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Contents

Changes in Ecological Landscape Pattern and Land Use from 1985 to 2014 in the Panshet Dam Catchment

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Abstract

The Sahyadri, the northern part of Western Ghats in the state of Maharashtra, India, are one of the most fragile ecosystems on Earth. There are major changes in the original ecosystem and land use in the Sahyadri over the past two centuries.

A ground survey was conducted by Ecological Society, Pune in 1985 as well as in 2014 to assess current land use and status of biodiversity in the Panshet dam catchment situated in Sahyadri. This study probes to understand factors responsible for decline of biodiversity and changed land use. We highlight the extent and causes for change in land use.

The study attempted to quantify this change by carrying out manual digitization of multispectral WV-2 satellite images by visual interpretation and ground truthing and compare with the study done by Ecological Society in 1985.

The mapping of the catchment area shows that areas towards western escarpment i.e. away from the dam wall have retained better vegetation cover while degradation is evident in eastern parts of the catchment.

Such studies will be useful for land use planning, understanding cost-benefits of nature conservation, assessing restoration potential, and developing conservation-restoration strategies on a regional scale. We recommend similar vegetation and land use class mapping for all dam catchments in the Western Ghats.

Keywords : *Sahyadri, Northern Western Ghats, Panshet, Pune, Land use pattern, Landscape, forest, GIS mapping, visual interpretation, vegetation class mapping, landscape-based ecosystems management, dam catchments*

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Introduction

The Western Ghats

The Western Ghats (WG) stretch nearly 1600 km along south-west peninsular India and stand testimony to several million years of geological history. The WG are the mountain range that is separated from the Arabian Sea by a narrow strip of the coastal plains of India. The hill range of WG has been recognized as one of the world's 35 biodiversity hotspots, i.e. a region of rich biodiversity threatened with destruction. It is

one of the world's eight hottest hotspots and declared as a World Natural Heritage site by UNESCO (Unesco, 2012).

There have been many studies about biodiversity and ecosystems of the W. Ghats, documenting changes in forest vegetation, threats, and conservation needs. Even though they do not contain specific mentions of forests and ecosystem health in Western Ghats, the Gazetteers of past governments mention the richness of flora and fauna present in immediate surroundings of town centers present at that time. From these references, it is evident that the forests of Western Ghats were more or less intact till 1836-37, when the revenue survey was introduced by the British India government. After this, forests in Western Ghats started converting slowly into cultivation plots for hill millets locally, and into monocultures of timber species as well as tea plantations in Southern parts. For several decades, the conversion for cultivating hill millets was low relative to the overall area of WG and there was a chance of it regenerating into a secondary forest during fallow period.

Land use change accelerated in the 20th century with the development of irrigation reservoirs in these high rainfall areas – the key reasons being submergence of fertile valley bottoms, hill communities being displaced to higher slopes, cultivation of slopes for millets, and extraction of coal for urban centers due to easy access to these remote parts (Gadgil 1979). This continued through the British period and after India's independence.

A study by (Jha, Dutt, Bawa, July 2000), which uses GIS mapping over 40,000 sq km of area in Southern Western Ghats showed 25.6% loss of forest cover in 22 years (1973 to 1995). It was also observed that the dense forest was reduced by 19.5% and open forest by 33.2%.

In Sahyadri, the number of reservoirs is very high, with almost all the rivers dammed in the source area. A similar situation was documented by (Gadgil M, 1979) and (Gole P., 1985) in their studies in dam catchments of Panshet, Warasgao and Mulshi near Pune.

Rationale for the study

"Land is the basic component of the natural resource system of any country. Natural resources are fundamental to sustainable economic development in most countries, particularly Asian developing countries where agriculture remains an important source of economy. Natural resources are increasingly subjected to intensive population pressure, widespread poverty and expansion of industrialization and urbanization. The rapid change in the socio-economic patterns of these countries has inevitably and adversely affected the natural resources. Natural resource problems have now become a major concern of development planners as they attempt to promote rapid development. These problems are partly caused by mismanagement of resources through serious exploitation." (Onchan Tongroj, 1993)

The above quote is pertinent in case of Sahyadri, where the forest cover is fast depleting due to development pressures. The reasons include agriculture, new roads, widening of existing roads, farm houses, recreational sites, hill stations, townships, horticulture and greenhouses, small-scale industrial units, and large-scale industrial activity like SEZs or new plants.

Availability of data and observations regarding ecological landscape of Panshet catchment from 1985-86 triggered the present study. We planned to assess land use changes occurring in the Panshet catchment after almost 30 years as this may guide further directions in planning.

Study area

Location and Physiography

The Panshet dam catchment, which is the area for the present study, lies in Sahyadri (Northern Western Ghats). It is situated at approximately 40 km west of Pune city and is a major irrigation and water supply project in the region.

The dam catchment is spread over 118.6 sq km, extending from 73°26'7.947"E and 18°17'43.641"N to 73°37'44.686"E and 18°23'14.33"N with elevations ranging from 626 m at valley to 1134 m at the ridge line (Pole village). The waterbody of Panshet dam is spread over 14.5 sq. km.

The River Ambi, an eastward flowing river originates at Dapsar and is bound by two main hill ranges running west to east separated by average distance of 6.6 km (Figure 1, 2, 4).

The catchment of Ambi comprises of twenty five mini watersheds (Figure 3).

Rainfall

The rainfall data shows variation from average annual 9000 mm at Western escarpment at village Dapsare, to 2100 mm at village Panshet where the dam is built. The 1985 study by Ecological Society divided the catchment into 4 zones (Figure 5).

Distribution of rainfall becomes an important factor as it decides natural vegetation character in the valley.

Figure 1, 2 : Location : Panshet dam catchment

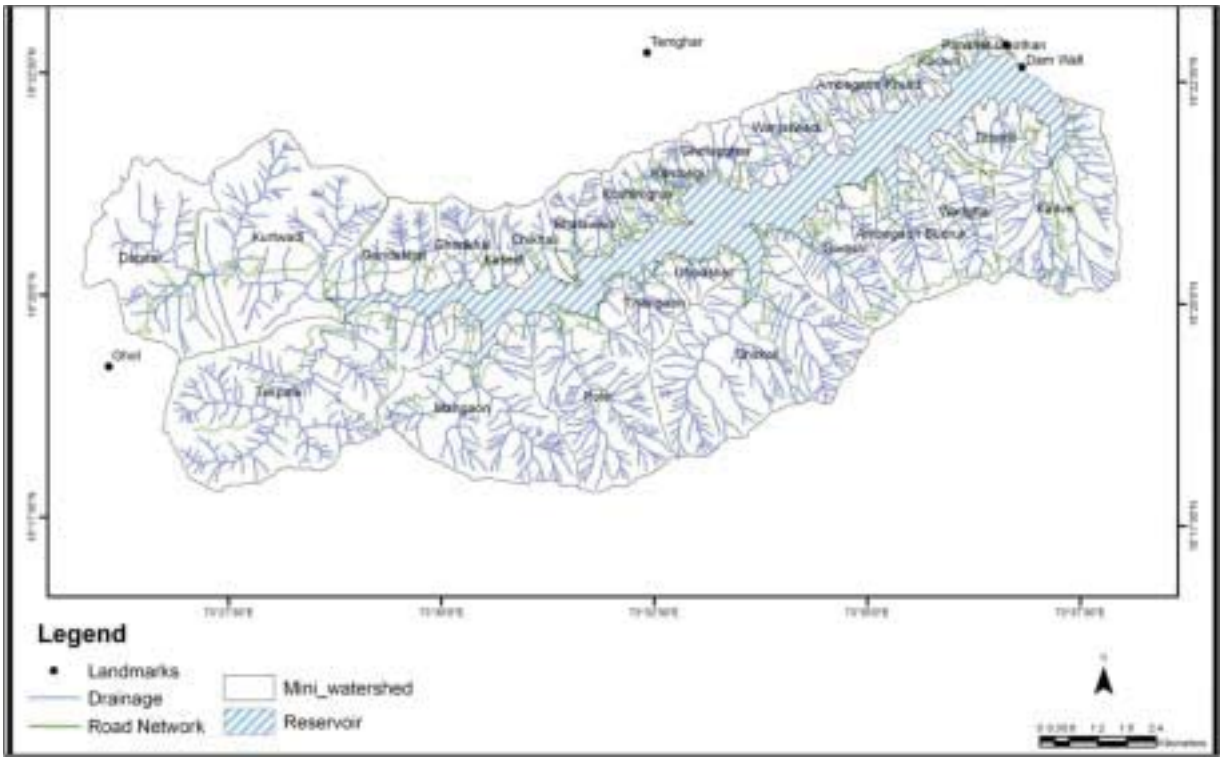


Figure 3: Hydrology of Panshet dam catchment

Figure 4: Physical map : Panshet catchment

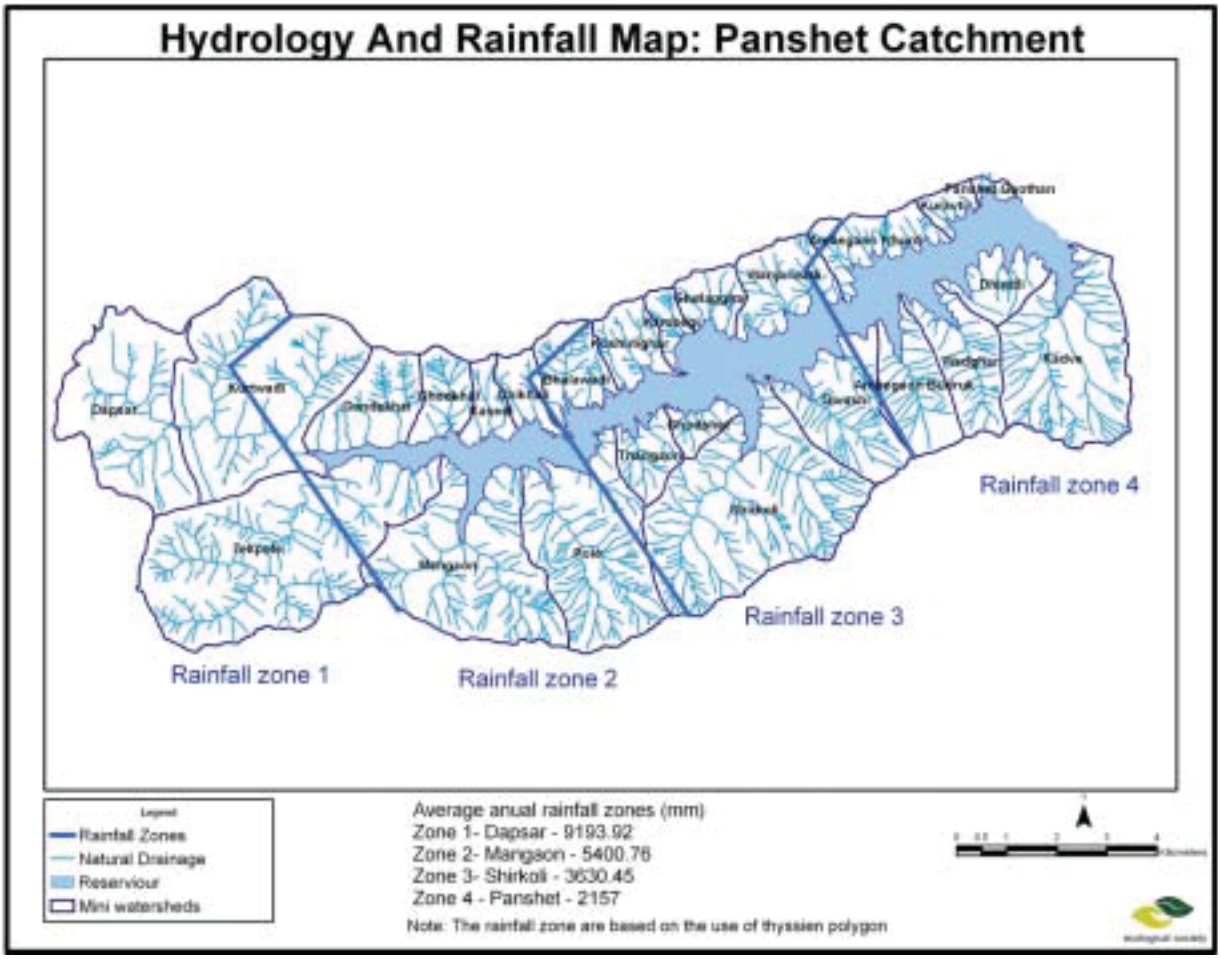


Figure 5: Panshet catchment : Rainfall zones

The variability in precipitation and topographical features create a wide range of vegetation types from semi-evergreen forests to moist deciduous, scrub to open grasslands and rocky outcrops.

Earlier Studies about the Study Area

Earlier studies of the Panshet catchment have studied the ecosystem, biodiversity, socio-cultural practices like Sacred Groves and land use. (Gadgil, M. and Vartak, V.D., 1976) mention that hill slopes fairly remote from the villages were still covered by some forest. Until about twenty years before the time of this study, the whole region was much better forested, particularly because the peasants left valuable trees standing even when they cleared a plot for cultivation.

The upper hill slopes were clothed by a rich natural forest of the semi-evergreen type, constituted into state-owned forest reserves. These forests were hardly exploited due to lack of transport facility. Prof. Gadgil also mentions a flourishing tanning industry at Bhor, near Panshet which was entirely based on Hirda (*Terminalia chebula*) collection from forests in these catchments which gradually declined as majority of forests were cut for coal by 1960. (Gadgil M, 1979)

Prof. Gole, with his detailed study of Panshet catchment in 1983-84 with respect to the ecosystem and socio-economic aspects, concludes that construction of the dam and allied activities led to speedy destruction of the original forest ecosystem in the catchment. The major reasons leading to this destruction are : submergence of fertile land, social dynamics of communities and resettlement, and construction of a ring road giving access to the urban market for coal. (Gole P., 1985)

Objectives of the 2014 study

The objectives of the present study (2014) are given below :

1. To prepare land use, land cover (LULC) maps for the Panshet catchment and to derive area estimates of vegetation and human land use classes
2. To survey and document biodiversity in various land classes
3. To evaluate degree of degradation by comparing the present data with data from 1985 study. We planned to use the 1983-85 primary data set as a reliable record of past biodiversity status
4. To prepare a restoration potential map

Land use and land cover is an important component in understanding the interactions of the human activities with the environment. Keeping these factors in mind GIS techniques and traditional surveying methods were used to get a real picture of the present land use and biodiversity status of the catchment.

Methodology

GIS analysis

High spatial resolution multi-spectral satellite image was used for visual interpretation. Standard WorldView-2 (4 band) images for 2013-14 were used. Land Use-Land Class (LULC) mapping for 2014 was obtained by manually digitizing the image. Data from the 1983-85 study was used to create a digital version of Land Use-Land Class mapping of that time.The datasets were then incorporated in ArcGIS 9.2 to convert that data into meaningful information.

Note : In case of smaller objects like ponds, water tanks, small shifting cultivation patches etc, the scale was temporarily changed.

Methodology Steps

The following methodology was adopted :

1. Generation of maps for all the input layers.
2. **Hydrology :** The natural drainage pattern was digitized taking toposheets as base. The contour pattern was studied and accordingly the drainage, mini-watersheds and entire watershed boundary was delineated. The drainage pattern was updated with the help of the false color composite (FCC).
3. **Rainfall :** Based on secondary data from the Meteorological Department**,** the project area was divided in four zones considering the average annual rainfall. The zones were derived based on the Thiessen polygon method.
   a. Zone 1- Dapsar- 9193.92 mm
   b. Zone 2- Mangaon- 5400.76mm
   c. Zone 3- Shirkoli- 3630.45mm
   d. Zone 4- Panshet- 2157mm
4. **Mapping of Stream Habitat :** The streams were digitized from the satellite image. The habitat of riparian zone along the rivers was mapped.
5. **Ground Survey for biodiversity and land use classes :** A Stratified Random Sampling approach was followed for ground survey. Based on the past experience of the team in this landscape, analysis of Google Earth images, observations from reconnaissance visits, and variation in land classes, we selected 47 randomly distributed areas and completed their detailed on-ground biodiversity survey over a period of 6 months.

These randomly sampled 47 points represent all the vegetation classes as well as physical conditions in the valley. These 47 points also covered all rainfall zones. As the focus of the study was to map special biodiversity of the catchment, this methodology served us well. However, the overall observations were not restricted only to the selected 47 points. Biodiversity was observed all along the catchment.

The images available were of two different seasons; one for 18th May 2013 and another for 28th Jan 2014. They were both World view 2- 4 band multispectral pan-sharpened satellite images. Both the images were used simultaneously to eliminate any wrong classification. The scale was set to 1:3000 for almost the entire watershed area. The final layer was then re-checked for any mismapping.

During the ground survey of sample points, the latitude, longitude and elevation was collected with the help of a hand held GPS device. Associated biodiversity was documented in standard formats. This format includes Endemism, IUCN status, and legal status of each species. The other information is location, brief description, area, co-ordinates, altitude, dominant flora, old growth flora, tall canopy flora, species with IUCN status, Indian forest department's scheduled species and photos. Vegetation classes were identified based upon current floral composition. Vegetation composition also changes due to anthropogenic activities including agriculture.

As the land classes have been drawn by manual digitization, the maps are the true representation of the real topography. Due to this method, the possibility of inaccuracy creeping in due to automated classification has been ruled out.

Vegetation and Land Use Classes

Following are the natural and human-influenced vegetation classes which were mapped in the form of polygons. The determination of land classes is based on their key vegetation characteristics and is similar to that proposed in Ghate (2014).

No.	Class	Description
1	Open grasslands	Areas with grasses as the dominant community
2	Scrub	Areas which combine evergreen thorny scrub vegetation with interspersed grass patches
3	Sparse vegetation	Areas with not too many grass patches but large clusters or regenerating trees
4	Karvi (Carvia callosa) patches	Areas with uniform Karvi (Carvia callosa) patches
5	Karvi (Carvia callosa) and dwarf canopy	Areas with Karvi (Carvia callosa) patches and low height canopy trees
6	Dense shrubbery	Areas with dense shrubs of similar height
7	Sparse vegetation dominated by trees	Areas with shrub cover dominated by regenerating trees
8	Dwarf canopy forests	Areas with mixture of shrubs, regenerating dwarf trees
9	Mature forests	Areas with original forest vegetation
10	Tall canopy	Areas with fairly dense cover with tall canopy trees
11	Potential stream habitat	Areas of stream-sides with dense tree vegetation
12	Rocky outcrop	Areas with occurrence of rocks and boulders, and less soil cover
13	Free face	Areas with vertical rock faces (usually inaccessible) and retaining original vegetation of rocky outcrop

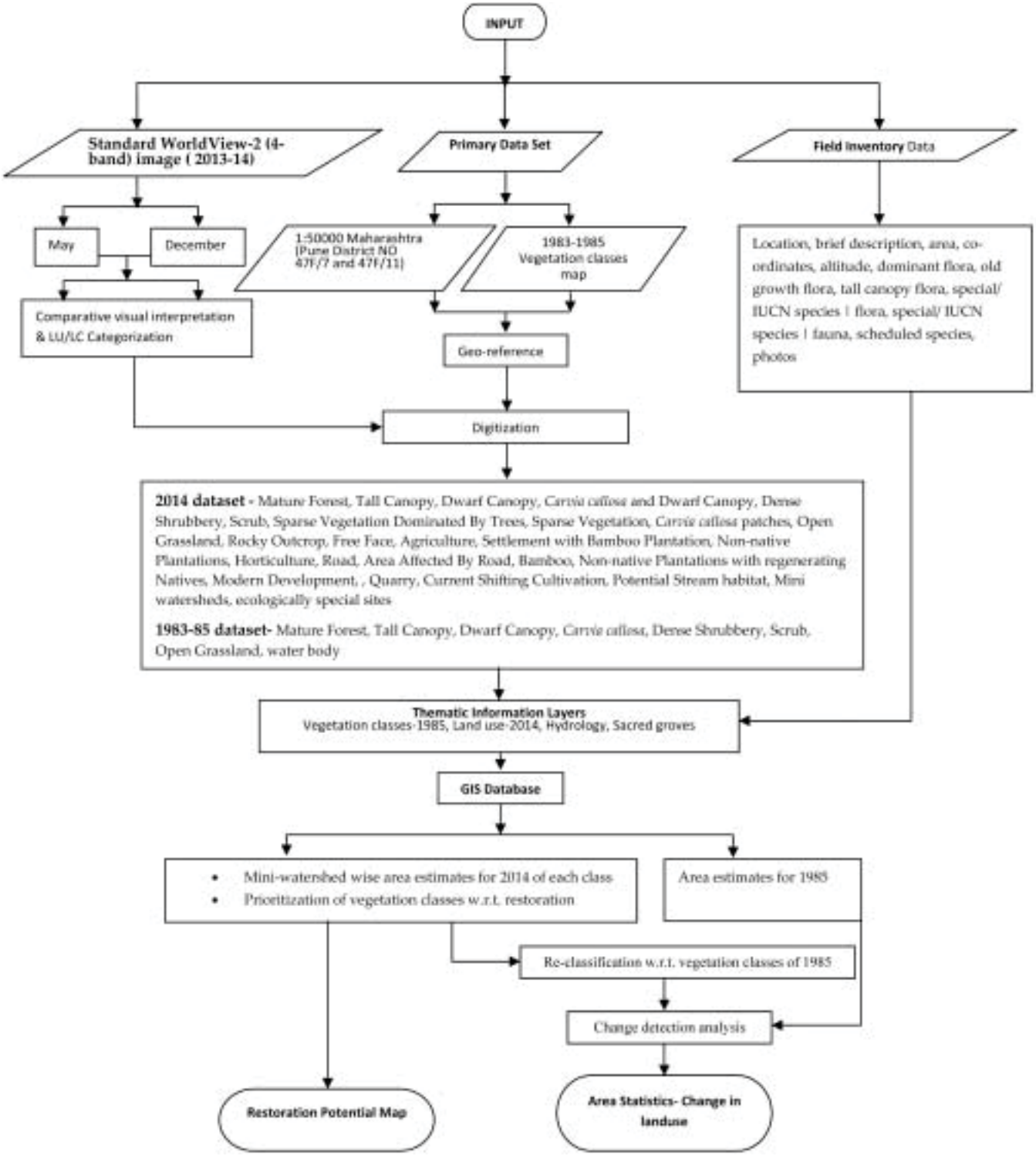
Table 1 : Vegetation classes

Apart from the above classes, there are man-made land use classes spread over the entire catchment. These are due to cultivation practices and modern developmental trends. These classes are :

No.	Class	Description
1	Agriculture	Permanent areas under cultivation, i.e. Paddy fields and other crops
2	Plantations	
	a. Non-native Plantations	
	b. Bamboo Plantation around Settlement	Plantations by local people, various government departments,
	c. Horticulture	or private land owners.
	d. Old Non-native Plantations with regenerating natives	
3	Road and Areas Affected By Road	Tar road and areas affected by road construction activity
4	Bamboo Plantation	Independent Bamboo plantation, typically for income generation
5	Modern Development	Farm house schemes, recreational sites, existing residential infrastructure, semi-urban areas, etc.
6	Quarry	Earth or stone extracted for construction
7	Shifting Cultivation Patches	A practice in this area which uses slopes for cultivation. These are patches of land used for cultivating hill millets for 2 or 3 years.
8	Settlements	Villages and areas around them

Table 2: Human-influenced land use classes

A chart describing the data collection and analysis process is given below :



Analysis

Primary Data set

Data was available in the form of tables, maps and text for the year 1983-85 (Gole P., 1985). In this earlier work, a hand drawn "vegetation classes" map was geo-referenced and then manually digitized. However, the vegetation classes were presented based on the species dominance. Hence, they were reclassified into new vegetation classes per our present classification and the 1983-85 map was re-produced by utilizing the association in table below. The association itself is based on the field observations of the authors and Ecological Society over the last several years in W. Ghats. Area estimates were carried out based on this map for the year 1983-85. This map is presented in Figure 8.

Land-use land-cover analysis for the year 2014

The satellite images used are shown in Fig. 6 and 7 (Note : Vegetation appears in red color).

Results and discussion

Land-use land-cover map for 1985 study

As discussed above, the historical data available was used to prepare 'vegetation classes' map of 1985 and an area statement was derived from it.

No	Species-dominant class as per [Gole P, 1985]	Reclassified class
1	Actinodaphne hookeri Heissm, Glochidion hohenackeri Bedd	Dwarf Canopy
2	Bridelia squamosa Gehrm, Terminalia tomentosa W	Dwarf Canopy
3	Butea monosperma Taub, Xeromphis spinosa Keay	Dwarf Canopy
4	Dendrocalamus strictus Mees, Syzygium cumini Skeels, Strobilanthes Sp	Dwarf Canopy
5	Erythrina variegata Merr, Euphorbia neriifolia Roth	Scrub
6	Heteropogon contortus P. Beauv, Themeda quadrivalvis O. Ktze	Open grassland
7	Latana camara L	Open grassland
8	Latana camara L- Carissa congesta Wight	Open grassland
9	Mangifera indica, Memecylon umbellatum Burm, Syzygium cumini Skeels, Ficus spp	Tall canopy
10	Memecylon umbellatum Burm, Ficus sp	Tall canopy
11	Phoenix humilis Bess, Dendrocalamus strictus Mees	Dwarf Canopy
12	Reserved Forest	Tall canopy
13	Reservoir	Water body
14	Sacred Grove, Mangaon	Mature forest
15	Strobilanthes callosus Mees	Carvia callosa
16	Syzygium cumini Sxeels, Wendlandia ihyroidea, Macaranga peltata Muella	Dwarf Canopy
17	Terminalia tomentosa W and A	Open grassland
18	Terminalia tomentosa W and A, Emblica officinalis Gaeri	Open grassland
19	Woodfordia fruticosa Kurz, Lasiosiphon eriocephalus Ocme	Scrub

Table 3 : Table showing reclassification of species-dominant classes from the 1985 study

Note : As the 1985 map is a hand drawn map, there could be statistical inaccuracies in the area computation of the land classes. Yet, this is the best source available for a comparative study.

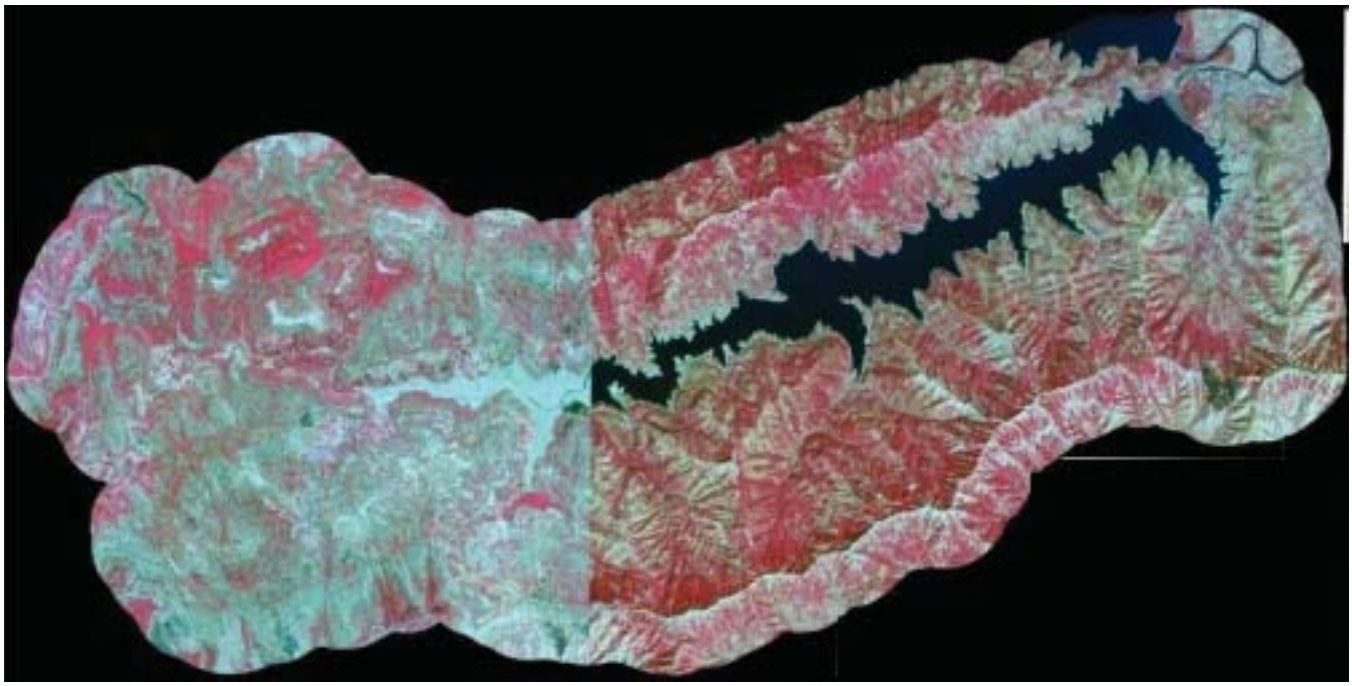


Figure 6 : Worldview -2 Pan-sharpened multispectral image – May 2013

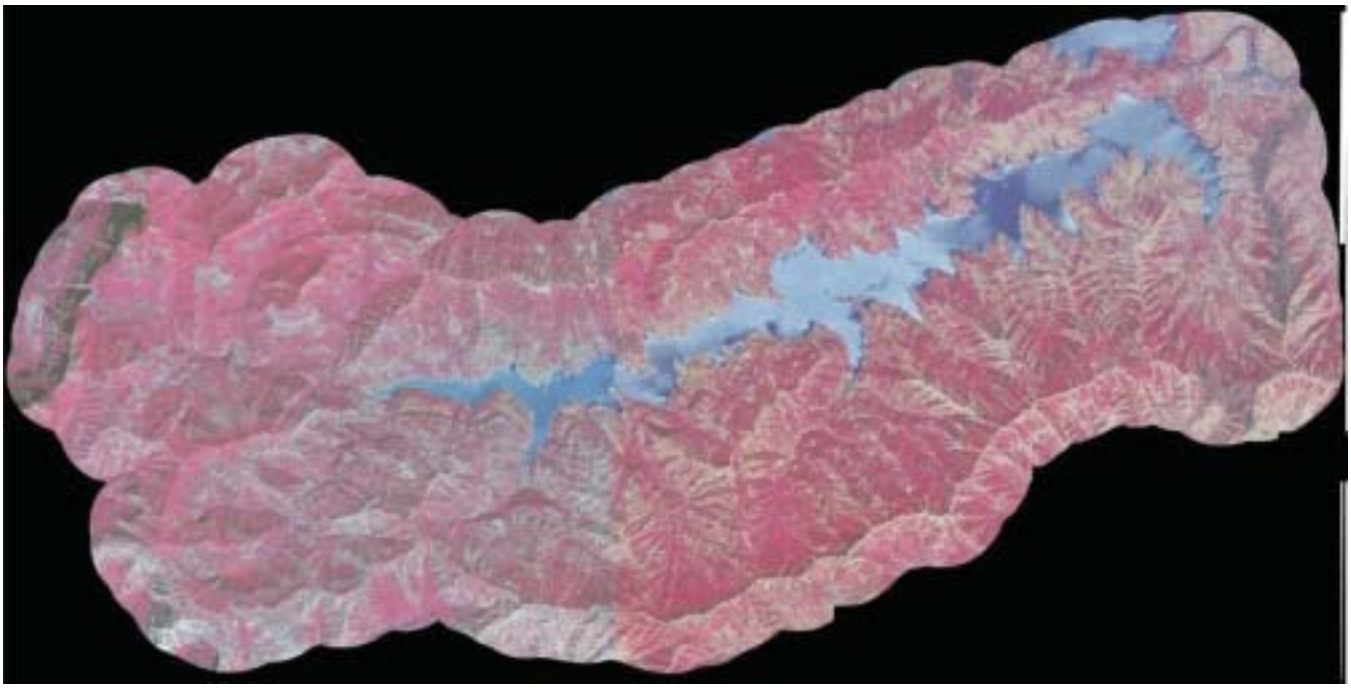


Figure 7 : Worldview -2 Pan-sharpened multispectral image – Jan 2014

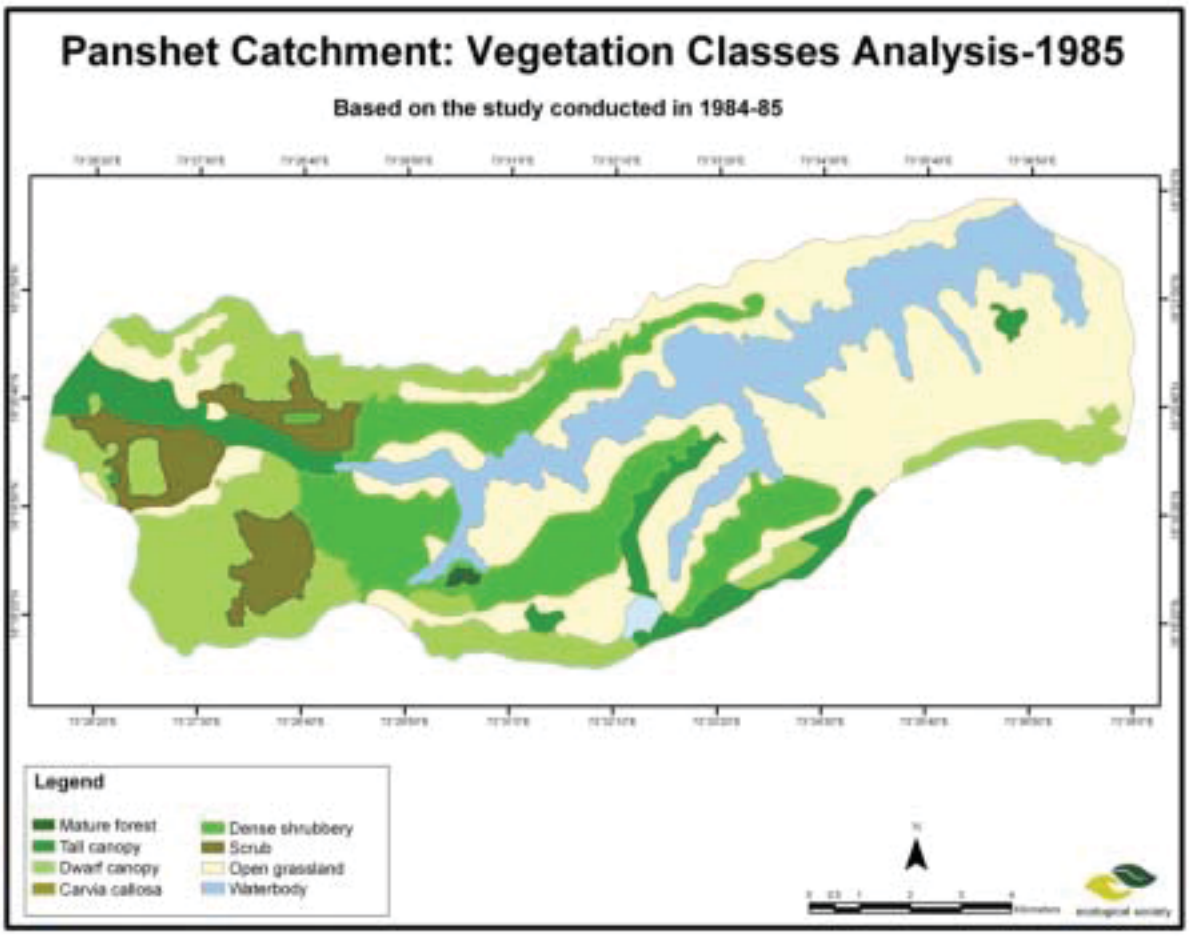


Figure 8 : Vegetation classes map - 1985

The area estimate for the above land use land cover map is given in the table below :

Area Statement for Panshet Catchment based on [Gole P,1985]

Sr. No	Class	Area (Acres)	Percentage of the total catchment
1	Dense shrubbery	4550.18	15.73
2	Dwarf canopy	5413.48	18.72
3	Carvia callosa	113.09	0.39
4	Mature forest	50.87	0.17
5	Open grassland	10507.10	36.34
6	Reservoir	4566.17	15.79
7	Scrub	1908.67	6.60
8	Tall canopy	1802.83	6.23
9	Human Use	Not assessed separately	NA
	Total	**28912.43**	**100%**

Table 4: Land-use land-cover area estimate for the 1985 study

Land-use land-cover map for 2014 study

Based on the land use pattern, the area under study was classified into 24 different classes. The classification was based on the methodology described earlier.

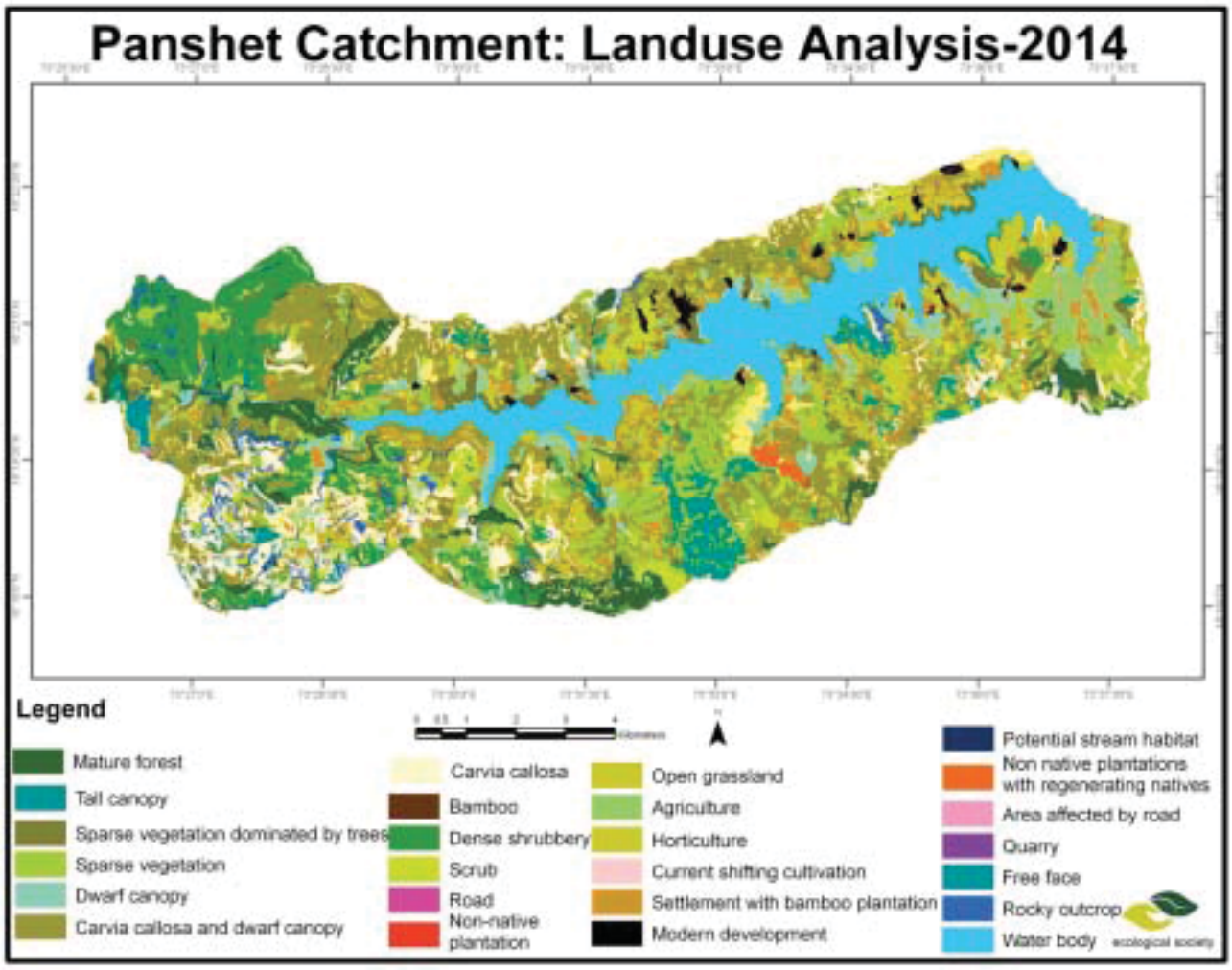


Figure 9: Land-use land-cover map - 2014

The area estimate for the above land use land cover layer is given in the table below :

Sr. No.	Vegetation Class	Area (Acre)	Percent (%)
1	Mature Forest	1542.16	5.26
2	Tall Canopy	1319.95	4.50
3	Dwarf Canopy	1026.05	3.50
4	Carvia callosa *and Dwarf Canopy*	*7034.84*	*23.98*
5	Dense Shrubbery	2052.47	7.00
6	Scrub	1502.26	5.12
7	Sparse Vegetation Dominated By Trees	821.31	2.80
8	Sparse Vegetation	1545.06	5.27
9	Carvia callosa *patches*	*2558.51*	*8.72*
10	Open Grassland	2616.16	8.92
11	Rocky Outcrop	651.97	2.22
12	Free Face	25.38	0.09
13	Agriculture	1571.16	5.36
14	Settlement, including nearby Bamboo Plantation	441.76	1.51
15	Non-native Plantations	289.7	0.99
16	Horticulture	44.94	0.15
17	Road	209.73	0.71
18	Area Affected By Road	27.98	0.10
19	Bamboo	1.25	0.00
20	Non-native Plantations with regenerating Natives	83.28	0.28
21	Modern Development	195.6	0.67
22	Quarry	3.56	0.01
23	Current Shifting Cultivation	158.21	0.54
24	Potential Stream habitat	34.61	0.12
25	Reservoir	3581.83	12.21
	Total	**29339.73**	**100%**

Table 5 : Area Statement of Vegetation Classes, 2014

Consolidated classes

Since the above classification had a large number of classes, the 24 land classes in the above table, except reservoir, were clubbed into 5 major land classes. This was based on the observations made during surveys and similarities in characteristics across land classes. Across these consolidated land classes, the status of biodiversity in the catchment was well-represented.

Consolidated Classes	Classes merged
Mature forest	Mature Forest, Tall Canopy, Potential Stream habitat
Dwarf canopy	Dwarf Canopy, Carvia callosa and Dwarf Canopy, Dense Shrubbery
Scrub	Scrub, Sparse Vegetation Dominated By Trees, Sparse Vegetation, Carvia callosa patches
Open grasslands	Open Grassland, Rocky Outcrop, Free Face
Human use	Agriculture, Settlement with Bamboo Plantation, Non-native Plantation, Horticulture, Road, Area Affected By Road, Bamboo, Non native Plantations with regenerating Natives, Modern Development, Quarry, Current Shifting Cultivation

Table 6: Table depicting the consolidated land-use land-cover classes, 2014 study

A qualitative description of these consolidated land classes is provided below.

Mature forest : The areas that have near original semi-evergreen vegetation, continuous canopy cover and represent the climax stage of forest.

Dwarf canopy: This class consists of dense shrubs and medium height trees in combination with Carvia callosa.

Scrub : This class contains areas with sparse, scattered vegetation, without much of canopy cover. This area is marked by some tress growing sparsely.

Open grasslands : This land class covers areas which are dominated by seasonal grass. It appears extremely dry and barren during the summer season. Grasses grow here only during the rainy season. It also contains exposed boulders of basalt- the significant rocks of Deccan plateau.

Human use : This class contains land use directly related to human interaction.

The table below provides an area statement for the 1985 study under the set of 5 consolidated land classes.

Land use	Merged classes	Areas under merged classes (acres)
Mature forest	Mature forests + Tall canopy	1853.70
Dwarf canopy	Dense shrubbery + Dwarf canopy + Carvia callosa	10076.76
Scrub	Scrub	1908.67
Open grasslands	Open grasslands	10507.10
	Total	**24346.23**

Table 7: Area Statement for consolidated land use classes, 1985 study

The table below provides an area statement for the 2014 study under the set of 5 consolidated land classes.

No.	Land class	Area (acres)	Percent (%)
1	Mature forest	2896.72	11
2	Dwarf canopy	10113.36	39
3	Scrub	6427.14	25
4	Open grasslands	3293.51	13
5	Human use	3027.17	12
	Total	**25757.89**	**100**

Table 7A: Area Statement of the consolidated land use classes, 2014 study

It is evident from present study that area under mature forests i.e. the near original semi-evergreen forest cover in Sahyadri is not sufficient (11%) and it is largely present in the high rainfall zone within catchment. The reason for the latter could be this zone is little away from city center and the fact that a direct road up to this zone was made recently (2010). Presence of Sacred Groves, the largest one at Mangao (~ 40 acres) has contributed majorly to this land class. So it is observed that preservation of mature forest is directly and inversely impacted by nearness and access from the city.

Analysis of changes in land-use land-cover classes from 1985 to 2014

As per Tables 7 and 7A, the total areas under the consolidated five land classes from the 1985 and 2014 are different. This is because the map of the 1985 study was originally prepared manually and then digitized in the 2014 study. However, the difference between the total areas of 1411.66 acres is only 5.5% of the total area from the 2014 study (refer to tables 7 and 7A). Since this is a relatively small percentage difference, we believe it is fair to compare the changes in land-use land-cover over the period 1985-2014. Here we have the following key observations :

- Area in acres under Mature Forest has increased significantly (1043 acres) from 1985 to 2014. This could be due to better protection of reserve forests. However as a % of total area, it is still low at 11% in 2014, as discussed above.
- Area under Dwarf Canopy has increased by an insignificant amount (36.6 acres) from 1985 to 2014.
- Area under Open Grasslands has decreased significantly (7213 acres) from 1985 to 2014. In the

1985 study, a relatively larger portion of the catchment was under shifting cultivation and this area was likely counted under Open Grasslands. Our 2014 socioeconomic study for the Panshet catchment (published simultaneously) points to three trends over the last 30 years : 1. Farmers have left more part of their land permanently fallow. 2. Where cultivation continues, the land under shifting cultivation has declined, and 3. Overall land under active agriculture has declined by around 33%. As a result of these trends, a large part of land which was potentially under shifting cultivation and classified as Open Grasslands in 1985 has returned to it's natural stage and is now in the stage of scrub land. This is also a possible reason for Scrub land increasing by 4518.46 acres from 1985 to 2014. Additional study is needed to confirm these trends. These changes are summarized in the table below.

Land use	Area (acres)		Difference
	1985	2014	
Mature forest	1853.70	2896.72	Increased by 1043 acres
Dwarf canopy	10076.76	10113.36	Increased by 36.6 acres
Scrub	1908.67	6427.13	Increased by 4518 acres
Open grasslands	10507.10	3293.51	Decreased by 7213 acres

Table 8: Changes in land use from 1985 to 2014

Additional results of the study are as follows :

- While the area under human use was not mapped separately in 1985, anecdotal evidence and the present study reveals a significant increase in modern developmental activities like farm houses, roads, etc. Modern Development, Roads, and Area affected by Road together constitute 433 acres and 1.5% of the catchment as per the 2014 study and trends indicate this is likely to grow over the next 1-2 decades.
- Change in land ownership from locals to developers has shown a positive impact on few areas where the shifting cultivation has stopped due to change in ownership. This was noted during the socio-economic surveys and is observed by local people over 2 decades.

Conclusion

(Gadgil M., 1979) has discussed the intensification of resource use with respect to dams and its consequences on forests in Sahyadri. It is worth mentioning that such intensification often results in exhaustion of resources and has undesirable effects on quality of human life in immediate surroundings. This adversely affects the local communities that are directly dependent on the quality of natural resources.

(Gole P., 1985) proposed a way out that will ensure a long life for reservoir, ensure ecological integrity and also protect local livelihoods, giving planned occupations for the local communities. However the current situation in the catchment has changed in the direction of further erosion of natural resources.

It is evident from our observations that man-made activities such as road constructions, modern development and construction have considerably increased, with irreversible impacts on natural ecosystems. The current and future threats to natural resources in this catchment come from uncontrolled, unplanned private developments.

From the study it can also be said that given a chance, natural succession happens and takes nature to the next seral stage in the ecosystem development (e.g. Open Grasslands transforming into Scrub). However this is a relatively slow process compared to the present rate of degradation.

Due to importance of natural resources in Sahyadri, the future lies in sustainable landscape level management of the region that will safeguard the ecology and provide long-term benefits from well managed landscapes.

Such an integrated effort will need strong political will, ecologically-sensitive landscape-oriented planning and concerted effort for sustainable development from all sections of society.

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