

EXISTING AGROFORESTRY SYSTEM AND ITS COMPONENT IN TEHRI DISTRICT OF GARHWAL HIMALAYA

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Abstract

The present study was conducted to investigate the existing agroforestry system and its component along altitudes in traditional agroforestry systems in Tehri district Garhwal Himalaya, India. Three different altitudes were considered: lower (286–1200 m), middle (1200–2000 m) and high altitude (2000–2800 m). All agroforestry components along altitudes were presented including trees, fruit trees and crops. The proportion of trees, fruit trees, and crops were 45.8 %, 22.9 % and 31.2 %, respectively. Total 22 forest tree species, 11 fruit tree species, and 15 crops species were recorded in the study area. The agri-silviculture, agri-horticulture and agri-hortisilviculture were the common agroforestry systems recorded in the region.

Key words: agro-climatic zone, altitudes, crops, *Grewia oppositifolia*, multipurpose tree.

Introduction

Agroforestry is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economic interactions between the different components (Lundgren and Raintree 1982). Agroforestry plays a vital role in the improvement of Indian economy through tangible and intangible benefits. In Garhwal Himalaya, agroforestry is permanent feature of agriculture landscape (Semwal and Maikhuri 1996, Bhatt and

Todaria 1999). It forms integral relationships with the farmer community to supplement fuel, fodder, fruits and fibers, on the one hand and balance the environment on the other. Farmers have common practice to integrate crops, trees, and livestock to solve the problem of acute shortage of fuel, fodder and other goods (Bhatt 2002). The farmers have little opportunities to select the tree species, and therefore, they accept whatever is available on their land (Bhatt et al. 2010). The assortment of trees on the edges of the agricultural field is farmer friendly and compatible. Selection of intercrops depends mainly on edapho-climatic conditions of the area, farmer's need and resource availability (Saroj and Dadhwal 1997). The present investigation is an

effort to examine the existing traditional agroforestry system and its components across different altitude in the Garhwal region of the Central Western Himalaya of Uttarakhand, India.

Materials and Method

The study was conducted in Tehri district of Garhwal Himalaya. The district lies between 30°3' and 30°53' N and 77°56' and 79°04' E, having geographical area of 3,642 km² (FSI 2011) (Fig. 1). The area has

been divided into three main agro-climatic zones: Sub-tropical zone (300–1200 m), Sub temperate zone (1200–2000 m) and Temperate zone (2000–2800 m), depending on the topography, altitude and temperature condition (Singh and Singh 1992). The study was carried out in the agricultural fields, mostly dominated by trees. Out of nine developmental blocks, six were selected in the district, representing three altitudes.

Total thirty villages were included in the present study. They are situated in six developmental blocks: six villages in

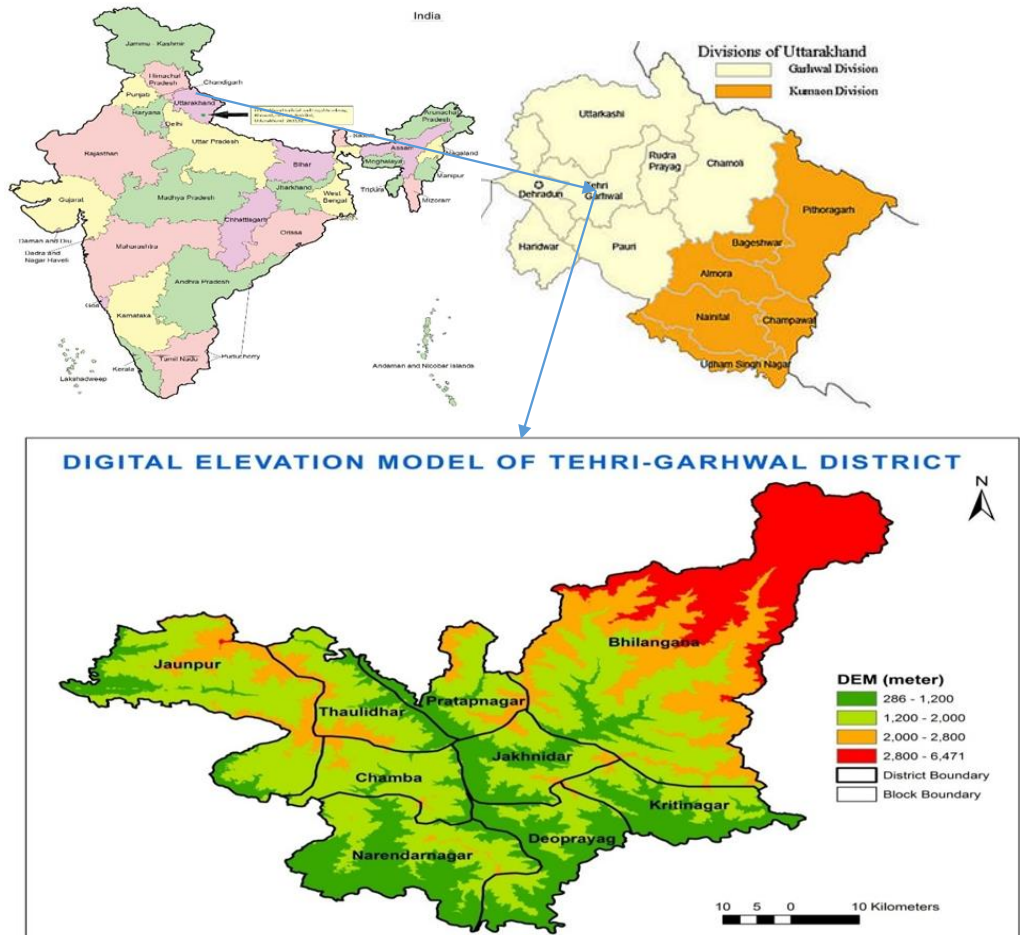


Fig. 1. Geographical location of study area.

Devprayag, Kritinagar, Chamba and four villages in Thauldhar, Jakhnidhar and Pratapnagar, respectively. Regarding the altitude, thirteen villages were within 286–1200 m (designated as lower altitude) and range 1200–2000 m (middle altitude) and four villages – within the range 2000–2800 m (high altitude) (Tables 1 and 2). Field survey was conducted in Kritinagar,

Devprayag, Chamba, Jakhnidhar, Pratapnagar and Thaulidhar blocks in July, 2014 (Table 1). The useful information like name of the village, altitude, GPS location, existing agroforestry system, tree species, and crops was also recorded. In each village, 10 sample plot of 20×10 m² were marked randomly for detailed study in the agroforestry field.

Table 1. Surveyed blocks/villages.

Blocks	Altitudes, m		
	286–1200	1200–2000	2000–2800
Devprayag	Bagi, Grothikhand, Palisen	Langur, Dungi	Jurana
Kritinagar	Maikhandi, Jakhand, Dhaulangi	Timal gaon, Dagar, Riskoti	-
Chamba	Kyari, Pali	Guldi, Purshal	Saur, Chopriyal gaon
Thauldhar	Dharwal, Jaspur	Indra, Sonara	-
Jakhnidhar	Raswari, Undoli	Manthal, Chah	-
Pratapnagar	Bausari	Kothaga, Kandakhal	Kualgarh

Results and Discussion

Based on the field survey, the common existing agroforestry systems in Garhwal Himalaya appeared to be agrisilviculture (trees and agricultural crops), agrihorticulture system (edible fruit trees and agriculture crops), and agrihortisilviculture system (trees including edible fruit trees, forest trees and agricultural crops) (Table 2). In the Himalayan region, a number of indigenous agroforestry systems have been known from Himachal Pradesh and Uttarakhand (Atul and Khosla 1990) out of which agrihortisilviculture, agrisilviculture and agrihorticulture are very frequent. Dadhwal et al. (1989) and Toky et al. (1989) have recognized these three agroforestry systems with their multifarious benefits.

Table 2 indicates that the proportion of forest trees, fruit trees, crops are found 45.8 %, 22.9 % and 31.2 % respectively. Total 22 forest tree species, 11 fruit tree species, and 15 crops were recorded in the study area. At middle Himalayan

altitude, tree species like *Grewia oppositifolia* Roxb., *Celtis australis* L., *Melia azedarach* L., *Morus alba* L., *Prunus cerasoides* D. Don, *Musa paradisiaca* L., *Celtis australis* L., *Ficus palmata* Forssk., *Pinus roxburghii* Sargent, *Bauhinia variegata* L., *Mangifera indica* L. were common along 1200–2000 m. In lower Himalayan altitude, *Adina cordifolia* (Roxb.) Hook. f. ex Brandis, *Mangifera indica*, *Citrus limon* (L.) Burm. f., *Artocarpus heterophyllus* Lam., *Anogeissus latifolia* (Roxb. ex DC.) Wallich ex Richard, *Cassia fistula* L., *Melia azedarach*, *Bauhinia variegata*, *Ficus palmata*, *Syzygium cumini* (L.) Skeels were common along 286–1200 m. *Grewia oppositifolia* was one of the species thriving in the diverse altitudinal range. In high Himalayan altitude, species like *Quercus leucotrichophora* A. Camus., *Malus domestica* Borkh., *Myrica esculenta* Buch.-Ham., *Juglans regia* L., *Prunus persica* (L.) Batsch., *Grewia oppositifolia* found along 2000–2800 m. In crops, *Echinochloa frumentacea* Link., *Glycine max* (L.) Merr., *Cajanus cajan* (L.) Millsp., *Cur-*

cuma longa L., *Zea mays* L. these are common crops which are cultivated in the field of farmer's along diverse altitudinal range.

Table 2. Existing agroforestry system and its component.

Village	Blocks	Altitudes, m	Agroforestry system	Tree species	Crops
Dungi	Devprayag	1200–2000	Agrisilvi, Agrihorti	<i>Quercus leucotrichophora</i> , <i>Grewia oppositifolia</i> , <i>Melia azedarach</i> , <i>Rhododendron arboreum</i> Sm., <i>Celtis australis</i> , <i>Toona ciliata</i> M. Roem.	<i>Echinochloa frumentacea</i>
Bagi	Devprayag	286–1200	Agrihortisilvi, Agrihorti, Agrisilvi	<i>Adina cordifolia</i> , <i>Mangifera indica</i> , <i>Citrus limon</i> , <i>Artocarpus heterophyllus</i>	<i>Echinochloa frumentacea</i>
Langur	Devprayag	1200–2000	Agrisilvi, Agrihortisilvi	<i>Grewia oppositifolia</i> , <i>Celtis australis</i> , <i>Pyrus communis</i> L., <i>Ficus roxburghii</i> Wall., <i>Prunus cerasoides</i> , <i>Musa paradisiaca</i>	<i>Glycine max</i> , <i>Brassica campestris</i> L., <i>Solanum melongena</i> L., <i>Colocasia antiquorum</i> L.
Gorthikanda	Devprayag	286–1200	Agrisilvi, Agrihortisilvi	<i>Grewia oppositifolia</i> , <i>Anogeissus latifolia</i> , <i>Cassia fistula</i> , <i>Melia azedarach</i> , <i>Psidium guajava</i> L.	<i>Vigna mungo</i> (L.) Hepper, <i>Cajanus cajan</i>
Palisen	Devprayag	286–1200	Agrisilvi, Agrihortisilvi	<i>Grewia oppositifolia</i> , <i>Adina cordifolia</i> , <i>Morus alba</i>	<i>Cajanus cajan</i>
Jurana	Devprayag	2000–2800	Agrisilvi	<i>Quercus leucotrichophora</i>	<i>Zea mays</i> , <i>Brassica campestris</i>
Timal gaon	Kritinagar	1200–2000	Agrisilvi, Agrihortisilvi	<i>Grewia oppositifolia</i> , <i>Toona ciliata</i> , <i>Syzygium cumini</i> , <i>Mangifera indica</i>	<i>Amaranthus spinosus</i> L., <i>Glycine max</i> , <i>Zea mays</i> , <i>Echinochloa frumentacea</i>
Dagar	Kritinagar	1200–2000	Agrihortisilvi	<i>Ficus bengalensis</i> L., <i>Melia azedarach</i> , <i>Citrus sinensis</i> (L.) Osbeck, <i>Prunus cerasoides</i> , <i>Juglans regia</i> , <i>Toona ciliata</i> , <i>Musa paradisiaca</i>	<i>Echinochloa frumentacea</i> , <i>Vigna mungo</i> , <i>Curcuma longa</i>
Maikhandi	Kritinagar	286–1200	Agrisilvi, Agrihortisilvi	<i>Grewia oppositifolia</i> , <i>Toona ciliata</i> , <i>Celtis australis</i> , <i>Melia azedarach</i> , <i>Musa paradisiaca</i> , <i>Bauhinia variegata</i> , <i>Ficus palmata</i>	<i>Curcuma longa</i> , <i>Vigna mungo</i> , <i>Echinochloa frumentacea</i>

Riskoti	Kritinagar	1200–2000	Agrisilvi, Agrihortisilvi	<i>Grewia oppositifolia</i> , <i>Ficus roxburghii</i> , <i>Prunus cerasoides</i> , <i>Bauhinia variegata</i> , <i>Celtis australis</i> , <i>Mangifera indica</i>	<i>Vigna mungo</i> , <i>Glycine max</i> , <i>Zea mays</i> , <i>Amaranthus spinosus</i>
Jakhand	Kritinagar	286–1200	Agrisilvi, Agrihortisilvi	<i>Celtis australis</i> , <i>Toona ciliata</i> , <i>Grewia oppositifolia</i> , <i>Citrus limon</i> , <i>Psidium guajava</i> , <i>Celtis australis</i>	<i>Vigna mungo</i> , <i>Glycine max</i> , <i>Zea mays</i> , <i>Amaranthus spinosus</i>
Dhaulangi	Kritinagar	286–1200	Agrisilvi, Agrihortisilvi	<i>Ficus roxburghii</i> , <i>Pinus roxburghii</i> , <i>Syzygium cumini</i> , <i>Celtis australis</i> , <i>Toona ciliata</i> , <i>Melia azedarach</i>	<i>Amaranthus spinosus</i>
Kyari	Chamba	286–1200	Agrisilvi, Agrihortisilvi	<i>Grewia oppositifolia</i> , <i>Celtis australis</i> , <i>Prunus cerasoides</i> , <i>Quercus leucotrichophora</i>	<i>Vigna mungo</i> , <i>Echinochloa frumentacea</i> , <i>Zea mays</i>
Purshal	Chamba	1200–2000	Agrisilvi, Agrihortisilvi	<i>Grewia oppositifolia</i> , <i>Celtis australis</i> , <i>Prunus cerasoides</i> , <i>Quercus leucotrichophora</i>	<i>Vigna mungo</i> , <i>Echinochloa frumentacea</i> , <i>Zea mays</i>
Chaupriyal Gaon	Chamba	2000–2800	Agrihortisilvi	<i>Quercus leucotrichophora</i> , <i>Malus domestica</i> , <i>Pyrus communis</i>	<i>Echinochloa frumentacea</i>
Pali	Chamba	286–1200	Agrihortisilvi	<i>Juglans regia</i> , <i>Prunus armeniaca</i> L., <i>Prunus persica</i>	<i>Echinochloa frumentacea</i>
Guldi	Chamba	1200–2000	Agrihortisilvi	<i>Celtis australis</i> , <i>Grewia oppositifolia</i> , <i>Ficus palmata</i> , <i>Morus alba</i>	<i>Vigna mungo</i> , <i>Zea mays</i>
Saur	Chamba	2000–2800	Agrihortisilvi	<i>Malus domestica</i> , <i>Myrica esculenta</i> , <i>Juglans regia</i>	<i>Vigna mungo</i>
Dharwal	Thauldhar	286–1200	Agrihortisilvi, Agrisilvi	<i>Grewia oppositifolia</i> , <i>Ficus roxburghii</i> , <i>Bauhinia variegata</i> , <i>Melia azedarach</i>	<i>Echinochloa frumentacea</i> , <i>Glycine max</i>
Jasipur	Thauldhar	286–1200	Agrisilvi	<i>Grewia oppositifolia</i> , <i>Pinus roxburghii</i> , <i>Pyrus pashia</i> , Buch.-Ham. ex D. Don.	<i>Brassica campestris</i> , <i>Colocasia antiquorum</i> Schott
Indra	Thauldhar	1200–2000	Agrisilvi	<i>Melia azedarach</i> , <i>Celtis australis</i> , <i>Albizia lebbek</i> , L., <i>Ficus auriculata</i> Lour.	<i>Vigna mungo</i> , <i>Zea mays</i> , <i>Amaranthus spinosus</i>
Sonara	Thauldhar	1200–2000	Agrisilvi	<i>Pinus roxburghii</i> , <i>Celtis australis</i> , <i>Albizia lebbek</i> , <i>Ficus auriculata</i>	<i>Vigna mungo</i> , <i>Zea mays</i> , <i>Glycine max</i> , <i>Amaranthus spinosus</i>

Raswari	Jakhnidhar	286–1200	Agrisilvi	<i>Pyrus pashia</i> , <i>Celtis australis</i> , <i>Grewia oppositifolia</i> , <i>Melia azedarach</i> , <i>Prunus cerasoides</i>	<i>Glycine max</i> , <i>Amaranthus spinosus</i> , <i>Zea mays</i> , <i>Echinochloa frumentacea</i>
Undoli	Jakhnidhar	286–1200	Agrisilvi	<i>Melia azedarach</i> , <i>Ficus auriculata</i> , <i>Celtis australis</i>	<i>Echinochloa frumentacea</i>
Manthal	Jakhnidhar	1200–2000	Agrisilvi	<i>Grewia oppositifolia</i> , <i>Melia azedarach</i> , <i>Celtis australis</i>	<i>Amaranthus spinosus</i>
Chah	Jakhnidhar	1200–2000	Agrisilvi, Agrihorti	<i>Grewia oppositifolia</i> , <i>Celtis australis</i>	<i>Amaranthus spinosus</i>
Kaulgarh	Pratapnagar	2000–2800	Agrisilvi, Agrihorti	<i>Grewia oppositifolia</i> , <i>Malus domestica</i> , <i>Juglans regia</i> , <i>Prunus persica</i>	<i>Zea mays</i> , <i>Pisum sativum</i> , <i>Sesamum orientale</i>
Kotagha	Pratapnagar	1200–2000	Agrisilvi	<i>Grewia oppositifolia</i> , <i>Pyrus pashia</i> , <i>Melia azedarach</i>	<i>Echinochloa frumentacea</i>
Kandakhal	Pratapnagar	1200–2000	Agrisilvi	<i>Grewia oppositifolia</i> , <i>Melia azedarach</i>	<i>Echinochloa frumentacea</i>
Bausari	Pratapnagar	286–1200	Agrisilvi	<i>Grewia oppositifolia</i> , <i>Pyrus pashia</i> , <i>Melia azedarach</i>	<i>Echinochloa frumentacea</i>

Conclusion

The varying topography of the Tehri district affects its species diversity, composition and structure along the altitudes, even at small distances. Moreover, the exposition in the hilly topography also plays an important role in the vegetation pattern. The studies showed that agroforestry systems consist predominantly of multipurpose tree species and horticulture tree species. The present study compiles the list of such tree species including crops, which are present in the agriculture fields of the farmers along variable altitudinal range. The documentation of these multipurpose trees and agroforestry practices may be helpful for introducing them in other areas in the same agro-climatic zone.

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