EGU GENERAL ASSEMBLY 2022

AN INTEGRATED APPROACH OF AHP-GIS BASED DAM SITE SUITABILITY MAPPING - A NOVAL APPROACH FOR FLOOD ALLEVIATING MEASURES

EGU Id: 638454

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INTRODUCTION

- Water is one of the most fundamental needs of all living things. There can be no life without water (Masum et al. 2020).
- Climate change and fast population growth are driving up, water demand (Schewe et al., 2014)
- The need for constructing dams has grown in order to meet the demands for irrigation, drinking water, water resource productivity, and drought control systems, and the construction dams has social, environmental, and economic impacts (Islam et al., 2019).
- GIS and Multi-Criteria Decision Analysis (MCDA) are powerful spatial analysis and decision-making tools (Malczewski, 2004).

- The majority of research used different types of decision-making techniques to establish the most acceptable location for dam sites (Gholami & Rasouli, 2014).
- As a result, multi-criteria decision-making (MCDM) and GIS has been being integrated to improve site suitability analysis (Abdulkareem et al., 2018).
- Due to its simple handling approach, the AHP is the most prevalent and widely utilised MCDM technique.
- Dam sites suitable for dams have been proposed along the Lower Tapi River due to the region's need for reservoir capacity

OBJECTIVE

- Because of the management and replenishment of water resources, explore suitable places in the lower Tapi basin for dam construction. To check whether there is any shortage of water at particular node.
- Categorize and plan relevant geomorphological, geological, and meteorological factors, to determine their contribution to identify the best sites for dam construction.
- To create a dam site suitability, by using AHP approach of decision making followed by overlay analysis.

STUDY AREA

- Surat district is situated in the delta region of the Tapi River between latitudes and longitudes of 21°03′ N to 21°18′ N and 72°42′ E to 72°55′ E respectively.
- An average annual rainfall of 1376 mm has been received by the Lower Tapi basin
- The district spans a total area of 4,418 km2 with an average elevation of 13 m.The village is over 11 metres above sea level.

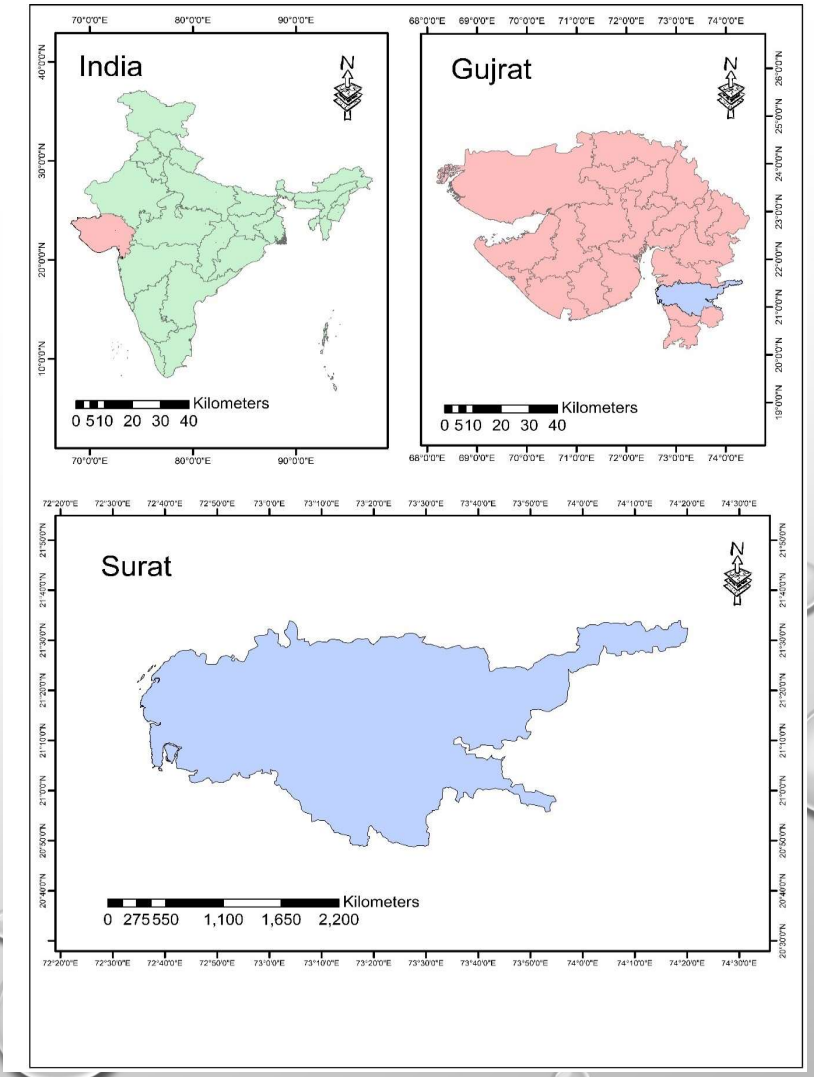


Figure 1. Index Map of Study Area

METHODOLOGY

- To begin, we need to obtain the raw data needed to create the research area's thematic layer maps. Population Forecasting.
- In the second stage, processing of raw data was done to create thematic layers.
- In the last stage, overlay analysis is done by processing the thematic layers to map and model the suitable dam location best suited for the Surat district. Simulation.

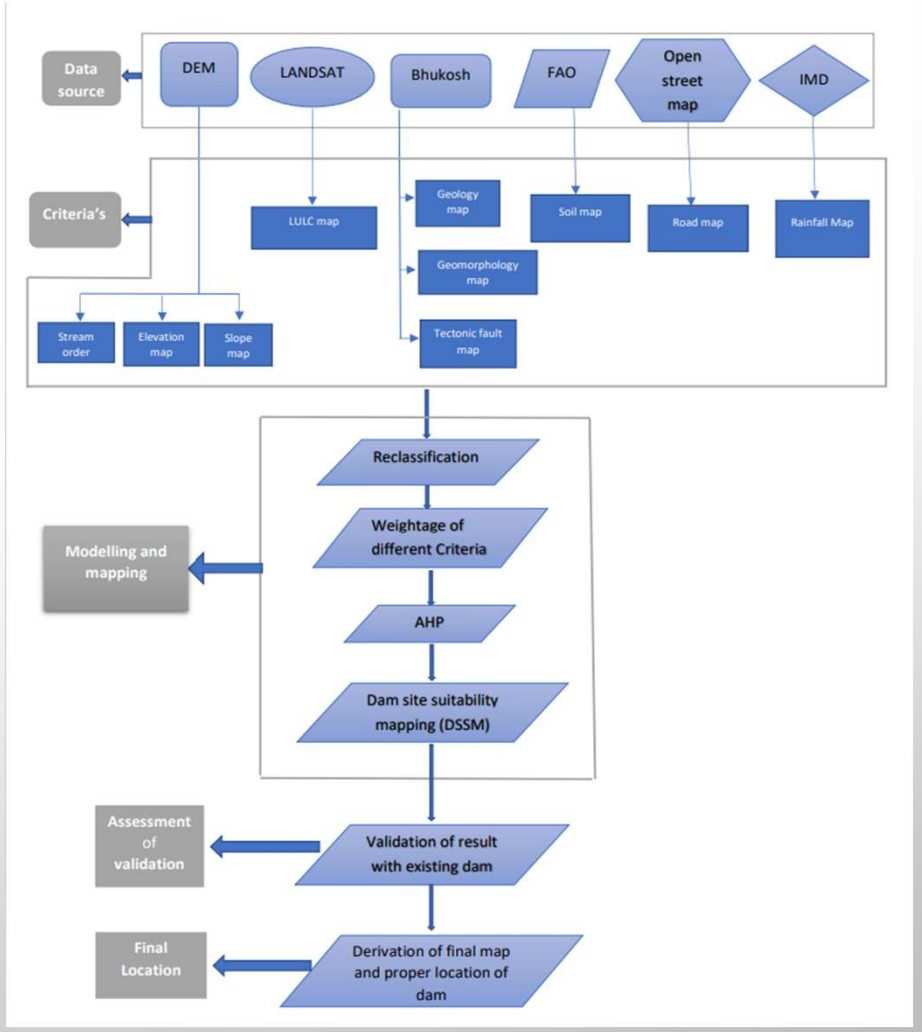
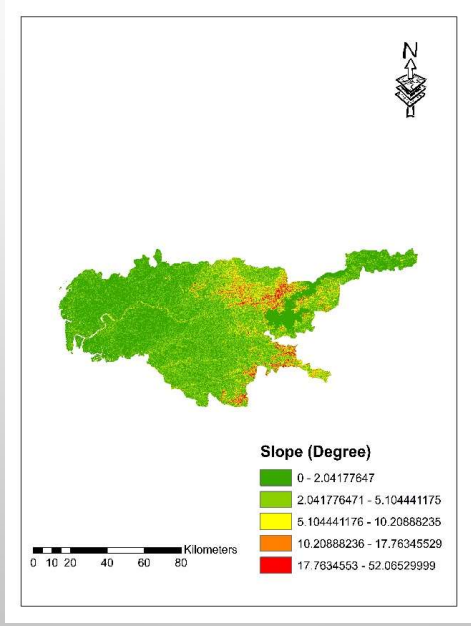


Figure 2. Flow Chart for Methodology

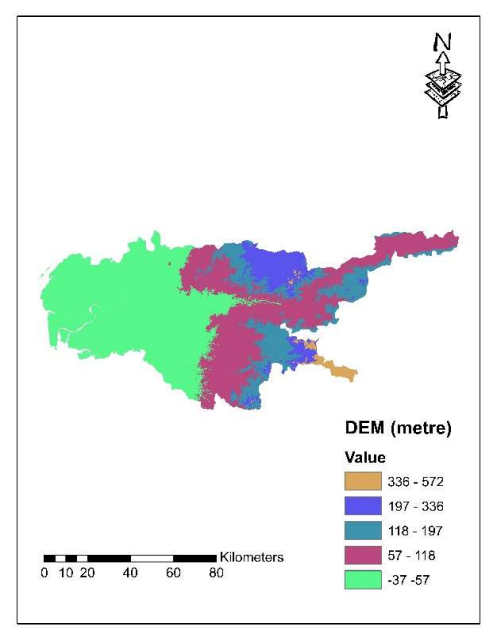
CRITERIA USED FOR MODEL BUILDING

- **Slope:** Usually, slopes have a very significant role in various aspects, like infiltrated water to the ground, flow speed, and reservoir volume.
- The possibility of water accumulation will be higher when the slope is low. Climate change and fast population growth are driving up, water demand (Schewe et al., 2014)



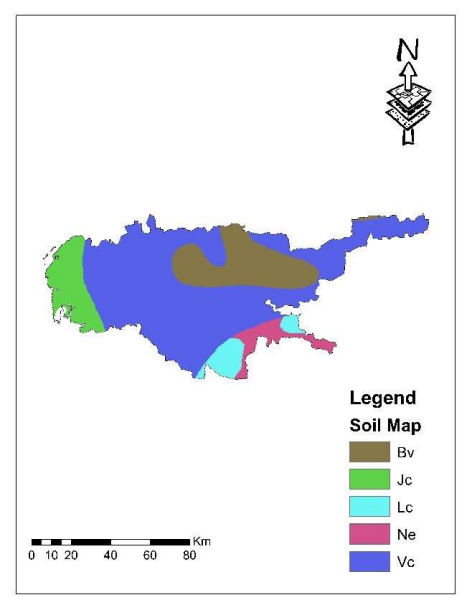
CRITERIA USED FOR MODEL BUILDING

- **Elevation:** Elevation influences dam location as it affects the flow accumulation and water velocity.
- Generally, because the accumulation of groundwater as well as precipitated water is higher at low elevations, it has been considered the best criteria for the construction of dams



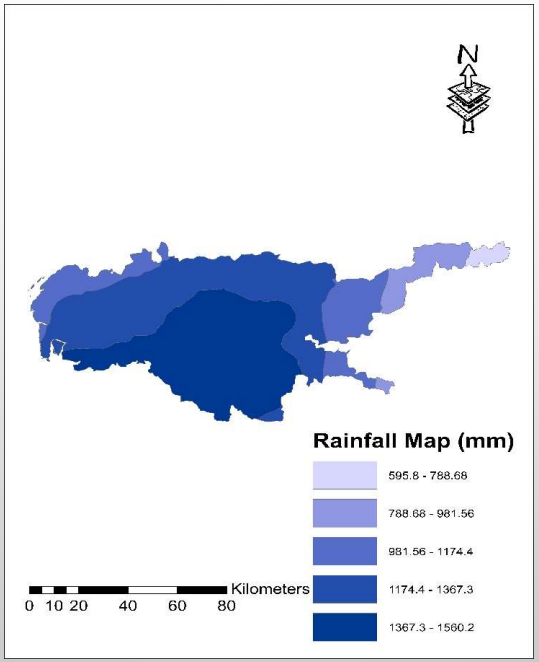
CRITERIA USED FOR MODEL BUILDING

- **Soil texture:**. Soils with a high concentration of sand have relatively large pores, allowing water to drain freely. These soils have a lower drainage rate.
- The size of the pore space shrinks as the quantity of clay in the soil increases, restricting water circulation through the soil and increasing runoff



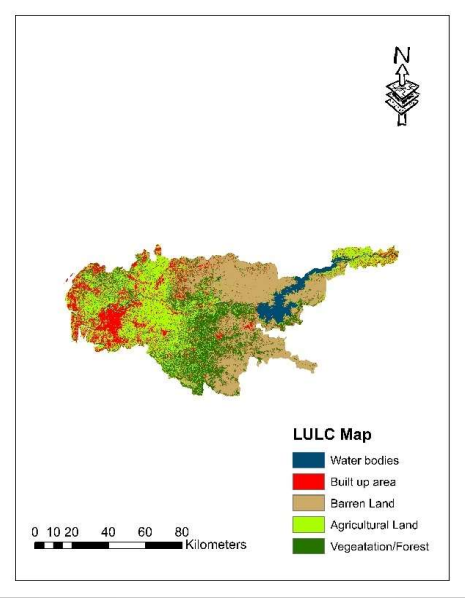
CRITERIA USED FOR MODEL BUILDING

- **Rainfall:** The peak discharge of a river is attained when there is a high intensity of rainfall.
- The higher the intensity of rainfall, more will be water in the river, so higher the discharge.



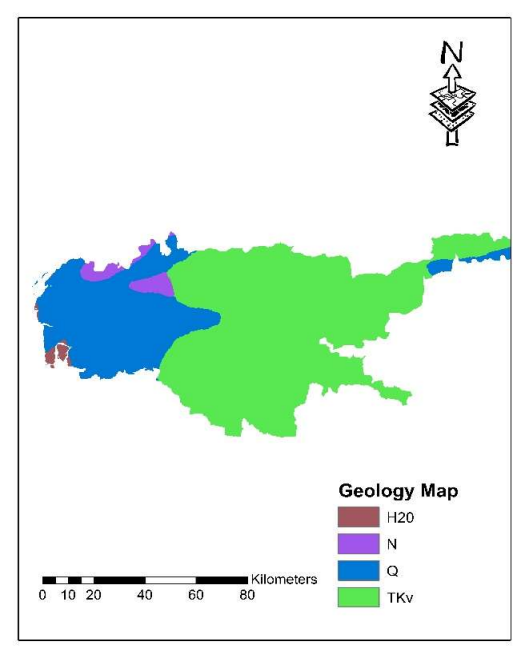
CRITERIA USED FOR MODEL BUILDING

- **Land use land cover:** The land cover of an area is one of the most essential aspects because it indicates the current use and pattern of the land, as well as the significance of that usage in relation to the population and current growth
- Built up area, which has low impermeability and Water bodies have high chance of flood area.



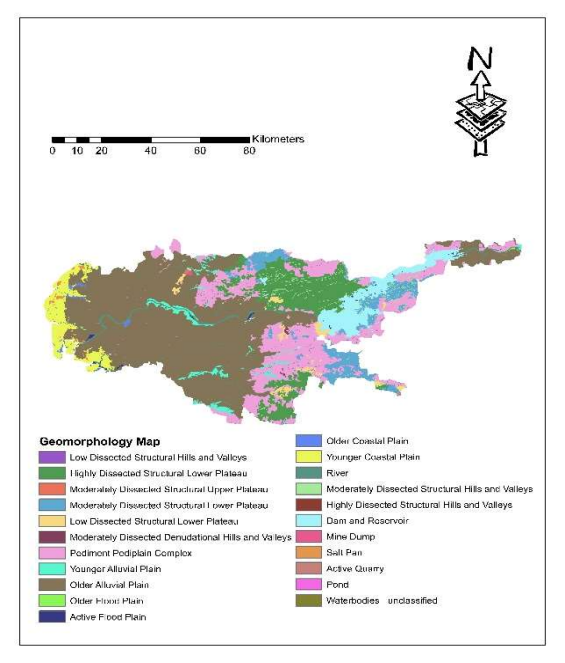
CRITERIA USED FOR MODEL BUILDING

- **Geology:** The geology beneath the dam is a critical component in integrating the dam's base wall.
- Generally, hard rock is suitable for dams.



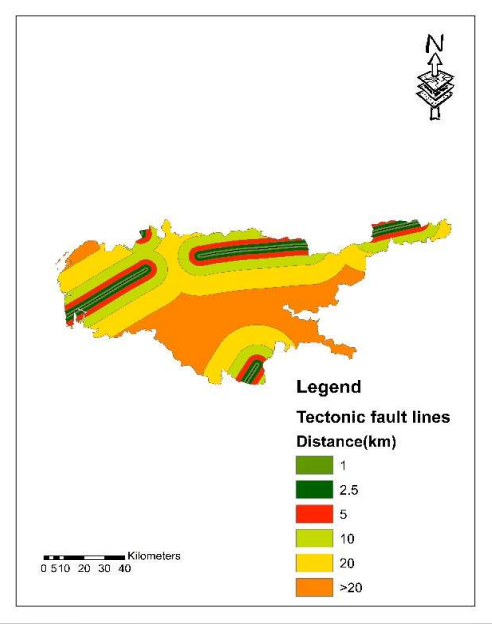
CRITERIA USED FOR MODEL BUILDING

- **Geomorphology:** The geomorphology layer represents the physical features (primarily concrete buildings and asphalt roads etc).



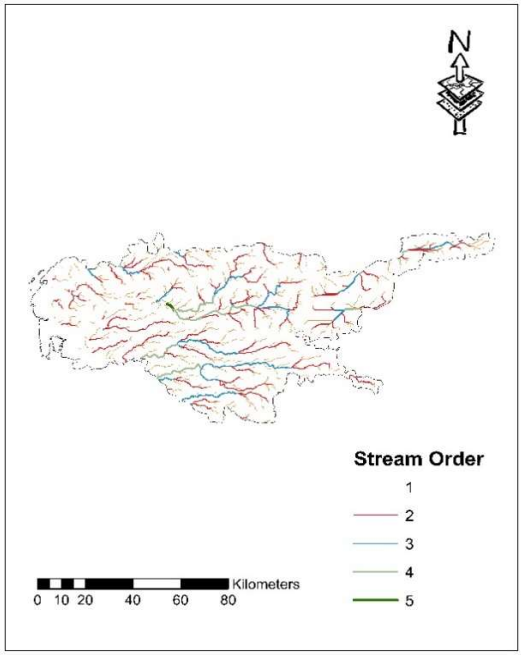
CRITERIA USED FOR MODEL BUILDING

- **Major fracture Euclidean distance:** Based upon major fracture line the streamflow directs from higher to lower points.
- For considering a suitable dam site at least, a distance of 100m minimum away from the tectonic fractures and faults should be there.



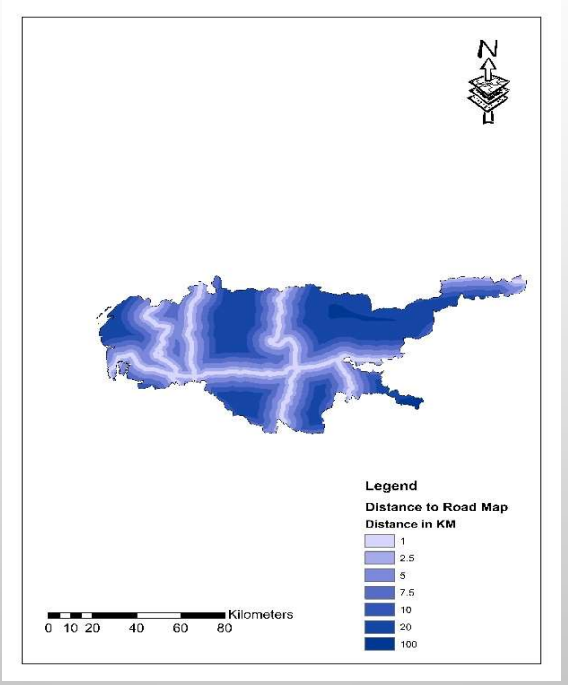
CRITERIA USED FOR MODEL BUILDING

- **Stream order:** The total amount of surface water available is proportional to the stream order, and some structures are better suited to a specific drainage order, such as check dams, which should be built-in lower order streams.



CRITERIA USED FOR MODEL BUILDING

- **Distance to road:** The distance of the dam site from the main road is one of the significant socio-economic criteria for the construction and population of the city.
- The dam site should be easily accessible for transportation of goods



RECLASSIFICATION

- The reclassify tool of ArcGIS has been used for the reclassification of the raster layers.
- Based on expert judgments, raster layers were reclassified into five groups, except for geology, which has been classified into four groups.
- The pixel size of each layer has been kept at 30 m x 30 m spatial resolution.
- While identifying the suitable site for the analysis of potential dam sites, all of these criteria were taken into account.

ANALYTICAL HIERARCHY PROCESS (AHP) ANALYSIS

- It is one of the Multi-Criteria Decision Making tools developed by Prof. Thomas L. Saaty in 1990.
- The parameters are arranged in a structured hierarchy at multiple levels, such as objective, criteria, and alternatives.
- The criteria's priority is determined by a pairwise evaluation of the criteria with respect to the desired objective. Then, to ensure a fair level of consistency in terms of proportionality and transitivity, the derived priorities are tested for consistency of assessments.
- Developing local priorities for the options, i.e. determining preferences for each criterion independently and then checking for consistency if needed.
- Developing overall priorities means combining all alternative options collected while taking into account the weight of each criterion to determine the alternatives' overall priorities. The best option will be the one that has the highest priority.

RESULT:

ANALYTICAL HIERARCHY PROCESS (AHP) ANALYSIS

Factors	Final Weight (%)
Rainfall	24
Stream Order	24
Slope	12
Geology	9
Geomorphology	9
Soil	6
LULC	5
Elevation	5
Tectonic Fault Line	3
Distance to Road	3
Total weight	100

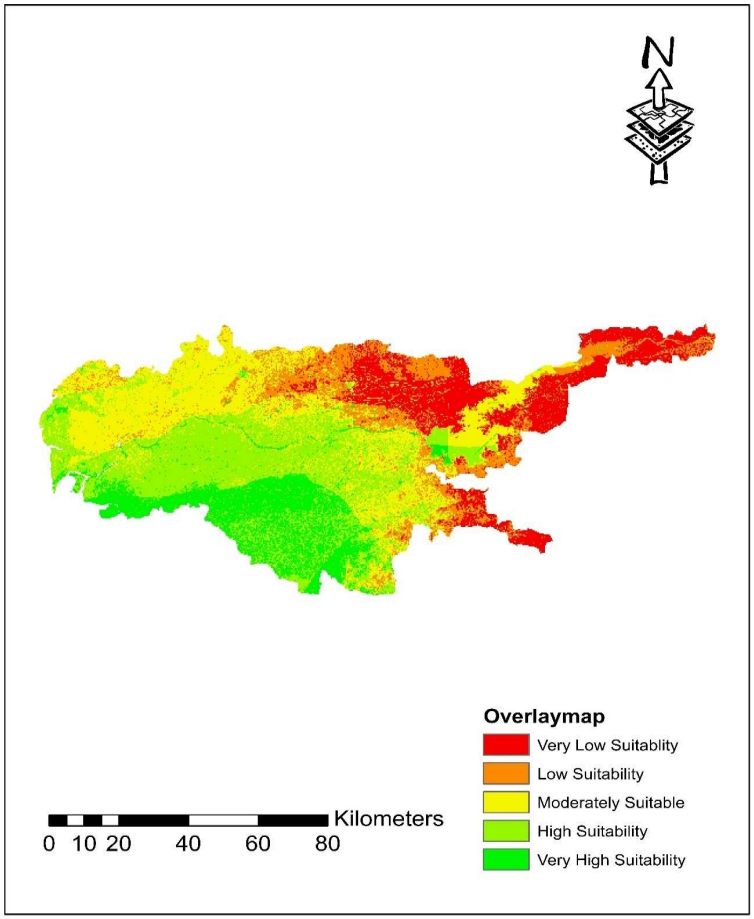
Table 1 Weightage for each factor

OVERLAY ANALYSIS

- The values of weights from the above table were given to the "scale value" and "impact percent" options in the tool.
- The spatial resolution of 30m × 30 m and their derived weights are entered into all raster layers.
- In the first step, stream order was incorporated into the overlay analysis.
- In the second step, the Euclidean distance layer is employed to calculate the stream order reciprocal.

DAM SUITABILITY MAP AND ITS IMPACT

- After calculating the weightage of each map from AHP and applying them in the ArcGIS overlay analysis, we have obtained the dam suitability map.
- The map was created by using a reclassified raster layer with the same pixel size as other layers in overlay analysis, i.e. 30 m X 30 m.
- A suitability map for constructing dams in Surat district, which is shown in fig 4, was prepared using overlay analysis with five different suitability levels: Extremely Low Suitability, Low suitability, Moderately Suitability, High Suitability and Very High Suitability.



DAM SUITABILITY MAP

CONCLUSION

Following are the concluding remarks from the study:

- A dam suitability map and various prospective dam sites with profiles were created for the Surat district in Gujarat in this study.
- For this investigation, ArcGIS was utilised as the software tool. Rainfall, stream order, geomorphology, geology, distance to road, soil, land use, and land cover were among the ten thematic layers evaluated in the development of the DSSM.
- The newly discovered technology can be used in conjunction with established methods to find new dam construction sites because it is more efficient and saves time and money.
- this method is less time consuming, more accurate and can be used to find potential locations for different large watersheds.

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THANK YOU