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PERCOLATION SPOT LOCATION USING GIS FOR CHECK DAM CONSTRUCTION- TIRUTTANI BLOCK

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Abstract - In this wide world, the human kind is abundantly depends upon ground water for living and meeting their day to day needs. Ground water is considered as a vital source in the universe, which contributes inherently in total annual supply. But, there comes the problem of over – exploitation too. This may be provoked due to the carelessness of the people, faulty storage methods etc. Therefore, the storage of water is treated mandatory. One of the ways is about assessing the water pot zones or potential zones for ground water recharge. These zones are utilised for protection and management of ground water systems. The mission of the paper is to identify such zones using Geographic Information System techniques at the particular study area "Tiruttani". The usage of thematic layers for the study area namely soil texture, soil infiltration, geology, geomorphology, land use land cover, rainfall, drainage and slope (Mohanavelu Senthilkumar et al., 2019) and the method of Weighted Overlay Analysis in Arc GIS software is examined in detail. The outcome is retrieved in three categories viz. Low, medium and high suitability areas and thence generated the percolation spot location for check dam construction.

Keywords: Water pot zones, potential zones, QGIS, Arc GIS, check dam.

I. INTRODUCTION

There may be several stuff in this globe seem to be indispensible where water bags the first position. Water is essential to all the living creatures for their existence. From individual activities like drinking, bathing etc., to heavy production activities like agriculture, industries etc., use water every day. So, the **water is known as irreplaceable component.** But, while using water, a limited amount of water is exploited without the user's knowledge. Each and every civilian living in this resourceful world, are answerable for the depletion of water level which ultimately results in scarcity. Thus, **water conservation** has become an enormous responsibility for every humans being. **But natural changes like global warming, climatic crisis, flood, drought etc., add more hard knocks, also hindering the conservation process at a whole.**

In order to sustain water content for the forthcoming generation, it is essential to diagnose the percolation spots. Defining the process of **percolation, it is the downward flow of surface water through the layers of soil** which enhances ground water recharge. This recharge is achieved naturally through lakes, rivers etc., which varies from one place to another. But the place which has plentiful content of water is considered as the perfect percolation spot location and this can be accomplished with the erection of check dams. A **check dam is a small weir like structure** which are constructed to reduce slope and sediment issue and retard the velocity of water which subsequently scaling down the erosion problem. These **structures are not compulsorily permanent, but can be temporary also** that are erected across a waterway or drainage ditch, using the materials like rocks, sediments retention fibre rolls, masonry etc.,. The construction of these check dams at the rich contented percolation spot using GIS is the motive of this project.

II. OBJECTIVE AND SCOPE

Every paper has its own objective and scope, so that the purpose of the paper is easily interpreted by the readers. Objectives and scope may look alike but there exists a difference. The **objective or aim is the result** that is obtained at the end or predetermined on the process of the execution and the **scope is that stage where the data is prepared or collected** which makes way to achieve the result.

So, the **objective of this paper** is

- → To score an intensive wisdom in the stream of GIS.
- → To expertise in locating the check dam positions.
- → To generate suitability map for the study area.
- → To figure out the percolation spots with high accuracy.
- → To become familiar in the software QGIS and Arc GIS.

Also, the **outlook or scope of this paper** is

- → To formulate the required thematic layers in all categories.
- → To halt the erosion of land and use water efficiently.
- → To analyse the water scarcity level and locate the percolation spot accordingly.

III. ATTRIBUTES OF THE STUDY AREA - TIRUTTANI

Our study area, Tiruttani is a town which is in the state of **Tamil Nadu** in the district of **Tiruvallur** (Fig. 1). The location is spotted at the coordinates of **13.18°N 79.63°E**. It has an average elevation of **76 metres *i.e.*, 249 feet**. This region has a time zone of UTC+5:30 (IST). The climatic type prevailing is tropical climate *i.e.*, the average temperature of above 18°C (64°F) and has considerable precipitation during the least part of the year. The average precipitation for this area is **1047mm (41.2 inches).** The superficial area of Tiruttani is **448 km^2** in which rural and urban area is covered for 435.5 km^2 and 12.5 km^2 respectively. Based on the census of 2019/20, the population of Tiruttani is between **72003 and 91303**. In order to conserve these many people and their land, the water from various sources like rain water, ground water etc. the construction of check dams is considered serviceable. Moreover, in this region May month and December month is mediated as the warmest and coldest months of the year with the average temperature of 33.2°C (91.8°F) and 24.1°C (75.4°F) respectively.

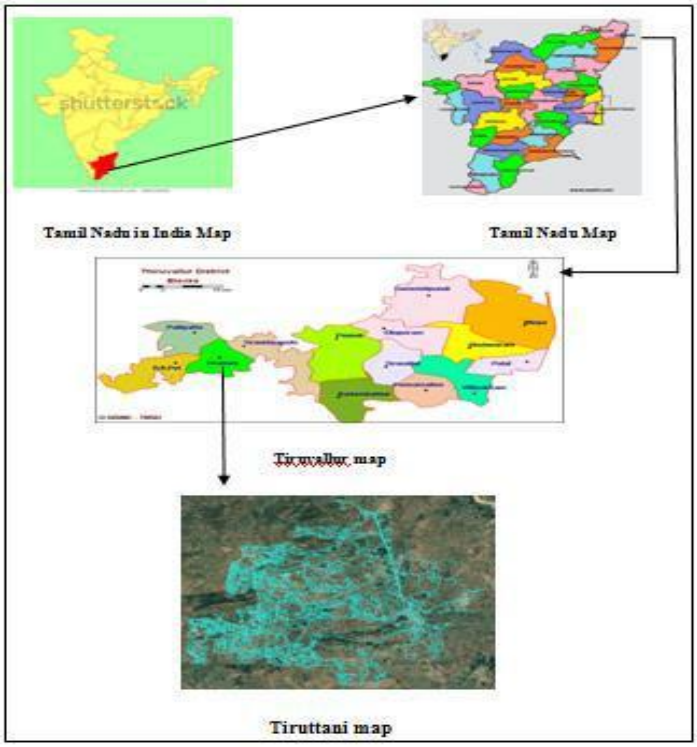

Fig.1 Key Whole Map

IV. METHODOLOGY

The methodology flow chart is required to know the procedure pictorially. Thus Fig. 2 represents the methodology chart

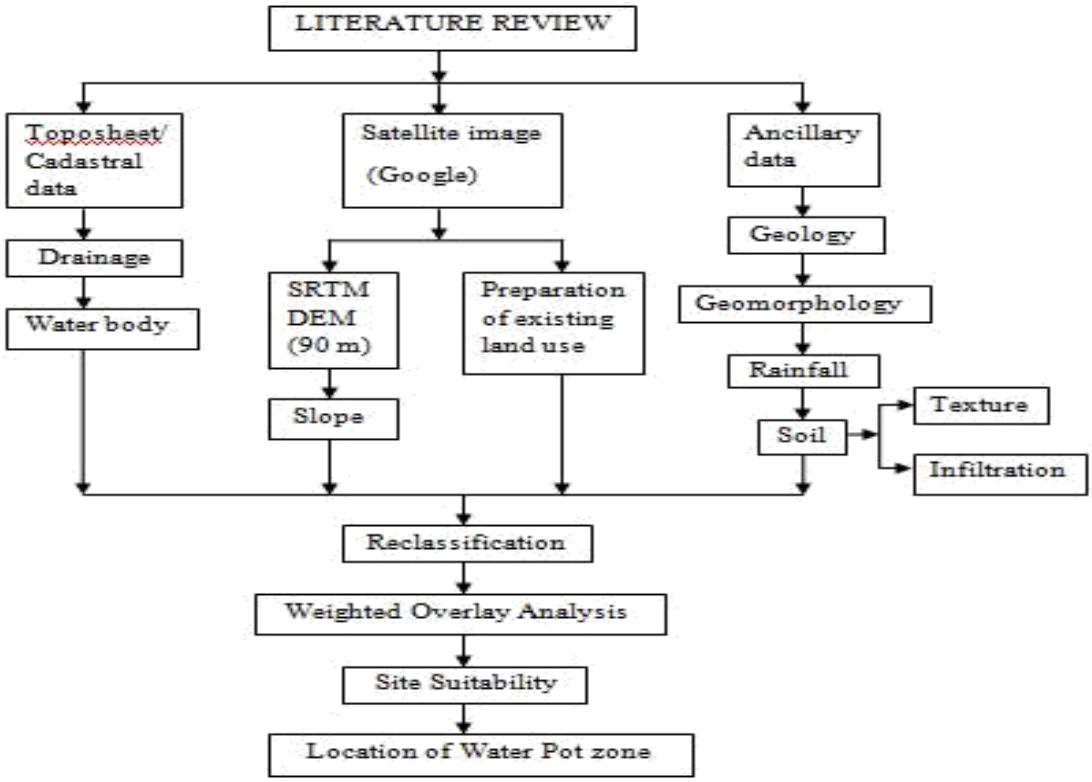

Fig. 2 Methodology Flow Chart

A. Sources Of Required data

- From toposheets, drainage pattern is obtained.
- From satellite and SRTM DEM data, slope details are obtained.
- From satellite, land use land cover data is obtained.
- Geology map from Geological Survey of India.
- Geomorphology map from Bhuvan, a national Geoportal hosted by ISRO.
- Rainfall data from Indian Meterological Department (IMD).
- Soil texture and infiltration maps from Tamil Nadu Agricultural University (TNAU).

After the above collection, the **steps of reclassification, digitization and analysis** are done where Arc GIS software is utilized. The result has been obtained on the basis of above sources and analysis, under the categories of low, moderate and high suitable areas for check dam construction and suitability map for our study area is thus generated.

B. Thematic Layers

The discussion of thematic layers is the heart of this paper. A thematic layer is used to grow the variations and limitations in various boundaries. Thus the thematic layer is said as a **distinct spatial entity** which entails separating spatial information in the form of theme and also delineated **as points, lines and polygons**. These layers may be single layering or multi layering procedure. These are the inputs of the paper from which we obtain the required results and in our paper, it is a **multi layering approach**. The following are the thematic layers used in this paper.

Vector datasets in which points and lines are used for spot representation.

- Soil texture
- Soil infiltration
- Geology
- Geomorphology
- Land use land cover
- Rainfall
- Drainage
- **Raster datasets** in which series of cells are used for spot representation.

- Slope.

V. SUMMARY OF EACH LAYER

A. Soil texture and its map

The **determination of the class of the soil and relative percentage** of sand, silt and clay based on the physical texture either in field or laboratory or both is called soil texture. There are two typical modes *i.e.,* **quantitative mode** which includes hydrometer method and **qualitative mode** which includes sensitivity of touch (Tabor .N.J *et al.,* 2017 and Yolcubal *et al.,* 2004). In this property, the **chemical and mineral properties are excluded**. It has an additional application in agriculture during crop suitability determination and to foresee the response of soil to environment and management conditions. For Tiruttani, the soil particles focussed are clay, clay loam, loamy sand, sand, sandy clay, sandy clay loam, silty clay and urban settlement (Fig. 3).

B. Soil infiltration and its map

The seeping action in the downward direction of surface water into the soil is called as soil infiltration. These are associated by two forces namely **gravity and capillary forces**. Gravity forces come into action for small pores and capillary forces for very small pores. The infiltration capacity is measured in terms of **inches per hour or millimetres per hour** based on the maximum rate of infiltration. **Infiltration capacity decreases with increase in the soil moisture content**. Rarely, the use of physical blockage is encouraged when the precipitation rate exceeds the infiltrate rate thereby runoff occurs. Numerous factors influencing soil infiltration are precipitation, soil characteristics, soil moisture content, land cover, slope and organic materials in soil. In our Tiruttani, the range varies from 0 to 9.34 (Fig.4).

C. Geology and its map

The **study of the rocks and other similar substances, on and beneath the Earth's surface and their processes** to obtain the shape of the structure is called as Geology. According to a **Scottish geologist, James Hutton** who is the **father of modern geology**, "Geology is not static and underwent perpetual transformation over long periods of time". He also put forward the thesis of "a system of the habitable Earth" which is designed to keep the world eternally suitable of humans. This is **highly relied upon mineral and hydrocarbon exploration and exploitation** and remediation of environmental problems. Tiruttani has a geological pattern of basic rocks and gnesis (Fig. 5).

D. Geomorphology and its map

There are many ways to define Geomorphology. The **study that deals with the landforms and their processes, form and its sediments at the surface of the Earth** is called as Geomorphology (Waiker.M.L and Aditya Nilawar.P, 2014). Also, it is the scientific study of the origin and evolution of topographic features. Geo-morphologists combine their field observation, physical experiments and numerical modelling in order to predict the future diversification. In our study area, it includes alluvial plains, denudational hills, flood plains, pediments, plains and structural hills (Fig. 6).

E. Land use land cover and its map

Land use can be entitled as the name suggests *i.e.,* what and how a part of land is benefitted to the public and what sort of community or settlement is used in that part of land. One such common definition states that **"the total of arrangements, activities and inputs that people undertake in a certain land cover type"** (Diana Eastman, 2020). Land use can be understood by knowing the past of the land that shall be utilised as an indicator for the future use of the same land. There are five types of land use: Recreational, transport, agricultural, residential and commercial. **Land cover is the physical material at the surface of the Earth that includes grass, asphalt** etc. The United Nations of Food and Agricultural Organisation **(FAO)** gives the trivial statement as **"The observed biophysical cover on the Earth's surface".**

In Tiruttani, land use land cover focuses on dry crops, fallow forests plantation, land with scrubs, barren rocks, salt affected, scrub forests, wet crops, towns and cities (Fig. 7).

F. Rainfall and its map

Rainfall is the one which is elementary and obligatory for the water cycle process. The **liquid in the form of droplets that condenses from atmospheric water vapour is called as rainfall. It usually becomes heavy and fall down due to gravity**. Rainfall takes many forms such as small drops known as drizzles, drop diameter of 0.5mm called rain and the higher sized particles called ice. But everything is considered to contribute in the continuity of water cycle. If this cycle is disturbed then the world is under the fear of water scarcity. Therefore, it plays a significant role. Tiruttani has the rainfall of about 750 to 1050mm (Fig. 8).

G. Drainage and its map

Drainage is the process in which **water is eliminated from upper soil layers to lower layers**. It can be **natural or artificial removal** of surface and sub surface water from an area that has excess water. Proper drainage is important for the well being of the living beings. In nature, certain minerals such as sand particles enhance drainage rapidly while heavy volume materials like clay can resist drainage. In our study area, the first and sixth order drainage pattern is shown (Fig. 9).

H. Slope and its map

Slope can be defined as the **measure of change in elevation** or the rise and fall of the land surface. It is **the declination or inclination of the land surface** with respect to horizontal (Senthilvelan, 2015). The degree of slope controls several factors like quantity and velocity of runoff, intensity of erosion, frequency and amount of transportation and deposition which are important for landform development. Thus the slope of the region is needed to determine about the terrain conditions. Our Tiruttani varies from 0° to 109.6° (Fig.10).

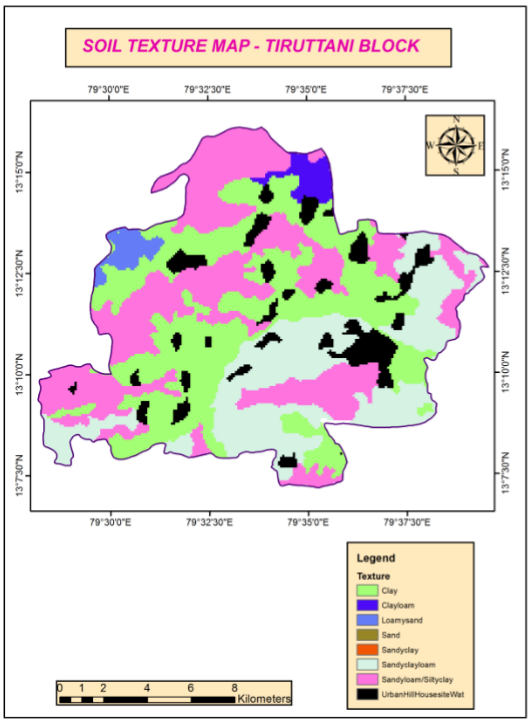

Fig.3 Soil texture Map

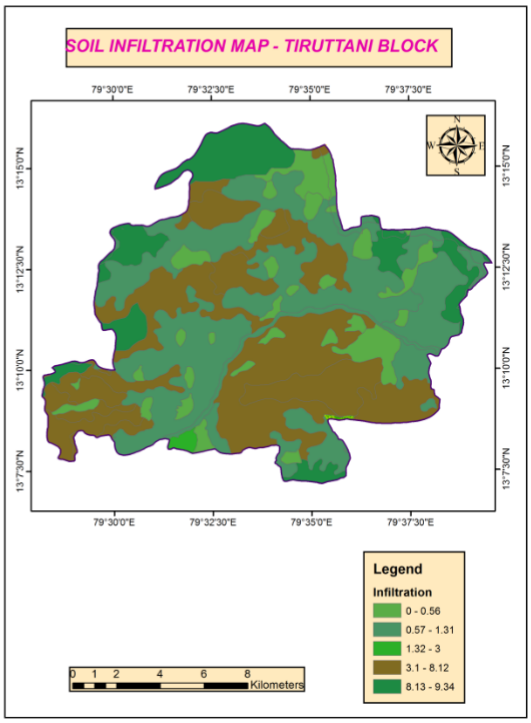

Fig.4 Soil infiltration Map

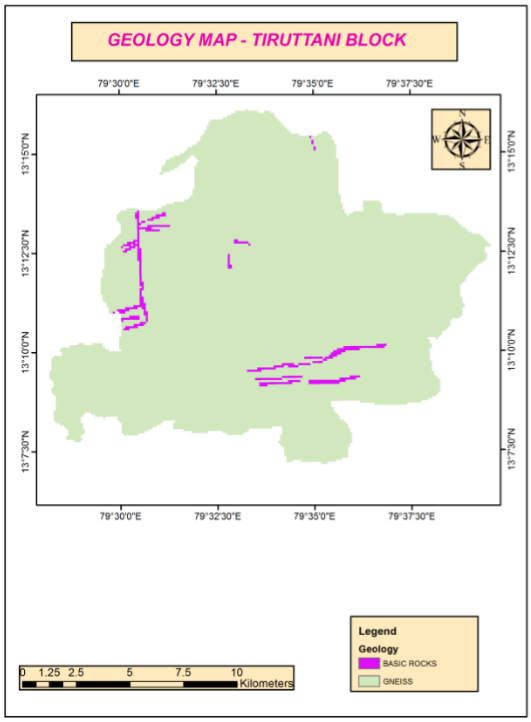

Fig.5 Geology Map

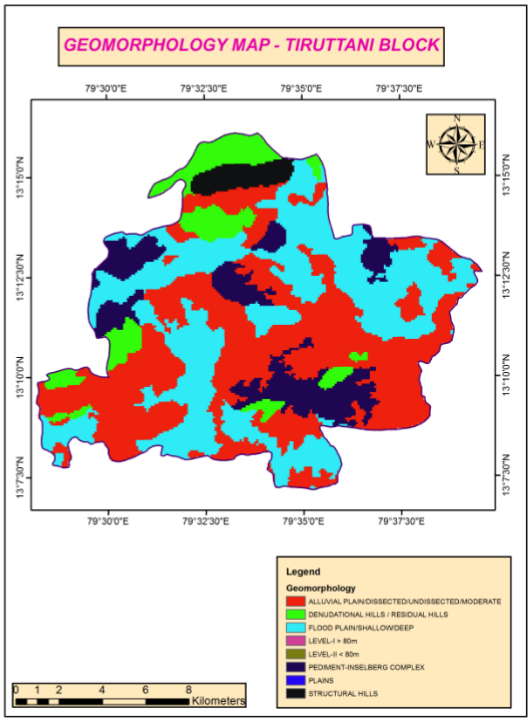

Fig. 6 Geomorphology Map

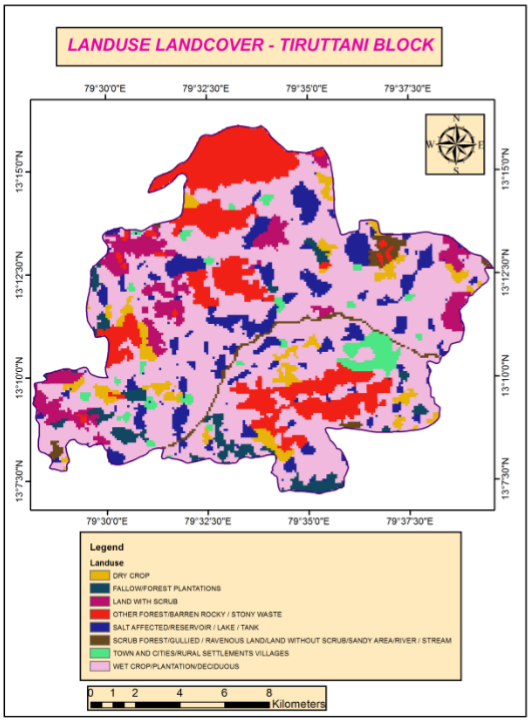

Fig .7 Land use land cover Map

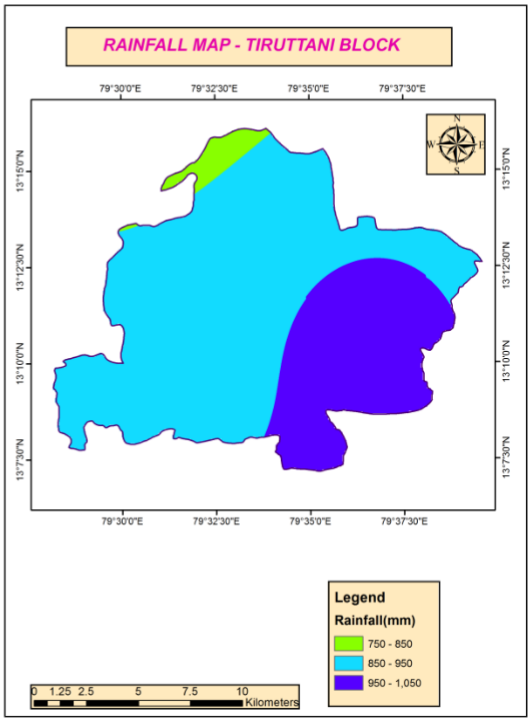

Fig. 8 Rainfall Map

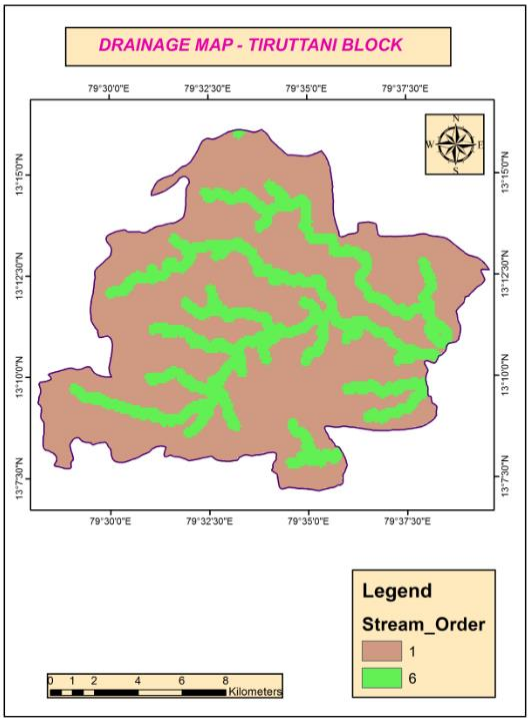

Fig. 9 Drainage Map

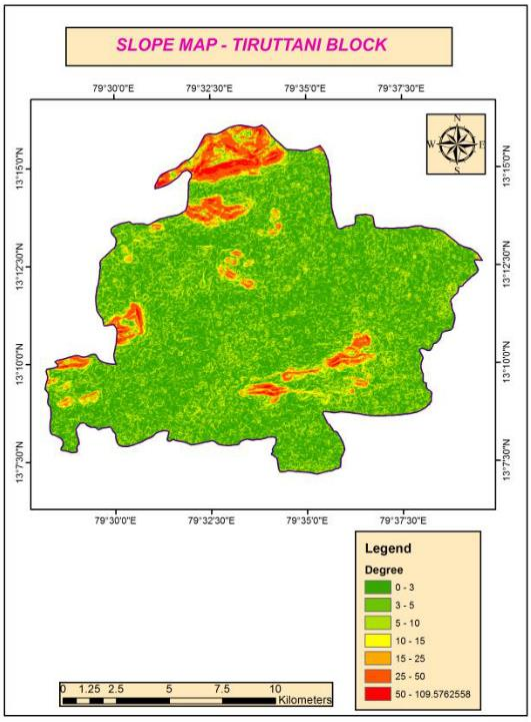

Fig. 10 Slope Map

VI. ANALYSIS AND RESULTS

In the above thematic layers, the slope data is alone raster datasets whereas all the other data are vector datasets. It has to undergo two important steps in Arc GIS: a) Conversion b) Reclassification.

a) First of all, those vector datasets are converted to raster using Arc toolbox.

Arc toolbox → Conversion tools → To Raster → Polygon to raster

b) Now, all the raster layers are input datasets. These are reclassified under spatial analysis tool in Arc toolbox and the steps are:

Arc toolbox → Spatial analysis tool → Reclass → Reclassify

After this, the analysis process is done and this technique used is **Weighted Overlay Analysis**. This is **multi-criterion analysis study** where investigation is carried out with multifaceted things for determining certain themes with the aid of assigning rank followed by assigning weightages to the respected features depending on impact (Mohanavelu Senthilkumar *et al.*, 2019). Additionally, the factors in the analysis may not be same for all layers and we can prioritize it based on the impact of that layer.

c) **Ranks** were assigned based on the influence of each feature in all the layers. **Ranks may range from 0 – 9** where '0' indicates less influence and '9' indicates higher influence and also in contrariwise. After this, **weightages** are given for all the layers on the basis of importance. As this technique accepts only integer raster as input, the output raster can be weighted by influence and **summed up to 100**. Also **higher the factors influencing percolation, higher will be the weightage given.** Weightages and rank allocation is given in Table 1 below. The procedure is as follows:

Arc Toolbox → Spatial Analysis tool → Overlay → Weighted overlay

- In the dialog box, assign weightage as integer to the thematic layers according to the percentage influence.
- Sum up the integer values to 100 (never more or less than 100)and proceed.
- Assign an output name and save as .tif folder and generate the suitability map for the study area.

Table I Weightages and Ranks for Suitability Analysis

S.No.	Layers	Class	Ranks	Weightage
1	SOIL TEXTURE	Urban hill	1	20
		Clay	2	
		Clay loam	3	
		Sandy clay	4	
		Sandy clay loam	5	
		Sandy loam	6	
		Loamy sand	7	
		Sand	8	
2	SOIL INFILTRATION	0 - 0.56	1	13
		0.57 - 1.31	2	
		1.32 – 3	4	
		3.1 - 8.12	7	
		8.13 - 9.34	9	
3	GEOLOGY	Basic rocks	1	10
		Gnesis	3	
4	GEOMORPHOLOGY	Structural hills	2	7
		Denudational hills	3	
		Plain	4	
		Alluvial plain	5	
		Flood plain	6	
		Level -1 > 80 m	7	
		Level -1 < 80 m	8	
		Pediment	9	
5	LAND USE LAND COVER	Town and cities	1	20
		Reservoirs	2	
		Barren rocks	3	
		Wet crops	4	
		Dry crop	5	
		Fallow forests	6	
		Scrub forests	7	
		Land with scrub	8	
6	RAINFALL	750 - 850	4	7
		850 - 950	5	
		950 -1050	6	
7	DRAINAGE	Stream order 1	1	10
		Stream order 6	6	
8	SLOPE	0%-3%	1	13
		3%-5%	2	
		5% - 10%	3	
		10% -15%	4	
		15% - 25%	5	
		25% - 50%	6	
		50% - 109.58%	7	

After the above procedure of analysis, the resultant map or suitability map for percolation zone (Fig.11) is precisely obtained and the categories are classified as three *i.e.*, **low suitability, moderate suitability and high suitability with the colours red, dusky brown and green respectively** (Mohanavelu Senthilkumar *et al.*, 2019). From this, it is inferred that the check dam construction can be done successfully at the high suitability area. So, the people in Tiruttani will be able to use the stored water for their agricultural needs, animal husbandry and also for their home needs without facing scarcity.

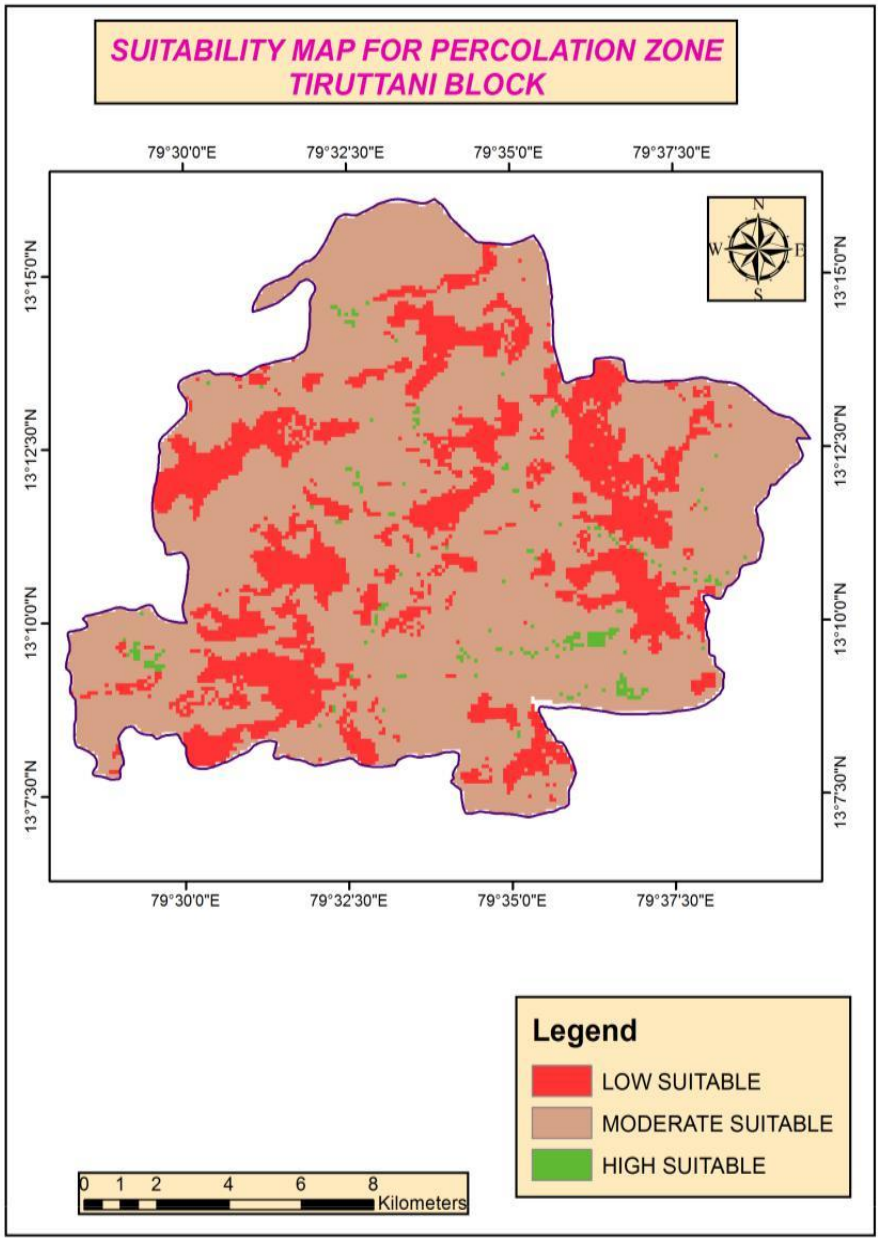

Fig. 11 Suitability map for percolation zone

VII. DISCUSSION AND CONCLUSION

From the reviewed paper, we can infer that **GIS and remote sensing technology has a significant value in the field of Civil Engineering** also. In this paper, the location of high percolation site is spotted where the erection of check dam is relevant. The application of GIS in the spot location **increases the accuracy**, which may not be achieved when done manually. Moreover, it is easier and faster in retrieving the results and also done in **cost efficient** manner.

The access of GIS software is indeed effortless since it is **a free and open source platform aided for viewing, editing and analysing geospatial data**. Arc GIS is a stream under GIS used for working with maps and managing geographic information.

The fertility of ground water capacity is a vital scale to know the prosperity of the country. Now, GIS and remote sensing is integrated for **evaluating the development and management** for the ground water systems. Thereby, it is wrapped up as:

- The percolation spot location is done with the ease using GIS technology.
- The check dam construction is made beneficiary not only for water storage but also to counteract soil erosion.
- The upcoming technical software is studied and experienced as well.

This research paper will definitely assist as a base for further researches in upcoming decades.

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