RESEARCH PAPER

ASSESSMENT OF ANTHROPOGENIC IMPACT ON FOREST ECOSYSTEM: A CASE STUDY OF KUMBHALGARH WILDLIFE SANCTUARY, INDIA

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ABSTRACT. In the era of the modern world, natural resources are continuously diminishing and simultaneously the human population is also increasing, which is alarming for the present and future world. Global biodiversity is playing a pivotal role in all ecosystem services, meanwhile, anthropogenic activities and encroachment are the main drivers for the widespread loss of local biodiversity. In India, Kumbhalgarh Wildlife Sanctuary is situated in the world's oldest Aravali Mountain range. Near protected areas of this wildlife sanctuary have an entire concentration of rural populations, which are interdependence with this forest ecosystem. The key objective of the research study is to measure the anthropogenic impact on Kumbhalgarh Wildlife Sanctuary. It's a micro-level study based on primary and secondary data through GIS mapping as well as Socio-Economic & Physical factors to inter-connect with forest habitats. Especially, core and periphery LULC have been obtained from the Multispectral images from ETM+ and OLI sensors of Landsat satellites. This study examines the spatial and temporal patterns of LULC change along the boundary of Kumbhalgarh from 2000 to 2020. The research also describes land use and land cover pattern, forest cover and vegetation index, and human encroachment, Eventually, the situation would be alarming for the local biodiversity and habitat due to the high pressure of anthropogenic activities and encroachment.

KEYWORDS: Forest Ecosystem; Forest Cover; Land use and land cover; Biodiversity Conservation

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INTRODUCTION

The man-environment relationship is interconnected from the beginning of human civilization. From the Palaeolithic to the modern technological age relationship has been changed. Then, man was depended on their adjacent environment for food, water, and shelter with eco-friendly behaviours. Now, the sustainability of the environment is reliant on humans and the risk of survival of humankind is emerging with environmental degradation (UNEP 2014; Akpan et al. 2010).

There are several natural and artificial phenomena occurring on a global to local scale such as climate change, environmental degradation, deforestation, overpopulation, genetic engineering, pollution, resources depletion, industrialization, urbanization, etc. The earth is facing high rates of biodiversity loss and corrosion which are escorted by ecosystem degradation. It's impacting human well-being through the loss of benefits ("ecosystem services") that ecosystems provide (Bhagabati et al. 2014). As a result, degradation, fragmentation, and loss of natural habitats (Hososuma et al. 2005), depletion of prey animals, and poaching to supply a large illegal global trade in their body parts have pushed wild animals and their landscapes to the brink of extinction. These threats are exacerbated by the limited capacity for conservation action. Anthropogenic activities are major threats to providing various forest ecosystem services to people (Millennium Ecosystem Assessment (MA) 2005).

People derive direct and indirect benefits from forest ecosystem services in terms of support, provision, regulation and cultural services (Benzes et al. 2020; Manning et al. 2018). But cultural services are the strongest of them all. The increasing demand for these services has put enormous pressure on the forest ecosystem, and in such a scenario, eco-tourism is another additional stress (Holting et al. 2019). Meanwhile, conservation of forests has numerous advantages viz. promotion of cultural services, increase in carbon storage and sequestration, reduction in greenhouse gasses emission (Houghton, 2012; Ravindranath, 2008; Asner et al. 2010), watershed protection, natural hazard regulation, sustaining food security and cultivation services, improvement of medical services and ecotourism (Sierra et al. 2013; Wasserstrom et al. 2013; Fagua et al. 2019; Foley et al. 2007). Therefore, the forest ecosystem services defiantly mitigate climate change such as conserving the habitat, water quality, quality of life, global carbon cycle, economic growth, demographics, agriculture, and forest products, regional and planning policies through sustainable practices (FAO, Global Forest Resources Assessment, 2020; Kissinger et al. 2012).

Across the world, the forest ecosystem is rapidly decreasing due to the greediness of humans. Various species of flora and fauna have been extinct and various are near threatened. There is a positive correlation between population growth and decreasing forests (Corvalan et al. 2005; McMichael 2013). Global to local scale, humans use forests to fulfill the demand for commercial and household goods and services (Thomas et al. 2006; He GM et al. 2009; Salerno et al. 2010; Swanson et al. 2011; Pan et al. 2012).

India is a treasure trove of different vegetation and fauna. There was a blistering decline in the figures of numerous species. Severe reductions in flora and fauna can be get ecological imbalances, affecting numerous aspects of the climate and ecosystem. The most recent exertion in this regard passed during the British period was the Protection of Wild Birds and creatures, 1935. This demanded to be upgraded because the corrections given to nimrods and dealers of wildlife products weren't in proportion to the huge fiscal benefits they entered. Before the enactment of this Act, there were only five public premises in India.

The Act also provides for the protection of a listed species of creatures, catcalls, and shops and also for the establishment of a network of ecologically important defended areas in the country. For the first time, a comprehensive list of exposed wildlife in the country was prepared. The act banned the stalking of exposed species. Trade in listed creatures is banned as per the vittles of the Act. The Act provides for licenses for the trade, transfer, and possession of certain wildlife species. It provides for the establishment of wildlife sanctuaries, public premises, etc (Wildlife Protection Act 1972).

Wildlife Sanctuaries are present areas where species are protected against poaching, hunting, and hunting. Here animals don't seem to be reared for commercial exploitation. The species is shielded from any disturbance. Catching or killing of animals isn't allowed inside the sanctuaries. A wildlife sanctuary is said by the government by a notification. The boundaries are often changed by a resolution of the state legislature. Human activities like timber harvesting, the gathering of minor forest products, and personal ownership rights are permitted as long as they are doing not interfere with the well-being of the animals. Limited act is permitted. they're hospitable the overall public. But people aren't allowed without protection. There are restrictions on who can enter and/or reside within the bounds of the sanctuary. Only public servants, persons having immovable property inside, etc. are allowed. People using the highways passing through the sanctuaries also are allowed inside (Wildlife Protection Act, 1972).

MATERIALS AND METHODS

Study Area

The Kumbhalgarh Wildlife Sanctuary is chosen as the study area (Fig. 1). It is situated in the most fragile ecosystem of the world's oldest mountain range Aravali, Rajasthan, India. It is 80k.m. in the North of the world's famous tourist city Udaipur. Geographically this sanctuary is located between 25^0 North to $25^0 40'$ North Latitudes and $73^0 2'$ East to $73^0 30'$ East Longitude. The core area of the sanctuary is 610.528 Sq. km.

The Sanctuary was a natural tiger habitat till 70s and declared as wildlife sanctuary in 1988 (RajRAS. 2019). The sanctuary is spread over the entire Aravalli range covering parts of the Rajsamand, Udaipur, and Pali districts, at an altitude of 500 to 1,300 meters (1,600 to 4,300 ft). It is part of the Khathiyar-Gir dry deciduous forests ecoregion. It is named after the impressive historical fort of Kumbhalgarh. The wildlife sanctuary covers a core area of 224.890 km (87 sq. mi) and a buffer area of 385.638 km (149 sq. mi). It includes the four hills and mountain ranges of the Aravallis: The Kumbhalgarh Range; Sadri Range; Desuri Range and Bokhada Range. Twenty-two villages are located inside the sanctuary. The soil in this area is generally thin, mostly sandy loam (Bohra & Sultana 2013).

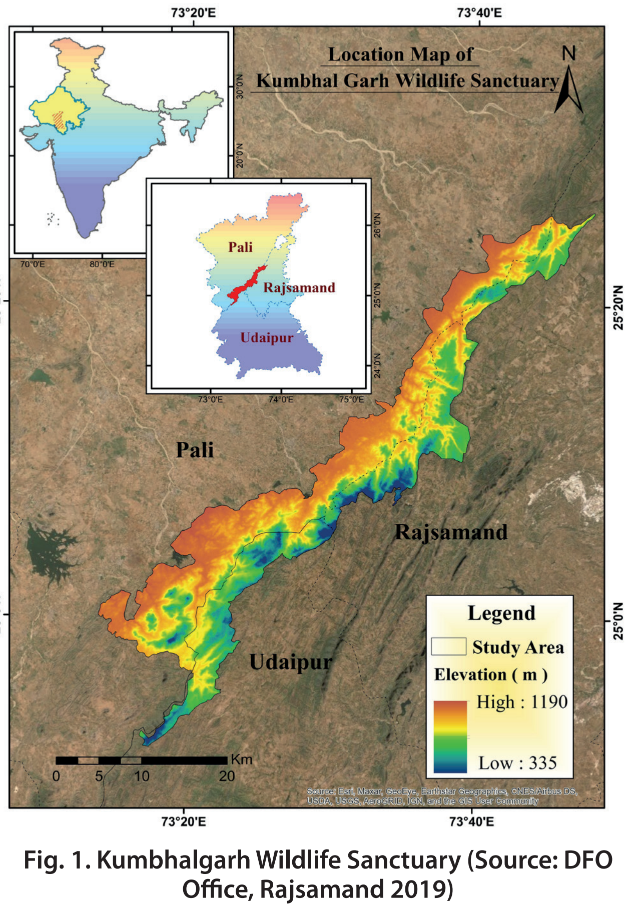


Fig. 1. Kumbhalgarh Wildlife Sanctuary (Source: DFO Office, Rajsamand 2019)

The natural environment of Kumbhalgarh is very attractive and captivating as well as this sanctuary is home to a variety of wildlife, some of which are endangered species. The wildlife found here includes the Indian wolf, Indian leopard, sloth bear, striped hyena, golden jackal, wild cat, sambar, nilgai, chausingha (four-horned antelope), chinkara, and Indian hare. The leopard is the supreme predator in the sanctuary (Bohra & Sultana 2013). The birds of Kumbhalgarh include the normally shy and unreliable gray wildebeest. Peacocks and pigeons can also be often seen here. Birds like the red bird, parrot, golden oriole, gray pigeon, bulbul, pigeon, and white-breasted kingfisher are also seen near the water holes. Kumbalgarh Sanctuary was one of the places which were considered for the reproduction of the Asiatic lions (BOHRA 2013). Biodiversity flourishing in this sanctuary is moderate and the status of threatened species in different blocks is also moderate. Central and Southern parts of the sanctuary have a high level of anthropogenic disturbance (FES report 2010). In this research, the prime objective was to assess the anthropogenic pressure on the forest ecosystem of the Kumbhalgarh Wildlife Sanctuary. The result shows that anthropogenic pressure is chronically changing. The South and south-west part of the sanctuary has maximum anthropogenic pressure due to the maximum population in this area but the dependency on forest resources of these people is decreasing because of the availability of alternative resources which is a good indicator for this sanctuary. The climate of this sanctuary is sub-tropical with extremely hot summer and relatively moderate winter. The three main seasons is summer, winter, and rainy season. The average rainfall is 752 mm. The number of rainy days is approx. 25 on average. The highest rainfall was observed in July (Chhangani 2002).

Dataset and Methodology

The methodology is presented on the Fig. 2

Dataset

The satellite images were sorted and classified for analysis and interpretation. Landsat images are among the widely used satellite remote sensing data and their spectral, spatial, and temporal resolution made them useful input for mapping and planning projects (Singh and Sen 2018). Landsat Thematic Mapper 5 and 8 were used for land use and land cover classification in 2000, 2010, and 2020. Landsat-5 was used for the years 2000 and the year 2010 and 2020 Landsat-8 was used. The resolution of both datasets is 30m. These datasets were downloaded from the USGS (United States Geological Survey) site. For the calculating height of the study area, SRTM DEM was used at a resolution of 30m. For data preparation, Erdas Imagine and ArcGIS software were used. Satellite data sets were imported into the ERDAS Imagine software to create a false-colour composite (FCC). The FCC images were layer-

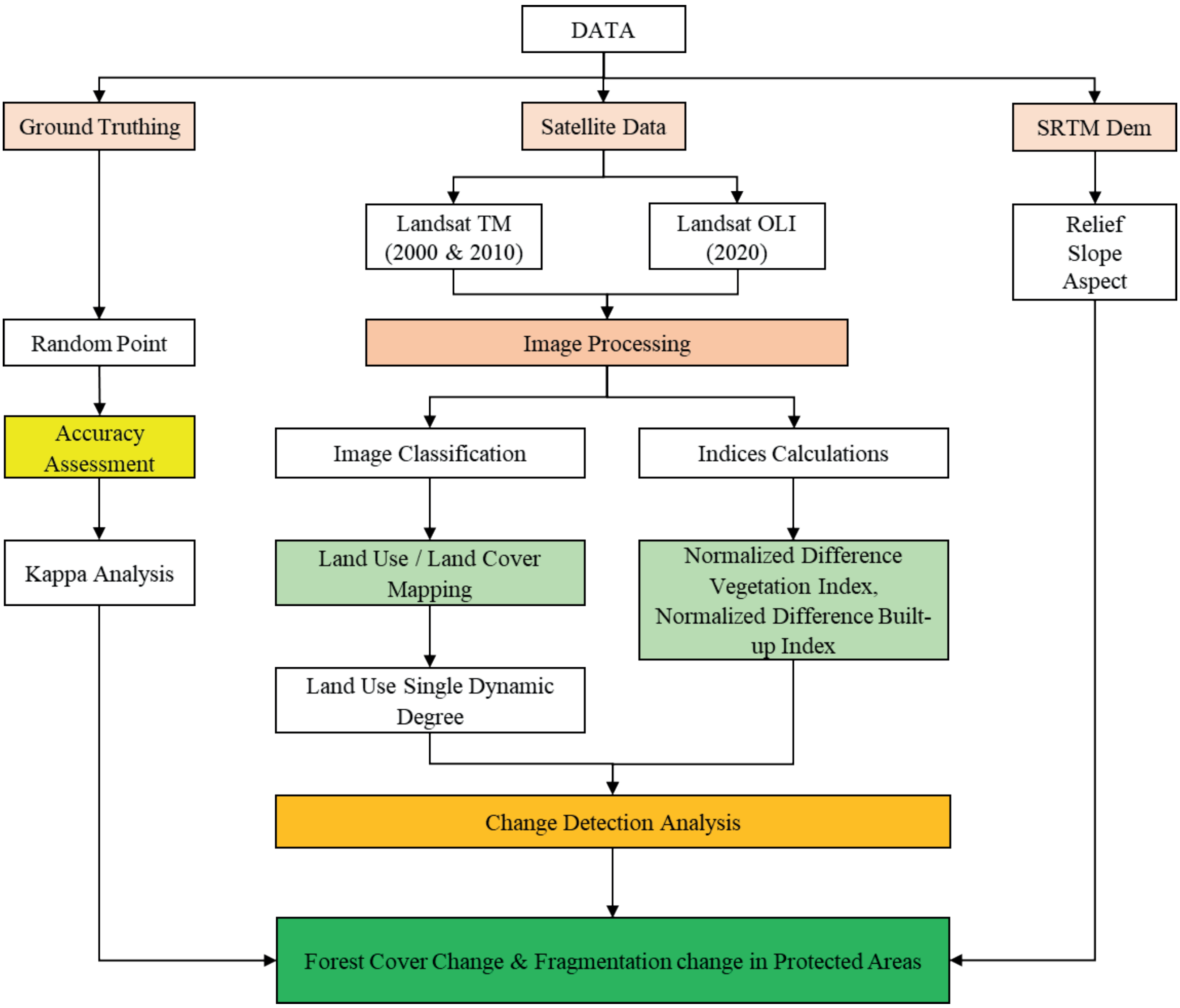


Fig. 2. Research Methodology Chart

stacked and then all data sets were mosaicked. Other work and analysis were done using Arc GIS software using geo-referenced shapefiles of the study area collected from the DFO Office, Rajsamand, 2019.

Land use and land cover change analysis

Supervised Classification: To analyse the land use and land cover change of the Kumbhalgarh Wildlife Sanctuary, a Supervised classification method was applied in the ERDAS imagine software. This classification method is used Maximum Likelihood Classifier algorithm (Singh and Sen, 2018; Singh et.al., 2021). The images were classified into 7 respective classes (Table 1).

Calculation of the Accuracy Assessment or Error Matrix: Accuracy Assessment is an important part of any classification project. Accuracy Assessment or error matrix compares the classified image to the ground truth data. For calculating the Accuracy of the classified image create a set of random points and these points are verified in a Google Earth computer program.

Kappa Coefficient: Kappa Coefficient essentially evaluates how well the classification performed as compared to the randomly assigned values. The Kappa Coefficient ranges from -1 to 1. A value of 0 indicates that the classification is no better than a random classification. A negative value signifies that the classification is worse than random. If the value is close to 1 then the classification is signified classification is better than random. This is defined by the small "k" (1).
This is calculated as:

$$k = \frac{OA - AC}{1 - AC} \quad (1)$$

Here, k = kappa coefficient, OA= Overall accuracy, AC= Expected by chance agreement,
1 = Constant value

Create Random Point: After classifying all the images, create an equalized random point in the Arc GIS and then these points are saved as a KML (Keyhole Markup Language) layer to collect the ground-truth value of all classified imageries with the help of Google Earth.

Table 1. Description of the land use and land cover

Land use/land cover class	Description
Water Bodies	Includes the rivers, ponds, streams, etc.
Fellow Land	all piece of land that is normally covered with vegetation but that is left with no crops on it for a season
Barren Land	Includes the Barren Land and Hilly Area.
Arable Land	Agriculture Land, Sown area
Sparse Vegetation	Includes the all-small plants, grassland, and shrubs.
Dense Vegetation	Includes the areas which are covered by the trees.
Settlement	Includes the areas of construction, roads, bridges, houses, etc.

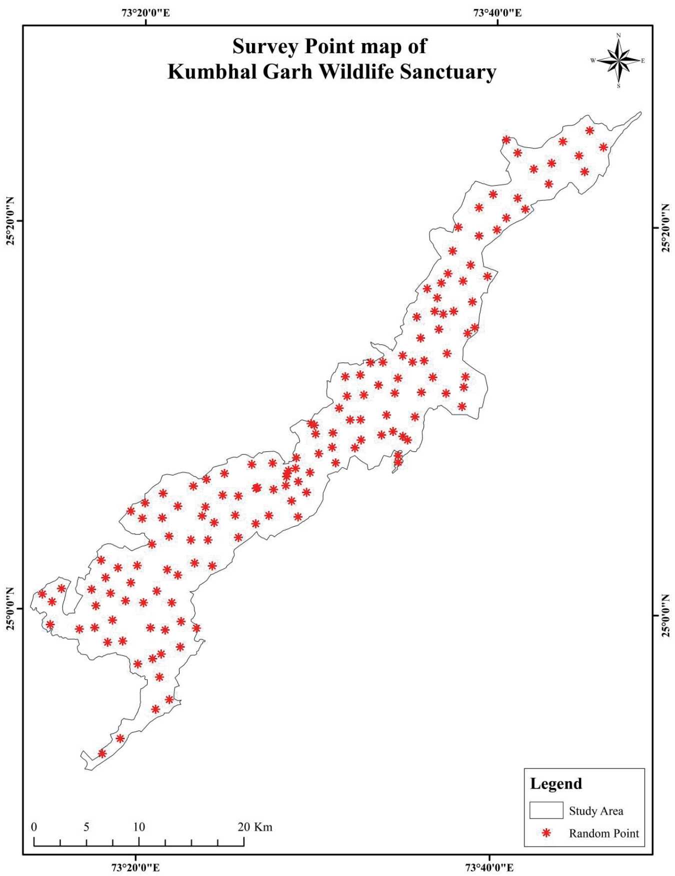


Fig. 3. Random Points

Single Land uses dynamic degree: The Single Land Use Dynamic Degree Index has been chosen for this study to measure the temporal and spatially changing characteristics of land use. The dynamic degree of land use refers to the total amount of changes in certain types of land use over a given period in the study area (Hong-zhi, et al. 2002).

This can be calculated as:

$$LC(K) = \frac{u_b - u_a}{u_a} \times \frac{1}{T} \times 100\% \quad (2)$$

In this formula, u_b is the area of a certain land use category at the last year of the research period, and u_a, is the area of a certain land-use type at the initial year of the research period. T is the length of the research period respectively (2). LC represents the dynamic degree of certain types of land use within the study period or at one time.

Built-up Index Indices: Normalized Difference Built-up Index (NDBI) is used to extract the built-up features and it ranges from +1 to -1. It is calculated by formula (3):

$$NDBI = (SWIR - NIR) / (SWIR + NIR) \quad (3)$$

Here, SWIR is Short Wave Infrared and NIR is Near Infrared

Normalized Vegetation Index: Normalized Difference Vegetation Index (NDVI) is calculated from the visible and near-infrared light reflected by vegetation. Healthy vegetation absorbs most of the visible light that hits it and reflects a large portion of the near-infrared light. Unhealthy or sparse vegetation reflects more visible light and less near-infrared light (earthobservatory.nasa.gov). The NDVI values lie between 1 to -1.

The formula of NDVI is:

$$NDBI = \frac{(Near\ Infrared) - (Red\ Band)}{(Near\ Infrared) + (Red\ Band)} \quad (4)$$

Weighted Overlay Analysis: The weighted overlay is a standard GIS analysis technique that is often used for solving multi-criteria problems such as generating surfaces representing site suitability and travel cost. The weighted overlay is used when several factors of varying importance should be considered to arrive at a final decision (Singh et.al., 2021).

Weighted overlay is calculated by (5):

$$*Weighted\ Overlay = LULC(25) + NDVI(45) + NDBI(30) \ldots \quad (5)$$

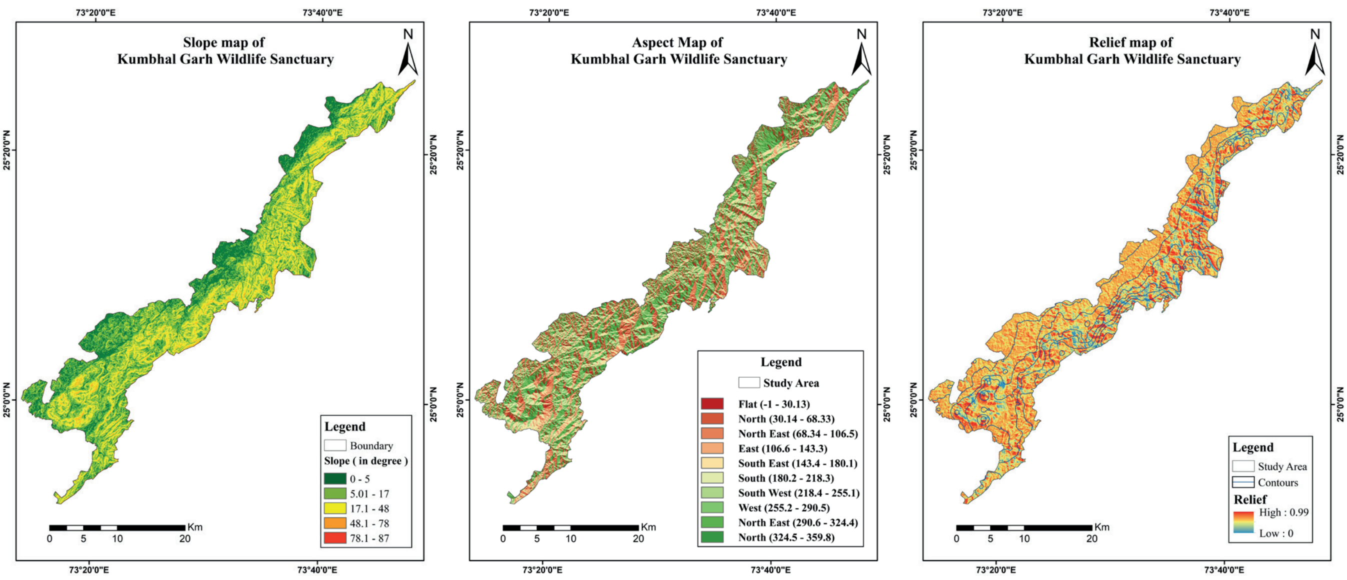
Three input Rasters have been reclassified to a common measurement scale of 1 to 3 for the Study area (Fig. 8a, b, c). Each raster is assigned a percentage influence. The cell values are increased by their proportion effect, and the results are added composed to create the output raster.

RESULTS

Terrain Maps: By using SRTM Dem data, these terrain maps are created in Geospatial Software. A slope map provides a colorized representation of the slope (Fig. 4a). The degree of slope steepness is depicted by light to dark color - flat surfaces as green, shallow slopes as yellow, moderate slopes as light orange, and steep slopes as Red. An aspect-slope map instantaneously displays the aspect (direction) and degree (sharpness) of slope for a topography (or another continuous surface) (Fig. 4b). Relief maps depict the contours of landmarks and terrain, based on shape and height (Fig. 4c).

Land use /Land cover change analysis: The land use and land cover (LULC) of the Study Area has been slightly changed by anthropogenic pressure, deforestation, agricultural and subsidiary activities, and unplanned or unprofessional slope cutting for infrastructure developments (Fig. 5). In agricultural areas and grassland found in areas of high population density, especially along economic corridors, soil degradation has increased in low lands areas.

From 2000 to 2020 all the land use/ land cover types are changed dynamically. Fellow Land and Barren Land was Dramatically decreased in the 2000 - 2010 period and again increased in 2020. In 2000, Fellow Land and Barren land covered an area of about 19263.15 Hectares and 7455.18 Hectares but it decreased in 2010 by 387.54 and 2226.29 Hectares. The total area of Barren land again increased to 1637.64 and 5382.26 Hectares in 2020. Settlement was increased over the past 20 years but it's quite low. In 2000, 7.62 Hectares areas were covered by Settlement and it increased in 2010 by 27.13 hectares and 95.68 Hectares in 2020. On the other hand, the Sparse and Dense Vegetation area increased in the 2000-2010 period and slightly decreased in the recent decade. In 2000, Sparse and Dense Vegetation covered an area of 9396.90 Hectare and 1905.30 Hectare but it increased by 23427.54 and 22613.4 Hectare in 2010 and again its slight decreases in 2020, by 21332.16- and 12027.69-Hectare area. Arable land has covered 19737.27 Hectare areas in 2000 and was decreased in 2010 by 8953.65 Hectare but again it increased in 2020 and covered an area of 17043.66 Hectare due to decreasing Vegetation cover in the recent period (Table 2).

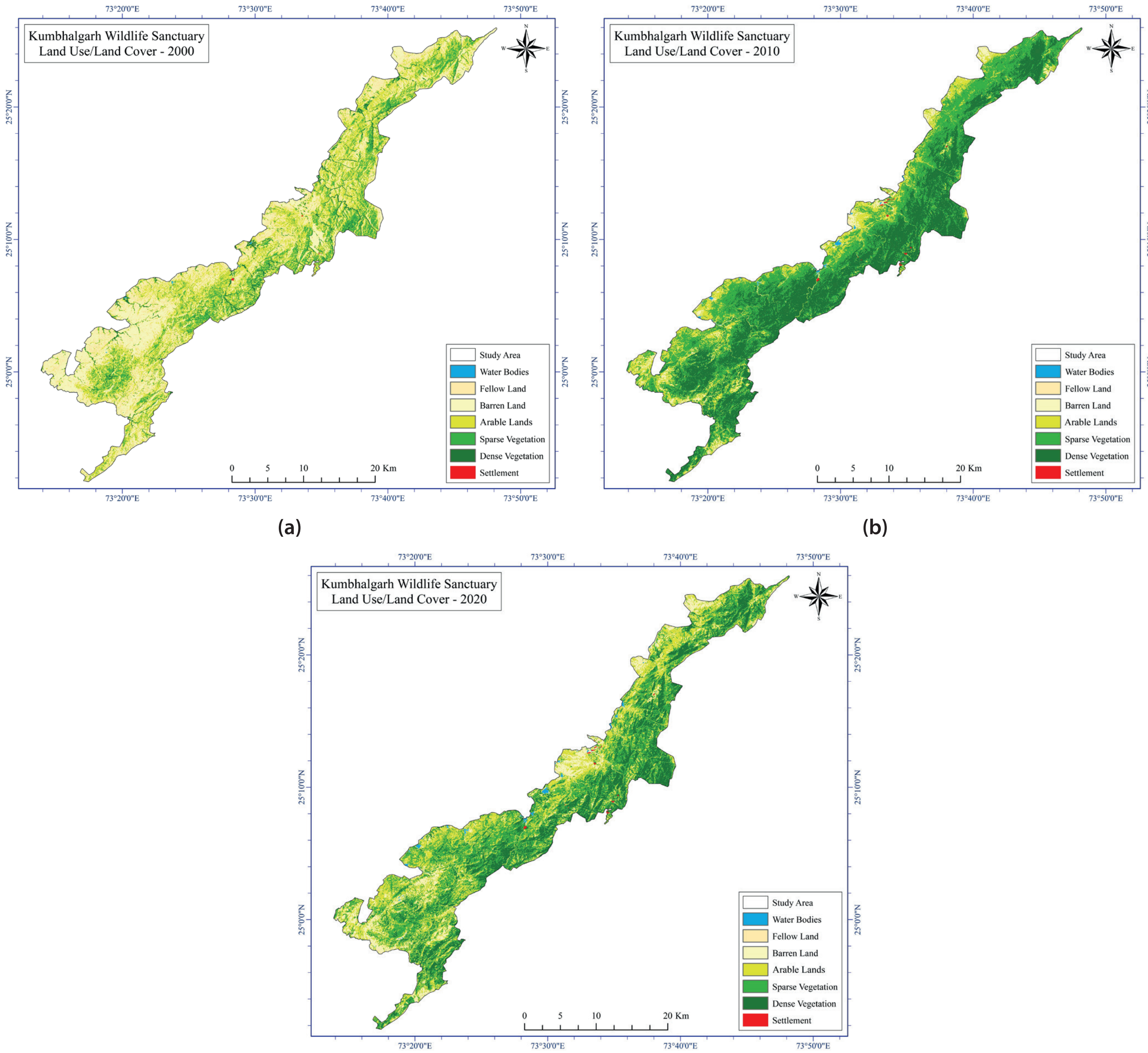


(a) (b) (c)

Fig. 4. Terrain Features a. Slope, b. Aspect & c. Relief Maps

Table 2. land use and land cover area in Hectare

Land use/cover categories	Area, 2000 (Ha)	Area, 2010 (Ha)	Area, 2020 (Ha)
Water Bodies	27.36	157.23	273.69
Fellow Land	19263.15	387.54	1637.64
Barren Land	7455.18	2226.29	5382.26
Arable Land	19737.27	8953.65	17043.66
Sparse Vegetation	9396.90	23427.54	21332.16
Dense Vegetation	1905.30	22613.4	12027.69
Settlement	7.62	27.13	95.68



(a) (b)

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Fig. 5. Land Use & Land Cover Maps a. LULC 2000, b. LULC 2010, c. LULC 2020

Land Use Land Cover Change (LULCC) % and Single Land Use Dynamic Degree (SLUDD): From 2000 to 2010, the area of the Water bodies, Settlement, Dense Vegetation, and Sparse Vegetation increased by 474.67%, 255.85%, 1086.87%, and 19.31% respectively. On the other hand, the other three classes have witnessed decreasing pattern in these years (Table 3). From 2010-to 2020 the area of the most classes seen an increase such as Water bodies, Fellow land, Barren land, Arable land, and Built-up land by 74.07%, 322.57%, 141.76%, 90.35%, and 252.67%. On the other hand, Sparse and Dense Vegetation cover decreased by 8.94% and 46.81%. Overall, from 2000-to 2020, most of the lands were witnessed increasing patterns such as Water bodies, Sparse and Dense Vegetation along with Settlement. The increasing percentages were 900.33, 127.01, 531.28, and 1154.98% respectively. Fellow Land, Barren Land, and

Arable land witnessed decreasing patterns during these periods with 91.50%, 27.81% and 13.65% respectively. (Table 3).

From table 3 of Single Land Use Dynamic Degree, we can find out that the water bodies were increased by 45.02% each year from 2000 to 2020. From 2000 to 2020 highly increased LULC classes were built-up land. It increased each year by 57.75% from 2000 to 2020. The Barren lands were decreasing slightly in these years by 1.39%. The annual increasing rate of Sparse and Dense Vegetation is quite impressive with 6.35 and 26.56%. Followed by the Arable land is slightly decreasing by 0.68% annually from 2000 to 2020.

Human and natural interventions can be attributed to these changes. Around the year 2000, a wide area of Rajasthan experienced severe drought, its effect is clearly visible in all the maps of the year 2000. It can be seen in Figure 5A and Table 2 that all the attractive classes with vegetation have very low value and the value of fallow land or barren land is very high. After that till the year 2010, there has been considerable improvement in the vegetation. In this, where water bodies are increasing, the same sparse vegetation and dense vegetation are also increasing (Figure 5b). The main reason for these changes can be attributed to changes in people and strict actions of the government with regard to biodiversity conservation, such as in 2002, the Supreme Court of India, following the advice of its Central Empowered Committee, declared that all the sanctuaries in the country It was decided to impose a complete ban on all types of human uses, the main one being the ban on grazing, harvesting and timber harvesting. But in the year 2020 map 5c, it can be seen that again there has been a negative change in the vegetation cover, the amount of sparse vegetation and dense vegetation has decreased as compared to the year 2010. The main reason for which is also clear from this map and table that how settlement and farming have taken their place. The movement of people again increased a lot, which has to be controlled, otherwise, the decrease in vegetation in the sanctuary will continue to increase.

Accuracy Assessment and Kappa Coefficient: Accuracy assessment of the LU/LC classification results obtained showed an overall accuracy of 84% for 2000, 80.67% for 2010, and 88% for 2020. Kappa coefficients for these imageries were 0.81 for 2000, 0.77 for 2010, and 0.86 for 2020 (Table 4).

Normalized Differential Built-up Index

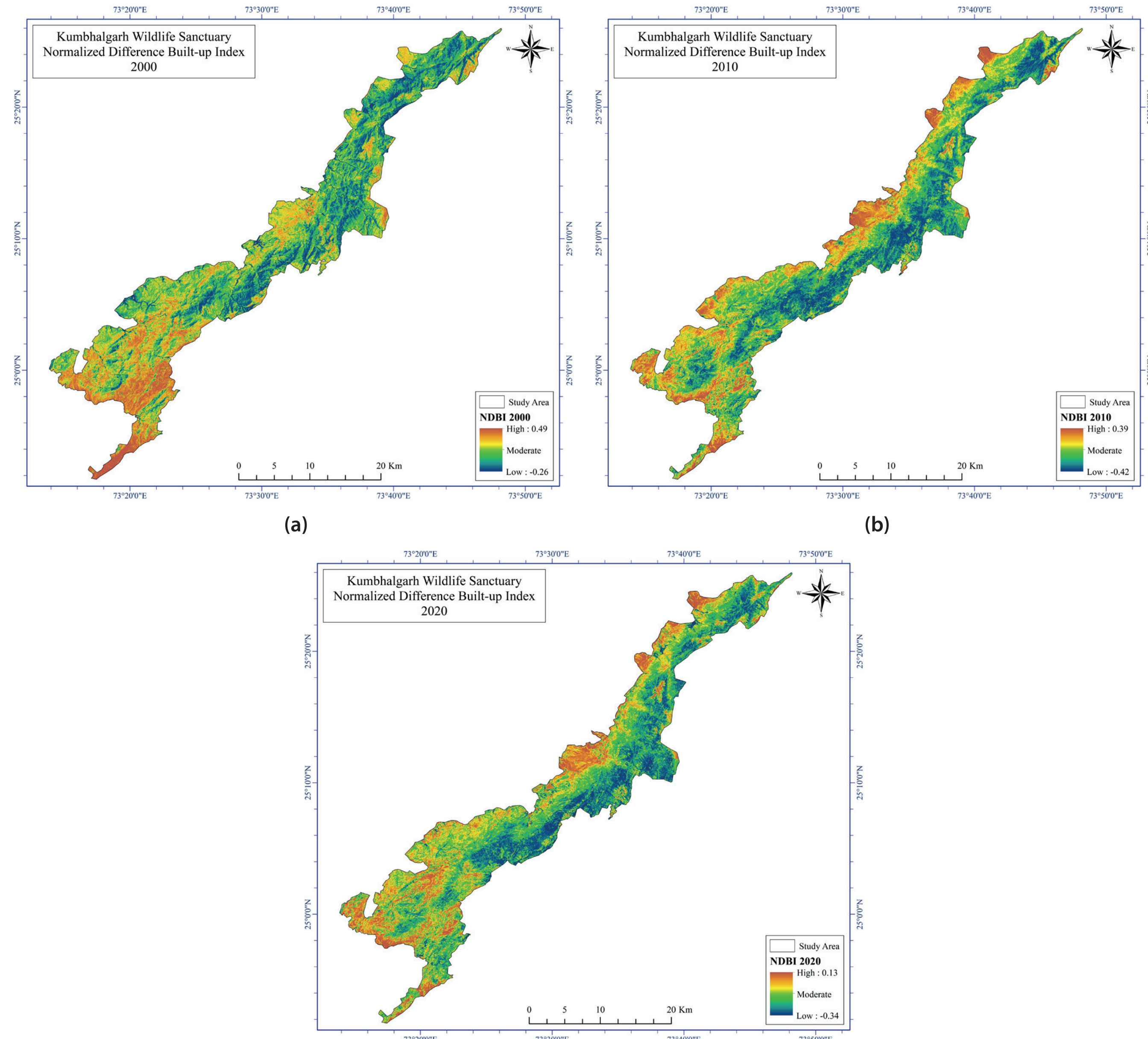
NDBI method is used to map built-up areas in the study area. All three maps of NDBI are highly comparable to one another. The NDBI value for the Study Area is -0.26 to 0.49 for the year 2000 (Fig. 6a), -0.42 to 0.39 for the year 2010 (Fig. 6b), and -0.34 to 0.13 for the year 2020 (Fig. 6c). In comparison with supervised classification, NDBI enables built-up areas to be mapped at a better degree of accuracy and objectivity. The absence of coaching samples from the mapping makes subjective intervention from the human

Table 3. lland use and land cover area change in % and Single Land Use Dynamic Degree

Sr. No.	Land Use Land Cover	2000 - 2010		2010 - 2020		2000 - 2020	
		LULCC	SLUDD	LULCC	SLUDD	LULCC	SLUDD
1	Water Bodies	474.67	23.73	74.07	3.70	900.33	45.02
2	Fellow Land	-97.99	-4.90	322.57	16.13	-91.50	-4.57
3	Barren Land	-70.14	-3.51	141.76	7.09	-27.81	-1.39
4	Arable Land	-54.64	-2.73	90.35	4.52	-13.65	-0.68
5	Sparse Vegetation	149.31	7.47	-8.94	-0.45	127.01	6.35
6	Dense Vegetation	1086.87	54.34	-46.81	-2.34	531.28	26.56
7	Settlement	255.85	12.79	252.67	12.63	1154.98	57.75

Table 4. Accuracy Assessment Table for year 2000, 2010 & 2020

Years	2000		2010		2020	
LULC	Producer Accuracy	User Accuracy	Producer Accuracy	User Accuracy	Producer Accuracy	User Accuracy
Water Bodies	86.36	90.48	84.21	94.12	90.48	95.00
Fellow Land	88.46	85.19	82.61	90.48	91.30	87.50
Barren Land	82.76	80.00	77.78	72.41	80.95	80.95
Arable Land	86.36	79.17	73.91	68.00	92.00	85.19
Sparse Vegetation	77.27	85.00	80.00	80.00	88.89	88.89
Dense Vegetation	86.36	82.61	85.19	82.14	82.14	85.19
Settlement	71.43	100.00	81.82	90.00	92.86	100.00
Overall Accuracy	**84.00**		**80.67**		**88.00**	
Kappa Coefficient	**0.81**		**0.77**		**0.86**	



(a) (b)

(c)

Fig. 6. Normalized Difference Built-up Index Maps a. NDBI 2000, b. NDBI 2010, c. NDBI 2020

analyst redundant. this suggests that identical results are derived no matter the analyst or what percentage of times the mapping is repeated.

Normalized Differential Vegetation Index

For the Study Area, NDVI maps have been used to assess different types of vegetation health and their uses. The NDVI value for the Study Area is -0.22 to 0.52 for the year 2000 (Fig. 7a), -0.11 to 0.71 for the year 2010 (Fig. 7b), and -0.052 to 0.57 for the year 2020 (Fig. 7c). NDVI values are in the middle of 0.2 and 0.4 and linked to areas with bare vegetation, the NDVI value of moderate vegetation inclines to lie between 0.4 and 0.6, and the NDVI value above 0.6 shows the highest possible density of greeneries. There are very small patches of forest that can be found in the year 2000, most areas are full of grass and shrubs. But there are increased values in the year 2010, Whereas in the year 2020, there are some good patches that can be seen in the whole part of the map (Fig. 7).

Therefore, in the period between 2000 and 2020, land cover change in the Kumbhalgarh Wildlife Sanctuary, whether in the direction of increase or decrease in density, is likely to be greater in areas relatively closer to human access. Therefore, some areas of mixed density are likely to be highly exploited during this period, while other areas of similar coverage have little or no impact, progressively moving into higher levels of vegetation density. Humans in Kumbhalgarh seem to be agents of change, but potentially in many directions.

Weighted Overlay Analysis

Weighted Overlay analyses were used to identify the site selection or suitability of the area and to determine the foremost effective place or site related to anthropogenic Impact. The results were categorized into five parts, from Very Low to Very High from the sight of vulnerability (Fig. 8). The sites in the Very High category have the most anthropogenic sites and are vulnerable to animals and human encounters. The very Low, Low & Moderate categories have very rare points for this kind of activity as this area is not at the point of interaction between humans and wildlife.

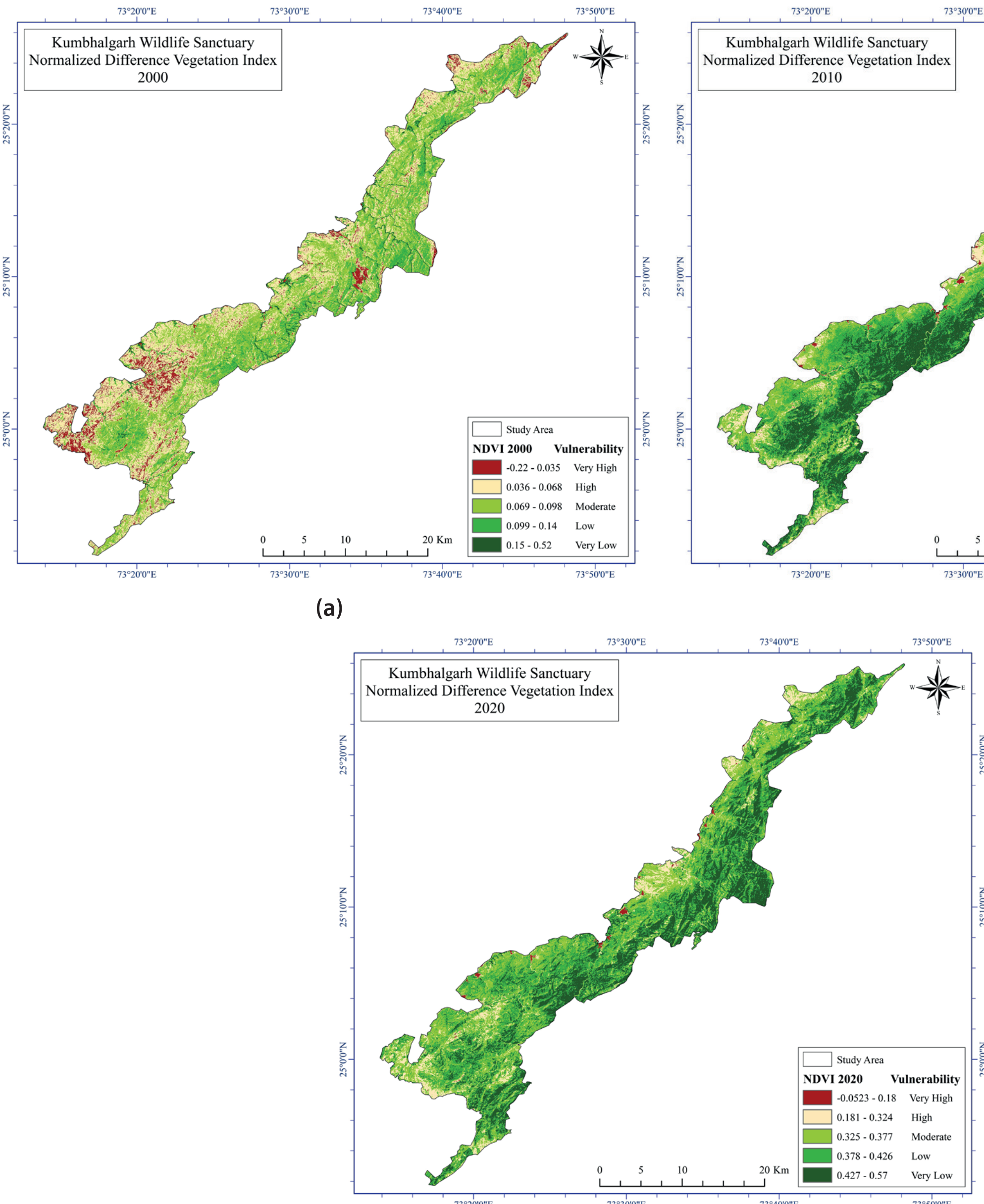


Fig. 7. Normalized Difference Vegetation Index Maps a. NDVI 2000, b. NDVI 2010, c. NDVI 2020

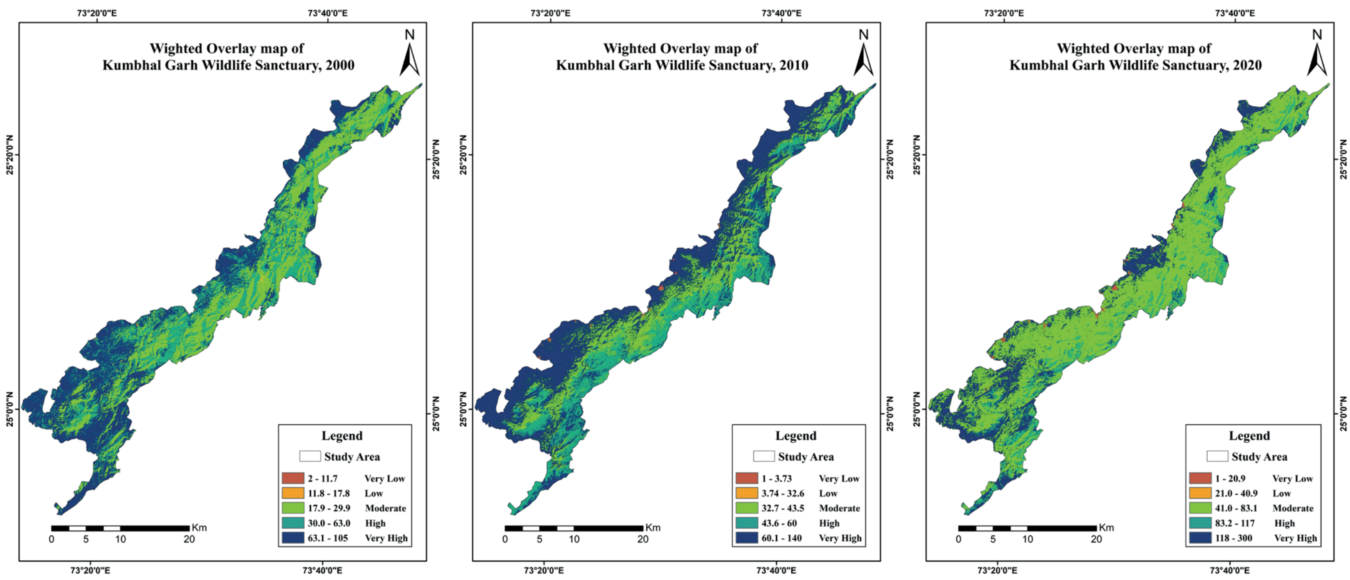


Fig. 8. Weighted Overlay Analysis Maps, the a. year 2000, b. the year 2010, c. the year 2020

DISCUSSIONS

This research study documented the anthropogenic impacts on the forest ecosystem of the Kumbhalgarh Wildlife Sanctuary, India. Anthropogenic pressure has highly negative results in this sanctuary viz. degradation of forest resources, fragmentation, loss of natural habitats, depletion of prey animals, poaching, illegal trade of body parts of wild animals (Hososuma, N. et al. 2005). The results of the research study showed that the lower and southwest part of the study area has maximum vulnerability due to high anthropogenic pressure while the other parts are less vulnerable.

The study results emphasized that a complete and comprehensive approach can minimize the anthropogenic pressure by the use of eco-friendly techniques and increasing the awareness level of local people. The ecosystem services of this sanctuary are constantly decreasing day by day and future generations will get depleted biodiversity resources. And, threats are increasing with climate change and anthropogenic pressure on the forest resources. Therefore, the forest ecosystem degradation shows that in the coming 40 to 50 years' biodiversity and ecosystem services can no longer be treated as endless and free goods. People of the surrounding areas obtained direct and indirect benefits from the forest ecosystem of this wildlife sanctuary which includes different types of services in terms of supporting, provisioning, regulating, and cultural services.As the results indicate that in the year of 2000 A.D. anthropogenic pressure shows a high interrelationship between local people and forest resources because they were dependent on it to fulfill their basic requirements. They expanded their agricultural land, built-up area or residential area, roads, and other physical structures on the forest land through deforestation. Hence the pressure level has been increased in this forest ecosystem of the Kumbhalgarh Wildlife Sanctuary. The map for the year 2020 A.D. clearly shows that the area of maximum anthropogenic pressure has been increased in the form of low vegetation areas which is a negative indicator for forest resources.

CONCLUSION

The Kumbhalgarh Wildlife Sanctuary has a diversity of biodiversity resources which is the source of the development of flora and fauna in the region. With time the trend of people is also changing and they are becoming the most dangerous source of degradation of the forest ecosystem. Research studies have found that anthropogenic impact varies from region to region according to the size of the population of the surrounding areas. The forest ecosystem of this sanctuary and the tribal community are intertwined, so this is a positive factor as well as a negative one. Domestic use of wood for cooking is one of the major factors of deforestation and others are grazing, collection of food and fodder, expansion of agricultural activities, habitat loss, climate change, development of the built-up areas, transportation routes, and poaching of wild animals, etc.

The southern and southwest part of this wildlife sanctuary has a higher density of human population than other areas. Therefore, the anthropogenic impact is also high in this area as compared to other parts of the sanctuary. There is less anthropogenic pressure on the forest ecosystem in the core areas and northern and north-eastern parts of this sanctuary, hence forest resources and wildlife are thriving in these areas. Due to anthropogenic pressure, the forest cover is decreasing day by day and it is a threat to the wildlife. Biodiversity issues suffer from inadequate integration into broad policies and rigorous strategies and programs at the local level and globally.

Protected areas must be designated and effectively managed to protect the ecosystem and hence the organisms that live there. Today, protected areas around the world cover about 15 percent of our land, about 10 percent of coastal and marine areas under national jurisdiction, and 3.4 percent of our oceans. While their effectiveness varies from country to country, it is important to continue efforts to advance protected areas. The study is a testimony to the need for comprehensive interventions to holistically tackle environmental problems caused by anthropogenic pressure in this sanctuary. This research study relied on satellite imagery data, LULC, NDBI, NDVI, etc., and statistical data collected by the Census and Forest Department, which may slightly limit this result, for extensive research, on other factors of deforestation. Like climate and soil also have to be used. This will make research more efficient.

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