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Research Article

Woodlot farming by smallholder farmers in Ganderbal district of Kashmir, India

Azeem Raja
Division of Natural Resource Management, Faculty of Forestry, SKUAST-Kashmir, Benhama, Ganderbal-191201 (J&K), India
M. A. Islam*
Division of Natural Resource Management, Faculty of Forestry, SKUAST-Kashmir, Benhama, Ganderbal-191201 (J&K), India
T. H. Masoodi
Division of Natural Resource Management, Faculty of Forestry, SKUAST-Kashmir, Benhama, Ganderbal-191201 (J&K), India
P. A. Khan
Division of Forest Biology and Tree Improvement, Faculty of Forestry, SKUAST-Kashmir, Benhama, Ganderbal-191201 (J&K), India
A. A. Wani
Division of Natural Resource Management, Faculty of Forestry, SKUAST-Kashmir, Benhama, Ganderbal-191201 (J&K), India
A. A. Gatoo
Division of Natural Resource Management, Faculty of Forestry, SKUAST-Kashmir, Benhama, Ganderbal-191201 (J&K), India
Showkat Maqbool
Division of Animal Genetics and Breeding, Faculty of Veterinary Sciences & Animal Husbandry, SKUAST-Kashmir, Suhama, Ganderbal-190006 (J&K), India

*Corresponding author. Email: ajaztata@gmail.com

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Abstract
Forest degradation and deforestation are serious threats to resource conservation, subsistence livelihoods and rural income diversification. Woodlot farming on farms has been established as a potential option to increase forest resources from agricultural landscapes and remove human pressure from forests. The study investigated the land-use and landholding pattern, woodlots types and species preference and extent of spatial distribution, land allocation and growing stock of woodlots in the Ganderbal district of Kashmir. Multistage random sampling technique was employed to select 349 farm woodlots from 12 sample villages. Secondary sources were used to collect village-level data on land-use and landholding pattern. Primary data concerning the trees were collected through farm woodlot inventories. The data were analyzed using simple descriptive statistics. Results revealed that the total land area in the sample villages is 888.60 ha; 521.60 ha (58.70%) is cultivated land, which is mostly (80.78%) occupied by 1244 marginal farmers. The prevalent woodlots established were plantations of *Populus*, *Salix*, *Robinia* or mixed species. The farm woodlots (61.59 ha) contributed 11.81% of cultivated land and 6.93% of the total geographical area. The average growing stocks of woodlots were estimated to be 204.05 m^3/ha for *Populus*, 191.77 m^3/ha for *Salix*, 109.51 m^3/ha for *Robinia* and 62.31 m^3/ha for Mixed. The findings suggested that woodlot farming is the key alternative for forest resource production, livelihood resilience and socioeconomic improvement; hence, the policy must be implicated towards the promotion of woodlot farming by re-orienting the land use through farmer's motivation and technical, financial and farming input assistance.

Keywords: Woodlot farming, smallholder, land use, growing stock, Kashmir, India.

INTRODUCTION

Woodlots have been known as a doubtless valuable component of farming systems that contribute to a transition from subsistence-oriented farming to an additional commercially oriented farming system (Buyinza *et* *al*., 2008). Woodlot farming is a major supply of diversification of rural livelihoods by providing subsistence consumption, cash incomes and employment opportunities at the household level (Gizachew, 2017). To deal with the matter of high rural impoverishment and livelihood insecurity, many international organizations have collectively emphasized on-farm woodlot plantation as one of the tools for raising the economic welfare of rural communities (Kiyingi *et al*., 2016). Woodlots are increasingly recognized for their contribution to solving forest resources crises, energy problems, enhancing biodiversity conservation, addressing deforestation and mitigating climate change (Deressa *et al.,* 2009). Woodlot farming encourages the households to establish and manage their own sources of wood and non-wood products on their farmlands (Dixit and Dixit, 2010; Soucya *et al*., 2020). Woodlots offer a variety of provisioning, regulating, supporting and important cultural ecosystem services not only locally but also conjointly globally (Singunda, 2010). The provisioning services are well acquainted, tangible and direct merchandise products extracted from the woodlots to be used or sold such as logs, fuel wood, fibre, fodder, leaf litter, tans, dyes, oilseeds etc. (Dessie *et al*., 2019). The regulating services include the flexibility of the woodlot to store carbon, reduce erosion, improve water quality and cut back the effects of floods (Hingi, 2018). Non-material social and cultural benefits of woodlots embody recreational opportunities, aesthetic enjoyment and religious enrichment, as well as a diverseness and conservation appreciation (Ndayambaje *et al*., 2013). The supporting services performed by the woodlots include soil formation, nutrient cycling, water regulation and oxygen production (Wari *et al*., 2019).

Woodlots farming have become the crucial investment opportunity nowadays among smallholder farmers in Kashmir valley (Dar *et al*., 2018). The smallholder farmers grow woodlots in their agricultural landscapes for meeting forest resources, economic development and ecological reasons (Islam *et al*., 2016). Basically, woodlot farming on agricultural landscapes intensifies the natural resource management outside protected forests to support both livelihoods and conservation goals (Bhat *et al*., 2019). The enforcement of limited access to natural forests and forest products by fringe communities without the provision of alternative sources has compelled the people to face challenges in meeting daily livelihood requirements for fuel wood, building materials and NTFPs (Islam *et al*., 2012). The establishment of managed woodlots on farms by the farmers supports many of the forest resources needs provided by forests, namely, fuel wood, timber, fodder, wicker, leaf litter, and NTFPs and offset potentially human pressure on forests (Mushtaq *et al*., 2012). Because of the adaptability, productivity and multi-functionality, the farm woodlots have become a significant resource for a wide range of goods and services in rural areas (Ajit *et al*., 2017; Islam *et al*., 2017a). Woodlot farming is an important possible opportunity to rehabilitate the wastelands for life-support system, assured supply of industrial raw material, conservation of already scarce forest resources, employment and income generation, poverty reduction and environmental amelioration (Banyal *et al*., 2011). The importance of woodlot farming is expected to increase in the future due to increased demand of forest resources, restricted reliance on natural forests and climate change mitigation (Islam *et al*., 2017b). However, shift in land-use management for woodlot farming in many households is insignificant due to smaller land holding and intense pressure to cultivate food crops (Zafar *et al*., 2018). To mobilize the land-use for woodlot farming for livelihoods and well-being, incentives such as the provision of financial grants, farming inputs, capacity training and access to markets for forest products are the major factors that can motivate the smallholder farmers. Understanding the forest resource management strategies through woodlot farming on agricultural landscapes outside of protected areas for local use is imperative for framing appropriate policies and management plans to sustain and maintain woodlot structure and functions in Kashmir. The present study is an attempt to investigate the land-use and landholding pattern, types of woodlots and species preference and extent of spatial distribution, land allocation and growing stock of woodlots in agricultural landscapes of Kashmir valley.

MATERIALS AND METHODS

Study area

The study was undertaken in district Ganderbal of Jammu and Kashmir UT, located between 34.23°N Longitude and 74.78°E Latitude at an altitude of 1650 to 3000 meters above mean sea level (Fig. 1). The geographical area of the district is 39304 ha which is differentiated as forest (27.86%), non-agricultural use (14.65%), barren and un-cultivable land (8.04%), permanent pastures/ other grazing land (4.55%), cultivable waste land (2.48%) and net area sown (42.42%) (Anonymous, 2011). The total human population in the district is 297446, of which 158720 are male and 138726 are female. The district has a literacy rate of 59.98%, sex ratio of 874 female per 1000 males, a family size of 6.62 and a population density of 1148/km^2. Of the total population, 84.19% lives in rural region and 15.81% inhabit in urban region. The rural population has occupied 136 villages and 44831 households (Census of India, 2011). The site encounters both temperate and sub-alpine conditions. The average temperature ranges from 5^0 C to 20^0 C and monsoon brings more than 700 mm of rainfall.

Sampling procedure

Multi-stage random sampling technique (Ray and Mondol, 2004) was applied to select the blocks, villages and farm woodlots. In the first stage, all four blocks including Lar, Kangan, Wakura and Ganderbal were selected. In the second stage, of the 115 villages, twelve were sampled, including two (Dangerpora and Bagh-Mahanand) from Lar block, four (Najwan, Lari, Chiner and Barwalah) from Kangan block, three (Wonhama, Gozahama and Badampora) from Wakura block and another three (Babosi-pora, Hakim-Gund and Gund-Rehman) from Ganderbal block. In the third stage, all the 349 farm woodlots were selected from the sample villages.

Data collection and analysis

Data were collected from both secondary sources and primary field survey. The village level data on land use classification and land holding pattern were collected from secondary sources including line departmental records, village records, census reports, institutional technical reports and national informatics centre (NIC). The woodlot inventories were carried out for the entire 349 woodlots to study the plantation's stand structure, composition, spatial distribution, and characteristics (Singunda, 2010). Diameter at breast height (dbh) for woodlot trees was measured using diameter tapes at 1.37 m above ground. Total height of the trees was measured using clinometers. The volume of individual trees was estimated using the formula, $V = (\pi x\ dbh^2 \times H \times 0.5)/40000$, where V is the volume of tree bole (m^3), dbh is the diameter at breast height (cm) and H is the tree height (m). A form factor of 0.5 was applied to each tree in order to account for the taper effect of diameter and height measurements on tree volume (Newbould, 1967; Opuni-Frimpong *et al*., 2013). The standing volume per hectare was determined by extrapolating the total tree volume of the farm woodlot in hectare basis. The data were analyzed by the simple descriptive statistics *viz*., frequency (f), percentage (%), average (x) and range (Snedecor and Cochran, 1967) on MS Excel software.

RESULTS AND DISCUSSION

Land-use and landholding pattern

The total land availability in the sample villages is 888.60 ha, of which 38.59% is under irrigated net cultivated land, 20.11% is under un-irrigated cultivable land, 13.71% is under forest, 9.65% is under non-agricultural use, 8.27% is under barren and uncultivable land, 6.56% is under permanent pastures and other grazing land and rest 3.11% is under cultivable wasteland (Table 1). The patterns of rural land use are invariably associated with micro-geographical conditions such as topography, geology, soil fertility, climate and weather conditions (Islam *et al*., 2015a; Hettig, 2016). Land use plays a vital role in the national economy, rural development, employment and occupation, agro-industries, food and nutrition security, growth and survival, socioeconomic and cultural conditions, poverty alleviation and livelihood sustainability (Ebanyat *et al*., 2010; Garedew *et al*., 2012).

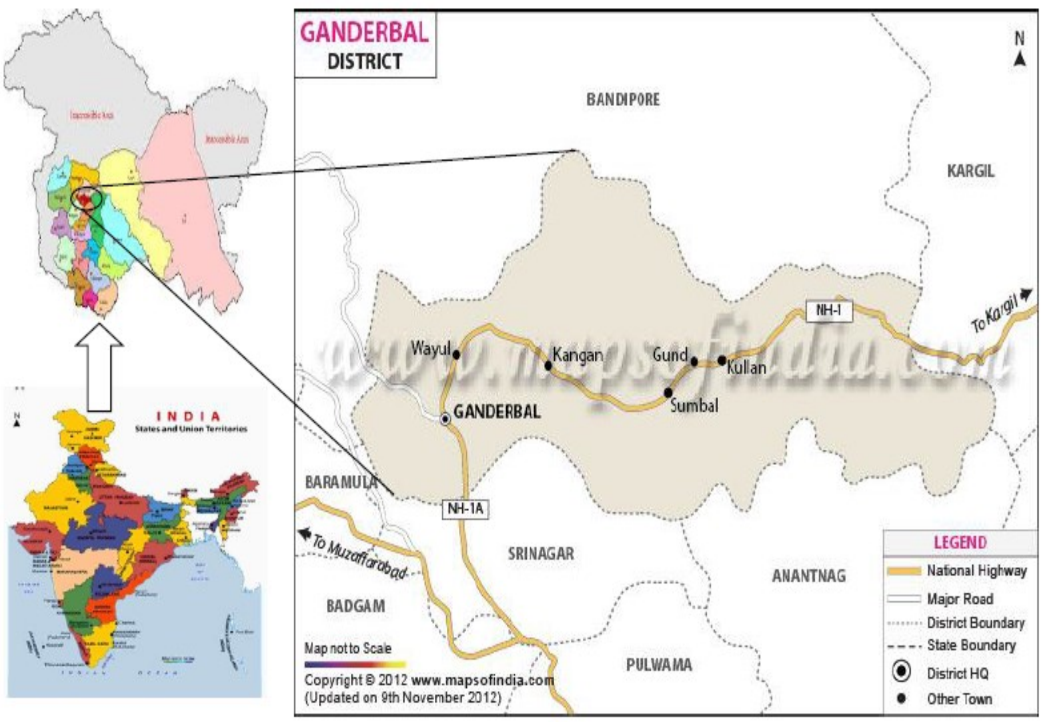

Fig 1. *Ganderbal district in Kashmir showing the location of the study area.*

Table 1. Land use classification in the sample villages.

Land use categories	Area (ha)	Percentage (%)
1. Total geographical area	888.60	100.00
2. Non-agricultural use	85.78	9.65
3. Permanent pastures and other grazing land	58.32	6.56
4. Barren and uncultivable land	73.44	8.27
5. Forest	121.84	13.71
6. Cultivable waste land	27.62	3.11
7. Net cultivated land	521.60	58.70
(a) Irrigated	342.93	38.59
(b) Un-irrigated	178.67	20.11

Table 2. Classes of farmers and land holding pattern in the sample villages.

Classes of farmers	No. of house-holds	No. of people	Land holding (ha)	Per capita land holding (ha)
Landless (0.00 ha)	55 (3.57)*	420 (3.80)*	0.00	0.00
Marginal (< 1.00 ha)	1244 (80.78)	8838 (79.87)	186.83	0.02
Small (1.01-2.00 ha)	168 (10.91)	1272 (11.49)	176.64	0.14
Medium (2.01-4.00 ha)	69 (4.48)	499 (4.51)	141.69	0.28
Large (> 4.00 ha)	4 (0.26)	37 (0.33)	16.44	0.44
Total	1540 (100)	11066 (100)	521.60	0.05

*Figures in the parentheses indicate percentage

The pattern of land holding among various farmer classes in the sample villages (Table 2) indicated that 1244 marginal farmers occupied about 186.83 ha (80.78%) of the total operated land. The proportion of land owned by the 168 small farmers was 176.64 ha (10.91%) of the total operated land while the percentage of operated land under 69 medium farmers was 141.69 ha (4.48%). The size of land holding accounted by the 4 large farmers was only 16.44 ha (0.26%) of the total operated land holding, whereas 55 landless families owned no land for cultivation. The per capita land holding among marginal, small, medium and large farmers were 0.02, 0.14, 0.28 and 0.44 ha, respectively, whereas among all the households together, the per capita average operated land holding was 0.05 ha. Cultivable land is the productive asset which plays a vital role in food and livelihood security, farming system, cropping pattern, integration of subsidiary occupations, on-farm employment and income opportunities, standard of living, nutrition and health, credit facility, financial, technical and input support from various institutions (Garedew *et al*., 2012; Islam *et al*., 2015a). Consequently, the higher the farm size under the possession of the households, the higher is the local recognition and socioeconomic status (Wani *et al*., 2009; Islam *et al*., 2015b; Oduro *et al*., 2018). The smaller size of average land holding among the farmers is due to the relatively large population and the highest land competition in the sample villages.

Woodlot types, spatial distribution and land allocation

The study documented 4 types of woodlots commonly established either as monoculture plantations or polyculture plantations by the smallholder farmers in the locality (Table 3). Generally, the dominant tree species preferred for monoculture woodlot plantations were *Populus deltoides*, *P. nigra*, *Salix alba*, *S. triandra* and *Robinia pseudoacacia* whereas the polyculture plantation included cultivation of mixed species of *Morus alba*, *Ulmus villosa*, *Aesculus indica* and *Alianthus altissima*. The development of woodlots is an additional source of livelihood and land management option for smallholder farmers to meet forest resource subsistence consumption, cash income, safety net and family employment in rural areas (Islam *et al*., 2015c; Dar *et al*., 2018). The species preference for woodlots plantations, adoption of monoculture or mixed woodlots and land allocation for the plantations depends upon a multitude of socioeconomic, psychological, communication and biophysical factors of the smallholder farmers (Nigussie *et al*., 2016; Islam *et al*., 2017a).

Among the 349 woodlots established in the sample villages, the *Populus* woodlots comprised the largest proportion (46.42%) followed by *Salix* woodlots (27.79%), *Robinia* woodlots (16.91%) and mixed woodlots (8.88%). The farm woodlots contributed about 61.59 ha of tree cover in the sample villages, which is spatially distributed as, *Populus* woodlots (55.24%), *Salix* wood-

Table 3. Woodlot types and species planted in the sample villages (N=349).

Woodlot type	Species	Family	Local name	Uses
Populus	*Populus deltoides*	Salicaceae	Rues phrass	Leaves- fodder; Branches- fuel wood; Bole- timber
	P. nigra	Salicaceae	Kaeshur phrass	Leaves- fodder; Branches- fuel wood; Bole- timber
Salix	*Salix alba*	Salicaceae	Veer/ white willow	Twigs - tooth brush; Branches/ bole - fuel wood; Bole- small timber; Leaves- fodder; Bark – antiseptic for wounds
	S. triandra	Salicaceae	Veerkani/ wicker willow	Tender branches – wicker handicrafts; Branches- fuel wood/ small timber; Leaves- fodder
Robinia	*Robinia pseudoacacia*	Pappilionaceae	Kikar/ black locust	Leaves- fodder; Branches- fuel wood; Bole- timber
Mixed	*Morus alba*	Moraceae	Bottul/ white mulberry	Leaves- fodder; Branches/ bole- fuel wood; Fruits- edible
	Ulmus villosa	Ulmaceae	Braen/ Himalayan elm	Leaves- fodder; Branches/ bole- fuel wood; Bole- timber
	Aesculus indica	Hipocastanacea	Haandeun/ Indian horse chestnut	Branches- fuel wood/ small timber; Seeds- medicinal; Bark- tannins
	Alianthus altissima	Simaroubaceae	Haankul/ tree of heaven	Branch/ bole- fuel wood

Table 4. Spatial distribution of various farm woodlots in the sample villages (N=349)

Woodlot type	Woodlots		Tree cover	
	No.	%	Area (ha)	% share
Populus	162	46.42	34.02	55.24
Salix	97	27.79	16.49	26.77
Robinia	59	16.91	7.67	12.45
Mixed	31	8.88	3.41	5.54
Total	349	100	61.59	100

Table 5. Land allocation pattern for farm woodlots in the sample villages (N=349).

Land allocation range (%)	No. of households (%)	Woodlot area (ha)	Woodlot ownership (ha/hh)	Percentage (%)
< 25%	165 (47.28)	16.33	0.10	26.51
25-50%	112 (32.09)	21.99	0.20	35.72
> 50%	72 (20.63)	23.27	0.32	37.77
Total	349 (100)	61.59	0.18	100

lots (26.77%), *Robinia* woodlots (12.45%) and mixed woodlots (5.54%) (Table 4). The choice of trees for woodlot farming is dependent on a variety of factors ranging from economic gain, subsistence consumption, safety net functions, land security, soil and water conservation, micro-climatic modification, climate shelter, preservation of rural heritage and traditions, risk coping intervention, and ability to integrate well with other economies (Meijer *et al*., 2015). Nevertheless, the farmers managed different types of woodlots depending on the subsistence uses and commercial demand of various types of forest products (Dar *et al*., 2018). The main reasons for planting woodlots were timber production for housing and hutments, fruit box, cricket bats, plywood, wicker handicrafts, scaffoldings, ladders, poles for wooden fence, roofing, fuel wood and charcoal, fodder, leaf litter etc. (Islam *e al*., 2016).

The land allocation up to 25% by the 165 farmers (47.28%) comprised about 33.32 ha (26.51%) of woodlot area in the study villages whereas the land allocation of 25-50% by the 112 (32.09%) farmers occupied 44.89 ha (35.72%) and land allocation above 50% by the 72 (20.63%) farmers included 47.48 ha (37.77%). The woodlot ownership was 0.10 ha for the farmers allocated up to 25% of land for woodlot farming, 0.20 ha for the farmers who allocated land between 25% to 50%, 0.32 ha for the farmers who allocated land between above 50% while among all the households to-

Table 6. Growing stock of woodlot trees in the sample villages (N=349).

Woodlot type	Volume (m^3/ha)		Height (m)		Diameter (cm)		Tree density (trees/ha)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Populus	204.05	107.12	18.10	3.90	24.80	7.60	467	159.10
Salix	191.77	92.68	16.10	5.80	23.30	5.30	559	253.12
Robinia	109.51	77.42	12.45	3.82	19.23	6.22	606	328.36
Mixed	62.31	42.56	10.64	3.63	15.50	4.91	621	327.80

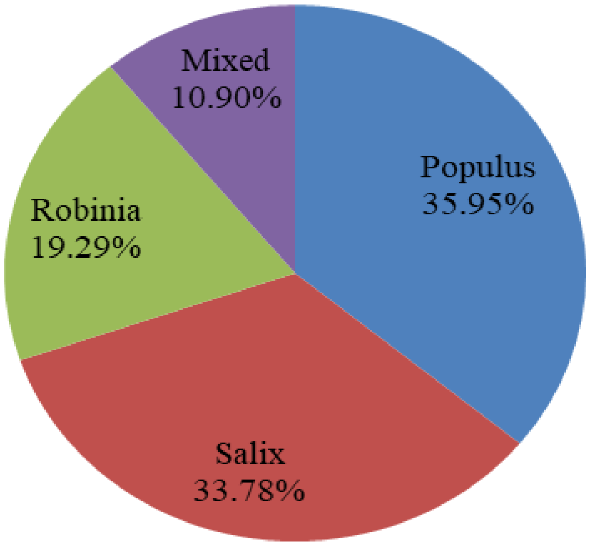

Fig. 2. *Volume of woodlot trees in the sample villages (N=349).*

gether, the per household average woodlot holding was 0.18 ha (Table 5). The land is the main requirement for tree planting and managing trees in woodlots and the woodlot size is directly proportional to the household landholding. Generally, the woodlots farmers were characterized by higher land holdings than the non-woodlot farmers. The majority of the farmers in all the study villages owned land below 1 ha, of which a large proportion is allocated for crop cultivation which is mandatory for household food and nutritional security. Therefore, the tree growers had limited land available for woodlots establishment. To avoid land scarcity for woodlots, nearly all the farmers had adopted agroforestry practices as agrisilviculture, hortisilviculture, hortisilvipasture, hortisilviagriculture, homegardens etc. that combine both crops and forestry in the same unit of land (Islam *et al*., 2017a; Bhat *et al*., 2019). Further, the household decision to establish woodlots is also influenced by the site factors like slope, aspect, soil condition, level, accessibility, irrigation facilities etc. of farm lands (Oduro *et al*., 2018).

Growing stock of woodlot trees

Average standing volume of woodlot trees in the study villages was found to be 204.05 m^3/ha for *Populus*, 191.77 m^3/ha for *Salix*, 109.51 m^3/ha for *Robinia* and 62.31 m^3/ha for Mixed. The mean number of woodlot trees is estimated to be 467 stems/ha for *Populus*, 559 stems/ha for *Salix*, 606 stems/ha for *Robinia* and 621 stems/ha for Mixed. The height of the woodlot trees varied from 10.64 to 18.10 m, while diameter at breast height ranged between 15.50 to 24.80 cm (Table 6). The total standing volume of woodlots is largely contributed by *Populus* (35.95%) followed by *Salix* (33.78%), *Robinia* (19.29%) and Mixed (10.90%) (Fig. 2). The differences in standing volume per ha among the *Populus*, *Salix*, *Robinia* and Mixed woodlots could be linked to the stand age, density, growth characteristics, farming experience, management practices, access to woodlot, levels of farmers' motivations etc. (Zoysa and Inoue, 2016; Bailey *et al*., 2021).

Conclusion

Woodlots represent a vital resource base for rural communities outside the natural forest areas in temperate landscapes of Kashmir Himalayas. They provide important forest resources for housing, bio-energy, livestock production, agricultural support, cottage industries, health care and socio-culture. The woodlots play a crucial role in the livelihood security of the local people by sustaining subsistence consumption, cash income, employment opportunities and safety nets during exigencies.

Household reliance on managed woodlots relieves pressure, reduces forest degradation and deforestation and promotes ecological restoration in the landscapes. Woodlot farming is recognized as a highly remunerative forestry intervention that has tremendous potential to generate income and employment for rural inhabitants. The farmers viewed woodlot as a worthwhile investment and therefore have planted trees on their farms as plantation enterprises. From a policy perspective, it is clear that woodlots and woodlot products are important in current livelihoods, socioeconomics and rural development throughout the study area. Therefore, woodlot farming should be promoted as a specific livelihood strategy in the locality by re-orientating the prevailing land use for the revival of the potentials of resources, bridging the gap between demand and supply of forest resource, ecological stability, restocking the existing forests and enhancing the tree cover. The tree planting and management should be ensured by technical assistance, supply of free seedlings and other farming inputs to motivate farmers to establish woodlots.

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Conflict of interest

The authors declare that they have no conflict of interest.

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