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Change Monitoring and Forest Density Classification of Gir Wildlife Sanctuary, India

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Abstract:
In India we found a main 5 types forest classification. As India covers the 21.7% of the total land in Forest. Forest are the main and most important ecosystem on earth without forest there is impossible for any creature to survive on earth, because almost 70% of the resources are obtained from the forest. In this research we have study the forest change monitoring of the Gir sanctuary in Saurashtra district of Gujarat. The forest of Gir sanctuary is Dry deciduous forest. As this district covers the main portion of the forest cover in Gujarat state. With the help of remote sensing and GIS we can easily monitor the change monitoring and forest density change in the area by taking the 20 years difference 1999 to 2019. This study identifies the change monitoring and density classification in the Gir wildlife sanctuary and we have also taken 40 km buffer zone near the sanctuary. It was observed that there is increase in the forest cover while comparing the images of Sentinel-2 (1999) and landsat-5 satellite data (2019) of the study area that the Forest cover since the year 1999 has increased with an increase in Forest density. There is an increase in the human population in the 40 kilometres buffer zone. This human population is mainly dependent on the agriculture and animal husbandry business. An increase in the livestock population may also increase the issue of overgrazing. Plus, the conflict of wildlife with the livestock may also harm the wildlife. Hence government must look in the issue of increasing human population near the sanctuary area.

Keywords: Change detection, Forest density, Human population, remote sensing and GIS, Land use Land cover.

Introduction:

Forest in India, from the ancient time, have played important role in social, economic and religious activities. But it suffered severe degradation in last few decades due to ever increasing demand of goods and services. In view of the deteriorating forest resources and their importance of the national economy and environment, the government have been emphasising the sustainable development of forest resources, as well as conservation of ecosystem. The Gir Forest, Gujarat, India, contains the 177 remaining Asiatic lions and remnant populations of many wild ungulates once found over wider areas in India. The ecosystem is being adversely affected chiefly by overstocking, logging and tourism. In order to preserve the forest as a wildlife sanctuary, it is suggested that domestic livestock should be reduced. (Berwick, 1976).(Berwick, 1976) The importance of forest is unaccountable, forest and humans were associated with each other. There is wide use of forest products in our day-to-day life, we need forests to survive on earth.

The humans rely on forest for both the ecological and the economic aspects of life, and it has a great significant contribution to sustain the life on earth.

Valuation of ecosystem is an important area offering scope for innovations in approaches and methodologies. This is particularly important in the case of an ecosystem where valuation of both costs as well as benefits have significant implications for convincing local communities who directly get affected by the conservation measures. Gir Protected Area in the western part of Gujarat (India) represents a situation with a large population of wild life surrounded by about 100 villages in the periphery. Prima facie, protecting this eco-system should take into consideration both- ecological as well as economic benefits given the extent and nature of the trade-off between the two (Shah,2002). Advancement of geospatial technologies provides a method to evaluate forest cover in the inaccessible and remote areas. In this study, the forest canopy density of Gir National Park and Sanctuary a tropical forest area was evaluated using remote sensing and GIS. These techniques are very much cost effective; provide information at a satisfactory accuracy level which will be beneficial for the biodiversity management and planning specially the forestry sector (Alam,2014).

Area Covered:

Gir sanctuary and National Park	**1412.13 km2**
Gir sanctuary	**1153.4 km2**
Gir National Park	**258.71 km2**

Table 1: Area covered

Forest are the most important resources on the earth, they need a sustainable management, problems like maintaining the resources, climatic changes and other natural and human activities affects the forest ecosystem greatly. The conventional methods of forest assessment and monitoring is to use the remote sensing and GIS (Geographic information system) techniques. Remote sensing is to collect, store and manipulate the data from the satellite and GIS is used for the spatial analysis and mapping thus it is most important to use this advanced technique for the forest management and assessment. By doing the land use land cover mapping we can detect the change in area and forest and monitor the variations that are happened in past and also density can be easily detect by the use of RS and GIS. Thus, Remote sensing and GIS are widely used in forest for mapping analysis.

Mukherjee Wilske et al, in 2004 observed that the Gir National Park and sanctuary is one of the seven protected areas selected for biodiversity conservation through the Eco-Development Project funded by the Global Environmental Facility and implemented by the World Bank The prohibition of resource use and resettlement of people from the protected area were done to meet the need of national policy (Wildlife Protection Act). However, the perception of the locality was that one of the major steps taken was restricting the inhabitants of the forest from entering the National Park and thus restricting them to the fringes of the protected areas. Over the years, however, it has been realized that effective management of the protected area is not possible without addressing the legitimate needs of the local people.

In this research the author studied that the wildlife habitats are under significant threat due to rapid development activities. At present, remote sensing and GIS has been used widely for modelling, evaluating and monitoring wildlife habitats. These techniques have proven to be efficient tools for integrating the spatial and non-spatial data required for monitoring wildlife habitats. The study focuses on modelling the forest cover, assessing the hydrology and land surface features of the Girnar wildlife sanctuary using such

geo-spatial techniques. The forest of Girnar is known for Asiatic lions, birds and its rich floral diversity, in which habitat characteristics and land surface features are poorly known. The spatial data from various Earth observation satellites were acquired, interpreted and analysed using different tools on the GIS platform to derive the hydrology, land use-land cover and land surface parameters of the sanctuary. Geospatial maps were prepared showing suitable forest cover, drainage pattern with respect to elevations, and the land surface temperature with respect to NDVI. The LST-NDVI plot shows the inverse correlation between the surface temperature and vegetation indicating the importance of dense vegetation in the dry deciduous forest. These deliverables will help policy makers in evaluating suitable habitats for Asiatic lion and its prey base in Girnar and formulating effective habitat enhancement and conservation strategies. Aditya, D. (2021).

In this paper the authors specificly studied abot the endangered Asiatic lions (Panthera leo persica) that are found in the Asiatic Lion Landscape, Gujarat, which includes protected areas and a multi-use land matrix. Therefore, monitoring lions' space-use and spatio-temporal location is vital for managing various facets of human−lion interaction. The study demonstrates how this was achieved by tracking lions using GPS radio-collars, triggering prompt action via an efficient communication network across political and forest administrative boundaries. They monitored the movement of 19 individual lions for 436.5 ± 32 days and also derived the mean daily activity from three-axis accelerometer-based activity-sensing feature of a radio-collar. We also monitored geofence breaches.From a management standpoint, we discussed the efficacy of the virtual geofence in preventing accidents when lions moved and also presented the advantages of being able to track dispersal through a case study of sub-adult lions. To strengthen their response to lion immobility, they developed a predictive model that specifically highlights an individual lion's health status and makes the alert response more precise. In conclusion, they critically reviewed the capabilities provided by GPS telemetry and provide protocols that help in the conservation management of lions and that will also have a wider application. Ram et al., (2023).

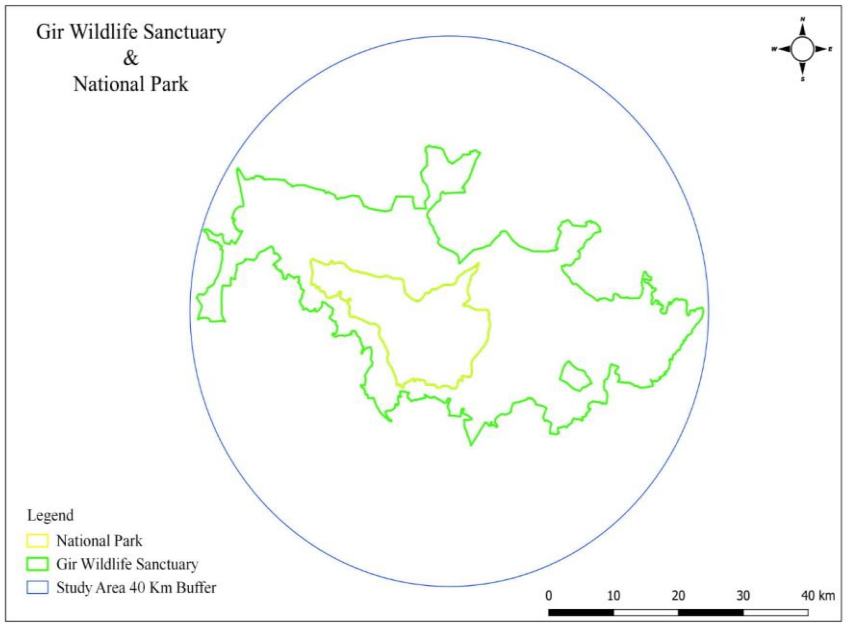
Diverse, often inter-disciplinary, approaches have been proposed to advance the conservation of lions (Panthera leo) and their natural habitats. The IUCN guidelines for the conservation of lions in Africa call for effective national policies at all scales, and legal frameworks with specific Action Plans preferably at a regional/population level, to achieve the goals of lion conservation while also planning for the equitable distribution of costs and benefits amongst local communities. However, general approaches must be tailored to specific circumstances, so here we provide an overview of the factors relevant to the particular case of Asiatic lions (p.l.leo). Taking stock of what has contributed to the remarkable recovery of these lions from the brink of extinction, we provide readers with background understanding of the steadily growing lion population in Gujarat, India. The study focus on the management challenges that have arisen during the past two decades during which lions have increasingly moved, and dispersed, beyond the Gir Protected Area (Gir PA). They illustrate how the positive intersection between cultural predisposition, regulatory frameworks, and management interventions have contributed to this accomplishment. Despite the apparent history of success, the currently fruitful intersection of these factors are in fact dynamic and, to remain positive, need continuous review and adaptation. It highlights how mitigations that may strongly foster conservation when applied in moderation may be counter-productive in excess and also go on to evaluate the extent to which some of the lessons learnt can be generalised. Venkataram M. et al., (2023)

Human-wildlife conflicts are escalating in Talala sub-district because of changing cropping pattern on the periphery of Gir National Park and Sanctuary (GNPS), Gujarat, India. Changes in agricultural practices and in human-wildlife conflicts in Talala were investigated. Sugarcane cultivation has increased by 87%

and mango cultivation by 103% during the years from 1992 to 1999. Incidences of Asiatic lions (Panthera leo persica) and leopards (P. pardus) straying into agricultural land have increased by 55% and 46% respectively from 1997 to 1999. Significant correlations were found between the increases in sugarcane and mango cultivation and the number of straying lions (r = +0.827, df = 2) and leopards (r = +0.981, df = 2). Furthermore, during the years 1992 to 1998 out of 11 lions rescued, eight (72%) were from farmland and out of 32 leopards rescued, ten (31%) were from farmland. Ten lions (91%) and five leopards (41%) were found dead in farmland from 1994 to 1999. The straying of big cats from the GNPS to adjacent farmland has also led to increased encounters with humans. Out of a total of 13 attacks on people by lions, ten were reported from areas of sugarcane and mango cultivation. Of the total 25 leopard attacks, 59% (including four deaths resulting from the attacks) were recorded from farmland. Livestock deaths caused by big cats straying into farmland have increased by 150% within two years (1998 and 1999). Vijayan and Pati, (2001).

Materials and Method:

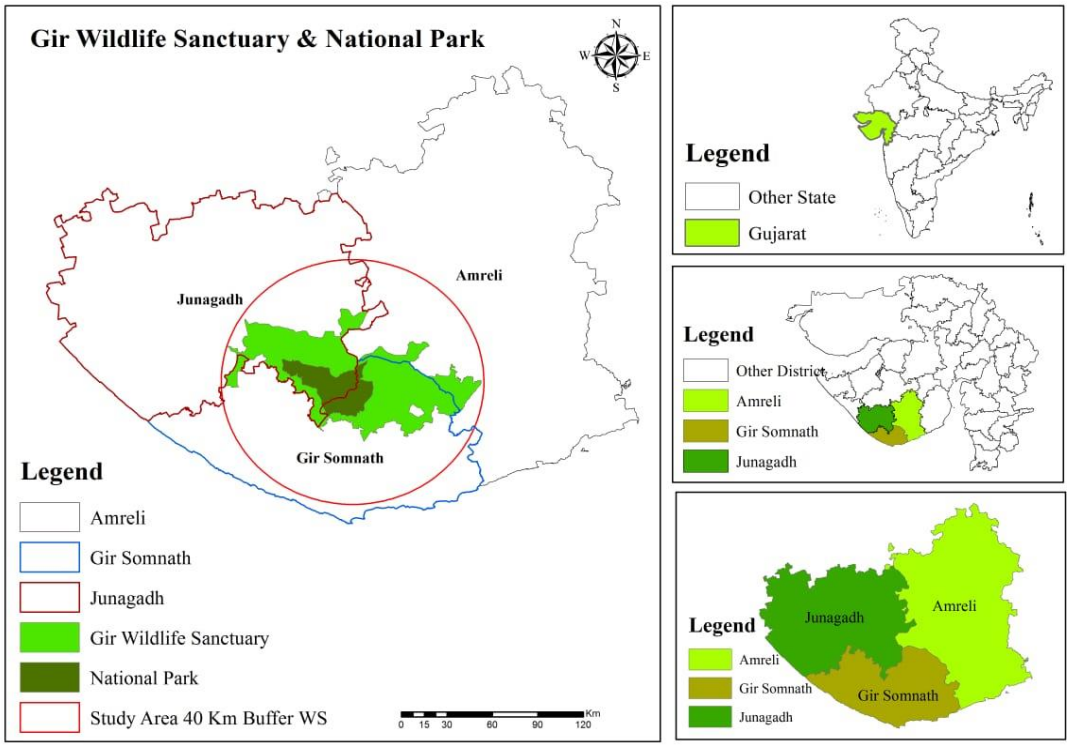
Study area: -



Map 1: Map of study area

Junagadh district with its famous Girnar hills and Gir forest of Gir wildlife sanctuary and National Park both covers an area of around 1412.13 km^2, it lies between the parallels of latitude 24º44'and 21º53' North, and meridians of longitude 70 and 72 East. Barda hills near Porbandar, which was earlier included in Junagadh district has now been separated into separate district of Porbandar. Gir wildlife sanctuary covers an area around 1153.4 km^2, and the area covered by the Gir national park is 258.71 km^2. Around Gir forest there is the belt of coastal forest, along the Arabian Sea. We had taken a study area of 40 km buffer zone around the Gir wildlife sanctuary and National Park. Gir as well as Girnar are surrounding areas of the district have some principal rivers, some of them having perennial source of water, expecting in the years of severe drought. Hiran, Datardi, Shingoda, Machhundri, Raval, Ghodhavadi, Shetrungi these are the main seven rivers if the Gir lying in the Junagadh district.Water in the nallas, stream sand seasonal rivers dry up during summer. However, there are some deep-water pools retained in their course which are called “Ghuna” and “Kund”. All the rivers flow from north to south, tract of which is cut up by innumerable

streams. Wildlife in the region mostly depends on these deep, stagnant pools of water i.e., Ghuna, Virda or kutia's.



Map 2: Index map of study area

Flora: - Gir wildlife sanctuary and national park comes under the category of dry savannah forest and dry deciduous forest. Flora is wide spread in the whole forest, many of the species grows depending on their climate and habitat, hence there are many more different varieties of plants and shrubs grows in the forest and also, they are wide spread outside the whole Junagadh, Amreli and Gir-Somnath districts.

Fauna: - Gir wildlife sanctuary and national park has unaccountable number of fauna species it consists of 179 Birds species, 33 Reptiles, 30 Mammals and many more. Birds like baron owl, amur falcon, black eagle, Brown fish owl, Kingfisher, Indian blackbird, asian paradise and etc there are around 523 lions and more than 300 leopards. Carnivores like Asiatic lions, Indian leopard, striped hyena, golden jackal, ruddy mongoose, jungle cat, Indian grey mongoose and etc. Herbivores like chital, nilgai, sambar, chinkara, wild boar and etc many more herbivores animals seen in Gir wildlife sanctuary.

Photo Plate 1: Blue bull

Photo Plate 2: Tiger

Photo Plate 3: Gir Forest

Photo Plate 4: Gir Forest

Photo Plate 5: Gir Forest

Photo Plate 6: Gir Forest

Vegetation:

Vegetation Type	Percentage area
Moist mixed forest	12.76%
Mixed forest	16.95%
Acacia – Tectona	13.48%

Table 2: Vegetation Percentage

Methodology:

This chapter deals with the details of methods adopted for analysis of data various phases of methodology used to carry out the study are discussed under the following sub heads.

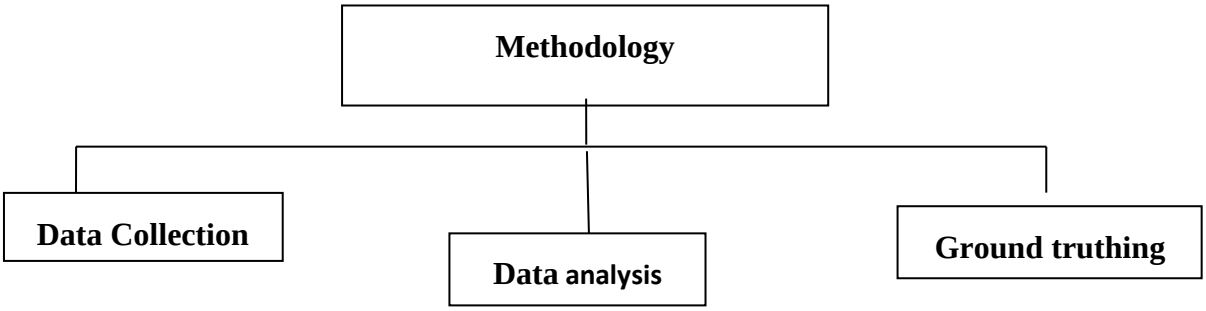


Figure 1: Flow chart of Methodology

Data Collection:

Satellite dataset:

Firstly, we had open the USGS that is the tool that provides to query, search and download the satellite images by the sensors taken by in the satellite regarding their various dates and ability for the resolution to the different bands and satellites. To download any image it is necessary to login to the USGS earth explorer.

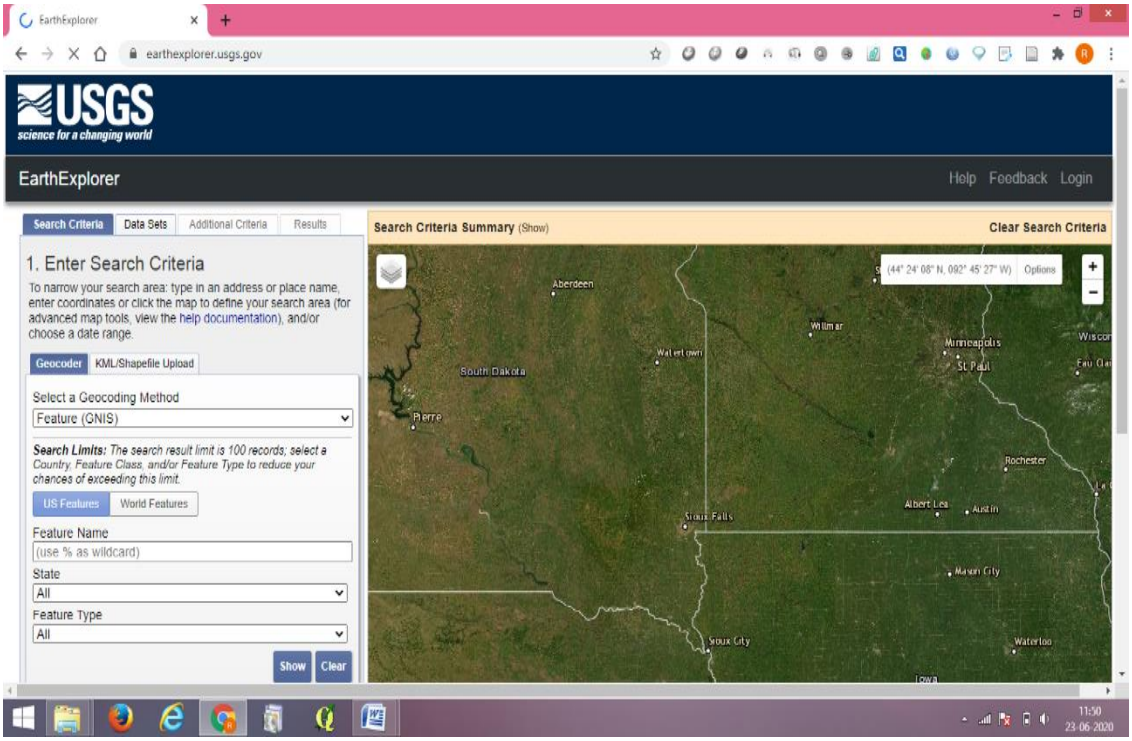


Photo Plate 7: USGS Earth Explorer

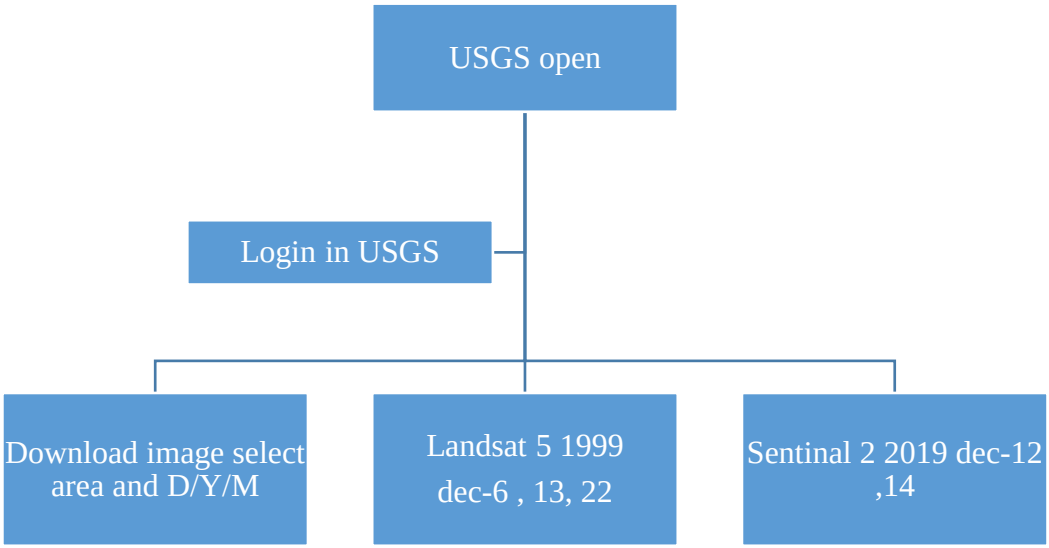


Figure 2: Flow chart to download image

Remote sensing data has been acquired by operational Sentinel-2 Multispectral imager (MSI) sensors. This sensor delivers 13 spectral bands ranging from 10 to 60meter pixel resolution. Blue (B2), Green (B3), Red (B4), NIR (B8) channel have 10meter resolution. Sentinel-2 consist of 2 satellites Sentinel-2A and Sentinel-2B launched on 2015 and 2017 respectively which combined offers a revisit time of 5 days. Landsat 5 was launched from Vandenberg Air Force Base in California on March 1, 1984, and like Landsat 4, carried the Multispectral Scanner (MSS) and the Thematic Mapper (TM) instruments. Landsat 5 delivered Earth imaging data nearly 29 years - and set a Guinness World Record for 'Longest Operating Earth Observation Satellite', before being decommissioned on June 5, 2013. Bands used in Landsat 5 are Blue (B2), Green (B3), Red (B4) and NIR (B5). We had taken the 20 years of the different 1999-2019 to

calculate the forest density of the Gir wildlife sanctuary and national park, usually LANDSAT-5 is commonly used for the satellite images before 1997 it gives a nice resolution of the old satellite images.

Area	Date and year	Satellite image	Bands used
Gir wildlife sanctuary	December 6 1999	LANDSAT -5	B2, B3, B4, B5
Gir wildlife sanctuary	December 12 2019	SENTINAL -2	B2, B3, B4 ,B8

Table 3: Satellite Image Information

Software used

1). QGIS 2.12

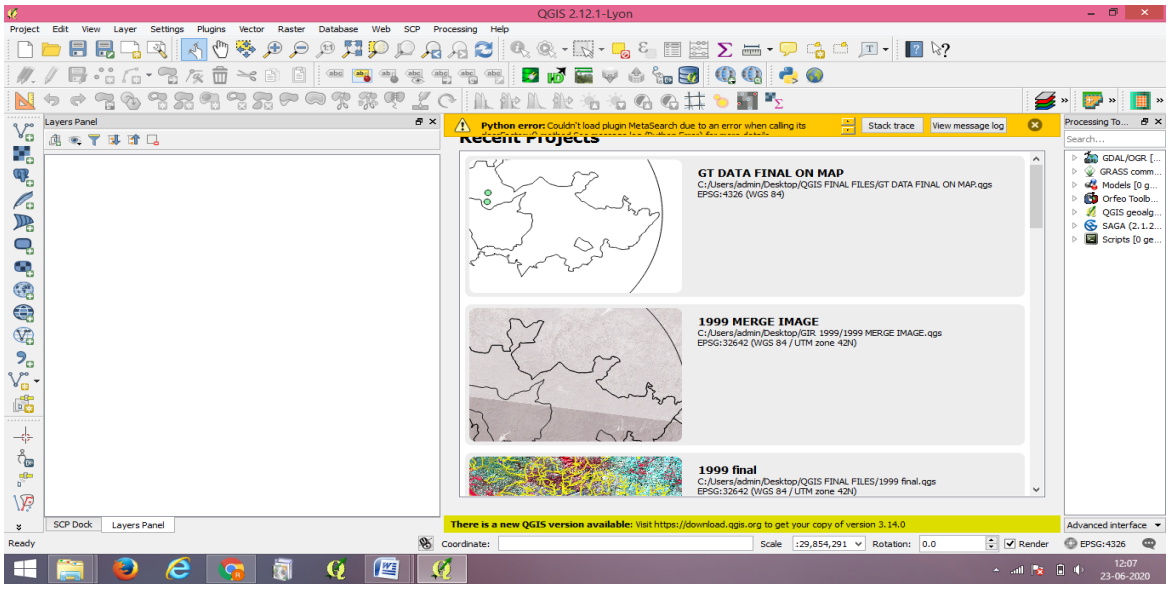


Photo Plate 8: QGIS Software

2). Google earth

3). Field area measurements for GPS points

4). GPS essentials for GPS points

Data Analysis

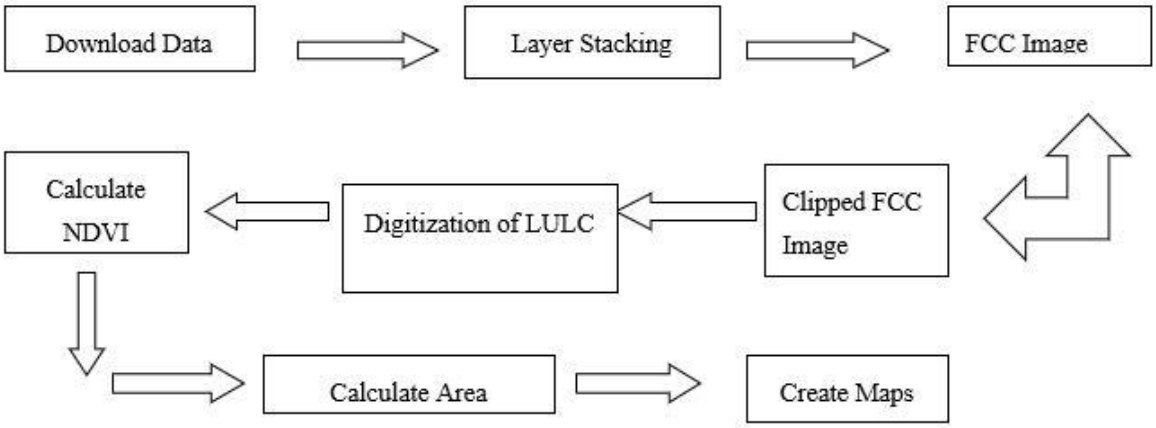


Figure 3: Flow Chart of Data Analysis

Method

In this work we had taken a 20 years of gap 1999-2019 to find the change detection in the forest density of the Gir wildlife sanctuary and national park by taking the Sentinel 2 and Landsat 5 satellite images as per their resolution over their bands with different categories and download it from the USGS earth explorer and then layer stack all the images and we get the FCC image that is the False color composite image and then we had clipped that image and after adding the shape file to the vector layer and by using the various tools like split features, polygon and etc used in the digitization of the land use and land cover change and also with different categories like Built-Up, Agriculture , Waterbody , forest and wasteland. In this work we had taken the 40 km buffer area to cover the whole wildlife sanctuary and national park.

Layer stacking:

There are different ways of visualizing data using layer-stacking it can be either a True Color Composite using band combination (B4, B3, B2) or a False Color Composite (FCC) we are more interested in generating a FCC image as we tend to enhance the vegetative properties in our scene so we use Color Infrared (B8, B4, B3) combination where the target objects have natural vegetative properties appear red in color which becomes easy to identify the vegetation area and also based on color we can know the health of vegetation and also the stage of any agricultural areas .

Study area clipping:

After FCC generation it is important to clip out our study area and remove the unnecessary scene from our data as it can slower our upcoming processing duration, as describe study area is Gir wildlife sanctuary and national park, for clipping the study area 40 km buffer Boundary was provided by BISAG Gandhinagar which was used to clip the scene from the FCC images of multiple date.

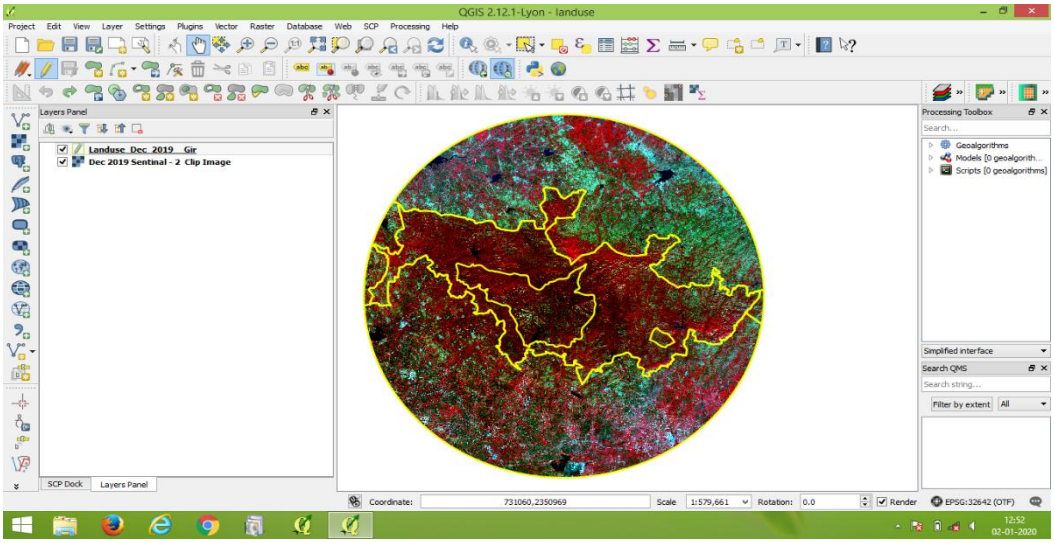


Photo Plate 9: Clipped image

Classification of categories using digitization

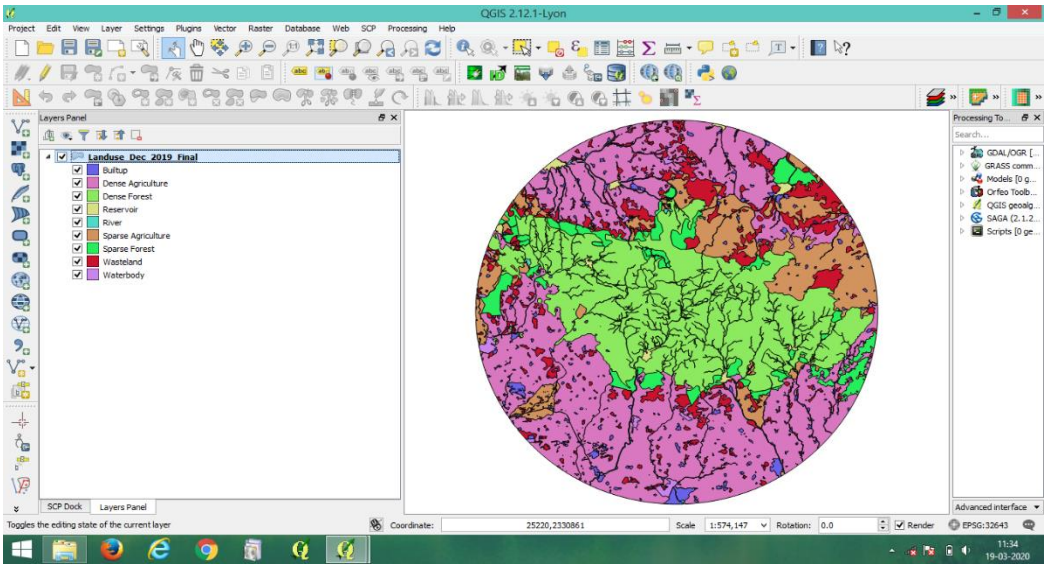


Photo Plate 10: Digitization of Study area

Traditionally supervised classification is used of land use and land cover change detection but due to mixing of spectral signature of different classes, many times some classes tend to mix with other classes which causes reduction of total accuracy in land use land cover change classification. By using the different tools like split features, polygons and fill ring and other topological features are used to carry out the classification of different classes and categories

NDVI: (Normalized Difference Vegetation Index)

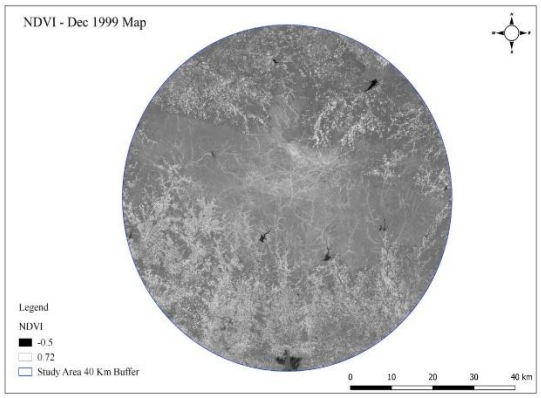
DN values can have a range from 0 to 255 in all 3 bands and their combination contains many classes but in order to make the vegetation feature more appearing, further improve our visualization and know the density, health of vegetation NDVI is performed. NDVI is given as:

- NDVI = NIRRED)/(NIR+RED),

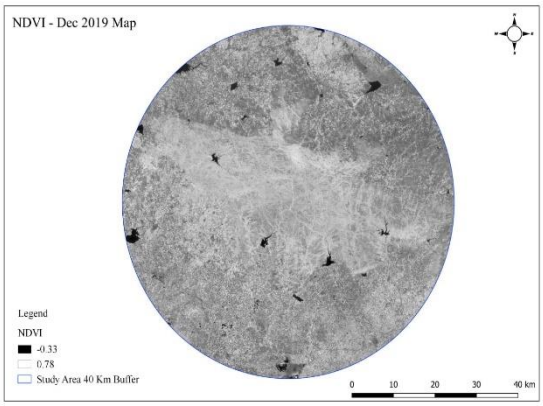
In case of Sentinel-2 bands the formula can be given as:

- NDVI: (B8-B4)/(B8+B4)

Because near-infrared (which vegetation strongly reflects and red light (which vegetation absorbs), the vegetation indexes good for quantifying the amount of vegetation. The formula for normalized difference vegetation index is(B8-B4)/(B8+B4). The NDVI values ranges from -1 to 1, while high values suggest dense canopy, low or negative values indicate urban and water features.



MAP 4 NDVI 2019



MAP 5 NDVI 1999

Calculate Area: -

To detect the change in the area of different categories and classes of the Gir Wildlife Sanctuary and National Park in the observation period of 20 years of gap. Area calculation was further done in the QGIS 2.12 tool box by using the images of 1999 and 2019. By using the tool like Raster Calculator, we can easily obtain areas of our different classes and categories of the study area.

Mapping: -

QGIS 2.12 is a tool that has a print composer that allows to the GIS layers and packed them to create maps. To create maps is the last step in the Digitization so that we can know the exact result of the land use and land cover change. Various QGIS versions has different methods of creating Maps. To create maps, it is necessary to use various tools like navigations, directions and axis in a proper direction. Various Maps like Forest Density, Water Bodies, Built-up, Wasteland, Transport network, Village, Land use Land cover change map have been created

Ground truthing: -

For ground point collection, we have used the various applications like field area measurement, Google earth explorer, GPS essentials for collecting the GPS points in the study area. For GPS point collection the site was selected based on the features identified in the images. We have taken the points of the various categories like water bodies, built up, agriculture, forest and forest density.

Gir Ground truthing GPS Points:

Gir sanctuary Site Ground truthing Data	Category	latitude	longitude
Near Itali Village (Out of Sanctuary area) Visavadar	West land	21.301825°	70.556329°
Itali Settlement	Settlement	21.302487°	70.552230°
Ambajad Reservior (Near Jambudi Village)	Reservior	21.278921°	70.730245°
Near Jambudi Village (Visavadar Site) Mangro Tree Farm	Horticulture (Agriculture)	21.286880°	70.723712°
Asisatic Lion Safari booking Office (Sasan- Gir)	Built up	21.169369°	70.598685°
Sinh Sadan Campus (Sasan- Gir)	Built up	21.170232°	70.598608°
Wildlife Division Office (Sasan- Gir)	Built up	21.170674°	70.600217°
Low Density Forest (Sasan-Gir to Somanath Road site)	Forest	21.156742°	70.576891°
Hiren River (Sasan-Gir to Somanath Road site)	Waterbodies	21.109441°	70.553416°
Talala Builtup Area (Sasan-Gir to Somanath Road site)	Built up	21.054929°	70.530956°
Hiren-2 Reservior (Sasan-Gir to Somanath Road site)	Waterbodies	21.021923°	70.481495°
Veraval Builtup (Sasan-Gir to Somanath Road site)	Built up	20.910688°	70.378595°
Triveni Sangam (Somnath) Prabhas Patan	Built up	20.883310°	70.410060°
Mining (Ambuja Cement) Near Kodinar City	Mining	20.846358°	70.712161°
Kankai Mandir in Gir Wildlife Sanctuary	Dense Forest	21.143305°	70.786416°
Bhuva tirath River Near Kankai Temple	Dense Forest	21.143998°	70.787773°
Sasan Area	Built up	21.169367°	70.596236°
Amrut vale (Adjoining point)	Built up	21.121115°	70.636633°
Devaliya park (Bhalachel area)	Forest	21.176808°	70.571843°
Devaliya campus (IRC)	Built up	21.169093°	70.503378°
Devaliya Entrance	Low dense	21.166599°	70.504847°
Devaliya park	Low dense	21.156740°	70.503030°
Devaliya park	Dense Forest	21.161427°	70.502214°
Devaliya park	Dense Forest	21.161923°	70.505320°

Devaliya park	High dense	21.161950°	70.502345°
Devaliya park	High dense	21.161647°	70.504120°
Devaliya park	High dense	21.165779°	70.511214°
Hiran River	Forest	21.173744°	70.593478°
Sasan Area (Pickup Busstand)	Built up	21.168767°	70.597370°
Nursury Sasan (Gir arbotorium and birding points)	Forest	21.172626°	70.593370°
Hiran River (Tributary)	forest	21.175992°	70.588076°
Sunset point (Devaliya approach)	Forest	21.181785°	70.556291°
Hotel Astar homestay	Built up	21.170726°	70.595859°
Bavad vala chowk vistar	High dense	21.175454°	70.615949°
Kamleshwar Dam	High dense	21.190830°	70.651739°
Malanka Dam	Reservior	21.258007°	70.494647°

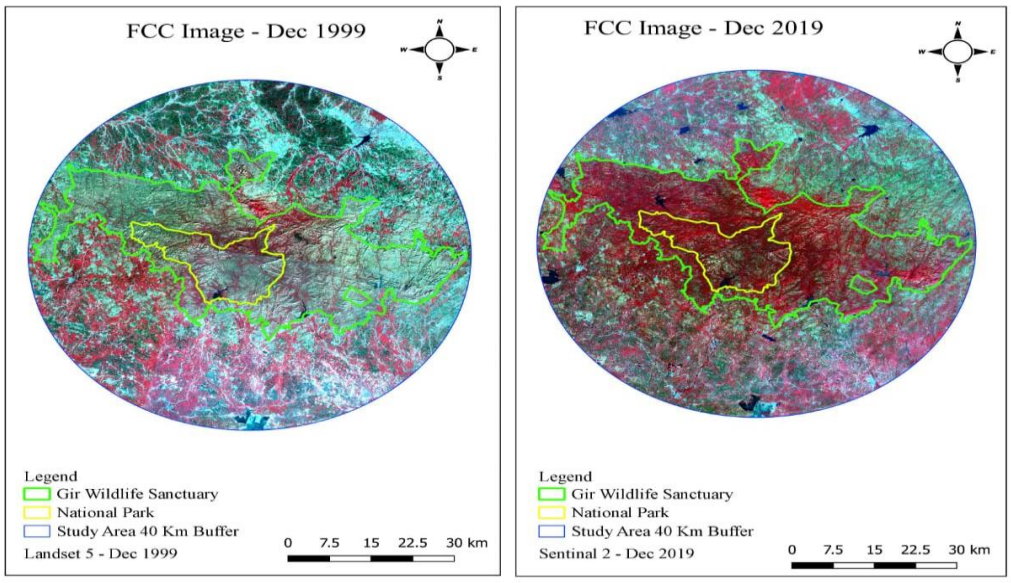
Table 4: Ground Truth points

Result and Discussion:-

During the present study, we have used Landsat-5 and Sentinel-2 satellite data to make various maps like Forest density map, Transportation network map, NDVI map, GPS points map, Water bodies map, Village-settlements map, Land use Land cover map etc to understand the factors affecting the 'forest density' in Gir Wildlife sanctuary. To conduct the present study, these maps were made using Q-GIS 2.12 version which is an open source type of GIS software.

Change Monitoring of the Study area:

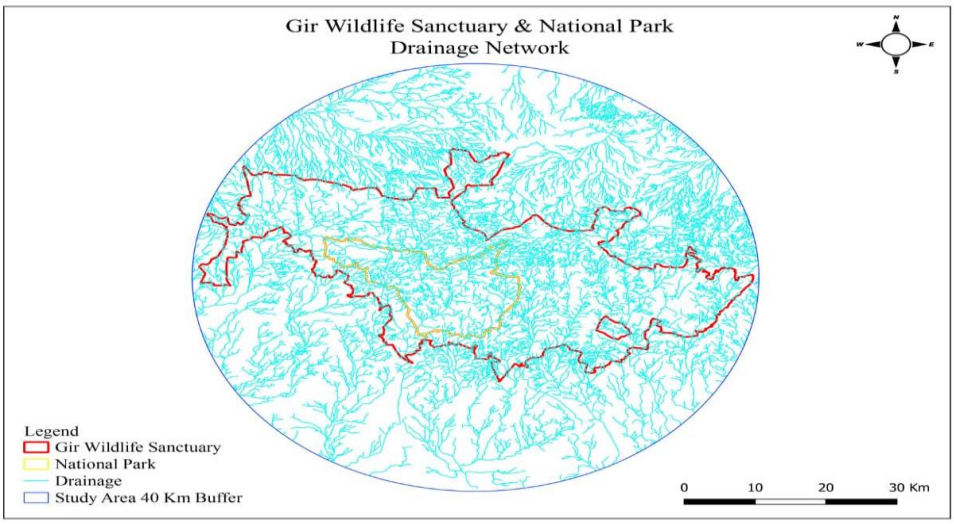
In the present study, we have taken Landsat-5, FCC image of the year 1999 and Sentinel-2 FCC image of the year 2019 to understand the change in the forest cover and forest density of Gir wildlife Sanctuary and the forty kilometres buffer zone selected. By looking at both the satellite images, it is our observation that the forest density in the Gir wildlife sanctuary has increased with the increase in the area of water bodies as well.



Map 5: Change monitoring map

Drainage Network map:

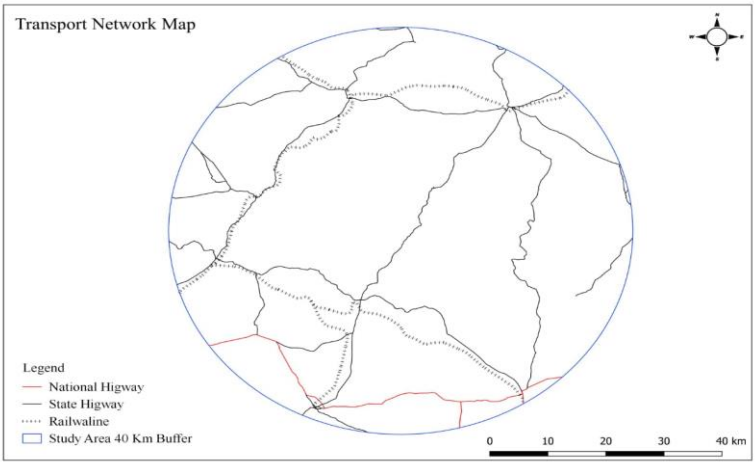
The Drainage Network map was prepared to understand the status of the fresh water sources in the study area i.e. Gir Wildlife Sanctuary and the forty kilometres buffer zone. The study area includes three districts viz. Gir-Somnath, Amreli and Junagadh district. The map gives a clear idea of rain water propagation in the study area. It is one of the prime factors which affect the forest density of the study area. We have used the latest sentinal 2 image to understand the status of the drainage system in the study area. It is our observation that there are areas in the study area, which gets dried up during pre-monsoons but gets enough waters during and after monsoons.



Map 6: Drainage Network Map

Transportation Network Map:

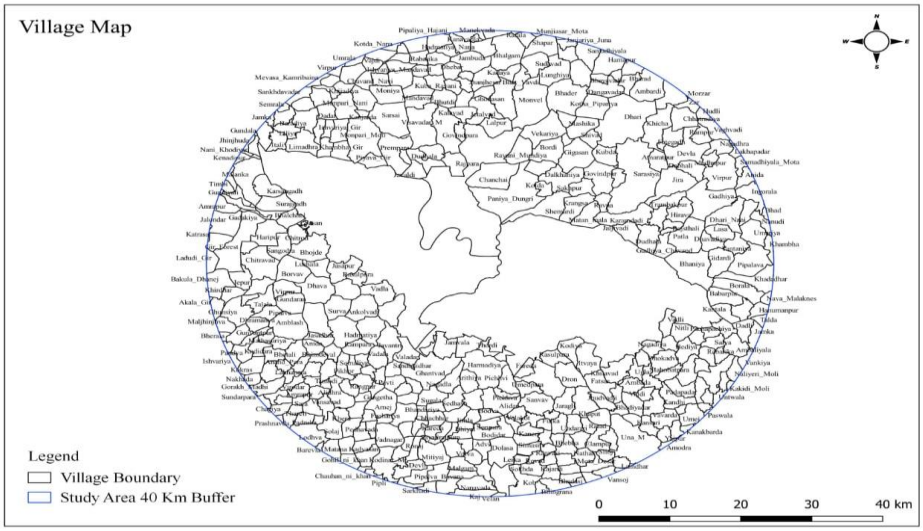
In the study area including 40 km buffer zone, we have created a map of the 'Transport network' of the Gir wildlife sanctuary.The understanding of the transportation network inside the study area is also one of the prime factors affecting the forest density. Hence it was very much important to understand the human interventions affecting the forest cover and forest density. By creating 'Transportation network map' it was observed that the road network in the study area has an enormous increase since two decades. It was also observed that the area has a steady increase in the number of tourists visiting the study area. There has been an increase in the road network inside the forest areas which are denser for wildlife life tourism.



Map 7: Transport Network Map

Village map:

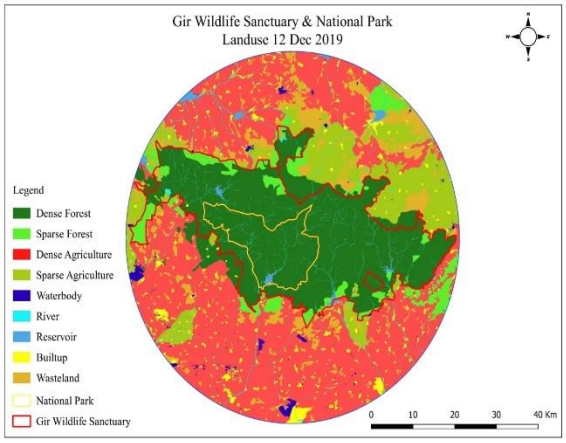
We have mapped and identified the various villages that are in the forty kilometres buffer zone of the study area. The village and settlements map was created to understand the anthropogenic factors affecting the forest cover and forest density. It is assumed that the people living in the buffer zone are associated with the agriculture as we can see agricultural fields in the LULC map. The agriculture is one of the major factors affecting the forest cover and forest density. The study area faces the issue of over-grazing as the major population of the area is associated with the Animal Husbandry. It was our observation in LULC map that there was a steady increase in the Village settlements areas; which also suggests that the buffer zone is facing a problem of increase in the human population.



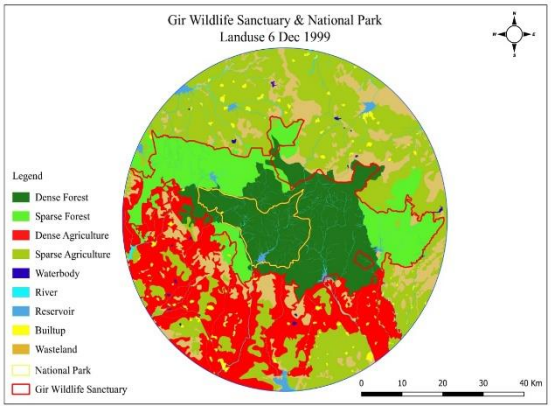
Map 8: Village Map

Land Use Land Cover Change:

We can clearly observe that there has been a steady change in the various categories like the built-up, wasteland, agriculture, Forest Density and Water Bodies while looking at LULC Map. During the study, we have categorised the forest into two sub categories viz. the 'Dense Forest' and 'Sparsh Forest'. The agriculture was also categorized into two categories viz. 'Dense Agriculture' and Sparsh Agriculture'. While comparing the satellite images of 1999 with the 2019 satellite data, it was observed that the forest cover has increased with an increase in the forest density. There was also an increase in the built-up area which gives a clear idea about the increase in the human population. There was also an increase in the area of water bodies like rivers, dams and Canals which gives an idea about the increased human interventions. But, the same factors might also help in increasing the forest area. It was also observed during the study that Agriculture in the study area has also increased enormously with a decrease in the wasteland area. It is very much important to prepare LULC map while understanding the factors affecting the forest cover and forest density.



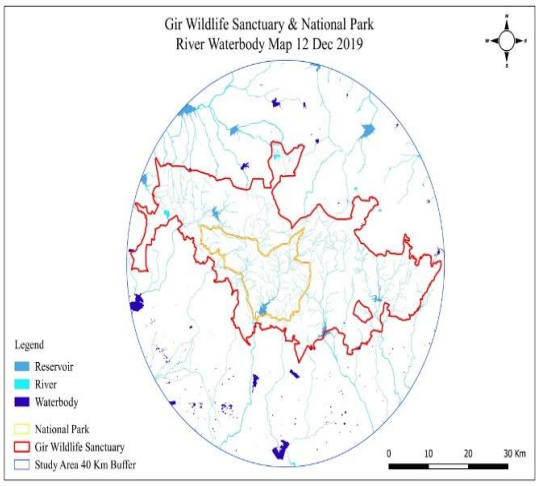
Map 9: LULC 2019



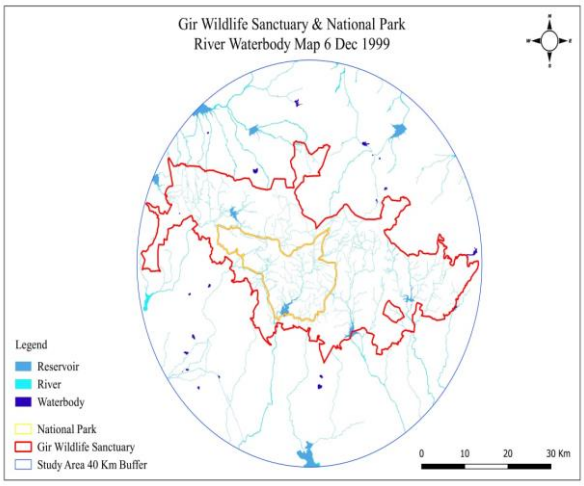
Map 10: LULC 1999

Water Bodies Map:

By comparing the water body maps of the years 1999 and 2019, it was observed that there is an increase in the water bodies in the study area. The dams in the area have increased due to which the area has enough storage of water. The water table has also increased in the Sanctuary due to the new check-dams and dams constructed since past two decades. It is supporting the agriculture in the 40 kilometres buffer area. It was observed during the study that the old tributaries of rivers like Hiran, Macchundri and Sattadhar got rejuvenated. The Kamleshwar dam, which is a new development on River Hiran, has played a very important role in increasing the Forest Cover in the study area as it has also become one of the major source of Fresh water in the area.



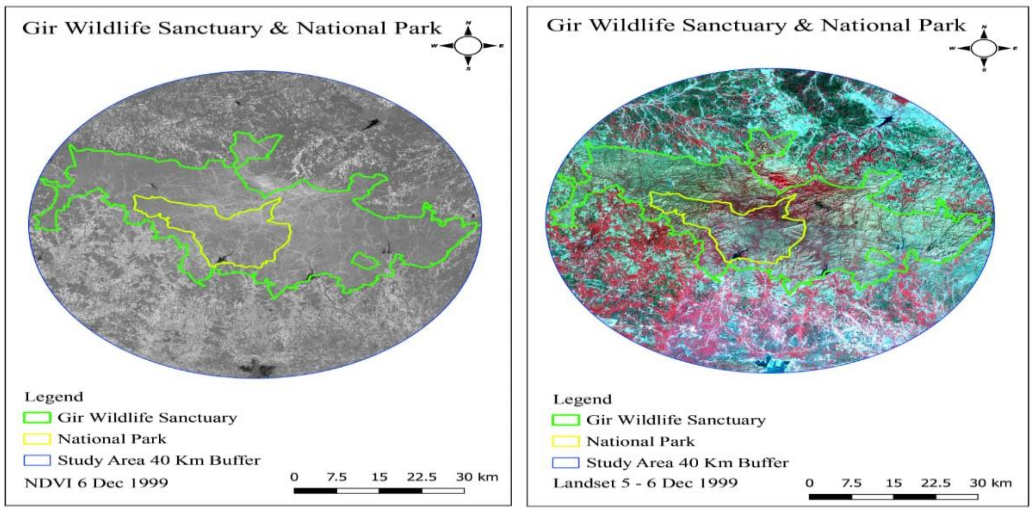
Map 11: Water Bodies 1999



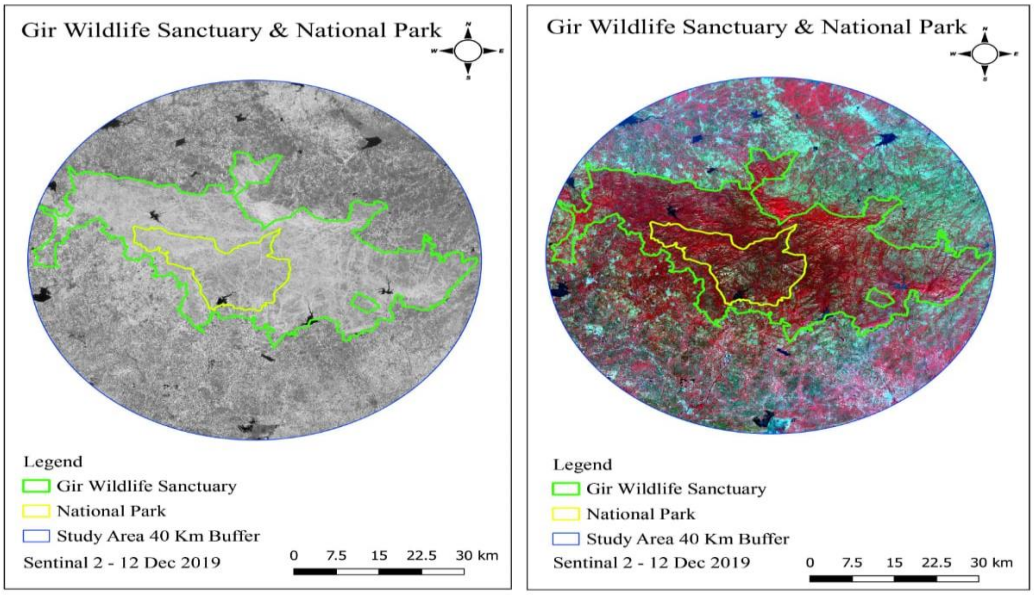
Map 12: Water Bodies 2019

NDVI Map:-

Normalized Difference Vegetation Index (NDVI) is a common measure in remote sensing for Vegetation, capturing how much more near infrared light is reflected compared to visible red. It helps differentiate bare soil from grass or forest, detect plants under stress, and differentiate between crops and crop stages. NDVI map also gives an idea about the vegetation and the water bodies of the study area. The NDVI map gives a clear idea about the dense forest of the area.



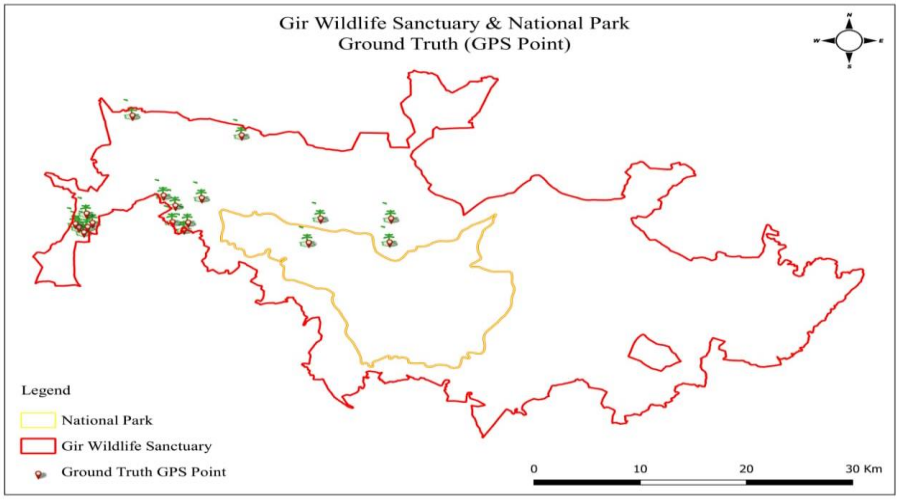
Map 13: NDVI and Satellite Image Comparison Map 1999



Map 14: NDVI Satellite Image Comparison Map 2019

GPS points location maps:

While using Remote sensing technology for any study, Random Ground truth is very much important as one cannot rely on office interpretations of any study area. Ground truth points were taken using the various applications like the field area measurements and Google earth. We have taken the points of the various categories viz. forest density, built-up areas, water bodies, dense forest and agriculture for ground truth in the study area. The GPS point map shows the points where ground truth was done after the remote sensing analysis.

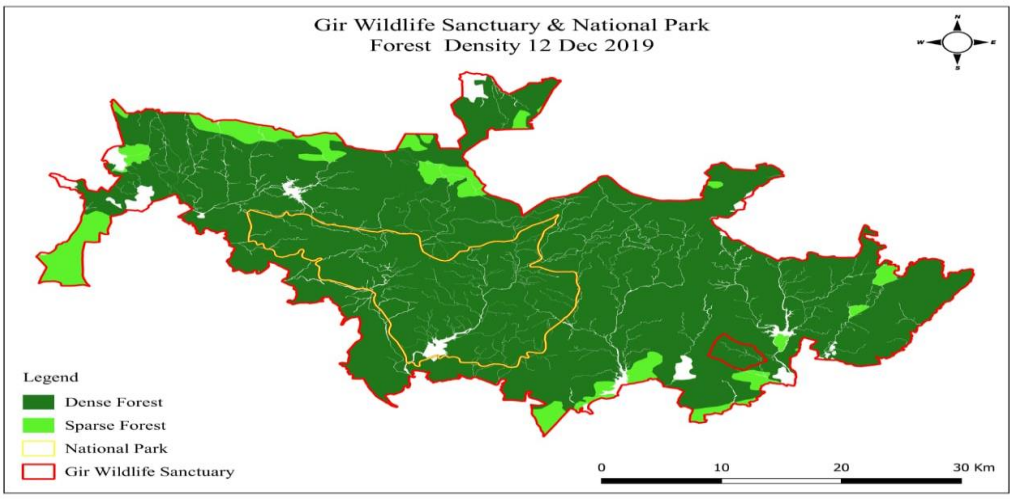


Map 15: Ground Truth Map

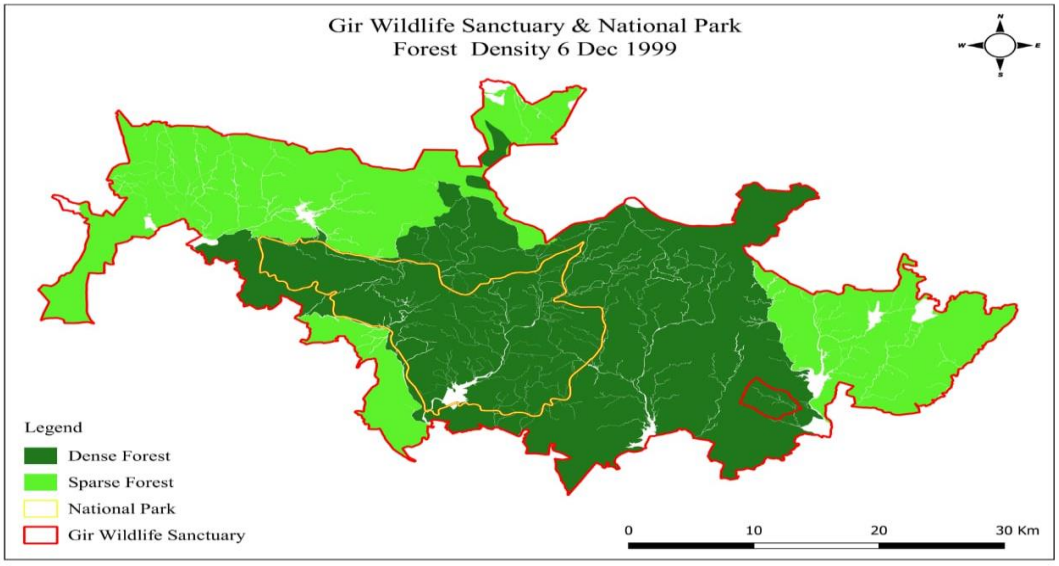
Forest Density map:

The Forest density maps were prepared using Sentinal-2 and Landsat-5 satellite data of the study area. One can easily observe that the Forest cover has increased in the study area in the past two decades. The map also shows an increase in the forest density in the study area. The LULC map clearly gives an idea about the factors affecting the Forest cover and Forest density in the study area. The increase in the fresh

water sources is one of the major factors which increased the forest cover. Though, it was also observed that the area is facing an issue of increase in human population and tourism. There has also an increase in the road network in the sanctuary area. The new check-dams and dams have also been constructed in the past twenty years. The area has a large human population which depends on animal husbandry. Despite an increase in these factors, the map clearly shows an increase in the forest density.



Map 16: Forest Density 2019



Map 17: Forest Density 1999

Area Covered:

1. Forest Density Area Covered

The forest density area of the Gir wildlife sanctuary and national park were calculated using the QGIS 2.12 software by taking the satellite images of LANDSAT-5 for 1999 and SENTINEL-2 for 2019 by taking the 20 years of gap we have observed that the area of the Gir forest has increased in the year 2019 compared to 1999, there we can also a increase in the forest density area of the Gir forest and also there is increase in more dense agriculture due to the increase in the human and animal population and water bodies we can easily detect the change area in the forest density

Total Forest Area Covered 1999:-

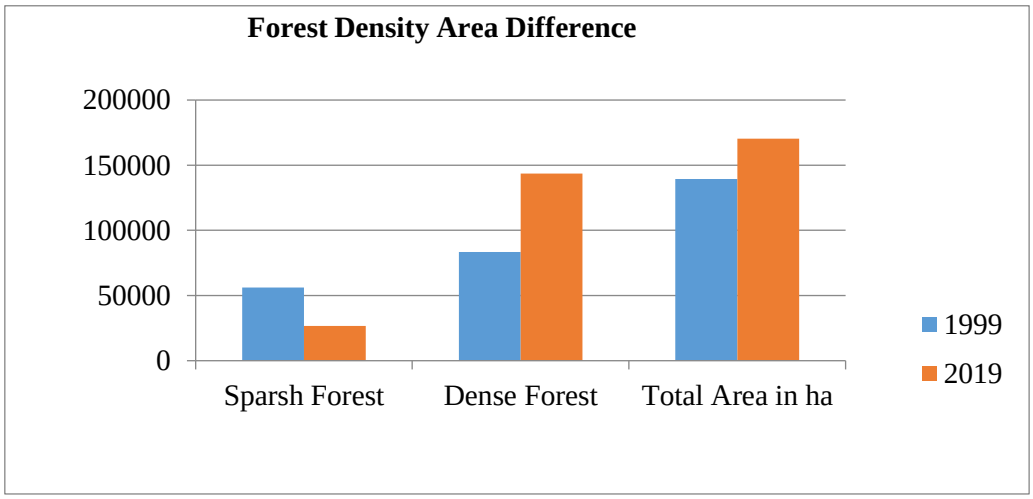
TYPE	CLASS	CATEGORY	AREA in ha
1). Forest Density 6 Dec 1999	Forest	Sparsh	56108.54
2). Forest Density 6 Dec 1999	Forest	Dense	83413.05
3). Total Forest Density 6 Dec 1999	Forest	Sparsh and Dense	139521.59

Table 5 Forest area covered 1999

Total Forest Area Covered 2019:-

TYPE	CLASS	CATEGORY	AREA in ha
1). Forest Density 12 Dec 2019	Forest	Sparsh	26631.38
2). Forest Density 12 Dec 2019	Forest	Dense	143659.50
3). Total Forest Density 12 Dec 2019	Forest	Sparsh and Dense	170290.88

Table 6 Forest area covered 2019



Graph 1: Forest Density Area Difference Comparison

Water body Area covered:

By comparing both the satellite images of the year 1999 and 2019 we observed that there is a increase in the year 2019 area of the water bodies like the rivers, ponds, reservoirs due to increase in the human population and also due to construction of dams and step wells in the Gir forest compared to the year 1999. Hence by area calculation of the water body we can easily detect the change in the area of the total forest. Hence water body is a major factor affecting the forest density of the Gir sanctuary and national park.

Total Water body Area Covered 1999:-

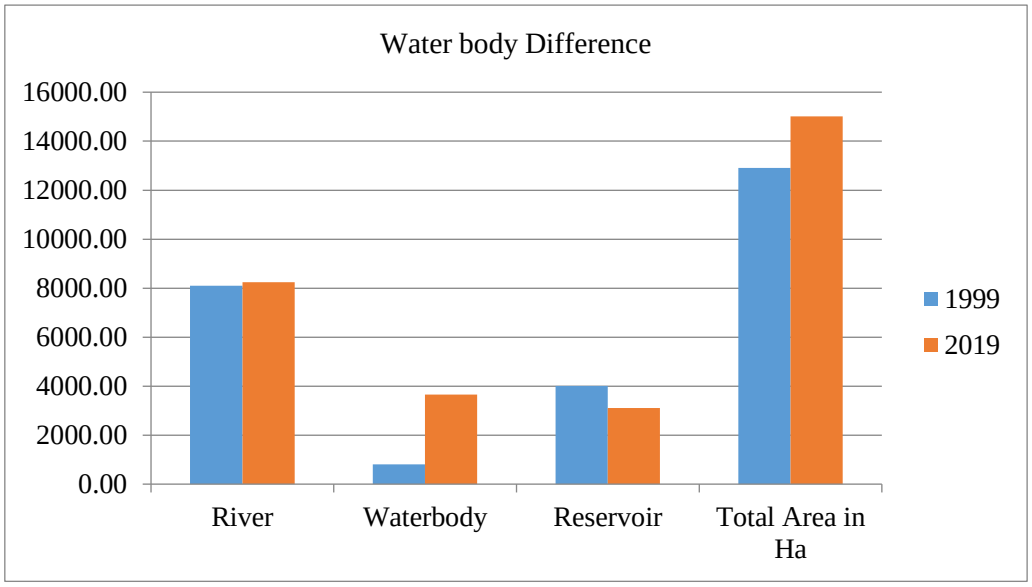
TYPE	CLASS	CATEGORY	AREA in Ha
Water-body December 1999	Water-body	River	8097.94
Water-body December 1999	Water-body	Reservoir	4003.49
Water-body December 1999	Water-body	Water-body	800.97
Total Water bodies area covered 1999	Water-body	River. Reservoir, Water-body	12902.40

Table 7 Water body area covered 1999

Total Water body Area Covered 2019:-

TYPE	CLASS	CATEGORY	AREA in Ha
Water-body December 2019	Water-body	River	8237.86
Water-body December 2019	Water-body	Reservoir	3110.71
Water-body December 2019	Water-body	Water-body	3659.74
Total Water bodies area covered 2019	Water-body	River. Reservoir, Water-body	15008.31

Table 8 Water body area covered 2019



Graph 2: Water body Area Difference

and use and land cover change area detection:

From the area calculation of the water body and the forest density we can clearly examine that the change area in the land use and land cover of the Gir wildlife sanctuary and national park had increased in 2019

with compared to the year 1999. Here we have taken the various classes and sub categories to calculate the total area of the study area. Agriculture, forest, water-body, built-up and wasteland these are the classes that we have detect the change in the area calculation of the Gir forest. There are various factors that affect the change in the area of the forest like transport, canals and dams. Agriculture, human population, settlements etc

Land-use and Land-cover Area Change Detection 1999:-

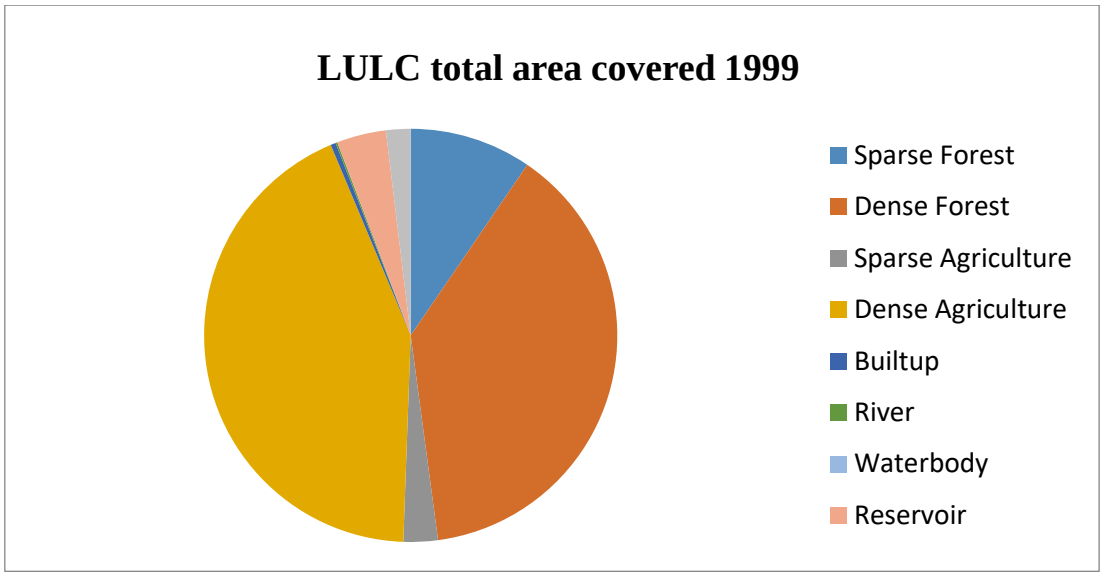
TYPE	CLASS	CATEGORY	AREA in Ha
LULC - 1999	Forest	Dense	8776.68
LULC - 1999	Forest	Sparsh	2185.42
LULC - 1999	Agriculture	Dense	9867.32
LULC - 1999	Agriculture	Sparsh	615.14
LULC - 1999	Water-body	River	32.56
LULC - 1999	Water-body	Water-body	0.73
LULC - 1999	Water-body	Reservoir	882.53
LULC - 1999	Built-up	Built-up	91.77
LULC - 1999	Wasteland	Wasteland	440.91
LULC – 1999 Total Area Covered	LULC – 1999 Total Area Covered	LULC – 1999 Total Area Covered	22893.06

Table 9: LULC area detection 1999

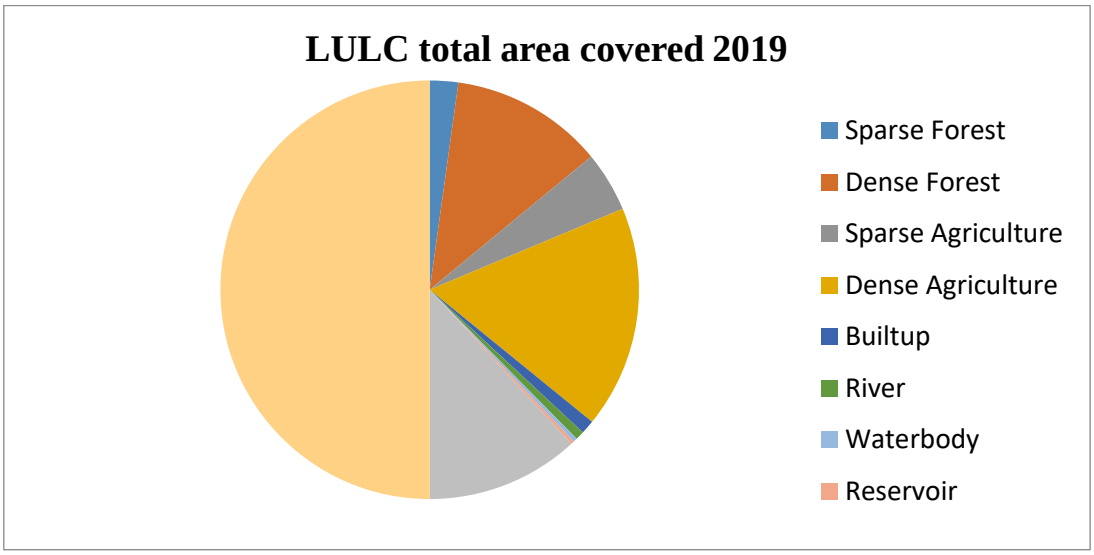
Land-use and Land-cover Area Change Detection 2019:-

TYPE	CLASS	CATEGORY	AREA in Ha
LULC – 2019	Forest	Dense	143659.50
LULC – 2019	Forest	Sparsh	26631.38
LULC - 2019	Agriculture	Dense	208728.85
LULC - 2019	Agriculture	Sparsh	56449.74
LULC - 2019	Water-body	River	8237.86
LULC - 2019	Water-body	Water-body	3659.74
LULC - 2019	Water-body	Reservoir	3110.71
LULC - 2019	Built-up	Built-up	12954.28
LULC - 2019	Wasteland	Wasteland	41176.33
LULC - 2019	LULC – 2019 Total Area Covered	LULC – 2019 Total Area Covered	504608.39

Table 10: LULC area detection 2019



Graph 3 LULC area covered 1999



Graph 4: LULC area covered 2019

Conclusion:

QGIS 2.12 is a Free Open source platform for Remote Sensing and GIS which has a simple yet effective workflow environment. For GPS point collection Field Area Measurement, Google earth and GPS essentials of free version were used provided by GOOGLE, it has good accuracy and contains high resolution image which makes easy to identify the ground objects (Plots) with some handy features are very useful. Classification of different categories based on NDVI value range is a faster, accurate way of classification compared to supervised classification and also results are satisfying. With the help of different tools used in the digitization of the study area by taking the 40km buffer zone can be easily detected the land-use and land-cover change and by comparing the 20 years of gap between 1999-2019. It was easy to observe changes in the forest density and Forest Cover in the Gir National Park and the Wildlife sanctuary using RS and GIS. We have classified the forest in two categories that is the 'Dense' and the 'Sparsh' forest. It was observed during the study while comparing the images of Sentinel-2 (1999) and landsat-5 satellite data (2019) of the study area that the Forest cover since the year 1999 has increased

with an increase in Forest density too. While on the other hand, there is an increase in the human population also. A rise in the number of tourists visiting the area can also be seen. While preparing the maps of road network, it was observed that the road network has also increased inside the forest area in the last two decades.

There is an increase in the number of check-dams and dams which can be held responsible for the recharge of dried-up drainage systems in the study area. We have observed an increase in the water bodies too while preparing LULC map. There is an increase in the human population in the 40 kilometres buffer zone. This human population is mainly dependent on the agriculture and animal husbandry business. An increase in the livestock population may also increase the issue of overgrazing. Plus the conflict of wildlife with the livestock may also harm the wildlife. Hence government must look in the issue of increasing human population near the sanctuary area. The government must also try to control the numbers of tourists visiting the area as tourism is also a threat to the forest area. Effective Forest Management Plan should be made to control the invasion of invasive species so that the invasion dose not happens in the forest area. Participatory Forest Management Practices should be implemented so that the real stake holders are not neglected. Prosopis Juliflora can be a major threat to the Forest cover in the study area as it has already invaded in Gir-Somnath and Amreli District. Hence the government should train the people living around the study area/near-by villages so that the invasion of such species can be stopped. Mining activities can also be seen while studying the satellite data which can also be a possible threat to the Forest cover and Forest density as well. Lack of coordination between Forest department and Mining department may harm the forest area. Effective coordination between the departments is also necessary at policy level. It was observed in the water-body maps of the years 1999 and 2019 that there is an increase in the water bodies in the study area. The dam development activity is positive for human beings but harms the forest cover dramatically. Hence such construction activities should be avoided inside and outside the study area. It was observed during the study that the old tributaries of rivers like Hiran, Macchundri and Sattadhar got rejuvenated. The Kamleshwar dam, which is a new development on River Hiran, has played a very important role in increasing the Forest Cover in the study area as it has also become one of the major source of Fresh water in the area. Hence it is our suggestion to the administration that construction of large dams should be avoided. Instead of large dams small check-dams and recharge wells should be constructed to fulfil the need of fresh water in the study area.The availability of fresh water for irrigation may have increased the agriculture area in the forty kilometres buffer zone. We have observed a steady increase in the agriculture area while preparing LULC map of the buffer zone. It was also observed during the study that the fellow land has decreased in the region which also suggests that availability of irrigation water has increased the agriculture in the area. The Government can think about giving alternative employment to the people living in the buffer zone so that they don't indulge themselves in the illegal cutting of forest for wood or harming the forest resources for money in the future.

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Ethical statement

The authors declare that they have conducted all the ethical practice in relation to development, writing, and development of the article.

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Authors' contributions

1. Ruchita Mainani: Data collection and processing, field data collection, methodology implementation, Draft manuscript preparation.
2. Dr. Rohan thakker: Drafting the data and preparation of manuscript.
3. Dr. M H Kalubarme: Guidance for data analysis, Supervising progress of the work, Manuscript finalization.
4. Dr. Hitesh Solanki: Guidance, supervision and reviewing the progress of data analysis and Manuscript finalization.

Data availability: The data is retrieved from the open foris software that is freely available software for the forest monitoring.

Declaration of competing interest:

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript.

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