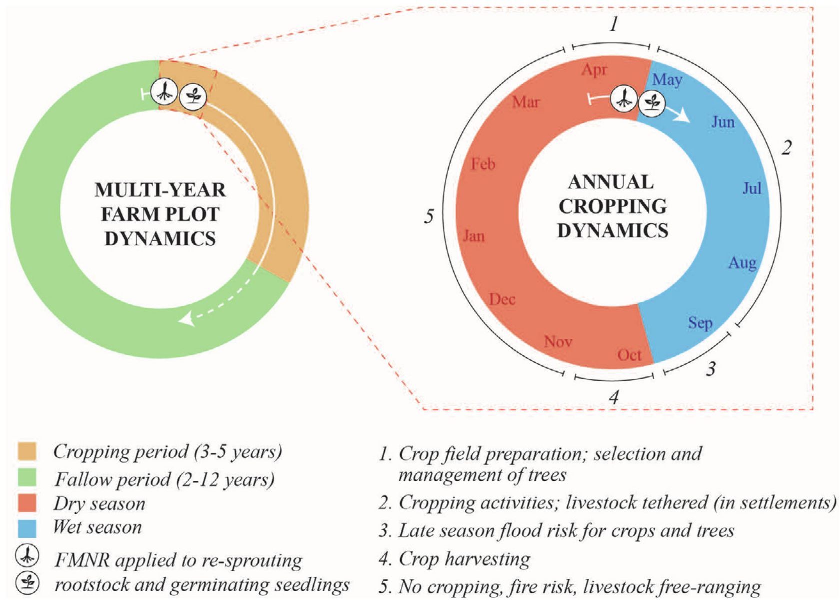

Fig. 5. Temporal dimensions of FMNR in our study area. The annual cropping dynamics diagram indicates that farmers make their most important FMNR decisions during crop field preparation. The multi-year farm plot dynamics diagram demonstrates that the fallowing component of the local farming system is necessary for supporting the possibility of FMNR.

materials for commercially valuable planted trees (exotics and indigenous). In contrast to other studies (Haglund et al., 2011, Binam et al., 2017, Iiyama et al., 2017; Ouédraogo et al., 2019), our results make us skeptical that large landholders, despite possessing the biophysical scope for FMNR in their compound fields, would likely practice FMNR. Our study's findings suggest that farmers who maintained access to smaller compound fields, and who therefore relied on their mobility to manage multiple, geographically discrete fields during the wet season (including most importantly bush fields), were the most appropriate stakeholders for FMNR project teams to engage. However, some farmers might benefit more from FMNR than others, particularly when tree tenure systems disadvantage social groups such as women, younger people, and migrant farmers (Boffa, 1999; Kandel et al., 2021).

Iiyama et al. (2017) found that climate influences whether farmers decide to grow trees using FMNR techniques or through planting. It is possible that farmers in our study generally preferred growing commercially valuable planted trees because it is relatively easier in Guinea and Sudanian savannas than in the Sahelian savanna zone, where FMNR has been shown to be most successful (Reij & Garrity, 2016; Smale et al., 2018). However, we are cautious in interpreting the potential long-term influence of climate on FMNR practices in our study area, as climate change projections in West Africa are affected by large uncertainties and show contrasting, but still physically-plausible, scenarios (Amanambu et al., 2019; Dosio et al., 2020). While temperature is projected to increase across West Africa, the projection of moisture exchange between the Gulf of Guinea and the Sahel region is affected by large uncertainties which are reflected in the projection of monsoonal precipitation. Precipitation projections show contrasting trends in both the projected mean precipitation during the whole rainy season and precipitation frequency and intensity, particularly in the early phase of the rainy season. The response of vegetation (both crops and trees) to these changes in climate is difficult to anticipate, as it is complex to model and highly nonlinear (e.g., Adjonou et al., 2020, Sultan, Defrance, & Iizumi, 2019, Sultan & Gaetani, 2016). Ultimately, climate is only one of many variables affecting resource manager decision-making and it intersects with a host of other contextual factors, including land and tree tenure (Toulmin & Brock, 2016). Furthermore, climate-related narratives–such as 'desertification'--have historically misinformed policies and marginalized local resource managers in dryland West Africa (Behnke & Mortimore, 2016; Wardell, 2020), so additional caution is warranted when interpreting the influence of climate for policy.

A limitation to these diagrams (Figs. 4 and 5) is that they do not capture pastoralists' perspectives on where and when (or whether) FMNR was suitable in the landscape, as we collected limited interview data from pastoralists and key informants with knowledge about mobile herding practices in the region. Given that FMNR is largely implemented in agropastoral areas (Chomba et al., 2020), future research should prioritize the perspectives of pastoralists, especially since there is a lack of thinking about FMNR within an agrosilvopastoral context (but see Tougiani et al., 2009, Sendzimir, Reij, & Magnuszewski, 2011). Another limitation to Fig. 4 is that riparian forest, an important land class in northeastern Ghana (Wardell et al., 2003), is not represented since we did not conduct fieldwork in this vegetation type. However, remotely sensed data analysis (Wardell et al., 2003), combined with insights from interviews we conducted with two pastoralists who were familiar with riparian forests, indicate that even though croplands were expanding, there was still dense vegetation in these areas (but see Lovett and Phillips (2018) on how commercial harvesting of rosewood and other hardwood species for timber and wood-fuel, along with seasonal riverbank farming, is leading to riparian deforestation in northern Ghana). This suggests that in riparian forest, like in bush fields, there was greater biophysical scope for FMNR. Nonetheless, riparian forests tenure regimes were characterized by complex interactions between statutory law, customary tenure, and informally negotiated agreements between farmers and forestry officials (Ministry of Lands & Resources, 2016; Ministry of Water Resources, 2013; Wardell, 2005). Further research would be needed to assess whether resource managers perceive FMNR as suitable for this part of the landscape.

6. A framework for assessing the suitability of FMNR in an agricultural landscape

Despite the strong focus on scaling up FMNR (Reij & Winterbottom, 2015), FMNR is not a "panacea" for degraded landscapes (Chomba et al., 2020, p. 3), as other restoration practices, agroforestry-based or otherwise, might be more appropriate depending on context. Therefore, any upscaling of FMNR should be evidence driven (Chomba et al., 2020; Lohbeck et al., 2020) and grounded in empirically-based understandings of local contexts, which should include attention to social and political dimensions (Chazdon et al., 2020; Elias et al., 2021). Table 2 presents an FMNR suitability assessment framework which is intended to support project teams in determining whether FMNR might be effective and scalable in an agricultural landscape. The framework reflects a key conclusion of our study: assessing the suitability of FMNR in a landscape requires understanding whether resource managers' preferences, the local agricultural system, land and tree tenure systems, and biophysical conditions enable or constrain FMNR; and how these enabling or constraining factors have changed over time, how they might change in the future, and how they might have created specific knowledge and skills gaps amongst resource managers. As power and politics shape landscape restoration (Chazdon et al., 2020; Elias et al., 2021; Reed et al., 2020), the framework recognizes the potential for socially differentiated intervention outcomes as well as inequities in decision-making—the "procedural" dimension in environmental justice frameworks. This dimension tends to receive limited attention in social equity analyses (Martin, Myers, & Dawson, 2018), despite being fundamental for (equitably) building the processes and structures necessary for landscape restoration (Elias et al., 2022; Reed et al., 2020). It is possible that FMNR is most suitable in parkland systems (Lohbeck et al., 2020), which might also explain why the evidence base supporting FMNR skews heavily towards the Sahelian region generally and Niger in particular (Chomba et al., 2020). However, emerging evidence from outside the parklands demonstrates that

Table 2
FMNR suitability assessment framework. The framework contains six assessment questions (column A) and their respective rationales (column B). To illustrate the evidence-based conclusions that might be drawn from each question, results from our study are provided (column C). Building on findings in the secondary literature, column D assesses some wider implications of these results for designing FMNR interventions vis-à-vis each assessment question. Relevant secondary literature to consult (column E) for each assessment area are also provided, and, as appropriate, grouped with implications assessed in column D.

A	B	C	D	E
Assessment questions	Rationale(s) for question	Illustration: results from this study	Implications for designing FMNR interventions	Relevant secondary literature
1) Where are tree and shrub species naturally regenerating; what are the species; and is regeneration from rootstock or germinating seedlings?	FMNR requires *in situ* rootstock or germinating seedlings. Management approaches differ based on species/source of regeneration.	Regenerating trees and shrubs were most prevalent in fallows, bush fields, woodlands, and riparian forests.	● Target areas of the landscape most supportive of natural regeneration. ● Enrichment planting can support FMNR where natural regeneration is lacking.	Binam et al. (2017); Lohbeck et al. (2020); Hagazi et al. (2019)
2) Can FMNR support the local agricultural system? If so, which social groups would most likely benefit or be more likely than others to experience costs and risks?	Resource managers fundamentally consider the utility of FMNR within the context of the local agricultural system.	FMNR was most suitable in bush fields (Figure 4). Farmers managing bush fields were most likely to benefit from FMNR.	● Assess the local farming system and consider where, how, when and why FMNR might be suitable. ● Conduct a social equity assessment to identify potential inequitable outcomes.	Duriaux-Chavarría et al. (2020); Kandel et al. (2021)
3) Where and for whom do land and tree tenure systems most support FMNR?	Land and tree tenure systems condition socially differentiated authority, control, and access over land and trees, influencing who practices and benefits from FMNR.	Community FMNR was unsustainable post-intervention as it did not fully align with the local land and tree tenure system.	● Conduct tenure assessment based on actual rights (rights as practiced) to trees and land. ● If FMNR is paired with enrichment planting, assess how tree and land tenure regimes might condition socially differentiated outcomes.	Mclain et al. (2020); Kandel et al. (2021)
*4) How does long-term change (*e.g. *political, biophysical, land use, cultural) influence the suitability of FMNR?*	Contextual factors impact farmers' decision-making, the scope for FMNR, and who might benefit from FMNR.	Growing *Vitellaria paradoxa* (shea) might now be based on a combination of FMNR and planting due to commoditization trends.	● In-depth case studies are important for providing an empirical evidence base for whether FMNR might be suitable.	Boffa (2015)
5) Do resource managers prefer other tree growing methods over FMNR; are these preferences socially differentiated; and do biophysical factors constrain or enable these other approaches?	Farmers might prefer other tree growing methods, such as planting trees, especially in higher and less variable rainfall zones.	Female farmers demonstrated a preference for growing shea trees from planted rather than germinating seedlings in compound fields.	● Assess suitability of other tree growing methods in the target area. ● Climate influences the suitability of FMNR. FMNR might be most suitable in drier savannas.	Boffa (1999); Iiyama et al. (2017); Chomba et al. (2020)
6) Do resource managers possess gaps in knowledge pertaining to FMNR and are these gaps socially differentiated?	Interventions should address context-specific gaps and needs, with recognition of how communities are heterogenous and stratified by power relations.	Some participants acquired no new knowledge from the intervention whereas others cited learning outcomes. The importance farmers assigned to learning outcomes revealed gendered differences.	● Assess knowledge, skill gaps, and needs of resource managers pertaining to FMNR.	

FMNR can effectively be adapted to different farming systems (Duriaux-Chavarría et al., 2020). Our FMNR suitability assessment framework provides a systematic approach for thinking about where, when, and for whom FMNR might be appropriate in an agricultural landscape.

7. Conclusion

Based on our 2019–20 study in northeastern Ghana, this paper addresses how and why farmers practiced FMNR, and how context influenced farmers' rationales for practicing FMNR. Farmers' preferences, biophysical contexts, the spatial and temporal dimensions of the local farming system, and land and tree tenure systems were especially important in conditioning the suitability of FMNR in the landscape of our study area. We found that long-term social, political, agroecological, cultural, economic, and land use change in the region shaped the context in which FMNR was or was not practiced by farmers. While some farmers in our study indicated that they had preexisting knowledge of FMNR techniques, this view was not shared by all, suggesting that even in the West African parklands, where traditional agroforestry practices inspired the development of FMNR (Rinaudo, 2007; Tougiani et al., 2009), there was a rationale for FMNR capacity strengthening. However, FMNR implementation strategies must align with farmers' preferences and local land and tree tenure systems, otherwise they will likely be unsustainable post-intervention, as we found was the case with community FMNR. We conclude that despite the rush to scale up FMNR, more attention should be directed to assessing where, when, and for whom FMNR might be appropriate. Our FMNR suitability assessment framework, informed by farmers' perspectives and related studies, was designed to support these efforts.

Significant efforts have been made to scale up agroforestry for landscape restoration (Plieninger et al., 2020; van Noordwijk et al., 2020), particularly because it can reconcile agricultural, conservation, and development objectives. This includes attempts to scale up traditional agroforestry practices, or "Cinderella agroforestry systems" (Nair et al., 2017), and FMNR fits within this tradition, given its roots in the West African agroforestry parklands (Binam et al., 2017; Tougiani et al., 2009). However, the evidence base supporting landscape restoration initiatives should be methodologically diverse (Reed et al., 2020). While advancements in satellite-based observation have increasingly led policymakers and practitioners to rely on geospatial data to inform restoration decision-making (van Noordwijk et al., 2020), empirically-based understandings of local contexts are needed to support the effective scaling up of landscape restoration (Reed et al., 2020). In-depth qualitative research, which formed the basis of our study design, is most suited for illuminating how and why resource managers may or may not practice a restoration activity, as well as how context, which includes the social and political dimensions (Chazdon et al., 2020; Elias et al., 2021; Reed et al., 2020), influence resource managers' decision-making.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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