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FORESTS AND FOREST RESOURCES OF CENTRAL RAJASTHAN

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ABSTRACT

The largest state in India, Rajasthan, covers an area of 342,239 square kilometres and features a climate and vegetation that are extremely varied. The present research mapped Rajasthan's plant types and land use by using data from the multi-season IRS P6 LISS III satellite. The variability of land cover classes was mapped at a scale of 1:50,000 using a technique known as visual image interpretation. Using georeferenced phytosociological data, we were also able to differentiate between the various types of vegetation formations. Within the boundaries of the study region, a total of twenty-six different vegetation type categories were mapped. The percentage of land covered by vegetation in the state's geographical area is 16.78%. The percentage of land that is occupied by woods that makes up the overall vegetation cover is 4.71%. The dry deciduous woods, thorn forests, broad-leaved hill forests, Dhauk forests, teak mixed forests, and riverine forests are the most common types of forests in Rajasthan. At the level of the landscape, having a map of the various types of vegetation that has been formed is an essential component in gaining an understanding of biodiversity.

Keywords:*Rajasthan,forest, forest resources*

INTRODUCTION

The vegetation is one of the irreplaceable natural resources that shifts in terms of its extent and distribution throughout the course of time. When it comes to the planning and management of natural resources, having correct data on the range and distribution of different types of vegetation is absolutely necessary. Understanding the different forms of vegetation has been increasingly significant in recent years for assessing and monitoring the likely sensitivity of natural ecosystems to changes in the global environment brought about by human activities. This has been the case particularly in recent years. The degree of difficulty in mapping the spatial patterns of the various types of vegetation is significantly influenced by the amount of biodiversity that is being researched as well as the scope of that research. In this context, the mapping of vegetative systems through the use of remote sensing and geographic information systems (GIS) has proven to be advantageous and has experienced tremendous growth over the past several years (Madden, 2004).

There is a wide variety of methods that can be mapped, identified, and tracked for natural resources at both the global and the micro levels that are made available by technologies for remote sensing. When selecting data for satellite remote sensing, the mapping size and spatial resolution are two of the most important aspects to take into consideration. It has been determined that satellite image data acquired by MODIS and AVHRR, with pixel sizes ranging from 250 to 1,000 metres, are appropriate for vegetation mapping on scales ranging from regional to continental. Estimates of forest cover are provided by a number of international programmes, such as the Global Land Cover Facility (GLCF), the assessments conducted by the Food and Agriculture Organisation

(FAO), and the MODIS Land Cover Estimation. These estimates are based on data with a coarse resolution, which may not meet the requirements of ecologists and planners (Hansen et al., 2000; Lotsch et al., 2003). However, a spatial resolution of 20–30 metres is more appropriate for mapping and identifying habitats with a variety of mixed vegetation types, single species dominated systems, locale-specific formations, and degraded types. Because of this, it is important for studies of vegetation mapping at the landscape scale (Singh et al., 2002). Both qualitative and quantitative approaches to data collecting are utilised in the process of vegetation mapping (Hasmadi et al., 2009). This is done so that the resulting database can contain information regarding the spatial location of the plants as well as the attribute table information.

It can be difficult to map the many types of vegetation in tropical forests using only satellite data collected during a single growing season and digital image classification methods. Spectral confusion is a common problem that can be produced by a variety of factors, including the diverse kinds of land cover and the fluctuations in illumination angle across small areas. In addition, edaphic conditions and human disruptions generate seral vegetation stages and locale-specific varieties, both of which might contribute to uncertainty regarding the spectrum (Helmer, 2000). It was determined that the on-screen visual picture interpretation approach was appropriate for distinguishing between different plant varieties. This is due to the fact that the flora types in the tropical parts of India represent a diversity of diverse shapes (Singh et al., 2005; Reddy et al., 2008; Reddy et al., 2009).

Using data from the IRS P6 LISS III, which has a spatial resolution of 23.5 metres, the current study established baseline information on the various types of vegetation that may be found in Rajasthan, India. Utilising a method of visual picture interpretation in conjunction with the information obtained from phytosociological surveys was the approach that was taken in order to accomplish the objective of compiling an exhaustive map of the various types of vegetation.

OBJECTIVES

To study Forests and Forest resources of Central Rajasthan

RESEARCH METHODOLOGY

The climate, altitude, and types of vegetation of Rajasthan are highly variable across the state, making it a very unique and interesting area to visit. The south-eastern plateau, the Aravalli hills, and the western desert (also known as the Thar Desert) are the three primary physiographic zones that can be found in Rajasthan. The Aravalli range, which consists of some of the world's oldest folded mountains, is the most interesting geographical feature. It traverses the state in a diagonal direction from end to end, travelling from the north-east to the south-west, so dividing the state into two fifths of a semi-arid region in the east and three fifths of a desertic zone in the north-west. In a direction that is north-easterly, the Aravalli range gradually decreases in elevation, reaching a maximum height of 1,772 metres at Mount Abu (Gurushikar), 1100 metres in Bijapur, 913 metres at Harshanath, and 792 metres at Khetri. The height then falls to an all-time low of 335 metres in Delhi, which is located beyond the borders of the state. The overall forest area within the state measures 16,036 km2, which accounts for 4.69% of the state's total land area (FSI, 2009).

According to the 2001 Census, 56.61 million people call Rajasthan their home. The climate of the state is quite varied, ranging from sub-humid conditions in the southern parts (Jhalawar, Banswara, and Mount Abu) to

extremely dry weather in the northwest (Jaisalmer). Despite this, the majority of the state, which accounts for 94% of the state's landmass, experiences dry weather that borders on semi-arid conditions. Temperatures range anywhere from 32 to 45 degrees Celsius during the pre-monsoon season, which runs from April to June and is considered to be the hottest time of the year. Temperatures as low as 0 degrees Celsius can be found in a number of cities in Rajasthan, including Churu, during the winter months of January through March.

There have been a total of thirty-six acquisitions of IRS P6 LISS III data, and these data cover the whole state of Rajasthan. The use of data from multiple seasons was chosen because it provides the best ability to differentiate between the various kinds of vegetation. The orthorectified Landsat ETM+ datasets were downloaded from the GLCF website (http://glcf.umiacs.umd.edu/). The data from the Landsat ETM+ satellite was used in the collection and geometric adjustment of each and every one of the sceneries. The planimetric accuracy criterion of an inaccuracy of no more than one pixel was satisfied in each and every situation. The IRS-P6 LISS-III False Colour Composite (FCC) mosaic for the entire state of Rajasthan is shown in Figure 1. Additionally, the datasets from IRS P6 AWiFS (2008) and Landsat ETM+ (2001) were consulted for this study. In addition to ancillary data from Survey of India toposheets on a 1:50,000 scale, the study incorporated spatial datasets such as elevation data (from the Shuttle Radar Topography Mission), the location of villages, road networks, and the Digital Chart of the World (DCW).

DATA ANALYSIS

The total land area of Rajasthan is covered with natural vegetation making up 16.78% of the state (Figure 1, table 1). Figure 2 shows that mixed formations account for 79.22% of the total forest area among the five forest systems that were evaluated at level 1. This is followed by gregarious formations (12.98%), degraded formations (3.68%), and finally forest plantations (3.50%). It was clear by looking at the map of the various types of vegetation that 4.71 percent of the area is covered in woods. The majority of the state's forests have been classified as the following types: broadleaved hill, dry deciduous, dhauk woodland, thorn, teak mixed, riverine forest, tree/shrub savannah, and forest plantation. woodland plantations are also present. Both grasslands and scrub cover a significant amount of the country, with 2.87% and 9.18% of the total area being covered by these types of vegetation, respectively. Mount Abu Wildlife Sanctuary in the Sirohi district is the only place in which you can find the broad-leaved hill forest that spans 80.25 square kilometres. The mixed dry deciduous forest is the most prevalent deciduous ecosystem, covering a total area of 10,443.81 km2 in the world. It is then followed by teak, which covers 456.03 km2, and Anogeissus pendula Edgew., which covers 1354.13 km2. Following the mixed thorn woodland in size is the Prosopis cineraria (L.) Druce area (72.12 km2) and the *Acacia senegal* (L.) Willd. area (212.19 km2). The riverine forest, which is a form of flora that only grows in certain areas, occupies 99.69 km2 of land. In addition to being one of India's dry and semi-arid regions, Rajasthan accounts for 1.39% of the country's total land area and has a relatively small amount of land that is covered by water bodies, including wetlands (4768.84 km2) in total. Agriculture is the primary land use in Rajasthan, taking up an estimated 250123.15 km2 (73.08%) of the state's total land area.

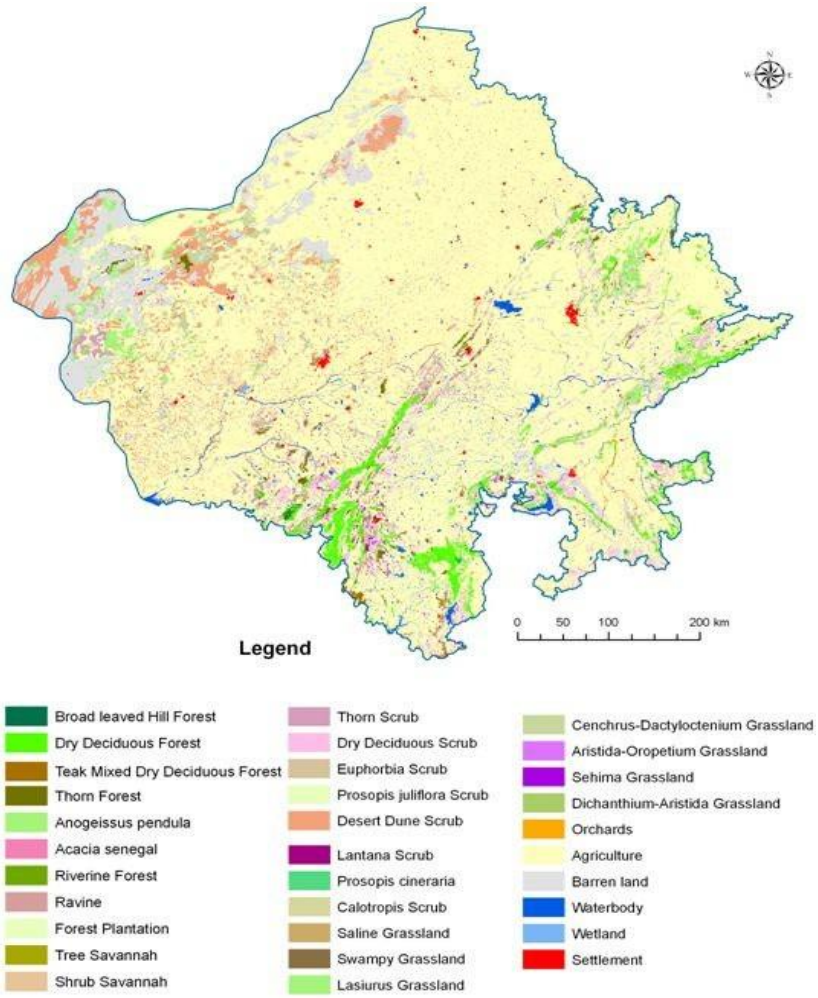

Figure1Map showing the types of vegetation and land uses in the Rajasthan region

Below, we examined the many types of plants that may be found in Rajasthan:

Broadleavedhillforests: Champion and Seth (1968) categorised the broad-leaved hill forests of Rajasthan as Central Indian subtropical hill forests (8A/C3). Within these forests, one can find both evergreen and deciduous tree species. Mangifera indica L., *Syzygium cumini* (L.) Skeels, Lannea coromandelica (Houtt) Merr., Anogeissus lalifolia (Roxb. ex DC.) Well. ex Guill. and Perr., and Anogeissus sericea Brandis are the most common species found there. This particular forest occupies an area of 80.25 square kilometres, which is equivalent to 0.02% of the overall land area. There is a greater proportion of dry vegetation, which, although it has some evergreen characteristics, more closely resembles a dense deciduous forest at the present time. The steep and treacherous slope

Table1.Extent of Rajasthan's Various Vegetation and Land Use(areainkm^2)

Sl.No.	Class	Area (km2)	Area (%)
A	Forest		
I	Mixed formations		
1	Broad leaved hill forest	80.25	0.02

2	Dry Deciduous forest	10448.62	3.05
3	Thorn forest	2252.16	0.66
	Sub total	12781.04	3.73
II	Gregarious formations		
4	Dhauk forest (Anogeissus pendula Edgew.)	1354.13	0.40
5	Teak Mixed forest	456.03	0.13
6	*Acacia senegal* (L.) Willd	212.19	0.06
7	Prosopis cineraria (L.) Druce.	72.12	0.02
	Sub total	2094.48	0.61
III	Locale Specific formations		
8	Riverine forest	99.69	0.03
	Sub total	99.69	0.03
IV	Degraded formations/Woodland		
9	Tree Savannah	468.44	0.14
10	Shrub Savannah	125.07	0.04
	Sub total	593.52	0.17
V	Forest Plantation		
11	Mixed Plantation	564.89	0.17
	Sub total	564.89	0.17
B/VI	Scrub/Shrubland		
12	Thorn Scrub	4788.36	1.40
13	Dry Deciduous Scrub	12440.38	3.63
14	Euphorbia Scrub	130.68	0.04
15	Prosopis juliflora (Swartz.) DC.Scrub	92.44	0.03
16	Desert Dune Scrub	13958.24	4.08
17	Lantana Scrub	8.26	0.002
18	Calotropis Scrub	4.77	0.001
19	Ravine scrub	48.47	0.01
	Sub total	31471.61	9.20
C/VII	Grassland		
20	Saline Grassland	25.36	0.01
21	Swampy Grassland	2.80	0.001
22	Lasiurus-Panicum Grassland	3339.45	0.98
23	Cenchrus-Dactyloctenium Grassland	5430.01	1.59
24	Aristida-Oropetium Grassland	80.15	0.02
25	Sehima-Apluda Grassland	667.28	0.19
26	Aristida-Dichanthium Grassland	283.59	0.08
	Sub total	9828.64	2.87
D/VII I	Orchards	321.11	0.09
E/IX	Agriculture	250123.15	73.08
F/X	Water bodies	4685.00	1.37

G/XI	Wetlands	83.84	0.02
H/XII	Long Fallow/Barren land	26439.93	7.73
I/XIII	Settlement	3152.17	0.92
	Grand total	342239	100

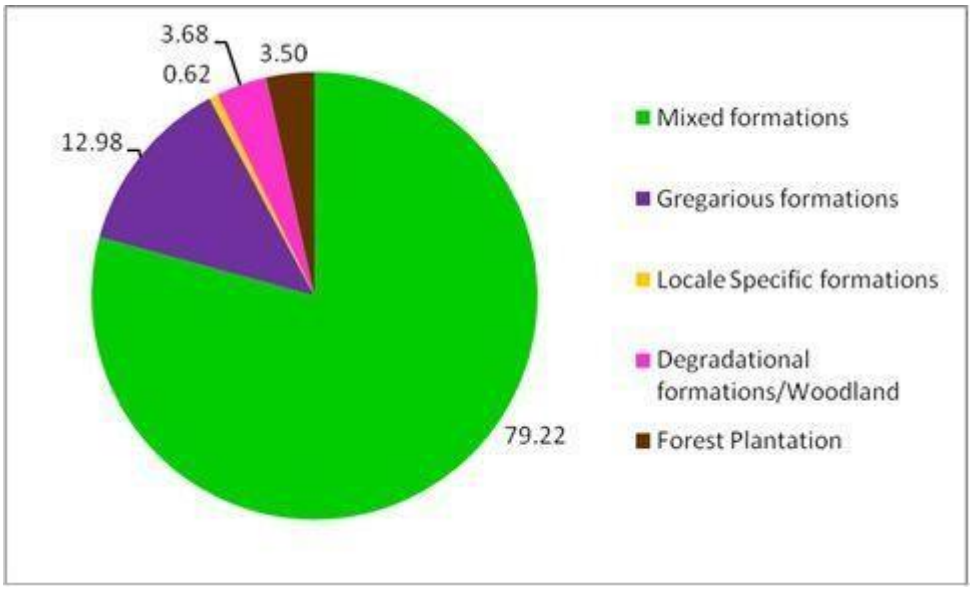

Figure2.Distribution of level 1 Forest categories in a pie chart

The terrain may be distinguished from the environment around it very simply. The image conveys the impression that both summer and winter are harsh in certain parts of the world.

Dry Deciduous forest: It is identical to the dry mixed deciduous woods that are found in the northern regions (5B/C2). Anogeissus pendula Edgew. (which is often referred to as Dhauk), Butea monosperma (Lam.) Taub, Lannea coromandelica (Houtt) Merr, Boswellia serrata Roxb ex Coleb, *Anogeissus lalifolia* (Roxb. ex DC.) Well. ex Guill. and Perr., and Diospyros melanoxylon Roxb. According to Champion and Seth, 1968, the regions of Udaipur, Rajsamand, Ajmer, Kota, and Chittorgarh contain the highest concentrations of dry deciduous forests. These regions are also known as Tropical Dry Deciduous forests. It often takes place at an altitude ranging from 200 to 600 metres above sea level. It has now spread throughout 10,448.62 km2 (or 3.05%) of TGA and is expected to continue expanding. During the green season, a satellite image of a dry deciduous forest will display a dark red colour and a rough texture due to the absence of leaves, however during the dry season, the same areas will appear a greenish tint. This is because the absence of leaves causes the texture to become more rough. This system is differentiated from others by the reflection of a dry ground cover that is regularly burned. It is not uncommon to find large sections of these woods connected together, and often, the contrasting neighbouring forests are only visible during the dry season. This phenomenon is known as "woodland mosaic."

Dhaukforest*(Anogeissuspendula*Edgew.):The categorization system developed by Champion and Seth in 1968 identifies this type of forest as an edaphic climax forest (class 6/E1). This variety is primarily determined by the *Anogeissus pendula*, which results in virtually pure harvests, which are frequently well stocked, and which can grow to a height of roughly 6 metres. These forests are most likely to be found in the Aravalli Mountains' northern and central regions, as well as the eastern portion of the range. A flourishing population of Anogeissus pendula can also be found in the Kumbalgarh wildlife sanctuary, which is located in the southern

Aravallis. The trees are devoid of their leaves from February to June. The species that are connected are those that live in dry deciduous forests. The annual precipitation typically ranges from 500–900 millimetres. There are a total of 1354.13 km2 that fall under this category's purview. When subjected to heavy browsing, Anogeissus pendula takes on the appearance of a thin, crawling shape.

Teakmixedforest: According to Champion and Seth's classification, this ecosystem is a dry teak forest that falls within the 5A/C1b category. Teak Mixed Dry Deciduous Forests can be found in the southern section of the state of Rajasthan, namely in the districts of Dungarpur and Banswara. This particular type of biome covers a total area of 456.03 km2, which accounts for 0.13% of TGA. Some of the species that belong to this category include Tectona grandis L, Anogeissus lalifolia (Roxb. ex DC.) Well. ex Guill. and Perr., Butea monosperma (Lam.) Taub., Diospyros melanoxylon Roxb., Lannea coromandelica (Houtt) Merr., and Boswellia serrata Roxb. ex Coleb. However, during the dry season, it is difficult to differentiate from dry deciduous forest and instead appears as a dark brown tone with a rough texture on satellite photos. This is because of the lack of moisture in the air. One of the most distinguishing characteristics of an association is the presence of contiguous tracts, which are typically found in the foot hills and low-altitude hills of a plateau. Confirmation calls for a relatively intense ground truthing despite its trademark smoky-looking dry deciduous tone at times.

Thorn forest: It is analogous to the tropical thorn forests that can be found further north (6B). The bulk of thorn woods may be found in Rajasthan's central Aravalli Mountains as well as the Thar Desert. Common examples of plants that belong to this category include Acacia senegal (L.) Willd, Acacia nilotica (L.) Willd. ex Del, Acacia leucophloea (Roxb.) Willd., Acacia tortilis (Forssk.) Hyene., *Prosopis cineraria* (L.) Druce., and Zizyphus mauritiana Lam. Capparis decidua (Forssk.) Edgew. is a plant that serves as an indication for the thorn woodlands that are found in western Rajasthan. There is a lower degree of species mixing in dry deciduous woods compared to its analogue in the southern tropical thorn forests of Peninsular India (Champion and Seth, 1968). This is one of the key findings of the study. Images taken during the dry season and the wet season both benefit from its rough texture, which ranges from bright to dark tones.

Riverine(riparian)forest: According to Champion and Seth, these kinds of forests are known as dry tropical riverain forests (5/1S1). Riverine woods are found strewn throughout deciduous ecosystems and can be found anywhere that streams and rivers run as surface channels for longer periods of time than the lands surrounding them. These are the shorter lengths that can be found running along the hilly crossroads where the larger streams meet. Some of the species that make up these woods include *Syzygium heyneanum* (Duthi.) Wall.ex Gamble, *Terminalia arjuna* (DC.) Wight and Arn., *Syzygium cumini* (L.) Skeels., *Holoptelea integrifolia* (Roxb.) Planchon., and *Ficus racemosa* L. Other species include Ficus racemosa L. On the shot, the contrasts are practically ideal when it is during the dry seasons. The photograph shows the vibrant colours that are present during both seasons in these specific areas.

Woodland: The classification provided by Champion and Seth indicated that it was a dry savannah woodland (5/DS2). The way in which the forest degrades and changes into a woodland is determined by a number of elements including fire, grazing, and the conditions of the soil. In the Aravallis of Rajasthan, there were two types of woodland that were frequent depending on the level of disturbance. These two types of woodland are known as Tree savannah and Shrub savannah. Tree height and spacing are the sole characteristics that differentiate shrub savannas from tree savannas. Tree Savannah has a texture that is somewhere between medium and coarse, and its hue is a deep maroon with a hint of pink. The Shrub Savannah has a texture that is in between medium and coarse, and its hue is a pale maroon with a dash of cyan.

Scrub:A shrub or poorly growing tree is the primary component of a scrub, which is a form of vegetation cover that is characterised by a crown density of less than 10% and is typically comprised of small or stunted trees. It covers a total area of 31,471.61 km2 and is the first and most prevalent kind of vegetation. Only 13,958.24 km2 of desert dune scrub may be found in sandy desert environments, and even then, it is only found on partially stabilised and shifting dunes. It is by far the most common type of scrub in Rajasthan. A ubiquitous sight, thorn scrub can typically be found on hilltops, on the outskirts of thorn woods, and in close proximity to human settlements. It is common to find dry deciduous scrub in and around dry deciduous forests, however this type of scrub has been subject to a larger degree of deterioration. Calotropis scrub is most commonly found in desert regions, particularly in places that have been fallow for an extended period of time and at the borders of crop fields. Only in areas of the Aravallis and the desert that are extremely rocky and have been badly eroded can you find the Euphorbia scrub. Euphorbia caducifolia Haines is the species that predominates in this very open formation. (Reddy, 2008) Prosopis juliflora (Swartz.) DC. and Lantana camara L. are the two most harmful invasive alien species that represent a threat to native biodiversity. Both of these species originate from other planets. Because of their invasive tendencies, Prosopis juliflora and Lantana camara are responsible for the formation of dense thickets that are referred to, respectively, as Prosopis scrub and *Lantana* scrub. It is common for Prosopis juliflora to thrive along roads, canals, and other degraded thorn woodland habitats. *Prosopis juliflora* spreads swiftly between the Aravallis and the desert. The subhumid areas of broadleaf hill forests, as well as the openings and borders of dry deciduous forests, are ideal habitats for the *Lantana* camara plant.

Other Non Vegetation Classes: Orchards are the collective name given to areas of land that are devoted to the cultivation of various plants, including fruit trees. The majority of Rajasthan's orchards may be found among the districts that are located in the state's east. The classification of agricultural land as a single category on the map includes both cropland and fallow land. A large proportion of Rajasthan's total land area (73.08% of TGA), which can be attributed to the state's population density, is used for agricultural purposes. Approximately 66 distinct kinds of agricultural produce were grown throughout the state. Wheat, barley, jowar, lentils, mustard, maize, and bajra are the primary agricultural products. It is possible to determine a single cropping area or several cropping areas using satellite remote sensing in conjunction with operational estimating methods that are already in place. In addition, we mapped features such as sand, water, settlements, barren terrain, and wetlands. These features can all be differentiated from one another and are significantly easier to read than the categories that came before them, particularly in light of the scheme's present level of precision. A visual interpretation technique can be used to minimise common digital processing problems, such as when distinguishing between circumstances involving scrub, barren landscapes, settlements, water, and wetlands. This is only one example of how this approach might be used.

CONCLUSIONS

According to the findings of the study, remote sensing is one of the most cutting-edge technological technologies that can be utilised for mapping and identifying the complex vegetation patterns seen in India. The geographical data that are generated by vegetation type maps are an essential source of information for the study of landscape ecology. Changes in biodiversity brought about by human activity are related with shifts in the distribution as well as the spatial extent of different types of plants.

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