



M G SCIENCE INSTITUTE

# GEOLOGY

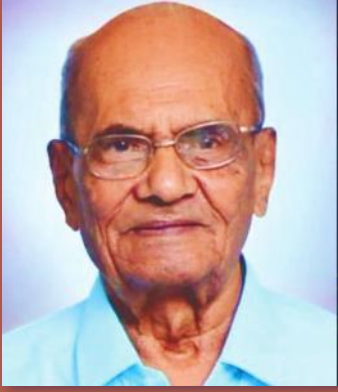
# NEWSLETTER

**GEOLOGY DEPARTMENT**  
**M. G. SCIENCE INSTITUTE**



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**THE AHMEDABAD EDUCATION SOCIETY**





Dedicated this issue to....

**Late Prof. Girishkumar B. Pandya**

(21-12-1933 – 28-04-2021)

Retd. HOD Geology Department

## HISTORY OF DEPARTMENT



*First Geology Department of Gujarat. Establishment of Undergraduate Department – in the year of 1948 by Prof. S. Mukharjee. Geology department was affiliated to Bombay University till 1949. Establishment of Postgraduate Department in 1950-51.*

## VISION

*The Department of Geology strives to foster an environment in which students learn to think, conduct research, apply knowledge in order to prepare/turnout well-trained, competent, academic and professional geoscientists capable of responding societal needs*

## MISSION

*Prepare students for professional positions in industry and government and for careers in academic research and teaching. We try to make students to understand and safely manage Earth and its resources for the future. Establish the Department of Geology as the center for research in Earth Sciences and nationally recognized. Develop a greater awareness of Earth Sciences in the general public through outreach programs.*

# Explore

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# Faculty and Staff



**Dr. N. Y. Bhatt**

HOD/Associate Professor



**Dr. P. M. Solanki**

Associate Professor



**Dr. H. V. Majethiya**

Associate Professor



**Dr. Rahul Gayakvad**

Senior Research Fellow



**Pooja Mishra**

Project Fellow



**Purvesh Muniya**

Laboratory Assistant



**Jagdish Makwana**

Peon

1. **Dr. N. Y. Bhatt, Dr. P. M. Solanki and Dr. H. V. Majethiya** becomes the member of the “Interview Panel – Committee” at “R. R. Mehta College of Science, Palanpur” for the appointment of the post of Assistant Professor for the B. Sc. course on 3<sup>rd</sup> December, 2021.
2. **Dr. N. Y. Bhatt and Dr. P. M. Solanki** of the Geology department received a research project on “Source-to-Sink spatio-temporal variability in sediment fluxes and their control on coastal sediment dispersal systems in Gujarat”, sponsored by Ministry of Earth Sciences (MoES), New Delhi, worth Rs. 21,18,360/- for the period of three years (2019-20 to 2021-2022). Mr. Rahul G. Gayakvad has been selected as a SRF in the project.
3. **Dr. N. Y. Bhatt** of the Geology department received a research project on “Spatial and Temporal Variations in Polar Land Ice Surface Morphology, Melting and Energy Balance Components”, sponsored by SAC-ISRO, Ahmedabad. Project started in January 2021 and Ms. Pooja Mishra has been selected as a JRF in the project.
4. **Dr. H. V. Majethiya** has delivered lecture on the theme ‘The Ocean, Our Climate and Weather’ on World Meteorological Day, a scientific talk organized by Gujarat Council of Science City at Science City, Ahmedabad on 23<sup>rd</sup> March, 2022.

1. Solanki, Tarun, Prizomwala, S. P., Makwana, Nisarg and **Solanki, P. M.** (2021) Assessing the climatically triggered aggradation-incision processes in a dryland environment during the Late Quaternary period from Shetrunji River basin (Saurashtra), India. *Quaternary International*, 585, 70-84.
2. Chauhan, H. Y., Gayakvad, R. G., Shah, P. P., Purohit, A. N., Jhala, M. D. and **Solanki, P. M.** (2021) Occurrences of the Trace Fossils of Paleogene-Neogene age from Naredi and surrounding area of Western Kachchh, Gujarat, India. *Aegaeum*, 9(1), 332-342.
3. Purohit, Arpita N., Patel, Shreekumari M., Thaker, Ashka D. and **Solanki, P. M.** (2021) Compositional and morphological analysis of Gassendi crater. *Journal of Earth System Science*, 130 57.
4. Majethiya, **Heman V.**, Morya, Jyoti and Shah, Aagam (2021) Coastal geomorphological study from Kavi to Dahej coastline, Gulf of Khambhat, Gujarat using remote sensing and GIS. *GIS SCIENCE JOURNAL*, 8(9), 1151-1156.
5. Morya, J. S., Shah, A. K. and **Majethiya, H. V.** (2021) Geomorphology of Ghogha to Dholera Coast, Gulf of Khambhat, western India: A Remote Sensing and GIS Approach. *Science Technology and Development*, 9(10), 80-84.
6. Shah, A. K., Morya, J. S. and **Majethiya, H. V.** (2021) Application of Land-Use Land-Cover Map for Sand Replenishment Study: A case study of Orsang River, Gujarat. *Infokara*, 10(9), 18-25.

7. Shah, A. K., Morya, J. S. and **Majethiya, H. V.** (2021) Morphometric Analysis of Kaswali River Basin, Kachchh, Gujarat, western India using Remote sensing and GIS. *Science Technology and Development*, 10(10), 1-5.
8. Sabhaya, Mehula B., Patel, Rinku A. and **Solanki, Paras M.** (2021) Palaeoichnology of Jurassic sequence of Jara Dome, Kachchh, western India. *Science, Technology and Development*, X(V), 41-50.
9. Gayakvad, Rahul G. and **Solanki, Paras M.** (2021) Ichnotaxonomy of the sediments of Middle-Upper Jurassic age of the Keera Dome, Kachchh, Western India. *Science, Technology and Development*, X(IX), 34-43.
10. Gayakvad, R. G. and **Solanki, P. M.** (2022) Palaeoenvironmental interpretation based on lithofacies derived from Keera Dome, Kachchh, western India. *Journal of Scientific Research*, 66(1), 11-21.

# Compositional and geologic insights from Vavilov crater

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## 1. Introduction:

One of most fundamental of all processes that have occurred on the terrestrial planets is the impact of solid bodies on their surface (Shoemaker, 1977). This forms a depression called impact crater which are generated by the hypervelocity impact of a smaller body on the surface of a planet, moon, or other solid body in the Solar System or elsewhere. Craters are useful features to determine age of a planetary surface and even the nature of its interior. Study of such impact crater mechanics also is important to understand the mineral variation within a planetary body, its geological evolution as well as the morphological features produced due to impact cratering provide aid the study of the behavior of the terrestrial planetary crust. Based on the structural and morphological characters, impact craters have been classified into two main types, (a) simple and (b) complex.

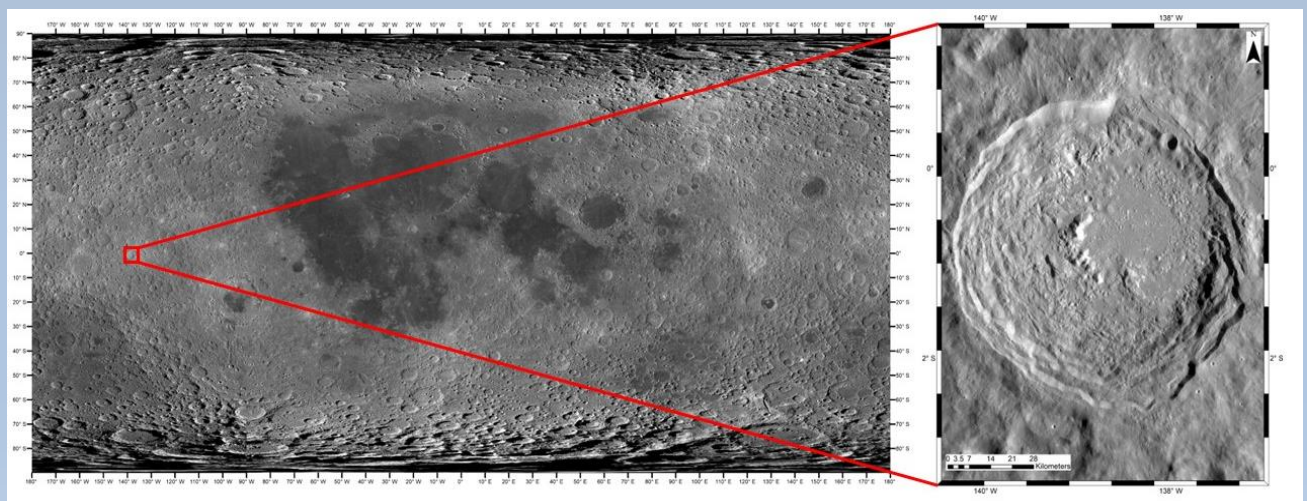


Figure 1. Location of Vavilov crater highlighted with the red coloured box on LROC WAC global map (Source: NASA/GSFC/ASU; Projection: Simple Cylindrical, inset projection: stereographic).

## **2. Study Area:**

Vavilov (0.8°S, 137.7°E) is a prominent impact crater with the average diameter of 99 kilometres (Anderson and Whitaker, 1982). It is located on the highland area of the lunar far side and hence, cannot be viewed directly from the Earth. The crater has reached optical maturity (Mahanti et al., 2016). Vavilov crater has well-defined features that has undergone a minimum of erosion due to subsequent impacts.

## **3. Data Acquisition:**

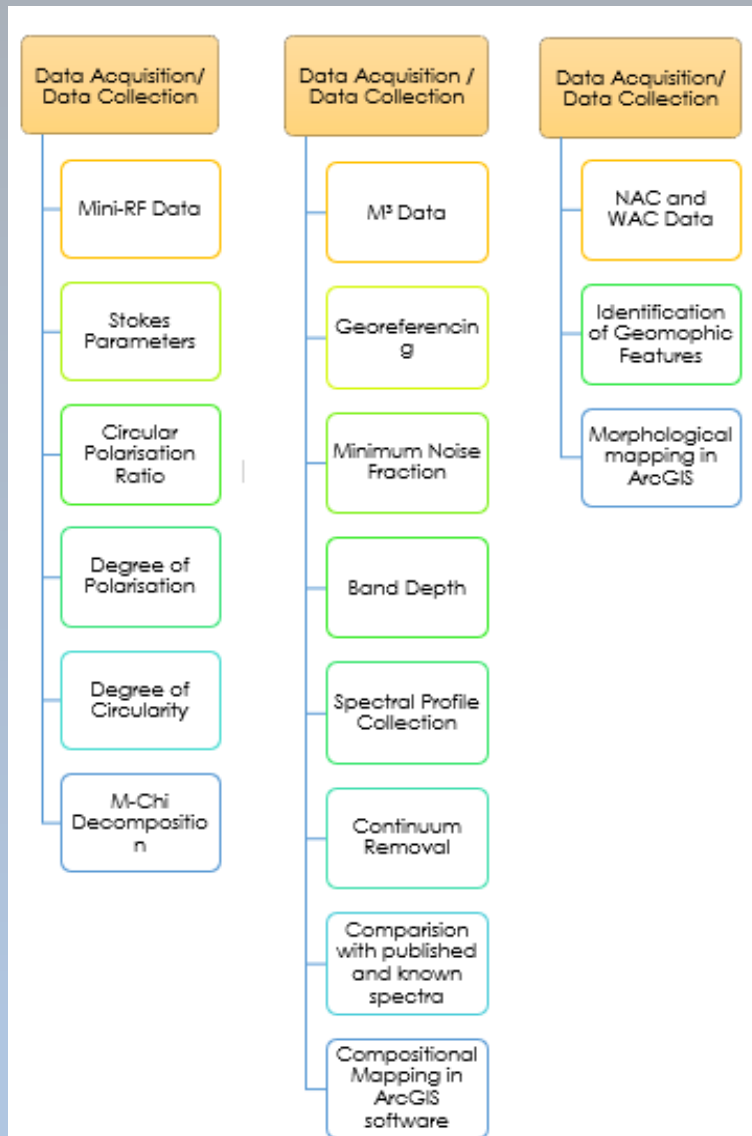
In this study three different types of data have been used to analyse the crater. The compositional analysis has been carried out from the Moon Mineralogy Mapper (M<sup>3</sup>) Data onboard ISRO's Chandrayaan – 1. The morphometric and morphological study was done from the two instruments, Wide-Angle Camera (WAC) and Narrow-Angle Camera (NAC) onboard the NASA's Lunar Reconnaissance Orbiter (LRO). The surface and sub-surface roughness along with the ejecta have been studied from Miniature Radio Frequency (Mini-RF) which also onboard the Lunar Reconnaissance Orbiter. For topographical studies, LRO LOLA – SELENE Kaguya TC DEM merge was utilised.

## **4. Methodology:**

### *4.1 Cumulative Size Frequency Distribution (CSFD):*

The surface area of the target unit and the diameter of each crater inside the target unit are calculated using the cumulative size-frequency distribution method (CSFD) (Thesniya et al., 2020). To determine the age of the melt pool in the Vavilov crater, the Crater Tools extension for ArcGIS (Kneissl and Michael, 2013) was used, with craters with diameters greater than 8 m being evaluated. The CSFD curves are constructed from the obtained diameters of primary craters, known as crater count data, and the crater model ages are derived using the crater stats tool (Michael and Neukum, 2010). Since there are contradictory claims about the age of the

crater, CSFD of the melt pools of the continuous ejecta blanket was necessary to determine whether the crater is Copernican or Eratosthenian in age. The model age of the crater is found to be  $1.7 \pm 0.1$  Ga which is in harmony with the study by Kirchoff et al. (2013).



Flow chart of Methodology.

## 5. Results and discussion:

### 5.1 Compositional Analysis:

The spectral graphs are used to perform the compositional analysis since each mineral has its own set of absorption bands (Pieters et al., 2009).

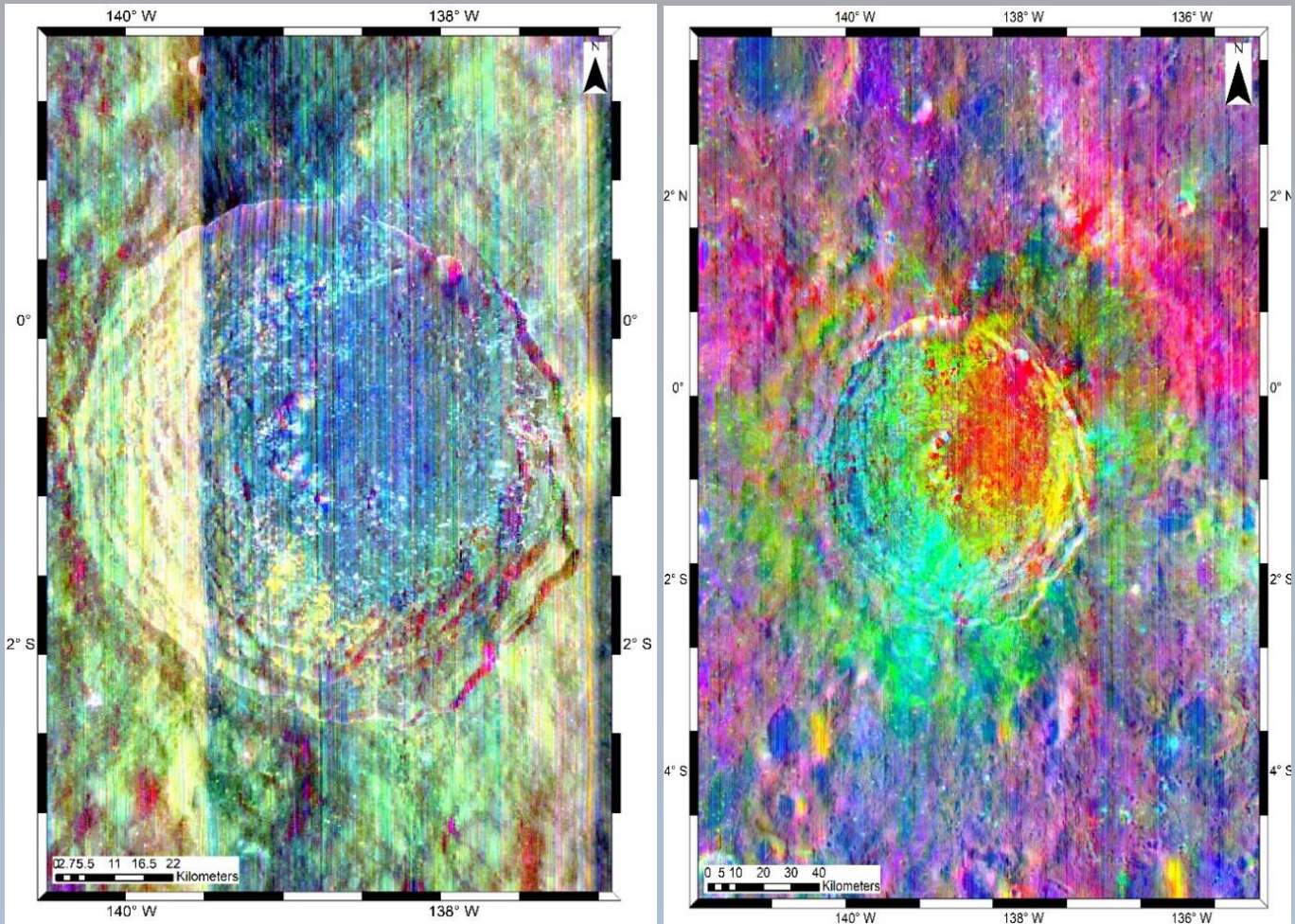


Figure 2. (Left) Band parameter map with R: 1900nm, G: 2300nm and B: 1250nm prepared from the M<sup>3</sup> data. (Right) Minimum Noise Fraction image with R: Band 5, G: Band 7 and B: Band 8 (Projection: Stereographic).

Figure 3. (A) M<sup>3</sup> FCC (R: 930 nm, G: 1249 nm and B: 2018 nm) showing reflectance spectra locations 1-Plagioclase, 2-Mg Spinel, 3-HCP, 4-Plagioclase+Pyroxene, 5-Olivine+Pyroxene, 6-LCP. (Projection: Stereographic), (B) Reflectance spectra and (C) Continuum Removed spectra.

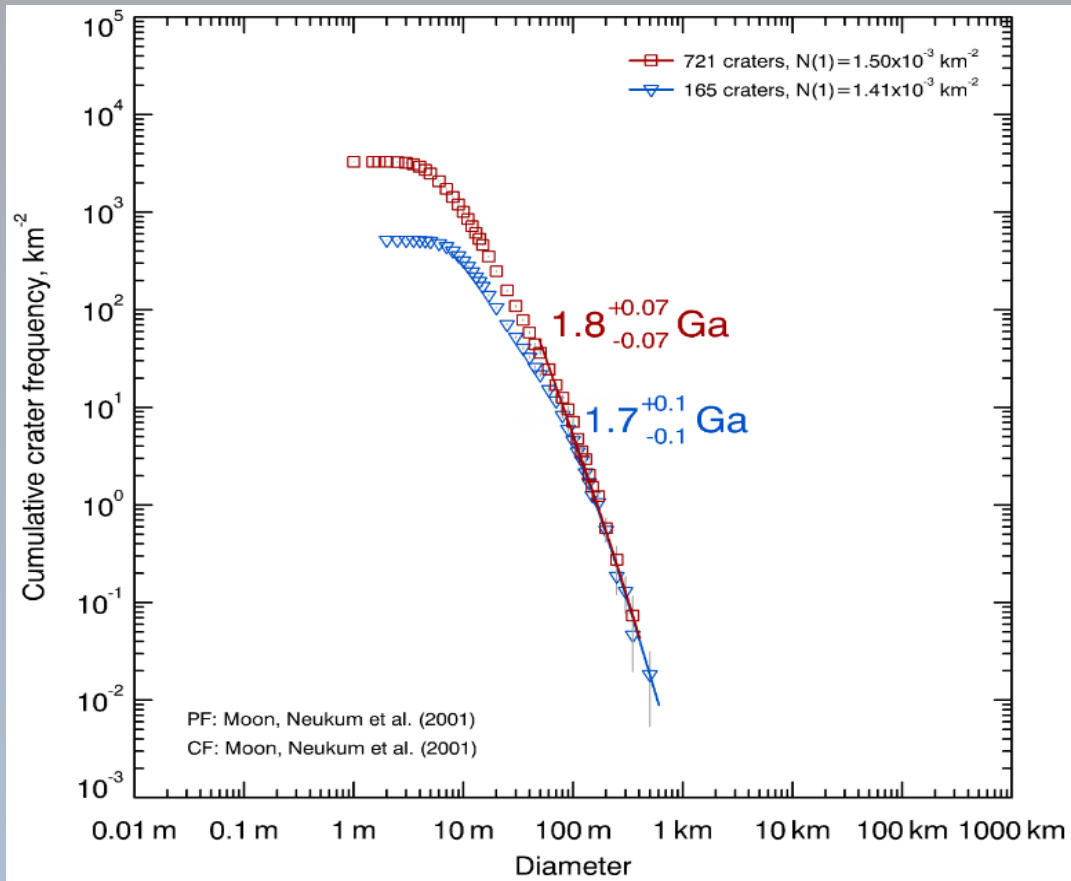
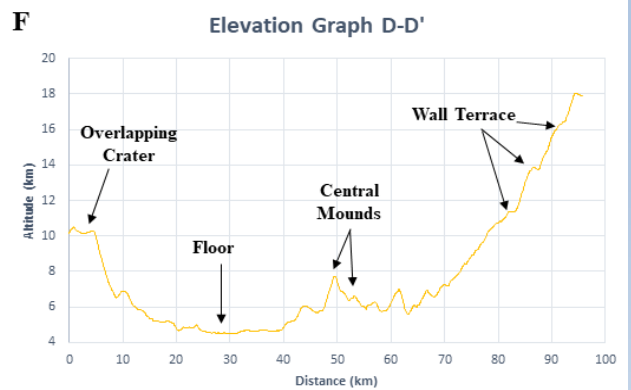
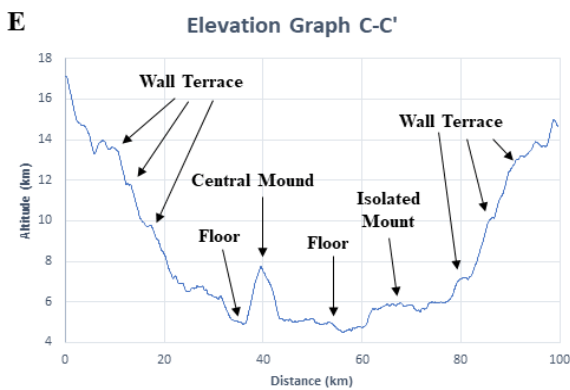
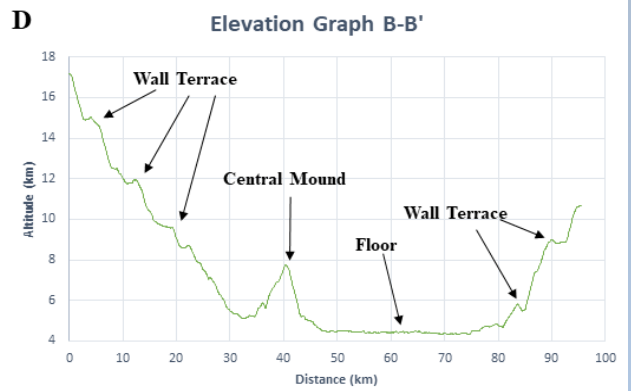
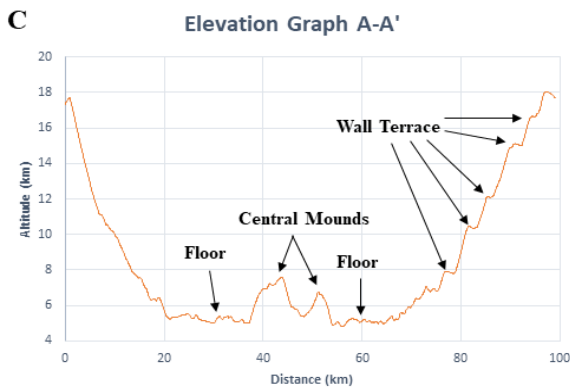
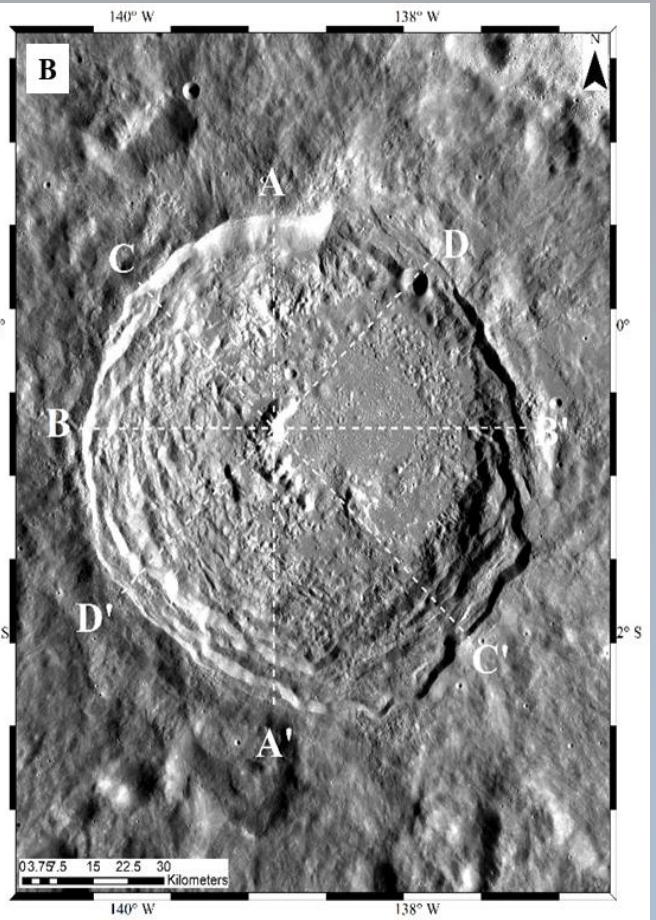
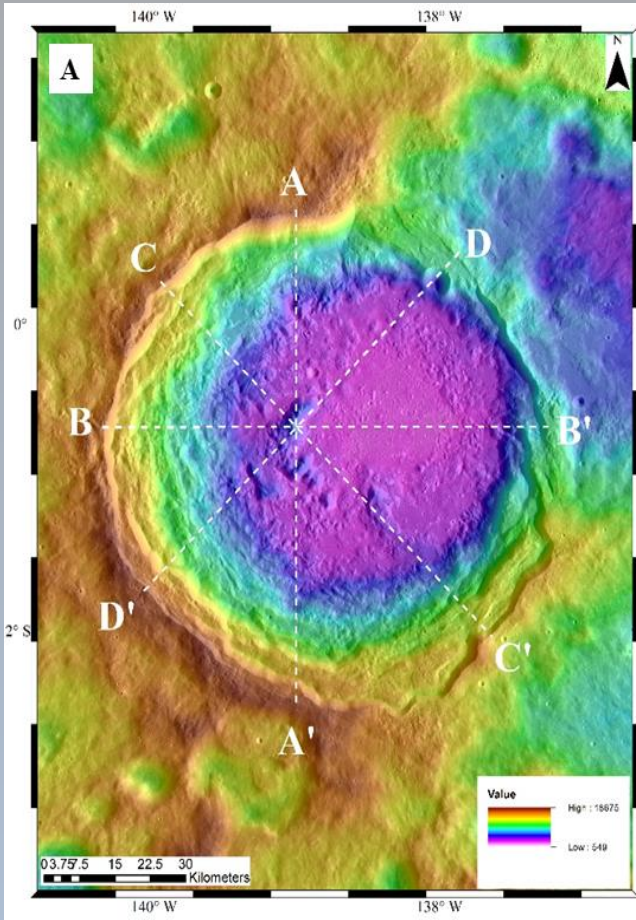


Figure 4: The crater model age is determined using the crater stats tool, and the cumulative size-frequency distribution (CSFD) curve is generated by mapping the principal craters in the two melt pond zones.

## 5.2 Morphological Analysis:

Various morphological features have been found from this crater, a detailed explanation of each feature can be found from Hargitai and Kereszturi,(2015).

Figure 5. (A) Kaguya-LOLA DEM image overlaid on the WAC image featuring four topographic sections A-A', B-B', C-C' and D-D' (Projection: Stereographic), (B) WAC image featuring four topographic sections A-A', B-B', C-C' and D-D' (Projection: Stereographic) and C-F shows the elevations graphs.



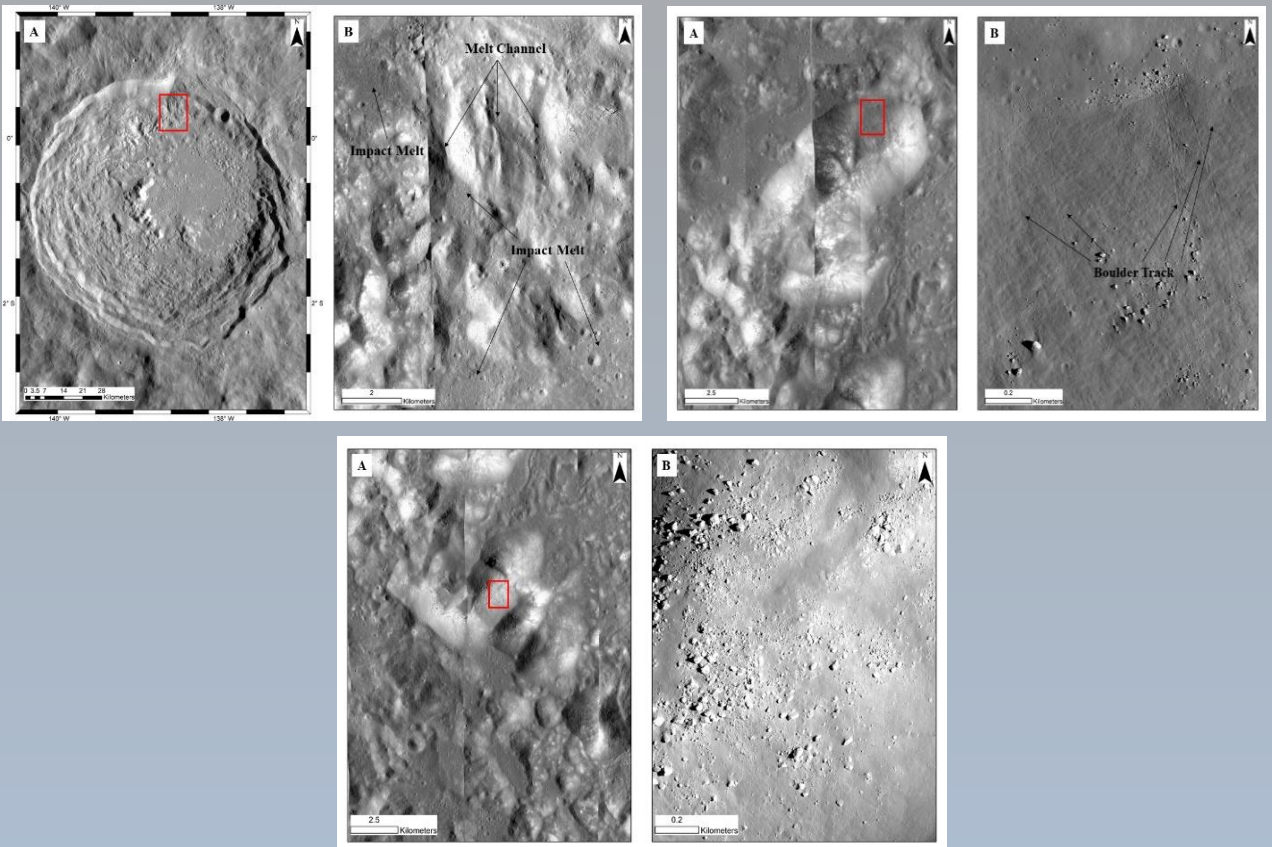


Figure 6. NAC Images of Melt channel, boulder tracks and boulder fields.

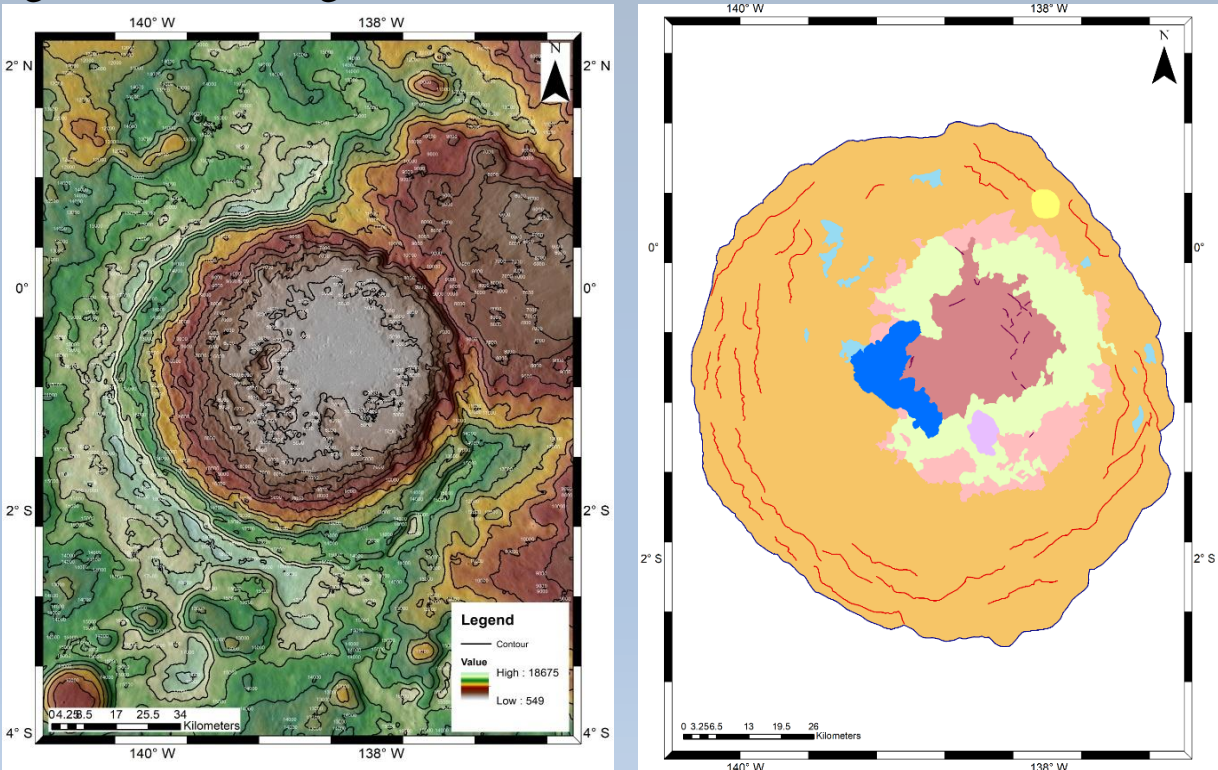


Figure 7. (Left) Contour Map of Vavilov with the contour interval of 1000 m prepared from LOLA-Kayuga DEM. (Right) Morphological map of Vavilov crater.

### 5.3 Radar Analysis:

From the SAR data, ejecta blanket of Vavilov crater can be easily seen, which is not observable from optical data. Single-bounce backscattering occurs on relatively smooth lunar surfaces, indicating low CPR values of around  $<0.4$ , whereas double-bounce backscattering occurs on slightly rougher lunar surfaces, indicating high CPR values of 1 and above (Carter et al., 2012). The material excavated from a crater cavity upon impact is known as impact ejecta, when ejecta velocity is less than escape velocity forms a deposit, or layer, of debris around the crater cavity (Barlow et al., 2015). Continuous ejecta blanket and dis-continuous ejecta were observed. The continuous ejecta blanket has an asymmetrical distribution. Continuous ejecta blanket can roughly reach up to one crater radius from the rim and is largely made up of fragmented target materials, on the other hand, discontinuous ejecta can cover thousands of crater radii and is patchy and thin (Melosh, 1989).

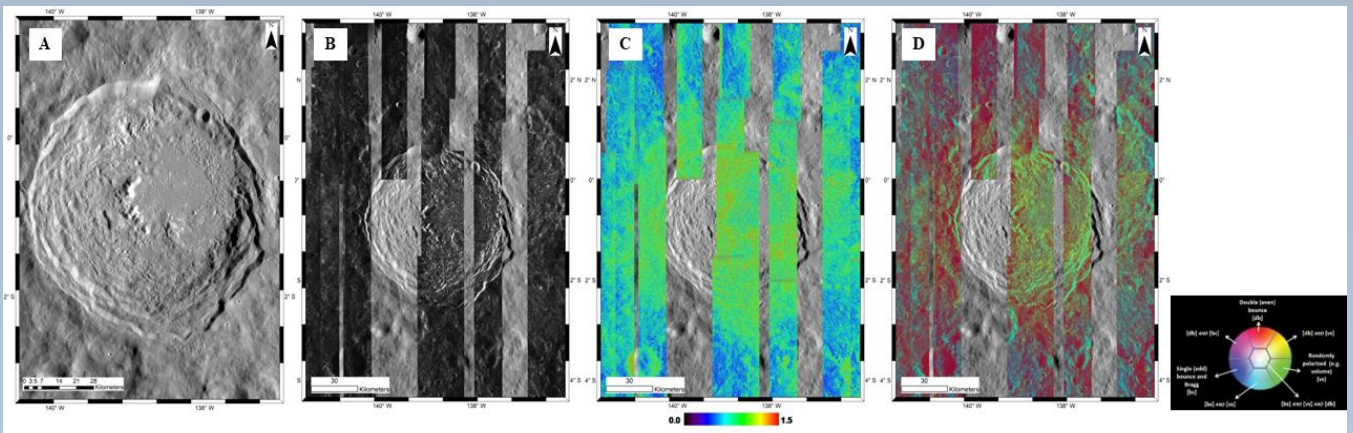


Figure 8. (A) WAC image of Vavilov crater, (B) Total power radar backscatter ( $S_1$ ) overlain on WAC image, (C) Colour-stretched CPR image overlain on WAC image and (D) m-chi decomposition overlaid on WAC image. Each m-chi scattering (red: double bounce (db); blue: single bounce (bs); green: volume scattering (vs)) and combinations of these scatterings are highlighted on the colour wheel.

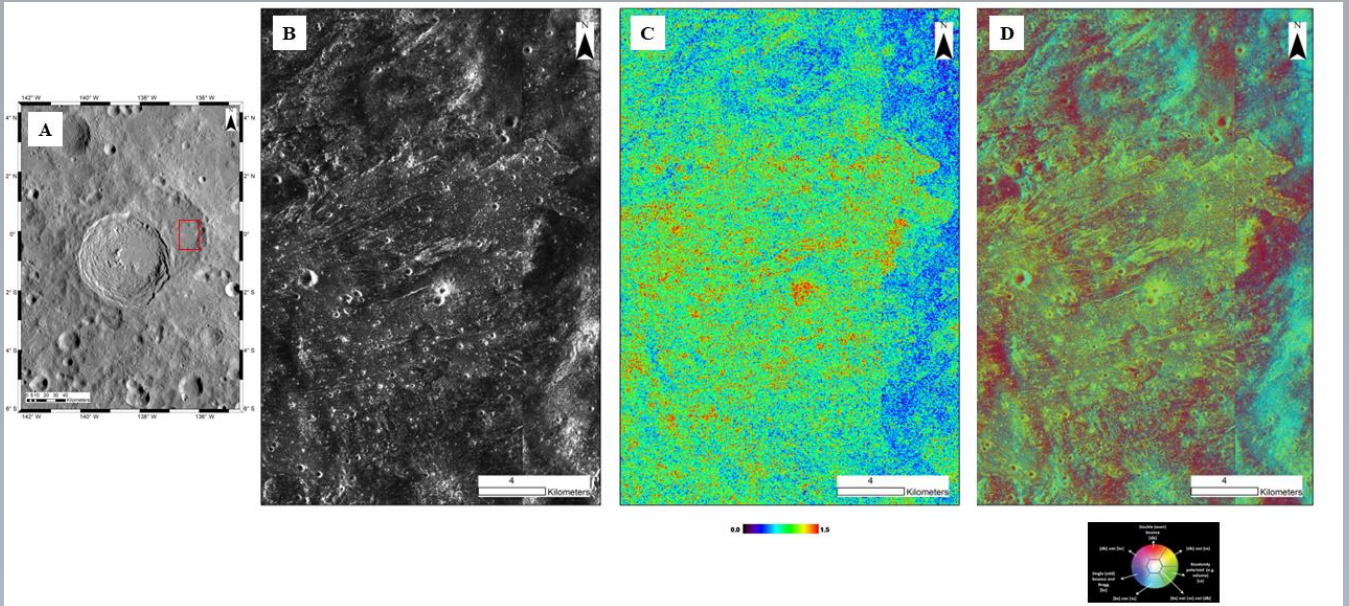


Figure 9. (A) WAC image of Vavilov crater with highlighted box showing impact melt, (B) Total power backscatter ( $S_1$ ), (C) Colour-stretched Circular polarization ratio (CPR) and (D) m-chi decomposition image.

### **Acknowledgement:**

We would like to thank the M<sup>3</sup> and LROC teams for making high-resolution data available in the public domain and making it available through the PDS Geoscience Node.

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# **Mineral Resources of Kachchh district, Gujarat**

Janki P. Chaudhari

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## **1. Introduction:**

The geological diversity of Gujarat presents classical sequences of Mesozoic, Cenozoic sediments along with the Deccan Trap basalts and Precambrian metamorphics. The Gujarat state covers an area of approximately 1,96,000 sq km and is enclosed within 20° to 24° North latitude and 68° to 74° East latitude. The multidisciplinary and multi-faceted studies by different researches have provided a better understanding of the geological, geomorphological and structural evolution of the area.

Based on the physiographic expressions, the state of Gujarat can be divided into three broad divisions (Merh, 1995), viz.

1. Mainland Gujarat
2. Saurashtra-Kathiawar Peninsula
3. Kachchh

Each division exhibits distinct geological features and evolutionary trends as well as is marked by its own characteristic coastline.

Kachchh district, located at the western extreme of India, lies between 22° and 24° N latitudes and between 68° and 71° E longitudes. It is the largest district in the India, and has an area of 45,612 sq km. The district is flanked on the south by the Arabian Sea. In the north and the east it is flanked by two vast saline marshes, the Great Rann of Kachchh (~15127 sq km), and the Little sq km), with few small rocky islands in between (~83 sq km). In the west lies aRann (~4000 vast unfinished delta with tidal creeks and thickets of mangrove (1285 sq km).

Between the Great Rann and the hilly central part lies a vast featureless saline plain with patches of halophytic grasses, which is called the Banni (~2525 sq km). Most of the human habitations in Kachchh district lie especially in the central part of the district, along an elongated tract with rugged hilly terrain and flanked by shallow plains, which is called the 'Kachchh Mainland'. The shape and the broad topographic configuration of Kachchh Mainland resemble that of a tortoise shell, which is possibly why the name 'Kachchh' (a Sanskrit word for tortoise) was given to this land. The district has an arid climate. The structural styles, the lithological make-up and the tectonic events have played crucial roles in the geomorphological evolution of the district, as well as in shaping its present landforms.

## **2. Physiography and Geomorphology of Kachchh**

Taking into consideration the factors of altitude, slope and ruggedness of relief, Kachchh can be divided into the following four major E-W trending zones of physiographic units from north to south: (1) the Rann, (2) the low-lying Banni Plain, (3) the Hilly Region, and (4) the Southern Coastal Plain.

## **3. Stratigraphy of Kachchh**

The stratigraphic succession, ranging in age from Middle Jurassic to Holocene, is exposed in the highlands of the Kachchh Basin.

### **3.1 Mesozoic Stratigraphy:**

The Mesozoic rocks of Kachchh were first mapped by Wynne (1872). Waagen (1875) proposed the popular four-fold subdivisions, namely, the Pachham, the Chari, the Katrol and the Umia Series. Biswas (1977) recognized three main lithologic provinces within the basin. He classified the rocks of each province separately and named the units according to their strato-types (Biswas, 1977). The litho-stratigraphic sequence of the mainland is divided into four Formations, named as the Jhurio (Jhura), Jumara, Jhuran and Bhuj Formation (Biswas, 1977, 1981).

strato-types (Biswas, 1977). The litho-stratigraphic sequence of the mainland is divided into four Formations, named as the Jhurio (Jhura), Jumara, Jhuran and Bhuj Formation (Biswas, 1977, 1981).

### 3.2 Tertiary Stratigraphy:

Biswas (1974) proposed a revised stratigraphy and established that the Tertiary sediments in Kachchh were deposited on the eroded surface of the Deccan Trap and the Mesozoic sedimentaries. Deposition started with a marine transgression during Lower Eocene and ended in Pliocene. During Paleogene, deposition was restricted to the western part of the Kachchh Mainland, the thickest parts being exposed in the southwestern coastal plain which was the deepest part of the basin. Most of the minerals are deposited in Tertiary age. The following Table 1 shows brief summary of the Tertiary Formations as described by Biswas (1974).

Table 1: Tertiary stratigraphic divisions of Kachchh.

AGE	FORMATION	LITHOLOGY
Middle Miocene-Pliocene	SANDHAN —Unconformity—	Sandstones, minor limestones and shales
Early Miocene (Burdigalian)	CHHASRA	Silty shales and impure limestones
Early Miocene (Aquitainian)	KHARINADI —Unconformity—	Variegated siltstones and sandstones
Oligocene (Rupelian-Chattian)	MANIYARA FORT —Unconformity—	Foraminiferal limestones, shales, coral bioherms and lumpy claystones
Middle to early L. Eocene (Lutetian-Bartonian)	FULRA	Dense foraminiferal limestones.
Early Middle Eocene (Lutetian)	HARUDI —Unconformity —	Claystones/limestones, coquina, etc.
L. Paleocene to E. Eocene (Thanetian-Ypresian)	NAREDI —Unconformity —	Claystones, limestones and gypseous shales
Early Paleocene (Thanetian)	MATANOMADH —Unconformity—	Volcanoclastics, shales and sandstones
(Maastrichtian-Danian)	DECCAN TRAP	Basalt



Figure 1. Mineral map of Gujarat.

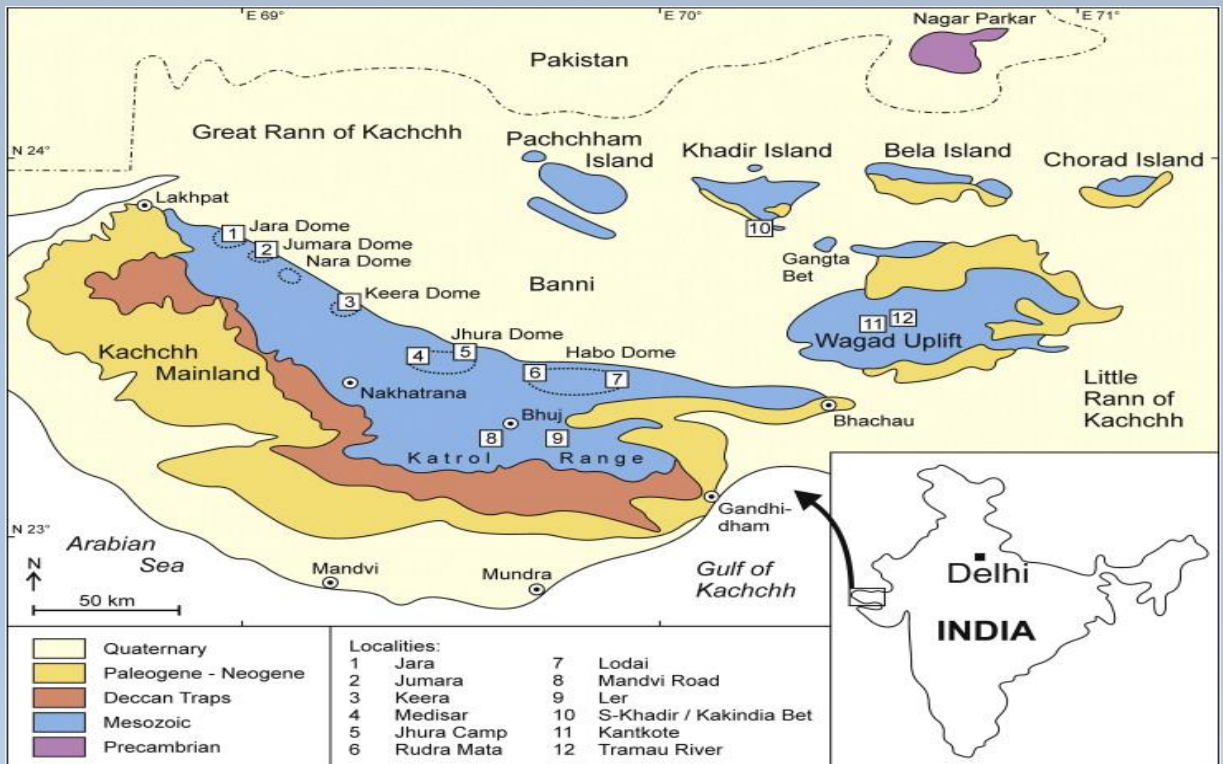


Figure 2. Geological map of Kachchh.

#### **4. Mineral resources of Kachchh**

Many different types of minerals are found in Gujarat as shown in Fig.1 and particular in Kachchh district minerals like agate, bauxite, gypsum, sandstone, bentonite, china clay, silica sand, lignite, limestone , Semi-precious stone- agate is also known as Gomed. Rock crystals- Amythyst or Neelmani and other precious stones are also found in different parts of Kachchh & their stratigraphic division shown in Fig.2 .Minerals are controlled by Gujarat Mineral Development Corporation (GMDC) as well private miners.

- **Bauxite** is a metallic mineral. A big size Aluminium plant could be established in the section for production of Bauxite. Bauxite contains 50% aluminium oxide. It is mostly found in Mandvi and Abdasa talukas. It is used for many catalytic substance applying and for producing a number of aluminous chemicals like aluminium sulphate, alum and alumina. Kachchh and Mevasa Bauxite Mines, Dist. Devbhoomi Dwarka from last four decades produces bauxite. Plant Grade Bauxite is consumed for manufacturing of refractories, abrasives, monolithic binder, and specialized alumina cement.
- **Bentonite** is also known as 'Weathered Basalt'. Bentonite has a very good quality of export market. Bentonite has brought Kachchh on the world mineral map. Sodium based Bentonite is used in steel plant, oil investigation, medicines etc. Bentonite is found in almost green or brown colours, but sometimes it is also found in red colour. Bentonite is available in Bhachau, Rapar, Anjar, Bhuj, Mandvi, Abdasa, Mundra, Nakhatrana and Lakhpat talukas. Bentonite is also used for workshop, sand bond, polarization of iron solid, drilling dirt, activated bleaching soil, civil engineering, refectories, ceramics, pharmaceutical aid, welding, electrode, fillers, insecticides etc. Bentonite is controlled by the department of Geology and Mining. Two types of Bentonite are seen in Kachchh: Sodium Predominant and Calcium Predominant.

- **China Clay** is also called Kaoline. It is mostly used in potteries and ceramics. It is found in Bhuj, Lakhpat and Rapar talukas. It is also used in paper, paint and pharmaceutical industries. Department of Geology and Mining controls production of Kaoline. It is soft white clay that is an essential ingredient in the manufacture of china and porcelain and is widely used in the making of paper, rubber, paint, and many other products.
- Two types of **Gypsum** are normally found in Kachchh: Marine Gypsum and Pan Gypsum. Gypsum is usually found in Adesar and in other parts. Gypsum is used as Plaster of Paris, manufacturing of paints, crayons and paper etc. It is also used as natural fertilizer, surgical plaster, dental plaster, cement etc.
- **Lignite** is also known as 'Brown Coal' or 'Tertiary Coal'. Lignite is produced 95% in Kachchh except the other minerals of Kachchh. All other minerals are produced only 5%. It is found in brown colour. Mostly, it is found in Nakhatrana, Lakhpat and Mandvi talukas. Lignite is used as a raw material for set up of power plant, for exploration of fuel and for power production. Lignite is controlled by GMDC. Kachchh Thermal Plant of 140 MW capacity at Panandhro is based on the Lignite deposits.
- **Limestone** is found all over Kachchh, especially in Lakhpat and Abdasa talukas. Limestone is used for manufacturing cement, as a building stone, as a flux in the metallurgy industry, for manufacturing Calcium Carbide and Calcium Cyanide etc. Limestone is also controlled by the department of Mining.
- **Sandstone** is normally found in Dahinsara, Naranpur, Palara, Shedada, Mathal Meghpur, Moti Wandh, Ravapur, Kotada-Roha, Manghwena, Mamura and in other places of Kachchh. Sandstone is used as a building raw material and it is controlled by the local panchayat of Kachchh. Sandstone can easily be cut into blocks and it is available in white, light purple, reddish brown and cream yellow.

- High grade **Silica sand** and **glass Silica** sand are found in Anjar taluka. Silica is the mineral of 21<sup>st</sup> century. Normally, Silica is found in Nadapa and Mamuara village in Bhuj taluka, Sapeda and Nagalpar in Anjar taluka, in Bhachau taluka and in Lakhpat taluka. Silica is used in glass industries and for manufacturing of Sodium Silicate.
- **Ochre, Petroleum** and **Laterite** are the other minerals found in Kachchh. Ochre is generally known as 'Gheru'. It is found in red, white or yellow colours. Survey indicates availability of petroleum reserves in Abdasa taluka. Low grade Bauxite containing more iron is called Laterite and it is used for cement manufacturing.

Kachchh is a wonderful land and so has it is special place among the places of Geotourist attractions in the world.

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# **Determination of hydrological and land surface parameters using remote sensing to aid long-term habitat management in Girnar wildlife sanctuary, Gujarat, India.**

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## **Abstract:**

In late Cretaceous or early Eocene, the Girnar laccolith was intruded into thick basaltic layer which was hauled up in the shape of a Dome. Wildlife habitats are under the significant threat due to rapid development activities. In present times, remote sensing and GIS have been used widely to model the wildlife habitat for evaluation and monitoring. This technique has proven to be an efficient tool for integrating the spatial and non-spatial data required for monitoring of wildlife habitats. This study focusses on modelling the suitable forest cover and assessing the hydrology and land surface features of the Girnar wildlife sanctuary, known for the Asiatic lion and its rich biodiversity. The spatial data from various Earth Observation satellites were acquired, interpreted and analysed using different tools on GIS platform to derive the hydrology, land use-land cover and land surface parameters. As an output of this study, the maps were prepared showing suitable forest cover, drainage pattern with respect to elevations, and the land surface temperature with respect to NDVI were also derived. The LST-NDVI plot shows the inverse correlation between the surface temperature and vegetation. These deliverables will help policy makers in evaluating the lion habitat of Girnar and formulating an effective habitat enhancement and conservation strategies.

**Keywords:** GIS; Greater Gir ecosystem; Hydrology; LST-NDVI relation; habitat management.

## 1. Introduction:

India is a rich country in bioresources as well as having a long history and conservational tradition, since the period when human beings and wildlife co-existed in nature as long as man was not a dominant organism (Chakraborti, 1990; Dharaiya and Dharaiya, 2021). In the present era, wildlife is vanishing rapidly due to growing influence of humans, as a consequence of the pressure of developmental activities and over exploitation of resources which have been the prime causes for the decline of wildlife in almost all the countries (Kushwaha & Roy, 2002; Rao et al., 2000). Resources like food, water, forest cover and corridors are the essential components for any wildlife for their natural growth and dispersal (Dharaiya and Dharaiya, 2021; Kunte, 2008; Western and Gichohi, 1993). Unprecedented and increasing loss of native species and their habitats has been caused by different human activities. Management strategies have focused mainly on single species and protected areas. There is a need to develop some advanced habitat evaluation and management techniques which can help in formulating long term conservation strategies (Prins and Henne, 1998). Wildlife management involves the management of a complete ecosystem (De Wulf et al., 1988). Managements takes place within various influences like, psychological, socio-economic, political and cultural that are broadly referred as human or social values to the environment (Dharaiya and Dharaiya, 2021; Keeney 1992; Riley et al., 2002). Wildlife management requires reliable and consistent information on the abundance, distribution of species and their habitats as well as threats and also focuses on the maintenance of some desired state of the resource base within the reserve, while controlling factors have negatively impacted on which they depend (de Leeuw et al., 2010; Dharaiya and Dharaiya, 2021; Janzen, 1986). Modern civilization, viz., clearing the forests for settlements, agriculture and by setting up large hydroelectric projects and industries has done irremediable damage to the natural system (Kotwal and

Parihar, 1988; Lamprey 1963; Panwar, 1986; Rao et al., 2000). Traditionally, large carnivore species have served as flagship and umbrella species for biodiversity conservation, worldwide. In Asia, lions have been driven almost to extinction, apart the only surviving free-ranging population of Asiatic lion (*Panthera leo persica*) is in and around the Gir forests of Gujarat, India (Divyabhanusinh, 2005). From 1920 to present date, the current population has increased from 20 to 674 (Dharaiya and Dharaiya, 2021; Singh, 2007). However their conservation is bristling with difficulties due to inhabitation at low densities, requirement of large areas, and often conflict with human through predation on livestock and sometimes on people (Banerjee et al., 2010; Dalerum et al., 2008).

The geospatial analysis and remote sensing technology play a key role and one of the quickest possible ways in deriving the environmental map layers to develop contemporary strategies for wildlife habitat assessment, biodiversity analysis and mapping and modelling of animal movements (McDermid et al., 2009). Remotely sensed datasets are capable of providing synoptic, real time, frequent and accurate informations, even for large scale area, it also allows to produce self-made environmental information which are prompted by wildlife studies (Dharaiya and Dharaiya, 2021; Kushwaha & Roy, 2002; McDermid et al., 2009; Scott et al., 1993). Wildlife managers have been using topographic maps and other maps of their interest in order to map the wildlife habitat similar to land cover mapping for formulation of management plan (Best 1984; Dharaiya and Dharaiya, 2021; Leopold 1933; Lindgren 1985). A wide variety of products based on remote sensing are available, which ranges from relatively inexpensive land use and land cover maps generated with well-known unsupervised/supervised classification techniques to the complicated and expensive multi-attribute databases produced through advanced mapping and modelling (Dharaiya and Dharaiya, 2021; Franklin et al., 2000; McDermid et al., 2009; Townshend and Justice, 1980). Remote sensing and Geographical Information System (RS and GIS) have been used as a fundamental tool for getting information about the habitat preference of the wildlife species and helps in monitoring areas of land that are suitable to endangered species, through of various

habitat variables of both spatial and non-spatial nature (Davis and Goetz, 1990 integration and interpretation; Dharaiya and Dharaiya, 2021; Prajapati et al., 2014).

On India's west coast, the province of Kathiawar comprises a peninsula where the land is mostly flat, with huge lava flows known as the Deccan Trap covering it (Mathur et al., 2017). In the plains of Kathiawar, the Girnar Hills are an imposing and distinctive geographical feature. The Girnar Compound's terrain is highly mountainous and rugged, with moderate to very steep slopes that regularly descend into precipitous inclines, with the upper sections of the centrally located Mount Girnar forming a sheer vertical wall at times. The shrines on the summit of the hill are visited by a huge number of pilgrims every year, and they are of great religious and archaeological significance while are no less significant geologically, although little is known about the fascinating rock types they contain or the structure of the mountain ranges. The topographic features and quaquaversal dip in the surrounding basalt may suggest a volcano, but there is little doubt that the rocks are a plutonic intrusion in the form of a laccolith, with a large number of differentiated types, which is likely unique in being the first of its kind studied in India (Evans, 1901). Girnar's comagmatic litho-semblage outcrop has an oval shape amid a landscape revealing Deccan basalts, and it seems to be a volcanic eruption. Gabbro, Diorite, Lamprophyre rock groups, and Syenite are among the rock types found in the complex (Bose, 1972; Krishnan, 1926; Paul et. Al., 1977). Silicic intrusive bodies of microgranites and porphyrites have been found around the main complex and have been shown to be unconnected to the main hill's sub-volcanics (Mathur et al., 1926). The sequence of crystallisation of the comagmatic rocks of the Girnar hills, namely Gabbro -> Diorite -> Lamprophyric rocks + Nepheline Syenite, was determined based on field relationships and geochemical features. The last two rocks were thought to be complimentary components of a very alkaline, iron-rich leftover liquid (Bose, 1973; Chandra, 1995). The intention behind this study is to map the current vegetation cover suitable as the habitat for wildlife of Girnar Wildlife Sanctuary, especially the Asiatic lion.

The study also focuses on mapping of existing water channels to aid in the water conservation in the area. RS and GIS technology have been used in this study in order to identify the habitat suitability of the area. Remotely sensed spatial data of the sanctuary along with the land use layers, and Digital Elevation Models (DEMs) were applied, interpreted and analysed on the GIS platform to assess the lion habitat.

## **2. Materials and methods:**

### ***2.1 study area:***

The Girnar hills in Junagadh district of Gujarat, are famous since ancient times as a place of pilgrimage for both Hindus and Jains. The town of Junagadh is situated practically at the foothills of Mount Girnar, the highest peak in Gujarat state of India with the apex elevation of 1,177.4m. In the Girnar Forests, there are very few flat or undulating areas. These hills lie between the parallels of latitude North 21° 25' and 21° 35' and meridians of longitude East 70° 30 ' and 70° 40' (Dharaiya and Dharaiya, 2021; Singh & Gibson, 2011). The aerial view of the Girnar resembles a circular disc of the diameter of 16km (Figure 1). Mount Girnar is a major igneous plutonic complex which intruded into the basalts towards the close of the Deccan Trap period (Surba Rao, 1964; Sukheswala, 1982). The climate of Girnar is semi-arid with a mean temperature and mean annual precipitation of 25.7 °C and 827mm, respectively along with more than 800 species of plants and more than 200 faunal species. The Girnar forests is approximately 50km far from the Gir National Park and Wildlife Sanctuary. The area of 180km<sup>2</sup> of Girnar wildlife sanctuary (WLS) is now known as a part of greater Gir ecosystem constituted for the conservation of Asiatic lion, the only population of free ranging Asiatic lion. Once, the forests of Girnar were contiguous with the Gir forest, but gradually the urbanization and agricultural expansion have isolated these two forests converting Girnar as an isolated compact patch of forested habitat.

### ***2.2. Data Sources***

The satellite imagery of Sentinel-2A of the study area was acquired from 28

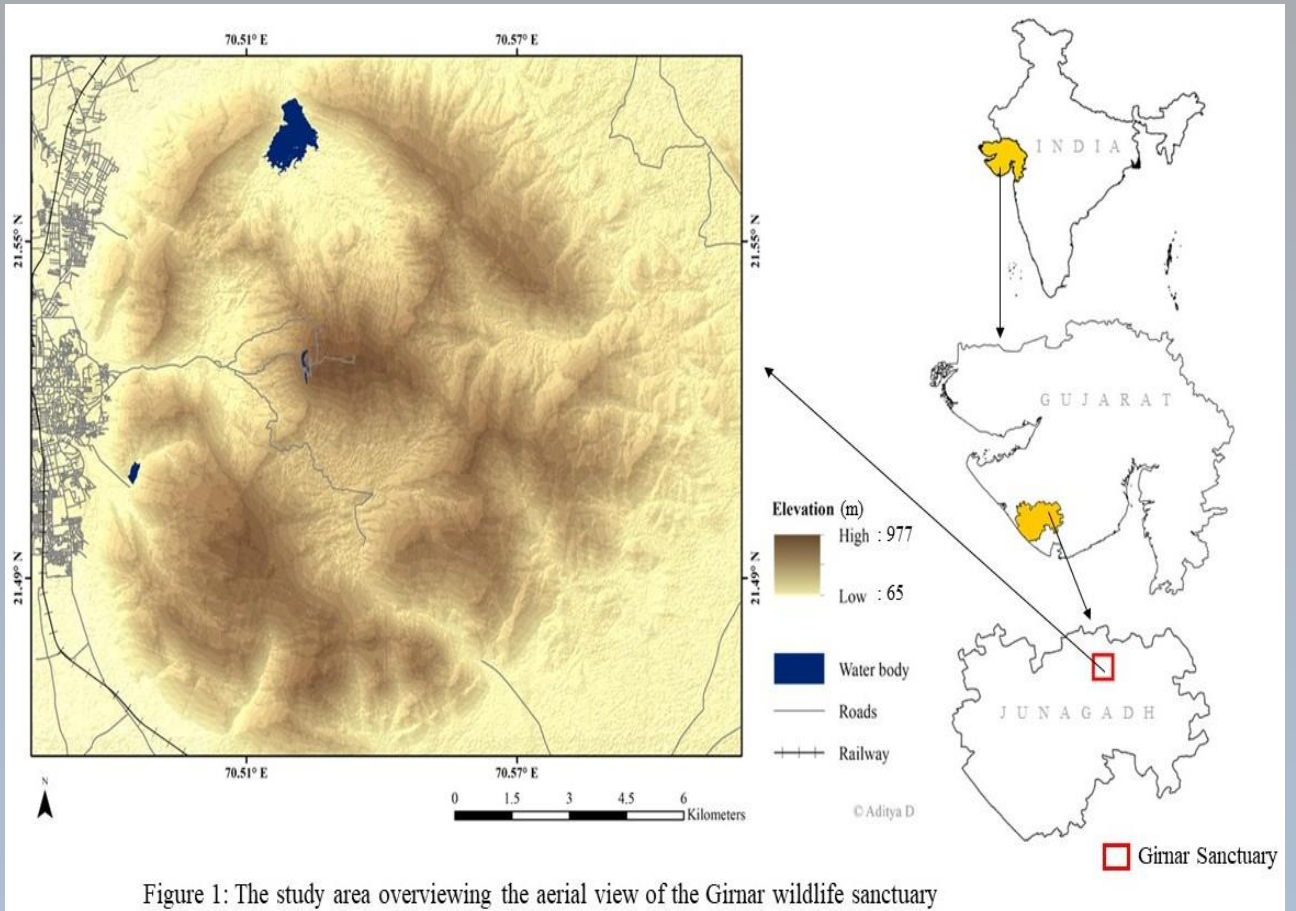


Figure 1: The study area overviewing the aerial view of the Ginnar wildlife sanctuary

Copernicus open access hub developed by European Space Agency (ESA) <https://scihub.copernicus.eu/dhus/#/home>. The Cartosat-1 Digital Elevation Model (DEM) of Ginnar wildlife sanctuary, was acquired from Indian Space Research Organisation (ISRO)'s Geoportal Bhuvan, <https://bhuvanapp3.nrsc.gov.in/data/download/index.php> It is an interactive versatile Earth-Browser which showcases multi-sensor, multi-platform and multi-temporal images with capabilities to overlay thematic information, interpreted from such imagery as a vector layer (Bhatt et al., 2014). The acquisition of Landsat 8 OLI data was done using <https://earthexplorer.usgs.gov>. The United States Geological Survey (USGS) Earth Explorer data portal is one free and open-source portal for obtaining various earth imagery across available geo-spatial datasets (Leemhuis et al., 2016; Sundarakumar et al., 2012). OpenStreetMap (OSM) is also an open source and a collaborative project to create a free editable map of the world.

<https://www.openstreetmap.org/#map=15/24.4803/72.7920&layers=N>. In this study, several landuse layers such as roads, railways, built-ups, etc., were extracted along with the country and state boundaries of Gujarat and India from the OSM server and were digitized using ArcGIS tool (Brinkhoff, 2016; Marsudi, 2019).

### ***2.3. Data analysis:***

#### ***2.3.1. Terrain and hydrology***

The Digital Elevation Models (DEMs) are digital records of terrain elevations for ground position at regularly spaced intervals. The elevation values of terrain are valuable for modelling the terrain, drainage area, as well as studying the land use patterns (Shamsi & Fletcher, 1994). It was used to compute the elevation range and to process several hydrological functions. At first, it was taken as an input raster to process the Fill tool, which resulted a depression less raster with all the sinks, filled. This output was taken as desired input raster to process the Flow Direction tool which will generate the pixel value based on the flow path of water from higher elevation to lower elevation and also assigns a flow eight to each grid cell in the catchment, such that each grid cell tends to flow only in one of the eight neighbouring grid cells with the steepest slope (Tarboton, 1997; Teng et al., 2020). It identifies all the sinks in the DEM and raises their elevation to the lowest level of pour point around their edge by using the eight directions pour point model. While running the flow direction algorithm, the resulting values ranges from 1, 2, 4, 8, 16, 32, 64, and 128 which describes all the adjacent eight directions at a given point. For processing the Flow Accumulation tool, the output rasters i.e., Fill and flow direction were taken as input rasters. Basically, in this sub-step, it calculates the total number of grid cells contributing to each grid cell in the catchment and assigns this value to this grid cell as flow accumulation (Gangodagamage, 2001; Lei et al., 2011). After processing it, an algebraic expression was given to determine the threshold value while ordering the stream network, where flow accumulation = > 9500 which calculates all the respective streams and its branches in the output raster.

Based on the above calculation, the calculated raster and flow direction raster were taken as an input raster and processed the Stream order tool where the ordering method used was STRAHLER (Dharaiya and Dharaiya, 2021; Pradhan, 2017). This function based on the above user-defined threshold values of accumulation delineates the stream network for the catchment (Schade et al., 2007; Teng et al., 2020). Lastly, the above output raster of stream order was converted into vector layer by processing the tool, stream to feature. With this, the drainage pattern or the Streams are generated. Using DEM, the Hillshade tool along with slope and aspect tool (Dharaiya and Dharaiya, 2021; Pareta, 2011) was processed to analyse surface features of the study area to correlate with the stream network from the highest to lowest elevation points.

### ***2.3.2. Land Use Land Cover (LULC)***

The monitoring of vegetation is an accepted technique for habitat assessment. The sentinel 2A satellite consists of 13 bands in the visible, near infrared and short-wave infrared part of the spectrum which supplies multi-spectral data and a spatial resolution of 10, 20 and 60 m. Thus, it makes possible to figure out large amount of minute details of various ground features. In order to classify the image, the band composite function was processed for layer stacking to obtain a False Colour Composite (FCC). Maximum Likelihood Supervised Classification was performed in the Sentinel imagery and six different classes (i.e., waterbody, built ups, barren lands, open forests, moderate vegetation and dense vegetation) were differentiated based on the spectral signatures of each pixel. Maximum Likelihood Classification assumes the statistics in each class in each band are equally distributed and defines a specific class in which the given pixel value falls, where each pixel is assigned to the class that has highest probability (i.e., Maximum Likelihood). The area of each class was interpreted based on pixel count and resolution of cell. Other Land Use layers like roads, and railways were extracted from the open-source data repository, Open Street maps (OSM) which is used as a server and digitised in GIS environment through Web Mapping Services (WMS). A WMS

defines an interface or a consortium that allows a client to get maps of geospatial data and can able to gain detailed information on specific features shown on the map. WMS can produce a map, as a picture, series of graphical elements or a set of geographic data, also it can answer basic queries about the content of the map.

### ***2.3.3 Estimation of Land Surface Temperature (LST)***

The Landsat 8 OLI data was used to determine the Land Surface Temperature (LST) of the study area. It consists of two sensors OLI and Thermal Infrared Sensors (TIRs) in which OLI comprises of 8 bands located in the visible, near infrared and the short-wave infrared region of the spectrum which provides the data of 30 m spatial resolution. The TIRs senses the Thermal Infrared (TIR) radiance at a spatial resolution of 100 m with the help of two bands located in the atmospheric window between 10 and 12  $\mu\text{m}$  (Taloor et al., 2021). For pre-processing the imagery, the first step is to convert the Digital Number (DN) values of band 10 to spectral radiance, by using the constant values from the metadata of Landsat 8 as shown in Table 1. Secondly, In order to calculate the Fractional Vegetation Cover (FVC), the Normalised Difference Vegetation Index (NDVI) was calculated in the Landsat imagery which is necessary for further calculations of emissivity, and proportional vegetation (Box et al., 1989; de Leeuw et al., 2010; Hame et al., 1997; Hess et al., 1996) NDVI values vary between  $-1$  and  $+1$ , and are undefined when both  $\lambda_{\text{NIR}}$  and  $\lambda_{\text{RED}}$  are zero (Rulinda et al., 2012; Tucker, 1979). From the above output the Fractional Vegetation Cover (FVC) was calculated followed by Land Surface Emissivity (LSE) and Land Surface Temperature (LST) calculations. The LST is the radiative skin temperature of the land surface, as measured in the direction of the remote sensor, which is estimated from TOA brightness temperatures from the Thermal infrared spectral channels of geostationary satellites. Its estimation further depends on the albedo, the vegetation covers and the soil moisture (Alexander, 2020; Becker, 1987; Taloor et al., 2021). The above parameters were calculated using the equations as suggested by Dharaiya and Dharaiya, 2021. Figure 2 shows a diagrammatic representation of the entire methodology.

**Table 1: The metadata of Landsat 8 OLI consisting required constant values for calculations.**

Constants	Value	Description
$O_i$	0.29	Correction value, Band 10
$Q_{calmax}$	65535	Maximum value of Quantized Calibration
$Q_{calmin}$	1	Minimum value of Quantized Calibration
$k_1$ and $k_2$	774.8853 and 1321.0789	Thermal constants, band 10
$L_{max}$	22.00180	Maximum value of Radiance, Band 10
$L_{min}$	0.10033	Minimum value of Radiance, Band 10

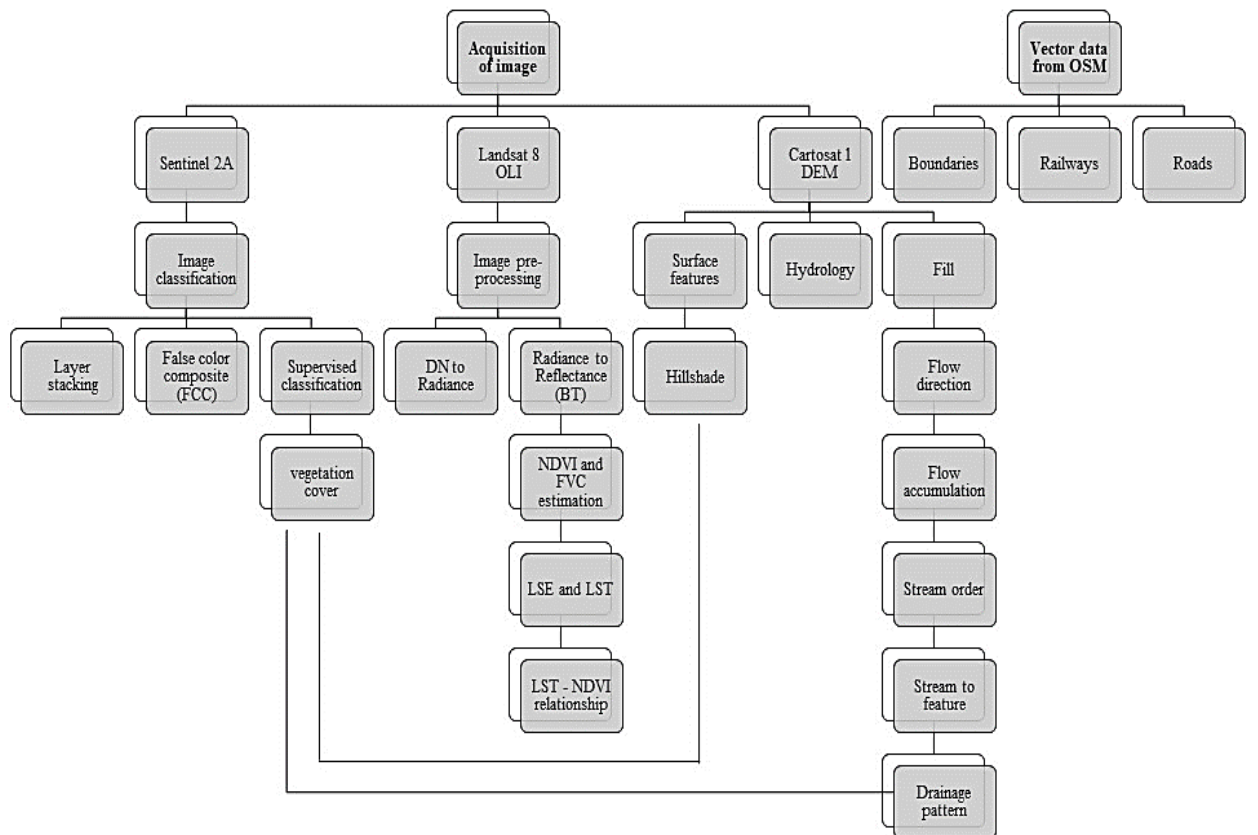


Figure 2: A flow-chart illustrating the entire methodology

### 3. Results and Discussions

#### 3.1. *Vegetation cover*

The Land use Land Cover (LULC) classification shows a great significance in detecting regions that are covered by different type of vegetation and the land use in a particular area. Thus, LULC maps are the best source of information to the managers for understanding the landscape of any particular region. Figure 3, shows the LULC classification of the study area which comprises of 0.08 % (0.19 sq.km) of Water body, 2 % (5.67 sq.km) of Built-up areas which are mostly the old temples and hermitage. However, there is no any new other development or built-up structure was recorded in the area. Further, the habitat of Girnar forest was classified as the forest area with moderate vegetation 49 % (117.89 sq.km), dense vegetation 11 % (26.1 sq.km), along with 37 % (88.15 sq.km) open forest and 1 % (1.76 sq.km) of Barren lands. Figure 4, depicts the forest with dense vegetation can be a suitable wildlife habitat. Generally, lions are considered as best example in predator-prey relationships as they usually hunt in groups and also pondered ambush predators, choosing prey catchability over prey abundance and rely on concealment during hunting (Hopcraft et al., 2005; Packer et al., 1990). Therefore, dense vegetation enables the predators like lion and leopard to ambush their prey and also provides cover (Davies et al., 2016). vegetation 11 % (26.1 sq.km), along with 37 % (88.15 sq.km) open forest and 1 % (1.76 sq.km) of Barren lands. Figure 4, depicts the forest with dense vegetation can be a suitable wildlife habitat. Generally, lions are considered as best example in predator-prey relationships as they usually hunt in groups and also pondered ambush predators, choosing prey catchability over prey abundance and rely on concealment during hunting (Hopcraft et al., 2005; Packer et al., 1990). Therefore, dense vegetation enables the predators like lion and leopard to ambush their prey and also provides cover (Davies et al., 2016).

#### 3.2. *Hydrology*

Water is said to be a most important driving factor in wildlife habitat and also acts as a source of life for all the animals.

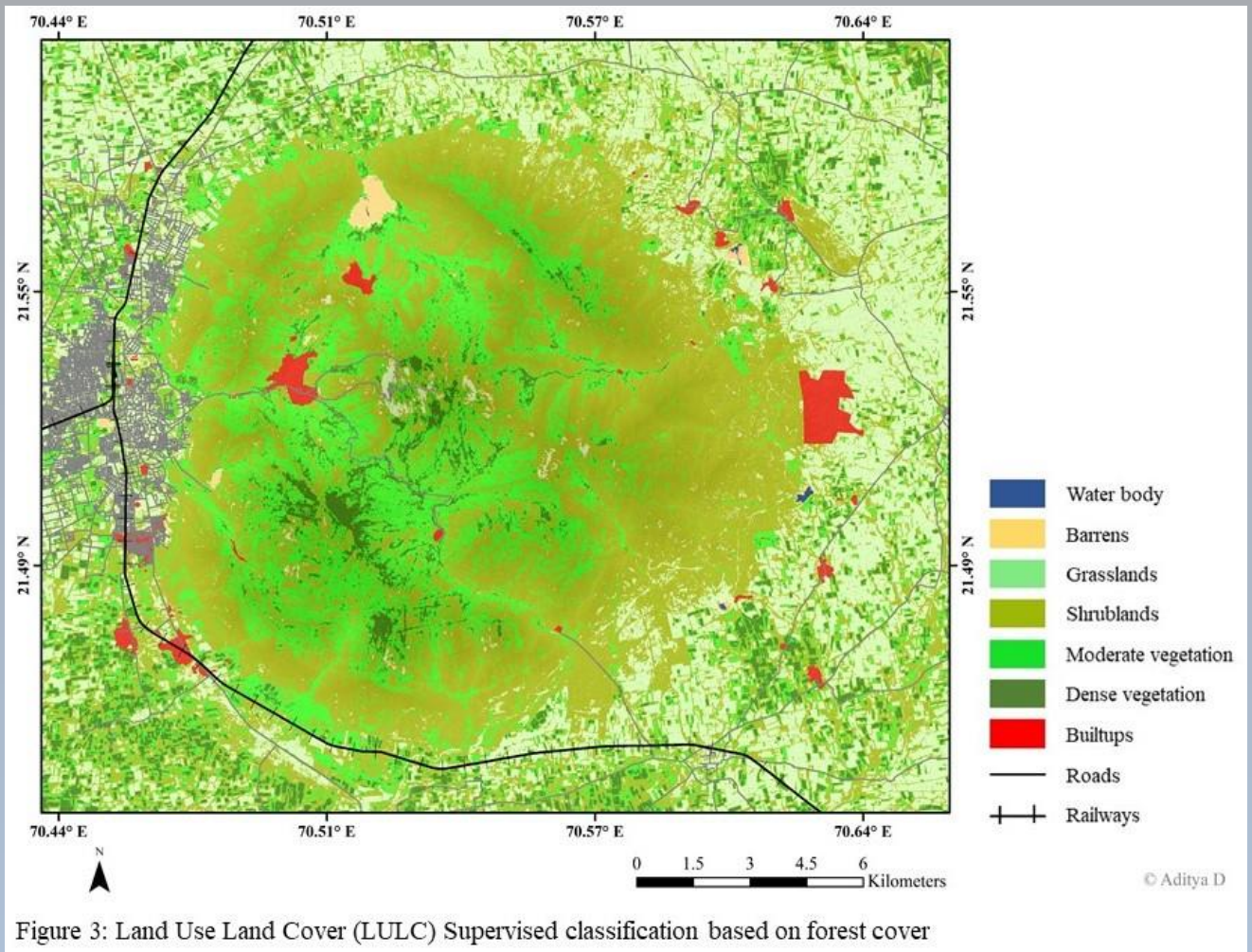
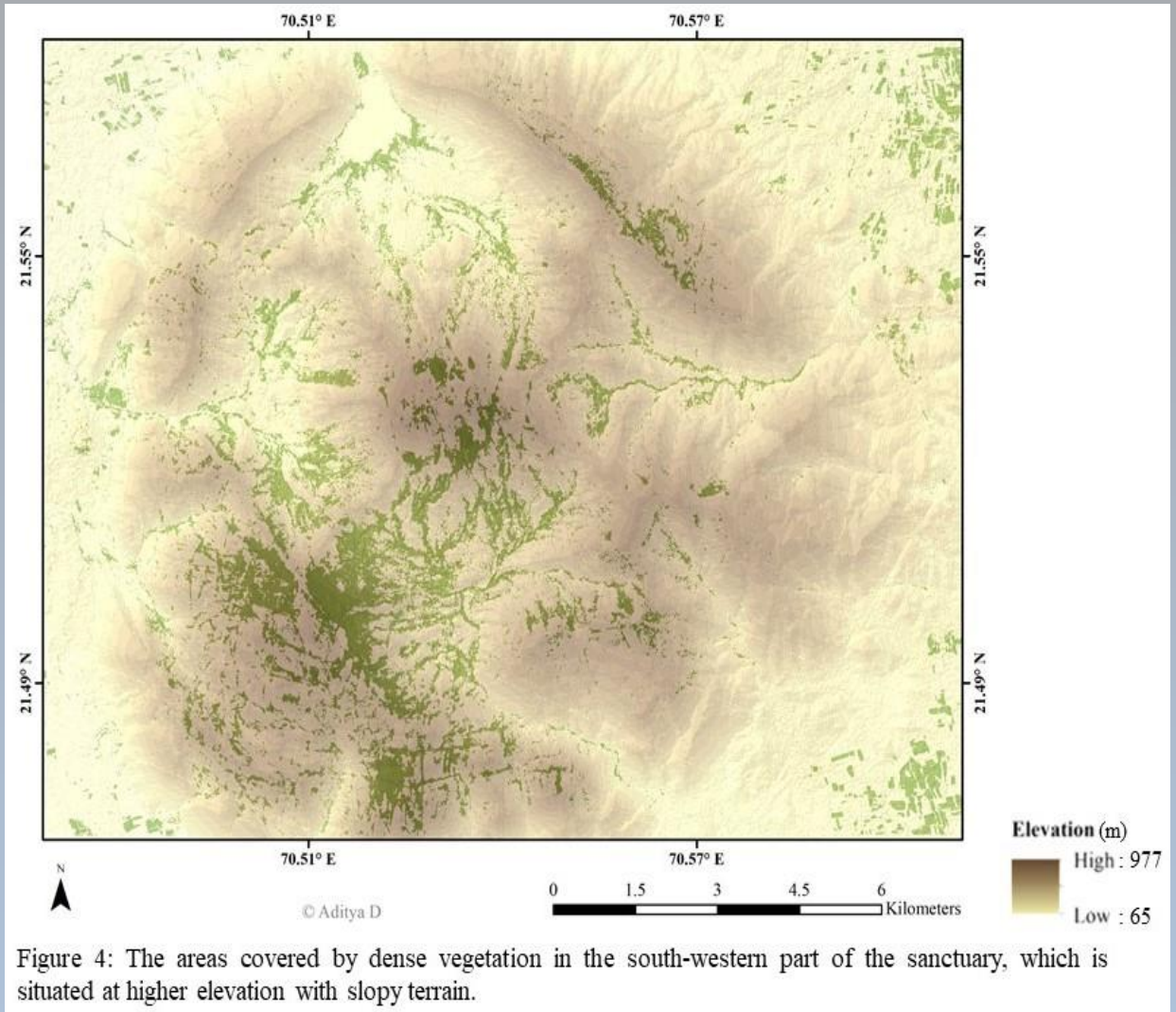


Figure 3: Land Use Land Cover (LULC) Supervised classification based on forest cover

Figure 5 depicts five streams or water channels flowing from an elevation range of ~ 100 to 300m and also two of the five streams form the junctions at the reservoir at an elevation of 66 and 79m. Alongside, the majority of the dense forests is observed in these elevation range constituting a suitable wildlife habitat (Figure 4). Figure 5 depicts that all the streams in Girnar forest are of first order stream according to STRAHLER Order stream classifications (Pradhan, 2017), and are considered as primary or minor streams. These water channels flow and make their path in almost every direction from the origin point. As these are of first order, hence there are very less chance of getting some water catchment areas and the amount of water carried by each stream. Unlike the Girnar wildlife sanctuary, the other sanctuaries of Gujarat, like Jessore (Malik et al., 2018) and Ratanmahal, several junctions of streams were identified on the basis of STRAHLER order, that provides an opportunity to wildlife manager to create the natural



water catchment areas or check dams. So, in case of Girnar wildlife sanctuary, artificial water points such as wildlife.

### ***3.3. Land Surface Temperature:***

A habitat quality is often driven by the land surface temperature and (LST) influenced by the extent of vegetation and surface roughness. LST also helps in depriving various soil characteristics and both NDVI and LST can act as an indicator of drought as well (Karnieli et al., 2010). In this study, the relationship between LST and NDVI is shown in the form of scatter plot using Landsat 8 datasets (Figure 6). The LST in the sanctuary has been ranged from 20 °C to 90 °C and the scatter plot depicts a negative or inverse relationship between LST and NDVI.

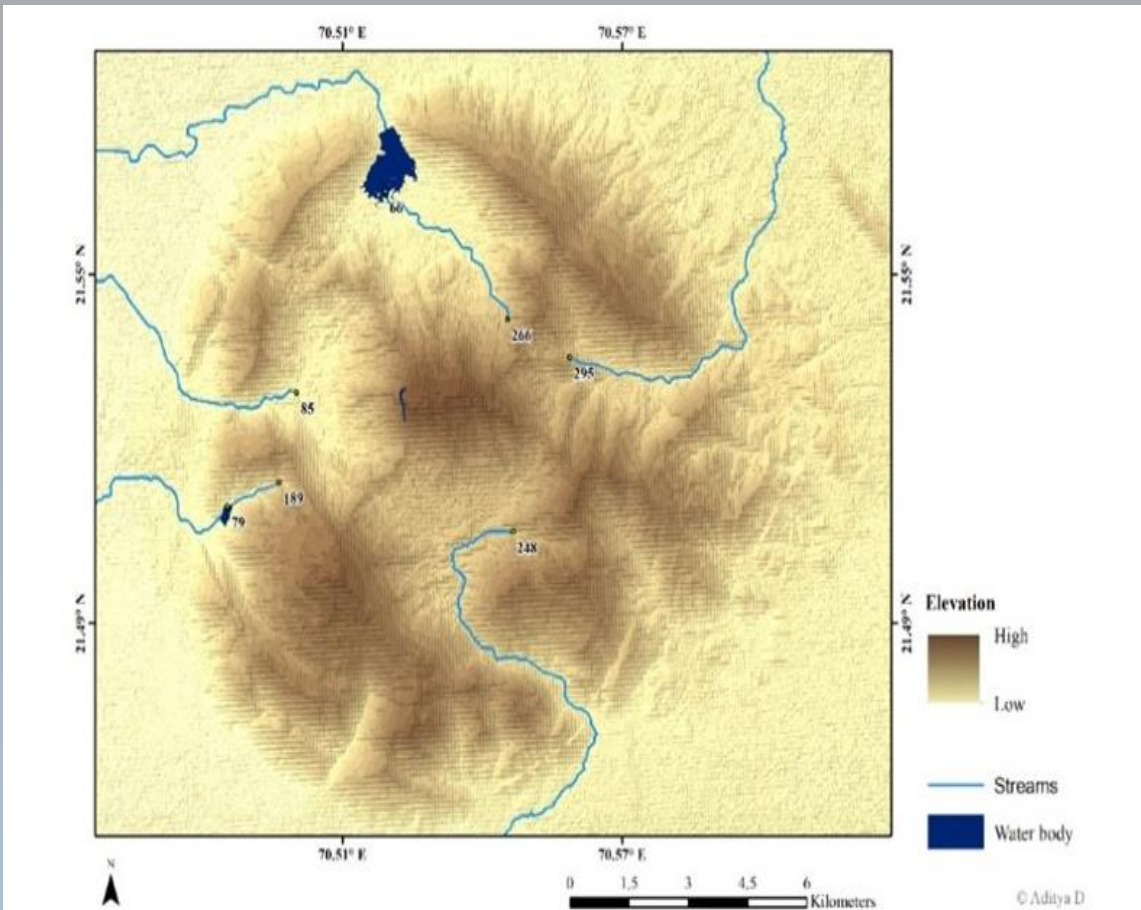


Figure 5: The pattern of water channels with respect to elevation in the sanctuary

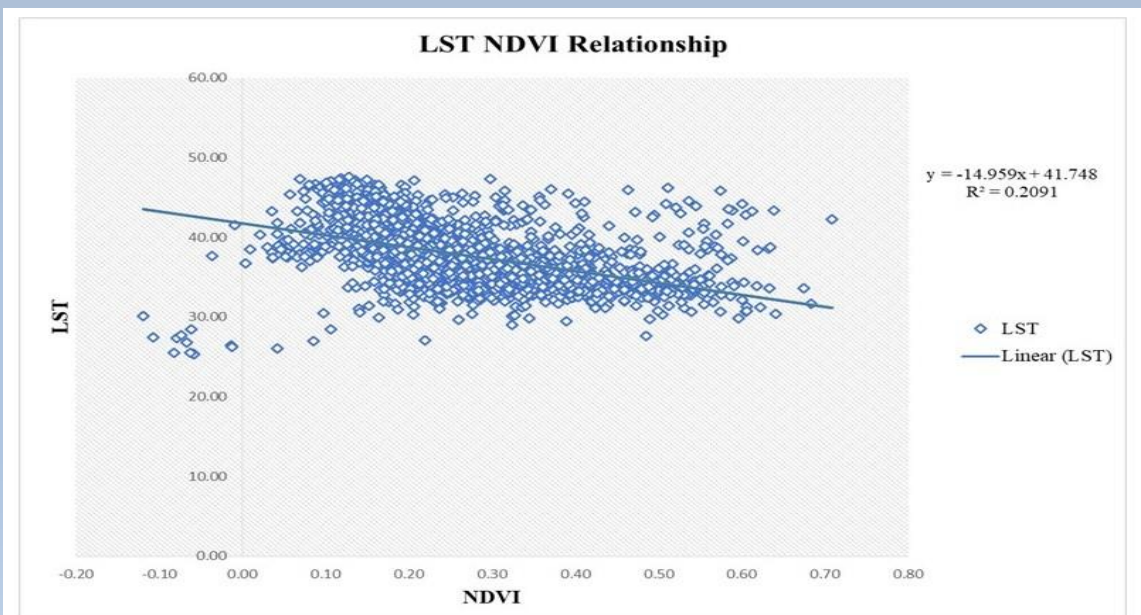


Figure 6: The Scatter plot shows the inverse relationship of Land Surface Temperature (LST) and Normalised Difference Vegetation Index (NDVI), which implies that Denser the vegetation, lesser is the Surface temperature, hence it induces evapotranspiration and cools the surface.

With increasing NDVI, say denser vegetation, the LST gradually decreases which indicates that dense vegetation induces more evapotranspiration and cools the surface (Price, 1990; Sun & Kafatos, 2007). This plot also suggests that decrease in LST with increase in NDVI should not be interpreted as a sign of vegetation stress and hence LST could be a great determining factor to help in improving and understanding the water availability, to aid resource management and improve weather forecasts (Guha et al., 2020; Sun, 2008).

#### **4. Conclusion:**

Remote sensing and geospatial analysis techniques may prove as an effective and advanced tool to conserve the natural resources such as forests and water. In present study, the forest habitat of Girnar hills and the water channel along with the Land Surface Temperature therein were analysed and mapped to understand the lion habitat. The outcomes thus, can be utilized for further assessment, evaluation and monitoring of this habitat for the conservation of Asiatic lion and its associated fauna. Alongside, the inverse relationship of LST-NDVI will might come handy in determining future environmental planning to maintain the vegetation density in the sanctuary. The water channels assessed might help the forest department to manage the water resources during the dry season through water conservation structures. The ability of GIS to capture, store and manage every type of datasets has proved that the outcomes deprived are self-understandable and self-explanatory to the laymen and persons who are unfamiliar with these emerging techniques. At a long term, the advancing in habitat management using geo-spatial technology will help the forest manager, to formulate the future conservation and management strategies.

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**M. Sc. students have carried out their geological field work in various parts of the Kachchh district during 18<sup>th</sup> to 24<sup>th</sup> December, 2021 under the guidance of Dr. P. M. Solanki.**



**B. Sc. Sem VI students have carried out Geological field work at the Abu road and Ambaji area during 22<sup>nd</sup> to 25<sup>th</sup> December, 2021. They have been guided by Dr. H. V. Majethiya.**



**Dissertation field work of M. Sc. Sem IV students have carried out in parts of Dahod district during 02<sup>nd</sup> and 3<sup>rd</sup> January, 2022 under the guidance of Dr. P. M. Solanki of the Geology department.**



**B. Sc. Sem IV students have carried out Geological field work at Himmatnagar, Bhiloda and Shamlaji area on March 16, 2022. They have been guided by Dr. P. M. Solanki.**



- ❖ Patel, Deep D., Patel, Shreekumari M. and **Solanki, Paras M.** (2022) Mineralogical and Geological diversity of Vavilov crater derived using Remote Sensing data. Abstract accepted in the 53<sup>rd</sup> Lunar and Planetary Science Conference (LPSC) held at Houston, Texas from 7th -11th March, 2022.
- ❖ Patel, Deep D., Patel, Shreekumari M. and **Solanki, Paras M.** (2022) Mineralogical and Geological diversity of Philolaus crater derived using Remote Sensing data. Poster presented in 3<sup>rd</sup> Indian Planetary Science Conference (IPSC-2022) organized by Physical Research Laboratory (PRL), Ahmedabad during 14-16 March, 2022.
- ❖ Patel, Deep D., Patel, Shreekumari M., **Solanki, Paras M.** and Majethiya, Heman V. (2022) Diversity and inclusion in Geoscience. Paper presented at Advancing IDEAS in Planetary Science by the Lunar Planetary Institute from April 25-29, 2022.
- ❖ **Ms. Siddhi Patel** of Geology Department received **Prof. S. Mukherjee Gold Medal** from the Gujarat University as she secured highest marks in M. Sc. Geology for the year 2021-22.
- ❖ The students of T. Y. B.Sc. and M. Sc. of Geology Department have participated and received certificates at '**National Science Day Exhibition-2022**' organised by IQAC, M. G. Science Institute on 28<sup>th</sup> February, 2022.
- ❖ **Ms. Shreekumari M. Patel** got selected for **Post-Doctoral Fellow** in Research and Development Division of Khalifa University, Abu Dhabi (February-2022 onwards).

National Science Day Exhibition-2022



*Dr. Shreekumari M. Patel has completed her Ph. D. degree on “Remote Sensing studies of Lunar Mare Basalts and its comparison with Basalts of Gujarat” from the Gujarat University in December 2021 under the guidance of Dr. P. M. Solanki.*

*Congratulations..*



*Dr. Rahul G. Gayakyad has completed his Ph. D. degree on "Palaeoenvironmental interpretation based on Sedimentology and Ichnology of Keera Dome, Kachchh, Gujarat" from the Gujarat University in December 2021 under the guidance of Dr. P. M. Solanki.*

**Congratulations..**



## DEDICATED TO GURU...

ઘોર અંધારે ઊભો હોઊ તો,  
ઊજજવલ પ્રકાશ બનીને આવજો  
મઝદરિએ દિશા જો ખોઈ બેસુતો,  
મારો ખરો કિનારો બનીને અવજો  
ભરતડકે ઘગઘગનો બળતો હોઊતો,  
ઘટાદાર વુક્ષની છાયા બની ને આવજો  
અક્ષાન ની ઓથે અટવાઈ પડુતો,  
ક્ષાન ની સાચી સમજ બની ને આવજો  
મજીલ ના રસ્તે ભટકી પડુતો,  
ભોમીયો બની ને આવજો  
ઊપર ઊડવાની હિમત જો હારી બેસુ તો,  
ખુલ્લા આકાસે ઊડવાની અતુટ તાકાત બની ને આવજો  
હર જન્મમા જો હુ શિષ્ય હોઊતો,  
તમેજ મારા ગુરુ બની ને આવજો  
તમેજ મારા ગુરુ બની ને આવજો...

ગુરુ શુ છે?  
ગુરુ એક લાગણી છે,  
જે હૃદયમા આવે છે ને જ્ઞાન આપીને જાય છે.  
ગુરુ એક દીવાની જયોત છે.  
જે શિષ્યના અંધારારુપી જીવનમા અજવાળું કરી જાય છે...  
ગુરુ એક પવનની લહેર છે  
જે અજ્ઞાન રુપી ધુળને ઉડાળી જાય છે...  
ગુરુ 'Universal ocean panthalsa' છે,  
જે શિષ્ય રુપી 'Super continent pangea' ને તેરતુ રાખે છે.  
ગુરુ એક પવિત ભાવ છે, જે  
જે મનની અશુદ્ધિ ઓને વહાવી નાખે છે...  
ગુરુ એક મૂર્તિકાર છે.  
જે કાચી માટી રુપી શિષ્યને આકાર આપે છે.



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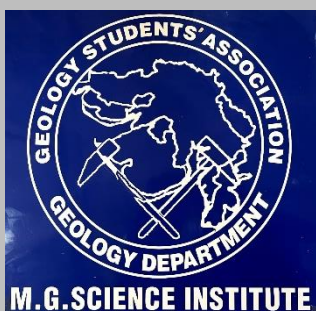
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