Original Research Article

Structure and Floristic Composition of Existing Agroforestry Systems in Allahabad District of Uttar Pradesh, India

Abstract

The Structure and Floristic Composition of Existing Agroforestry Systems was carried out in the farmers field of village Kashari (site-I) and Korihar (site-II) at Allahabad District of Uttar Pradesh, India during 2008-2010. The quantitative characteristics of vegetation were determined by the quadrat method. The floristic diversity study was made by adopting random sampling approach, under which, 20 quadrates of 10 m x 10 m were laid down. The density, frequency,abundance,IVI, Species –diversity,concentration of dominance,species-richness, equitability and beta diversity and other useful parameters for comparison of different types of existing agroforestry systems were analyzed by the simple arithmetic calculation.20 quadrates of 10 x 10 m size were laid out in each site for the observation of trees and shrubs. The vegetative structure of trees and shrub in each four sites was estimated for frequency; density and abundance by using expressions given by Curtis and Mc Intosh, 1950. Floristic diversity studies of the herbaceous species were not attempted.

Introduction:

India has a long existing of agroforestry (AF) systems and several indigenous agroforestry systems, based on people's needs and site-specific characteristics have been developed over the years. The existing agroforestry systems in India include trees on farms, community forestry and a variety of local forest management and ethno forestry practices (Gairola et al 2008). In India, the practice of growing scattered trees on farmlands is quite old and has not changed much over centuries; these trees are multipurpose, used for shade, fodder, fuel wood, fruit, vegetables and medicinal uses (Bijalwan, etal., 2011, Dey et al, 2022). The landuse pattern is one of the important aspects for analyzing the structure, composition and phyto diversity for understanding the vegetation dynamics of the existing sites (Umrao et al, 2017). The farmers have adopted the trend of growing trees around agricultural land due to significant economics as well as social benefits. But it will be worthwhile to work out an integrated approach with the help of agricultural and forestry scientists, depending on the suitability of crops and locations (Ranjan*et al.,* 2016, Chaurasia et al,2022).A new land-use options that increase livelihood security and reduce vulnerability to climate and environmental change are necessary (Pathak *et al.,* 2016, Mishra et al, 2022). Community structure, composition and vegetative function are the most important ecological attributes of forests, which show variations in response to environmental as well as anthropogenic variables (Gairola*et al.,* 2008; Timilsina*et al.,* 2007).Species diversity is an important concept and one of the major attributes of a natural community (Chaurasia et al, 2020).These variations in vegetation structure, richness, diversity and distribution are directly correlated with the intensity of variables like geographical location, agricultural practices and their extent (Criddle*et al.*,2003).In Central and Eastern Uttar Pradesh, the agroforestry systems are well established. Asmultiple cropping is a kind of natural resource management based on environmental, social and economic criteria which is done by combination of trees, pasture

and cropland, in order to increase social, economic and environmental benefits (Rawat et al, 2009). Planting and harvesting of wood products, fruits, roots, leaves, fuel, and fodder along with agricultural crops on the same piece of land has been practiced since the old days. However, under present conditions, the agroforestry techniques applied by the farmers appear to be poorly developed and exploitative. In most cases, the trees are neither protected nor properly managed. Hence, there is immense potential for improvement of traditional agroforestry systems in order to realize the real production potential of existing agroforestry systems. Greater agrobiodiversity also may ensure longer term stability of C storage in fluctuating environments (Henry *et al.*, 2009), apart from augmenting biomass production potential (Kumar, 2006). Main aimed of this paper are to describe the structural attributes of density, frequency, diversity, equitability and species richness on the existing agroforestry systems in Fatehpur and Allahabad districts of Uttar Pradesh. These studies helps in determination of predominating communities of timber trees, horticultural trees and shrubs species and further identify the localities having protection and promotion of these plants.

MATERIAL AND METHODS:

The study was carried out in the two selected village sites in Allahabad in eastern part of UP. The two sites namely Kashari (site-I) and Korihar (site-II) were selected in Allahabad district, these sites are situated on the right side of the Ganga river at a distance of about20 km and 35 km away from Allahabad city ($81^0$50' E longitude and 25^0 27 ' N latitude).

Map.1 - Map of study areas

Floristic -Diversity: The floristic diversity study was made by adopting random sampling approach, under which, 20 quadrates of 10 m x 10 m and 5 m x 5 m size were laid out in each sites for the observation of trees and shrubs respectively. The status of density, frequency, Abundance,IVI, Species –diversity, concentration of dominance, species-richness, Equitability and Beta diversity and other useful parameters for comparison of different types of existing agroforestry systems were analyzed by the simple arithmetic calculation. The quantitative characteristics of vegetation were determined by the quadrat method.The vegetative structure of trees and shrub in each two sites was estimated for frequency; density

and abundance by using expressions given by Curtis and Mc Intosh, 1950.The floristic diversity study was made by adopting random sampling approach, under which, 20 quadrates of 10 x 10 m size were laid out in each sites for the observation of trees and shrubs. The vegetative structure of trees and shrub in each four sites was estimated for frequency; density and abundance by using expressions given by Curtis and Mc Intosh, 1950. Floristic diversity studies of the herbaceous species were not attempted. Basal area of trees was calculated as cross sectional area of stem at DBH (1.37 m), while basal area of shrubs was calculated as cross sectional area of main stem at 15 cm above from the ground level. Basal Area = π ($d^2/4$), Where d is the diameter of tree

$$\text{Frequency} = \frac{\text{Number of sampling units in which species occurred}}{\text{Total number of sampling unit studies}} \times 100$$

$$\text{Density} = \frac{\text{Total number of individual of species}}{\text{Total number of quadrat studied}}$$

$$\text{Abundance} = \frac{\text{Total number of individual of the species in all sampling units}}{\text{Number of sampling unit in which the species occurred}}$$

$$\text{Basal area per tree} = \frac{\text{Total basal area of trees}}{\text{Number of trees}}$$

Relative Basal Area: The relative density, relative frequency, relative basal areas were calculated using following formula.

$$\text{Relative density} = \frac{\text{Density of individual of species}}{\text{Total density of all species}} \times 100$$

$$\text{Relative frequency} = \frac{\text{Frequency of the individual species}}{\text{Total frequency of all the species}} \times 100$$

$$\text{Relative basal area} = \frac{\text{Basal area of the individual of species}}{\text{Total basal area of all the species}} \times 100$$

Importance Value Index: The importance value index (IVI), which is an integrated measure of the relative frequency, relative density and relative basal area/dominance, was calculated for each tree species given by Curtis, 1959.

Importance Value Index (IVI) = RD+RF+RBA

The number of trees falling in the sample unit was counted and classified as per their diameter and height characteristics. The Species diversity (Shannon index), concentration of dominance (Simpson index) and other useful parameters for comparison of different types of existing agroforestry systems were calculated (Shannon and Weaver, 1963 and Simpson, 1949).

Tree diversity analysis:

Tree diversity in all four sites of agroforestry systems (trees and shrubs) were calculated by the following diversity indices.

(a) **Species Diversity Index.** It was calculated by the formula given byMargalef, 1958.

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$$H = -\sum [(ni/N) \log (ni/N)]$$

Where ni was the total number of individuals of species N was the total number of individuals of all the species on that site.

(b) **Concentration of dominance** was measured by the formula of Simpson Index developed by Simpson, 1949.

$$Cd = -\sum\left[\left(\frac{n_1}{N}\right)^2 + \left(\frac{n_2}{N}\right)^2 + - - - \left(\frac{n_n}{N}\right)^2\right]$$

Where N was the total number of individuals of species ni was the total number of individuals of all the species on that site.

(c) **Equitability(e)** was calculated as suggested by Pielou (1975)as

$$e = H/ \text{In } s$$

Where H is the Shannon – Wiener Index and s = total number of species

(d) **Species richness** was calculated by the following equation of Margalef (1958)

$$d = s- 1/\text{In } N$$

Where s = number of species, and N =number of individuals of all species

(e) **Beta diversity** was calculated as outlined by Whittaker, 1977
bd = Sc / s

Where Sc = total number of species in all sites and average species per site.

RESULTS AND DISCUSSION

Floristic-diversity analysis and distribution patterns of tree species:

The distribution patterns and species composition of existing agroforestry systems viz. agrisilvicultural and agrihorticultural system commonly practiced in Allahabad was studied.

Floristic diversity at Site –I (Kashari) of Allahabad district: The results of florisitic-diversityat site-I are presented in table 1 and graphically illustrated in figure 1. It is evident from the data that among tree species available in site –I timber and fuelwood, horticultural and shrubs species were 18, 8 and 4, respectively. The dominant and co-dominant species were *Acacia nilotica* and *Azadirachtaindica* showed IVI values of 24.54 and 24.09, respectively. The highest (70 trees ha^{-1}) value of density was recorded for *Acacia nilotica* in timber and fuel wood tree species followed by *Azadirachtaindica* (65 trees ha^{-1}). The highest tree density was recorded for*Emblica officinalis* (70 trees ha^{-1}) among horticultural tree species followed by *Mangiferaindica* (35 trees/ha). Total basal cover for tree was recorded higher for *Ficusreligiosa (*5.144 m^2/ha) followed by *Madhucalatifolia (*5.1094 m^2/ha). Among horticulture and shrubs species, the dominant and co-dominant species were *Emblica officinalis* and *Mangiferaindica* with IVI values of 18.89 and 16.207, respectively.

Table 1: Floristic- diversity of site-I (Kashari)of Allahabad district

Timber and fuelwood trees									
Name of the species	**Density ($100m^2$)**	**Frequency**	**Abundance**	**BA (cm^2)/ $100m^2$**	**Relative Density**	**Relative Frequency**	**Relative Basal Area(RBA)**	**IVI**	**B.A. M^2/ha.**
*Acacia niloticaL.*Willd.ex del.	0.70	55	1.27	393.56	8.04598	8.02920	8.46728	24.54246	3.9356
Aegle marmelos(L.)Corr.	0.25	20	1.25	151.81	2.87356	2.91971	3.26609	9.05936	1.5181
*Artocarpushetero phylus*L.	0.25	15	1.67	146.61	2.87356	2.18978	3.15428	8.21762	1.4661
*Azadirachtaindica*L.	0.65	60	1.08	365.45	7.47126	8.75912	7.86248	24.09287	3.6545
Dalbergiasissoo Roxb.	0.20	15	1.33	138.80	2.29885	2.18978	2.98625	7.47488	1.388
Eucalyptus teretiocornis Sm.	0.30	25	1.20	143.23	3.44828	3.64964	3.08144	10.17935	1.4323
Ficusbenghalensis L.	0.25	20	1.25	373.92	2.87356	2.91971	8.04468	13.83795	3.7392
*Ficusglomerata*L.	0.30	25	1.20	179.69	3.44828	3.64964	3.86592	10.96383	1.7969
Ficusreligiosa L.	0.35	20	1.75	514.40	4.02299	2.91971	11.06723	18.00992	5.144
Limoniaacidessima L.	0.25	25	1.00	162.47	2.87356	3.64964	3.49556	10.01875	1.6247
Madhucalatifolia Macb.	0.40	30	1.33	510.94	4.59770	4.37956	10.99258	19.96984	5.1094
Pongamiapinnata L.	0.20	10	2.00	187.04	2.29885	1.45985	4.02408	7.78279	1.8704
Populus deltoids Bartrx.ex.Marsh	0.20	15	1.33	87.226	2.29885	2.18978	1.87663	6.36526	0.8723
Prosopisjuliflora (sw) DC.	0.25	15	1.67	34.851	2.87356	2.18978	0.74980	5.81315	0.3485
Syzygiumcumini(L.)Skeel	0.20	10	2.00	187.26	2.29885	1.45985	4.02875	7.78745	1.8726
Tamarindusindica L.	0.20	15	1.33	224.53	2.29885	2.18978	4.83072	9.31935	2.2453

*Tectonagrandis*Linn.f.	0.60	50	1.20	194.27	6.89655	7.29927	4.17967	18.37549	1.9427
*Zizyphusmaritiana*Lam	0.25	25	1.00	129.84	2.87356	3.64964	2.79346	9.31666	1.2984
Horticultural trees									
Carica papaya L.	0.20	10	2.00	12.031	2.29885	1.45985	0.25885	4.01755	0.1203
*Carissa corandus*L.	0.30	25	1.20	9.9589	3.44828	3.64964	0.21426	7.31217	0.0996
*Citrus lemon(*L)Burm.f	0.30	30	1.00	10.424	3.44828	4.37956	0.22427	8.05210	0.1042
Cordia myxaRoxb.	0.15	10	1.50	3.5652	1.72414	1.45985	0.07670	3.26070	0.0357
Emblica officinalis Gaertn	0.70	60	1.17	96.851	8.04598	8.75912	2.08372	18.88882	0.9685
Mangiferaindica L.	0.35	30	1.17	362.76	4.02299	4.37956	7.80474	16.20729	3.6276
*Musa paradesiaca*L.	0.15	10	1.50	2.3339	1.72414	1.45985	0.05021	3.23420	0.0233
*Psidiumguajava*L.	0.15	10	1.50	21.959	1.72414	1.45985	0.47245	3.65644	0.2196
Shrubs species									
*Bougainvillaglabra*L.	0.20	15	1.33	0.8458	2.29885	2.18978	0.01820	4.50683	0.0085
Jatrphacurcas L.	0.15	10	1.50	0.6453	1.72414	1.45985	0.01388	3.19788	0.0065
Ricinuscommunis L.	0.15	15	1.00	0.7074	1.72414	2.18978	0.01522	3.92914	0.0071
Ziziphuszizyphus L.	0.10	10	1.00	0.0332	1.14943	1.45985	0.00071	2.60999	0.0003
Total	**8.70**	**685**	**40.74**	**4648**	**100.0**	**100.0**	**100.0**	**300.0**	**46.48**

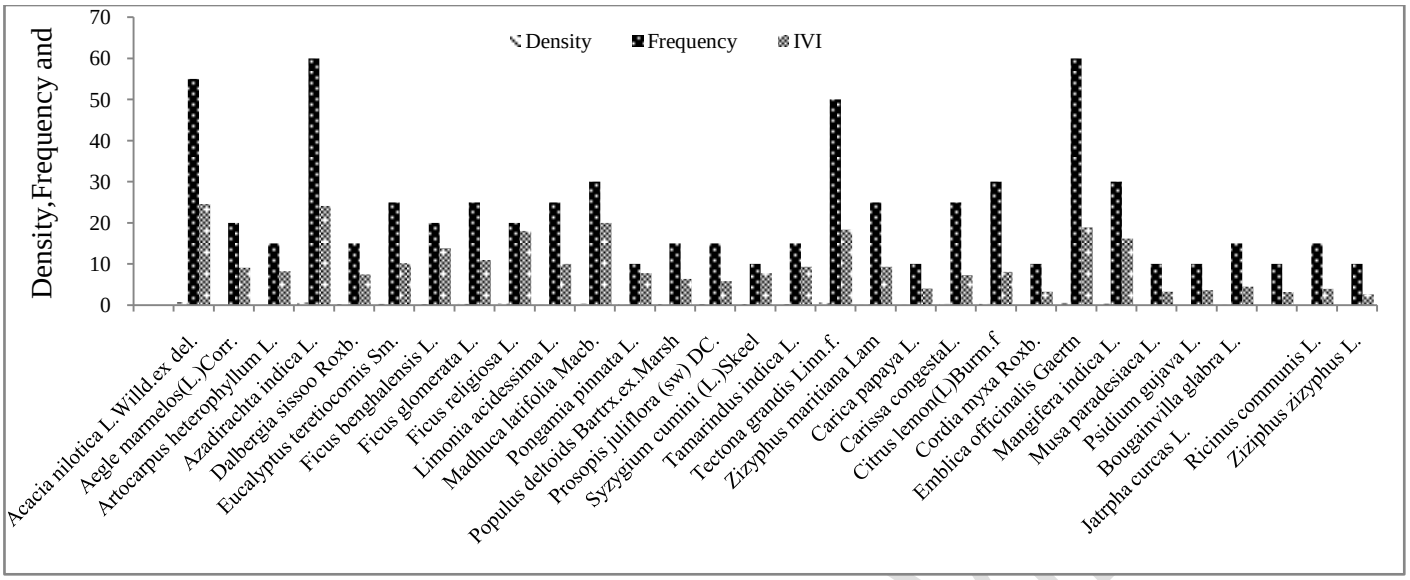

Fig .1:Floristic diversity of site-I (Kashari)of Allahabad district

2.Floristic- diversity analysis at site –II (Korihar) of Allahabad district:

Data on Floristic diversity findings of tree layer at site-IV are presented in table 2 and graphically illustrated in figure 2 revealed that total number of timber and fuel wood, horticultural and shrubs species were 18, 6 and 4, respectively. The dominant and co-dominant species were *Tectonagrandis* and *Acacia nilotica* and showed IVI values of 23.24 and 23.0, respectively. The highest density value was recorded for *Tectonagrandis* (65 trees ha^{-1}) followed by *Acacia nilotica* (60 trees ha^{-1}). In horticulture and shrub species, the dominant and co- dominant species were *Mangiferaindica* and *Emblica officinalis* with their IVI values of 18.05 and 18.01, respectively. The highest value of tree density was recorded for *Emblica officinalis* (60 trees ha^{-1}) followed by *Madhucalatifolia* (30 trees ha^{-1}). Total tree basal cover was observed comparatively higher in *Madhucalatifolia* (4.53 m^2 ha^{-1}) followed by *Azadirachtaindica*(3.631m^2 ha^{-1}). In horticultural and shrubs species, basal cover was comperatively greater in *Mangiferaindica*(4.27 m^2 ha^{-1}) and *Emblica officinalis* (0.830 m^2 ha^{-1}). The results also conform to the earlier findings of Bijalwan*et al.* 2011.

Table 2 Floristic -diversity of site-II (Korihar) of Allahabad district

Name of the species	Density (100m^2)	Frequen-cy	Abundan-ce	BA (cm^2)/ 100m^2	Relative Density	Relative Frequency	Relative Basal Area(RBA)	IVI	B.A. M^2/ha.
Timber and fuelwood trees									
*Acacia niloticaL.*Willd.ex del.	0.60	50	1.20	281.36	7.69231	8.19672	7.19095	23.0799	2.8136
Aegle marmelos(L.)Corr.	0.25	20	1.25	137.94	3.20513	3.27869	3.52549	10.0093	1.3794
Albiziaprocera L.	0.15	10	1.50	62.999	1.92308	1.63934	1.61011	5.17253	0.63
*Artocarpusheterophylus*L.	0.25	20	1.25	127.23	3.20513	3.27869	3.25165	9.73547	1.2723
*Azadirachtaindica*L.	0.50	45	1.11	363.06	6.41026	7.37705	9.27909	23.0663	3.6306
DalbergiasissooRoxb.	0.25	15	1.67	219.78	3.20513	2.45902	5.61721	11.2813	2.1978
Eucalyptus teretiocornis Sm.	0.25	20	1.25	123.95	3.20513	3.27869	3.16787	9.65169	1.2395
Ficusbenghalensis L.	0.20	20	1.00	281.84	2.56410	3.27869	7.20319	13.0459	2.8184
*Ficusglomerata*L.	0.30	25	1.20	189.05	3.84615	4.09836	4.83165	12.7761	1.8905
Ficusreligiosa L.	0.20	20	1.00	268.56	2.56410	3.27869	6.86371	12.7065	2.6856
*Madhucalatifolia*Macb.	0.40	30	1.33	453.11	5.12821	4.91803	11.58055	21.6267	4.5311
*Pithecellobiumdulce (*Roxb.)Benth.	0.20	15	1.33	152.19	2.56410	2.45902	3.88953	8.91265	1.5219
Pongamiapinnata L.	0.30	25	1.20	129.73	3.84615	4.09836	3.31562	11.2601	1.2973
Populus deltoids Bartrx.ex.Marsh	0.20	10	2.00	41.854	2.56410	1.63934	1.06969	5.27314	0.4185
Prosopisjuliflora (sw) DC.	0.30	15	2.00	41.821	3.84615	2.45902	1.06885	7.37402	0.4182
Syzygiumcumini(L.)Skeel	0.20	10	2.00	143.61	2.56410	1.63934	3.67024	7.87369	1.4361
*Tectona grandis*Linn.f.	0.65	55	1.18	230.62	8.33333	9.01639	5.89412	23.2438	2.3062
*Zizyphusmaritiana*Lam	0.35	25	1.40	102.33	4.48718	4.09836	2.61529	11.200	1.0233
Horticultural trees									
Carica papaya L.	0.20	10	2.00	12.031	2.56410	1.63934	0.30749	4.51094	0.1203
*Carissa corandus*L.	0.30	25	1.20	9.9589	3.84615	4.09836	0.25453	8.19904	0.0996

Emblica officinalis Gaertn	0.60	50	1.20	83.015	7.69231	8.19672	2.12169	18.0107	0.8302
*Mangiferaindica*L.	0.30	20	1.50	427.76	3.84615	3.27869	10.93273	18.0575	4.2776
*Musa paradesiaca*L.	0.15	10	1.50	2.3339	1.92308	1.63934	0.05965	3.62207	0.0233
*Psidiumguajava*L.	0.15	10	1.50	21.321	1.92308	1.63934	0.54491	4.10733	0.2132
Shrubs species									
*Bougainvillaglabra*L.	0.20	15	1.33	0.8458	2.56410	2.45902	0.02162	5.04474	0.0085
Jatrphacurcas L.	0.15	15	1.00	3.7623	1.92308	2.45902	0.09616	4.47825	0.0376
Ricinuscommunis L.	0.15	15	1.00	0.7074	1.92308	2.45902	0.01808	4.40017	0.0071
*Ziziphuszizyphus*L.	0.05	10	0.50	0.0166	0.64103	1.63934	0.00042	2.28079	0.0002
Total	**7.80**	**610**	**37.6**	**3912.8**	**100.0**	**100.0**	**100.0**	**300.0**	**39.128**

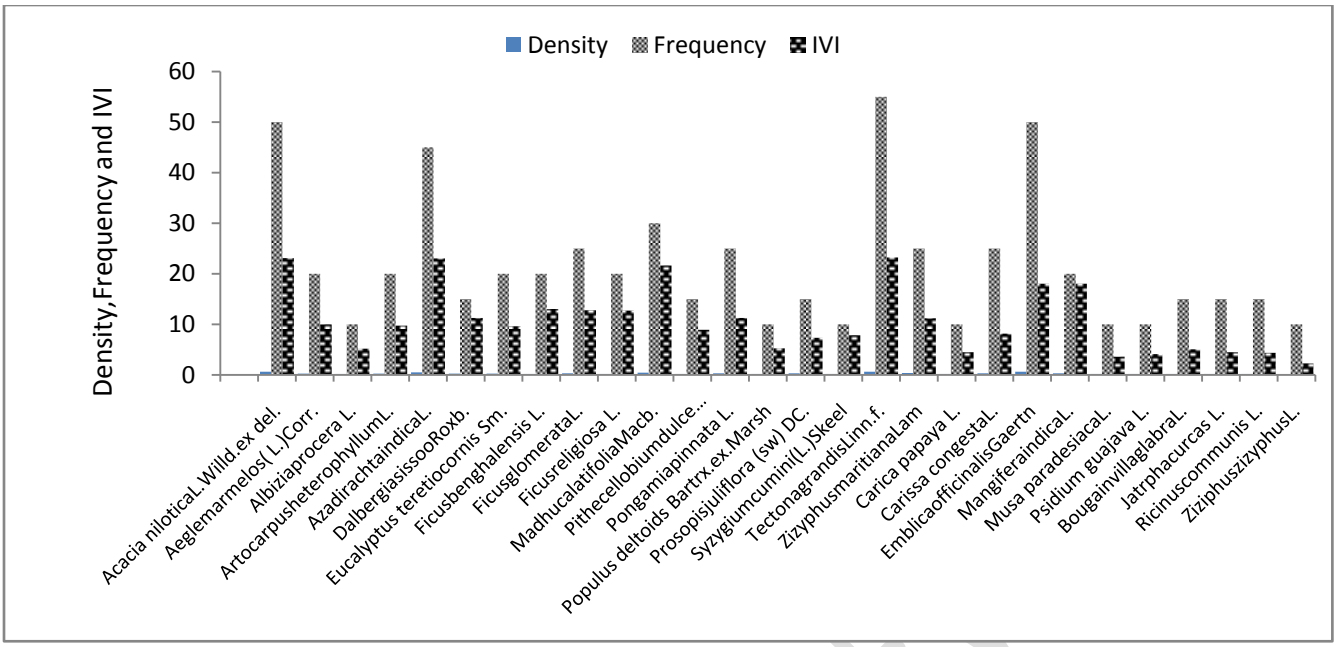

Fig2 Floristic diversity of site-II(Korihar)of Allahabaddistrict

3. Diversity index analysis: Diversity index analysis of vegetation of both sites of the district Allahabad are presented in Table 3.The value of index of dominance (Simpson index) was higher in agrisilviculture system at site –II (0.038) followed by site-I (0.035).The species diversity (sd) was highest at site –II (0.999) In agrihorticultural system highest species of diversity was recorded at site-I (0.330) and lowest at site-II (0.308). Equitability (e) of trees were found maximum (0.055) in agrisilviculture system at site-I, whereas minimum was recorded at site-II (0.038) in agrihorticulturesystem.Highest Species richness was found in agrisilviculture system in site –II (0.153) followed by site –I (0.152) in agrihorticulture system where as in lowest found in agrisilviculture system in site -I(0.146).Beta diversity were found highest in agrihorticulture system in site –II (5.167) and lowest at site –I (3.875) in agrihorticulturesystem.The results of diversity index are also supported by the findings of Knight, 1975. In case of modified Simpson's Index Value almost similar observation was reported by Jose *et.al.*, (1994). Basha (1987) has also reported Simpson's index of diversity of 0.94 for evergreen forests of Silent Valley. The Shannon-Wiener Index Value (H') showed that the diversity was almost similar to that in a tropical forest (5.45). H' value in tropical rain forest generally varies between 5.06 in a young stand to 5.4 in an old stand (Knight, 1975).

Table 3: Diversity Index of study sites-I and II of Allahabad districts:

AF system	Species – Diversity Index (Shannon Index)		Simpson Index(Concent-ration of Dominance)		Species Richness		Equitability		Beta Diversity	
	Trees	**Shrubs**	**Trees**	**Shrubs**	**Trees**	**Shrubs**	**Trees**	**Shrubs**	**Trees**	**Shrubs**
AS/S_I	0.970	0.060	0.035	0.0002	0.146	0.250	0.053	0.020	3.944	4.667
AS/S_{II}	0.999	0.064	0.038	0.0002	0.153	0.272	0.055	0.021	3.944	4.667
AH/S_I	0.308	0.027	0.007	0.0002	0.152	0000	0.038	0.027	3.875	6.000
AH/S_{II}	0.262	0.028	0.008	0.0002	0.147	0000	0.043	0.028	5.167	6.000

CONCLUSIONS:

In view of the above findings, it is concluded that the IVI was recorded maximum in *Acacia nilotica* in both the research sites. As far as concerned to maximum value of Concentration of Dominance (Simpson Index), Equitability, Beta diversity and Species diversity, Site-I (Kashari) is superior while species richness was found at site –II (Korihar).

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