GEO-SPATIAL TECHNIQUES FOR STRATEGICAL PLANNING IN WATER RESOURCES MANAGEMENT AT SURENDRANAGAR

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ABSTRACT

Natural resources are important for development of any country and water is one of the precious natural resources as well as very complex to manage at the same time. In Gujarat many region are semi-arid region. Surendranagar region is the one of Semi- arid region which is located in Gujarat and facing problem related to water. This study aimed for sustainable management of water resources by the strategic planning and management. Models have been established in past for studying complex hydrological parameters. Resources assessment in Surendranagar region was accomplished by using remote sensing technique and GIS based Soil and Water Assessment Tool (ArcSWAT) was used for Runoff estimation.

Land use and land cover changes also affect the runoff and essential input parameter in model. Hence it is important to detect the land use changes. Land use and land cover for the years 1993,1998,2005,2009 and 2015 were obtained through processing of satellite imaginary LISS-III (IRS) and TM (LANDSAT) sensors with spatial resolution of 23.5m and 30 m respectively in ArcGis 10.2 software using supervised classification technique. Geographic information system is essential for mapping of land use. Eight major land use parameters are taken for this study area are water body, vegetation, open land, waste land, sandy, aquatic vegetation, agricultural field, urban. Various parameters CARTOSAT-1 Digital Elevation Model (DEM), Land use, soil data and temporal data such as precipitation, temperature, wind speed, relative humidity was used as a input parameter in model. Analysis exposed that evapotranspiration losses are high because of high percentage of vegetation cover.

Keyword: - *ArcSWAT, Sustainable Management, Water Resources, GIS.*

1. INTRODUCTION

Prosperity of nation mainly depends on its natural sources; one of such important resources is water. WATER is a precious natural resource and at the same time very complex to manage. It is a fundamental resource for human life. There is no doubt that India has done very well in the sector of water resources development, which has played a significant role in the progress of the country. Due to the increasing demand on water resources, the pressure on its consumption is also increasing. Besides being precious, water is also very complex to manage because of its dynamic behavior. The issues of sustainable management of water resources are vital for many developing countries. In India, varying weather conditions as well as the spatial changeability of land use result in nonlinear performance of the watersheds result in many regions facing problem of water. Hence, water resources need to be managed in sustainable way. Watershed is a hydrological unit for management of water resources.

Definition & Terms:-

Water resources: Water resources are sources of water that are potentially useful. Uses of water contain household and environmental activities.

Water resources management: Water resources managements the activity of scheduling and managing the prime use of water resources.

Watershed: Watershed is a unit draining runoff to common point of outlet.

Hydrological model: Hydrologic models are simplified, theoretical representations of a part of the hydrologic cycle. They are primarily used for hydrologic forecast.

Geographical Information System: A computer assisted system for the procurement, storing, examination and presentation of geographic data.

Remote Sensing: Remote Sensing is the Science of making inferences about objects from measurements, made at a distance, without coming into physical interaction.

Land use: The usage of land could be agriculture, urban, development, logging, and mining among many others.

Land cover: Land cover classes could be cropland, forest, wetland, pasture, roads, and urban zones. The state of vegetation, such as forest or grass cover

Image classification: Digital image classification techniques cluster pixels to signify land cover features. Land cover could be forested, urban, water, open land, agricultural and other types of features. There are two main image classification techniques.

This study aims for optimizing Remote sensing techniques for analysing hydro-climatic behaviour enhanced use of digital image processing to evaluate impact of land use parameter over water resources. It also covers determination of hydrological measurement via spatial analysis i.e. calculation of watershed basin and sub basin parameter and development of framework to obtain weather cantered hydrological parameter i.e. runoff, Infiltration, sedimentation, aquifer condition and flow pattern. At the end evaluation of derived framework over hydrological climaxes i.e. methodology assessment using correlation analysis is done.

Remote Sensing is the Science of making implications about matters from measurements, made at a distance, without coming into physical Interaction with the objects under study. Remote sensing data have been used to develop thematic evidence on numerous natural resources. Land use map and digital elevation model casing the study area were resulting with help of remote sensing.

GIS is combined into hydrologic models for measuring the impact of various land use and land cover. GIS is an effective tool in watershed modelling as Remote sensing resulting information can be well combined with the conservative database for approximating Runoff which can help in arrangement suitable soil and water conservation measure. The development of remote sensing and GIS techniques has permissible the use of spatially and physically based hydrologic models to pretend as simply and realistically as possible the operative of watershed systems.[1] Both qualitative and quantitative variations in land cover have been positively checked with remote sensing, with research dominated by efforts at monitoring change in vegetation and forest canopies.[2] GIS is a suitable tool for the effective organization of large and complex record and to provide a digital representation of watershed features used in hydrologic modeling. Expansion of remote sensing (RS) techniques and Geographic Information System (GIS) abilities has encouraged and improved the expanded use of watershed models worldwide.[3] Land cover evidence is carried out by study of remotely sensed imagery and provide evidence of land use such as vegetation, water body and water quality.[4] Use of mathematical model for hydrologic assessment of watershed is the current tendency along with extraction of watershed parameters by means of remote sensing and GIS.[5] Remotely sensed data are a valuable tool and have scientific worth for the study of human environment connections; specially land use and land cover variations.[6]

2. STUDY AREA & DATA USED

2.1 Study Area

The study area has been taken is Surendranagar district of Gujarat. The Surendranagar district is one of the districts of the Saurashtra. It lies approximately between 22°8′N – 23°31′N latitude and 70°57′E – 72°11′E longitude. The length from north to south is about 155.4 km and breadth from east to west about 127.5 km. It is bounded on the north by the little Ran (Desert) of Kutch and the Patan district. In the south are parts of the district of

Ahmedabad and Bhavnagar, on the west it is bounded by Rajkot district and on the east again by the Ahmedabad district. The area of this district is 10,489 square km.

2.2 Data Used

The climate of this region is characterized by a hot summer and overall dryness excluding during the south-west monsoon period. The year may be separated into four seasons. The cold period from December to February is followed by the hot season from March to May. The period from June to September founds the southwest monsoon season. The period from October to November is the post-monsoon period. Temperature and Wind Data's are collected and used.

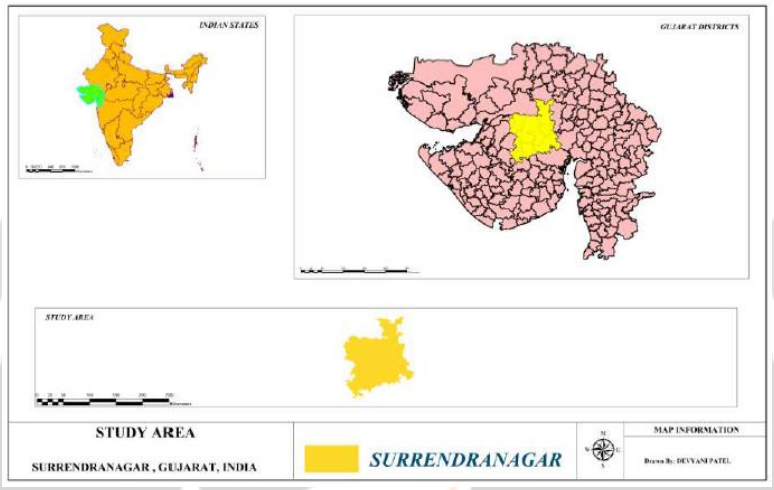

Figure 1 Location Map of Surendranagar

There are five core types of soils in the Surendranagar region. They are alluvial, light sandy soil, rocky, medium rocky and red soil. The medium black soil is the most prime variety of soil in the area. It shields about 80 per cent of the area of the district. This kind of soil is highly spongy of moisture and is sticky and is, therefore, best matched for cultivation of cotton. Cotton is, therefore, one of the significant cash crops of the area. In some parts of the area, an especially part of Dasada and Lakhtartalukas soil is shaped by receded sea and therefore, naturally has moderately superior degree of salinity. In Dhrangadhra, soil is molded from sand stone and hence soil is thin and sandy and visible to erosion. Red soil is originated in parts of Halvad and Dhrangadhratalukas. Hilly soils are originated in the Chotilataluka, where around 25 percent of the area is predictable to be below the result of these hills.

Table 1 : Details of Satellite Image

http://vedas.sac.gov.in:8080/SDIS_Web/Sdis_Query.jsp

Name of Satellite/ Sensor/ Spatial Resolution/ Swath	Band	Date
IRS II/ LISS III/ 23.5 m/ 141 km	Band 2: 0.52-0.59 mm Band 3: 0.62-0.68 mm Band 4: 0.77-0.86 mm Band 5: 1.55-1.70 mm	14/11/2016 19/03/2016

3. METHODOLOGY

The methodology used for this study includes hydrological model and data collection, data preparation which was used in the simulation of model. Validation of model is also carried out. Soil and Water Assessment Tool (SWAT) is applied.

3.1 Data Collection:

The long period climatologically datasets of precipitation, temperature, wind speed, solar radiation relative humidity and soil data are mandatory for the hydrological modeling. For SWAT model, the records of precipitation and temperature are the least Mandatory involvements and the other parameters are non-compulsory. LANDSAT4-5TM (1990-2011) and L8 (2012- 2016) satellite images are essential for study area to examine land use and land cover database. CARTO-DEM is vital for topography and hydrology study such as slope map, flow direction, Flow accumulation, and stream network and delineate of watershed.

3.2 Creation of Database:

The simulation of the water balance of a study area by SWAT model needs a large amount of spatial and time series datasets in order to found the water balance Equation. The topography, land use/land cover and soil data are spatial datasets which defines the land scheme of any zone and the most necessity of the hydrological model.

3.3 Digital Elevation Model (DEM):

The CARTO-DEM of 2.5m resolution used for the extraction of flow direction, flow accumulation, stream network generation and delimitation of the watershed and sub-basins. The topographic factor such as terrain slope derived from the DEM.

3.4 Land Use

LANDSAT 4-5TM AND L8 satellite imageries are mandatory to assess land use of study area. LANDSAT image has spatial resolution 30m. The supervised classification is used to differentiate land use classes. Eight major classes are so identified. Water body, Vegetation Open land, waste land, sandy, aquatic vegetation, agricultural field and urban.

3.5 Software Used

IGIS: This is established by ISRO and used to convert L-3 format to TIFF format

ArcGIS 10.3: software used for digital image processing on satellite data and digital elevation model to create land use map and to perform hydrological assessment.

Microsoft excel: is used to calculate land use area and to create pie chart.

3.6 Digital Image Processing

For estimation of area of various land use in Surendranagar area, it was prearranged to downloading satellite data such as LISS-III satellite imaginary and CARTOSAT-1 DEM (digital elevation model) from official website VEDAS at ISRO and LANDSAT 4-5 TM satellite imaginary from USGS earth explorer. Geo-referencing of satellite imaginary by selecting ground control points in ArcGIS software and sub-set of Surendranagar area using boundary shape file then classify satellite image adopting appropriate classification technique.

There are two types of classifications used mostly.

1.) Unsupervised classification

2.) Supervised classification

Unsupervised classification is not beneficial for this study because of merging of cluster it was not able to identify specific land use class. Therefore supervise classification is used for better result.

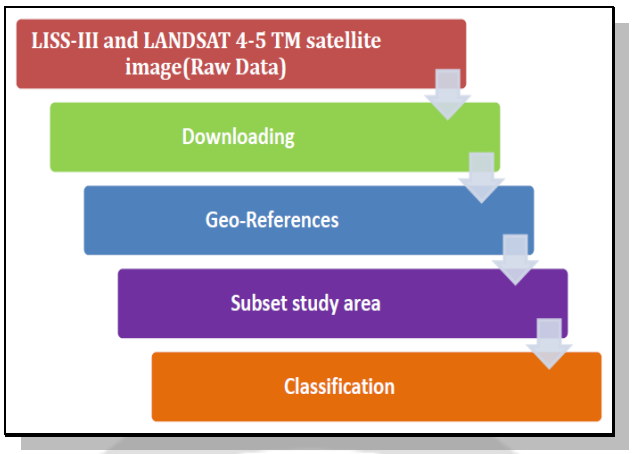

Figure 2. General Elaborative Methodology

In supervise classification there are some features which were difficult to identify such as waste land, vegetation and agricultural field for that NDVI (normalised vegetation index) technique is used.

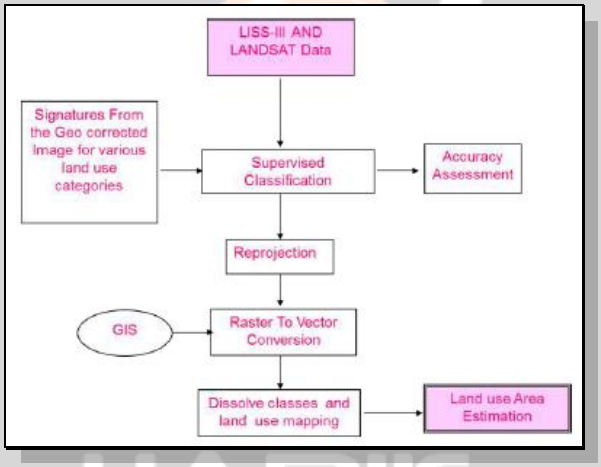

Figure 3. Flowchart of Land use Area Mapping

3.7 Data Downloading & Interpretation

LISS-III and LANDSAT data of Surendranagar have been downloaded from official websites. When data have been downloaded successfully it has been examined so that it can be taken for advance processing.

3.8 L-3 Format To Tiff Format

LISS-III images were in L-3 format which is converted into TIFF format using header or footer file of satellite image in IGIS software which is established by Indian Space Research Organisation (ISRO).

3.9 Image Interpretation

Multispectral image may be in true colour composite or false colour composite. False colour composite is a result of combination of different bands of satellite image. It is generally advisable combination for user.

3.10 Geometric Correction:

The geometric correction of image data is a **significant** in geographic information systems (GIS) and other image processing software. To procedure the data with other data in a GIS, all of the data must have the similar reference system. A geometrical correction, also called **georeferencing**, is a technique where the content of a map will be allotted a spatial coordinate system (geographical latitude and longitude).

3.11 Sub-Image Extraction:

The technique of extracting the area of interest from the satellite image is called sub-image extraction. Study area is extracted using boundary shape file from DIVA-GIS. Extracted study area is processed rather than processing the entire image.

3.12 Supervised Classification Technique

Classification is a method of identification and grouping of features. Supervised classification is based on the spectral appearances of features .Technique of the supervised classification contains three stages.

1.) Training stage

2.) Classification stage

3.) Output stage

Description of land use classes:

Water body: Water seems dark black or dark blue and in light blue form depending upon quality of water. Turbid water will seems in light blue tone and clear water appears as black shade.

Vegetation: Vegetation gives red colour for infrared reflection.

Urban area: Area with regular or irregular man-made structures. Which having very low vegetation and it appears light grey or white tone.

Waste land: Waste land seems light green colour and waste land will have rough texture.

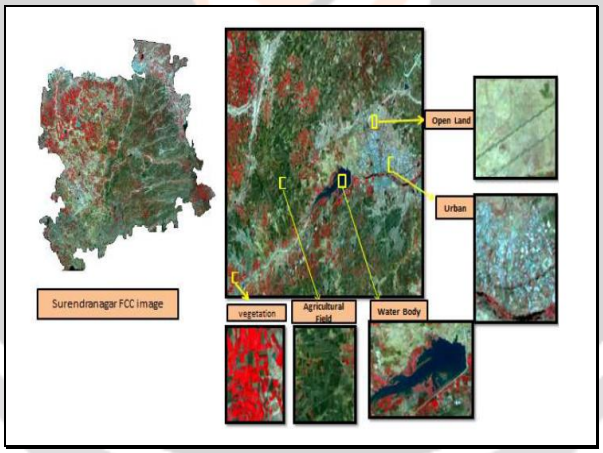

Figure 4. Identification of land use class on satellite FCC image

Aquatic vegetation: It appears as dark reddish black colour and black colour is for water. Aquatic vegetation located near water bodies.

Sandy: Sandy seems white tone to bright white tone which indicate seashore

Open land: Land which is large and appears as light cream colour.

Agricultural field: Field have regular geometry shape and seems dark green colour.

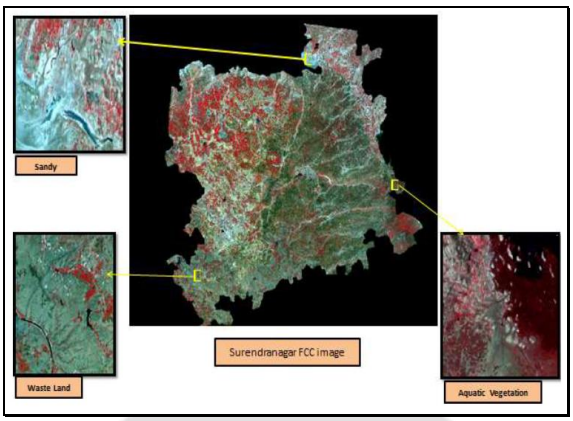

Figure 5: Identification of land use class on satellite FCC Image

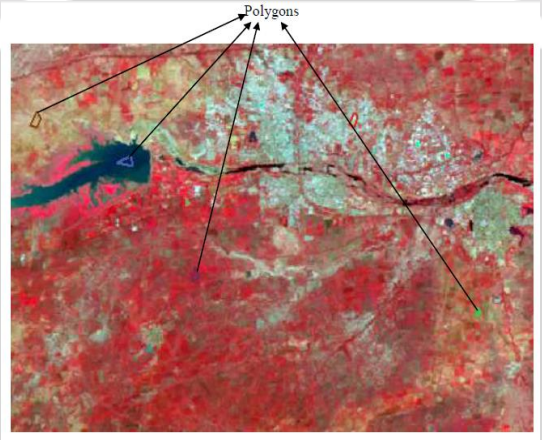

Figure 6: Polygons on LISS-III Image

Training stage:

In this phase the pixels from the image are identified which is popularly known as signature set. The signature is taken as polygons on the image. The class may have variant in signature from different place for the same class and merge all in to one. This will give the more precise result.

Training Sample Manager

ID	Class Name	Value	Color	Count
1	WATER BODY	1		1212
2	VEGETATION	57		479
3	waste land	4		1238
4	agriculrual field	58		21
5	sandy	65		313
6	urban	94		17
7	open land	100		156
8	aqautic vegetat...	106		194

Figure 7: Signature Set for Supervised Classification

3.13 NDVI Technique

The normalized difference vegetation index (NDVI) is the most widely used for identification of vegetation. NDVI range is between -1 to +1.NDVI is used when numbers of classes are merging with each other and difficulties arise in classification. In ArcGIS software NDVI is generated from satellite image and reclassified NDVI using reclassify tool by applying NDVI reclassify values in tool.

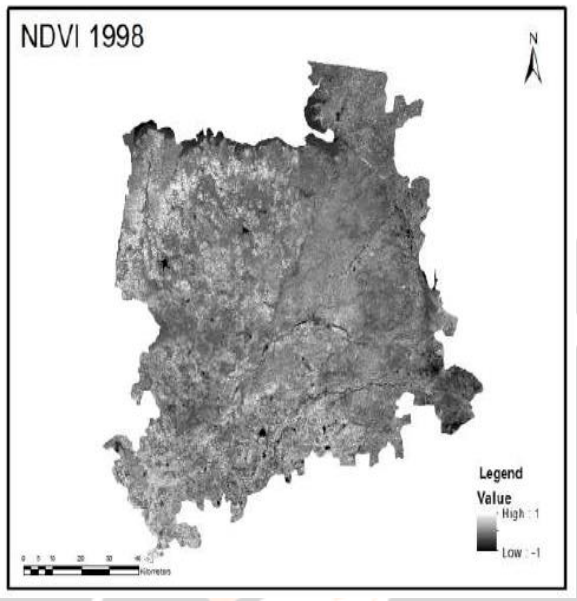

Figure 8: NDVI Image 1998

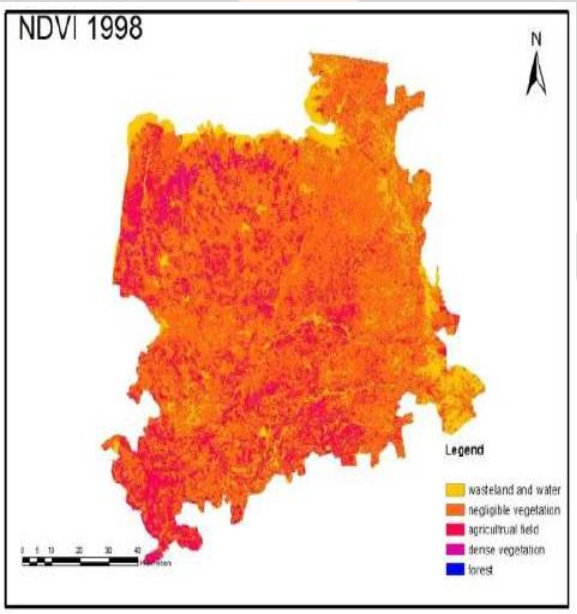

Figure 9: Reclassified NDVI Image 1998

4. ANALYSIS, RESULTS & DISSUCISION

4.1 Land Use Mapping & Area

Human activities have modified the environments over years. Water body, vegetation, agricultural, waste land, open land, sandy and other land uses have impact on earth's surface. Land uses have major effects on hydrological systems. An understanding of past and present land use change is essential for proper management.

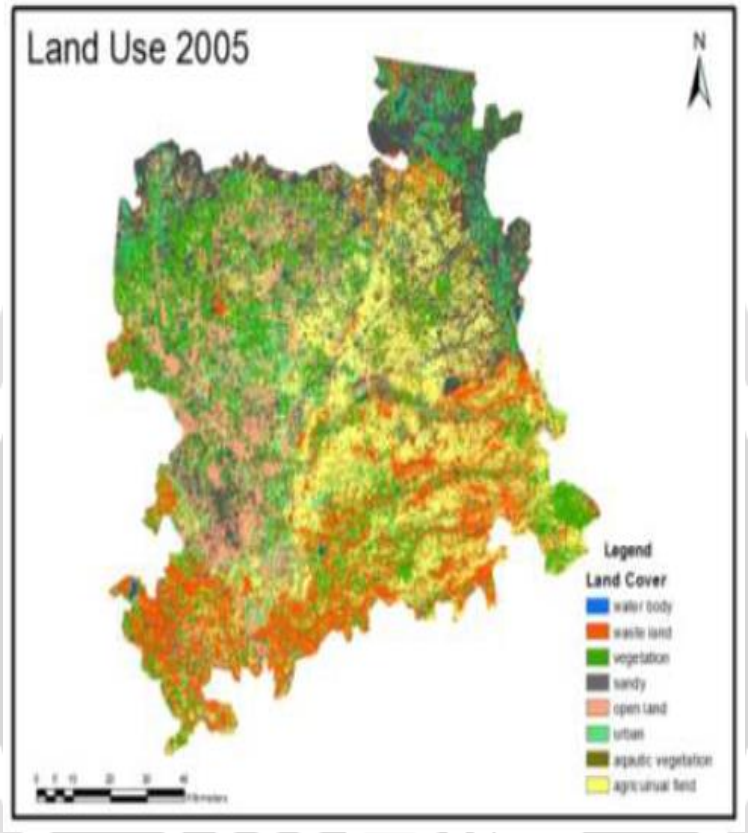

Figure 10: Land Use 2005

Land use is an input in SWAT model. Eight major classes identified for this study:

1) Water body
2) Vegetation
3) Agricultural field
4) Waste land
5) Aquatic vegetation
6) Sandy
7) Urban
8) Open Land

Land use area is estimated from land use map using Raster to Vector tool in ArcGIS software and area is measured in sq.km. Geographical area of Surendranagar is 10489 sq.km.

In 2009, Surendranagar land use scenario is open land 8%, sandy 13%, agricultural land 27%, water body 2%, waste land 25%, vegetation 19%. Land use parameters such as Vegetation, agricultural field and waste land were found out in a large area than other parameters in Surendranagar region.

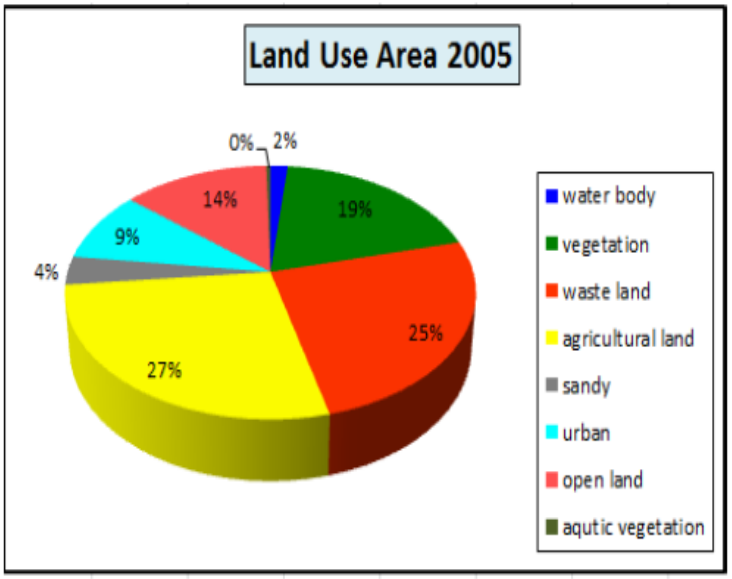

Figure 11: Pie Chart of Land Use 2009

4.2 Accuracy Assessment

Table 2: Accuracy Assessment

Year	1993	1998	2005
Class Name	Users Accuracy(%)	Users Accuracy(%)	Users Accuracy(%)
water body	88.76	90.01	92.26
vegetation	80.6	82.5	81.79
waste land	82.2	79.8	80.25
agricultural land	79.9	82.65	81.58
sandy	85.33	84.55	81.23
urban	60.54	62.21	61.78
open land	70.33	71.22	71.56
aqutic vegetation	89.21	91.48	90.33
Total	79.60875	80.5525	80.0975

4.3 Application of Model

Soil and Water Assessment Tool (SWAT) is a physically based and semi-distributed model was established to simulate and predict the runoff, sediment load for large and complex watersheds having different soil type and land use. SWAT model is beneficial when watershed have no stream flow record. In SWAT model watershed is divided into sub -watershed which having unique land use and soil type. It is termed as Hydrological Response Unit (HRU).

Therefore land use and soil data is essential in SWAT model to obtain runoff. Climatic data is also important as Input information in model such as Rainfall, Relative humidity, Wind speed, solar radiation and Temperature. Daily values for weather are collected from GLOBAL WEATHER DATA FOR SWAT. Soil database is created in model using soil textured data such as %silt and %clay due to having difference of soil name in model and Surendranagar area.

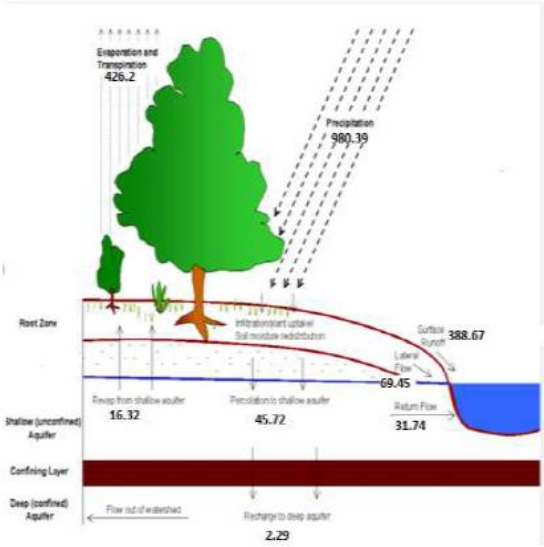

Figure 12: SWAT Output of 1993

Fig. 12 shows systematic representation of hydrological cycle in 1993. Hydrological parameters such as rainfall is 980.39 mm, evaporation and transpiration is 426.2 mm, percolation to shallow aquifer is 45.72 mm, lateral flow 69.45 mm and runoff is 388.67 mm.

5. CONCLUSIONS

One of major problem faced in India is water scarcity and another main problem in hydrology is to collect field statistics to describe hydrological procedure. Remote sensing is a tool which provide spatial information and that can be used as a input parameter in hydrological modelling. Use of remote sensing data with GIS technique in hydrological modelling provide prime solution for water resources management .the observation was carried out for 12 years period from 1993 to 2005.

SWAT model is suitable for the hydrological process and it is most significant part for strategic planning of water resources management. The model was applied for Surendranagar region to evaluate runoff. Input parameters land use and land cover produced using geo spatial technique are applicable in swat model which affects runoff. Proper relation between land use, soil and water was brought out using model.

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