Agroforest Syst (2021) 95:1327–1342
https://doi.org/10.1007/s10457-020-00546-x

Farmers' perception and reasons for practicing farmer managed natural regeneration in Tigray, Ethiopia

Tigist Kibru · Rikiatu Husseini · Emiru Birhane · Jeremy Haggar · Negasi Solomon

Received: 2 October 2019 / Accepted: 18 September 2020 / Published online: 18 October 2020

Abstract Farmer Managed Natural Regeneration (FMNR) is a rapid, low cost and easily replicated approach to restore and improve degraded agricultural, forest and pasture lands. The study was conducted in low (500–1500 m.a.s.l) and mid (1500–2300 m.a.s.l) altitude agro-ecologies of Tigray region assessing farmer's perception and reasons to practice FMNR. Purposive sampling was used to select three peasant associations (PA's) from each agro-ecology. Simple random sampling was used to select respondents from household heads practicing FMNR. There were 15 respondents from each PA. Total respondents used for the study in both agro-ecologies were 90. All the data required for the study was collected through in-depth household survey and group discussions. Forty two percent (42.2%) of the respondents had 21–30 years of FMNR experience. Seventeen percent of the respondents with FMNR experience were from lowland and 26% were from mid land agro-ecology. FMNR has been practiced for more than two decades in the study areas. In both low and midland agro-ecologies, motivation of the respondents to practice FMNR was the training received from expert's (37.1%) and neighbors' success (29.2%). In the lowland, respondent's main purpose to practice FMNR was fuel wood and fruit collection (49%) while in the midland the objectives were for fuel wood (50%), soil conservation (47%) and fodder (47%). FMNR has enormous importance in the livelihoods of the rural people especially in providing fuel wood, food/fruits, construction materials and farm equipment.

Keywords Agro-ecology · Agroforestry · Natural regeneration · Ethiopia

T. Kibru · E. Birhane · N. Solomon (✉)
Department of Land Resources Management and Environmental Protection, Mekelle University, Mekelle, Ethiopia
e-mail: solomonnegasi@gmail.com

T. Kibru
e-mail: tktigana13@gmail.com

T. Kibru · R. Husseini
University for Development Studies, Tamale, Ghana
e-mail: rikihuss@yahoo.com

J. Haggar
Natural Resources Institute, University of Greenwich, Medway, London ME4 4TB, UK

N. Solomon
Tigray Institute of Policy Studies (TIPS), P.O Box 902, Mekelle, Ethiopia

Introduction

Climate change is one of the biggest challenges that the world is facing today (Gattinger et al. 2011). It has already affected developing countries, especially Sub-

Saharan Africa (SSA), with the increasing frequency and intensity of climate-related disasters, especially recurrent droughts, floods and irregular rainfall (Alemneh 2010). Therefore it is clear that truly sustainable and climate-friendly development is needed (Gattinger et al. 2011). Some studies suggests that by focusing more on natural productive systems, smallholder farmers in developing countries may combat climate change in providing improved ecological and social functions (Lott et al. 2009), while meeting adaptation needs and building resilient agro-ecological systems that actively sequester carbon (Neupane and Thapa 2001). Therefore, both mitigation efforts to reduce GHG emissions and adaptation measures to maintain crop yields are of global importance (Harvey et al. 2014).

Attempts to implement a 'green revolution' model in Africa using subsidies and inputs such as fertilizers have been costly and unsustainable, as technology cannot fully replace the services that trees would normally provide (Mueller et al. 2012). The current debate on sustainable intensification of agriculture underlines the importance of diversification as a way to improve crop and land management by integrating trees in land use systems (Gockowski and Asten 2012; Mueller et al. 2012). Although there are many ways to achieve sustainable agricultural intensification, there are few options where agro-ecosystem diversity and farm productivity are enhanced simultaneously (Koohafkan et al. 2012).

Ethiopia is one of the most vulnerable east African countries to the adverse effects of climate change (NAPA 2007). Smallholder agricultural production in the country remains low which is attributed to erratic and unreliable rainfall and the failure of current agricultural techniques to mitigate such conditions; inefficient use of agricultural resources such as soil amendments and rainwater that contributes to soil degradation (Jirata et al. 2016). Tigray region is found in the northern part of Ethiopia which is the most degraded part of the country. Except in some remote areas and around churches, the natural dry land forest and woodland vegetation of Tigray region has been destroyed (Araya and Edwards 2006; Birhane et al. 2007). In the region, more than 50% of the highlands are severely degraded; about 46% of its cropland suffers severe soil erosion because of high rates of rainwater runoff (Michael and Waters-Bayer 2007). Consequently, the natural resource base suffers from soil erosion, nutrient depletion and soil compaction (Abraha 2009) and thereby accelerating ecological degradation (Nedessa et al. 2005).

Sustainable land management practices and interventions are required to restore the degraded natural resource. Farmer managed natural regeneration (FMNR) is one of the practices implemented by famers to restore the tree resource base of agro-ecosystems. Farmer managed natural regeneration, like agroforestry is an empowering form of social forestry. It is said to complement the evergreen agriculture, conservation agriculture and agroforestry movements (Francis et al. 2015). It can be said to be an agroforestry system that depends on natural regeneration aimed at continuous tree-growth, provide food and fodder without the need for frequent and costly replanting.

Farmer Managed Natural Regeneration (FMNR) is an easily replicated approach, a rapid and low cost to restoring and improving agricultural, forested and pasture lands. It is a practice of encouraging the systematic re-growth of existing trees or self-sown seeds. It gives individuals and communities responsibility for the care and nurture of naturally occurring woody vegetation and rewards from the sustainable harvesting of wood and non-timber forest products (World Vision International 2012). According to Francis et al. (2015), since its inception in Niger in 1983, FMNR has spread across five million hectares or 50 percent of Niger's farmlands, which is the largest positive environmental transformation in Africa in the last 100 years. Since then, FMNR has been introduced in 18 countries across Sub-Saharan Africa, Southeast Asia, Timor-Leste, and most recently India and Haiti.

The principles of FMNR aren't new. They have been practised in one form or another for centuries in various parts of the world (Francis et al. 2015; Rinaudo et al. 2019). Woody plants integrated with the agricultural crops of smallholders characterize various forms of traditional agroforestry systems from different countries and is almost a universal occurrence in Ethiopia (Mohammed and Asfaw 2015). In Ethiopia crop cultivation was started through forest clearing. The farmers gradually open up the forests and woodlands to expand their cultivation but useful forest plants are deliberately retained in situ (Asfaw 2001). Fields and villages in southern parts of Ethiopia are dotted with trees and shrubs, showing that the adoption of open field cultivation has been made possible while

some woody species are allowed to grow. In order to integrate trees on farms, farmers apply a number of criteria, including fast growth, utility, compatibility, multipurpose use-value, drought resistance, and access to seedlings (Mohammed and Asfaw 2015).

Famer Managed Natural Regeneration is known to benefit those who depend more on tree resources: farmers, herders, and particularly women and children who harvest wood and non-timber forest products (Abdirizak et al.2013). On farmland, the practice is seen as a potent tool in increasing food security, resilience and climate change adaptation in poor, subsistence farming communities. Consequently, the concept is now being considered as a promising climate-smart agricultural practice that represents an affordable means of enhancing rural livelihoods as well, and may contribute to climate change mitigation by sequestering substantial amounts of carbon in tree biomass and soil in addition to conserving biodiversity. Despite this potential of FMNR as an efficient way to contribute to climate change mitigation and livelihood, there has been so far no attempt to substantiate anecdotal evidence with factual data provided by field-based experiments (Sawadogo et al. 2015). Given the fact that the Government of Ethiopia has committed to reforest 15 million hectares of degraded land using FMNR as part of a climate change and renewable energy plan to become carbon neutral status by 2025 (World Vision Australia 2014; UNDP 2011), any effort toward the understanding of climate smart FMNR will go a long way to augment its use as sustainable option for climate change mitigation and adaptation in the region (Biocarbon Fund 2017). In addition, the potential of FMNR as a key ecological rehabilitation means for Ethiopia has to be recognized among high-level policy and decision-makers as well as government and civil society organizations in the country. Achieving this requires an assessment of the current practices of FMNR to serve as a foundation for a solid awareness-creation programme of the practice or technology to all stakeholders at federal and regional level. This study, therefore, sought to investigate farmers' perception of FMNR and the nature of activities involved in the practice in Tigray region..

Materials and methods

Study area

Tigray is located at the northern limit of the central highlands of Ethiopia (Fig. 1). The region lies between 12°15′N-14°15′N latitude and 36°28′E-39°59′E longitude. The altitude varies from about 500 m.a.s.l in the northeast to almost 4000 m.a.s.l. in the southwest. According to local agro-climatic classification, about 53% of the land is lowland (kola), as it is less than 1500 m.a.s.l.; 39% is of medium altitude (weina dega), situated at1500–2300 m.a.s.l.; whilst 8% is classified as highland (dega), located at over 2300 m.a.s.l. (Atakilte et al. 2001). The region has diversified agro-ecological zones and niches each with distinct soil, geology, vegetation cover and other natural resources (Taffere 2003).

The region's climate is generally subtropical with an extended dry period of nine to ten months and maximum effective rainy season of 50–60 days. The rainfall pattern is predominantly uni-modal. The main rainy season is between June to early September (Atakilte et al. 2001; Taffere 2003). Exceptions to the rainfall pattern are areas in the southern zone and the highlands of the eastern zone, where there is a little rain during the months of March to mid-May; with more than 90% of the region being categorized as semi-arid region (Taffere 2003). Situated in the African drylands, the region is characterized by sparse and highly variable seasonal rainfall and frequent droughts (Warren and Khogali 1992). Agriculture is one of the important activities in Tigray, where about 65% of the land is under cultivation, with the rest taken up by pasture, forests and wasteland. Over 95% of the cultivated area is farmed by smallholders (BoANRD 1997) cited in Atakilte et al. (2001), engaged in subsistence rain-fed agriculture; most of whom follow a mixed crop or livestock system (Atakilte et al. 2001).

Research design and procedures

This study used a descriptive and cross-sectional research design which combined qualitative and quantitative methods of data collection and analysis. Two different agro-ecological zones; low (Qola) altitude that ranges between 500–1500 m above sea level (m.a.s.l.) and mid land (Weina Dega) altitude,

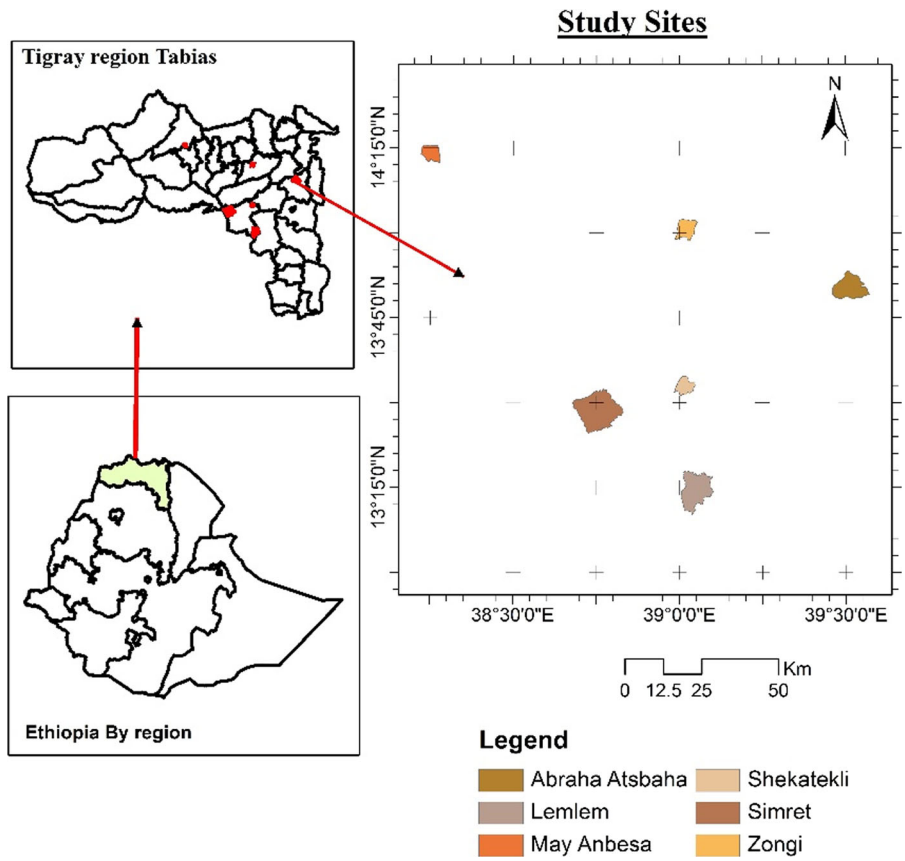

Fig. 1 Location of the study sites in the lowland and midland agro-ecologies of Tigray region, northern Ethiopia

ranging between1500 and 2300 m.a.s.l. were selected from the Tigray region in northern Ethiopia using stratified random sampling. In each agro-ecological zone, three Kebele's or Peasant Associations (PA's) were selected purposively based on their recognition of, and involvement in FMNR practice in the region (Table 1). The PA's were recommended by Tigray bureau of agriculture and natural resources. A total of six kebeles/PAs were thus sampled for the entire study (Table 1). Purposive sampling technique was used because it afforded the researcher to select Kebeles whose members are known to be knowledgeable in the phenomenon under study within the two agro-ecological zones.

Table 1 Study zones, sampled PAs and households sample size for the study

Agro-ecological zones	PA	HH size	Altitude (m.a.s.l)	Annual rainfall (mm)	Annual Min. and Max. To (°C)	No. of hh heads sampled
Low land	Simiret	1981	1621–1656	400–600	23–38	15
	Lemelem	1224	1599–1657	450–600	23–38	15
	Shoha-tekhli	946	1543–1688	400–600	21–41	15
Mid land	Myanbesa	604	1872–1892	639–1200	20–28	15
	Zongi	1136	1983–2018	495–900	20–28	15
	Abreha-Astbeha	911	1600–2100	350–600	21–27	15
Total	6					90

In each sampled PA, 15 households (Household heads) practicing farmer managed natural regeneration (FMNR) on their own farmland were randomly selected for the study. This gave a total of 90 respondents for the study. Random sampling technique was used to ensure that each member of the target population (FMNR practicing farmers) had equal chance of being selected for the research. This enabled the generalization of the findings to a larger population. Table 1 shows the study zones, sampled peasant associations and the number of respondents sampled for the study.

Method of data collection

This study was conducted between the periods of May 2017 to August 2017. A reconnaissance survey was conducted to identify and familiarize with the study sites with the help of Tigray Bureau of Agriculture and Natural Resources Office and the woredas or district Agriculture offices.

The primary data on farmer managed natural regeneration practices, perceptions on FMNR practice, the nature of management activities and factors affecting FMNR practices was collected from the 90 household heads (farmers) through in-depth interviews and group discussions. The household survey was achieved using structured interview schedule comprising both open and close ended questions. Structured interviews ensure that the same of questions are administered to the respondents and gives a high degree of reliability and validity as compared to unstructured interview.

The questionnaire was prepared in English but administered in the local dialect of the respondents through enumerators who could speak both the local dialect and English.

Group discussions were also conducted in all the six study sites. The group discussion also focused on farmers who are practicing FMNR on their own farmland. The essence to corroborate the results from the interviews and to fill in information gaps emanating from the household survey on the subject under study The groups were composed of six to eight respondents who were either model farmers, female and male farmers, development agents or experts and PA leaders. A discussion guide was used to hold a group discussion. The guide was developed for two main objectives of the study: (1) the nature of FMNR in the area:—opinion on FMNR practice, how to practice FMNR, management activities applied, time of execution and method of management activities and influences of FMNR on agricultural activities and products; (2) factors affecting FMNR activities:—problems encountered while practicing FMNR, solutions taken to reduce the problems encountered while practicing FMNR, factors affecting FMNR activities.

Data analysis

Data collected using the questionnaire was coded, classified, analyzed and interpreted using SPSS software version 20. Multiple response analysis, cross tabulation and Pearson's chi ($\chi 2$) square test, frequencies and non-parametric tests and means were used to analyze the data. Analysis of the information from the group discussions was done through discourse analysis.

Results

Demography of respondents

The majority (84.4%) of the respondents were male headed (84.4%) household (Fig. 2). The majority (73.3%) of the sampled households were between the ages of 31–60 (Fig. 3). In the lowlands, majority of the households had a family size of 5 while the midlands had 6 (Fig. 4). The land holding size of the respondents in the lowland areas was found to range from 0.253 ha with the majority of the respondents (21.35%) having land holding size of 1–2 ha. In the midland agro-ecology, the land holding size was found to be between 0.25–2 ha, with the majority of the

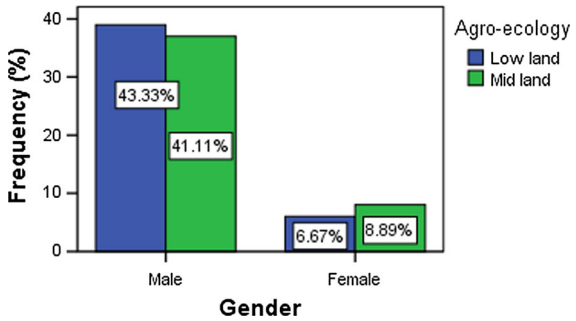

Fig. 2 Gender of respondent's across the lowland and midland agro-ecology in Tigray

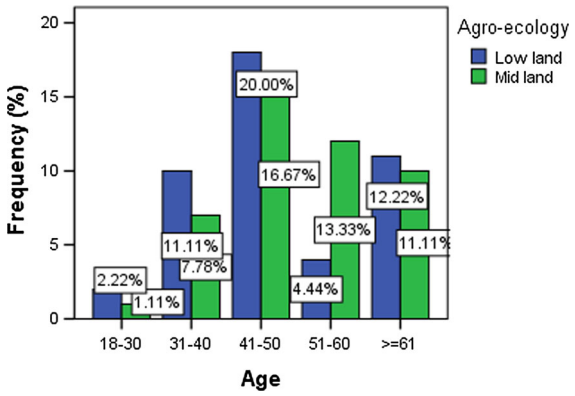

Fig. 3 Age of respondents across the lowland and midland agro-ecology in Tigray

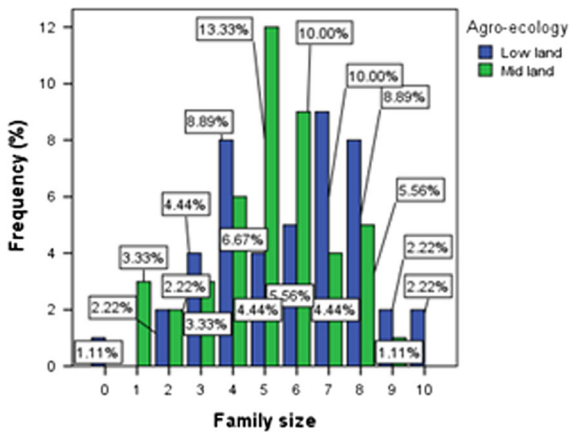

Fig. 4 Family size of respondents in both low and midland agro-ecologies in Tigray region

respondents (32.58%) having a land holding size of 0.5–1 ha (Fig. 5). In both agro-ecologies, 50% of the household respondents were illiterate, while 50% of the respondents had taken formal and informal education (Fig. 6).

Nature of farmer managed natural regeneration (FMNR) activities in the study areas

About 40% of the respondents had 21–30 years of FMNR experience in both agro-ecologies. Also respondents with family inherited FMNR practices were 10%, however only 1.1% of respondents had 41–50 and 51–60 years of FMNR experience (Table 2).

The farmers' response on the motivations to practice FMNR showed that 60% of the respondents

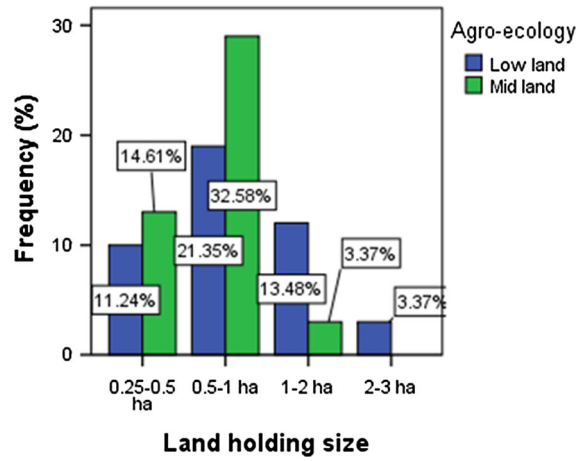

Fig. 5 Land holding size of respondents in both low and midland agro-ecologies in Tigray region

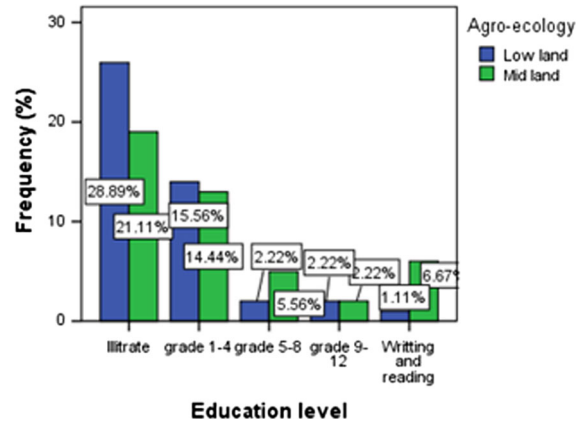

Fig. 6 Education level of respondents in both low and midland agro-ecologies of Northern Ethiopia

in both agro-ecologies were motivated by the 'training they got from experts to practice FMNR; among whom 33(37.1%) respondents were from lowland and 23% were from midland agro-ecology. Those motivated by their 'own understanding' of the benefits of FMNR were 38.2% respondents; of which 20.2% respondents were from lowland and 18% from midland agro-ecology (Table 3).

With regards to farmers' response on reasons for practicing FMNR, the most popular responses were fuel wood, fodder, soil conservation, fruit/food, pole and timber as the main reasons to practice FMNR (Table 4). Similarly, in the midland agro-ecology the most frequent responses were fuel wood, fodder, soil conservation, fruit/food, pole and timber as the main

Table 2 Farmer managed natural regeneration practice experience across agro-ecology

FMNR experience	Low land		Mid land		Total	
	Number	%	Number	%	Number	%
1–10 years	10	11.1	6	6.7	16	18
11–20 years	10	11.1	10	11.1	20	22.2
21–30 years	16	18	20	22.2	36	40.0
31–40 years	3	3.3	4	4.4	7	7.8
41–50 years	1	1.1	0	0.0	1	1.1
51–60 years	1	1.1	0	0.0	1	1.1
Family inherited	4	4.4	5	5.6	9	10.0
Total	45	50	45	50	90	100

Table 3 Respondents' views on source of motivation for practicing FMNR in the midland and lowland agro-ecologies of Tigray region

Motivations	Low land		Mid land		Total	
	number	(%)	Number	(%)	Number	(%)
Training from experts	33	37.1	20	23	53	60
Neighbors success	3	3.4	26	29.2	29	32.6
Family inherited knowledge	6	6.7	18	20.2	24	27.0
Own understanding on the benefits of FMNR	18	20.2	16	18	34	38.2
Total	44	49.4	45	50	89	100

Table 4 Reasons for practicing farmer managed natural regeneration in low and mid land agro-ecologies of Tigray region

Reasons for practicing FMNR	Low land		Mid land		Total	
	Number	%	Number	%	Number	(%)
Soil conservation	35	39	42	47	77	86
Fuel wood	44	49	45	50	89	99
Timber	42	47	28	31.1	70	78
Fruit/food	44	49	31	34.4	75	82.2
Fodder	42	47	42	47	84	93.3
Pole	42	47	32	36	74	82.2
Construction materials	7	8	1	1.1	8	9
Farm equipment	30	33.3	9	10	39	43.3
Fence	7	8	7	8	14	16
Medicine	1	1.1	0.0	0.0	1	1.1
Shade	17	19	4	4.4	21	23.3
Hay storage	1	1.1	0	0.0	1	1.1
Income source	1	1.1	1	1.1	2	2.2
Soil fertility	1	1.1	10	11.1	11	12.2
Charcoal	1	1.1	2	2.2	3	3.3
Total	45	50	45	50	90	100

reasons to practice FMNR on their land. The study showed, timber ($p = 0.00$), fruit/food ($p = 0.00$), pole ($p = 0.00$), construction materials ($p = 0.03$), farm equipment's ($p = 0.00$) and shade ($p = 0.00$) were significantly more frequent reasons for conducting FMNR in the lowland agroe-cology, while soil conservation ($p = 0.02$) and soil fertility ($p = 0.00$) were significantly more frequent reasons for conducting FMNR in the midland agroe-cology. There was no significant difference in fuel wood, fodder, fence, medicine, hay storage, income source and charcoal reasons for conducting FMNR across the agro-ecologies.

Influence of FMNR on agricultural activities and products in the low and midland agro-ecologies of Tigray

Management activities mainly practiced by most farmers in the lowlands were revealed to be selection of tree species seedling, fencing, tending operations and coppicing in March–May (32%) and June–August (44%), while in the midland agro-ecology site preparation was conducted in March–May (9%) and June–August (6%). There were also management activities that were done throughout the year. These are harvesting of tree products in the lowland while in the midland they were tending operations, watering, coppicing and harvesting of tree products (Table 5).

Response on the influence of FMNR on agricultural products and activities showed that almost all respondents in both agro-ecologies responded that FMNR had increased availability of fodder, fruit, pole, firewood, seasonal/annual income and soil fertility. Also 23% and 17% of respondents who mentioned reduced crop yield and no effect on crop yield respectively (Table 6).

Factors affecting FMNR practices

Response of the farmers in both agro-ecologies showed that more than half of the respondents from each agro-ecology have encountered problems while practicing FMNR. The rest 18 respondents from lowland and 19 from mid land agro-ecology said they didn't encounter any problem (Table 7). The major problems mentioned by those who answered in the affirmative include; shading effect of the trees on crops, birds, competition for space, and water and nutrient competition (Table 8).

Farmers were asked to list the measures or actions they have taken to reduce the shading effects of trees on their agricultural crops, and their responses showed that majority (58%) of them mentioned pruning/trimming; with 21 respondents from lowland and 8 from mid land agro-ecology (Table 9). Cutting away birds nest from the branches of trees was the second highest measure in terms of percentage (26%) response; with 9 respondents from lowland and 4respondents from midland agro-ecology (Table 9).

Challenges to practice FMNR in the lowland and midland agro-ecologies in Tigray region

Major challenges to the practice of FMNR for both agro-ecologies were revealed to include (in a descending order); damage by animals with a total percentage response of 59.3%, shortage of farm land (51.9%), the distance from house (44.4%), tree tenure security problem (34.6%), crop yield reduction (28.4%) and lack of labour (21%) (Table 10).

Discussion

The present study showed that male headed respondents were higher in number compared to female headed respondents. This trend is similar to that reported by Linger (2014) and Mohammed and Asfaw (2015), on similar studies in North-eastern Ethiopia and North-western Ethiopia respectively. In both studies, male headed households respondents were higher in number compared to the female headed household respondents. This outcome may mean that decisions of FMNR activities on farms are likely to be dominated by the male populace of the communities since they form the majority. This implies that issues or needs of FMNR that are peculiar to women may be side-lined unless conscious measures are taken to bring women on board.

Majority of farmers in both agro-ecologies fall within the age range of 41–50 years. Similarly in a study conducted by Abrha (2015) in Tigray region most respondents' age range was 46–56 years. Certainly this trend is a positive situation for the development of agricultural sector in the region since most of the populace in the active working age is into

Table 5 FMNR management activities practiced by farmers in the lowland and midland agro-ecologies of Tigray region

Management activities	Agro-ecology																Total							
	Low land								Mid land															
	Sep–Nov		Dec–Feb		March–May		Jun–Aug		Sep–Nov		Dec–Feb		March–May		Jun–Aug		Sep–Nov		Dec–Feb		March–May		Jun–Aug	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Site Preparation	–	–	0	0.0	0	0.0	2	2.2	–	–	7	7.8	21	23.3	19	21.1	–	–	7	7.8	21	23.3	21	23.3
Seedling spp. selection	0	0.0	0	0.0	29	32.2	40	44.4	1	1.1	2	2.2	8	8.9	5	5.6	1	1.1	2	2.2	37	41.1	45	50
Tending Operations	1	1.1	1	1.1	35	38.9	41	45.6	15	16.7	18	20	27	30	31	34.4	16	17.8	19	21.1	62	68.9	72	80
Weeding	1	1.1	0	0.0	0	0.0	3	3.3	2	2.2	1	1.1	5	5.6	4	4.4	3	3.3	1	1.1	5	5.6	7	7.8
Watering	1	1.1	1	1.1	0	0.0	0	0.0	9	10	7	7.8	7	7.8	6	6.7	10	11.1	8	8.9	7	7.8	6	6.7
Coppicing	0	0.0	1	1.1	26	28.9	28	31.1	6	6.7	7	7.8	21	23.3	19	21.1	6	6.7	8	8.9	47	52.2	47	52.2
Harvesting tree products (fuel wood, fruit, fodder etc….)	27	30	31	34.4	26	28.9	27	30	21	23.3	25	27.8	36	40	22	24.4	48	53.3	56	62.2	62	68.9	49	54.4

farming. That notwithstanding, the result also indicated that there are more of the younger generation in agriculture in the lowland areas with over 13% of respondents falling within 18–40 years as against 8.89% in the midland areas. In the midland areas however, the older generation dominate in agriculture with over 33% of respondents falling within 51–60 years and above. lowland.

None of the demographic characteristics of the respondents and FMNR experience had a significant relationship across agro-ecology. However, the composite result of the land holding size and FMNR experience of the respondents showed a significant relationship. This indicated land holding size has an influence on FMNR experience of the respondents in the study areas. Similarly, the composite result of the two agro-ecologies showed a significant relationship between the age and FMNR experience of the respondents. This indicated that the age of the respondents does have a relationship with FMNR experience. In other words, the farmers experience in FMNR depends on the age, with the older generation showing more interest in the practice and hence having more experience in it. In the present study, there was no significant different in FMNR experience across agro-ecologies. This may be attributed to the fact that most farmers protect naturally regenerated wildlings to establish woody species on their farms (Seifu 1998; Birhane 2014). For instance, the *Faihderbia albida* parkland system in Tigray and the rift valley of Ethiopia (Bekele 2018).

The FMNR e results showed that the farmers have been practising it for more than two decades in the study areas. According to Estifanos (2018), many indigenous multipurpose tree species are found scattered on farmlands in Ethiopia. In addition, Francis et al. (2015) and Rinaudo et al. (2019) stated the principles of FMNR are not new. This supports our finding that FMNR has been practiced for decades and this is evident from the number of respondents (nine) who said their experience was inherited from their families. In the early 2000s, the non-profit development organization World Vision with the financial and technical support from the World Bank and its Bio Carbon Fund tried to expand FMNR in Ethiopia (Rinaudo et al. 2008). Another study conducted in western Ethiopia by Yusuf and Solomon (2019) reported that branch pruning, coppicing, thinning, pollarding and protection from animal damage are

Table 6 Farmers' perception on the influence of FMNR on different agricultural products in the lowland and midland agro-ecologies of Tigray region

Influence of FMNR	Low land						Mid land						Total					
	Reduced		Increased		No effect		Reduced		Increased		No effect		Reduced		Increased		No effect	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Crop yield	20	23	8	9	15	17	1	1.1	35	39	1	1.1	21	24	43	48	16	18
Type of crops grown	1	1.1	3	3.4	37	42	1	1.1	29	33	0	0	2	2.2	32	36	37	42
Fodder availability	–	–	39	44	2	2.2	–	–	42	47	1	1.1	–	–	81	91	3	3.4
Fruit availability	–	–	43	48	1	1.1	–	–	34	38	0	0	–	–	77	87	1	1.1
Pole availability	–	–	43	48	0	0	_	_	38	43	2	2.2	–	–	81	91	2	2.2
Firewood availability	–	–	44	49	–	–	–	–	45	51	–	–	–	–	89	100	–	–
Seasonal/annual income	–	–	30	34	2	2.2	–	–	23	26	9	10	_	_	53	60	11	12.4
Disease incidence	0	0	5	6	2	2.2	7	8	2	2.2	10	11	7	8	7	7.9	12	13.5
Soil fertility	_	_	29	33	6	7	–	–	43	48	1	1.1	–	–	72	81	7	7.9

Table 7 Farmers Responses on whether or not they have encountered problem while practicing FMNR

		Agro-ecology				Total	
		Low land		Mid land			
		Number	%	Number	%	number	%
Problems encountered in practicing FMNR	Yes	26	28.9	26	28.9	52	57.8
	No	18	20	19	21.1	37	41.1
	Did not notice	1	1.1	0	0	1	1.1
Total		45	50	45	50	90	100

common management practices of the woody species. This is also in line with our finding, in the study area management activities are carried out through selection of tree species seedlings, tending operations and coppicing.

The farmers' response on the motivations to practice FMNR showed that there was a significant relationship across agro-ecology. Motivation of the farmers significantly increased due to training from experts, neighbors' success and family inherited knowledge. The result indicated that farmers are more influenced or motivated to practice FMNR due to training from experts and the benefits they obtain for themselves in both agro-ecologies. Similarly, the practice of FMNR in Niger, were initiated by extension services and development projects and the main objectives were to combat desertification, ensure environmental protection, improve agricultural yield and for other goods and services (Mahamane et al. 2012). This result is also a good indication that FMNR has been practiced in the mid agro-ecology for long period compared to the lowland agro-ecology since the family inherited knowledge of FMNR is low in the lowland agro-ecology. Thus, this calls for awareness creation on the myriad importance of FMNR practice and its potential for household income generation and

Table 8 Problems encountered by farmers while practicing FMNR

Problems encountered	Agro-ecology				Total	
	Low land		Mid land			
	Freq	%	Freq	%	Freq	%
Excess soil fertilization	0	0.0	2	3.7	2	3.7
Cropping land competition	1	1.2	7	13	8	14.8
Water and nutrient competition	0	0.0	7	13	7	13
Shedding effect	19	35.2	16	29.6	35	64.8
Birds	10	18.5	7	13	17	31.5
ownership conflict on boundary trees	1	1.9	0	0.0	1	1.9
Pest and disease	0	0.0	3	5.6	3	5.6
Allelopathic effect	0	0.0	1	1.9	1	1.9
Total	26	48.1	28	51.9	54	100

Table 9 Response on the measures taken to reduce the problems encountered in practicing FMNR

Solutions taken to resolve problems	Agro-ecology				Total	
	Low land		Mid land			
	Freq	%	Freq	%	Freq	%
No Action Taken	0	0.0	1	2	1	2
Cutting and thinning	3	6	3	6	6	12
Cutting away birds nest	9	18	4	8	13	26
Lopping/pollarding/debranching	1	2	7	14	8	16
Pruning/trimming	21	42	8	16	29	58
Reach for agreement with the help of local communities	1	2	0	0.0	1	2
Reducing canopy cover	0	0.0	4	8	4	8
Reducing organic fertilizer application	0	0.0	1	2	1	2
Removal of plants with Allelopathic effect	0	0.0	2	4	2	4
Support	1	2	0	0.0	1	2
Total	27	54	23	46	50	100

especially on its role in rehabilitating degraded lands and improving soil fertility in the lowland agro-ecologies.

In terms of nature of the practice, discussants in the lowlands mentioned during the group discussions that FMNR is better practiced at homestead farms but not on farms far from household because of theft by other farmers who do not have trees. It was also made known by discussants that some years ago the farmers were having troubles to find farm equipment, fuel wood and construction materials. However, due to extension services by the development agents and woreda experts, now they are managing trees and as a result they have sufficient trees for different purposes.

Discussants (farmers) in the mid agro-ecology especially in Zongi mentioned that tree planting and protection was a serious practice in the years of 1974/75 from the training given by soldiers of Tigray People's Liberation Front (TPLF) (054 code of the army) and politicians of Tehahet. According to the discussants due to these happenings, the vegetation cover of the area has increased. They explained that, to sustain the vegetation cover, if someone needs to harvest his own tree, permission has to be granted by the local leader called **Abogereb**.

Also in Abreha We-Atsbeha the discussants during the group discussions mentioned that due to lack of knowledge on the importance of trees, farmers were reluctant to plant and regenerate trees in the past. Currently because the support of different organizations such as Mekelle University, Tigray Agricultural Research Institution (TARI) and the World Vision

Table 10 Respondents views on challenges to practicing FMNR in the lowlands and midland agro-ecologies of Tigray

Challenges that affect FMNR	Agro-ecology				Total	
	Low land		Mid land			
	Number	%	Number	%	Number	%
Shortage of land	36	44.4	6	7.4	42	51.9
Less suitable land	3	3.7	3	3.7	6	7.4
Lack of knowledge	1	1.2	12	14.8	13	16
Shortage of water	3	3.7	10	12.3	13	16
Lack of Labor	11	13.6	6	7.4	17	21
Crop yield reduction	21	25.9	2	2.5	23	28.4
Damage by animals	34	42	14	17.3	48	59.3
Low survival and growth of naturally regenerated seedlings	1	1.2	8	9.9	9	11.1
Shortage of naturally regenerating plant materials	6	7.4	4	4.9	10	12.3
Drought intolerance of naturally regenerated plants	1	1.2	3	3.7	4	4.9
Lack of gov't motivation	1	1.2	5	6.2	6	7.4
Tree tenure security problem	25	30.9	3	3.7	28	34.6
Land tenure security problem	2	2.5	4	4.9	6	7.4
Distance from house	22	27.2	14	17.3	36	44.4
Total	45	55.6	36	44.4	81	100

Ethiopia, farmers are now practicing agroforestry extensively and regenerating plants on their farms.

Regarding for the reasons to practice FMNR that notwithstanding, there were some similarities and differences among in both agro-ecologies. The result indicated that besides the common reasons for both agro-ecologies, there were more farmers in the lowlands, who consider timber, fruits/food, poles, construction material and shade as additional important reasons for practicing FMNR than farmers in the mid lands. On the other hand, there were more farmers in the mid lands who had more concern for soil conservation, soil fertility and farm equipment's as reasons for practicing FMNR than farmers in the lowlands. These are similar to findings of Mahamane et al. (2012) who found fire and service wood, combating desertification, improving soil fertility, provision of fodder from trees, provision of shade and combating wind and water erosion as reasons for adoption of FMNR in some three villages in Niger; and also with other previous studies (Tougiani et al. 2009; Rinaudo 2011; Hachoofwe 2012; Etongo et al. 2015) who reported, improved soil fertility and water stress by providing mulch and soil organic matter, protection from winds, fuel for firewood and income generation by selling wood, fruit, building material, fuel wood, timber and non-timber forest products as reasons for adoption of FMNR in their study areas.

In the lowlands where the problems of land degradation is severe, community participation in planting and managing trees is quite low. This, therefore, requires awareness creation among the farmers on the importance's of trees on the farm land for rehabilitating degraded lands and improving soil fertility besides for household consumption. A similar finding was observed in a study conducted in Tigray region Ethiopia by Hachoofwe (2012) farmers prioritize the provisional services over the regulatory services. In Adi gudom with low levels of adoption of trees on farm, farmers were more concerned about provisioning services such as firewood. While in Abreha-weatsebha farmers concern was more towards regulatory services than provisioning such as water purification.

Many farmers believe that natural regeneration has significantly increased crop yields. This is in line with the findings of Pye-Smith (2013), where farmers in Niger were reported to have explained that FMNR has

totally changed their way of life because families had more wood to sell; women expending less time to gather firewood; more availability fodder for livestock as well as increased in their household incomes. The results also support similar findings by Le Houérou (1980), who asserted that FMNR provides higher protein fodder sources especially in the dry season. According to Haglund et al. (2011) FMNR has a significant positive impact on per capita gross income, crop diversity, tree density, and tree diversity. FMNR adopters grew an average of almost four crops on their farms while the non-adopters grew just over three that suggests FMNR adoption increases crop diversity. The adoption of FMNR also appears to increase tree diversity between one—three tree species per farm, and increase tree density by 12–16 trees per hectare. Similarly, in the present study responses from farmers in the midland agro-ecology indicated that, out of 45 respondents 29 responded that the types of crops grown (diversity) had increased. While in the lowland agro-ecology out of 45 respondents 37 of the respondents said FMNR practice has no influence on diversity of crops grown. Similar findings were also reported by Tougiani et al. (2009) where farmers in Maradi region, Niger feared that crop yields would be severely compromised at 40 trees/ha densities, but crop yields increased, even with higher tree densities, and on some farms densities exceed 150 trees/ha. Obviously, the varying responses in farmers perception on the influence of FMNR show the practice has both positive and negatives effects on agricultural activities and products which have to be understood and acknowledged by practitioners. These effects were observed by Arnold and Dewees (2014) who asserted that there are both positive and negative interactions among components when trees and crops are planted on the same plot.

These responses from respondents in the present study on shading effects of trees and cropping land competition confirms the findings by Mohammed and Asfaw (2015), who found 11.5% farmers responded shading effect of trees, lack of awareness, poor seedling establishment and drought are among the problems for which they do not want to have trees on their farms in Northeastern Ethiopia. The results also agree with that of a study conducted in Burkina Faso by Etongo et al. (2015), where farmers could not plant trees on their farm because of insufficient land, lack of seedlings/higher prices for seedlings, health problem, unsuitable land, lack of knowledge on management of trees, and lack of tenure security to land and trees. Nevertheless, result of the present study is in contrast to the findings of Haglund et al. (2011) who found soil type, market distance, and the educational level of the head of household as significant factors that affected the probability of adoption of FMNR in Niger. The authors explained that the probability of a household being an FMNR adopter increased with distance from market town until a distance of about 15 km, after which it decreases. But in this study, the challenge for most farmers was distance from home/house to farm. Also issues of educational level of household head and soil type were not considered challenges to the practice of FMNR in both agro-ecologies.

Moreover, in the group discussion, discussants lamented about theft of trees as a serious challenge to the planting of trees on their farms. They explained that the trees are as a child for them because they have been taking care of the tree right from emergence from the soil or from seedling stage until it becomes a mature tree. Only to finally watch the trees that they have been growing and tending to stolen, make them feel like they have lost a child by death. Due to these reasons they are discouraged to plant trees on their farm. Some discussants requested that, the government should set serious legal practice on the people who cut trees which do not belong to them. Other challenges that were discussants include: shortage of water, no replacement planting after cutting the trees, lack of knowledge on suitability of trees on the farm, poor sense of ownership on the trees, shortage of equipment for the management of the trees.

More so, the agriculture development strategy of the region is designed to be based on the rehabilitation, conservation and development of natural resources, and is known as conservation-based agricultural development policy (Belete 2002). Therefore the scaling up of the practice is a positive indicator towards meeting the development strategy of the region. According to Rinaudo (2011), FMNR has proven effective from small scale to landscape scale, as a means of restoring degraded land, reversing

desertification, enhancing ground water recharge and contributing to reforestation.

Conclusions

In the lowlands most respondents' motivation for practicing FMNR was training from experts, while in the midland agro-ecology neighbors success was the major motivation to practice FMNR. In both agro-ecologies the common reasons for practicing FMNR by most respondents were soil conservation, fuel wood, timber, fruit/food, fodder, and pole and farm equipment. Main management activities carried out in FMNR practice include: tending operations, harvesting tree products, seedling species selection and coppicing in both Agro-ecologies. In both agro-ecologies, the influence or effects of FMNR on agricultural activities and products were increased availability of firewood, pole, fodder, fruit and soil fertility. Respondents in the lowland mentioned reduction in crop yield as a negative effect of practicing FMNR. The major challenges to practicing FMNR were shortage of land, damage by animals, tree tenure security problem, distance from house and crop yield reduction in the lowlands where as in the midland damage by animals, distance from house, lack of knowledge and shortage of water.

Therefore the farmer has to consider the potential gains from the tree with possible losses from shade, nutrient or water competition. It is however important to note that the observations of farmers in the present study on the influence of FMNR on crop yields are mere perceptions and need to be substantiated by empirical studies to enhance farmers understanding of the potential gains, losses and tradeoffs from FMNR in both agro-ecologies.

Acknowledgements The author's would like to thank CIRCLE program for funding this research, Mekelle University for collaborated support. We would also like to thank Destaalem Gebremeskel, Mulugeta Sibhatleab, Angesom Shishay, Yemane Adane, Tigray Bureau of Agriculture and Natural resources, the district agricultural offices, the Tabia leaders for their support and help during the data collection process and the local farmers for giving us their precious time during interviews.

Funding This research was funded by Climate Impact Research Capacity and Leadership Enhancement (CIRCLE) Program form the African Academy of Sciences (AAS) and Association of Commonwealth Universities (ACU).

References

Abdirizak H, Gudka M, Kibor B, Kinuthia M, Kimeu P, Leeuw Jd, Maimbo M, Safriel U, Njenga M, Iiyama M (2013) Farmer-managed natural regeneration: how to regenerate pasture and farmland on a low budget. Technical proof. World Agroforestry Centre. https://www.researchgate.net/publication/263280755_Farmer-managed_natural_regeneration_How_to_regenerate_pasture_and_farmland_on_a_low_budget/stats

Abraha GG (20090 Land use change effects in Northern Ethiopia: runoff, soil and nutrient losses, soil quality, and sediment as nutrient sources. Norwegian University of Life Sciences, Department of Plant and Environmental …, Ås, Norway

Abrha BK (2015) Factors affecting agricultural production in Tigray region, Northern Ethiopia. University of South Africa

Alemneh D (2010). Strengthening capacity for climate change adaptation in the agriculture sector in Ethiopia. In Proceedings from National Workshop Held in Nazreth, Ethiopia, pp 5–6

Araya H, Edwards S (2006) The Tigray experience: a success story in sustainable agriculture. Environment and development series 4. Third world network; 131, Jalan Macalister; 10400 Penang, Malaysia. Printed by Jutaprint 2 Solok Sungei Pinang 3, Sg Pinang 11600 Penang, Malaysia. ISBN: 983-2729-74-2. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwje6o2G7rPsAhVG9IUKHXs6DGkQFjABegQICBAC&url=https%3A%2F%2Ftwn.my%2Ftitle%2Fend%2Fpdf%2Fend04.pdf&usg=AOvVaw1mcReSHBWZDf9oak_aEhw_

Arnold JM, Dewees PA (2014) Farms Trees and farmers: Responses to agricultural intensification. Routledge, Abingdon

Asfaw Z (2001) Origin and evolution of rural homegardens in Ethiopia. Biologiske Skrifter: Danske Videnskabers Selskab 54:273–286

Atakilte B, Gibbon D, Haile M (2001) Understanding diversity in farming practices in tigray. Ethiopia. IIED. Managing Africa's Soils, No. 24. Printed by Russell Press, Nottingham. ISSN 1560-3520. https://pubs.iied.org/9043IIED/

Bekele SE (2018) Parkland agroforestry of Ethiopia; key to production, productivity, biodiversity conservation and climate change mitigation: a review. Open J For 8:472

Belete T (2002) Efforts for sustainable land management in Tigray: the role of extension. In: Policies for Sustainable Land Management in the Highlands of Tigray, Northern Ethiopia

Biocarbon Fund (2017) Ethiopia: Humbo assisted natural regeneration project. A project-level initiative 2004–2020. UNFCCC Reference No.: 2712. https://www.biocarbonfund.org//node/55

Birhane E (2014) Agroforestry Governance in Ethiopia. Consultancy report

Birhane E, Teketay D, Barklund P (2007) Enclosures to enhance woody species diversity in the dry lands of eastern Tigray, Ethiopia. East Afr J Sci 1:136–147

Bureau of Agriculture and Natural Resources Development (BoANRD), (1997) Tigray soil and water conservation action programme, draft main report, Mekelle, Tigray

Etongo D, Djenontin I, Kanninen M, Fobissie K (2015) Smallholders' tree planting activity in the ziro province, southern burkina faso: impacts on livelihood and policy implications. Forests 6:2655–2677

Estifanos SB (2018) Parkland agroforestry of Ethiopia; key to production, productivity, biodiversity conservation and climate change mitigation: a review. Open J For 8:472–488. https://doi.org/10.4236/ojf.2018.84030

Francis R, Weston P, Birch J (2015) The social, environmental and economic benefits of farmer managed natural regeneration. Business Communications Consultant, Australia, p 44

Gattinger A, Jawtusch J, Müller A, Mäder P (2011) No-till agriculture–a climate smart solution? Climate change and agriculture. Report No. 2. Bischöfl iches Hilfswerk MISEREOR e.V., Aachen, Germany

Gockowski J, Asten PV (2012) Agricultural intensification as a climate change and food security strategy for sub-Saharan Africa. In: Wollenberg E, Nihart A, Tapio-Bostro ML, Grieg-Gran M (eds) Climate change mitigation and agriculture. International Center for Research in Agroforestry-International Center for Tropical Agriculture, London, New York, pp 382–390

Hachoofwe EM (2012). Local ecological knowledge of trees on farms, constraints and opportunities for further integration in Tigray Region, northern Ethiopia: A case study of smallholder farmers in Abreha Wa Atsbeha and Adi gudom. Bangor University

Haglund E, Ndjeunga J, Snook L, Pasternak D (2011) Dry land tree management for improved household livelihoods: farmer managed natural regeneration in Niger. J Environ Manag 92:1696–1705

Harvey CA, Chacón M, Donatti CI, Garen E, Hannah L, Andrade A, Bede L, Brown D, Calle A, Chara J (2014) Climate-smart landscapes: opportunities and challenges for integrating adaptation and mitigation in tropical agriculture. Conserv Lett 7:77–90

Jirata M, Grey S, Kilawe E (2016) Ethiopia climate-smart agriculture scoping study. FAO, Rome

Koohafkan P, Altieri MA, Gimenez EH (2012) Green agriculture: foundations for biodiverse, resilient and productive agricultural systems. Int J Agric Sust 10:61–75

Le Houérou HN (ed) (1980) Agroforestry techniques for the conservation and improvement of soil fertility in arid and semi-arid zones. In: Browse in Africa: the current state of knowledge. International Livestock Centre for Africa, Addis Ababa, pp 692–698. https://cgspace.cgiar.org/handle/10568/67392

Linger E (2014) Agro-ecosystem and socio-economic role of homegarden agroforestry in Jabithenan District, North-Western Ethiopia: implication for climate change adaptation. SpringerPlus 3:154

Lott J, Ong C, Black C (2009) Understorey microclimate and crop performance in a Grevillea robusta-based agroforestry system in semi-arid Kenya. Agric For Meteorol 149:1140–1151

Mahamane L, Iro DG, Matig OE, Idrissa IA (2012) Farmer managed tree natural regeneration and diversity in a Sahelian Environment: case study of Maradi region Niger. Cont J Agric Sci 6:38–49

Michael YG, Waters-Bayer A (2007) Trees are our backbone: integrating environment and local development in Tigray region of Ethiopia. Iied, London

Mohammed HA, Asfaw Z (2015) Smallholder farmers' perceptions, attitudes, and management of trees in farmed landscapes in northeastern ethiopia. USAID, Washington

Mueller ND, Gerber JS, Johnston M, Ray DK, Ramankutty N, Foley JA (2012) Closing yield gaps through nutrient and water management. Nature 490:254

NAPA (2007) Climate change national adaptation programme of action (NAPA) of Ethiopia. In: Tadege A (ed) The federal democratic republic of Ethiopia: ministry of water resources national meteorological agency. Addis Ababa, Ethiopia. https://www.preventionweb.net/english/professional/policies/v.php?id=8522

Nedessa B, Nyborg I, Ali J (2005) Exploring ecological and socio-economic issues for the improvement of area enclosure management: a case study from Ethiopia. DCG report

Neupane RP, Thapa GB (2001) Impact of agroforestry intervention on soil fertility and farm income under the subsistence farming system of the middle hills Nepal. Agric Ecosyst Environ 84:157–167

Pye-Smith C (2013) The quiet revolution: how niger's farmers are re-greening the croplands of the sahel. World Agroforestry Centre, Nairobi

Rinaudo T (2011) Natural resources scoping visit to Lebanon. 25–29 September 2011. World Vision Australia. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiFz5uTjbTsAhWS4IUKHaopCVwQFjAAegQIAxAC&url=http%3A%2F%2Ffmnrhub.com.au%2Fwp-content%2Fuploads%2F2014%2F04%2FTony-Rinaudo_Natural-Resources-Scoping-Visitto-Lebanon.pdf&usg=AOvVaw1a4oHPXm8Zkcq-nNzQhMUU

Rinaudo T, Dettman P, Tofu A (2008) Carbon trading, community forestry and development: Potential, challenges and the way forward in Ethiopia. World Vision, Uxbridge

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

Sawadogo P, Touré S, Rufino M (2015) How climate-smart is the Farmer Managed Natural Regeneration method? World Agroforestry Centre, CCAFS West Africa. Online: https://ccafs.cgiar.org/blog/how-climate-smart-farmer-managed-natural-regeneration-method#.X4b0lVBS_IU

Seifu A (1998) Farmer's private tree planting and management tradition at Wondo Genet, Ethiopia. MSc thesis, Wageningen University, Wageningen, The Netherlands.

Taffere B (2003) Efforts for sustainable land management in Tigray: the role of extension. Policies for Sustainable Land Management in the Highlands of Tigray. EPTD Workshop Summary Paper, pp 28–29

Tougiani A, Guero C, Rinaudo T (2009) Community mobilisation for improved livelihoods through tree crop management in Niger. GeoJournal 74:377

UNDP (2011) Draft country programme document for Ethiopia 2012–2015. Executive board of the united nations development programme, the united nations population fund and the united nations office for project services. Annual session of 2011 6 to 17 June 2011, New York, Item 6 of the provisional agenda. Country programmes and related matters. https://digitallibrary.un.org/record/702532?ln=en#recordfiles-collapse-header

Warren A, Khogali M (1992) Assessment of desertification and drought in the Sudano-Sahelian Region, 1985–1991. Wageningen, United Nations Sudano-Sahelian Office

World Vision Australia (2014) Case study: Humbo community-community managed natural regeneration project. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwi52uPYmbTsAhXE7eAKHTaqA6MQFjADegQIARAC&url=http%3A%2F%2Ffmnrhub.com.au%2Fwp-content%2Fuploads%2F2014%2F11%2F7604_FMNR_Case-Study_HUMBO_2pp_Final-LR.pdf&usg=AOvVaw0nPJnRE9BPJ3dlpWmBnxL9

World Vision International (2012) Farmer managed natural regeneration: an effective approach to restoring and improving agricultural, forested and pasture lands. World Vision Guidance for Development Programmes. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjwsrvEnrTsAhWIx4UKHSVwCXUQFjAAegQICBAC&url=http%3A%2F%2Fwww.e-alliance.ch%2Ftypo3conf%2Fext%2Fnaw_securedl%2Fsecure79fa.pdf%3Fu%3D0%26file%3Dfileadmin%2Fuser_upload%2Fdocs%2FAll_Food%2F2013%2FFMNR_PM.pdf%26t%3D1433841544%26hash%3Daaa1be43dec135b31c73270657ea1132&usg=AOvVaw0RnT1-5XcNGHU8xvREEoGT

Yusuf H, Solomon T (2019) Woody Plant Inventory and Its Management Practices in Traditional Agroforestry of West Hararghe Zone, Oromia National Region State Ethiopia. Am J Environ Prot 8(5):94–103. https://doi.org/10.11648/j.ajep.20190805.11