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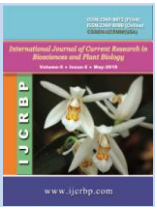

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Presence of Trees under Agroforestry Systems along Altitude in Gangotri Valley of Garhwal Himalaya, India

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ABSTRACT

In this study, the tree species found on farm lands under agroforestry systems in different villages of Gangotri valley along altitude was documented. The three altitudinal range *viz.,* lower (1000-1500 m), middle (1500-2000 m) and higher (2000-2500 m) were studied. The higher diversity was recorded in forest tree species (29 species with 18 families) compared to horticulture trees (17 species with 10 families). Among forest trees, gymnosperms were represented by five species (three families) and angiosperms by 24 species (15 families). Maximum number of forest trees were found in mid-altitudinal range (18 species), whereas in horticulture trees the highest presence was observed in lower altitude (14). In the forest trees, 2 species yield fiber, 4 ornamentals, 5 edibles, 10 recognized with medicinally important, 12 have other uses, 15 as fodder, 18 as timber and 23 for fuel-wood purpose. Fruits of all the horticulture trees are mostly edible but some time used for other domestic purpose too. Both forest and horticultural tree were reported to have significant importance to the local people.

Introduction

After food crop, the second place comes for trees because trees are also source of innumerable services. Trees are also a part of diverse agroforestry systems and traditional agroforestry systems have been practiced in Garhwal region of Uttarakhand since early period (Iqbal et al., 2014; Gupta and Arora, 2015). Agroforestry is an effective practice to improve farmer livelihood and simultaneously increasing the green cover of the area. The present study was an attempt to enlist the different forest and horticulture tree species growing on agriculture field under agroforestry.

Materials and methods

The study was conducted along altitudinal changes in Gangotri valley (Uttarkashi distict) of Garhwal Himalaya, India. Six villages namely, Siror (1394 m) and Netala (1459 m) in the lower altitude, Silla

(1765 m) and Malla (1837 m) in middle and Jhalagaon (2213 m) and Sukkhi (2500 m) in higher altitude were selected according to varying altitudinal ranges (lower altitude 1000-1500m, middle altitude 1500-2000 m and higher altitude 2000-2500 m). Random quadrats were laid in different areas according to species area curve during 2016-2017.

Results and discussion

In the present study, 29 species of forest trees were observed as agroforestry tree species comprising 18 families, out of which five species were of gymnosperms (three families) and 24 species (15 families) were of angiosperms (Table 1). In horticulture trees, there were 17 species (10 families). Middle (18 species) altitude region showed highest number of forest tree species followed by lower (16) and higher (6) altitude, whereas, in horticulture trees, lower (14 species) altitude showed greatest species diversity followed by middle (8) and higher (5) altitude region (Table 2). Some forest tree species were restricted to particular altitude region, where middle (9 species) altitude shows greatest confinement trailed by lower (7) and higher (3) altitude region. Among horticultural trees, lower altitude depicted highest number of restricted species (9), whereas, middle and higher altitude showed no species restriction. Seven forest tree species were observed in both lower-middle altitude regions namely, *Celtis australis*, *Grewia optiva*, *Jacaranda mimosifolia*, *Melia azedarach*, *Populus ciliata*, *Quercus leucotrichophora*, *Toona ciliata* and only one (*Pistacia integerrima*) species in middle-higher altitude region (Table 1). One peculiar species was *Cedrus deodara* which was observed in lower and higher altitude region, but not in middle altitude region. The most widely distributed species was *Pinus roxburghii*, which was observed in all three altitude regions.

Table 1. Forest Trees under Agroforestry system along elevation.

Family	Species	Vernacular name	English name	Uses	Elevation
Gymnosperms					
Cupressaceae	*Cupressus torulosa* D.Don. ex Lamb.	Surai	Himalayan Cypress	Wood is used as fuel and highly durable for timber	L
Pinaceae	*Cedrus deodara* (Roxb.) G. Don	Devdar	Deodar Cedar	Wood is durable timber and used in altar making for Homa (Havan) in religious ceremonies/ rituals	L, H
	Pinus roxburghii Sarg.	Chir	Chir-Pine	Seeds are eaten, wood is used as fuel and timber, turpentine obtained from sapwood, Leaf Needles used to make organic manure, surface roots contain ecto-mycorrhizae thus prevents leaching of phosphorous	L, M, H
	P. wallichiana A. B. Jacks.	Kail	Himalayan Blue Pine	Seeds are eaten, wood used as fuel and timber, turpentine obtained from sapwood, leaves used as animal bedding, surface roots contain ecto-mycorrhizae thus prevents leaching of phosphorous	H
Taxaceae	*Taxus wallichiana* Zucc.	Thuner	Himalayan yew	Wood is used as fuel and incense, wood has medicinal value	H

Family	Species	Vernacular name	English name	Uses	Elevation
Angiosperms					
Anacardiaceae	*Pistacia integerrima* J.L. Stewart ex Brandis	Kathkankad	Zebrawood	Leaves are used as fodder, wood used as fuel and timber, plant is medicinally important	M, H
Betulaceae	*Alnus nepalensis* D. Don.	Utis	Alder	Leaves used as fodder, wood as fuel and timber, plant fix N_2 through symbiotic association with actinomycete forming root nodules (*Frankia*)	M
Bignoniaceae	*Jacaranda mimosifolia* D. Don.	Neeli Gulmohar	Jacaranda	Wood used as fuel, plant is medicinally important, grown for ornamental purpose	L, M
Ericaceae	*Lyonia ovalifolia* (Wall.) Drude	Ainyaar	Oval Leaved Lyonia	Wood used as fuel and timber	M
	Rhododendron arboreum Sm.	Buransh	Tree Rhododendron	Wood is used as fuel, flowers has medicinal importance, used to make squash, jams, pickles, and offered to deities	M
Fabaceae	*Bauhinia purpurea* L.	Guriyal	Purple Bauhinia	Leaves are used as fodder, wood used as fuel and timber, grown for ornamental purpose also	L
	B. variegata (L.) Benth.	Kachnar	Orchid tree	Leaves are used as fodder and used to make eating plates (‘pattal’ & ‘dona’), wood used as fuel and timber, grown for ornamental purpose	L
	Erythrina variegata L.	Pangar	Indian coral tree	plant is medicinally important, grown for ornamental purpose	M
Fagaceae	*Querucs floribunda* Lindl. ex A. Camus	Moru	Green Oak	Leaves used as fodder, wood used as fuel, timber and used to make handles for agriculture implements	M
	Q. leucotrichophora A. Camus	Banjh	White Oak	Leaves used as fodder, wood used as fuel, timber and used to make handles for agriculture implements	L, M
	Q. semecarpifolia Sm.	Kharsu	Brown Oak	Leaves used as fodder, wood used as fuel, timber	M
Lauraceae	*Persea odoratissima (Nees) Kosterm.*	Kawla	Fragrant Bay Tree	Wood used as fuel, plant is medicinally important	M
Malvaceae	*Bombax ceiba* L.	Semal	Kapok, Red Silk Cotton	Flower buds are edible, fibres are obtained from inner fruit wall	L
Meliaceae	*Melia azedarach* L.	Dainkan, Bakain	China Berry	Leaves used as fodder, wood used as fuel and timber	L, M
	Toona ciliata M. Roem.	Toon	Red Cedar	Leaves used as fodder, wood used as fuel and timber, plant is medicinally important	L, M

Family	Species	Vernacular name	English name	Uses	Elevation
Moraceae	*F. palmata* Forssk.	Bedu	Wild Himalayan Fig	Fruit is edible, leaves used as fodder	M
	F. religiosa L.	Peepal	Sacred Fig	Fruit is edible, leaves used as fodder and in religious ritual, wood used as fuel	L
Myrtaceae	*Eucalyptus* sp.	Neelgiri	Eucalypt	Wood is used as fuel and timber, plant is medicinally important	L
Salicaceae	*Casearia tomentosa* Roxb.	Chhila	Toothed Leaf Chilla	Plant is medicinally important	M
	Populus ciliata Wall. ex Royle	Van Peepal	Himalayan Poplar	Leaves used as fodder, wood used as fuel and timber	L, M
Sapindaceae	*Acer acuminatum* Wall. ex D.Don	Kanjal	Tapering Leaf Maple	Leaves used as tea, wood in handles of agriculture implements, plant is medicinally important	H
	Sapindus mukorossi Gaertn	Reetha	Indian Soapberry	Leaves used as fodder, wood used as fuel, fruit pulp used as soap	L
Tiliaceae	*Grewia optiva* J. R. Drumm. ex Burret	Bhimal		Leaves used as fodder, fibre obtained from bark, wood used as fuel, timber, used to make handles of agriculture implements and as torchlight ('Muchala'), bark used as hair wash	L, M
Ulmaceae	*Celtis australis* L.	Khadik	European Hackberry	Leaves used as fodder, wood used as fuel and timber	L, M

Abbreviations: L – lower elevation (1000-1500 m, a.m.s.l.), M – middle elevation (1500-2000 m, a.m.s.l.), H – higher elevation (2000-2500 m, a.m.s.l.), m, a.m.s.l. – meters, above mean sea level

Among, horticulture trees, three species showed distribution in lower-middle altitude region *viz.*, *Citrus aurantium, C. sinensis* and *Ficus auriculata*, three species in middle-higher region – *Malus pumila, Prunus armeniaca* and *Pyrus communis* while, only one species was observed in all the three altitudes – *Prunus persica* (Table 2).

In forest trees, 23 species yield fuel-wood, 18 timbers, 15 fodder, 12 have other uses, 10 have medicinal importance, five are edible, four are ornamental and two yield fiber. In the edible species, the economically important part is flower bud (1 species), fruit (2) and seeds (2). In the fiber yielding species, fibers are obtained from inside of fruit wall and bark. Other uses of forest tree species are: religious, used in juice and squash, as torchlight, turpentine source, as soap, in making eating plates and bowls and in making handles of agriculture equipments. In the horticulture species fruits are edible, among the forest tree species, three species were found in- Fabaceae, Fagaceae and Pinaceae, and two species were recorded in Ericaceae, Meliaceae, Moraceae, Salicaceae and Sapindaceae and rest of the families contained one species each.

Present study, recorded different forest and horticulture tree species found under different agroforestry systems in the Gangotri valley of Uttarkashi district of India along varying altitudinal ranges. The forest tree species showed greater species diversity than horticulture species that could be : a) forest trees have a naturalized

presence over a long time, whereas, people started growing horticulture trees afterward for fruit purpose, b) the seeds of forest trees can use services of local seed dispersers or have winged seeds (e.g. *Pinus*, *Cedrus*) to disperse their seeds whereas, horticulture trees rely on human service for seed sowing or seedling/sapling plantation, c) forest trees are hardy and adapted to local climatic conditions, thus, they can better resist local environmental fluctuations, whereas, horticulture trees cannot resist climate extreme, and d) forest trees retained by the farmer are mostly multipurpose and supplement their daily domestic need.

Table 2. Horticulture trees under agroforestry system along elevation.

Family	Species	Vernacular name	English name	Uses	Elevation
Anacardiaceae	*Mangifera indica* L.	Aam	Mango	Fruit edible, wood used as fuel and timber, plant is medicinally important, leaves and wood used in religious rituals	L
Euphorbiaceae	*Emblica officinalis* L.	Amla	Indian Gooseberry	Fruit edible, plant is medicinally important, plant used in religious rituals	L
Juglandaceae	*Juglans regia*L.	Akhrot	Walnut	Fruit edible,wood used as fuel and timber	L, M, H
Lauraceae	*Cinnamomum tamala* (Buch.-Ham.) T.Nees&C.H.Eberm	Tejpatta	Indian Bay Leaf	Leaves used as spice, plant is medicinally important	L
Lythraceae	*Punica granatum* L.	Anar	Pomegranate	Fruit edible	L
Moraceae	*Ficus auriculata* Lour.	Timla	Roxburgh Fig	Fruit edible, leaves used as fodder	L, M
	Ficus glomerata Roxb.	Goolar	Cluster Fig	Fruit edible, leaves used as fodder, wood used as fuel and timber	L
	Ficus palmata Forssk.	Bedu	Wild Himalayan Fig	Fruit edible, leaves used as fodder, plant is medicinally important	L
	Morus alba L.	Shetoot	White Mulberry	Fruit edible, leaves used as fodder, wood used as fuel	L
Myrtaceae	*Psidium guajava* L.	Amrood	Guava	Fruit edible, leaves used as fodder, wood used as fuel, plant is medicinally important	L
Rhamnaceae	*Ziziphus mauritiana* Lam.	Ber	Indian Plum	Fruit edible, handles of agriculture tools	L
Rosaceae	*Prunus persica* (L.) Batsch	Aadu	Peach	Fruit edible	L, M, H
	Prunus armeniaca L.	Khumani/Chullu	Apricot	Fruit edible, wood used as fuel	M, H
	Pyrus communis Huds.	Naspati	Pear	Fruit edible	M, H
	Malus pumila Mill.	Seb	Apple	Fruit edible	M, H
Rutaceae	*Citrus aurantium* L.	Narangi	Bitter Orange	Fruit edible	L, M
	C. sinensis (L.) Osbeck	Malta	Sweet Orange	Fruit edible	L, M

Abbreviations: L – lower elevation (1000-1500 m, a.m.s.l.), M – middle elevation (1500-2000 m, a.m.s.l.), H – higher elevation (2000-2500 m, a.m.s.l.), m, a.m.s.l. – meters, above mean sea level.

A greater number of forest tree were found in middle altitude region on agroforestry because more number of population reside in the middle region moreover, mid-altitude represents a transition zone between lower and higher altitude region and thus, the middle altitude region does not possess the climatic extreme of lower and higher (freezing and moist winter) region. The more horticulture species were found in lower altitude region as compared to middle and higher altitude region. Bijalwan and Dobriyal (2016) recorded lesser number of trees in higher altitude and more tree density in lower altitude in different agroforestry systems in upper Yamuna region of Uttarakashi district. Some forest and horticulture tree species were found in two adjacent altitude regions and this can be attributed to the adaptive capacity of the tree, while species such as *Pinus roxburghii* was found in all the altitude studied, which could be due to species possessing a wide ecological niche.

Conclusion

The study concludes that forest and horticulture trees provide livelihood support to the villagers by multiple and multifunctional uses. Farmers also deliberately retain these tree species on their farmland for daily domestic and edible purposes.

Conflict of interest statement

Author declares that there is no conflict of interest.

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