



# **Identification of Agroforestry Systems and Socio-Economic Status of Farmers in Rural Areas of Jogindernagar in Mandi District of Himachal Pradesh, India**

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

The present study was carried out in rural areas of Jogindernagar in Mandi District of Himachal Pradesh with the aim of identifying the agroforestry systems and assessing the demographic features and socio-economic status of farmers. The methodology followed for the present study in order to site selection, sampling procedure, identification of agroforestry systems, data collection, an analytical framework and valuation. The study site was selected by multistage random sampling technique. The study revealed that there are six agroforestry systems viz., agrisilviculture, agri-silvi-horticulture, agri-horticulture, agri-silvipastoral, pastoral-silviculture and pastoral-horticulture which prevails among different categories of farmers. In the medium and small categories of farmers, all the six agroforestry systems were present, while in the marginal category of farmers, the agri-silvipastoral system was absent. The average family size of the sampled households was 5.59 individuals per family. The highest sex ratio was observed in marginal farmers (990) and the lowest in medium farmer category (834). The literacy rate was recorded at its highest (91.70) in the marginal category of farmers. Most of the women were employed in the agroforestry and their livelihood depends on the farm's income. The highest percentage of local breeds of cows was found in the all three categories of farmers. Overall, average land holding was recorded at 3.07 hectares in all sampled categories of farmers. The average land holding area was found to be maximum (1.58 ha) in medium, followed by small (1.01 ha) and marginal (0.48 ha) categories. Thus, small scale agroforestry viz., Agri-silvi-horticulture system in the subtropical region of Himachal Pradesh is recommended for social, economical and environmental benefits to the rural population for their livelihood and food security in the climate change era.

**Keywords:** *Agroforestry systems; subtropical region; socio-economics; employment generation; livelihood and food security.*

## 1. INTRODUCTION

Agroforestry entails the deliberate integration of trees with agricultural crops and/or livestock, either simultaneously or sequentially, on the same unit of land and has been an established practise for centuries from a long time for both ecological and economical benefits [1]. Farmers have a long tradition knowledge of keeping trees on their fields and pastures, producing crops underneath them, and/or rearing domestic animals on those same fields and pastures across the tropics and, to some extent, in temperate zones [2]. The history and variety of agroforestry models in India are largely influenced by the socio-economic, cultural, communicative, and demographic characteristics of the local people, the experiences of the farmers, and other relevant aspects. Agroforestry has drawn more attention recently as a result of the recognition of its advantages over traditional forestry and agriculture due to the effect of climate change and global warming [3,4]. These agroforestry systems contribute direct benefits such as fuel wood, timber, fodder, fruits, livestock and bioenergy etc [5]. Agroforestry is considered a problem-solving science based on solid ecological principles, and; in addition to creating social and ecological connections, it has evolved based on indigenous knowledge and time-tested

practices. Agroforestry is an evolving concept. It is thought to be a remarkable engine of rural development and a prominent example of a traditional eco-technological approach adopted by farmers. The practise of agroforestry, because of the interdependence of various components, utilises many of the agricultural and natural resource management disciplines and has been given different labels. In a non-technical aspect, it is synonymous with farm forestry, tree cropping, agrisilviculture, forest farming, forest intercropping, woody bioenergy production, silviculture energy farming, and short rotation intensive culture [6].

Agroforestry in Himachal Pradesh has been practised traditionally since time immemorial [7]. By promoting employment, raising family income, expanding crop diversity, and lowering dependency on natural forests, it has improved the socioeconomic and ecological situations of farmers. Present research project study was carried out in order to identify agroforestry systems and evaluate the socio-economic and ecological status of the identified agroforestry systems in the rural areas of Jogindernagar in Mandi district of Himachal Pradesh. In this research study, agroforestry projects have two main objectives: (1) to increase the efficiency of the use of rural resources by reducing or

eliminating ecologically destructive land-use practises and by introducing new or improved agroforestry enterprises in order to produce sustainable increases in incomes and living standards; and (2) to provide for social equity. Estimating the socio-economic impact of an agroforestry project is a way to measure the success of meeting the above fundamental objectives of economic and social equity and distributive efficiency. Agroforestry has gained considerable attention in the scientific community because it serves multiple functions and is able to mitigate various problems like a decrease in land area, degradation of fertile land, deforestation, watershed degradation, etc. through several mechanisms. In turn, the people practising them have seen these ecological benefits turn into economic benefits through the increase of agricultural output [8]. Agroforestry plots remain productive for the farmers and generate continuous revenue which is allow for the diversification of farm activity and the better use of environmental resources.

## 2. METHODS AND MATERIALS

The present research study was carried out in the rural areas of Jogindernagar in Mandi District of Himachal Pradesh (India) and area coordinates between 31°59'28"N latitude and 76°47'23"E longitude (Fig. 1). The altitude of study area is about 1220 m above mean sea level. The climate of area is mostly humid subtropical in the hills of Himalaya and receives

an average annual rainfall of about 1851 mm. The average annual temperature of Jogindernagar is 16°C (during summer- 24°C and winter- 8°C).

The methodology used for the study consists of research site selection, sampling procedure, identification of agroforestry systems, data collection, an analytical framework and valuation. The study site was selected by multistage random sampling technique [9] in which ten Gram Panchayats/ rural villages were chosen for the research study viz., Chauntra, Sainthal, Pipli, Passal, Sagnehr, Jimjima, Bihun, Balh, Harabagh, Galu. From each selected rural villages as per classification of Government of Himachal Pradesh, farmers were divided into three different categories on the basis of their land holdings i.e., marginal (<1 ha), small (1-2 ha) and medium (2-5 ha) and a random sample of ten farmers from each rural village was taken for the study. Primary socio-economic data was gathered through personal interviews with each head of the household family in each rural village. Agroforestry systems prevalent in the study area were identified based on structure (nature and arrangement) and function (role of output) of their components. The system type and system units were identified as suggested by Zou and Sanford [10]. Primary and secondary components of each system type were identified after recognizing the structure of the system and specific function of the components.

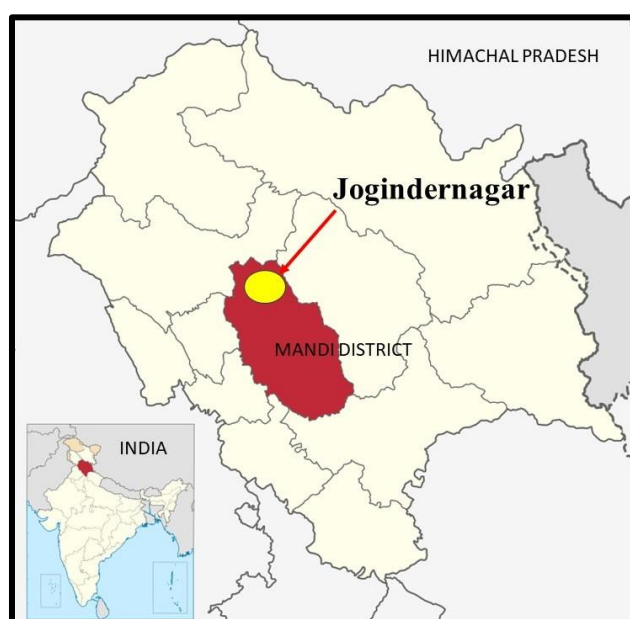


Fig. 1. Research Study Area Map of Jogindernagar, Mandi District, HP

### 3. RESULTS AND DISCUSSION

**Identification of agroforestry system types:** In the research area, total six different type of agroforestry systems, namely, (1) agrisilviculture (32.21%), (2) agri-silvi-horticulture (26.45%), (3) agri-horticulture (18.26%), (4) agri-silvi-pastoral (12.5%), (5) pastoral-silviculture (8.65%), and (6) pastoral-horticulture (1.92%) were identified and practiced by various categories of farmers (Table 1). The study revealed that the most dominating agroforestry system among different farmers category was agri-silvi-culture system (32.21%) and least dominating was pastoral-horticulture system (1.92%). Agrisilviculture was the most common system (47.16%) and agri-silvi-pastoral was practiced by a minority (7.56%) of farmers in the marginal category of farmers, while pastoral-silviculture and pastoral-horticulture were absent because of modest land holdings. In the small farmers category, agri-silvi-culture system was found most dominating (31.15%) agroforestry system, while pastoral-silviculture system was found to be the least dominating (8.19%) agroforestry system (Table 1). Majority of farmers in medium farmers category adopted agri-silvi-culture system (24.46%), whereas a minority of them practiced pastoral-horticulture system (4.25%).

Functional units under agricultural component were cereals viz., *Oryza sativa*, *Triticum aestivum* and *Zea mays*; oil seed crop viz., *Brassica rapa* Linn; vegetables viz., *Abelmoschus esculentus* (Linn.) Moench, *Allium sativum* Linn, *Brassica oleracea* Linn. var. *botrytis*, *Glycine max* (Linn.) Merr, *Phaseolus vulgaris* Linn, *Pisum sativum* Linn, *Solanum lycopersicum* Linn., *Solanum tuberosum* Linn.

The silviculture components were *Bauhinia variegata*, *Cedrus deodara*, *Cinnamomum tamala*, *Celtis australis*, *Grewia optiva*, *Morus alba*, *Prunus cerasoides*, *Quercus leucotrichophora*, *Rhododendron arboretum*, *Robinia pseudoacacia*, *Toona ciliata*. The main fruit tree species included *Citrus limon*, *Juglans regia*, *Pyrus communis*, *Prunus persica*, *Psidium guajava*, *Mangifera indica*, *Litchi chinensis*, *Citrus sinensis*, *Citrus limetta*. The grass species were *Agrostis* sp., *Apluda mutica*, *Arundinella nepalensis*, *Sorghum bicolor*, *Chrysopogon montanus*, *Cynodon dactylon*, *Dichanthium annulatum*, *Digitaria stricta*, *Heteropogon contortus*, *Imperata cylindrica*, *Setaria glauca*, *Themeda anathera*. Different combinations of forest trees, horticultural plants, agricultural crops and grasses were found in different existing agroforestry systems adopted by the farmers in the study area. Kapoor [11] identified five agroforestry systems, namely, agri-silvi-culture, horti-agriculture, horti-agri-silviculture, horti-silvi-pasture and silvi-pasture system in the Chirgaon in Shimla district of Himachal Pradesh [12]. Thakur [13] also observed six agroforestry systems viz., Agri-silviculture, Agri-horti-silviculture, Agri-silvi-horticulture, Horti-pastoral, Pastoral-silviculture and Pastoral-silvi-horticulture in southern region of Chuhar valley, district Mandi of Himachal Pradesh [13]. Kaler et al. [14] also reported various agroforestry systems viz., Agri-Silviculture (AS), Agri-Horticulture (AH), Agri-Silvi-Horticulture (ASH), Agri-Silvi-Pastoral (ASP), Silvi-Pastoral (SP), Pastoral-Silviculture (PS), Agri-Horti-Silviculture (AHS), Pastoral-Horticulture (PH), Horti-Pastoral (HP) and Pastoral-Horti-Silviculture (PHS) which practiced by the farmers in the Shivalik region of Himachal Pradesh [14].

**Table 1. Identified agroforestry systems practiced by different categories of farmers in Jogindernagar of Mandi District (HP)**

Agroforestry Systems	Number of families under different farmers category practiced agroforestry systems			Total families
	Marginal	Small	Medium	
AS	25 (47.16)	19 (31.15)	23 (24.46)	67 (32.21)
ASH	16 (30.18)	18 (29.50)	21 (22.35)	55 (26.45)
AH	8 (15.09)	12 (19.67)	18 (19.15)	38 (18.26)
ASP	4 (7.56)	7 (11.48)	15 (15.95)	26 (12.5)
PS	-	5 (8.19)	13 (13.83)	18 (8.65)
PH	-	-	4 (4.25)	4 (1.92)
Total families in each category	53 (100)	61 (100)	94 (100)	208 (100)

Note: Figures in the parenthesis are presented as percentage to the total; Abbreviations: AS: Agrisilviculture; ASH: Agri-silvi-horticulture; AH: Agri-horticulture; ASP: Agri-silvi-pastoral; PS: Pastoral-silviculture; PH: Pastoral-horticulture

**Table 2. Family structure of sampled households under different categories of farmers in Jogindernagar of Mandi District (HP)**

Particulars	Farmers category			Overall
	Marginal	Small	Medium	
Average family size	5.17	5.52	6.10	5.59
Adult male	2.10 (40.58)	2.15 (38.91)	2.45 (40.16)	2.24 (39.89)
Adult female	2.12 (41.06)	2.22 (40.27)	2.47 (40.57)	2.27 (40.63)
Children male	0.50 (9.66)	0.77 (14.03)	0.87 (14.34)	0.71 (12.67)
Children female	0.45 (8.70)	0.37 (6.79)	0.30 (4.92)	0.37 (6.89)
Sex ratio	990	888	834	904

Note: Figures in the parenthesis are presented as percentage to the total; Sex ratio is known as gender ratio and can be determined by multiplying the female population to male population ratio by 1000.

**Table 3. Education status under different categories of farmers in Jogindernagar of Mandi District (HP)**

Particulars	Farmer's category			Overall
	Marginal	Small	Medium	
Illiterate	0.40(8.29)	0.50(9.81)	0.50(8.66)	0.48(8.92)
Primary	0.42(8.81)	0.55(10.28)	0.50(9.09)	0.49(9.39)
Middle	1.00(20.73)	1.00(18.69)	1.10(19.48)	1.03(19.64)
Matric	0.57(11.92)	0.65(12.15)	0.65(11.26)	0.62(11.77)
Senior secondary	0.97(20.20)	1.10(20.56)	1.12(19.48)	1.06(20.08)
Graduate and above	1.45(30.05)	1.52(28.51)	1.85(32.03)	1.60(30.19)
Literate	4.81(91.70)	5.34(90.18)	5.72(91.34)	5.29(91.07)
Male literacy rate (%)	85.57	88.03	88.72	87.44
<b>Female literacy rate (%)</b>	<b>86.40</b>	<b>87.50</b>	<b>88.28</b>	<b>87.39</b>

Note: Figures in the parenthesis are presented as percentage to the total

**Table 4. Status of off farm employment among different categories of farmers in Jogindernagar of Mandi District (HP)**

Component	Category			
	Marginal	Small	Medium	Total
Total number of families	40	40	40	120
Total members	104	84	71	259
<b>Government service</b>				
Number of males	37	28	22	87
Average annual income/person (Rs.)	3,90,444	3,67,857	3,26,545	3,61,615
Number of females	7	5	4	16
Average annual income/person (Rs.)	3,25,000	3,16,600	3,03,143	3,14,914
<b>Private service</b>				
Number of males	51	46	40	137
Average annual income/person (Rs.)	1,95,720	1,69,305	1,56,089	1,73,704
Number of females	9	5	5	19
Average annual income/person (Rs.)	1,10,333	1,02,305	1,00,213	1,04,283

### Demographic and socio-economic status of the farmers:

**Family structure of sampled households:** The overall average family size was found to be 5.59 individuals. It was discovered to be the highest (6.10) in the medium farmers category and the lowest (5.17) in the marginal farmers category (Table 2). The average family size in the present

study area was higher as compared to the findings of Guleria [15]. The overall sex ratio was determined to be 904 females per thousand males (Table 2), which was lower than the state (972) and national (943) averages [16]. The highest sex ratio (990) was observed in marginal farmers category and the lowest (834) in medium farmers category. It is evident from the results that the population of adults was different from

children and there was dominance of male population over female population in subtropical region of H.P [17].

#### **Educational status of sampled households:**

Education status helps in determining the farmer's awareness level by influencing the mechanism of suggested modern technologies pertaining to the adoption of different agroforestry systems. Among different farmer categories, marginal category farmers had the highest literacy rate (91.70%), and the lowest (90.18%) was recorded in the small category of farmers. The overall average literacy and illiteracy rates in the study area were found to be 91.07 percent and 8.92 percent, respectively. The highest literacy rate (88.72%) of males was found in the medium farmer category. Similarly, in the case of females, the highest literacy rate (88.28%) was found in the medium farmer category (Table 3). The results revealed a higher literacy rate (91.07%) for the study area as compared to the overall literacy rate (82.80%) of Himachal Pradesh [16]. The people of the present study area are job-oriented; perhaps they owe it to their literacy rate. The majority of them were educated up to graduation level, so most of them were employed in various government and private sector services. Education is essential for developing professionalism and certainly adds to family income through employment and better knowledge of resources. Higher education helps in developing skill sets for acquiring jobs. Still, they were earning so much to sustain the education of their wards, which is a better indicator of the future literacy rate of people in the study area.

#### **Employment status of sampled households:**

Off-farm employment is an essential means by which farmers and their spouses can avoid household economic risks and maximise income during crop failure. The Overall, 87 males and 16 females were engaged in government services. Whereas, 137 males and 19 females were engaged in private services. Average annual income of ₹ 3,61,615 and ₹ 3,14,914 was observed in males and females under government services. Whereas, in the case of private services, average annual incomes of ₹ 1,73,704 and ₹ 1,04,283 were recorded for males and females, respectively (Table 4). The present study concluded that a higher number of males and females were involved in private services as compared to government services, but the annual income earned in government

services was higher as compared to private services. Males were more dominant than females in both the government and private sectors also reported by Thakur [13] and Kumar [17]. However, engagement of youth participation in agriculture-based livelihood activities in Himachal Pradesh is declining [18] due to agricultural knowledge, availability of land, interest in agriculture, fertile soil, favourable environment & temperature, availability of different types of soil, good transportation facilities and well connectivity as some of the factors determining rural youth participation in agriculture-based livelihood activities. Fast-growing agroforestry tree species should be introduced in this region for better income and new wood-based agroforestry technologies for better attraction of youth in agriculture [19].

#### **Livestock inventory of the sampled households:**

Livestock rearing is an integral part of farming systems. They play a significant role in rural livelihood and the economies of developing countries. In livestock-based agroforestry systems, there exists a symbiotic relationship between crops and animals, as various crops are used as fodder to feed the livestock. In return, livestock provide farmyard manure, which benefits the soil and enhances the productivity of the crop. They provide milk, meat, wool, and manure to improve the income and productivity of crops. The average number of cows was found highest in the small (1.22) farmer category and lowest in the marginal (0.82) farmer category. Whereas, in the case of buffalos, the highest percentage was observed in the medium (12.50%) farmer category, followed by the small (9.59%), and marginal (67.14%) farmers categories (Table 5). The highest percentage of local breeds of cows (61.22%) was found in the small category of farmers, followed by the medium (53.33%) and marginal (51.51%) categories of farmers. The highest percentage of improved breeds of cows (48.48%) was found in the marginal category of farmers, followed by medium (46.66%) and small (38.77%) categories of farmers. Whereas, the maximum percentage of milching was found among cows (86.66%) in the medium category and the minimum (83.67%) in the small category of farmers (Table 5). The total number of young stocks was found highest in the medium (21) category, followed by the marginal (13) and small (12) farmers categories. The results clearly showed that cows were the most preferred domestic animal for milking. Some of the families also domesticated goats for milk and meat purposes. The

**Table 5. Livestock status of sampled households under different categories of farmers in Jogindernagar of Mandi District (HP)**

Animal species	Number of animals	Average number/family	Local breed	Improved breed	Dry	Milch	Young stock
<b>Marginal farmers (Total number of families having livestock= 32)</b>							
Cow	33	0.82(78.57)	17(51.51)	16(48.48)	5(15.15)	28(84.84)	13(86.66)
Buffalo	3	0.07(7.14)	3(100)		1(33.33)	2(66.66)	
Bullock	2	0.05(4.76)	2(100)				
Goat	4	0.1(9.52)	4(100)			2(50.00)	2(13.33)
Total	42	1.04(100)					15(100)
<b>Small farmers (Total number of families having livestock= 38)</b>							
Cow	49	1.22(67.12)	30(61.22)	19(38.77)	8(16.32)	41(83.67)	12(75.00)
Buffalo	7	0.17(9.59)	7(100)		2(28.57)	5(71.42)	
Bullock	8	0.20(10.95)	8(100)				
Goat	9	0.22(12.33)	9(100)			5 (55.55)	4(25.00)
Total	73	1.81(100)					16(100)
<b>Medium farmers (Total number of families having livestock= 37)</b>							
Cow	45	1.12(70.31)	24(53.33)	21(46.66)	6(13.33)	39(86.66)	21(91.30)
Buffalo	8	0.20(12.50)	8(100)		3(37.50)	5(62.50)	
Bullock	6	0.15(9.37)	6(100)				
Goat	5	0.12(7.81)	5(100)				2(8.69)
Total	64	1.59(100)					23(100)

Note: Values in parentheses are presented as the percentages to the actual owners

**Table 6. Land use pattern of farmers in Jogindernagar of Mandi District (HP)**

Particulars	Land holding (hectare)			
	Marginal	Small	Medium	Total land holding
Arable land (agriculture)	0.37(77.08)	0.74(73.26)	1.09(68.98)	2.20(71.66)
a) Irrigated	0.15(31.25)	0.19(18.81)	0.26(16.45)	0.60(22.32)
b) Unirrigated	0.22(45.83)	0.55(54.45)	0.83(52.52)	1.60(50.60)
Non arable land (Pasture land)	0.11(22.91)	0.25(24.75)	0.44(27.84)	0.80(26.05)
Orchard	-	0.02(1.98)	0.05(3.16)	0.07(2.28)
Total	0.48(100)	1.01(100)	1.58(100)	3.07(100)

Note: Figures in the parenthesis are presented as percentage to the total; 1 Bigha = 0.08 hectare

population of bullocks observed per family was very low, which may be due to the fact that people were more dependent on tractors for farm operations and hired bullocks for ploughing and land preparation. The majority of the farmers in the study area preferred local breeds of cow and buffalo, which may be due to the disease-resistant nature and sturdiness of hilly cattle. Other livestock rearing practises, such as poultry, apiculture, horses, and mules, were found absent in the area. Guleria [15] reported the livestock status in the mid-hills of Himachal Pradesh that

cows of local breeds are found in the majority of the livestock population, followed by other animals [15].

**Land use pattern:** The land utilisation pattern determines the type of farming system prevailing in an area. Agriculture income is dependent upon the availability of arable land, its proper use, cropping schedule, transportation costs, and the market value of the agricultural produce. The average land holding of the farmers was 3.07 ha, out of which the fraction of agriculture, pasture,

and orchard land was 2.20 ha (71.66%), 0.80 ha (26.05%) and 0.07 ha (2.28%), respectively. Out of the total agricultural land (71.66%), 22.32 per cent land was irrigated and 50.60 per cent land was unirrigated (Table 6). Maximum arable land (1.09 ha) was found under medium category of farmers, followed by small (0.74 ha) and marginal (0.37 ha) categories of farmers. Similarly, the maximum non arable land (0.44 ha) was recorded under the medium category of farmers, followed by the small (0.25 ha) and marginal (0.11 ha) categories of farmers. Orchard land under small and medium categories of farmers was found to be 0.02 ha and 0.05 ha, respectively. Whereas, there was no orchard land under the marginal category of farmers. It was recorded that the average land holding size of marginal, small, and medium farmers was 0.48 ha, 1.01 ha, and 1.58 ha, respectively (Table 6). A diagnostic survey of agroforestry systems in the Balh valley of Mandi district in Himachal Pradesh by Upadhyaya (1997) revealed that more land was under agriculture and cultivation was done under rainfed conditions as it lacked irrigation, which corroborates our present findings [20].

Agroforestry is a very important marker of the social benefits for more vulnerable sections of the society such as women, children and marginalized groups in India. When socio-economic conditions of farmers compared who adopted agroforestry and those who did not adopted agroforestry systems in Bangladesh, the social and economic conditions were better of agroforestry practicing farmers [11]. In addition, agroforestry also provides higher yield per unit area, diversified products which ultimately leads for economic profits by providing annual and periodic incomes from the multiple outputs and reducing the risks associated with monoculture farming [21]. Agroforestry systems have also the ability to enhance the resilience against adverse impacts of climate change and provide a unique opportunity to combine the twin objectives of climate change adaptation and mitigation [22]. Thus, the several positive impacts of agroforestry systems on many aspects such as ecology, environment, aesthetics, culture, social and economic status of farmers which practicing agroforestry in the subtropical region of Himalaya as well as other parts of the world.

#### 4. CONCLUSION

From the present research study, six different agroforestry systems were identified and out of

them agri-silvi-culture and agri-silvi-horticulture systems were the most prevalent. The average family size was found to be 5.59 persons per family with the overall sex ratio of 904 females per thousand males. Men were more literate than women and majority of the family heads were literate which indicated more enthusiasm to implement modern agroforestry technologies. Thus, small scale agroforestry viz., Agri-silvi-horticulture system in the subtropical region of Himachal Pradesh is recommended for social, economical and environmental benefits to the rural population for their livelihood and food security in the climate change era.

#### DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during writing or editing of manuscripts.

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#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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