Analysis of Landslide Susceptibility on the basis of Rainfall Scenario

Under the guidance of Dr. Naveen James

Group members

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Introduction:

- Landslides are abrupt and often catastrophic shifts in the Earth's surface.
- They come in various forms, such as rock falls, debris flows, mudslides, and slope failures.
- Their destructive potential arises from their suddenness and unpredictability.
- Landslides are affected by interplay of several factors, including geological, climatic and human-related elements.

Why landslides matter?

- To develop strategies to mitigate their risks, and protect vulnerable areas.
- The landslide susceptibility (LS) of any mountainous region is significantly affected by influence of climate pattern .
- The future prediction of the LS using these climate pattern changes has not been quantified.
- Frequency of landslides in regions of Himachal Pradesh has been on meteorological rise in last three years.

Seven Fold Rise in landslides in last three years

Year	Landslides
2020	16
2021	100
2022	117

What is Landslide Susceptibility?

- Landslide susceptibility refers to the likelihood of a specific area experiencing a landslide event.
- Susceptibility analysis aims to identify and map areas that are at higher risk of landslides, helping authorities, planners, and researchers make informed decisions for disaster risk reduction and land management.

OUTLINE

- **Objective**
- **Literature**
- **Methodology**
- **Inference**

Objective

- Predict future landslide susceptibility map considering the future climate patterns changes.
- To gather comprehensive data.
- To analyze existing data.

- We want to develop a relationship between the rainfall data and the events of landslides that occurred in the region of study area because many roads in Himachal Pradesh are susceptible to this hazard in the rainy season. By application of cumulative rainfall and related thematic maps to determine landslide susceptibility as an approach to highway hazard management.

- **Susceptibility Mapping:**
    - Create a detailed landslide susceptibility map based on the spatial analysis results, emphasizing the areas most susceptible to landslides due to rainfall.

Literature

Authors	Causative Parameters
Gupta and Anbalagan	Structural discontinuities, slope, LULC, Hydrogeological conditions
Ghosh and Bhattacharya	Slope, LULC, Groundwater/ rainfall condition
Pandey et al.	Altitude, slope, curvature, aspect, geology, soil texture; distance to rivers, rivers and faults.

Methodology

- Data Collection: Identifying Relevant Sources: Collection of relevant landslide data from reputable news websites for years 2019,2020,2021,2022,2023.

- Types of Data: Collected historical landslide events data and topographic data.

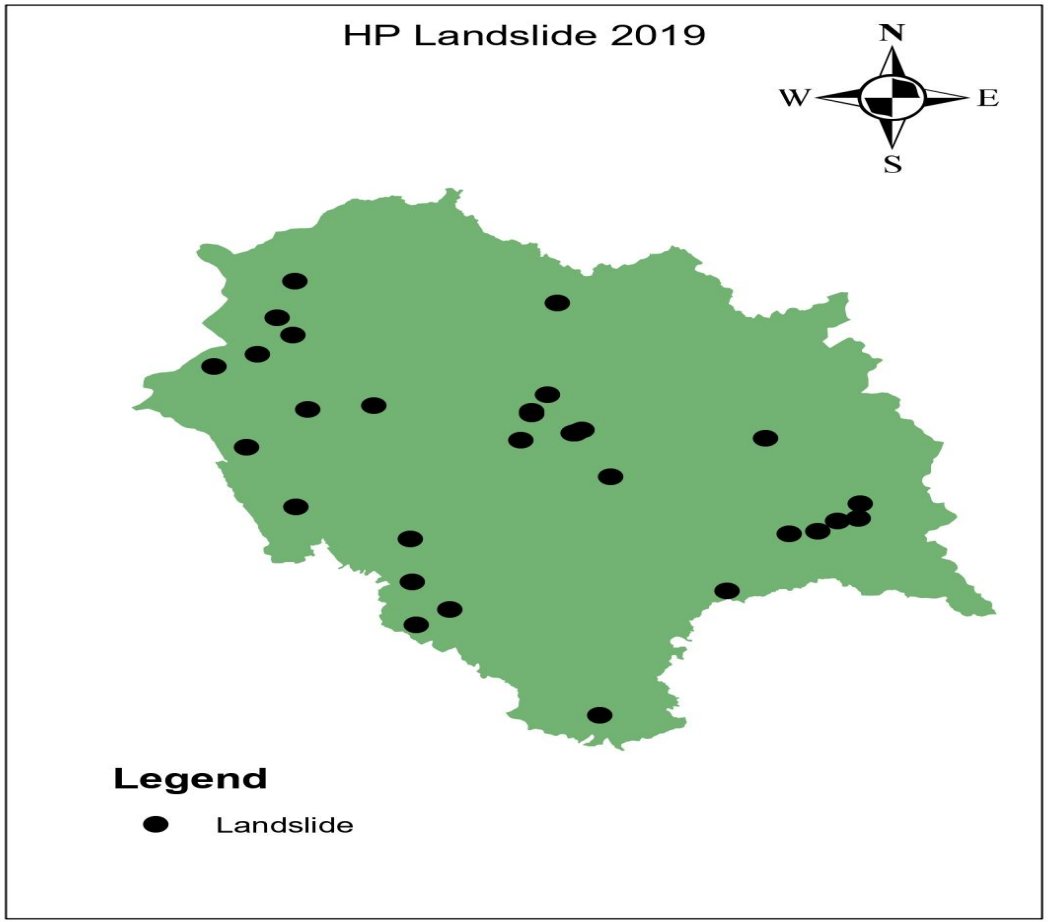
2023

Date	Locations
5 July	between UNESCO heritage Shimla and Kalka track
8 July	between Gramphu and Chota Dharra on Sundo-kaza-Gramphu
8 July	nohradhar Solan - Minus Road
9 July	Gurdwara Manikaran Sahib Flooded
9 July	Matholi village in Shimla district
9 July	Lankabekar village in Kullu district
9 July	6 Mile
9 July	Katiyan tehsil of Chamba
9 July	Kullu-Manali road
9July	Lahaul and Spiti, Chandrataal
9 July	A bridge connecting Aut-Banjar washed away as Beas river flows ferociously in #HimachalPradesh 's #Mandi district.
9 July	Lahaul Spiti district
9 July	national highway between kullu and manali
10 July	Ghanahatti - Ghandal Shimla
10 July	Rampur - Bushahar Madhawani village
10 July	Kotgarh area of the Shimla district
10July	Kalka Shimla Railmaarg
11 July	Bridge in Baddi Nalagarh Industrial Area of Solan
11 July	chewa village ,solan
11 July	shamti Solan
11 July	Sainj valley of Kullu district
13 July	Rampur-Jeori NH-5
13 July	Buri- Chamba (4 lane road)
16 July	kinnaur valley
17 July	Gumma-Bhagi and Gumma reoghati , Via Kith-Purag Road
22 July	jangal Kalala Village, Kothkahi, Shimla
22 July	NH-5 Wangtu in Kinnaur district, Himachal Pradesh
28 July	Baroni Khad in the Rampur Kinnaur district
2 Aug	Shimla-Chandigarh national highway
2Aug	Chandigarh-Shimla NH-5 near Solan district's Parwanoo.
6Aug	Manglad-Bagvat road n the Kinnu area of Rampur subdivision in Shimla
8 Aug	Aut-Luhri Road NH305 , Kullu
11 August	Shimla National Highway 5, between Thambu Mod and Chakki Mod
11 August	Four rooms of Nalagarh Fort collapsed, Solan
11 Aug	Khadel village in Sheel gram panchayat of Anni tehsil, Kullu
12 Aug	Kalka- Shimla Raiway track - Kandaghat
12Aug	Shimla's Dudhli
12 Aug	Zamanabad Kangra Raod
13 Aug	Shimla

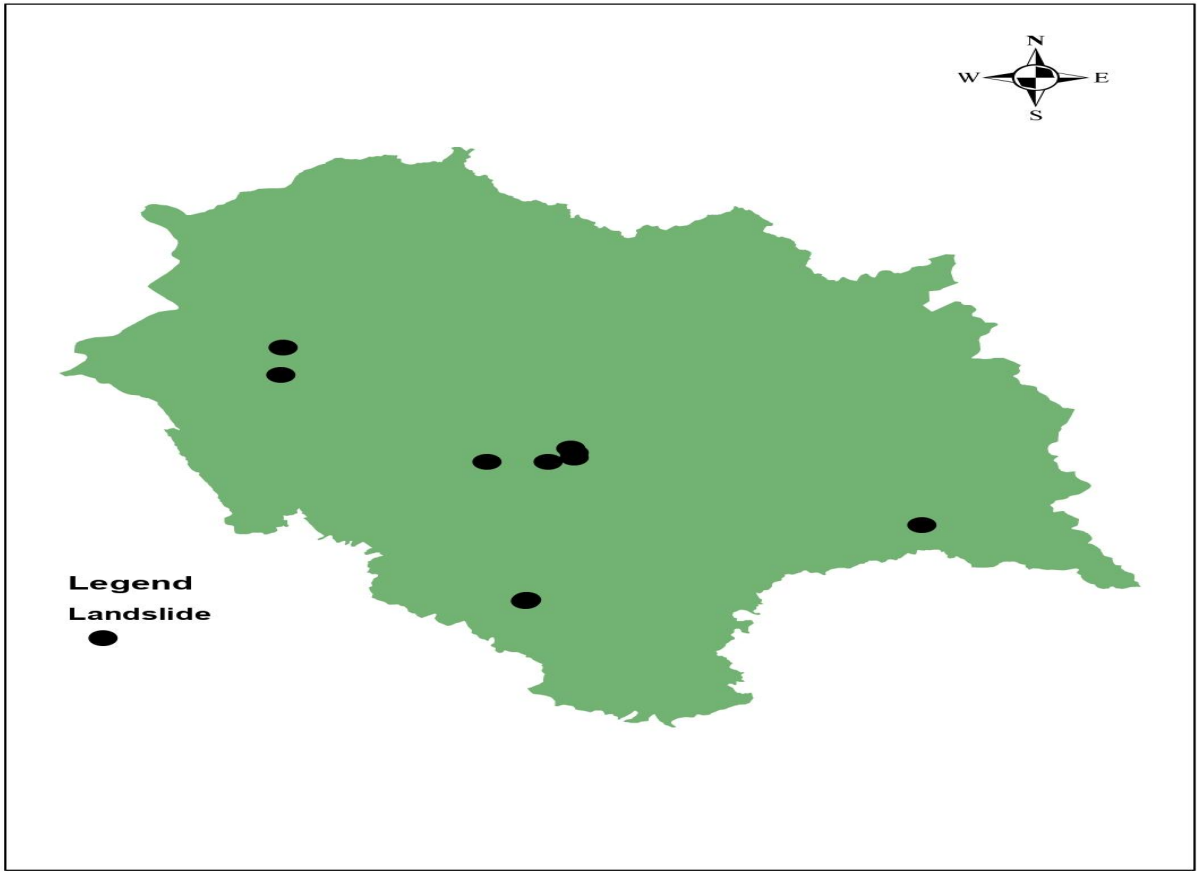
- **Plotting the collected data points (locations) onto the map of Himachal Pradesh:**

1)Locate these points or locations on the map using the data collected year wise in google earth pro, these points will automatically get saved as a different layer.

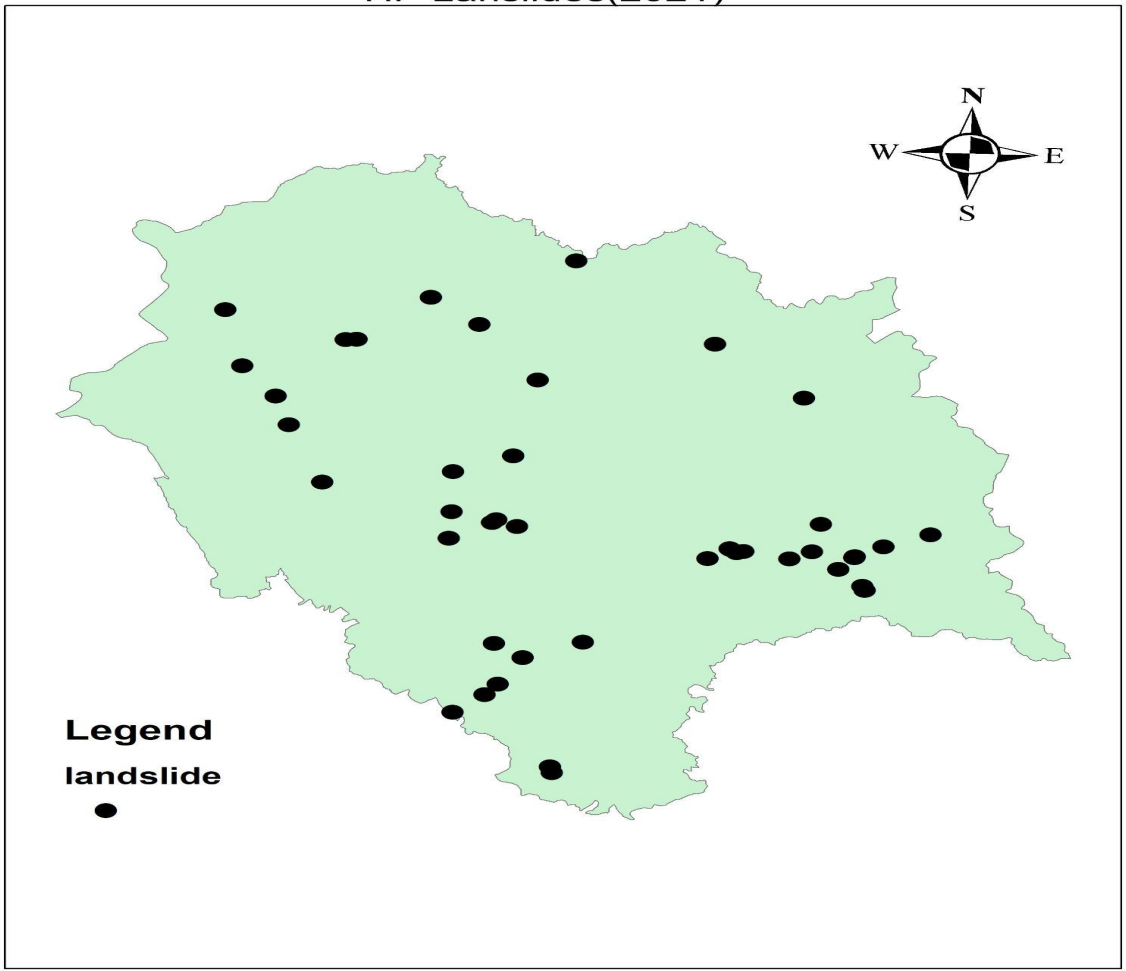
2) export the .kml file, then using this file we locate these landslides on the map of himachal pradesh with the help of ARCGIS by converting kml to layer.Landslide vector data of last 5 years is shown in the maps:


HP Landslide 2019
N
W
E
S
Legend
Landslide

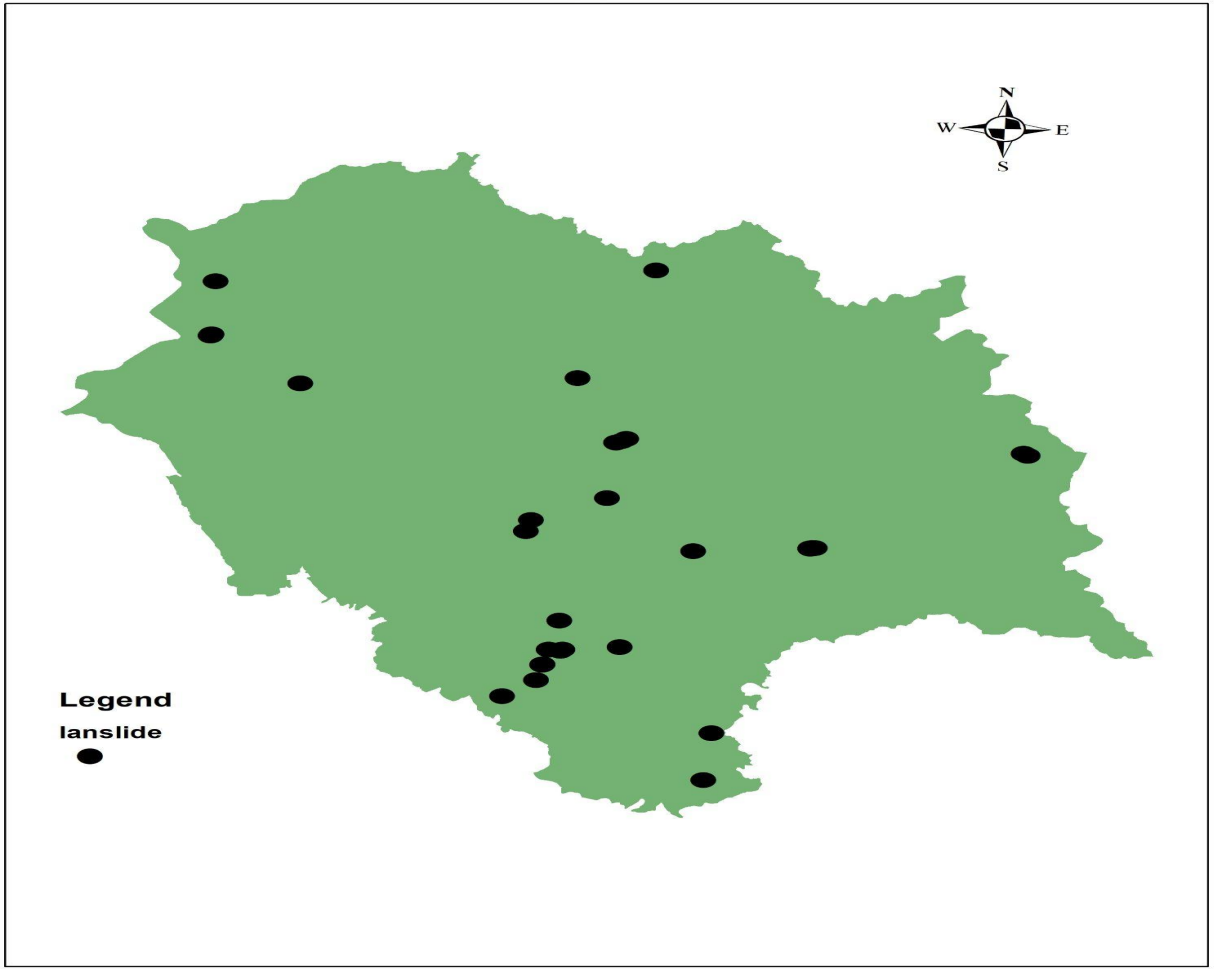
HP Landlsides 2020



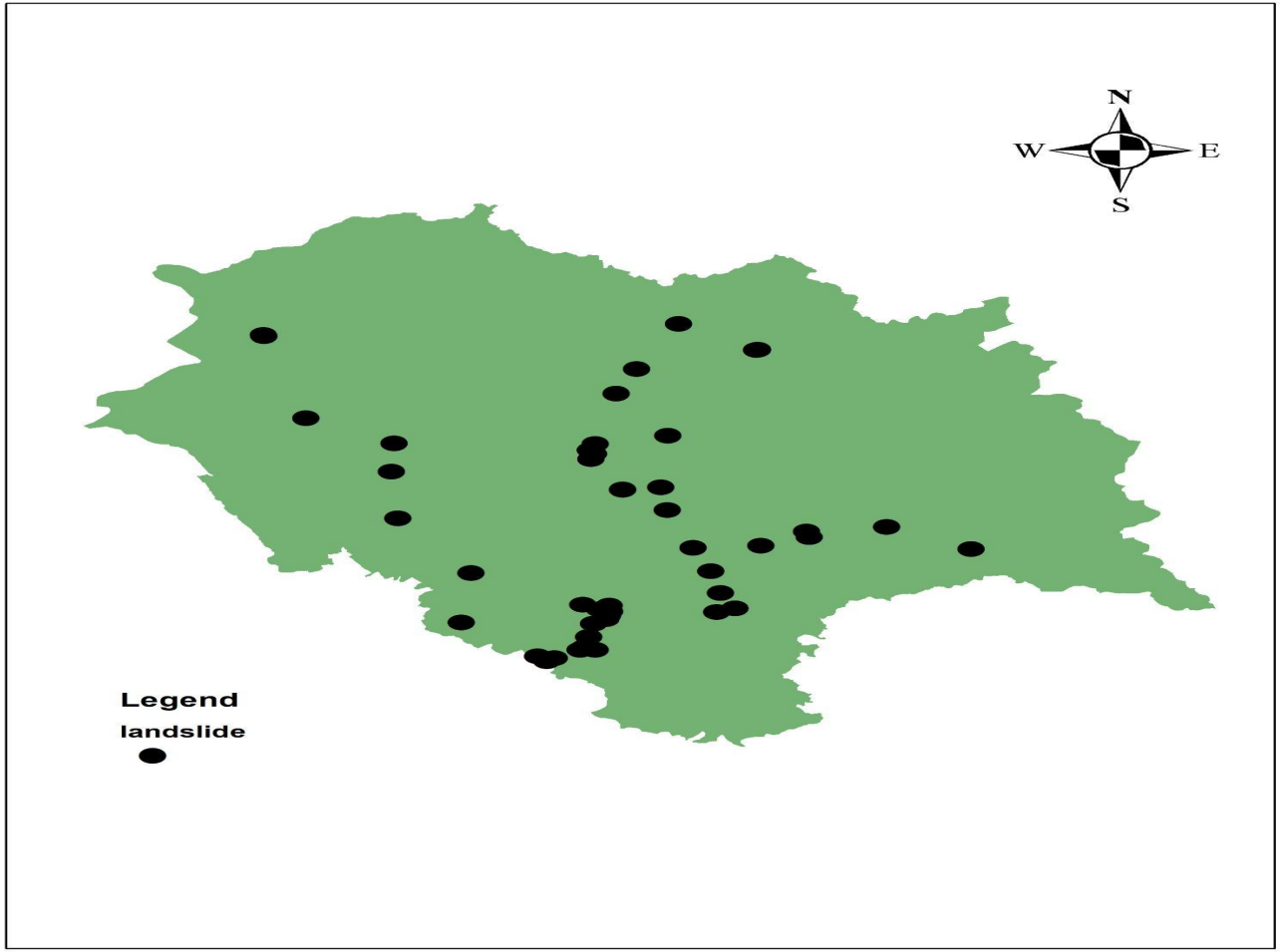
HP Lanslides(2021)



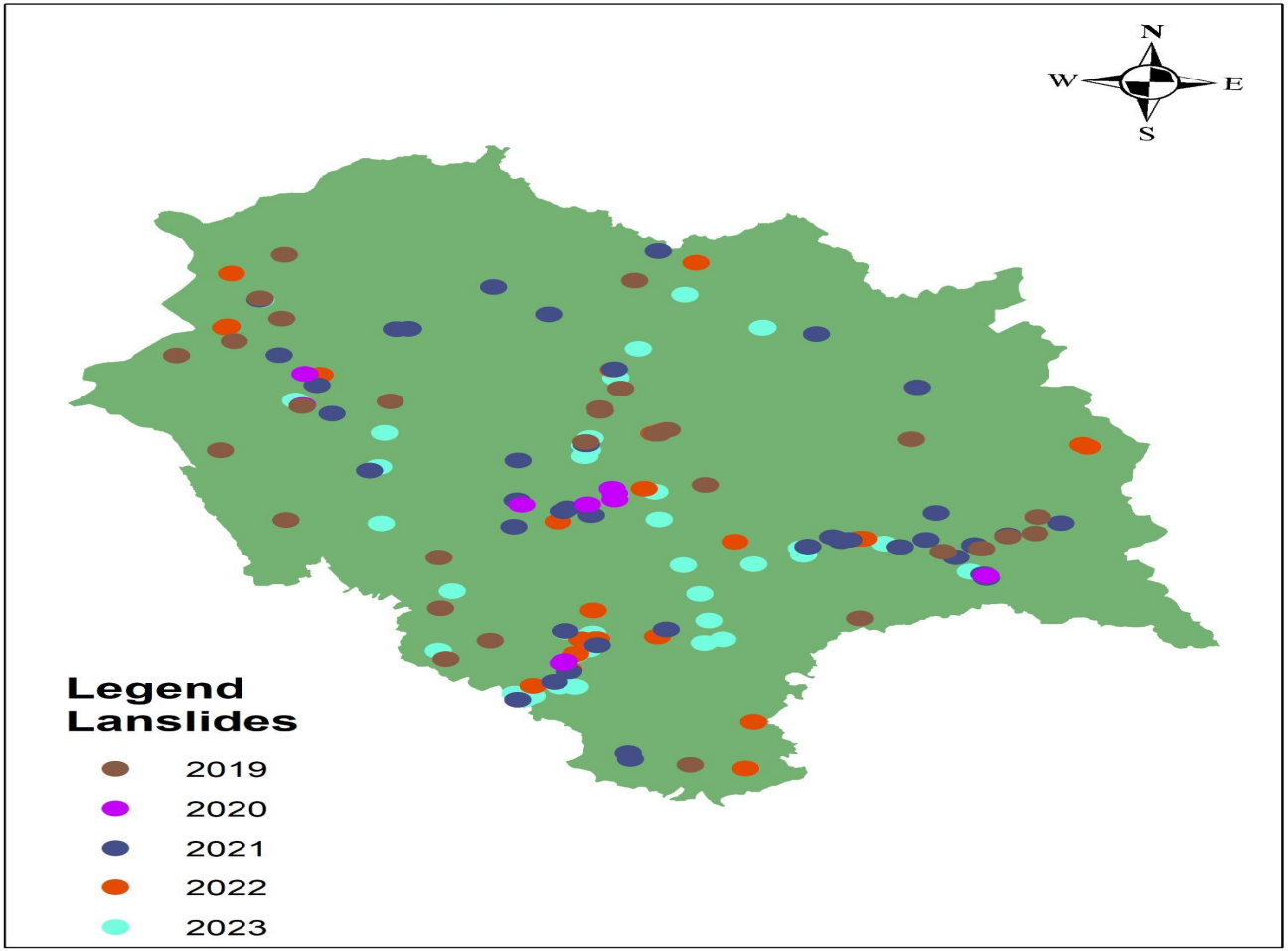
HP landslide 2022



HP landslide 2023



HP Lanslides 2019 - 2023

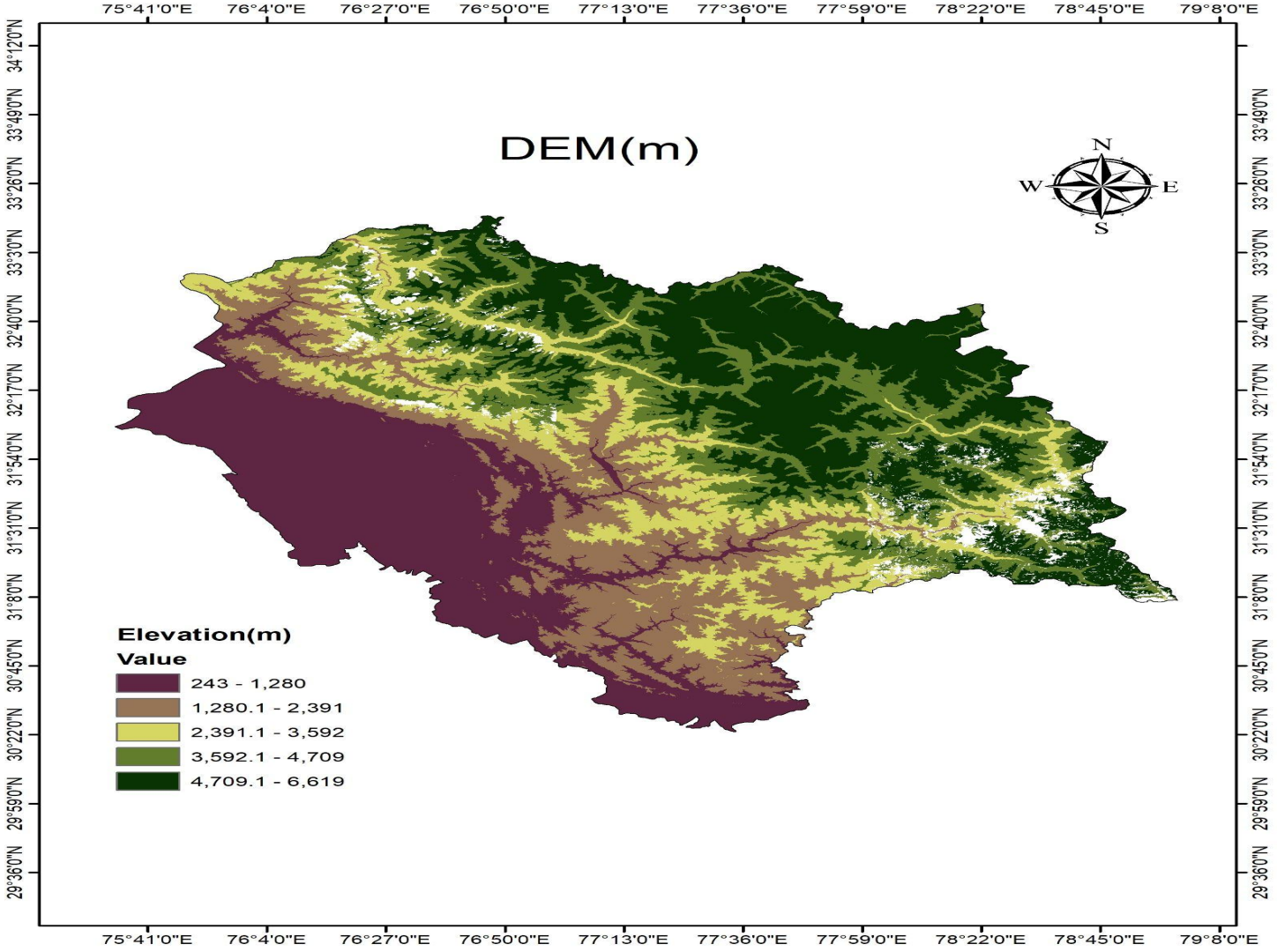


- USGS Data Retrieval:
  - Elevation Maps Data:

1)Access USGS Website(link) ,Earth Explorer(https://earthexplorer.usgs.gov/) .

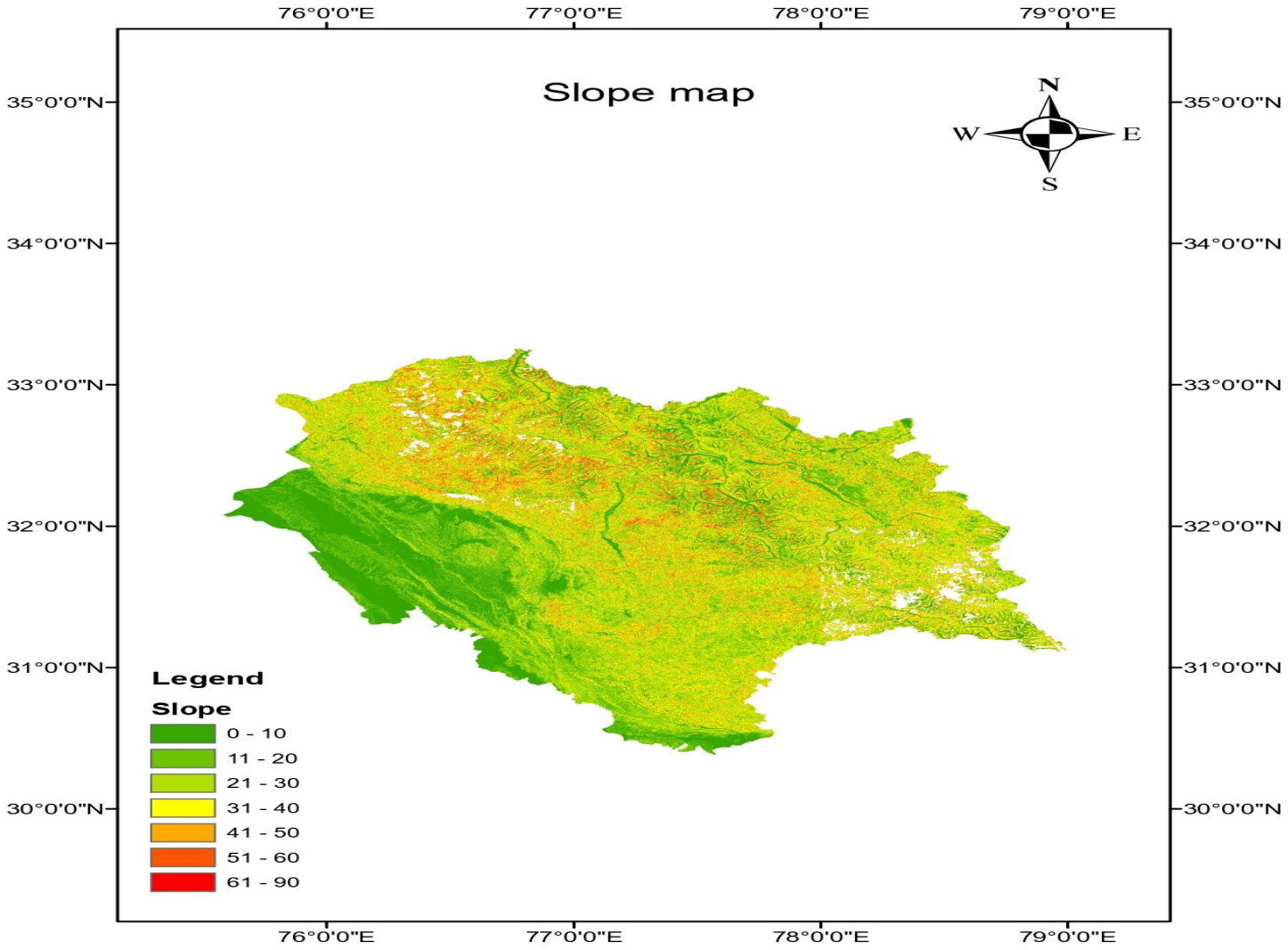
2)For digital elevation search for our study area ,then we selected point covering himachal pradesh then selected SRTM data under which SRTM 1 Arc-Second Global was selected.We obtained different tiles covering the area. All these tiles were downloaded as .tif files.

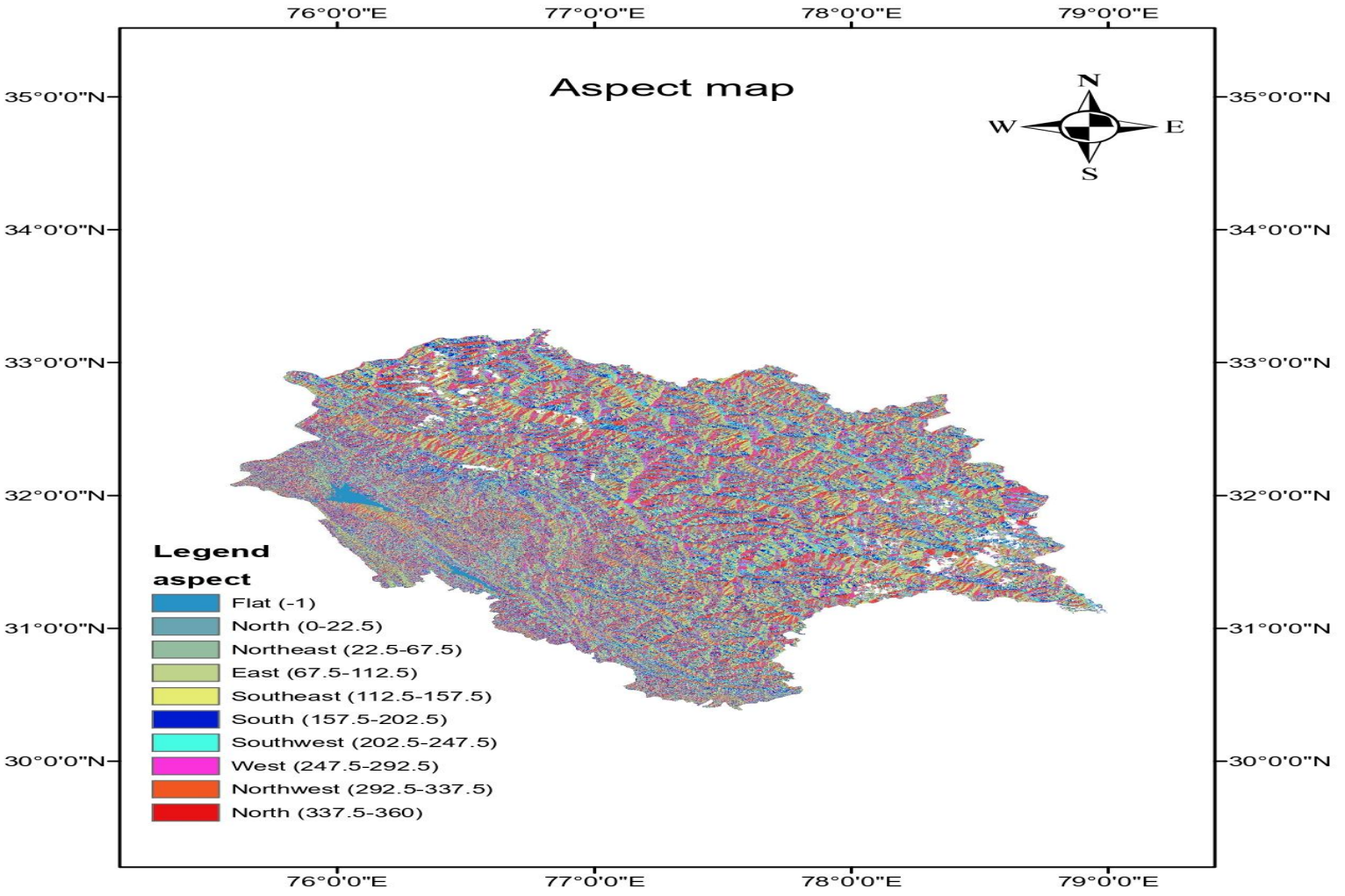
- We added all .tif files downloaded from earth explorer to arcgis then in ARCGIS an empty raster dataset is created. We mosaic all .tif and obtain them in previously created raster dataset as a single layer.Then add shape file of Himachal Pradesh and clip it with raster dataset of to obtain the Digital Elevation Model (DEM) (with resolution 1 ARC) of Himachal.


DEM(m)
N
W
E
S
75°41'0"E
76°4'0"E
76°27'0"E
76°50'0"E
77°13'0"E
77°36'0"E
77°59'0"E
78°22'0"E
78°45'0"E
79°8'0"E
34°12'0"N
33°49'0"N
33°26'0"N
33°3'0"N
32°40'0"N
32°17'0"N
31°54'0"N
31°31'0"N
31°8'0"N
30°45'0"N
30°22'0"N
29°59'0"N
29°36'0"N
Elevation(m)
Value
243 - 1,280
1,280.1 - 2,391
2,391.1 - 3,592
3,592.1 - 4,709
4,709.1 - 6,619

- Slope map: We made slope map of himachal using previously made DEM using spatial analyst tools in arcgis.The slope is divided into 7 different categories.
- Aspect map:Aspect represents the direction of the slope.It regulates the exposure to the sun ,the nature of erosion and the flow of water. Aspects are grouped into 9 classes such as: flat(-1°),north(0-22.5°),northeast(22.5° -67.5°),east(67.5°-112.5°),southeast(112.5°-157.5°),south(157.5° -202.5°),southwest(202.5°-247.5°),west(247.5°-292.5°),and northwest(292.5° -337.5°), north(337.5°-360°). The thematic layer of it is shown below. Similar to slope map we made aspect map of himachal using previously made DEM using spatial analyst tools in arcgis.

Note:For both the slope map and aspect map Check the projection and coordinate system of the datasets to ensure they align with your project's requirements. You may need to reproject or transform the data to match your analysis in ArcGIS.


Slope map
N
W
E
S
76°0'0"E
77°0'0"E
78°0'0"E
79°0'0"E
35°0'0"N
34°0'0"N
33°0'0"N
32°0'0"N
31°0'0"N
30°0'0"N
Legend
Slope
0 - 10
11 - 20
21 - 30
31 - 40
41 - 50
51 - 60
61 - 90


Aspect map
N
W
E
S
76°0'0"E
77°0'0"E
78°0'0"E
79°0'0"E
35°0'0"N
34°0'0"N
33°0'0"N
32°0'0"N
31°0'0"N
30°0'0"N
Legend
aspect
Flat (-1)
North (0-22.5)
Northeast (22.5-67.5)
East (67.5-112.5)
Southeast (112.5-157.5)
South (157.5-202.5)
Southwest (202.5-247.5)
West (247.5-292.5)
Northwest (292.5-337.5)
North (337.5-360)

- Soil map:

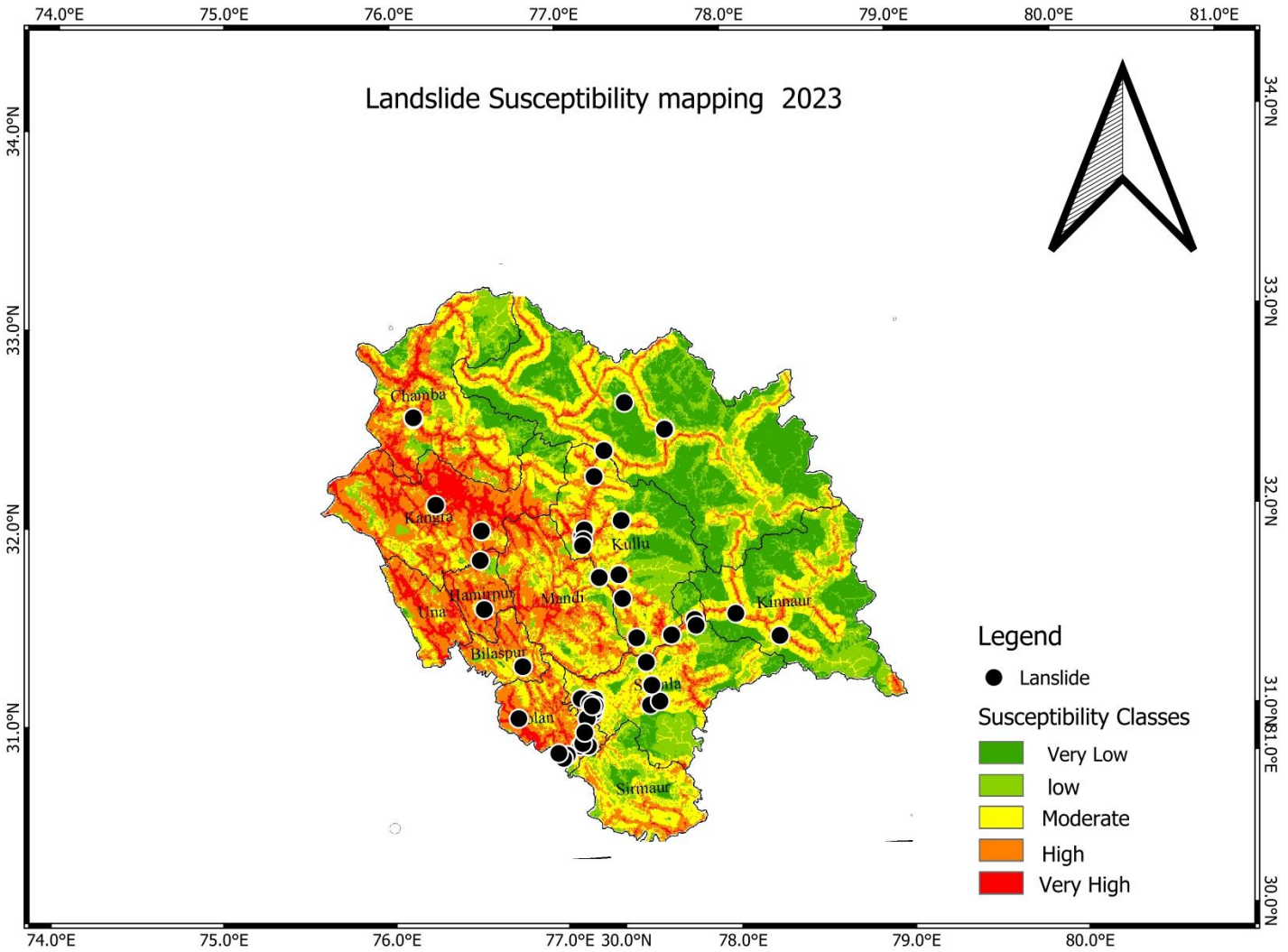
  1)Collected the data with the map containing soil types and their classification from FAO digital soil map of the world(dmsw) which is often available in .sbn and .shp formats.

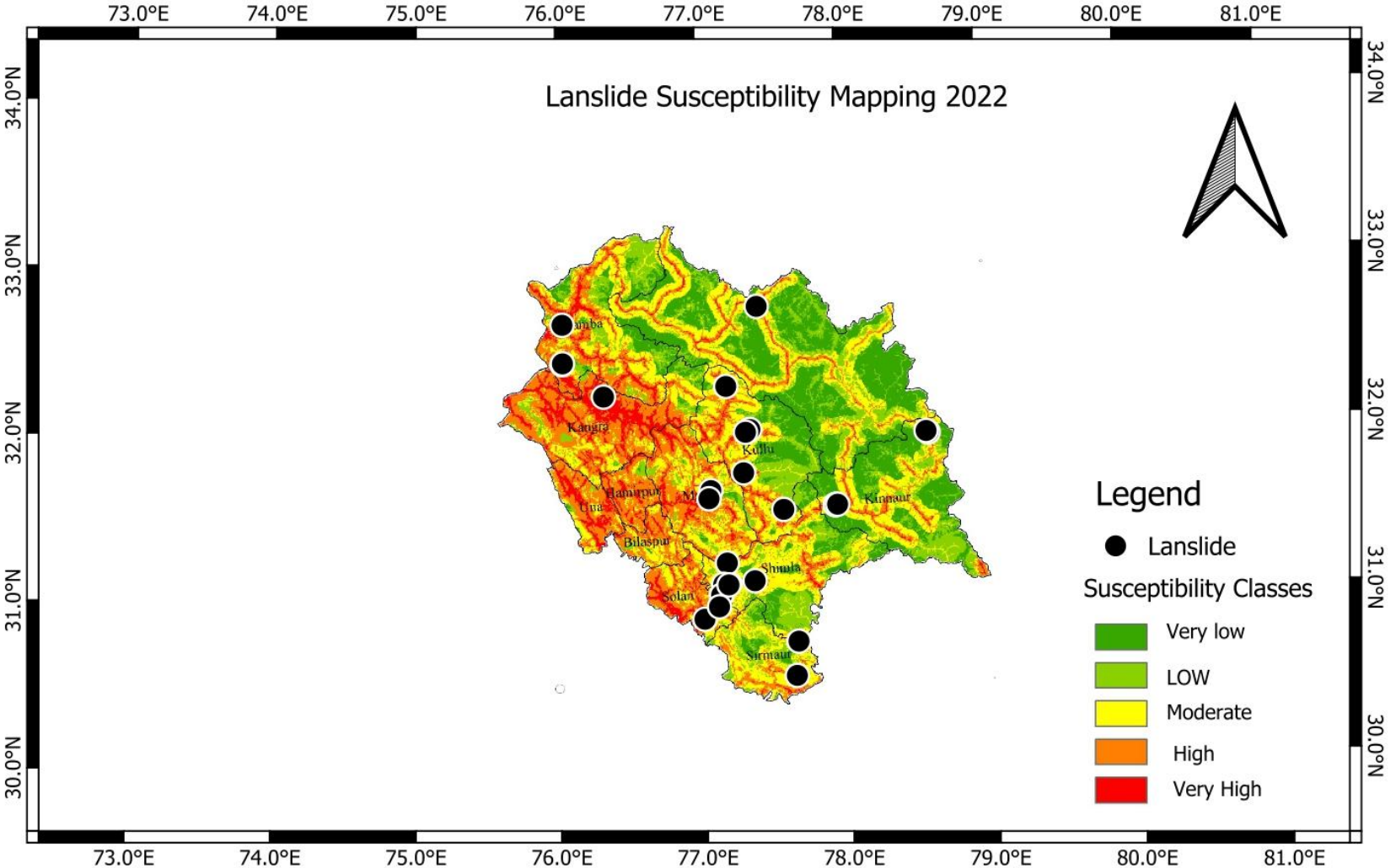
  2)From this map we need to impose a layer with himachal pradesh to obtain the classification map of the same.then add the labels,legends for the identification.

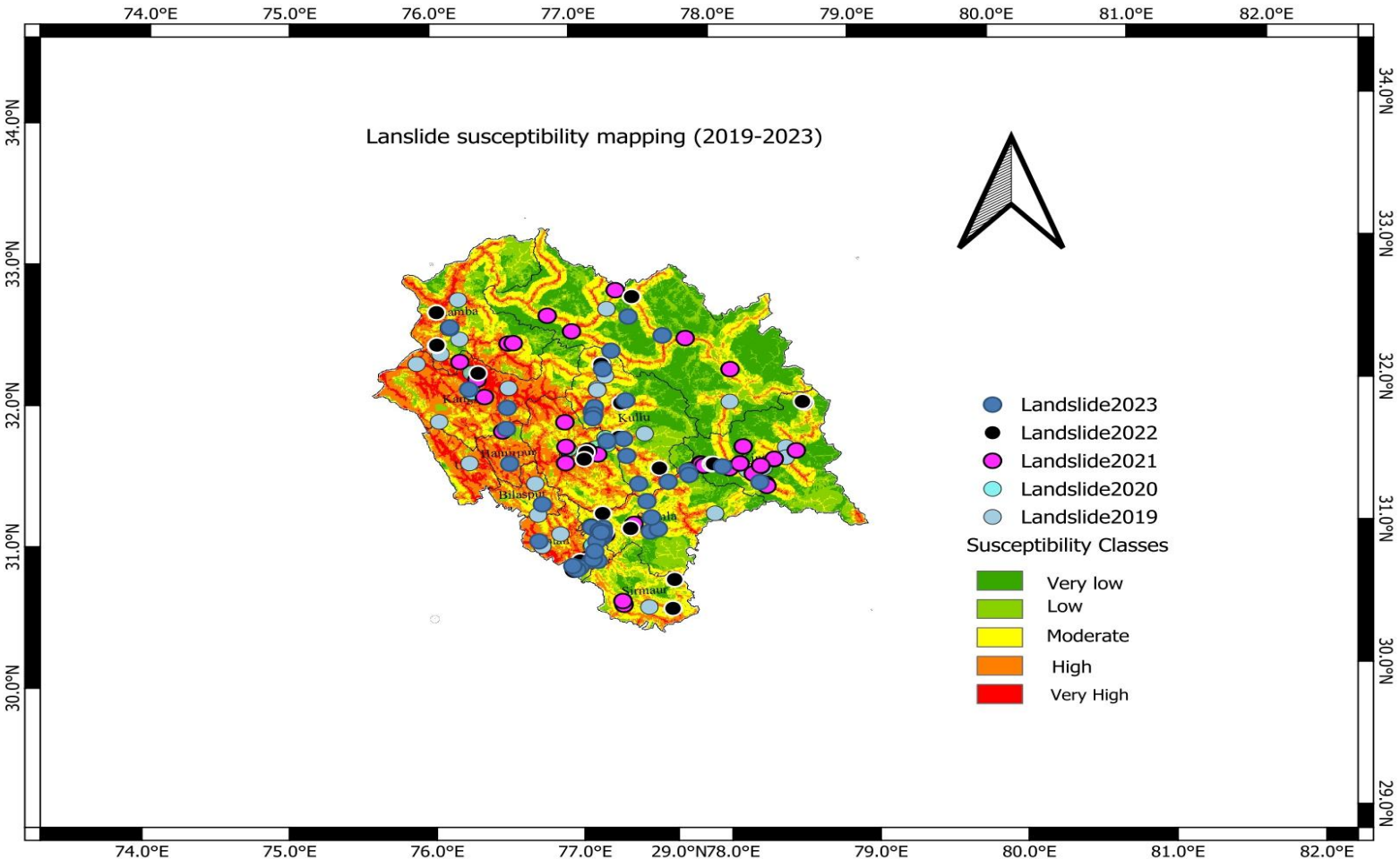
Soil map-himachal pradesh

Factors affecting Susceptibility

- Slope
- Lu & Lc(Land use and Land cover)
- Elevation
- Soil type
- Rainfall
- Drainage density
- Aspect
- Distance from road network


Landslide Susceptibility mapping 2023
74.0°E
75.0°E
76.0°E
77.0°E
78.0°E
79.0°E
80.0°E
81.0°E
34.0°N
33.0°N
32.0°N
31.0°N
30.0°N
Chamba
Kangra
Kullu
Hamirpur
Una
Mandi
Kinnaur
Bilaspur
Sirmaur
Legend
Lanslide
Susceptibility Classes
Very Low
low
Moderate
High
Very High


Lanslide Susceptibility Mapping 2022
73.0°E
74.0°E
75.0°E
76.0°E
77.0°E
78.0°E
79.0°E
80.0°E
81.0°E
34.0°N
33.0°N
32.0°N
31.0°N
30.0°N
Kangra
Kullu
Hamirpur
Una
Bilaspur
Shimla
Solan
Sirmaur
Kinnaur
Legend
Lanslide
Susceptibility Classes
Very low
LOW
Moderate
High
Very High


Lanslide susceptibility mapping (2019-2023)
74.0°E
75.0°E
76.0°E
77.0°E
78.0°E
79.0°E
80.0°E
81.0°E
82.0°E
34.0°N
33.0°N
32.0°N
31.0°N
30.0°N
29.0°N
Kullu
Bilaspur
Sirmaur
Landslide2023
Landslide2022
Landslide2021
Landslide2020
Landslide2019
Susceptibility Classes
Very low
Low
Moderate
High
Very High

Inference

- From the above three maps it can be observed that landslides occurred in the himachal region matches with the susceptibility map.Most of the landslides occurred lies in the very high susceptible class.

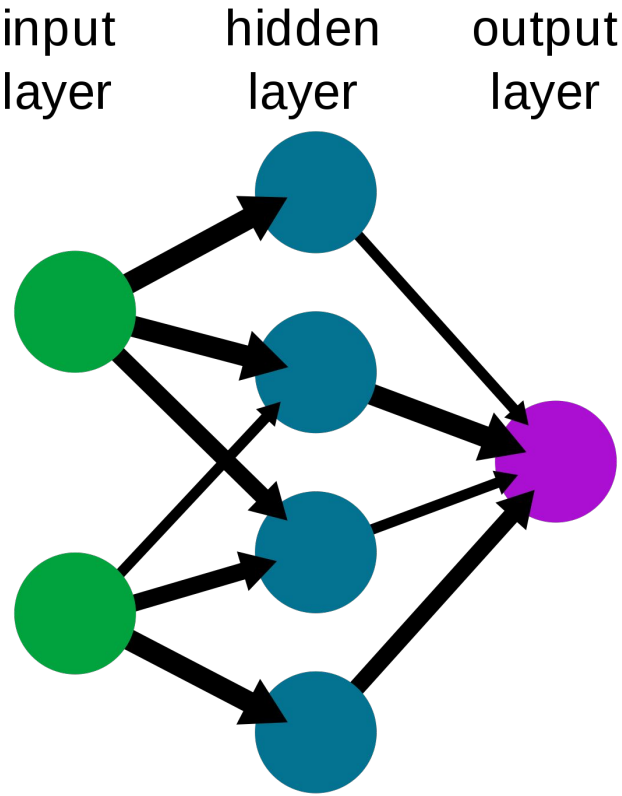
- The geographical visualization of both historical landslide events and susceptibility zones has provided valuable insights into the vulnerability of specific regions within the state.

References

https://www.usgs.gov/
https://indiawris.gov.in/wris/#/

Next Phase

- To develop rainfall susceptibility map using the collected rainfall data.
- Leveraging the power of neural networks to enhance our landslide susceptibility model.



Ongoing Project

Thank you