

# Groundwater Vulnerability Assessment Phenomenon using DRASTIC & Modified DRASTIC Modeling validated with Nitrate Concentration

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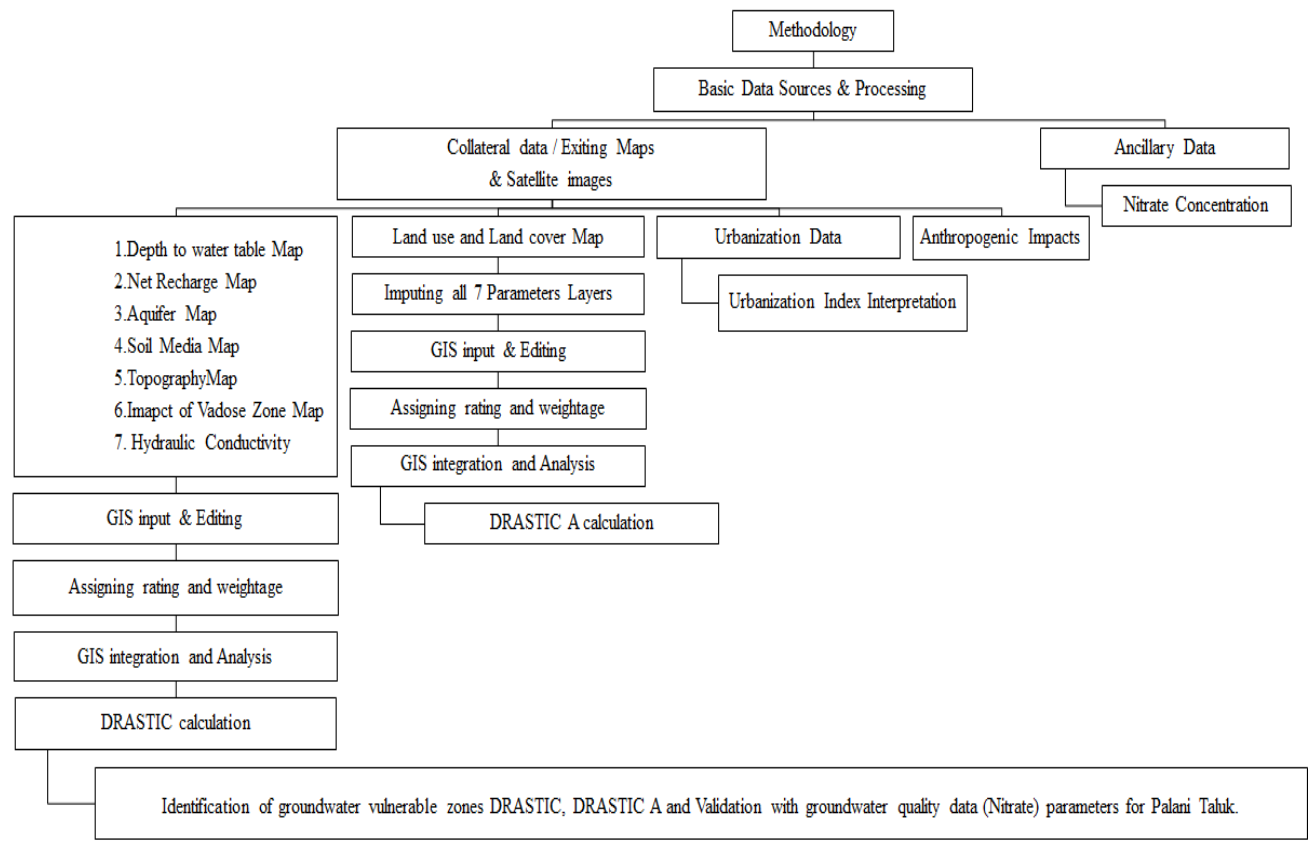
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## Graphical Abstract:



## Abstract

Urbanized areas groundwater vulnerability and contamination are serious issues that require due attention. There are other models, notably the DRASTIC models employed to assess the vulnerability of groundwater. In a modified version of the DRASTIC model known as

anthropogenic influence was incorporated into DRASTICA as a model parameter. The research used a cutting-edge methodology to define the anthropogenic employing satellite data of nighttime lighting to have an impact using human settlements as a stand-in and the Palani Taluk's surrounding land use/landcover. The spatial integration of various parameter maps was done using a geographic information system. According to data on groundwater vulnerability to pollution, around 29.98% of the area is in a very high vulnerability zone, followed by 23.68% of area covers high vulnerability, 25.18% comes under the range of moderate vulnerability, 12.14% covers the area in the zones of low vulnerability, and 8.97% area covers the total area in the ranges of very low vulnerability. Utilizing the amount of nitrate in ground water, the findings were confirmed. It was determined that in an urban environment, the suggested DRASTICA model achieved enhanced than the conservative DRASTIC model. The classifications are as follows: extremely high, high, medium, and low. Very high Vulnerability zones account for 214 values in Palani taluk, the research region, whereas very low vulnerability zones account for 3 values in Palani taluk. Urbanization index showed that anthropogenic impact and the depth of the water table had a substantial impact on groundwater susceptibility to contamination, indicating that manmade effect must be carefully taken into consideration in such studies. This study's modified-DRASTIC/DRASTICA model will aid in better classifying groundwater sensitive areas to contamination where manmade pollution is high, especially in and near metropolitan centers. The groundwater susceptibility possible map that is produced can be more successfully used as the main tool for managing, organizing, and safeguarding groundwater resources. Low nitrate concentrations are found in forests and arid terrain, whereas high nitrate values are found in urban areas. The majority of the Palani taluk has low to moderate nitrate concentrations. The Melkaraipatty and Thalaiyuthu Palani Taluk's urban areas are considered by high sensitivity because of low water levels and strong manmade effect.

Keywords: DRASTICA, Groundwater Pollution, Water Quality, Anthropogenic Activity, etc.

### **Abbreviations**

**DRASTIC** - Groundwater **D**epth, **R**echarge rate, **A**quifer media, **S**oil media, **T**opography, **I**mpact of the vadose zone, **C**onductivity

**NWWA** - National Water Well Association

**DVI** - DRASTIC Vulnerability Index

**MDI** – Modified Drastic Index

**CGWB** - Central Ground Water Board

**PWD** - Public Work Department's

**GIS** - Geographic Information System

## **1. Introduction**

Quantity and quality of groundwater are significant global issues. Groundwater quality and quantity rapidly declined as a result of rapid development (Shirazi et al. 2013; Roy et al, 2022). The phrase groundwater vulnerability refers to the natural ground features that control how easily groundwater may be contaminated by human activity (Adamat et al, 2003). Since it became clear that ground water needed to be protected from contamination, researchers have made strides in comprehending how susceptible ground water is to contamination (Anew model). However, there are significant ambiguities with the vulnerability assessment techniques that are currently in use (Aller et al, 1987). Application of pesticides and fertilizers to the land, animal waste from cattle and other animals, landfills, mining operations, and unintentional releases like chemical spills or storage tank leaks are stressors that have an impact on ground water quality (Alwathaf et al, 2011).

Groundwater is one of the most priceless natural resources on the planet, and it indirectly affects people's health and economic development (Barber C et al, 1993). It has become a significant and dependable source of water supplies in all climatic areas, serving both urban and rural areas in developed and developing nations due to its many inherent qualities such as Consistent temperature, widespread and continuous availability, excellent natural quality, limited exposure, low development cost, and drought reliability (Todd and Mays, 2005). Groundwater makes up around 22% of the estimated 37M km<sup>3</sup> of freshwater in the land, or about 97% of all the liquid freshwater that may be used by humans (Foster, 1998).

There is a significant water shortage problem in Palani Taluk, Dindigul District, Tamil Nadu, India for agriculture, industry, and domestic uses (Central Pollution Control Board, 2007). The monsoon season in recent years has been unpredictably unpredictable, making it impossible to guarantee surface water supply in the needed quantity

at the required time (Chakraborty 2007; Roy et al, 2021). The majority of the Palani Taluk's land is therefore dependent on groundwater, which is obtained by tube wells and digging wells (Evans BM, 1990). However, excessive groundwater pumping in some sections of the review zone has resulted in a decline in groundwater levels (Farzad et al, 2012; Easwer et al, 2022). Buried wells and hand pumps also dried up over the summer, which led to a worsening of Palani Taluk's chronic water shortage (Hasiniaina et al, 2010). The groundwater quality study by Sundararaj et al, 2022 was discussed about the quality of groundwater in the same district of the study region and concluded poor groundwater quality in half of the study region by analysis physico chemical parameter.

The DRASTIC model takes into account the primary hydrogeological aspects that could have an effect on aquifer pollution. Its initials stand for D - groundwater depth, R - recharge rate, A - aquifer, S - soil, T - topography, I - impact of the vadose zone, and C - hydraulic conductivity of the aquifer (Huan et al, 2012). The sum of the ratings and weights given to each of the parameters results in the DRASTIC Vulnerability Index (DVI) (Environ et al, 2010). We were able to identify three classifications, ranging from very low to very high, by examining the vulnerability map (Khodapanah et al, 2011). The variety of papers reviewed above assessed groundwater vulnerability without using anthropogenic effects as a DRASTIC model element (Napolitano et al, 1996). Anthropogenic factors are a significant factor in groundwater contamination in urban areas (National Research Council 1993). The type of aquifer and the availability of data influenced the model selection. The National Water Well Association (NWWA) and the US Environmental Protection Agency (EPA) collaborated to develop the DRASTIC model to investigate groundwater contamination vulnerability (Aller et al., 1987; Sivakumar et al, 2022).

The current study presented an altered DRASTIC model, also known as DRASTICA, in which the letter "A" stands for a new parameter known as effect of anthropogenic activities. The land use parameter was employed in a modified DRASTIC model by numerous additional researchers, including (Secunda et al. 1998; Adamat et al. 2003); Huan et al. 2012). Additionally, the new thing in this research is we compared nitrate concentration with DRASTICA results to validate the results of the analysis. By combining anthropogenic factors with satellite data as a proxy, we were able to successfully recognize groundwater sensitive zones in the research region of Palani Taluk.

## **2. Study Area**

The study area zone covers a 766.83 km<sup>2</sup> area with latitudes between 10°20'2" and 10°38'24" N and longitudes between 77°18'6" and 77°35'41" E. From which 116.85 km<sup>2</sup> of hilly landforms are made up. The location map of Palani taluk in Figure 1. The subject of the review is Dindigul region of Tamil Nadu. Precipitation in the south-west is a major source of groundwater season. For 33 years, the usual average rainfall is 690 mm (1980 – 2013). The major soil types of the study area namely Clayey Soil, Cracking Clay Soil, Gravelly Loam Soil, and Loamy Soil and the lithology of the area mainly consisted by Charnockite, Granite, Garnet, Granolite, and Hornblende-Biotite Gneiss.

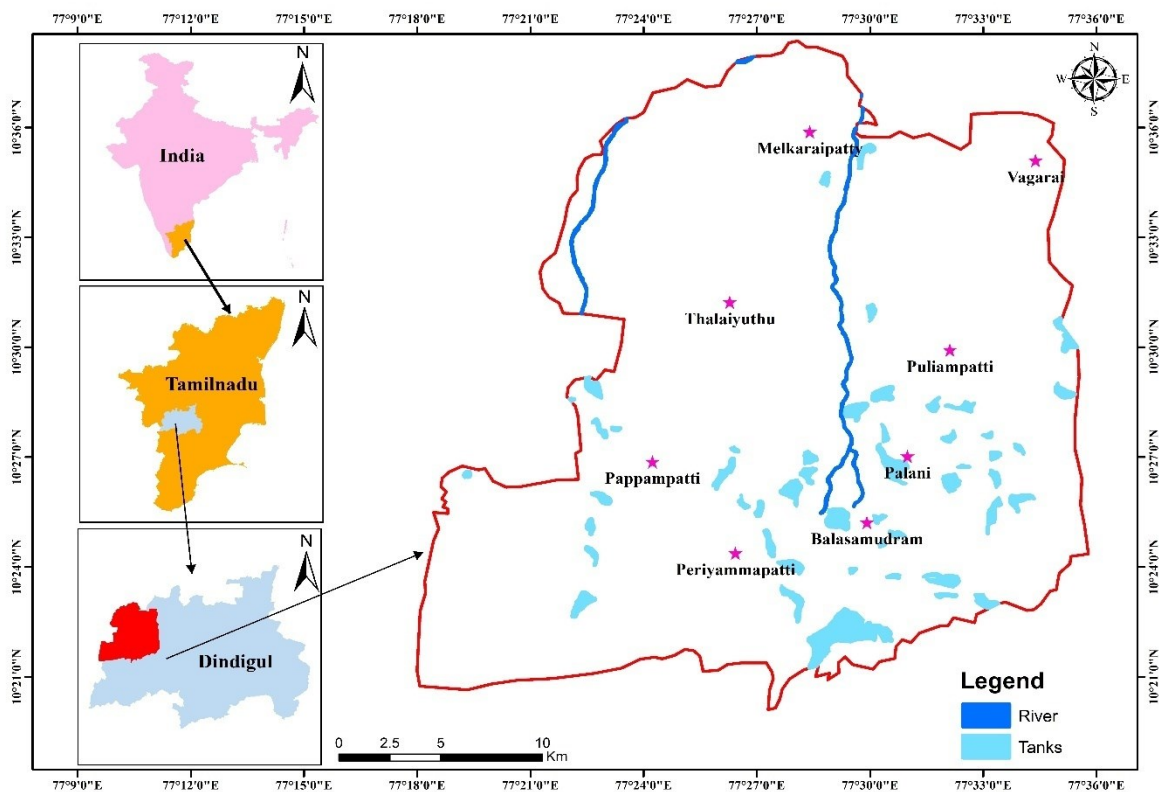


Figure 1: The Location map for Palani taluk region

### 3. Materials and Methodology

The specific data types and sources used to create the input parameter maps (layers) for the DRASTIC model. Using ArcGIS (version 9.3) software, input dataset preparation and

DRASTIC model implementation were completed. Figure 2 depicts the plan of the dispensation strategy used in the work.

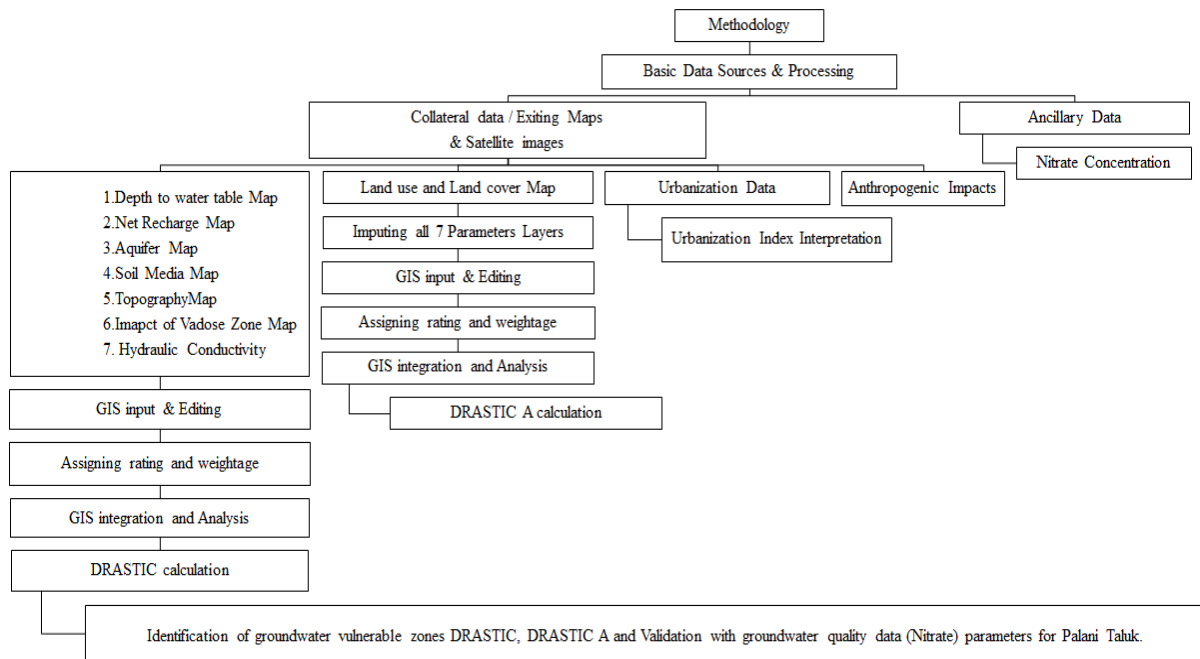


Figure 2: Methodology flow chart for Palani taluk region

### 3.1 Assessment of groundwater vulnerability to pollution

The US Environmental Protection Agency developed the DRASTIC model, which is one of the most used techniques for evaluating the vulnerability of groundwater to contamination, according to Aller et al. (1987). The areas that were more susceptible to pollution or groundwater vulnerability were identified using this approach. Planning, groundwater management, and groundwater protection can all benefit greatly from the groundwater vulnerability maps (Rosen L 1994). The following seven key hydrogeological and terrain factors are included in the model; they control the occurrence and transport of groundwater into the system. The ability of a pollutant to travel from the earth's surface to an active aquifer is measured by groundwater vulnerability (Rahman A 2008). The vulnerability studies can provide invaluable information about stakeholders working to stop further environmental deterioration (Mendoza and Barmen, 2006)

Depth to water level (D), Recharge (R), Aquifer media (A), Soil media (S), Topography (T), Impact of vadose zone (I), and Hydraulic conductivity (C) (Secunda S et al, 1998). These 7 variables were weighted based on their comparative significance to the aquifer's potential for pollution (Table 1). Depending on their relation significance to

contamination potential, each of these parameters was ranked (or referred to as ratings) and divided into various ranges and classes (Table 2). The following equation was used to calculate the DRASTIC Index: (Shirazi SM 2013)

$$\text{DRASTIC INDEX} = D_r D_w + R_r R_w + A_r A_w + S_r S_w + T_r T_w + I_r I_w + C_r C_w \dots\dots\dots (1)$$

where, respectively, r and w were the ratings and weights given to each parameter. The risk of groundwater pollution increases with the DRASTIC Index value.

Table 1: Weight assigned for seven parameters

Sl.NO	Drastic Parameters	Weights
1	Depth to water table	5
2	Net Recharge	4
3	Aquifer media	3
4	Soil media	2
5	Topography	1
6	Impact of vadose zone	5
7	Hydraulic Conductivity	3

Table 2: DRASTIC parameters classes and ratings for Palani taluk region (\*-Indicating the multiplication of rank and weight)

Parameters	Range	Rating	Weight	Total Weights Rating* Weight
Depth to Water Table (m)	< 3	10	5	50
	3 - 5	9		45
	5-10	8		40
	> 10	7		35
Net Recharge (mm)	55 - 100	5	4	20
	100 - 150	6		24
	150 - 200	7		28
	200 - 250	8		32
	250 - 300	9		36
	300 - 350	10		40
Aquifer media	Charnockite	5	3	15
	Granite, Garnet Granolite	8		24
	Hornblende-Biotite Gneiss	7		21

Soil media	Cracking Clay soil	8	2	16
	Gravelly Loam Soil	7		14
	Clayey Soil	6		12
	Loamy Soil	9		18
Topography (Degree of Slope)	0 – 15	10	1	10
	15 – 30	9		9
	30 – 50	8		8
	50 – 75	7		7
	75 – 89	6		6
Impact of vadose zone	Loamy Sand	5	5	25
	Sandy Clay	7		35
	Silty Clay	3		15
Hydraulic Conductivity (m/day)	1.5 - 3	1	3	3
	3 - 5	2		6
	5 - 8	3		9
	8 - 12	4		12
	12 - 15	5		15

#### 4. Results and discussions

Utilising DRASTIC, DRASTIC Modified, or DRASTICA techniques, seven and eight thematic maps were created for the study area's aquifer vulnerability assessment. The following are the subsequent steps.

##### 4.1.1 Depth to water table

The distance from the land surface to the water table, or depth to water table, is a key factor in determining how susceptible a region is to contamination. Deep water tables typically give contaminated infiltrating waters sufficient time to come into contact with the earth, allowing attenuation processes to remove contamination. Therefore, when determining the vulnerability using the DRASTIC method, the depth to groundwater was given the maximum weight of (5). (Table 1). After collecting the water level data from the Public Works Department, the depth to water table map was made. Figure 3 shows the depth to water table map has four rating categories (3, 3 - 5, 5 - 10, >10). The majority of the Palani



taluk regions are covered by between 5 - 10 and 3 - 5 (m) ranges according to the Depth to water table.

#### **4.1.2 Net recharge**

It is the term used to describe how much water percolates through the soil per square inch. Also it is a vital factor in the movement of the pollutants into the groundwater. The ratio of recharge to pollutant transfer is direct. According to the Public Work Department's (PWD) block-by-block net recharge analysis, the study area's net recharge ranged from 55 to 350 mm. As stated by the recharge was given a weight of (4) using the DRASTIC methodology. Reclassification of the recharge layer was done in accordance with the net recharge layer's DRASTIC ratings. Figure 4 shows the final depth to water table map has six rating categories (55 – 100, 100 – 150, 150 – 200, 200 – 250, 250 – 300 and 300 – 350 mm) The majority of the Palani taluk regions are covered by between 250 - 300 (mm) according to the Net Recharge. The recharge was computed using the formula for ground water fluctuation given below.

$$R=h \times S_y$$

Where R represents net recharge in metres, h represents the difference in water level in metres, and  $S_y$  is the percentage of specific yield for an unconfined aquifer.

#### **4.1.3 Aquifer media**

Aquifer mapping is a scientific process that evaluates the quantity, quality, and sustainability of ground water in aquifers using a combination of field and laboratory studies in geology, geophysics, hydrology, and chemistry. Because the aquifer's capacity to diluted contaminants helps control their concentration, the characteristics of the aquifer media determine vulnerability. The consolidated or unconsolidated material that acts as an aquifer is referred to as aquifer media. The rate at which contaminants come into contact with the aquifer is controlled by its media (Aller et al. 1987). The aquifer media map depicts in Figure 5 and it was prepared using borehole data. They are Charnockite, Granite, Garnet, Granolite, and Hornblende-Biotite Gneiss. Hornblende-Biotite Gneiss aquifer media covers the whole Palani taluk region.

#### **4.1.4 Soil media**

The aptitude of pollutants to travel steeply in the vadose zone depends in large part on the amount of recharge that can permeate into the groundwater. Additionally, the attenuation processes of filtration, biodegradation, sorption, and volatilization may be highly substantial where the soil zone is fairly thick. The soil data was used to create a soil map. Clayey Soil, Cracking Clay Soil, Gravelly Loam Soil, and Loamy Soil encircled the entire taluk territory. The soil media map displayed in Figure 6 was created by giving the soil types the appropriate ratings as given in Table 2.

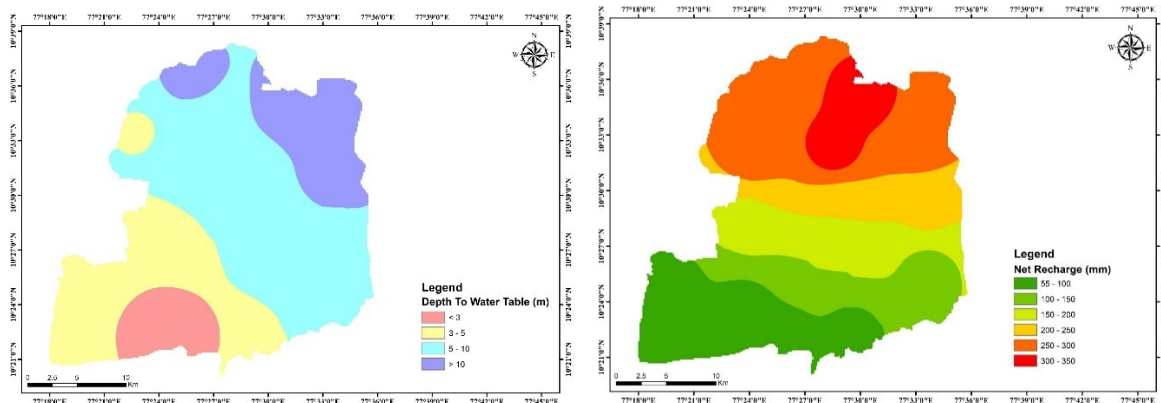


Figure 3: Depth to Water Table Map Figure 4: Net Recharge Map

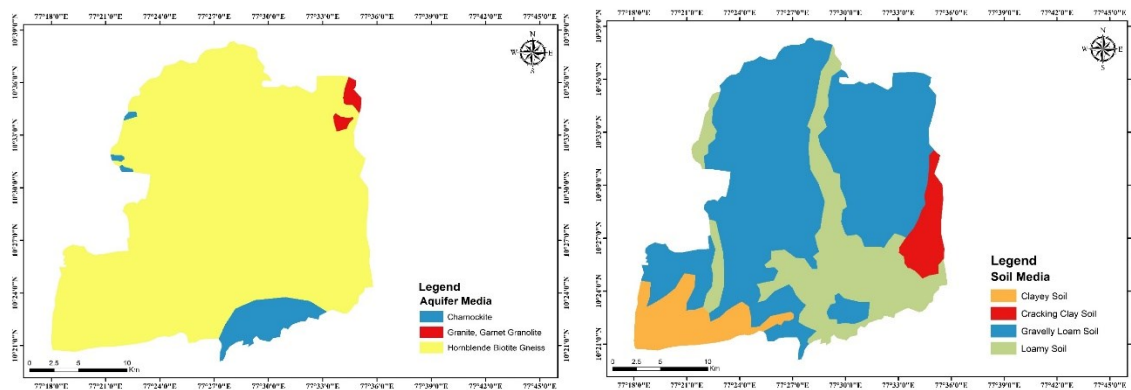


Figure 5: Aquifer Media Map

Figure 6: Soil Media Map

### 4.1.5 Topography

A slope map is a two-dimensional illustration of a surface's gradient. It displays the slope's current incline, whether it is steep or gentle. You may use slope maps to locate potential dangers, schedule building projects, and more. Topography affects the pace of infiltration by regulating the amount of time that water spends on the soil's surface. Additionally, topography indicates where pollutants are located. The study's digital elevation model was used to determine the topography Figure 7. area. Using the ArcGIS Spatial Analyst Tool, slope with the help of the topographic elevations,

values were determined. The ratings of the slope values were made using the standardized classification 5 categories like 0 - 15, 15 - 30, 30 - 50, 50 - 75 and 75 - 89. The most of the Palani taluk was covered by the ranges of 15 - 30 & 30 - 50 values. Slope maps are used to show the relief of the terrain, in contrast to topographic maps, where the altimetry is quantitatively represented with contour lines or with colour bands. The slope numbers, on the other hand, are proportional to the angle (in degrees) of the Earth's surface. Quantitatively, they exhibit the highest relief slope.

#### **4.1.6 Impact of vadose zone**

The zone above the water table that is unsaturated is known as the vadose zone. The material below the normal soil horizon and above the water table exhibits different attenuation characteristics depending on the type of vadose zone media used. The effect of the vadose zone feature is unit less, and the parameter's variety of standards is determined by the qualitative properties of the vadose zone material. By attenuating contaminants through filtration, chemical reaction, and dispersion mechanisms, this zone significantly reduces groundwater pollution (Shirazi et al. 2013). Sandy clay, silty clay, and loamy sand covered the Palani taluk. Sand and loamy clay made up the majority of the Palani taluk. The rating ranges of the characteristics listed in Table 2 were used to create the impact of vadose zone map shows in the Figure 8.

#### **4.1.7 Hydraulic conductivity**

Aquifer materials' hydraulic conductivity is their capacity to convey water. Only the aquifers are included in the hydraulic conductivity data, which is governed by the aquifer's material properties and the quantity of unified void places. Groundwater pollution has a great potential in the high hydraulic conductivity zone (Aller et al. 1987). Hydraulic conductivity was computed using data from borehole pumping tests (CGWB 2009). It was found that the study area's hydraulic conductivity ranged from 1.5 to 3, 3 to 5, 5 to 8, and 12 to 15. Figures 9 depict a map of the research area's hydraulic conductivity (m/day). As indicated by the parameters rating ranges in Table 2. Most of all Palani taluk was surrounded by 8 – 12 ranges in the analysis of Hydraulic conductivity.

#### **4.1.8 DRASTIC MODEL**

The DRASTIC model takes into account the primary hydrogeological aspects that could have an influence on aquifer pollution. Groundwater depth is denoted by the letters D, recharge rate by the letters R, aquifer by the letters A, soil by the letters S, topography by the letters T, vadose zone influence by the letters I, and hydraulic conductivity of the aquifer by the letters C. The groundwater vulnerability is assessed using the Drastic index approach and seven different dramatic themed layers are added using Arc GIS's raster calculation tool. The Drastic index values for this research region, which range from 3 to 214, have been reclassified into very low, low, medium, and high according to the new classifications for groundwater contamination, which range from very low to very high. The very high-class accounts for 29.98% of the population, followed by high class (23.68%), medium class (25.18%), low class (12.14%), and very low classes (8.97%). If the research area as a whole is more vulnerable to groundwater contamination. Areas in the research region's north east and south west were identified based on their low hydraulic conductivity and moderate to low risk. North-west and north-south directions are identified in this analysis as having extremely high and high vulnerability. The west and south of the research region are categorised as having low and extremely low groundwater susceptibility due to their higher hydraulic conductivity and groundwater infiltration rate. In addition, the shallowness of the aquifer makes it simple for agricultural pollutants to mix with recharge water and contaminate groundwater. DRASTIC Map shows in the figure 10. Table 5 shows the DRASTIC Vulnerability analysis for Palani taluk region.

#### **4.2 Land Use and Land Cover**

The type of LuLc pattern and manmade actions have a substantial impact on the majority of the area's groundwater susceptibility (Periyasamy et al, 2021). The Palani taluk Land use and land cover map was shown in Figure 11 depicted ten classifications of land: Barren Rocky, Built Up Land, Crop Land, Fallow Land, Forest, Grass Land, Plantation, River, Scrub Land and Tanks. The severity of pollution potential varied depending on the kind of land use, including urban, commercial, agricultural, and industrial. Hydrogeological characteristics can have a big impact on land use parameters. A significant majority of the study region is used for agricultural, according to the land use classification. The second significant portion of the area is made up of adjacent non-agricultural land and urban pavements. The remaining areas are further divided into Barren Rocky, Forest, Grass Land, River, Scrub Land and Tanks. In agricultural areas, groundwater is particularly susceptible to nitrate accumulation. Nitrate distribution in groundwater systems is primarily influenced by

soil dynamics, including recharge rate, groundwater movement, and on-ground nitrogen input (Shirazi et al. 2013). Palani taluk land use classification showed that agricultural and urban activities had a substantial impact on the research area's groundwater quality. Barren rocky covers 3.93 km<sup>2</sup>, built-up land occupies 24.54 km<sup>2</sup>, crop land occupies 290.17 km<sup>2</sup>, fallow land occupies 163.54 km<sup>2</sup>, forest occupies 42.86 km<sup>2</sup>, grass occupies 86.20 km<sup>2</sup> and plantations occur on 55.99 km<sup>2</sup>, rivers occupy 2.61 km<sup>2</sup>, scrub land occupies 38.74 km<sup>2</sup>, and tanks occupy 19.13 km<sup>2</sup>. Table 3 shows Land use and land cover classification table for Palani taluk.

### **4.3 Urbanization index dataset**

The urbanisation index map was produced using a visual interpretation of the urbanisation extraction data from Landsat 8 OLI/TIRS. Using a map of the research area's urbanisation index, the Lu/Lc map was further improved. Based on the urbanisation index map shown in Figure 12, the built-up class of the land use and land cover map for the Palani Taluk was further divided into five classes: built-up with very high density, built-up with very low density, built-up with high density, built-up with low density, and built-up with medium density.

### **4.4 Preparation of anthropogenic impact map**

The term human influence on the environment also known as anthropogenic impact describes modifications that humans either directly or indirectly make to biophysical environments, ecosystems, biodiversity, and natural resources. The physical environment is negatively impacted by a variety of human activities including deforestation, pollution, overcrowding, and the combustion of fossil fuels. Changes like this have contributed to climate change, soil erosion, poor air quality, and undrinkable water. The anthropogenic effect map was produced using the Lu/Lc map and the urbanisation index map for the Palani Taluk region. The creation of the anthropogenic impact map for the Palani taluk is depicted in Figure 13.

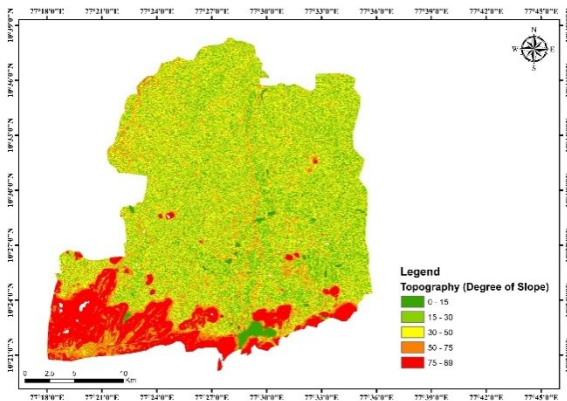


Figure 7: Topography Map

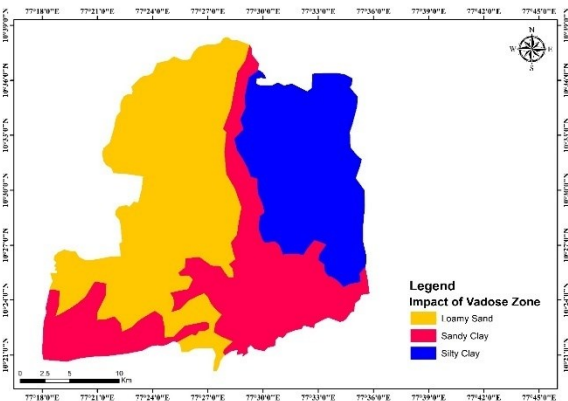


Figure 8: Impact of Vadose Zone map

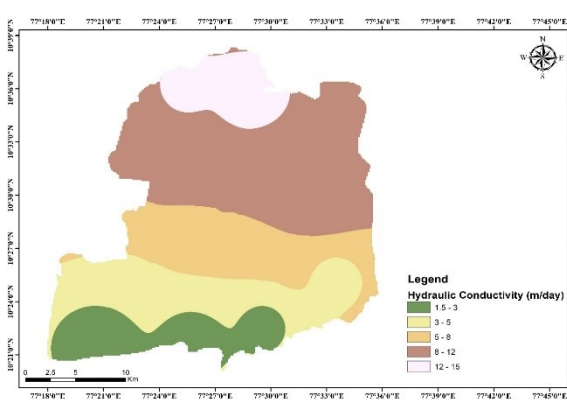


Figure 9: Hydraulic Conductivity map

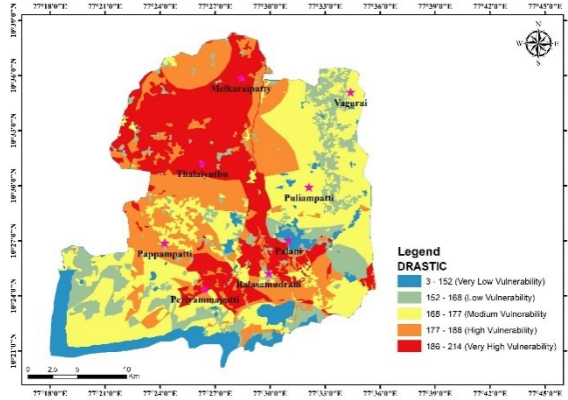


Figure 10: DRASTIC map

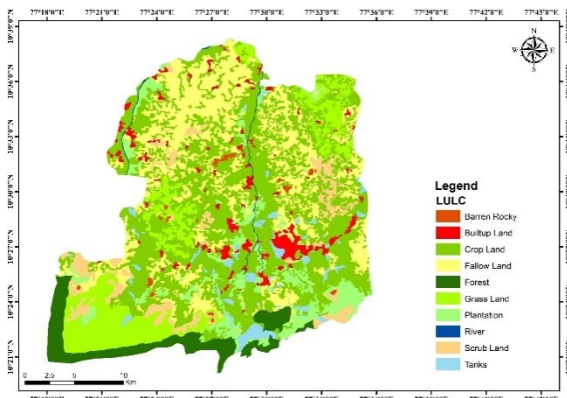


Figure 11: Land use and Land cover map

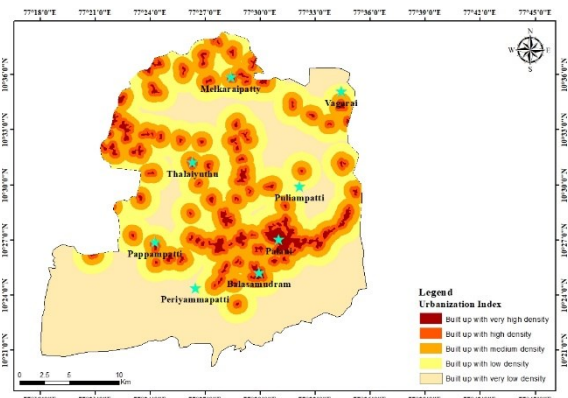


Figure 12: Urbanization Index map

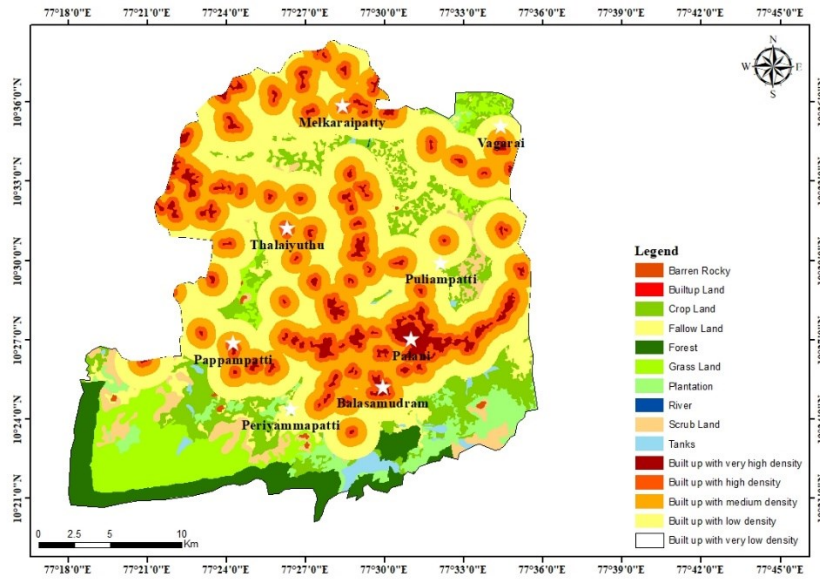


Figure 13: Anthropogenic Impact map for Palani taluk region

#### 4.5 Generation of an updated DRASTIC or DRASTICA risk map

After combining with the DRASTIC map, the study evaluated the groundwater susceptibility created on manmade actions. By incorporating anthropogenic effect as an additional element into the standard DRASTIC technique, the DRASTICA risk map was created. The altered DRASTICA method was the name given to this arrangement. Anthropogenic impact map was graded and weighted to create the modified DRASTIC map based on the assumptions of land use classes (Secunda et al. 1998; Al Adamat et al. 2003; Shirazi et al. 2013). The map of anthropogenic effect was converted into a raster grid and multiplied by the parameter's weight ( $A_w = 5$ ). The manmade effect map was placed over the traditional DRASTIC map in order to provide a spatial correlation between the two maps. The modified DRASTIC Index (MDI), also known as the DRASTICA index, was created by adding the final resultant grid coverage to the conventional DRASTIC Index (DI) according to the following equation (Shirazi et al. 2013). Table 4 show Lu/Lc Groups and their allocated scores.

$$\text{MDI or DRASTICA Index} = \text{DI} + A_r A_w \quad (2)$$

where  $A_r$  and  $A_w$  stand for the anthropogenic impact parameter's rate and weight, respectively. DRASTICA's map identified research area regions and human activity categories that are more likely to affect groundwater vulnerability.

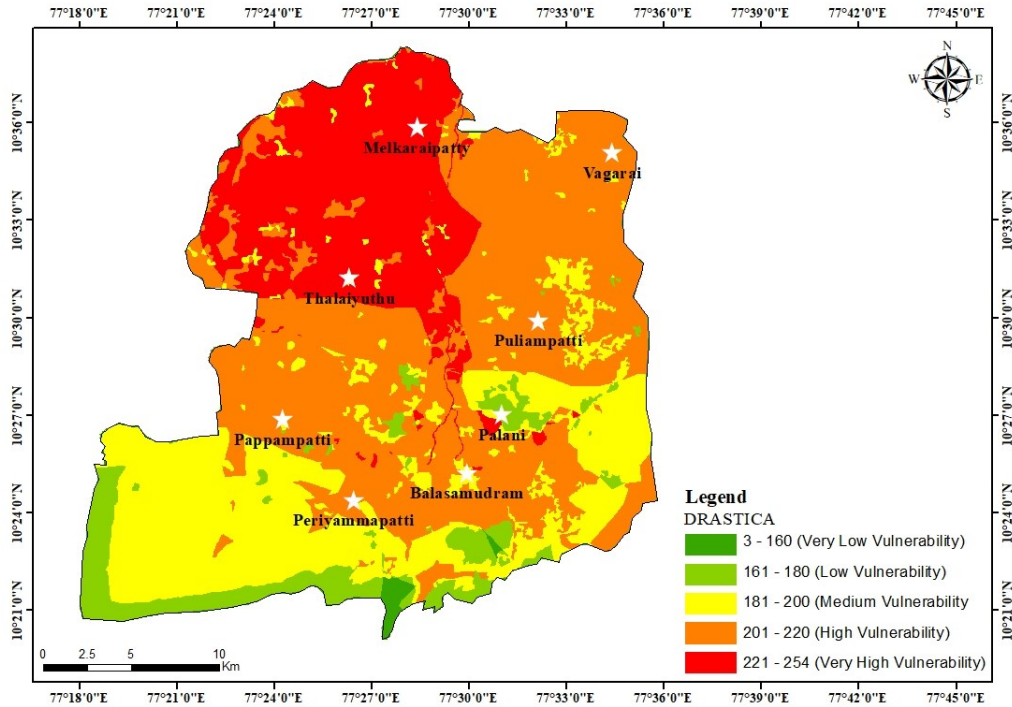


Figure 14: DRASTICA A Vulnerability map for Palani taluk region

Figure 14 of the DRASTICA risk map was arranged into five categories: very low (3–160), Low (161–180), moderate (181–200), high (201–220) and very high (221 – 254) susceptibility. The study’s conclusions revealed that 190.85 sq. km of the region are covered in very high highly sensitive zone, which covers 248.45 sq. km are the highly vulnerable zones, 126.8 sq. km are classified as a medium vulnerable zone, and 55.6 sq. km, under 5.6 sq.km are considered low and very low vulnerable zones. DRASTICA's risk map displayed indicates the highly vulnerable areas expanded by over 20% from the moderately vulnerable locations when contrasted to a DRASTIC map (Table 7). In comparison to conservative risk maps, the DRASTICA map depicts a more favourable scenario of vulnerability due to its confirmation by groundwater field data quality. Urban regions have exceptionally high levels of nitrate contamination as a result of human activity.

The resulting groundwater susceptibility map can be used more effectively as a foundational tool for the management, preparation, and defence of groundwater wealth. The Melkaraipatty and Thalaiyuthu due to shallow water levels and significant anthropogenic effect, Palani Taluk's urban areas are characterised by high susceptibility. The majority of the district is included in due to agricultural activities, there is a very high, high, and moderate sensitive zone. The locations near sources of water, forests, shrub land, and Low vulnerability applies to waste land. The city vulnerability of some locations to pollution was great.



Groundwater Urban samples also revealed significant nitrate levels concentrations. Table 6 shows the DRASTIC A Vulnerability analysis for Palani taluk region.

Table 3: Land use and land cover classification table for Palani taluk

Type	Area (Sq.km <sup>2</sup> )	Percentage (%)
Barren Rocky	3.93	1%
Builtup Land	24.54	3%
Crop Land	290.17	40%
Fallow Land	163.54	23%
Forest	42.86	5%
Grass Land	86.20	12%
Plantation	55.99	8%
River	2.61	2%
Scrub Land	38.74	5%
Tanks	19.13	2%
<b>Total</b>	<b>727.74</b>	<b>100%</b>

Table 4: Land use Classes and their assigned ratings

S.NO	LAND USE	Ratings
1.	Built up with very high density	10
2.	Built up with high density	9
3.	Built up with moderate density	8
4.	Built up with low density	7
5.	Built up with very low density	6
6.	Crop land	8
7.	Plantation	6
8.	Fallow Land	7
9.	River	6
10.	Tanks	9
11.	Scrub Land	6
12.	Grass Land	7
13.	Barren Rocky	3
14.	Forest	2

Table 5: DRASTIC Vulnerability analysis for Palani taluk region

S.No	Drastic Index range	Degree of Vulnerability	Area Covered in Sq.km
1	3-152	Very Low Vulnerability	65.3 (8.97 %)
2	152-168	Low Vulnerability	88.4 (12.14 %)
3	168-177	Medium Vulnerability	183.24 (25.18 %)

4	177-186	High Vulnerability	172.35 (23.68 %)
5	186-214	Very High Vulnerability	218.19 (29.98 %)

Table 6: DRASTICA Vulnerability analysis for Palani taluk region

S.No	Drastic Index range	Degree of Vulnerability	Area Covered in Sq.km
1	3 – 160	Very Low Vulnerability	5.6 (1 %)
2	161 – 180	Low Vulnerability	55.6 (7.02%)
3	181 – 200	Medium Vulnerability	126.8 (17.44 %)
4	201 - 220	High Vulnerability	248.45 (48.17 %)
5	221 - 254	Very High Vulnerability	190.85 (26.13 %)

#### 4.6 Nitrate Concentration

The nitrate water quality parameter was used to validate both the traditional DRASTIC and DRASTICA methodologies used (Figure 15). Nitrate does not typically occur in nature. Because of this, it occurs in a groundwater system identifies a source of pollutants like, from anthropogenic and agricultural activity. Nitrate (NO<sub>3</sub><sup>-</sup>) content in several of the groundwater samples from Palani taluk is found to be higher than the desired limit. Pointing to polluting sources' inputs. Correlations were created using nitrate concentrations use the usual DRASTIC Index (DI) values and DRASTIC Index, amended (MDI). A technique is correlation for inspecting the relationship between two quantifiable and continuous variables (Snedecor, 1900; Pearson, 1900; Cochran, 1980).

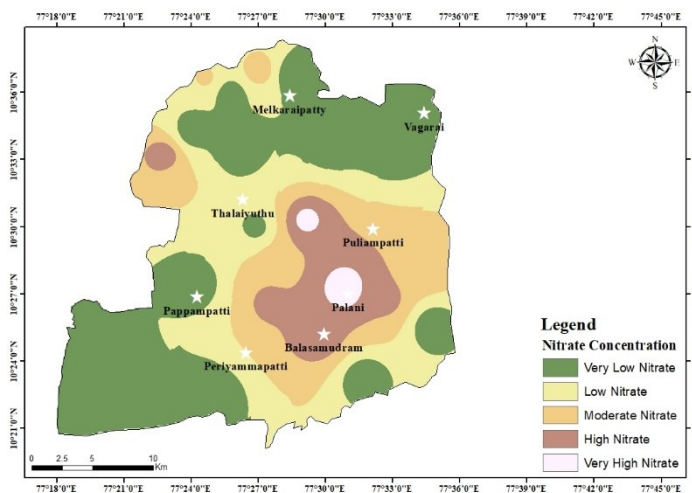


Figure 15: Nitrate Concentration map for Palani taluk

High nitrate values are shown in the urban zones and low nitrate concentration are shown in forest and barren lands; most of the Palani taluk covers low nitrate and moderate nitrate

concentration. Figure 15 shows the nitrate concentration map for Palani taluk. The fact that DRASTIC and DRASTIC A have high vulnerability ratings indicates that nitrate concentrations are higher than average, whereas low nitrate concentrations indicate low vulnerability. Melkaraipatty and Thalaisyuthu are responsible for the analysis of the very high sensitivity zones in DRASTIC and DRASTIC A. Pappampatti, Palani, Balasamudram, and Periyampatti are high vulnerability zones.

## 5. Conclusions

The study was conducted in Palani taluk, Tamil Nadu, by using the DRASTIC model, an empirical index. Additionally, a modified inventive methodology the development of the DRASTIC model or DRASTICA involved using both the manmade influence and the Satellite measurements of the Lu/Lc adjoining the Palani taluk area and nightlights from human settlements as a proxy. The traditional three classes (low, medium, and high) were displayed on the DRASTIC risk map. Changed DRASTIC or (high susceptibility) Four classes of vulnerability (low, medium, high, and very high vulnerability) were represented by the DRASTICA risk map. The DRASTICA procedure was used. to provide stronger evidence of groundwater vulnerability evaluation in urban settings. With the right tools, the technique can be applied in various metropolitan areas, alterations to hydrogeological setting ratings.

According to LULC analysis of Palani taluk, Bare rocky land makes up 1% of Palani Taluk, whereas built-up land makes up 3%, crop land makes up 40%, fallow land makes up 23%, forest makes up 5%, grass makes up 12%, plantations make up 8%, rivers make up 2%, scrub land makes up 5%, and tanks make up 2%. In DRASTIC Analysis, outcome of vulnerability zones occupying like very low vulnerability as 8.97%, Low vulnerability as 12.14%, Moderate vulnerability as 25.18%, high vulnerability as 23.68% and very high vulnerability zones covers 29.98%. In DRASTIC an Analysis, outcome of vulnerability zones occupying like very low vulnerability as 1%, Low vulnerability as 7.02%, Moderate vulnerability as 17.44%, high vulnerability as 48.17% and very high vulnerability zones covers 26.13%.

For validating the DRASTIC & DRASTIC A implement the Nitrate concentration for Palani taluk region, according to research high vulnerability zones are accumulated in urban or built-up areas, highly concentrated nitrate values are presented in the ground water sample near the same urban and city zones. Hence the values of DRASTIC and DRASTIC A have high vulnerability is means the values of nitrate concentration is more, the nitrate

concentration is less meaning the vulnerability is low. The analysis of DRASTIC and DRASTIC A the very high vulnerability zones come under the Melkaraipatty and Thalaiyuthu. High vulnerability zones come Pappampatti, Palani, Balasamudram and Periyampatti. Moderate zones are covers Puliampaati, Vagarai during DRASTIC analysis. These are all comes under high vulnerability in DRASTIC A analysis. In order to overcome with this groundwater vulnerability proper rehabilitation, maintenance and construction of public tube wells and renovation of dug wells in areas with geogenic contamination should be needed and proper artificial recharge structure need to construct as per the drainage network of the study region.

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