



Inventory and Composition of Prevalent Agroforestry Systems of Kashmir Himalaya

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Authors' contributions

This work was carried out in collaboration between all authors. Authors MD and KNQ designed the study and wrote the first draft of the manuscript. Authors SA and AAW managed the analysis of the study and finalized the interpretation. All authors read and approved the final manuscript.

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ABSTRACT

Agroforestry, which is the inclusion of woody perennials in farming systems, has been practiced as traditional land use and livelihood option in Jammu and Kashmir state of India since time immemorial. In the present investigation, Ganderbal district of Kashmir valley was selected with the objective to study the indigenous and prevalent agroforestry systems. The geographical area of the district is 39304 hectare, under which paddy is grown at about 8600 ha, wheat 50 ha, pulses 600 ha vegetables 1100 ha, fodder 3429 ha, oil seeds 3727 ha area. The cropping pattern is (paddy, maize, vegetables, and pulses) in kharif and oil seeds, oats, wheat and vegetables in rabi. Agroforestry systems have been classified according to the components present – trees with crops are referred to as *silvoarable* or *agrisilviculture*, trees and pasture as *silvopastoral*, fruit trees and crops as horti-agriculture, fruit trees with pasture as hortipastoral and trees with crops and animals as *agro-silvopastoral*. A total of eight agroforestry systems, including, home gardens, horti-

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agriculture, boundary plantation, horti-silvi-pasture, horti-silviculture, horti-silvi-agriculture, silvopastoral and hortipastoral systems were reported from the study area. Among the woody perennials, the highest preference was for fruit-yielding tree species.

Keywords: Inventory, composition; Agroforestry systems; Ganderbal; Kashmir.

1. INTRODUCTION

Integrating trees into the agricultural landscape has the potential to impact the local economy through increasing economic stability, diversification of local products and economies, diversification of rural skills, improved food and fuel security, improvements to the cultural and natural environment, and landscape diversification. Agroforestry is one of the sustainable approaches to land-use management where both agriculture and forestry combine into an integrated production system to get maximum benefits [1-2]. As per World Agroforestry Centre, "agroforestry is a deliberate integration of woody components with agricultural and pastoral operations on the same piece of land either in a spatial or temporal sequence in such a way that both ecological and economic interactions occur between them". There are more than 2000 tree species used in agroforestry [3]. According to a report of the world, around 1.2 billion rural people currently practice agroforestry the world over [4].

In this era of global warming, fast degradation of land productivity and other environmental hazards, agroforestry is indeed a stake for natural resources and socio-economic sustainability [5]. Agroforestry, like multifunctional agriculture, has the objective of promoting economically, socially, and environmentally sustainable rural development [6]. Agroforestry provides opportunities to increase the value of total production through marketing of multiple products from a given unit of land [7].

Traditional agroforestry systems, combining trees and shrubs with crop and livestock production have sustained farmers for generations. Agroforestry solutions are often location specific in their relevance, performance and farmer acceptability [8]. Traditional agroforestry systems which are time tested provide useful information for further improvement and extension to larger areas. Such information can also be used as basis for raising planting stock for agroforestry activities. Hence, documenting existing agroforestry systems in a given area is of greater importance [9].

Agroforestry is a permanent feature of agricultural landscape of Kashmir Himalaya. The farmers have integrated crops, trees and animals in their farming and land management systems reasonably for solving the problem of acute shortages of fuel wood, fodder and other produce. The management of lands in the Kashmir valley by growing multipurpose trees species and intercropping understory crops and fruits, livestock raising and protection of adjacent forests for variety of services is an adaptive century-old indigenous practice of the rural communities [10-12]. Since the scientific information on temperate agroforestry systems have been disproportionately lower in view of the general perception that they are low productive, these systems are seldom debated in research forums, government policies for their improvement despite providing sustenance to a large section of society. It is therefore, highly desirable to take up a comprehensive study regarding the traditional and prevalent agroforestry systems of Kashmir Himalaya.

2. MATERIALS AND METHODS

2.1 Study Area

District Ganderbal is located on the north side of world famous Srinagar city of Kashmir valley at an elevation of 1650 to 3000 meters above Mean Sea Level (MSL). It is flanked by district Baramulla in the west, district Srinagar in the south, newly created district Bandipora in the north-west, Arohoma forest in the north and district Kargil in the east. The district is located between 34.23°N Longitude and 74.78°E Latitude [13]. It covers a total area of 39304 thousand hectares. Out of this area, 18.12 thousand hectares is cultivated land, 0.988 thousand hectares under forests, 8.43 is under horticulture, 4.8 thousand hectares comes under barren and marshy lands, 1.67 thousand hectares as permanent pastures and 13.23 is under miscellaneous tree crops and other fallows. Agriculture in Ganderbal is the main occupation as more than 80% of the working population is engaged with it, thus making this district as one of the important districts of Jammu and Kashmir. The district has unique agro

climatic conditions, which allows cultivation of not only major fruit crops like apple, pear, cherry, walnut, but also rare and special fruits like grapes, strawberry etc. District Ganderbal consists of six tehsils Gund, Kangan, Ganderbal, Wakura, Lar, Tulmullah and seven blocks Lar, Ganderbal, Kangan, Wakura, Sheripathri, Safapora. It has been further divided into 112 panchayat halqas comprising 136 villages [14].

2.2 Climate

The climate of the region is moist temperate with mean annual precipitation of 730 mm received generally in the form of snow in winter and rains in March to June. The mean temperature of 13.3°C with maximum reaching upto 35°C in summer and may dip to -10°C in winter is generally experienced.

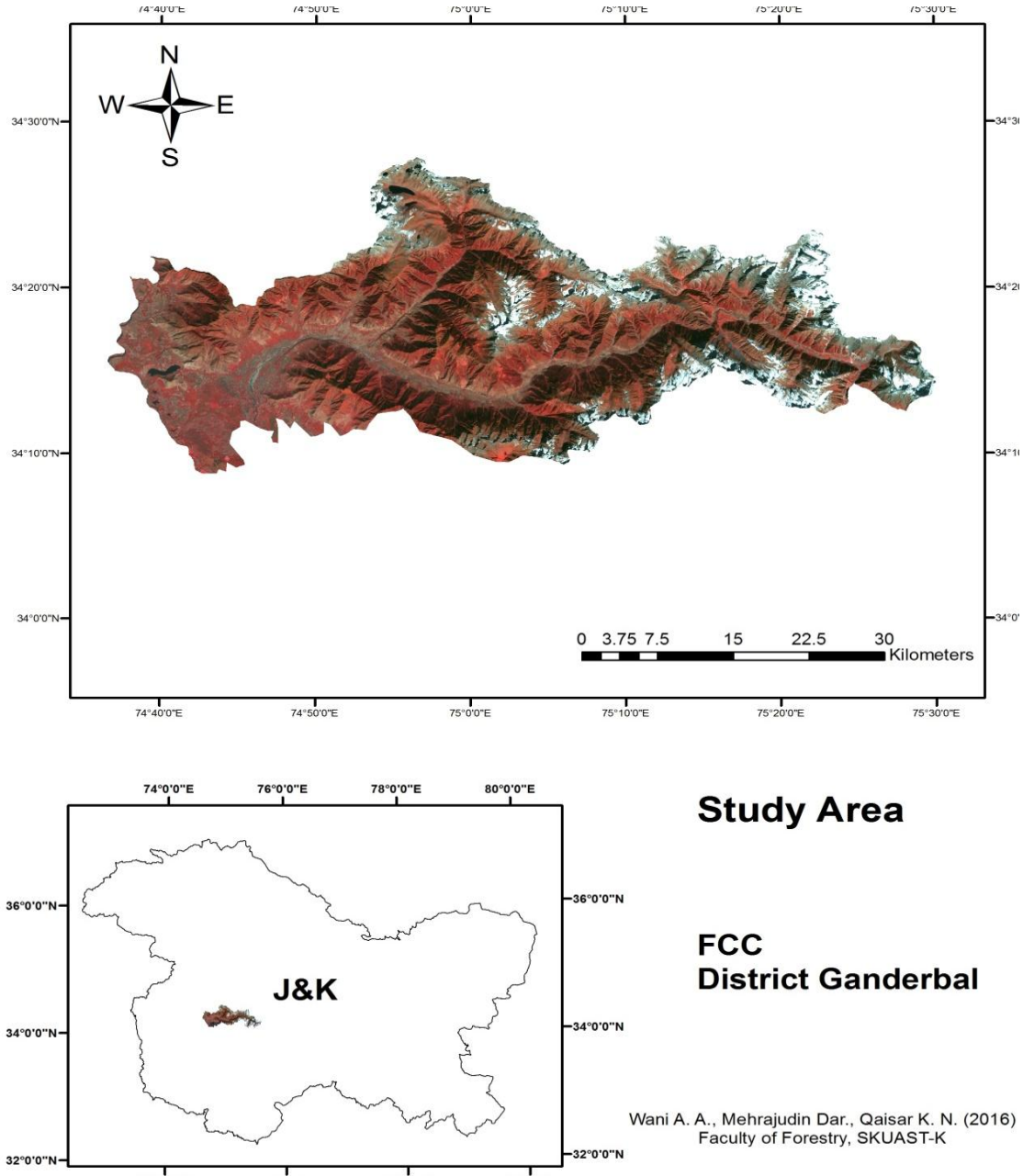


Fig. 1. False colour composite imagery of the study area

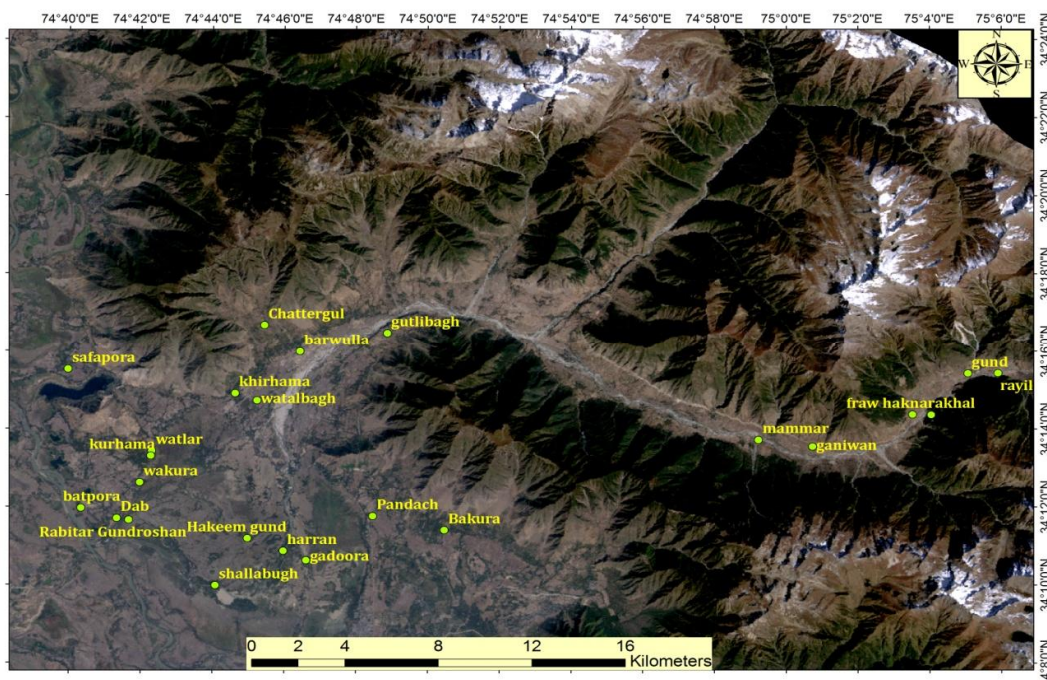


Fig. 2. Selected villages of district Ganderbal

2.3 Experimental Details

Survey based identification of prevalent agroforestry systems of District Ganderbal was carried out using multistage stratified sampling through random selection procedures, as shown

in the Table 1. Out of six tehsils, one block in each tehsil, four villages in each block and 8 farmers in each village were selected to carry out the investigation. A total of 192 farmers were selected and interviewed through pre-tested questionnaires.

Table 1. Selection of farmers

Tehsils →	Gund	Kangan	Lar	Wakura	Tullmullah	Ganderbal
Blocks (01) per tehsil	1	1	1	1	1	1
Villages (04 per block)	(4x1) 4	(4x1) 4	(4x1) 4	(4x1) 4	(4x1) 4	(4x1) 4
Farmers (08 per village)	(8x4)=32	(8x4) =32	(8x4)=32	(8x4)= 32	(8x4)=32	(8x4)=32

Table 2. Distribution of farmers across Ganderbal district for identification of prevalent agroforestry System

Tehsil	Block	Marginal	Small	Medium	Large	Total
Gund	Gund	21	10	1	-	32
Kangan	Kangan	18	8	3	3	32
Lar	Lar	19	8	5	-	32
Wakura	Wakura	19	8	4	1	32
Tullmullah	Tullmullah/sheripathri	21	9	2	-	32
Ganderbal	Ganderbal	17	12	2	1	32
Total	-	115	55	17	5	192
		(59.8)	(28.64)	(8.85)	(2.60)	

Figures in parenthesis represent % age of the total sample (192)

Table 3. Various agroforestry systems identified and their components across the study area

S. no.	Nature of system	Tree component	Fruit tree component	Crop component	
				Kharif	Rabi
1	Home gardens	<i>Salix, Poplar, Ulmus wallichiana, Robinia pseudoacacia, Ailanthus altissima, Aesculus indica, Morus alba</i>	<i>Punica granatum, Malus spp, Prunus persica, Prunus amygdalus, Vitis vinifera, Prunus avium, Juglans regia</i>	spinach, knol khol, carrot, kale, cauliflower, maize, Brinjal	Pea, Onion, garlic, Oat, Mustard, kale, Turnip, raddish, cabbage, Brassica,
2	Horti-agriculture	–	<i>Malus spp, Prunus persica, Prunus amygdalus, Vitis vinifera, Prunus avium</i>	Beans, knol-khol, chillies, potato tomato, Kale, maize	Oats, Mustard, , Kale, Turnip, knol-khol, Radish
3	Boundary planataion	<i>Salix alba, Populus deltoides, Ulmus wallichiana, Aesculus indica</i>	–	Rice	Oats/mustard
4	Horti-silvi-pasture	<i>Salix spp, poplar spp, R. pseudoacacia, U. wallichiana, A.altissima</i>	<i>Malus spp, Prunus amygdalus, Prunus species, Vitis vinifera, punica granatum</i>	<i>Trifolium repens, Trifolium pratense, Aegilops tauschii, Amaranthus spp, Echinochola crus-galli, Lolium perenne, Bromus japonicus, Avena sativa, Lolium multiflorum</i>	
5	Agri-silviculture	<i>Poplar. Salix spp, U.wallichiana, Aesculus indica, etc.</i>	–	Brinjal, chillies, potato, Beans	Mustard, garlic, onion, turnip, raddish, peas, knol-khol ,cabbage
6	Horti-silvi-agriculture	<i>P.deltoides, Salix alba, U.wallichinia, P.n igma, R.pseudoac acia, A.altissima</i>	<i>Juglans.regia, Malus spp, Prunus species, P.amygdalus</i>	knol khol, cucumber, cabbage,spinach,	Oats Mustard, garlic, onion, turnip, raddish, peas
7	Hortipastoral	-	<i>Malus spp, Prunus amygdalus, Prunus species, vitis vinifera, punica granatum etc.</i>	<i>Trifolium repens, Trifolium pratense, Aegilops tauschii, Amaranthus spp, Echinochola crus-galli, Lolium perenne, Bromus japonicus, Avena sativa, Lolium multiflorum</i>	
8	Silvopastoral	<i>Salix alba, Populus deltoides, Ulmus wallichiana, Aesculus indica, Pinus wallichiana, Cedrus deodara, Abies pindrow etc</i>	-	<i>Trifolium repens, Trifolium pratense, Aegilops tauschii, Amaranthus spp, Echinochola crus-galli, Lolium perenne, Bromus japonicus, Avena sativa, Lolium multiflorum, Agrostis spp., Poa spp., Phleum spp., Bromus inermis, Cynodon dactylon</i>	

3. RESULTS AND DISCUSSION

Agroforestry systems have been classified according to the components present – trees with crops are referred to as silvoarable or agrisilviculture, trees and pasture as silvopastoral, fruit trees and crops as horti-agriculture, fruit trees with pasture as hortipastoral and trees with crops and animals as agro-silvopastoral. A total of eight agroforestry systems, including, homegardens, horti-agriculture, boundary plantation, horti-silvi-pasture, horti-silviculture, horti-silvi-agriculture, silvopastoral and hortipastoral systems were reported from the study area. Among the woody perennials, the highest preference was for fruit yielding tree species. The state of Jammu and Kashmir, especially the valley of Kashmir has a rich diversity of traditional agroforestry models which are in existence since time immemorial [15]. Various agroforestry practices identified in our study are briefly discussed as:

3.1 Home Gardens

Homegarden is commonly defined as; land use system involving deliberate management of multipurpose trees and shrubs in intimate association with annual and perennial agricultural crops and invariably livestock within the compounds of individual houses, the whole tree-crop, and animal unit is being intensively managed by family labour [16]. The most popular system in both the rural and urban areas owing to marginal land holdings were home garden agroforestry systems. Homegardens in Ganderbal represented a subsistence land-use system, where interaction and intimate association of different production components (crop-tree-pasture) in situ were intensively facilitated and managed by family labour so as not only to meet the food production but also to generate additional income through sale of farm surplus. This interaction and intimate association made it ever evolving and added significance to the structure of homegardens. This system was very vibrant with farmers who had land holdings of less than 0.1 ha, just in and around their dwellings or away from home. Farmers grow fruit and forest trees with cereals and vegetable crops during rabi and kharif seasons. The commonly found tree species in this system were *Salix alba*, *Populus deltoides*, *Populus nigra*, *Robinia pseudoacacia*, *Ailanthus altissima*, *Morus alba* at very close spacing in single or double rows. The fruit trees included pomegranate, apple, cherry, pear, almond, plum, peach and grapes.

Vegetables were grown in the interspaces of fruit trees and include turnips, radish, cabbage, spinach, knol khol, kale, garlic, carrot, onion, potato, beans, chilli, tomato and brinjal. The diversity of these systems was very high practiced usually for home consumption and the source are labour were family members. Generally home gardens refer to the cultivation of a small portion of land which may be around the household or within walking distance from the home [17]. Home gardens can be described as a mixed cropping system that encompasses vegetables, fruits, plantation crops, spices, herbs, ornamental and medicinal plants as well as livestock that can serve as a source a supplementary source of food and income [18].

3.2 Horti-Agriculture

The vegetable crops, like, spinach, turnip, radish, carrot, beans, knol-khol, kale, cabbage, cauliflower and brinjal were cultivated under fruit trees especially apple in the alleys. This system was practiced in the areas where irrigation facility was available round the year. About 60.94% of the total farmers studied in the area adopted this system. Vegetables were grown when the fruit trees were in juvenile stage and thereafter grasses and legumes were allowed to grow in the interspaces, which provided fodder for the livestock. It was also observed that in some established orchards, *Avena sativa* (oats) was grown in winter season.

3.3 Boundary Planation (BP)

This is one of the oldest traditional systems practiced around the paddy fields. Farmers preferred to have the trees on the bunds of the field. The boundary planation is also available alongside the road and canal/irrigation channels and in the proximity of the agriculture fields to provide multifarious products in the form of fuel, fodder and small timber. Willows are preferred around the irrigation channels whereas, *Populus deltoides*, *Populus nigra*, *Populus balsamifera* find place on other available lands at different spacings. Oats and mustard are sown during the winter season. In some places, these tree species occurred in the form of small groves and woodlots in the cultivated fields.

3.4 Horti-silvi-pasture

This agroforestry practice had all the components of horti-silviculture system along with some forage species. Farmers preferred grasses like *Avena sativa* (oats),

Trifolium repens, *Trifolium pratense*, *Aegilops tauschii*, *Echinochola crus-galli*, *Lolium perenne*, *Bromus japonicus*, *Lolium multiflorum* in addition to multipurpose trees on their farms.

3.5 Horti-silviculture

The main motive of the system was fruit production. Multipurpose trees were raised on all sides of the orchard in single or paired rows along the boundary at closer spacings. The trees planted around the orchards provide wind protection to fruit trees besides providing fuel wood, fodder and small timber. The notable tree species included *Salix alba*, *Populus deltoides*, *Populus nigra*, *Robinia pseudoacacia*, *Ailanthus altissima*, *Morus alba*. These trees were regularly lopped and pollarded to serve as live- fence posts.

3.6 Horti-silvi-agriculture

The system was practiced in places where orchards were located either on terraces or flat lands with round the year irrigation facility. In this system farmers devote a little area within the orchard for raising vegetables during kharif and rabi seasons for domestic consumption. The vegetables grown were knol khol, cucumber, cabbage, onion, spinach, peas, potato, beans, brinjal, garlic and onion in different seasons. Trees and fruit components were same as that of horti-silviculture.

3.7 Horti-and Silvopastoral Systems

These systems, invariably, were forage based agroforestry systems practiced to supply nutritious fodder for the livestock. These represent agroforestry systems with an animal component. They include a variety of forms of land use and ordinance to achieve greater productivity of the livestock raising unit and are characterized by a combination and interaction of agricultural crops with grasses, shrubs, multiple use trees, and animal husbandry, managed simultaneously or successively in an integrated manner [19]. We observed that pasture component in these systems were low yielding and of less forage quality. There is ample scope for introduction of high yielding pasture grasses and legumes (*Dactylis glomerata*, *Festuca arundinaceae*, *Phalaris spp.*, *Lolium multiflorum*, *Lolium perenne*, *Avena sativa*, *Trifolium pratense*, *Onobrychis viciifolia*, *Trifolium alexandrinum*, *Medicago sativa*) in these traditional agroforestry systems [20].

Agrosilvicultural (cultivation of trees yielding timber, fuelwood, and fodder along with agricultural crops), agrosilvihorticultural (cultivation of trees yielding timber, fuelwood, fodder, and fruit along with agricultural crops), silvopastoral (forest grazing), hortiagricultural (cultivation of agricultural crops along with fruit tree plantations), hortisilvicultural (cultivation of trees yielding fruit, timber, fuelwood, and fodder) and hortipastoral (fruit trees and forage crops) systems are the main forms of traditional agroforestry practiced in Himalayan region [21]. Several agroforestry systems in Kashmir valley have been identified which include boundary plantations, agri-silviculture, horti-silviculture, horti-pasture, horti-silvi-agriculture and kitchen gardens [22]. Adequate representation of all the components is lacking in the systems and in some of the models tree component is far less and utilization of space in these systems is not efficient, besides the yield of agricultural crops is also less. The traditional agroforestry systems of Kashmir have rich agricultural and associated biodiversity, provide multiple ecosystem and production benefits and services and harbour precious socio-cultural values [23].

4. CONCLUSIONS

Our study revealed that farmers are knowledgeable about their environment and they described and listed the uses of various on-farm tree/crop species for the socio-economic development of their households. About 88.44 % farmers practicing agroforestry systems belonged to the marginal and small category. A high level of crop diversity in traditional prevalent agroforestry systems was maintained by rotation of crops in time and space together with the coexistence of mono and mixed cropping practices. Addition of organic waste and ash, better crop management and saving of labour on travel and transport due to proximity to home resulted in higher energy and economic efficiency of the home garden as compared to other agroforestry systems. Agroforestry systems support the production of a wide range of products including food, fuel, fodder, fruit, timber, thatching and hedging materials, gardening materials, medicinal products, craft products, recreation, and ecological services. The role of agroforestry in protecting the environment and providing a number of ecosystem services is a key benefit of integrating trees into farming systems. Other such benefits include regulation of soil, water and air quality, enhancement of biodiversity, climate change mitigation and

adaptation. We believe that more studies are needed to study the social, economic and environmental aspects of traditional agroforestry systems of the state of Jammu and Kashmir. There is an urgent need for consolidation of scientific and technological innovations in temperate agroforestry through intensification of on-farm testing with farmers.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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