International Journal of Emerging Trends & Technology in Computer Science (IJETTCS)
Web Site: www.ijettcs.org Email: editor@ijettcs.org, editorijettcs@gmail.com
Volume 7, Issue 2, March - April 2018 ISSN 2278-6856

Decision Support System For Guidance Assessment In Irrigation Areas Of Nanganji Dam In Dindigul District

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Abstract: ***The purpose of this research is to evaluate the groundwater quality in Dindugal district of Tamil Nadu based on the water quality index by geographic information system (GIS) and statistical analysis. This area consists of 80 functional tanneries around Dindigul town with a capacity to process about 200 Mt of hides and skins as leather. In 13 villages, as many as 1090 houses were damaged by tannery contamination. A total of 25 groundwater samples were collected to identify the geochemical sources and contamination. Moreover, Gibbs plots indicated that groundwater contamination was derived from the weathering of granitic gneisses as well as the leaching of evaporated and crystallized ions from agricultural and industrial effluents. The water quality index (WQI) exhibited 8% of the groundwater samples were not suitable for drinking purpose. The GIS maps showed that the poor water quality decreased toward the southern part of the study area. WQI of TDS, fluoride, sodium, potassium, and bicarbonate were high in groundwater. Multivariate statistical analyses (principal component analysis (PCA), factor analysis (FA)) suggested that the groundwater chemistry was changed by the weathering of source rocks ion exchange and leaching of inorganic components and addition from anthropogenic effluents. Finally, it is thought that the monitoring and assessment works are very useful to understand the degree and sources of groundwater contamination.***

Keywords: Decision Support System, Guidance Assessment, Irrigation Areas, Nanganji Dam, Dindigul District

1. INTRODUCTION

1.1 General

Dindigul, currently the most populous district of Tamilnadu, is endowed with bountiful of water resources, fertile land and favourable climate. A large network of many perennial rivers, mostly flowing from the mountains, contributes to its vast water resources potential and provides drainage to the district. At the same time, a deep alluvial aquifer underlies the vast plains, recharged annually by almost 1000 mm monsoon rainfall. Over the past century, one of the world's largest canal systems has been constructed, supporting predominantly rice-wheat cropping. Most of irrigation head works are run-of-river systems, supplemented by some small reservoirs at some places. Initially, most systems were initiated as a protective measure against droughts. However, with introduction of high-yielding varieties of crops in recent years, irrigation demand has significantly increased so most systems have been under major rehabilitation in recent years in order to augment their discharge capacities. The canal network under this study, which covers about 11 million ha.

Sustainability of agriculture is threatened by water-logging and consequent soil salinity-sodicity in canal command areas whereas groundwater depletion is also occurring in some other areas, resulting in reduced productivity. Meanwhile, there has been growing realization among the water resources development and management professionals lately in India that irrespective of sources (groundwater and surface water), water must be treated as a single entity. This prompts the need of conjunctive irrigation management policy to be adopted for effective water management Moreover, water use for agriculture cannot be considered in isolation of other uses. This requires an integrated approach for sustainable water resources planning, management and operation under a river basin framework.

The hydro-geology of the study area suggests that about 50-100 m unconfined aquifer of alluvial material ranging from clays to fine sands lies beneath a clay loam top soil. There is an impervious clay layer below this aquifer, and up to 4000 m of sediments below this layer. Surface gradients are very flat with large areas having slopes of less than 1 degree, resulting in poor natural surface and sub-surface drainage. Groundwater quality is good enough for irrigation.

1.2 Conceptual Framework of Decision Support System

A GIS-based Decision Support System for basin planning usually consists of a geo-database, models and an interface. The geo-database contains spatial data such as crops and other land use, canal infrastructure, socio-economics, hydro-geology etc and historical time-series data such as

rainfall, temperature, evaporation, canal flows, river discharge etc. Often, there are a range of models within the DSS, from simple regression relationships to complex process models such as rainfall-runoff models, flow routing models, groundwater models, crop water requirement computation models, economic models and so on. As the name suggests, DSS can be used to evaluate various management scenarios such as change in land use, canal lining, canal silting and desilting, availability of additional sources of water, prolonged droughts etc and thus help the water resources managers or planners make informed decisions.

A comprehensive geo-database has been developed for all spatial and time series data using Arc Hydro data model. The Arc Hydro Data Model is a standard database format for hydrologic applications including all spatial and time series data. It has been developed and his team at the Centre for Research in Water Resources (CRWR) in conjunction with ESRI.

1.3 Need for Decision Support in Agriculture

Sustainable Agriculture production and processing systems have become more complex with involvement of biological, chemical, physical processes such as soil, water, climatic scenarios and crop management practices respectively. Decision Support System (DSS) offers a framework within which complex systems can be represented in a structured way, allowing them to be more easily understood and helping to draw out additional information and new insights**.** It is an interactive computer based expert system that helps decision makers to utilize data and models to solve unstructured problems. The applicable use of successful decision support can assist in the sustainability of agricultural resources. Based on the important parameters in agriculture such as type of soil, seed, irrigation, fertilizers, and climatic data the activities in agriculture management can be classified into different categories. For effective and sustainable agriculture management decision support system at each of these activities is very much essential.

1.4 Environmental Impacts

For most of the world's existing stock of large dams, environmental requirements have played little part in their design and the specification of operating rules. Most dams have been constructed with the emphasis on maximizing the economic returns from the use of water, with little or no understanding of the long-term consequences of alterations to flow volumes, flow patterns and timing, and water quality. However, over the last 30 to 40 years, there has been an increasing awareness that dams modify, in both obvious and subtle ways, as well as at places far removed from the source of impact and often with long time lags, the conditions to which aquatic ecosystems have adapted. Flow regulation can, and frequently has, caused serious degradation of natural ecosystems.

In some places these changes have resulted in the loss of natural resources and processes that contributed to the livelihoods and well-being of the impacts of dams vary substantially from one geographical location to another and are dependent on the exact design and the way a dam is operated, as well as the ecological character of the riverine ecosystem and the socioeconomic context. Every dam has specific characteristics and, consequently, the scale and nature of environmental changes are highly site-specific and often very difficult to predict accurately.

2. METHODOLOGY

Figure 1 shows the methodology of the study

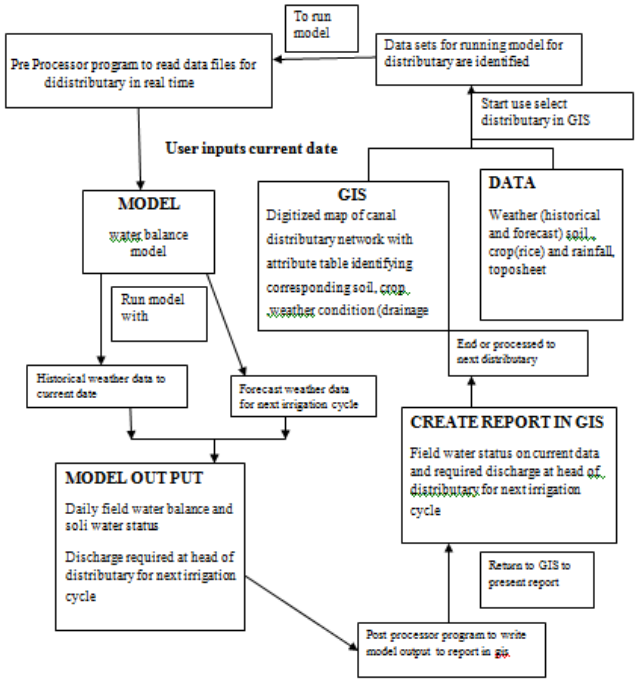

Figure 1 Methodology

3. STUDY AREA

Dindigul region is composed of a hard rock terrain in Tamil Nadu, South India, and it lies between 10.35° N latitude and 77.98° E longitude. The average rainfall and temperature of this region are 700 mm and 26.38°C, respectively. The main rivers in this district are Dodaganaru, Palar, Kuthiraiyar, Porandalar, Amravati, Manjalar, Varadhamanathi, and Maruthanathi. Three different climatic conditions prevail in this district. Tropical and sub-tropical climate are prevalent in plains and in the Palani and Sirumali hills. Due to the favorable climate, all kinds of horticultural crops are cultivated in this district. A semi and tropical monsoon type of rainfall is predominant in this district.

The geology of this study area is composed of hornblende biotite gneiss (HBG) and charnockite. HBG is the dominant one, and charnockite is covered by hilly terrain in the southern part. Moreover, two anorthosite patches are

observed in the central and eastern margins. Some of granulite patches and garnetiferous quartzofeldspathic gneiss are also present. Other minor rock types are pyroxene granulite, pink augen gneiss, garnetiferous sillimanite graphite gneiss, and granite. The soil types are red loam, laterite soil, black soil, sandy coastal alluvium, and red sandy soil. Red loams are widespread in Dindugal district, except Kodaikanal, while red sandy soils are present in Nilakottai, Oddanchatram, and Palani. Laterite and black soils are dominant in Oddanchatram, Natham and Nilakottai, Oddanchatram, Palani, and Vedasandur respectively.

They are characterized by deeper water levels with high fluctuation condition. Dug well types are the major groundwater extraction method of these zones. Figure 2 shows the Land sat image of the study.

Figure 2 Landsat Image

Figure 3 shows the Toposheet of the study area

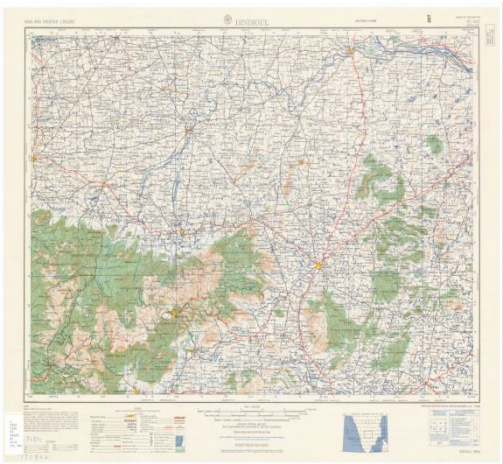

Figure 3 Toposheet on study area

Figure 4 shows the Location of the study area (Kodavanar watershed)

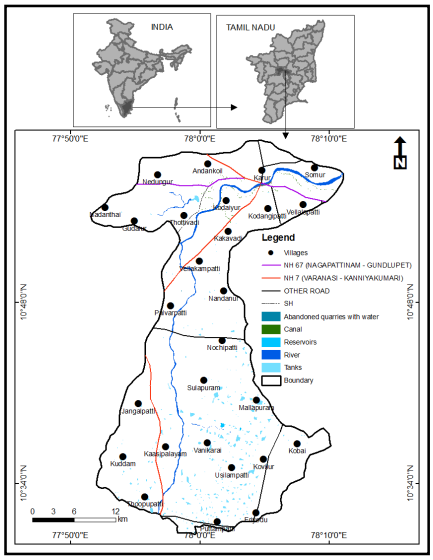

Figure 4 Location of the study area (Kodavanar watershed)

4. ABOUT SOFTWARE

Different software packages are important for GIS. Central to this is the GIS application package. Such software is essential for creating, editing and analyzing spatial and attribute data, therefore these packages contain a myriad of GIS functions inherent to them. Extensions or add-ons are software that extends the capabilities of the GIS software package. Component GIS software is the opposite of application software. Component GIS seeks to build software applications that meet a specific purpose and thus are limited in their spatial analysis capabilities. Utilities are stand-alone programs that perform a specific function. For example, a file format utility that converts from on type of GIS file to another. There is also web GIS software that helps serve data through Internet browsers.

4.1 Data

Data is the core of any GIS. There are two primary types of data that are used in GIS. A geodatabase is a database that is in some way referenced to locations on the earth. Geo databases are grouped into two different types: vector and raster. Vector data is spatial data represented as points, lines and polygons. Raster data is cell-based data such as aerial imagery and digital elevation models. Coupled with this data is usually data known as attribute data. Attribute data generally defined as additional information about each spatial feature housed in tabular format. Documentation of GIS datasets is known as metadata. Metadata contains such information as the coordinate system, when the data was created, when it was last updated, who created it and how to contact them and definitions for any of the code attribute data.

4.2 Remote Sensing System

With the background treatise on remote sensing we have made so far, it would now be easier make an analysis of the different stages in remote sensing. Origin of electromagnetic energy.

- Transmission of energy
- Intervening of energy or self emission
- Detection of energy
- Transmission or coding of the sensor output
- Collection of ground truth
- Data analysis and interpretation

5. DSS IN AGRICULTURE

Simulation based DSS models are widely applied in agriculture, as these models provide viable input to the management decisions because of their effective predictive capability. The first simulation based DSS comprising of soil module, weather module and crop module called as a Decision Support System for Agro-technological Transfer (DSSAT) is developed in different regions and crops to decide the type of seed to grow, when and how much to irrigate, rate of application of fertilizer and crop yield prediction. The DSSAT was then modified depending upon the type of crop and agriculture environment. Figure 5 shows the types of DSSAT

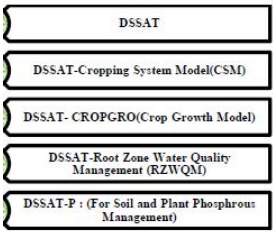

Figure 5 Types of DSSAT

The conventional DSSAT model considered crop predictions on the basis of only soil and plant Nitrogen (N) contents. Along with nitrogen, phosphorus (P) is a major nutrient required in plant growth and reproduction. Land degradation has caused soil P-deficiency which results in a decrease in crop productivity and land cover, increased vulnerability to soil erosion. To resolve this DSSAT was redesigned with soil and plant phosphorus model which is called as DSSAT-P model which helped in simulation of crop growth in P-deficient environments.

6. ANALYSIS DATA

6.1 Groundwater Quality Index

6.1.1 Drinking Water Quality Index (DWQI)

The 'DWQI' has been calculated to evaluate the suitability of groundwater quality of the Kodavanar watershed for drinking purposes. The WHO (2004) standards for drinking purposes have been considered for the calculation of DWQI. The physical and chemical parameters of pH, TDS, EC, Ca, Mg, Na, K, HCO_3, Cl, SO_4, NO_3 and F were utilized. Each of 12 parameters has been assigned a weight (w_i) according to its relative importance in the overall quality of water for drinking purposes (Table 1). Figure 6 shows the Annual average rainfall in the study area

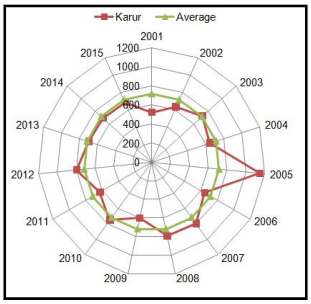

Figure 6 Annual average rainfall in the study area

Figure 7 shows the Geological Settings of (Kodavanar Watershed)

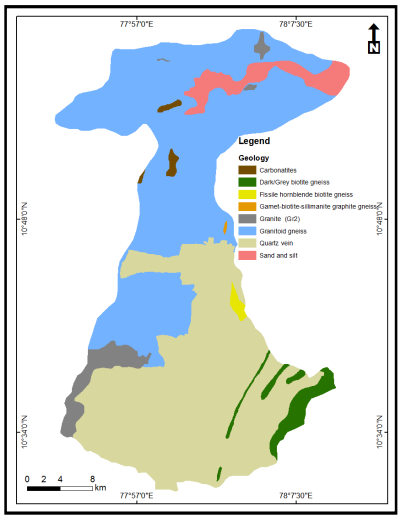

Figure 7 Geological settings of (Kodavanar Watershed)

Figure 8 shows the Pre, Post and Water Level Fluctuation of Study Area

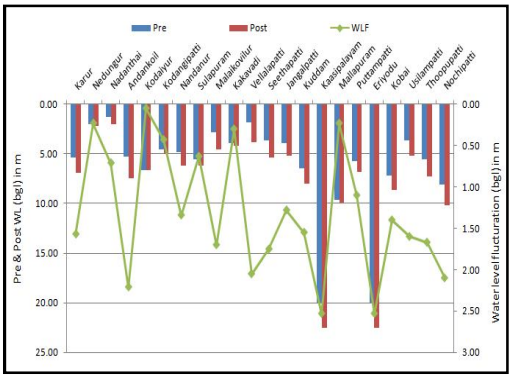

Figure 8 Pre, Post and Water Level Fluctuation of Study Area

Figure 9 shows False Color Composite (FCC) image of Kodavanar watershed (IRS P6 LISS III)

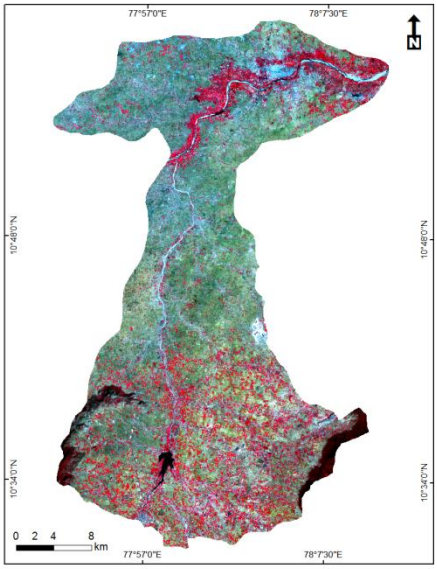

Figure 9 False Color Composite (FCC) image of Kodavanar watershed (IRS P6 LISS III)

Figure 10 shows Drainage pattern of study area

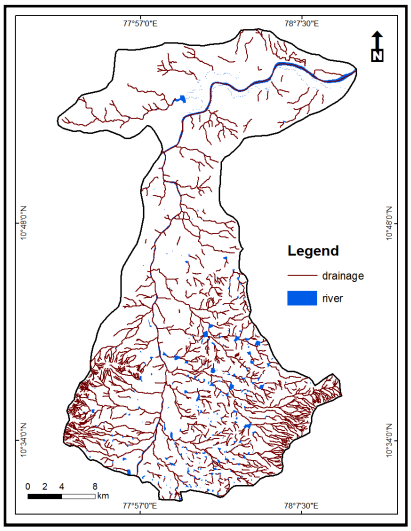

Figure 10 Drainage pattern of study area

Figure 11 shows Drainage density of study area

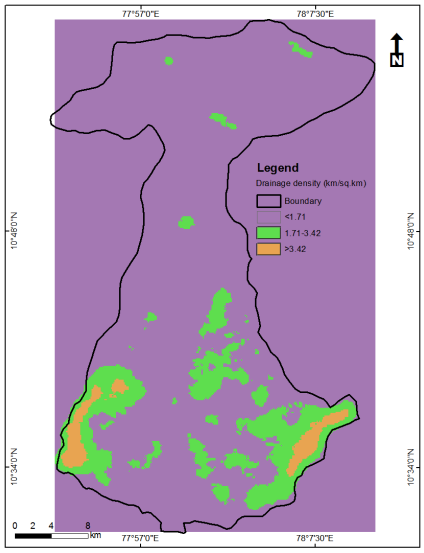

Figure 11 Drainage density of study area

Figure 12 shows Lineaments of study area

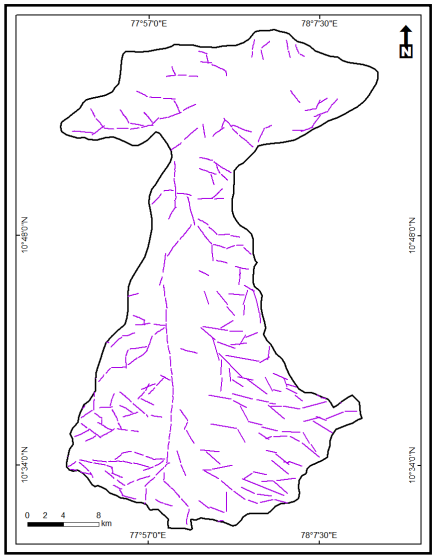

Figure 12 Lineaments of study area

Figure 13 shows Lineament density of study area

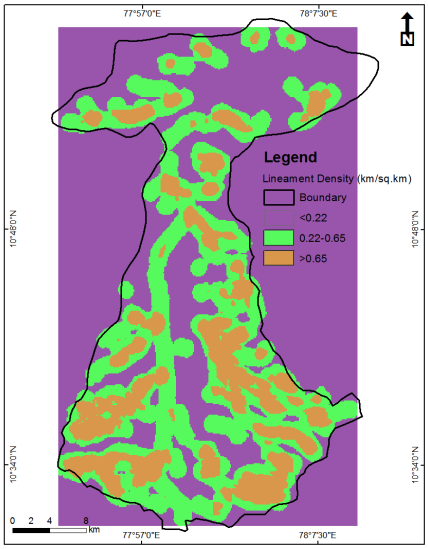

Figure 13 Lineament density of study area

Figure 14 shows Geomorphological features of study area

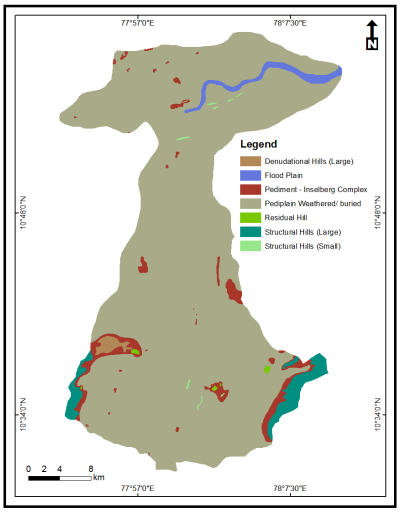

Figure 14 Geomorphological features of study area

Figure 15 shows Electrical conductivities in groundwater

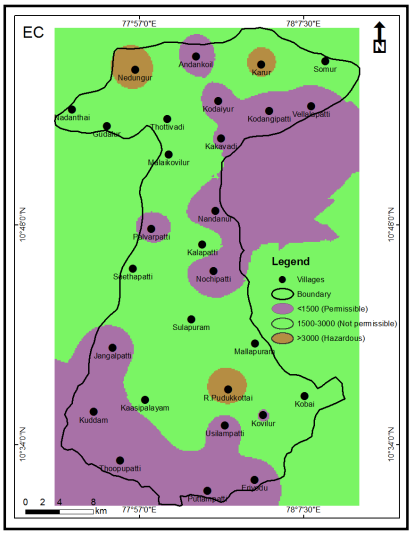

Figure 15 Electrical conductivities in groundwater

Figure 16 shows TDS Concentration in groundwater

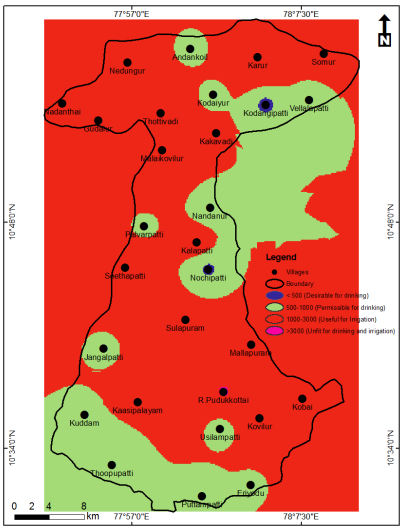

Figure 16 TDS Concentration in groundwater

Figure 17 shows Chloride concentrations in groundwater

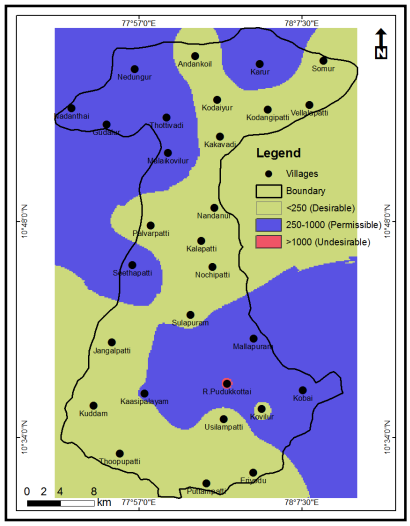

Figure 17 Chloride concentrations in groundwater

Figure 18 shows Concentration of fluoride in groundwater samples

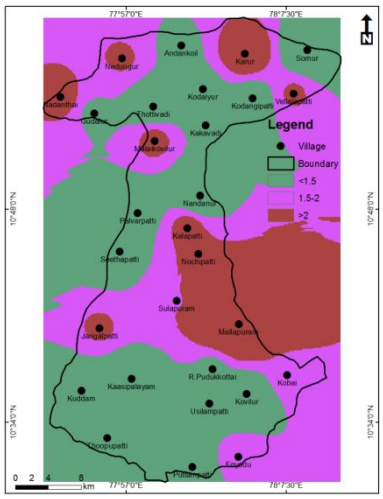

Figure 18 Concentration of fluoride in groundwater samples

Figure 19 shows Nitrate concentrations in groundwater

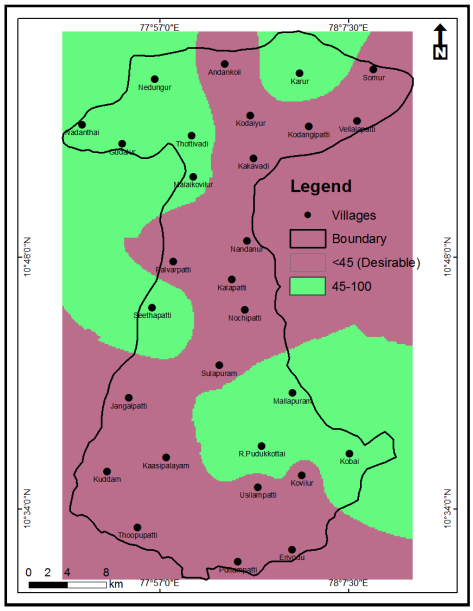

Figure 19 Nitrate concentrations in groundwater

Table 1 shows WHO standards weight (w_i) and calculated relative weight (W_i) for each parameter

Table 1: WHO standards weight (w_i) and calculated relative weight (W_i) for each parameter

Parameters	WHO standard	Weight (w_i)	Relative weight (W_i)
pH (mg/l)	7-9.2	4	0.105
TDS (mg/l)	500-1500	4	0.105
EC (mg/l)	1000-1500	2	0.053
Ca (mg/l)	75-200	2	0.053
Mg (mg/l)	30-150	2	0.053
Na (mg/l)	50-200	2	0.053
K (mg/l)	10-12	2	0.053
HCO_3 (mg/l)	300-600	4	0.105
Cl (mg/l)	250-600	3	0.079
SO_4 (mg/l)	200-600	4	0.105
NO_3 (mg/l)	50-100	5	0.132
F (mg/l)	0-1.5	4	0.105
Total		38	1.000

6.2 Irrigation Water Quality Indices (IWQI)

The various irrigation water quality indices were derived from the primary parameter of drinking water quality (Table 1). In order to assess the irrigation water quality in the watershed an attempt has been made to develop a model on Irrigation Water Quality Index (IWQI). The various irrigation water quality indices such as SAR, SSP, RSC, M-Hazard and K-Ratio were considered to assess the groundwater quality for irrigation. The indices value summed, then classified into excellent to unfit groundwater quality. The output has shown only 16% of area suitable for irrigation, whereas major parts of the area (84%) fall under poor to very poor category. The result has shown, the

quality deterioration in terms of irrigation, which requires sustainable irrigation practices including optimum utilization of fertilizers and selecting organic farming. Based on the quality deterioration the sub-basin further classified into sustainable to highly unsustainable state of groundwater quality for sustainable development.

7. CONCLUSION

- A significant part of canal command area Sub-basin, is affected by water-logging and consequent increase in fallow area, reduced productivity and growth in unhygienic living conditions in settlement area.
- One of primary reasons of water-logging in canal command area is canal-induced seepage and unauthorized practice of using more than raster allocation of canal water in head reach.
- Higher cost of groundwater irrigation is major bottleneck for more groundwater use.
- Nevertheless, simulating complex interaction of groundwater and surface water in conjunctive irrigation scenario is a challenging task and requires tools like DSS.
- Various scenarios can be evaluated related to change in canal operation and management, agriculture practice and land use, climate and so on. As far as its generic nature is concerned, it currently lacks capability to simulate any reservoir operation rule and its application is limited to run-off river canal systems. Nevertheless, additional source available from any reservoir or inter-basin transfer can be incorporated without any difficulty. Attempt has been made to make icrop generic enough to model any run-off river canal systems, particularly in our state.

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