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Dominance and distribution pattern of traditional agroforestry trees in Garhwal Himalayas

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Abstract
India has a long tradition of agroforestry. Farmer and land owners in different parts of the country integrate a variety of woody perennials in their crop and live stock production fields depending upon the agro-climatic conditions and local needs. From the Himalayan region, which is one zone of India, a number of traditional agroforestry have been documented from Himachal Pradesh and Uttarakhand have identified three most extensively practiced agroforestry system in H.P.; Similarly these practiced also be done in Uttarakhand are agri-silviculture, agri-horticulture, and agri-horti-silviculture. The study was conducted in Srinagar valley of District Garhwal. Within study areas, 6 villages were randomly selected for the purpose of study. In each study area 10 x 10 mquadrate were laid down to gain the quantitative information. For the phytosociological analysis of agroforestry trees of each village, ten quadrates each of 10 x 10 m were laid out randomly. Frequency, density and basal area for each species were calculated as per Curtis Mc. Intosh (1950), where as relative values were calculated as per Curtis (1959). Other information related to agroforestry tree and their uses was also collected from the local in habitants of the study villages. Between the traditional agroforestry and boundary plantations systems, the average total carbon in traditional agro forestry system was 32.56 t /ha where as in the boundary plantations system it was reported 20.24 t/ha. The tree components in agro forestry systems can be significant sinks of atmospheric C because of their fast growth and high productivity. In agro forestry systems mixed stand of trees considered to be more efficient than sole stands in carbon sequestration. Between these systems the carbon sequestrations per unit area can also be enhanced by proper management practices. In the boundary plantations system trees are normally felled in the age of 10-12 years period for economic benefits.

Keywords: agroforestry systems practices, phytosociological analysis, productivity

Introduction
A rapid population growth in recent times has increased the pressure on the natural resources such as the available land for sustaining the livelihoods, and with over exploitation and extraction of the natural resources the ecosystems are becoming unsustainable and fragile (Sundriyal & Sharma 1996). Besides basic needs of food, requirements of fuel wood, timber and fodder have equal importance to feed the growing population of India. In this agroforestry plays a key role. India has a long tradition of agroforestry. Farmer and land owners in different parts of the country integrate a variety of woody perennials in their crop and live stock production fields depending upon the agro-climatic conditions and local needs. In India a lot of work has been done in all the agro-climatic zones and a number of traditional agro-forestry system have been identified and documented. From the Himalayan region, which is one zone of India, a number of traditional agroforestry have been documented from Himachal Pradesh and Uttarakhand (Atul *et al.*, 1990) have identified three most extensively practiced agroforestry system in H.P.; Similarly these practiced also be done in Uttarakhand are agri-silviculture, agri-horticulture, and agri-horti-silviculture. (Singh and Dagar, 1990) have identified agri-silviculture system, agri-horticulture system, and agri-horti-silviculture system, silvi-pastoral system and homesteads in Mussoorie hills in the western Himalayas. Agroforestry has the potential to improve livelihood as it offers multiple alternatives and opportunities to farmers to improve farm production and incomes and also provides productive and protective (biological diversity, healthy ecosystems, protection of soil and water resources, terrestrial carbon storage) forestfunctions to the ecosystems while protecting the natural environment. It is promoted widely as sustainability-enhancing practice that combines the best attributes of forestry and agriculture. This practice is now recognized widely as an applied science that is instrumental in assuring food security, reducing poverty and enhancing ecosystem resilience at the scale of thousands of smallholder farmers in the tropics.

Trees on farms provide both products and services: they yield food, fuel wood, fodder, timber and medicines, and they replenish organic matter and nutrient levels in soils and help control erosion and conserve water. For example, the Himalayan alder (*Alnus nepalensis*) based agroforestry is particularly useful for supplying nutrients such as nitrogen and phosphorus also to the plantations or croplands located downstream (Singh 2002). The eastern Himalayan region also comprises diversity of agroforestry system as an important land use practice. Agroforestry is accepted as one of the sustainable management systems for provisioning functions adopted by the mountain communities in the region. Such systems conserve soil by improving the fertility levels and erosion, provide quality water for local consumption, fodder for livestock, fuel and timber for use as energy and construction materials, and traditional crops for food security. One good example of such a traditional agroforestry system is the cultivation of large cardamom as cash crop in the Indian state of Sikkim of the eastern Himalayan region. Such agroforestry systems are unique examples of the ecological sustenance and economic viability for the mountain peoples while providing goods and services to the downstream users.

Material and Methods

The study was conducted in Srinagar valley of District Garhwal. Within study areas, 6 villages were randomly selected for the purpose of study. In each study area 10 x 10 mquadrate were laid down to gain the quantitative information. For the phytosociological analysis of agroforestry trees of each village, ten quadrates each of 10 x 10 m were laid out randomly. Frequency, density and basal area for each species were calculated as per Curtis Mc. Intosh (1950), where as relative values were calculated as per Curtis (1959). Other information related to agroforestry tree and their uses was also collected from the local in habitants of the study villages.

Results and discussion

Budali

The present study was conducted in agroforestry model of Garhwal to assess the quantitative information. In the Budali village the relative density was maximum of *Grewia oppositfolia* (RD=50.50) and the minimum was of two species i.e.,*Leucaena leucocephala* and *Unknown 1* (RD=0.99). Similarly, the relative frequency was highest for two species *Grewia Oppositifolia* and *Bauhinia retusa* i.e., 20.69 and the lowest was of four species *Leucaena leucocephala*, *Morous alba*, *Meliaazadarach* and *Unknown 1* i.e., 3.45. The relative dominance was higher of *Bauhinia retusa* (RD=29.96) and the lower was of *Leucaena leucocephala* (RD=1.48). The IVI was maximum of *Gwevia oppositifolia* (80.13) and minimum was of *Leucaena leucocephala* (5.93).

Manjakot

In the village Manjakot a total of total 12 species of agroforestry tree were reported. Among the species the relative frequency was highest of *Grewia oppositifolia* (21.62) and the lowest was of two species *Ficus carica* and *Ficus auriculata* (2.70). The relative density was maximum of *Grewia Oppositifolia* (53.68) and the minimum was again two species i.e. *Ficus carica, Ficus auriculata* (2.70). The highest value of Relative dominance was recorded for *Toona ciliate* (22.82) and lowest was recorded for *Leucaena leucocephala* (0.23). The value of IVI was maximum 79.54 for *Grewia oppositifolia* and minimum 3.98 for *Leucaena leucocephala*.

Manao

In the village Manao the dominant tree was again *Grewia oppositifolia* (IVI-98.49) while the least dominant tree was *Melia azedarach* (IVI-26.06). The maximum and minimum values of relative frequency were reported for *Grewia oppositifolia* (33.33) *and Albizia lebbeck* (3.70) respectively. The highest and lowest values of relative density were reported for *Grewia oppositifolia* (58.81) and *Albizia lebbeck* (3.70). The value of relative dominance was ranged from 8.17 (*Acacia catechu*) to 27.94 (*Toona ciliata*).

Dungri pant

In the village Dungripant, a total of 12 species of tree were reported. The dominant tree in the village was *Toona ciliata* (IVI-60.18) and the least dominant tree was *Celtis australis* (14.60). The highest relative density was of *Melia azadirachta* (17.07) hence the lowest relative density frequency was of *Aegle marmelose* (0.81). The maximum and minimum value of relative frequency was reported for *Melia azadirachta* (15.38) and *Aegle marmelose* and *terminalia bellirica* having the same value i.e.(2.56). The highest and lowest value of relative dominance was recorded for *Aalge marmolus* (17.44) and *Leucaena leucocephala* (3.50).

Chamdaar

A total seven (07) species reported in the village. The dominant and co-dominant tree were *Grewia oppositifolia* (IVI-57.95) and *Toona ciliata* (IVI-54.28). however, least dominant species in the village was *Ficus religiosa* (IVI-14.80). The minimum and maximum value of relative frequency was reported for *Ficus religiosa* (2.94) and *Grewia oppositifilia* (20.59) respectively. Similary the highest value of relative density was of *Grewia oppositifilia* (28.21) however, the lowest density was of *Ficus religiosa* (1.92). The highest value of relative dominance was recorded for *Syzium cummini* (27.25) and lowest was of *Leucaena leucocephala* (5.44).

Keshu

In the village total seven species were recorded. While the dominant and least dominant tree were *Toona ciliata* (IVI-60.24) and *unknown* (27.82). The relative frequency was reported highest for *Toona ciliata* and *Grewia oppositifolia* (20.00), and the lowest relative frequency was reported for *Celtis australis* and *unknown* (8.57). The relative density was also reported highest for *Toona ciliata* (22.42), while least density was reported of *Unknown* (8.48). The value of relative dominance was maximum for *Celtis australis* (21.52) and minimum was *Melia azadarach* (8.73).

Table 1: Relative frequency, Relative density & Relative dominance of six villages in Gardhwal Himalayas

	Site-1Budali			Site-2 Mankakot			Site-3 Manao			Site-4 Dungripanth			Site-5 Chamdaar			Site -6 Keshu		
Species	**RF**	**RD**	**Rdom**	**RF**	**RD**	**Rdom**	**RF**	**RD**	**Rdom**	**RF**	**RD**	**Rdom**	**RF**	**RD**	**Rdom**	**RF**	**RD**	**Rdom**
Grevia oppositifolia	50.50	20.69	8.94	33.33	58.51	6.65	33.33	58.51	6.65	11.38	7.69	5.81	20.59	28.21	9.15	20.00	22.42	10.36
Celtis australis	8.91	17.24	4.89	8.11	3.16	4.29	3.16	4.29	17.24	3.25	5.12	6.22	14.71	16.03	16.69	8.57	9.09	21.52
Bauhinia retusa	16.83	20.69	29.96	10.81	7.37	4.84												
Mallotus philippensis	7.92	13.79	5.59	5.41	3.16	4.71												
Toona ciliata	1.98	6.90	6.14	2.70	1.05	22.82				28.45	20.51	11.21	17.65	14.74	21.89	20.00	19.39	20.84
Leucaena leucocephala	0.99	3.45	1.48	2.70	1.05	0.23	18.52	13.83	2.76	12.19	10.25	3.50	14.71	14.74	5.44			
Moras alba	3.96	3.45	5.06															
Melia azedarach	4.95	3.45	7.87	10.81	4.21	8.30	11.11	4.26	10.70	17.07	15.38	5.21	17.65	17.31	9.64	14.29	12.73	8.73
Ficus glomerata	2.97	6.90	27.69															
Unknown1	0.99	3.45	2.32															
Ougeinia oojeinensis				8.11	7.37	8.71												
Ficus semicordata				16.22	13.68	6.93				7.317	12.821	5.26						
Ficus carica				2.70	1.05	4.62												
Ficus auriculata				2.70	1.05	19.53				4.878	5.128	7.22						
Acacia catechu				8.11	3.16	10.79	18.52	15.96	8.17									
Albizia lebbeck							3.70	1.06	23.90									
Terminalia bellirica							7.41	4.26	19.89	3.25	2.56	8.92						
Aelge marmelos										0.813	2.564	17.44						
Ficus religiosa										2.439	5.128	8.87	2.94	1.92	9.93			
Bombax ceiba										2.439	5.128	10.06						
Syzgium cumini										6.50	7.69	10.27	11.76	7.05	27.25			
Pinus.roxburghii																17.14	15.76	18.15
Timro																11.43	12.12	9.63
Unknown 1																8.57	8.48	10.76

Table 2: IVI values of six villages in Garhwal Himalayas

Species	Site-1IVI	Site-2IVI	Site-3IVI	Site-4IVI	Site-5IVI	Site-6IVI
Grevia oppositifolia	80.13	79.54	98.49	24.89	57.95	52.79
Celtis australis	31.05	15.55		14.60	47.42	39.18
Bauhinia retusa	67.49	23.02				
Mallotus philippensis	27.31	13.27				
Toona ciliata	15.02	26.58	37.47	60.18	54.28	60.24
Leucaena leucocephala	5.93	3.98	35.11	25.95	34.89	
Moras alba	12.47					
Melia azedarach	16.28	23.32	26.06	37.66	44.60	35.74
Ficus glomerata	37.57					
Unknown1	6.77					
Ougeinia oojeinensis		24.19				
Ficus semicordata		36.83		25.40		
Ficus carica		8.38				
Ficus auriculata		23.28		17.23		
Acacia catechu		22.05	42.65			
Albizia lebbeck			28.67			
Terminalia bellirica			31.55	14.74		
Aelge marmelos				20.82		
Ficus religiosa				16.43	14.80	
Bombax ceiba				17.62		
Syzgium cumini				24.47	46.07	
Pinus.roxburghii						51.05
Timro						33.18
Unknown 1						27.82

Table 3: A/F Ratio of six villages of Garhwal Himalayas

Species	Site-1A/F	Site-2A/F	Site-3A/F	Site-4A/F	Site-5A/F	Site-6A/F
Grevia oppositifolia	0.142	0.08	0.068	0.16	0.090	0.08
Celtis australis	0.036	0.03		0.10	0.100	0.17
Bauhinia retusa	0.047	0.04				
Mallotus philippensis	0.050	0.08				
Toona ciliata	0.050	0.10	0.050	0.05	0.064	0.07
Leucaena leucocephala	0.100	0.10	0.052	0.09	0.092	
Moras alba	0.400					
Melia azedarach	0.500	0.03	0.044	0.06	0.075	0.08
Ficus glomerata	0.075					
Unknown1	0.100					
Ougeinia oojeinensis		0.08				
Ficus semicordata		0.04		0.04		
Ficus carica		0.10				
Ficus auriculata		0.10		0.15		

Acacia catechu		0.03	0.060			
Albizia lebbeck			0.100			
Terminalia bellirica			0.100	0.40		
Aelge marmelos				0.10		
Ficus religiosa				0.08	0.300	
Bombax ceiba				0.08		
Syzgium cumini				0.09	0.069	
Pinus.roxburghii						0.07
Timro						0.13
Unknown 1						0.16

Conclusions

Between the traditional agroforestry and boundary plantations systems, the average total carbon in traditional agro forestry system was 32.56 t /ha where as in the boundary plantations system it was reported 20.24 t/ha. The tree components in agro forestry systems can be significant sinks of atmospheric C because of their fast growth and high productivity. In agro forestry systems mixed stand of trees considered to be more efficient than sole stands in carbon sequestration.

Between these systems the carbon sequestrations per unit area can also be enhanced by proper management practices. In the boundary plantations system trees are normally felled in the age of 10-12 years period for economic benefits. The carbon sequestration both in tree and soil can be increased by increasing in felling age. Thus higher biomass in tree and long term input of litter in soil will increase level of carbon sequestration.

In traditional agroforestry system the carbon sequestration level can also be enhanced by avoiding over exploitation of the resources from the trees and its proper management. The over exploitation of resources from traditional agroforestry trees reduces input of biomass as well as input of litter in the agroforestry system. Thus regular inputs of litter in the soil and its decomposition will also enhance nutrient level for further biomass production of trees.

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