ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 12, December 2014

Remote Sensing and GIS tools used to analyse the Floristic diversity in South Gujarat

G.D. Bhatt[1], S.P.S. Kushwaha[2], Kiran Bargali[3]

Department of Environmental Sciences & Natural Resource Management, School of Natural Sciences, Shiv Nadar University, Gautam Budh Nagar, Uttar Pradesh, India[1]

Department of Forestry and Ecology, Indian Institute of Remote Sensing, Indian Space Research Organization Dehradun, Uttarakhand, India[2]

Department of Botany, Kumaun University, Nainital, Uttarakhand, India[3]

ABSTRACT: The present study evaluates the floristic diversity analysis in south Gujarat forest using stratify random sampling technique. The forest cover in south Gujarat is 5492.05 km^2 (17.54 %) out of total geographical area 31,495 km^2. The maximum forest area covered by teak mixed dry deciduous forest (14.98 %) and minimum by riverain forest (0.0004 %), respectively. Based on the area of forest vegetation types 157 sample plots of 31.62 m x 31.62 m were laid in different forest vegetation types of south Gujarat. The IVI was calculated in different vegetation types and highest value was observed in teak mixed dry and moist deciduous forest. The dominant families were Leguminosace (19) followed by Poaceae (13), Compositae (12), Amranthaceae (11), Malvaceae (10), Lamiaceae (09) and Rubiaceae (08) respectively. The study demonstrates integration of stratified random sampling techniques in south Gujarat for an assessment of medicinal and economical plants.

KEYWORDS: Floristic diversity, Remote sensing and GIS, South Gujarat, Phytosociology, Random sampling

I. INTRODUCTION

Conservation and maintaining biodiversity on this planet earth is a very important objective for sustainable natural resource management system [1]. The biodiversity indicators help to establish and to monitor levels of biodiversity in terrestrial and aquatic ecosystems[2-3]. The number of these biodiversity indicators, however, is vast and these ranges from gene to landscape level depends on different spatial scales. To simplify the monitoring of biodiversity surrogate measures have been proposed, which are closely correlated with direct measures of biodiversity, but are easier to measure[4]. These surrogate measures include indices accounting for three basic tree diversity aspects [5-6] i.e., the diversity of tree locations, species diversity and the diversity of tree dimensions e.g., stem diameters and tree heights. The surrogate role is based on the observation that a large variety of forest structures or tree species generally provides a large amount of habitats for different species[6-10]. Tree diversity indices are also good quantitative descriptions of forest structures [6-7, 9, 11-12], which is a key pre-requisite for understanding the interactions between patterns and processes in forest ecosystems. Diversity indices are also important input for the reconstruction of forest structures used in spatially explicit growth models and computer visualizations [12-17].There are two different strategies of data collection, mapping and sampling. Mapping involves the full spatial enumeration of all trees within a large observation window i.e., stem maps, while in sampling only a sub-set of trees and their spatial relationships are measured, usually in very small replicated observation windows [18]. Mapping is very common in ecological studies and the corresponding data allow the application of powerful statistics and detailed analyses of plant interactions [19-20]. However, often summary characteristics for larger geographic entities, such as forest districts, enterprises, political regions and whole countries, are required for management and political decision making. In this context sampling methods are the only feasible option. Since the observation windows, i.e., the sample plots and size used for this purpose are comparatively small, tree diversity and structural indices are naturally more suitable other than sophisticated characteristics from spatial statistics[15]. This also offers the opportunity of combining the sampling of diversity measures with existing forest resource inventories [21] and adds significant value to traditional forest inventory with a comparatively low additional effort. Such a combination of inventory objectives clearly facilitates the

DOI: 10.15680/IJIRSET.2014.0312057

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 12, December 2014

ideas of multipurpose forestry based on sustainable principles [22]. Although tree diversity measures for biodiversity conservation planning and management have been fully accepted. For example [23]investigated different sample sizes for the classification of mixed forest stands into diversity classes. They found that with a sampling intensity of about 1.5 percent of the total stem number almost 90 percent of the stands where correctly classified. Another sampling simulation study by [24]asserted that the sample size for the evaluation of diversity indices is often greater than 20 percent of the total stem number. Therefore, further research concerning on this topic will be valuable[25]. The objective of this study is to identify on phytosociological analysis using stratified random sample plot. Based on the data of large mapped forest stands a sampling simulator was used to compare different sampling methods and sizes, whereas sampling methods were chosen which are frequently used for forest resource inventories. The sampling simulations and analyses were carried out in such a way that the results are transferable to forest resource inventories at various scales. The results provide an answer to the question in what way, if at all; forest resource inventories and biodiversity monitoring can be done.

II.MATERIALS AND METHODS

STUDY AREA

The study area is bounded in the north by the Rajasthan, in the east by Madhya Pradesh, in the south by Maharashtra provinces, and in the west by international boundary of Pakistan, and on its western and south-western sides lies the Arabian Sea with two Gulfs- the Gulf of Kachchh and the Gulf of Khambhat. The south Gujarat lies between (21°14'-22°49'N and 72°22'-74°15'E) consists of seven districts *viz.*, Valsad, Navsari, The Dangs, Surat, Bharuch, Narmada and Vadodara covering a geographical area of 31,495 km^2. The plains of south Gujarat are watered by Purna, Par, Damanganga, Auranga, Kolak, Ambica, Darota, Narmada, and Tapi rivers. The region showed a typical sub-humid to humid climate [26]. The annual temperature is about 26°C and in the summer and winter temperatures are 46°C and 22°C respectively. The relative humidity is 70-75 percent. The annual rainfall varies from 600-2200 mm [27]. The study area is rich from floral biodiversity point of view. It has three wildlife sanctuaries (WLS) - Jambughoda WLS in Vadodara district, Shoolpaneshwar WLS in Narmada district, Purna WLS in The Dangs district, and Vansda National Park in Navsari district [28-29].Physiographically, the area is divided into two parts, *viz.*, the western part comprising coastal plain (locally known as *kantha vistar*) and the eastern part comprising hills (locally known as *dungar vistar*). The elevation ranges from 100-1000 m. The highest peak being 1000 m at Saputarain The Dangs district. The main forest types in the south Gujarat are- Moist teak forest ($3B/C_1(b,c)$), Southern moist mixed deciduous forest ($3B/C_2$), Southern secondary moist mixed deciduous forest ($3B/_2S_I$), Dry teak forest ($5A/C_1(b)$), Southern dry tropical riverain forest ($5/_IS_I$), Desert thorn forest ($6B/C_I$), Mangrove forest ($4B/TS_I$) and Mangrove scrub ($4B/TS_2$), [30]. The main tree species are- teak (*Tectona grandis*), sadad (*Terminalia crenulata*), shisham (*Dalbergia sissoo*), khair (*Acacia catechu*), timru (*Diospyros melanoxylon*), mahuda (*Madhuca longifolia* var. *latifolia*), dhavdo (*Anogeissus latifolia*), khakhar (*Butea monosperma*), kalam (*Mitragyna parvifolia*), bondarao (*Lagerstroemia parviflora*), billi (*Aegle marmelos*), moina (*Lannea coromandelica*etc. The critically endangered species are *Sterculia guttata*,*Toona ciliata* and *Wrightia dolichocarpa*. The endangered species are *Casearia championii*, *Tamrix aphylla*, *Melia dubia*, and *Ficus nervosa*. The vulnerable species are *Firmiana colorata*, *Boswellia serrata*, *Garuga pinnata*, *Ceriops tagal* and *Ehretia laevis*[31-32].

A. SATELLITE DATA ANALYSIS

The IRS P6 LISS-III satellite data was procured from National Remote Sensing Centre, Balanagar, Hyderabad. The satellite data was radiometrically and geometrically corrected using Landsat TM satellite data with spatial resolution 30 m was used. A total of six scenes covered whole of the study area. Dark pixel subtraction technique was used to minimize the haze in the images[33]. The satellite imagery was geo-referenced using Landsat TM ortho-rectified images (UTM projection and WGS 84 datum) and nearest neighborhood resampling method. The images were mosaiced using feather overlap function of ERDAS Imagine ver. 9.2 and the study area (31,495 km^2) was extracted. The satellite imagery was converted in False Color Composite (FCC). Based on the FCC a visual interpretation key (tone, texture, shape, size, color, association and pattern), was generated and prepared a vegetation type/land use map using on-screen visual interpretation techniques [34].

B. VEGETATION DATA ANALYSIS

It is required to have a ground truthing of the area before attempting to classify the forest vegetation pattern. Initially major forest vegetation types and unique ecological zones of characteristic nature was recorded and put to intensive study of tonal characteristics associated features from the enhanced FCC. An optimal number of GPS locations were

DOI: 10.15680/IJIRSET.2014.0312057

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 12, December 2014

taken for each forest vegetation types based on area under each forest types. The field survey was conducted from September 2008 to May 2012. In this duration ground truth was collected and 157 sample plots was laid in differentforest vegetation types for species composition, maximum canopy height, cbh (circumference at breast height) and tree density was recorded at all sites. The location of each field site was determined using GARMIN 12 GPS.. A vegetation type /land use map was generated for the south Gujarat. The sample size refers to the number of sample plots across different districts of the south Gujarat having different spatial and temporal variance of vegetation, distribution across different forest vegetation types of a region and distribution within a forest type. The distribution of sample size within forest vegetation types depends on the area of each sample unit was laid. In this connection the extensive studies conducted in forest ecosystems in different parts of the world, the plot sizes of 0.1 ha (31.62 m x 31.62 m) and 1 ha square plot was considered. The sample plot of 0.1 ha was randomly distributed across each stratum. The sample plot is reached on ground based on GPS locations. For sampling of shrub species one plot of 5 m x 5 m in centre was laid. For herbaceous plants, four plots of 1 m x 1m in opposite corners were laid. At each sample plots, the cbh of all tree species was recorded and marked with chalk to avoid duplication. The individuals with cbh ≥ 30 cm was considered as tree, with > 17 to < 30 cm cbh as saplings and <17 cm as seedlings. In the case of shrub, the cbh need to be measured about 30 cm above ground. Total number of seedling of various species was counted and average girth of each species was recorded. For shrubs, total number of tillers for each species was counted and for each species an average circumference at ground height was estimated. For herbaceous layer or ground flora, nested quadrate method with 1 x 1 m plot size was taken in east-west and north-south corners.

C.PHYTOSOCIOLOGICAL ANALYSIS

The main purpose of phytosociological data analysis is to understand vegetation characteristics and to estimate the species richness and species diversity existing in the south Gujarat. In this order to express the dominance and ecological success of any species with a single value, the concept of Importance Value Index (IVI) has been developed. This index utilizes three characteristics, viz., relative frequency, relative density and relative dominance were calculated. The analysis is generally carried out for each forest vegetation types for computing the IVI [35].

III.RESULTS AND DISCUSSION

On the basis of the remote sensing and GIS data and ground inventory analysis the forests of the south Gujarat were classified into nine main vegetation type's viz., Teak mixed moist deciduous forest, Teak mixed dry deciduous forest, Mangrove forest, Mangrove scrub, Riverain forest, Ravine thorn forest, Forest plantation, Degraded forest and *P. juliflora* Scrub. The major forest vegetation types identified from the maps generated on 1:50,000 scale in the study area are: Teak mixed dry deciduous forest occupied 4718.54 km^2 (14.98 %), Teak mixed moist deciduous forest 243.01 km^2 (0.77 %), Ravine thorn forest 144.29 km^2 (0.46 %) and *P. juliflora* scrub 257.85 km^2 (0.82 %) area. Analyses of forest vegetation type map of south Gujarat revealed that scrubs occupied most of the study area which was about 912.38 km^2 (2.90 %). Mangrove forest and mangrove scrub contributed 0.10 % (32.90 km^2) and 0.24 % (75.40 km^2), respectively. Degraded Forests were present in 0.36 km^2 (0.00011 %) while Riverain forest and forest plantation occupied 0.16 km^2 (0.0004 %) and 19.53 km^2 (0.06 %) area, respectively. The maximum forest area of south Gujarat covered by teak mixed dry deciduous forest. Out of 157 sample plots maximum plots laid in teak mixed dry deciduous forest followed by teak mixed moist deciduous forest, mangrove forest and degraded forest, respectively. The number of families, genera, herbs, shrubs and trees were calculated in different forest vegetation types. The total families were 216 having 317 genera encountered in different forest types of south Gujarat. Across the total study area 235 tree species, 57 shrubs and 154 herbs were encountered in different forest vegetation types(Table 1). The IVI values of the tree species of different forest vegetation types are shown in Fig. 1-10.*P. juliflora* was the most dominant species in the *P. juliflora* scrub land having highest IVI value followed by mangrove scrub, mangrove forest, degraded forest, scrub, riverain, ravine thorn, forest plantation, teak mixed dry and moist deciduous forest. The dominant species in mangrove scrub and mangrove forest was *Avicennia marina*. In degraded forest *Butea monosperma* was the dominant species and *Syzygium heyneanum* was dominant species inriverain forest with the maximum IVI value. The other species were almost equally distributed in riverain and ravine thorn forest. Though the *Tectona grandis* was dominant species in both the teak mixed dry and moist deciduous forests, but their associate species were entirely different. In teak mixed dry deciduous forest IVI for *Tectona grandis* was 26.62 followed by *Terminalia bellerica* (24.43), *Ficus racemosa* (18.44) and *Ficus religosa* (17.05) (Fig. 1), whereas in teak mixed moist deciduous forest *T. grandis* (IVI=37.76) was followed by *T. elleptica* (18.29), *Wrightia tingtoria* (13.63) and *Butea monosperma* (12.27) (Fig. 2). In mangrove forest,

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 12, December 2014

Avicennia marina was dominant species with maximum IVI (141.68) followed by *Sonneratia apetala*(80.27), *A. officinalis* (35.72) and *Bruguiera cylindrica* (15.68) (Fig. 3). But in mangrove scrub, *Avicennia marina* and *A. officinalis* were the only species with having the IVI value of 163.49 and 36.51, respectively (Fig. 10).*S. heyneanum* (IVI=71.82) was the dominant species of riverain forest followed by *F. racemosa* (57.32), *T. crenulata* (20.70), *Acacia nilotica* (31.51), *F. hispida* (28.60), *A. leucocephala* (24.79)(Fig. 5).The different forest plantations showed the dominance in their respective areas where they were planted accordingly (Fig. 6).In degraded forest,*B. monosperma* was having the highest IVI value (86.71) associated with *C. carandas* (25.63) and *Wrightia tingtoria* (22.94)(Fig. 7).Similarly in scrub lands, *Bridelia squomosa* was the dominant species (IVI=74.24) followed by *Diospyros melanoxylon*(48.04), *Garuga pinnata* (42.38) and *T. grandis* (26.23) (Fig. 8).In *P. juliflora* scrub land the associated species (*Salvadora persica, A. nilotica* and *Azadirachta indica*) have only 14% contribution in IVI and rest proportion was contributed by *P. juliflora*(Fig. 9).Among the families Leguminosace was represented by highest number of species (19) followed by Poaceae (13), Compositae (12), Amranthaceae (11), Malvaceae (10), Lamiaceae (09) and Rubiaceae (08), respectively.Several studies have explained the structural and functional features of different forest types of India on the basis of ground inventory[36-48].The present study produced the data base on the similar patterns as explained by the above mentioned researchers.Rastogi and Rastogi (2007)[49] have reported 68 plant species belonging to 41 families in plantations and natural Sal forests of Tripura. Thakur and Khare (2009) [50] have enumerated 73 tree species belonging to 32 families from the six forest communities of Sagar district in Central India. The value of present study also falls within the above reported ranges. Site specific characters play an important role in the distribution of species and their dominance [51] also showed in the present study.

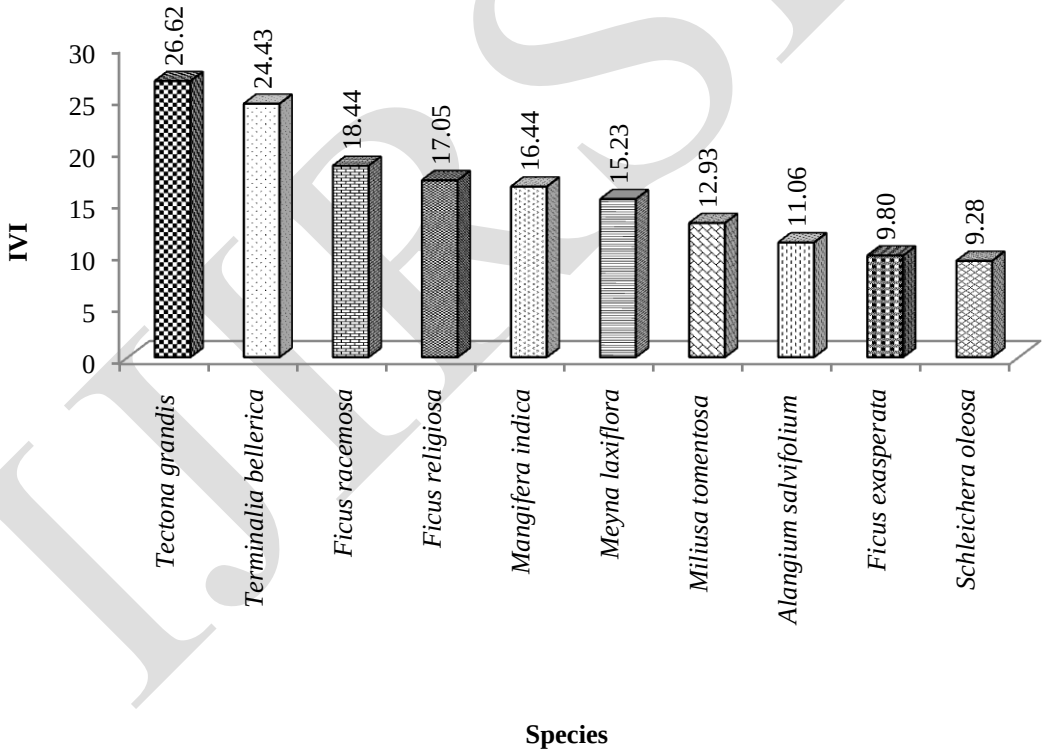

Fig. 1: Major species in teak mixed moist deciduous forest

DOI: 10.15680/IJIRSET.2014.0312057

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 12, December 2014

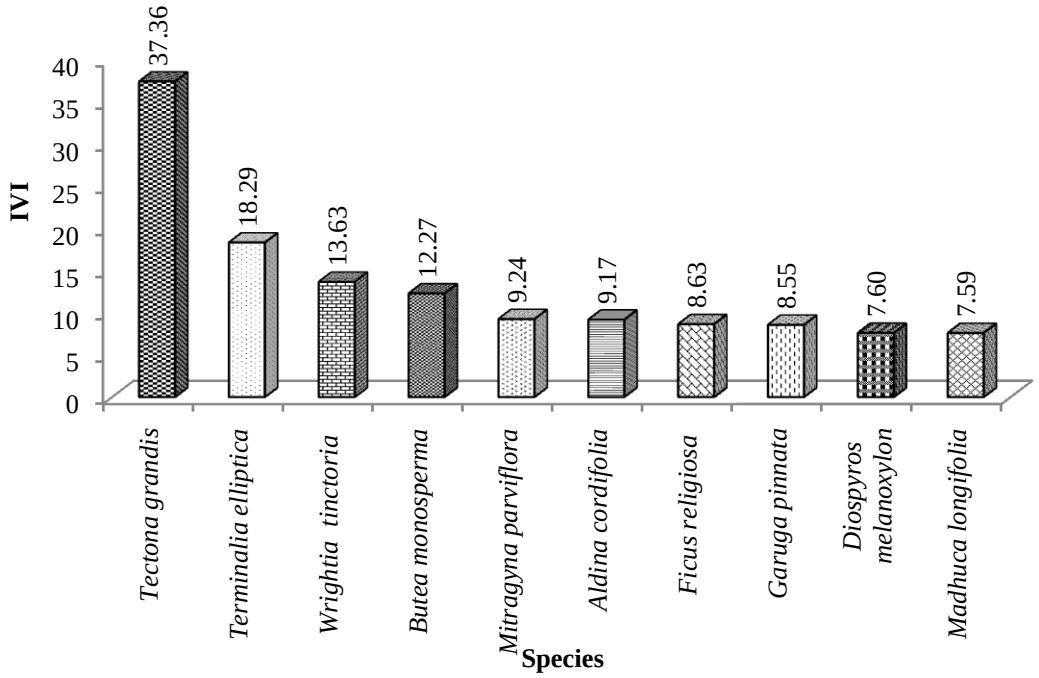

Fig. 2: Major species in teak mixed dry deciduous forest.

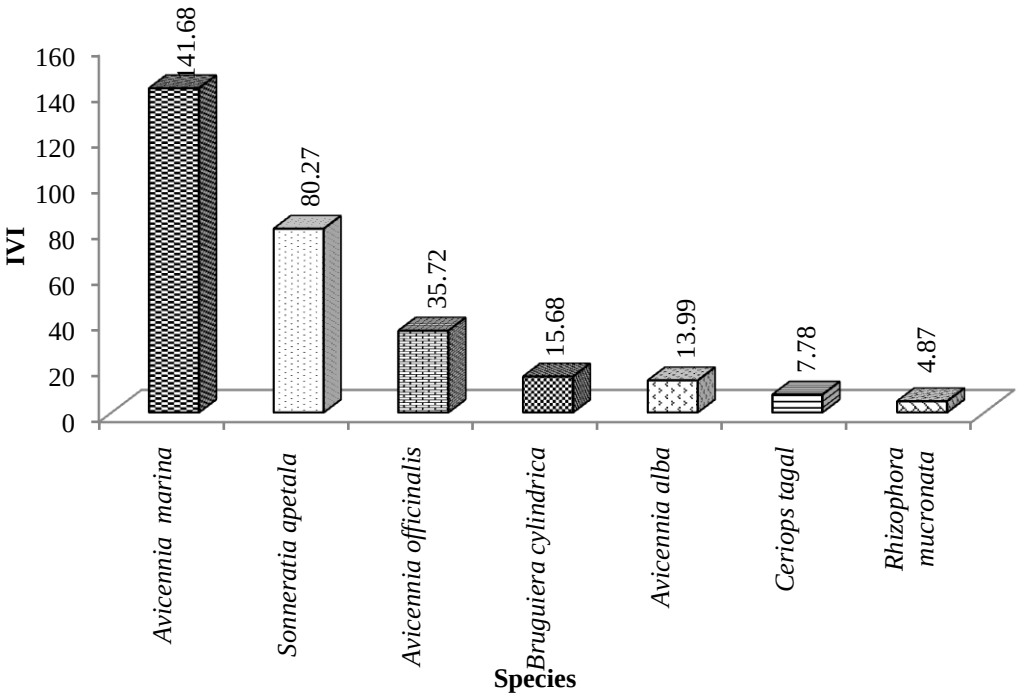

Fig. 3: Major species in mangrove forest.

DOI: 10.15680/IJIRSET.2014.0312057

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 12, December 2014

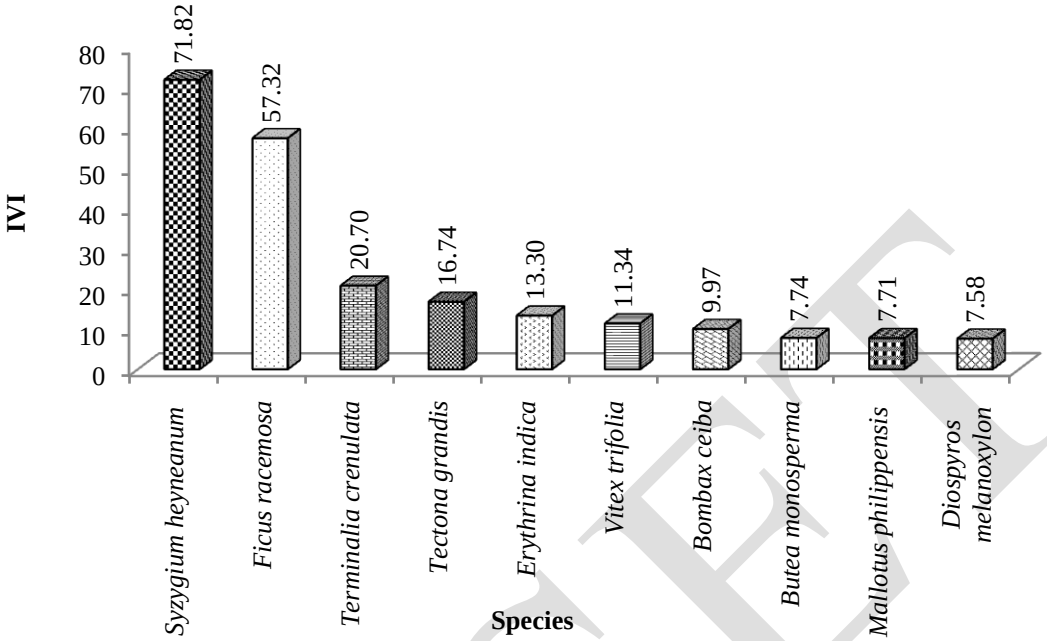

Fig. 4: Major species in riverain forest.

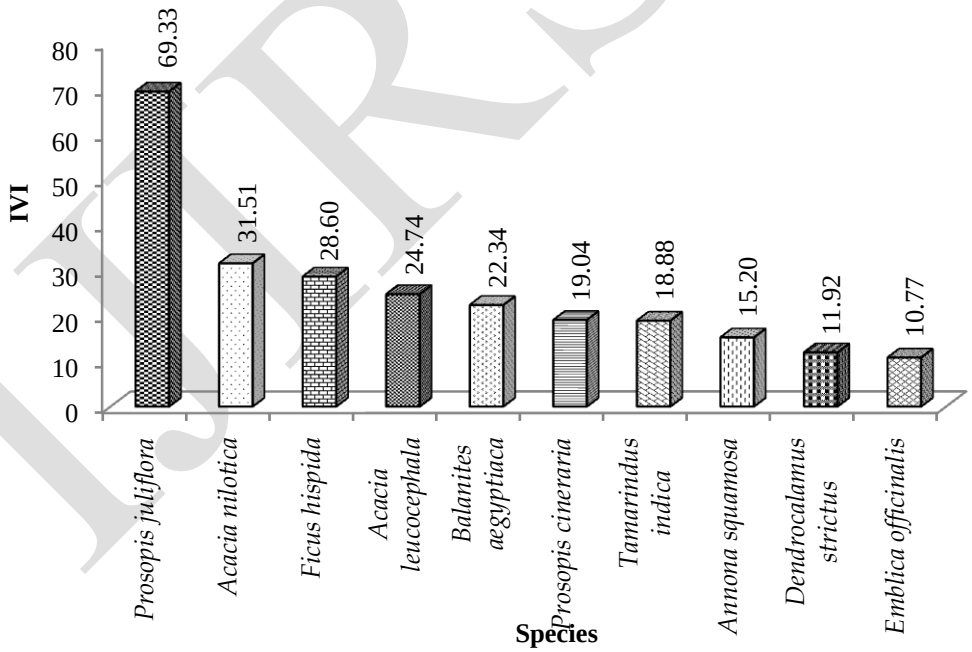

Fig. 5: Major species in ravine thorn forest.

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 12, December 2014

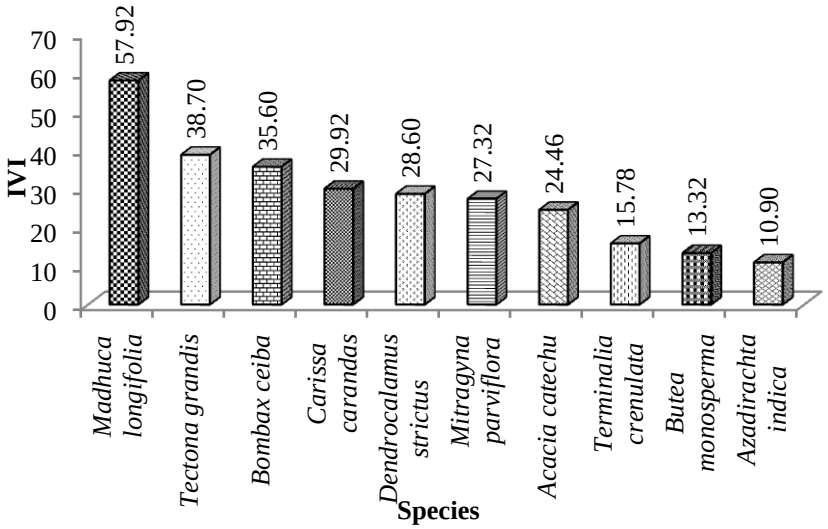

Fig. 6: Major species in forest plantation.

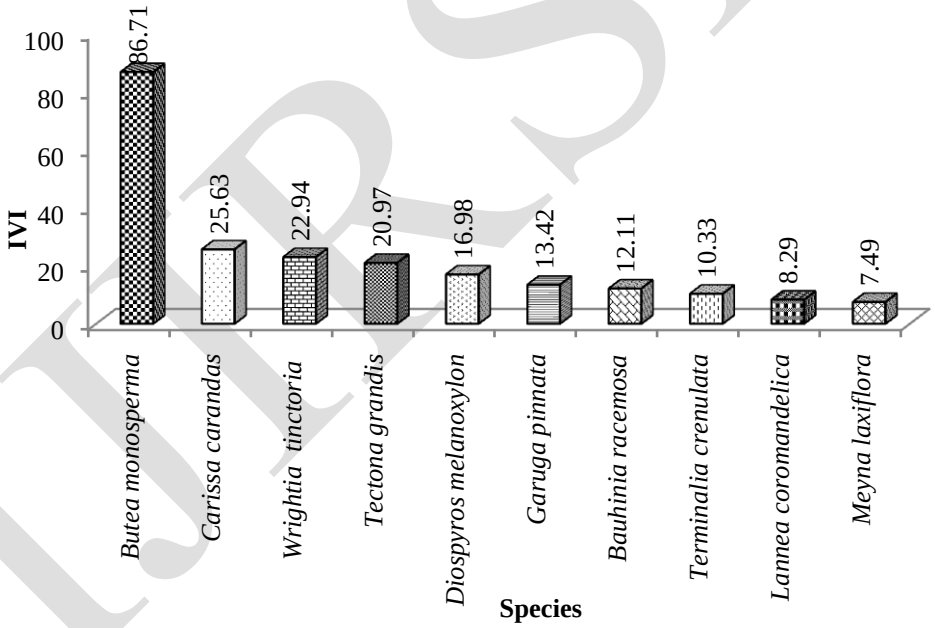

Fig. 7: Major species in degraded forest.

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 12, December 2014

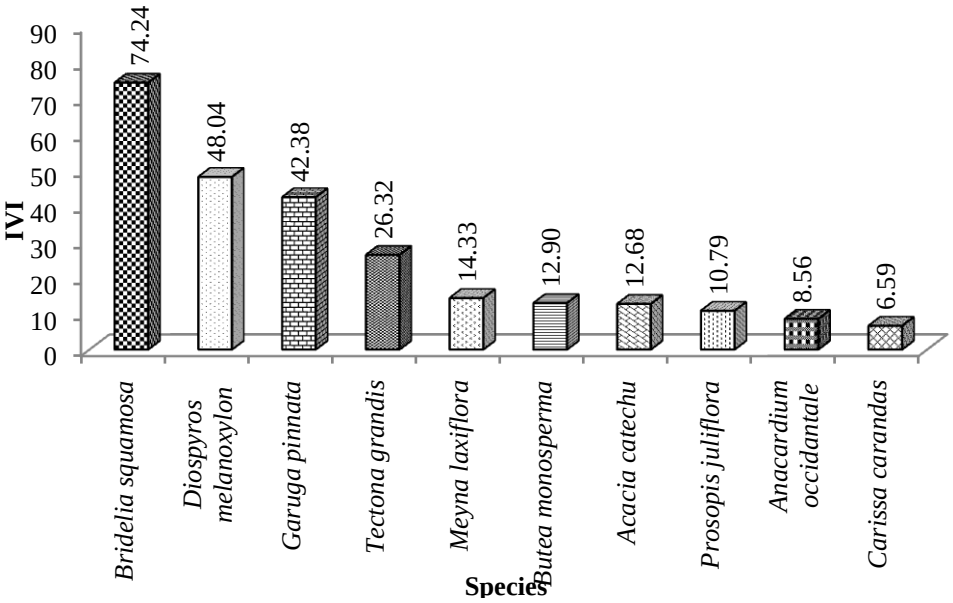

Fig. 8: Major species in scrub.

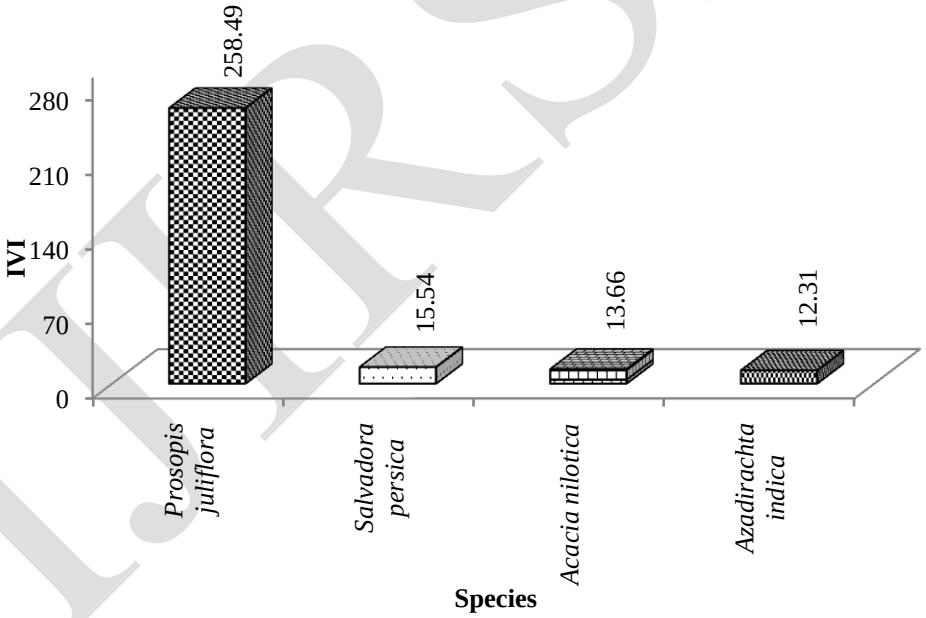

Fig. 9: Major species in *Prosopis juliflora* scrub.

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 12, December 2014

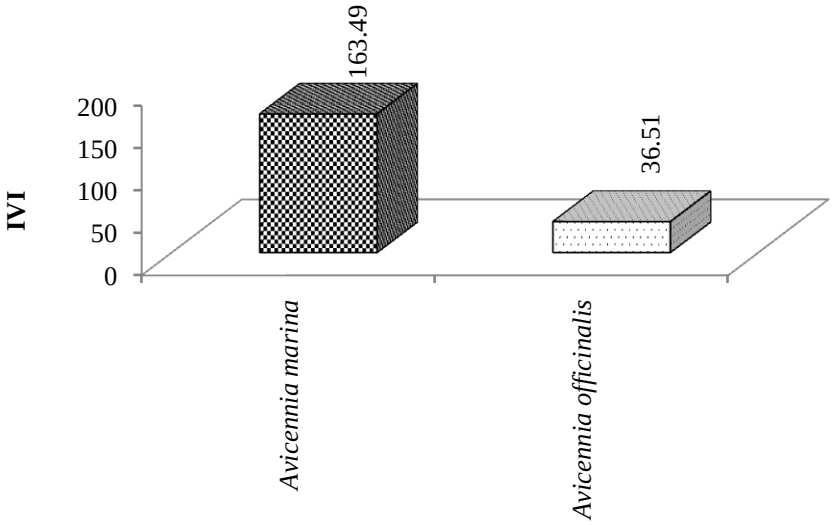

Fig. 10: Major species in mangrove scrub.

Table 1: No. of sample plots, families, genera and species in different vegetation types.

Forest vegetation types	No. of sample plots	No. of families	No. of genera	No. of species			
				Trees	Shrubs	Herbs	Total
Teak mixed dry deciduous forest	88	44	104	85	05	49	139
Teak mixed moist deciduous forest	14	30	47	37	04	16	57
Ravine thorn forest	07	21	20	17	04	05	26
Mangrove forest	10	10	14	07	03	06	16
Mangrove scrub	05	08	10	02	03	06	11
Riverain forest	06	25	38	29	06	05	40
Degraded forest	10	24	45	29	09	07	45
Forest plantation	06	12	18	12	05	06	23
Prosopis juliflora scrub	07	14	22	04	04	19	27
Scrub	04	28	53	13	14	35	62
Total	157	216	371	235	57	154	446

III.CONCLUSION

The study made to quantify (on sample basis) the flora of the south Gujarat. The existing literature on the occurrence of valuable plant species and the knowledge gathered through the present research work authenticate the species habitat relationship, ethno-botanical uses and potential species distribution in the forest ecosystems[52]. A comprehensive species database has been prepared for south Gujarat. Plant diversity assessment is tried at local and regional levels to understand the present status and to make effective management strategies for conservation. In this connection, stratified random sample plot technique and measurement are used based on objectives of the studies, and the availability of time, money and manpower is the major constrain. Several issues discussed in the present research in

DOI: 10.15680/IJIRSET.2014.0312057

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 12, December 2014

relation to phytosociological data analysis, sample size and possibility of incorporating other techniques in plant diversity studies[53]. To summarize, the sampling methods should satisfy the objective of the study and also to bring out the inherent diversity status of a south Gujarat region. The measurement of stem size in the field is the major issue in diversity assessment where, unanimous decision should be achieved among the studies in relation to the threshold of girth of stem considered to be a tree and the height at which it is to be taken from the ground. Sample size in plant diversity assessment is an important issue, which determines the success and failure of a diversity study to bring out the true diversity status[54]. High attention should be paid in this issue in determination of the sample size, and distribution of the samples. Much advancements and research should be made in this line to apply this methodology at species level characterization at landscape level.

IV.ACKNOWLEDGEMENTS

The study was supported by joint funding from the Departments of Space and Biotechnology, Government of India. Authors gratefully acknowledge the support and encouragement received from Director, Indian Institute of Remote Sensing, ISRO, Dehradun during the study. The authors are thankful to Dr. M.L. Sharma, Ex-Principal Chief Conservator of Forest, Govt. of Gujarat, Forest Department, Gandhinagar for collaborating in the project. We also thank Chief Conservator of Forest (Working Plans), Vadodara for coordinating the field work. The authors thankful to Dr. P. Nagar, Dr. M. Daniel and Dr. D. Tadvi, Department of Botany, M.S. University, Baroda, Vadodara, Gujarat for field data collection and plant identification. The first author acknowledge to Dr. U. Kedar, Associate Professor, Department of Petroleum Engineering & Earth Sciences, University of Petroleum and Energy Studies, Dehradun for valuable suggestions and encouragement.

REFERENCES

[1] Hunter Jr., L.M., "Maintaining Biodiversity in Forest Ecosystems," Cambridge University Press, Cambridge, 1999.
[2] Bhatt, G.D., SinhaKomal, Deka, P.K., and KumarAjay, "Flood hazard and risk assessment in Chamoli district, Uttarakhand using satelliteremote sensing and GIS techniques," International Journal of Innovative Research in Science,Engineering and Technology, Vol. 3, Issue 8, 15348-15356, 2014.
[3] Bhatt, G.D., Kushwaha, S.P.S., Nandy, S., and Bargali, K., Tadvi, D.M., Nagar, P.S., and Daniel, M. "Plant richness modeling in south Gujarat, India using remote sensing and geographic information system" Indian Forester, Vol., 139(9):757-768, 2013.
[4] Bhatt, G.D., Nagar, P.S., Tadvi, D.M., Kushwaha, S.P.S., Nandy, S., and Bargali, K., "Ethno-botanical practices associated with the tribal people of The Dangs district, south Gujarat", Oaks, Issue 8:29-38, ISSN: 0975-5918, 2013.
[5] Gadow, K.V., "Waldstruktur and diversitat, forest structure and diversity," Allgemeine Forst-Jagdztg, 170:117-122, 1999.
[6] Pommerening, A., "Approaches to quantifying forest structures," Forestry, 75:305-324, 2002.
[7] Aguirre, O., Hui, G., Gadow, K.v., Jimen' ez, J., "An analysis of spatial forest structure using neighborhood-based variables," Forest Ecology and Management, 183:137-145, 2003.
[8] Fuller, A.K., Harrison, D.J., Lachowski, H.J., "Stand scale effects of partial harvesting and clear cutting on small mammals and forest structure," Forest Ecology and Management, 191:373-386, 2004.
[9] Lexerod, N., and Eid, T., "An evaluation of different diameter diversity indices based on criteria related to forest management planning," Forest Ecology and Management, 222:17-28, 2006.
[10] Shirley, S., "The influence of habitat diversity and structure on bird use of riparian buffer strips in coastal forests of British Columbia, Canada," Canadian Journal of Forestry Research, 34:1499-1510, 2004.
[11] Pommerening, A., "Evaluating structural indices by reversing forest structural analysis," Forest Ecology and Management, 224:266-277, 2006a.
[12] Jhariya, M.K., Bargali, S.S., Swamy, S.L. and Kittur, B., "Vegetational structure, diversity and fuel load in fire affected areas of Tropical Dry Deciduous forests in Chhattisgarh," Vegetos 25(1): 210-224, 2012.
[13] Hasenauer, H., "Sustainable Forest Management Growth Models for Europe," Springer, Berlin and Heidelberg, 2006.
[14] Pommerening, A., and Stoyan, D., "Reconstructing spatial tree point patterns from nearest neighbour summary statistics measured in small sub windows," Canadian Journal of Forestry Research, 38:1110-1122, 2008.
[15] Zobel, D.B., Jeet Ram and S.S., Bargali, "Structural and physiological changes in *Quercus leucotrchophora* and *Pinus roxburghii* associated with stand disturbance in the Kumaun Himalaya, India," International Journal of Ecology and Environmental Sciences, 21:45-66, 1995.
[16] Swamy, S.L., Dutt, C.B.S., Murthy, M.S.R., Mishra, A. and Bargali, S.S., "Floristics and Dry matter dynamics of tropical wet evergreen forests of Western Ghats, India," Current Science, 99 (3): 353-364, 2010.
[17] Kittur B., S.L. Swamy, S.S. Bargali and M.K. Jhariya," Wild land fires and moist deciduous forests of Chhattisgarh, India: Divergent component assessment, "Journal of Forestry Research, DOI 10, 1007/s 11676-014-0471-0, 2014.
[18] Amrutkar, R.P., Kumar, S., Kushwaha, S.P.S. and Bhatt, G.D., "Forest biophysical parameter retrieval using polsar technique," 8th International Conference on Microwaves, Antenna, Propagation & Remote Sensing- ICMARS, Jodhpur, India, December, 11-15, 2012.
[19] Dale, M.R.T., "Spatial Pattern Analysis in Plant Ecology" Cambridge University Press, Cambridge, 1999.
[20] Illian, J., Penttinen, A., Stoyan, H., Stoyan, D., "Statistical analysis and modelling of spatial point patterns,' John Wiley & Sons, Chichester, 2008.
[21] Sterba, H., "Diversity indices based on angle count sampling and their interrelationships when used in forest inventories," Forestry, 81:587-597, 2008.

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 12, December 2014

[22] Pommerening, A., and Murphy, S., "A review of the history, definitions and methods of continuous cover forestry with special attention to afforestation and restocking," Forestry, 77:27-44, 2004.
[23] Merganic, J., and Smelko, "Quantification of tree species diversity in forest stands model BIODIVERSS," European Journal of Forest Research,123:157-165, 2004.
[24] Kint, V., DeWulf, R., Noel, L., "Evaluation of sampling methods for the estimation of structural indices in forest stands," Ecological Modelling, 180:461-476, 2004.
[25] Bhatt, G.D., and Agarwal, S.K., "Floral diversity assessment in Corbet National Park, Ramnagar, Nainital, Uttarakhnad," Indian Forester, Vol. 139(12):1084-87, 2013.
[26] Anonymous, "Working Plan for Rajpipla East and Rajpipla West Divisions," Vol. II. Research and Working Plan Division, Rajpipla, District, Narmada, Forest Department, Gujarat, India, 2006.
[27] Bhatt, G.D., "Plant richness modelling in south Gujarat using remote sensing and geographic information system. Ph.D. Thesis, Department of Botany, Kumaun University, Nainital, Uttarakhand, pp. 157, 2013.
[28] IIRS, "Biodiversity Characterization at Landscape Level in North-West India and Lakshadweep Islands Using Satellite Remote Sensing and Geographic Information System," Bishen Singh Mahendra Pal Singh, Dehradun, 2011.
[29] Bhatt, G.D., Kushwaha, S.P.S., Nandy, S. and Bargali, Kiran, "Vegetation types and land uses mapping in south Gujarat using remote sensing and geographic information system" International Journal of Advancement in Remote Sensing, GIS and Geography, Vol.1, No.1, 20-31, 2013.
[30] Champion, H.G., and Seth, S.K., "A Revised Survey of Forest Types of India," Government of India Publications, New Delhi, 1968.
[31] Ambasta, S.P., "The Useful Plants of India," C.S.I.R., New Delhi, pp.1- 918, 1986.
[32] Nayar, M.P. and Shastry, A.R.K. (Eds.), "Red Data Book of Indian Plants, Vol. I.," Botanical Survey of India, pp. 367, 1987.
[33] Lillesand, T.M. and Kiefer, R.W., "Remote Sensing and Image Interpretation," 5th Edition John Wiley and Sons, New York, 2004.
[34]Bhatt, G.D., Kushwaha, S.P.S., Nandy, S., Bargali, K., Nagar, P.S., and Tadvi, D.M., "Analysis of forest fragmentation and disturbance regimes in south Gujarat forests using geospatial technology," Tropical Ecology, Vol. 56(3), 2015.
[35]Curtis, J.T., "The vegetation of Wisconsin: An ordination of plant communities," University Wisconsin Press, Madison Wisconsin, pp. 657, 1959.
[36] Singh, J.S., and Singh, S.P., "Forest vegetation of the Himalaya," Botanical Review, 53(1): 80-192, 1987.
[37] Tripathi, B.C., Rikhari, H.C., Bargali, S.S., and Rawat, Y.S., "Species composition and regeneration in disturbed forest sites in the oak zone in and around Nainital," Proceedings of Indian National Science Academy, B57: 381-390, 1991.
[38] Nath, T.K., Hossain, M.K., and Alam, M.K., "Assessment of tree species diversity of Sita Pahar forest reserve, Chittagong hill tracts south forest division, Bangladesh", Indian Forester, 126(1):16-20, 2000.
[39] Pandey, P.K., Negi, J.D.S., and Sharma S.C., "Plant species diversity, composition, gradient analysis and regeneration behavior of some tree species in a moist temperate western Himalayan forest ecosystem," Indian Forester, 128(8):869-886, 2002.
[40] Negi, Chandra S. and Sunil Nautiyal, "Phytosociological studies of a traditional reserve forest - Thalke Dhar, Pithoragarh," Central Himalayas (India), Indian Forester, 131(4):519-534, 2005.
[41] Kumar A., Bruce G. Marcot, and Saxena, A., "Tree species diversity and distribution patterns in tropical forests of Garo Hills," Current Science, 91(10):1370-1381, 2006.
[42] Awasthi, K., Dwivedi, A., Tripathi, K.K., and Singh, P., "Assessing floral diversity of Bandhavgarh National Park: A phytosociological approach," Journal of Tropical Forestry, 23(I & II):63-76, 2007.
[43] Thakur, A.S., and Khare, P.K., "Species diversity and composition of forest vegetation of Sagar district in Central India," Indian Forester, 134(6):801-813, 2008.
[44] Shameem, S.A. and KangrooIrfana N., "Comparative assessment of edaphic features and phytodiversity in lower Dachigam National Park, Kashmir Himalaya, India," African Journal of Environmental Science and Technology, 5 (11):972-984, 2011.
[45] Bhatt, G.D. 2013. Plant diversity assessment at landscape level in Jamnagar district, Gujarat using satellite remote sensing and geographic information system. International Journal of Advancement in Earth and Environmental Sciences, Vol.1, No.1, 23-35.
[46] Bargali, K., Bisht, P., Khan, A., Rawat, Y.S., "Diversity and regeneration status of tree species at Nainital catchment, Uttarakhand, India," International Journal of Biological Conservation, 5(5): 270-280, 2013.
[47] Risser, P., and Rice, E.L., "Diversity in tree species in Oklahoma upland forest," Ecology, 52: 876 880, 1971.
[48] Shaheen Hamayun and Shinwari Zabta Khan, "Phytodiversity and Endemic Richness of Karambar Lake Vegetation from Chitral, Hindukush Himalayan Pak," Journal of Botany, 44(1):15-20, 2012.
[49] Rastogi, Nidhi and Alind Rastogi, "Phytosociological analysis of the restored Sal (*Shorea robusta*) plantations and natural Sal forest of Tripura," Indian Journal of Forestry, 30(4):377-385, 2007.
[50] Thakur, A.S., and Khare, P.K., "Composition of forest vegetation and floristics of Sagar district, Central India," Journal of Indian Botanical Society, 88(122): 11-17, 2009.
[51] Bijalwan, A., Swamy, S.L., Sharma, C.M., Sah, V.K., and Singh, R.K. "Phytosociological analysis of over storey and under storey woody perennials along with aspects in Balmdi watershed of mixed dry tropical forest in Chhattisgarh plain," Indian Journal of Tropical Biodiversity, 17(1):47-57, 2009.
[52] Kushwaha, S.P.S., Padmanaban, P., Kumar, D. and Roy, P.S., "Geospatial modelling of plant richness in Barsey Rhododendron Sanctuary in Sikkim Himalaya" Geocarto International, 20(2), 2005.
[53] Deepali Rana and Ganesh Datt Bhatt, "Factor analysis of associations for fish genera in streams of Doon valley," International Journal of Innovative Research in Science, Engineering and Technology, Vol. 3, Issue 8, pp. 15728-15736, 2014.
[54] Shannon, C.E., and Weaver, W. "The mathematical theory of communication," University of Illinois press, Urbana, pp. 125, 1949.
[55] Jhariya M.K., S.S. Bargali, S.L. Swamy, B. Kittur, Kiran Bargali and G. V. Pawar, "Impact of forest fire on biomass and carbon storage pattern of Tropical Deciduous Forests in Bhoramdeo Wildlife Sanctuary, Chhattisgarh," International Journal of Ecology and Environmental Science, 40 (1):57-74, 201

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 12, December 2014

BIOGRAPHY

Dr. S.P.S. Kushwaha is Professor and Head of Forestry and Ecology Department in Indian Institute of Remote Sensing (IIRS), ISRO at Dehradun, India. He is also Group Director of the Programme Planning and Evaluation Group of IIRS. He has 37 years of research and teaching experience and has published 200 papers in national and international journals and proceedings of symposia, seminars, and conferences. He is expert members of several academic and research committees in India and abroad. He is Fellow of Alexander von Humboldt Foundation, Bonn, National Institute of Ecology, Delhi, International Society for Tropical Ecology, Varanasi, and Life Member of Indian Society of Remote Sensing, Indian Society of Geomatics, Indian Meteorological Society, Indian National Cartographic Association, and Indian Astronautical Society. He is also recipient of several fellowships and awards from UNESC-MAB, ITTO, AvHF, etc. He holds a M.Sc. degree in Botany (1977), Ph.D. in Ecology (1982) from India and a Diploma in forest remote sensing (1989) from University of Freiburg in Germany. He specializes in Ecology, Forest Geoinformatics, and Biodiversity/wildlife habitat modelling. He has guided 12 Ph.D. students.

Dr. Kiran Bargali is presently working as an Assistant Professor in the Department of Botany, D.S.B. Campus, Kumaun University, Nainital, Uttarakhand, India. Prior to this she had worked as Young Scientist- DST and Pool Scientist/ Research Associate - CSIR. She did her M.Sc and Ph.D in Botany with specialization in Forest Ecology. She has completed 4 research projects sponsored by various agencies like UGC/DST/ICSSR etc. She had guided 5 Ph.D and 10 M.Sc students for their respective degrees.

Dr. Ganesh Datt Bhatt is Research Associate cum Post-Doctoral Fellow in Department of Environmental Sciences & Natural Resource Management under the School of Natural Sciences in Shiv Nadar University (SNU), Uttar Pradesh, India. Before joining SNU he was Lab Supervisor and Faculty in Department of Petroleum Engineering and Earth Sciences, University of Petroleum & Energy Studies, Dehradun, Uttarakhand, India. He has two and half years' experience inteaching and seven years' experience in research. He has a background of M.Sc. in Botany, M.Phil. in Geo-informatics, Post-Graduate Diploma in Remote Sensing and GIS from Indian Institute of Remote Sensing, ISRO, Dehradun and Ph.D in Botany from Kumaun University Nainital. His major work is Forest Ecology, Taxonomy, Biodiversity, Ecological modeling and EIA/EMP. He is an approved expert member in Land use/Ecology and Biodiversity by NABET. He is Life Member of Indian Society of Remote Sensing, Dehradun, Journal of Association for Plant Taxonomy, Dehradun and International Society of Environmental Botanists, Lucknow.

DOI: 10.15680/IJIRSET.2014.0312057