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

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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 km² (17.54 %) out of total geographical area 31,495 km². 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...
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 km². The plains of south Gujarat are watered by Purna, Par, Damanganga, Auran, 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 hilly (locally known as dungar vistar). The elevation ranges from 100-1000 m at Saputarain The Dangs district. The main forest types in the south Gujarat are: Moist teak forest (3B/C), Southern moist mixed deciduous forest (3B/C2), Southern secondary moist mixed deciduous forest (3B/S2), Dry teak forest (5A/C), Southern dry tropical riverain forest (5/S), Desert thorn forest (6B/C), Mangrove forest (4B/Ts), and Mangrove scrub (4B/Ts) [30]. The main tree species are: teak (Tectona grandis), sadad (Terminalia crenulata), shisham (Dalbergia sissoo), khair (Acacia catechu), tinru (Diospyros melanoxylon), mahuda (Madhuca longifolia var. latifolia), dhavdo (Anogeissus latifolia), khakhkar (Butea monosperma); kalam (Mitragnya parvifolia), bondarao (Lagerstroemia parviflora), billi (Aegle marmelos), moina (Lannea coromandelicae), 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 vers. 9.2 and the study area (31,495 km²) 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
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 different forest 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 shrub species one plot of 5 m x 5 m in centre was laid. For herbaceous plants, four plots of 1 m x 1 m 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 shrubs, 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 square 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 km² (14.98 %), Teak mixed moist deciduous forest 243.01 km² (0.77 %), Ravine thorn forest 144.29 km² (0.46 %) and P. juliflora scrub 257.85 km² (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 km² (2.90 %). Mangrove forest and mangrove scrub contributed 0.10 % (32.90 km²) and 0.24 % (75.40 km²), respectively. Degraded Forests were present in 0.36 km² (0.00011 %) while Riverain forest and forest plantation occupied 0.16 km² (0.0004 %) and 19.53 km² (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 mango grove 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 heynanum was dominant species in riverain 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 bellirica (24.43), Ficus racemosa (18.44) and Ficus religiosa (17.05) (Fig. 1), whereas in teak mixed moist deciduous forest T. grandis (IVI=37.76) was followed by T. elleptica (18.29), Wrightia tingitoria (13.63) and Butea monosperma (12.27) (Fig. 2). In mangrove forest,
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 squamosa 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.

![IVI Distribution](image)

**Fig. 1:** Major species in teak mixed moist deciduous forest
**Fig. 2:** Major species in teak mixed dry deciduous forest.

**Fig. 3:** Major species in mangrove forest.
Fig. 4: Major species in riverain forest.

Fig. 5: Major species in ravine thorn forest.
Fig. 6: Major species in forest plantation.

Fig. 7: Major species in degraded forest.
Fig. 8: Major species in scrub.

Fig. 9: Major species in *Prosopis juliflora* scrub.
Table 1: No. of sample plots, families, genera and species in different vegetation types.

<table>
<thead>
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<th>Forest vegetation types</th>
<th>No. of sample plots</th>
<th>No. of families</th>
<th>No. of genera</th>
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<td>216</td>
<td>371</td>
<td>235</td>
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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
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.

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