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TREE AND SHRUB SPECIES INTEGRATION IN THE CROP-LIVESTOCK FARMING SYSTEM

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ABSTRACT

Tree and shrub integration has been promoted as a means of enhancing rural livelihoods through sustaining watershed provision of services and products, especially in Ethiopia. However, research to support this effort has been limited. This study was conducted in *Borodo* watershed in central Ethiopia, to identify constraints to the process of tree and shrub integration in the watersheds. A household survey was conducted, supplemented with focus group discussions (FGDs), key informant interview and field observations. A total of 31tree and 11 shrub species were identified in different niches in the watershed. The key constraints to tree and shrub species integration included shortage of arable land, soil cracking, free grazing, lack of seedlings of desired species and water-logging. The main catalysts to the integration were availability of information on improved integration and cash for investment in the required activities, easy land certification and market opportunity for tree and shrub products. The tree and shrub growing niches preferred by farmers were homesteads (95.5%), gully sides (67.4%), stream sides (61.8%) road sides (60.7%), and crop land (12.4%). It is essential to address the factors that hinder tree and shrub species integration at various growing niche so as to improve the availability of tree products and services. Moreover, the capacity of farmers should be upgraded through training and demonstration of best tree planting, management and utilisation practices.

Key Words: Household, landscape, niche, watershed

RÉSUMÉ

L'intégration arbre-arbuste a été promue comme moyen d'améliorer les conditions de vie en milieux ruraux par la fourniture durable dans le bassin versant des services et produits, spécialement en Ethiopie. Par ailleurs, la recherche pour appuiyer cet effort a été limitée. Cette étude était conduite dans le basin versant de Borodo en Ethiopie Central, afin d'identifier les contraintes au processus d'intégration arbre-arbuste dans les bassins versants. Une enquête de ménages supplémentée par les groupes focaux de discussion était conduite, l'interview des personnes clées et des observations sur terrain.Un total de 31 espèces d'arbres et 11 arbustes étaient identifiées dans différentes niches de bassins versants. Les contraintes majeurs à l'intégration des espèces d'arbres et arbustes comprenaient la rareté des terres arables, le craquement du sol, la divagation du betail, manqué de plants des espèces désirés et innondation. Les pricipaux catalysants de l'intégration étaient disponibilité de l'information et le fonds d'investissement dans ces activitvs, la facilité de certilification des terres et l'opportunité du marché des produits d'arbres et arbustes. Les niches de production d'arbres et arbustes préférées par les fermiers étaient le voisinages de maisons (95.5%), le long des ravins (67.4%), le long des ruisseaux (61.8%), le long des routes (60.7%) et les terres reservées aux cultures (12.4%). Il est essentiel d'addresser les facteurs qui affectent l'intégration des espèces d'arbres et arbustes dans différentes niches de production afin d'améliorer la disponibilité des produits et services de bois. En plus, la capacité de fermiers pourrait être améliorée à travers la formation et la démonstration de meilleurs façons de planter les arbres, la gestion et les pratiques d'utilisation.

Mots Clés: Ménage, paysage, niche, bassin versant

INTRODUCTION

Watershed resources degradation is rampant in most Sub-Saharan African countries, with skewed agricultural development towards expanded rather than intensified land exploitation. Forest resources have suffered most and in Ethiopia, for instance, up to 50 million hectares have been lost to agriculture during 1980s (Dembner, 1991); yet forest resources are a major part of the natural resource base in the country. Unfortunately, such resources particularly, in the country's highlands have been targeted by the surge in human population, owing to their underlying fertile soil, sufficient rainfall and generally high agricultural potential (Bekele and Holden, 1997).

Consequently, several efforts have been made in the highlands by public and private sector to promote massive tree planting programmes since the 1970's to increase wood supply and properly manage the degraded watersheds (Zeleke and John, 2010). One component in this effort was through integration of tree and shrub species with crops and/or livestock (Neupanea *et al.*, 2002). Unfortunately, this effort has been bogged down by a milliard of factors, perhaps the main one being lack of a clear understanding of how to optimise the interphases between the trees and shrub species within the communities' socio-cultural setting (Saxaena and Ballabh, 1995).

The objective of the study was to develop a strategy for enhancing tree and shrub species integration in different niches of the Ethiopian central highlands watersheds.

MATERIALS AND METHODS

Description of the study area. The study was conducted in Borodo watershed in Dendi district, in central Ethiopia. Specifically, the watershed is located 9° 02'N and 38° 07'E with an altitude of 2210-2720 meters above sea level. The watershed covers 374 ha of land with Vertisol being the dominant soil type. The climate is of mild sub-tropical weather with a daily temperature ranging from 15 to 23 °C. The site experiences a bimodal rainfall with a mean annual value of 1042 mm (HARC, 2010).

Planted and naturally grown tree and shrub species are distributed on different landscapes of the watershed. The natural vegetation in most parts of the watershed, is scattered with the exception of *Danno* forest, which is situated in the upstream of the watershed. The forest is an important source of fuel wood, fodder, construction materials, farm implements, shade and honey for the inhabitants. *Acacia* spp., *Croton machrostachyus* and *Podocarpus falcatus* grow naturally and are scattered in the crop land. *Eucalyptus camaldulensis* and *E. globulus* are dominant among planted trees in different niches in the watershed.

Data collection. Data were collected using participatory rural appraisal (PRA), key informant interviews and a household survey.

PRA. The study was based on various complementary techniques. Using PRA tools/ techniques, qualitative data were collected that enhanced understanding of tree and shrub status and integration at different growing niches. PRA tools used for the study included observation/ transect walk, focus group discussion and historical trend analysis.

Observations. The field observations were conducted to document all tree and shrub resources growing in different niches in the watershed. It was also done with the purpose of getting guiding information that could contribute to designing questionnaire survey instruments.

Key informants interview. Key informant interviews were also conducted with development agents and experts to gain a deeper understanding of key watershed issues such as tree and shrub status and integration at different growing niches.

Focused group discussion (FGD). The interactions of different group of interests provided valuable information about tree and shrub species integration. Hence, focus group discussions with individuals from the Agriculture and Rural Development Office (ARDO), the local administrations, community representatives, and community members were held to understand the status of tree and shrub species in the watershed and to categorise the household based on wealth

status. Focus group discussion was held at each landscape position (upstream, midstream and downstream) of the watershed. The FGD included 8-10 participants composed of women, elders, youth, *Kebele* (the lower administrative unit in the government structure) leaders and ARDO staff members.

Survey. To achieve the study objective, quantitative data were collected from randomly selected households using structured questionnaire. The participants were selected randomly from five villages of the watershed after categorisation of the households into three wealth groups based on the information obtained from the FGD, key informant interviews and secondary data (Table 1). The villages were *Bako* with a total of 23.6% households in the upstream and, *Tsegereda 1* and *2 (*of the total 36.2% households), and *Borodo1*and *2(*of the total 40.2% households*)* in the midstream and downstream positions of the watershed, respectively. The three wealth groups are poor, medium, and rich farmers. A total of 89 sample households of which 14(16%) rich, 29 (32%) medium and 46 (52%), poor, were randomly selected.

A structured questionnaire was developed to verify and quantify the PRA survey findings. The questionnaire was tested before implementation for its consistency, logical flow, coding and length were amended. Enumerators who had completed secondary school studies, understood and spoke the local language (*Oromiffa*) were recruited and trained on the content of the questionnaires. All the interviews were conducted in *Oromiffa* in order to ensure locals give relevant answers to the questionnaire. We often provoked informal follow- up discussions and made use of our observations to assure the validity of our findings.

The data collected were analysed using Statistical Package of Social Science (SPSS). Respondents were categorised with those who do not integrate tree and shrub species on their respective holding. The results are presented in descriptive statistic forms i.e., frequency tables showing the number of households corresponding to their responses expressed in percentages.

RESULTS AND DISCUSSION

Tree and shrub species in the watershed. The respondents, irrespective of wealth status, showed a strong desire to plant and maintain native trees and shrubs in the watershed. A total of 74.16% embraced both planting and maintenance of the native trees and shrubs; the rest neither planted nor maintained the trees and/ or shrubs. Among the indigenous tree species, *Acacia abyssinica* species was the most common in the crop-livestock farms in *Borodo* Watershed. Most farmers were interested in *A. abyssinica* because of its capacity to improve soil fertility, and provide other service such as shade and bee forage; and products such as edible gum. This tree species is renowned for providing ecosystem services as envisioned by the respondents, additionally, it enriches the soil, particularly with nitrogen and calcium (Abdulrazak *et al.,* 2000). It also provides products such as farm tools and valuable brows during dry season. According to respondents its only disadvantage is spreading root nature that makes it unsuitable during ploughing.

TABLE 1. Wealth ranking criterion of the communities in the highlands of central Ethiopia

Criteria	Wealth category		
	Rich	Medium	Poor
Farmland	< 6.5ha	3-6 ha	< 2.5ha
Oxen	3 pairs of oxen	2 pairs of oxen	0 pairs of oxen
Crop production	Store grain and sale	Net grain sellers	Net buyers
Number of residential houses	2 corrugated	1 corrugated	1 Grass roof
Number of sampled households	14	29	46

According to the respondents, it was recently that most farmers in the watershed developed great interest in growing more *Eucalyptus camaldulensis* and *E. globulus* tree species. The shift towards tree growing was mainly sparked off by the depletion of the natural forest (*Danno* forest) within the watershed. In fact, the trend turned out to be towards integration of trees with shrubs owing to the multiple benefits provided by the trees together with the shrubs; beyond and above their respective monocultures. The benefits of this integration included improvement of land productivity, protection against soil erosion and reclamation of active gullies; in addition to serving as source of income, construction, energy, fodder materials; and environmental benefits. Similarly among the communities of northern Ethiopia where tree species such as *Eucalyptus* spp, *Shinus molle*, and *Acacia decerrens* were integrated with shrub species like *Sesbania* sp. for economic importance and ecological regeneration as part of the environmental reclamation program were reported by Zenebe (2007).

Potential tree and shrub growing niches. The tree and shrub growing niches identified across the landscapes were homesteads, gullies, streamside, hillsides, farm boundary, crop land and road side. Overall, however, respondents suggested the order of preference to be 96, 67, 62, 41 and 12% for homesteads, gully side, streamside, road side and crop land, respectively. They were, however, cautious in selecting sites where to plant trees and shrubs in their holdings, because of its accessibility and management need. Homesteads were the most intensively used niches and often consisted of a mixture of plants. Different tree and shrub species, including indigenous medicinal plants and fodder trees were planted in mixtures around the homesteads. Homesteads were preferred because they were more accessible and easy to involve women and the youth, the gender groups that often manage the constituent vegetation.

Space limitation was a major constraint of these tree growing niches and often the desired species diversification and integration with various high value tree and shrub species, including fruit trees is difficult to attain by the communities (Kindu *et al.*, 2009).

The establishment and maintenance of strips of tree and shrub species along streams and gullies, for soil and water conservation, was a common feature in the watershed. Farmers planted *Eucalyptus* spp. in these niches because they are fast growing and possess roots that are capable of binding the soil. This species is known to root deeply and profusely in the sub-soil, and thus hold soil against erosion (John, 2006; HBRC, 2002); though some species are known to leave the soil surface bare thus predisposing top soil to runoff and soil erosion losses (John, 2006). As such, the intervention in the gullies needed to be supplemented with mixtures of shrubs and grass species such as *Paspullum* spp.

Roadsides were also one components of the landscape in the watershed where communities planted and maintained trees and shrubs. However, free range livestock grazing was a challenge to this intervention and in other tree growing niches. About 41% of the households had holdings that shared boundaries with roads or foot paths, and were thus affected by the free range grazing practice.

Tree and shrub species could be integrated in crop land with different arrangements. However, farmers could not easily embrace planting of new trees because of fear of tree competition for moisture and nutrients; in addition to the difficulty in use of oxen plough-ing. Additionally, overstocking on farmlands, grazing lands and other areas supporting trees also aggravated the degradation of natural resources in the watershed. Prolonged heavy grazing contributed to the disappearance of palatable species and the subsequent dominance by other less nutritious, herbaceous plants or bushes (Mphinyane, 2001).

Status of trees and shrubs at different niches. The tree and shrub species richness in the watershed showed evidence of a gradual decline. According to the respondents, the status of forest resources and species diversity decreased in the last five decades. Most of the land in Ethiopia in general and the study area in particular was previously covered with indigenous tree and shrub species (EFAP, 1994).

During the military (*Socialist Derg)* regime of seventeen years (1974-1991), land became public property under the custody of the government. As a result, forest lands were converted into croplands, and erosion became a serious problem. Indeed, most of the forest resources were devastated during *Derg* period, though there was simultaneous push from the government to plant different tree species. Despite these efforts, there is still a widening gap between wood demand by communities and supply by the existing forest resources.

The number of tree and shrub species varied from one landscape to the other. *Cordia africana, Croton macrostachyus, Juniperus procera, Olea europaea, Podocarpus falcatus,* and *Prunus africana* severely declined followed by *Acacia abyssinica,* and *Apodytes dimidiata* (Tables 2 and 3).

Constraints to tree and shrub integration. The survey result revealed that 78 (88%) of the respondents experienced more than one discouraging factor. On cumulative basis of each factor, households mentioned a number of issues that constrained them from planting and maintaining tree and shrub species.

Socio economic factors. Up to 52% of the interviewees were in poor wealth category. Among this wealth category, 50% did not practice tree and shrub species integration most likely due to shortage of land. Most members of this category focused on growing traditional annual crops, such as *teff* (*Eragrostis* spp.), wheat (*Triticum* spp.) and maize (*Zea mays*), rather than planting trees and shrubs. There is, therefore, need for introduction of innovative technologies in the cropping systems of this category that target land productivity intensification for annual crops, resulting in release of land to planting of trees and shrubs.

Education level and awareness of the importance of trees and shrubs integration contributed greatly to embracing of the practice of tree and shrub planting among communities. About 50% of the households without formal education did not practice tree and shrub integration. Similar findings were reported elsewhere by Kamal and Paul (2009).

TABLE 2. List of shrub species identified in the watershed of highlands of central Ethiopia

Scientific name	Local name	Family name	Niche	Uses	Propagation
Calpurina subdecandra (L 'Hérit.) Schweick	Digitta	Papilionaceae	SS, Ho, RoS	C, Lf	Seed
Carissa edulis (Forssek.) Vahl.	Hagamsa/ Agam	Apocynaceae	SS, HS	FW,Df	Seed
Catha edulis (Vahl) Forssk. ex Endl.	Chati	Celastraceae	Ho	CG, stimulant drug	Root cutting/seed
Dovyalis abyssinica	Koshim	Flacourtiaceae	Ho, FB	Lf, Fo	Seed
Euphorbia candelabrum Kotschy	Adami /Kulkual	Euphorbiaceae	GS, HS	SC	Cutting
Maesa lanceolata Forssk	Abayi	Myrsinaceae	SS, GS, HS	FW, Mi(Fruit)	Seed
Opuntia ficus-indica	Beles	Cactaceae	GS, HS, SS	SC	Cutting
Rhamnus prinoides L' Her.	Gesho	Rhamnaceae	Ho	CG, LB	Seed
Ricinus communis L.	Qobo/Gulo	Euphorbiaceae	Ho	Fo (oil)	Seed
Rosa abyssinica Lindley	Kega	Rosaceae	SS, HS	Fo(fruit), FW, LF	Seed and cutting
Sesbania sesban (L.) Merr.	Sesbania	Fabaceae	Ho	Fe, Lf	Seed

Growing niches - (Homestead = Ho; Crop land = CL; Gully side = GS; Streamside = SS; Hill side= HS; Road side = RoS; Farm boundary = FB).

Uses- FI = Farm Implement, FW = Fuelwood, Sh = Shade, C = Construction, SFM = Soil fertility maintenance, Fe = Feed, Lf = live fence, Df = dead fence, CG = Cash generation, Fo = Food, Fr = Fruit, Ch = charcoal, Bf = Bee forage, SC = Soil Conservation)

TABLE 3. List of tree species identified in the watershed of highlands of central Ethiopia

Scientific name	Local name	Family name	Niche	Uses	Propagation
Acacia abyssinica Hochst. ex Benth	Lafto	Mimosaceae	CL, SS, HS	FW, Sh	Seed
Acacia decurrens	Akacha	Fabaceae	SS, HS, RoS	C, FW	Seed
Allophylus abyssinicus (Hochst.) Radlkofer	Embus/ Tatesa	Sapindaceae	SS, HS	FW, Ch, SC, Sh	Seed
Apodytes dimidiata E. Mey. ex Benth. O	Chalalaqa	Icacinaceae	Ho, CL, SS, HS	FW, Sh, C	Seed
Bersama abyssinica Fresen	Lolchissa/Azamir	Melianthaceae	SS, HS	FW, Bf,	Seed &cutting
Celtis africana Burm. f.	Cheke	Ulmaceae	SS, HS	FI, Sh	Seed
Citrus aurantifolia (Christm.) Swengle	Lomi	Rutaceae	Ho	Fo, Mi	Seed
Combretum molle R.Br. ex G Don	Didegsa	Comberetaceae	SS, HS	FW, Ch, C	Seed
Cordia africana Lam.	Wodesa	Boraginaceae	Ho, SS, HS	FW, Sh, FI,C, Fo, Bf	Seed
Croton macrostachyus Del.	Bakanissa	Euphorbiaceae	Ho,CL, SS, HS	Sh, SFM, FI, Mi	Seed
Cupressus lusitanica Mill.	Yeferenji tid	Cupressaceae	Ho, RoS	C, Lf	Seed
Dichrostachys cinerea	Adesa	Mimosoideae	Ho, SS, HS	FW, Ch	Seed & root sucker
Diospyros abyssinica (Hiern) F. White	*Lokko*	Ebenaceae	HS	FI, FW	Seed
Dodonea angustifolia L.f.	Kitkita	Sapindaceae	HS, SS	C, FW, Fe	Seed
Dombeya torrida (J.F. Gmel.) P. Bamps	Danissa	Sterculiaceae	SS, HS	FI, C, FW	Seed
Ensete ventricosum (Welw.) Sheeseman	Workie	Musaceae	Ho	Fo	Suckers and seed
Entada abyssinica Steud. Ex A.Rich.	Hambalta/Kontir	Mimosoideae	Ho, HS	Lf, FW	Seed
Eucalyptus camaldulensis Dehnh.	Key bahir zaf	Myrtaceae	Ho, SS, GS	FW, C,SC	Seed
Eucalyptus globules	Nech bahir zaf	Myrtaceae	Ho, SS, GS	FW, C,SC	Seed
Ficus sur Forssk.	Shola/Habru	Moraceae	SS, GS, HS	Sh, Fo(fruit)	Seed & cutting
Grevillea robusta R. Br.	Grevila	Proteaceae	Ho	C, SFM	Seed
Juniperus procera Hochst. Ex Endel.	Gatira	Cupressaceae	Ho, SS, HS	FI, C, Sh	Seed
Malus domestica	Apple	Rosaceae	Ho	Fo	Grafted seedling
Maytenus arbutifolia (A. Rich.) Wilczek	Atat	Celastraceae	SS, HS	FW, Df, FI	Seed
Millettia ferruginea (Hochst.) Bak.	Birbira	Fabaceae	Ho, SS	C, Sh, FW	Seed
Olea africana Mill.	Ejerssa	Oleaceae	Ho, SS, HS	FW,C, flavor	Seed
Podocarpus falcatus (Thunb.) Mirb.	Birbirsa	Podocarpaceae	Ho, SS, HS	C,Sh,	Seed
Prunus africana (Hook.f.) Kalkm.	Buraya	Rosaceae	Ho, CL, SS, HS	FW,Sh, C	Seed
Schefflera abyssinica (Hochst. ex A.	Harfatu	Araliaceae	SS, Ho, RoS	FI	Seed & cutting
Syzygium guineense (Willd.) DC.	Dokma	Myrtaceae	SS, HS	FW, Bf	Seed
Vernonia amygdalina Del.	Grawa	Asteraceae	Ho, SS	Fe, Mi, Fe	Seed & cutting

Growing niches - (Homestead = Ho; Crop land = CL; Gully side = GS; Streamside = SS; Hill side = HS; Road side = RoS; Farm boundary = FB). Uses- FI = Farm Implement, FW = Fuelwood, Sh = Shade, C = Construction, SFM = Soil fertility maintenance, Fe = Feed, Lf = live fence, Df = dead fence, CG = Cash generation, Fo = Food, Fr = Fruit, Ch = charcoal, Bf = Bee forage, SC = Soil Conservation)

Gender was partly a determinant of tree and shrub planting activities within the watershed. While barely 28% of the women were involved in tree and shrub species integration, up to 85% of the male counterparts practiced the culture. The reason for minimal female involvement in tree and shrub planting could be mainly due to cultural factors such as their pre-occupation with a lot of primary household chores (child care, food preparation and collection of firewood) which traditionally are not associated with males. These results are consistent with the findings of Zeleke and John (2010) in the highlands of Ethiopia; whereby female-headed households were less likely to grow trees than male-headed households.

Land size also had a bearing on the communities' participation in tree and shrub planting as a practice. Households with a less than 2 ha of land rarely practiced tree and shrub planting activities and/or maintained naturally grown ones. In contrast, households with larger land size (>2 ha) demonstrated great interest (67%) in the integration tree and shrub species on their holdings. It is possible that availability of extra land provided flexibility to farmers to be able to deal with the risk of growing trees and not agricultural crops, to cope with the growing household food insecurity in the country. The positive relationship of land holding and tree planting findings in the present study is in consistent with the findings of Ajayi *et al.* (2003) and Zeleke and John (2010).

Biophysical factors. The most common constraints mentioned include shortage of land (46%) was a decisive constraint to tree and shrub species integration. It was more prevailed for the early married younger groups that were still dependent on the lands of their parents. Hence, for those farmers, the prime need to produce food took priority over the long term value of trees and shrubs growing. This result is in line with the findings of Emtage (2004), and Zeleke and John (2010). The other constraints included problems of soil cracking(33%) free grazing (24%); poor seedling survival (16%); lack of seed and seedlings of desired species (17%) and water-logging conditions (5%).

Lack of planting materials was also cited by households as being a limitation in the watershed. According to the respondents in the study watershed, seeds and seedlings of desired species were not sufficient to meet their needs and sometimes were not available. Likewise, among communities in Wondo Genet, Ethiopia and Leyte Province, Philippines lack of preferred seeds/seedlings was reported as a major constraint to integrate trees and shrubs species (Abebe, 2000; Emtage, 2004).

Furthermore, free grazing had been identified as one of the constraints limiting tree/shrub integration activity. Similar results by Kindu (2001) depicts uncontrolled browsing has effect on tree and shrub species integration success. In fact, this problem is relatively low in the case of niches around homestead at *Borodo*, since young seedlings could be protected with thorny fences and household members could watch the livestock for better protection and management of newly planted tree and shrub species.

The survey result also showed that farmers noticed water-logging; usually seen in downstream and midstream of the watershed, although certain landscape features in upstream could make 'wet spots' during rainy season. Water-logging cases were commonly reported in *Borodo 1*and *2*, and *Tsegereda 1*and *2 Gottes'*. These *Gottes'* were characterised by Vertisol soil type and features like valley bottoms with the slope characterised by inadequate drainage. Therefore, tree and shrub species that were not tolerant to this condition didn't survive and farmers discouraged to plant such tree and shrub species.

Institutional and policy factors. Approximately 6% of the households had no land certificate. Possession of a land certificate is necessary to guarantee ownership and security of medium- and long-term investments such as in tree production. The non-certificate bearers got land to produce crops on a sharecropping basis. The importance of tenure security for tree and shrub species integration is emphasized by various studies (Caveness and Kurtz, 1993). In this study, tenure security is defined as the perceived probability of winning ownership of a part or the whole of one's land.

TABLE 4. Tree and shrub tenure of the households in the highlands of central Ethiopia

Households judgment	Percentage of respondents	
	Yes	No
Do you have land certificate for your holding?	84 (94)	5 (6)
Do you fill the security of ownership after the land certification?	84 (100)	–
Did you feel the security of tree ownership on your farms before the recent introduction of land certification?	2 (2)	82 (98)

Numbers in parenthesis are percentages

TABLE 5. Participatory ranking of factors that encourage farmers in the highlands of central Ethiopia to plant tree and shrub species

Factors influencing tree planting	No.	%	Rank
Availability of wood market	36	40	2
Land certification	31	35	3
Improved access information	39	44	1
Increased labour availability	12	14	6
Cash availability	17	19	5
Positive prospect of land and tree tenure	24	27	4

Out of 94% of the households who possessed land certificates, 2% of them felt secured before they obtained the certificates (Table 4). On the contrary, farmers supported the existing public tenure system and certification as the law encouraged them to plant and maintain tree and shrub species around the homesteads and the farm land. Similar findings on the positive relationship of land and tree tenure, and tree planting have been reported by Arnold (1991) and Habtemariam *et al.* (2011).

Opportunities for tree and shrub species integration. Different factors encouraged farmers to integrate tree and shrub species and maintain naturally regenerated trees. A total of 43.8% of the households were of the view that improved access to information pertaining to tree and shrub planting was the most important encouraging factor (Table 5). Information and knowledge about a given technology are key to adoption of agricultural practices, especially those associated with ecological benefits (Keil *et al.*, 2005). Similarly, 40% of the respondents reported availability of markets (Local market at *Ginchi*) for tree product was an important motivator to integration of trees and shrubs. The constant rise in local demand for tree products and services, and the revenue realised from tree products provided added opportunity for integrating different trees and shrubs species. Lastly, provision of seedlings to communities by ARDO of the district, at very low prices for many years, also persuaded up to 35% of the respondents to integrate tree and shrub species in different niches.

CONCLUSION

This paper evaluated tree and shrub integration to develop a strategy for enhancing tree and shrub species in different niches of the Ethiopian central highlands watersheds. Datasets from sample 89 households in the crop-livestock farming system of Borodo Watershed, Central Ethiopia were used.

As regards to factors underlying tree and shrub integration, our findings revealed a clear pattern, that exactly the same factors do not necessarily underlie the integration. Those factors that constrained tree and shrub integration in the watershed were, shortage of land, soil cracking,

free grazing, lack of seed and seedlings of desired species and water-logging. Although theses constraints were frequently mentioned, households needed more seedlings to integrate at different niches of their holding in the watershed.

Our findings also pointed out integration of tree and shrub species at the watershed varied depending on the wealth status, gender, education level, and size of landholding. Generally, tree and shrub integration by farmers in the watershed is affected by individual characteristics, the relative availability of production factors and market opportunity.

Results also suggest that access to information in relation to planting, managing and utilising tree and shrub species, availability of market, positive prospect of land and tree tenure, cash availability and land certification were the major factors that positively affected the integration of tree and shrub species.

Based on the findings of the study the following recommendations are proposed:

(i) Factors that hinder tree and shrub integration should be addressed properly to improve the coverage and roles of tree and shrub species in the watershed.
(ii) It is essential to integrate tree and shrub species in the watershed and maintain the existing ones to increase tree and shrub cover, and thus to reverse worsening watershed degradation, and to address the immediate needs of the farmers, such as food, fodder, fuel and various tree and shrub products.
(iii) Farmers' motivation to plant and maintain tree species need institutional support.

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