

# **NATURAL RESOURCE MANAGEMENT: ROLE OF MODERN CARTOGRAPHY AND GIS & RS TECHNOLOGIES**

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## **1.0 INTRODUCTION**

Natural resources are the measuring scale of any country's socio-economic development. A sustainable development needs proper management of natural resources. Developing countries like India having rich natural resources experienced a worst drought situation in recent past due to mis-management of natural resources. Any form of energy and / or matter essential for the fulfillment of physiological, socio-economic and cultural needs of humanity could be a resource. Those resources that are available freely from our planet Earth are natural resources. Some of them are renewable (fish, crops, forests) and other are non-renewable (oil, coal and other minerals ) (Nageswara Roa, 1996).

Water is a limited natural resource, which is indispensable for the existence of all-living matter; plant, animal and man. History bears eloquent testimony to the fact that civilization developed around abundant supply of water and disappeared in its absence. The influence of water on the economy of a country is well known. The demand of water for the development of agriculture, industry, urban use, power generation, navigation etc., is increasing at a very fast rate and in some of the advanced countries it is feared that the demand may outgrow the available supply, which will obviously put brake on the rate of development. This rapid technological advancement of the modern age has brought to a stage where the standard of life of a country is being judged on the basis of water consumption per capita. In order to meet the increasing demand in pursuit of better living, ceaseless efforts are being made to access the water supply, plan for economic utilization and to increase the water supply with the help of storage dams and watershed management.

The identification of water resources and its proper management practices are very essential with respect of the population growth and their increasing needs. In the modern cartography era Geographic Information System (GIS) and Remote Sensing (RS) are powerful tools to manage and analyze geographic information. Arc View, a powerful desktop GIS tool to visualize, update, analyze geographical Information, and create quality presentations that brings the power of interactive mapping. The advances in the field of cartography improved the quality presentation with

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accuracy of positions in real coordinates. The technology of desktop mapping has changed radically since the introduction of Arc View 1 by the Environmental Systems Research Institute in 1992. Arc View GIS, currently in version 3.2, offers the user unprecedented ease of use of creating maps from geographic data.

Cartography which is the making and study of maps, predates the invention of computerized geographic information system (GIS) by thousands of years (Ed Madej, 2001). In the modern era, traditional cartographic techniques employing ink pens, plastic overlays, and press-on type were slow and tedious, and did not allow for the generation of many alternative map products. If the map you were creating took a week of labour and chances are, there you had no extra time or energy to waste on seeing how it would look like with a different colour scheme, or if the data was symbolized using red rectangles rather than blue circles. Maps were made by professional cartographers, who had the time and the need to carefully plan where each map feature would be placed and to consider the visual impact of the final map product. Personal computers have become faster and less expensive, allowing the user to crunch large amounts of data in minutes that would have taken hours or days if attempted ten years ago. Short-run colour printing has become affordable. Putting colour on maps prior to the 1990s was an expensive and daunting proposition. Even the colour plotters used by GIS shops ran into the tens of thousands of dollars and require endless maintenance. Today, small printers with photo-realistic colour output can be found in any office supply store for a couple of hundred dollars.

GIS software has become less intimidating and less expensive. When Arc View 1 came out in 1992, it caused a sensation with its ability to visualize complex geographic data with themes that could be easily symbolized without using arcane typed-in command strings. Arc View 2 in 1994 introduced the idea of the map layout document, where geographic themes assembled in the view could be placed on a page and printed on a laser writer or plotter. The layout document, where geographic themes assemble in the view would be placed on a page and printed on a laser writer or plotter. Arc View 3.2 GIS the current version, has improved and strengthened these features, making it the most popular desktop GIS software package today, with nearly a quarter of million copies in use.

In the present study we have made an attempt to identify the potential water harvesting sites using the modern cartographic techniques to prepare Digital Elevation Model (DEM) and also the GIS & RS applications in a representative watershed of Central Himalayas with the following objects:

1. Identification of water potential source in Sadiyagad watershed.

The objective was selected because there is an acute shortage of water in the area. About 99% of the agricultural area, depend on rainfall. The existing under ground water sources and springs are barely sufficient to meet the drinking water needs and the requirement of livestock.

2. Locating suitable sites for constructing water storage tanks.

The villages in Sadiyagad watershed are scattered. Terrace farming is the traditional pattern of agriculture lands. The runoff water is lost along the drainage channels without much use. Identification of suitable sites along these channels can be useful for harvesting water for irrigation purposes.

## **2.0 STUDY AREA**

Sadiyagad watershed lies between Latitude 20° 20' 22" : 20° 35' 18" N and Longitude 79° 50' 33" : 81° 01' 00" E in Almora district of Uttaranchal in Central Himalaya. It is situated about 50 kms on the north east of district headquarter Almora and spreading over an area of 79.33km<sup>2</sup>. The elevation gradients in the watershed ranges from 700 to 2100 metres above the mean sea level. The undulating topography, uneven slope, deep valleys, uplands and series of ridges makes it unique in its form. The watershed included 47 revenue villages at different elevations having total population of 14,479 and the population density is 183 per square kilometre. The web of several small perennial and seasonal streams spread over the whole watershed where Sadiyagad the main perennial water source flows from west to east. It originates from the Ghauladevi and joins in the Panar River near Sadiyakhet.

The watershed falls within the sub-tropical climate in lower valley and sub-temperate climate in the higher elevations. The watershed vegetation, represents sub-tropical zone and is characterized by mixed forest dominated by pine (*Pinus Roxburghii*) and Oak (*Quercus leucotrichophora*), Deodar (*Cedrus Deodara*) and Sal (*Shorea rohusa*) an associated species at different altitudes (Singh and Singh, 1987). Agriculture is completely dependent on southwest monsoon rains from June-September. Apart from an additional short winter spell (Dec-Jan), the region experiences a rather long dry period. Sadiyagad is receiving an annual average rainfall of 114.6 cm and the mean monthly temperatures are varying between 9.65°C – 25.16°C during 1998. Since 1997 the highest and the lowest temperatures observed are 35.5°C and 0.5°C, respectively. Out of the watershed area of 79.33 km<sup>2</sup>, agriculture (including settlement) area constitutes 62.89% in 1996 and 46.44% during 1963. The agriculture extension is predominantly found between 1000 to 1700 metres elevations. Irrigation facilities do exist only in the lower elevations near the junction of the Sadiyagad with Panar River. Remaining agriculture terraces are dry, sloppy and scattered over the upper zones of the watershed. These areas need water harvesting through construction of check dams or storage tanks along the stream sources.

### **3.0 METHODOLOGY**

#### **3.1 Spatial Criteria used for Objective 1**

- i. Derivation of watershed model (Unique Basin) from the Digital Elevation Model. The area needed to be classified into smaller basins for better understanding of appropriate drainage pattern.
- ii. Identification of maximum water accumulation sites within each sub catchment. This is expected to provide water harvest sites for construction of storage dams from where adjoining agriculture areas in each basin can be irrigated.
- iii. A distance ranging between 500 to 1000 metres has been taken as criteria to select two successive water storage tanks.

### **3.2 Spatial Criteria Used for Objective 2**

- i. Identification of existing spring sources in the watershed area.

This information is further useful to assess water capabilities for drinking and livestock use, and provides information regarding deficit areas where drinking water sources are presently lacking.

### **4.0 DATA REQUIREMENT**

#### **4.1 The following available data has been used in the present study.**

Topographic sheet Nos. 53 O/14, 53 O/15 and 62 C/2 with scale 1:50,000

FCC- IRS1C LISS-III Band-2, 3, 4 Date: 17<sup>th</sup> Nov, 1996

Drainage Map (Perennial & Seasonal)

Land use Map

#### **4.2 The following maps were generated in the present GIS analyses study area using Arc View 3.0 software.**

An elevation contour point map was digitized from the topographic map.

Digital Elevation Model (DEM) was prepared using digitized elevation contour point map

Using Map Calculator, we have calculated the Flow Direction and Flow Accumulation using the filled DEM

Using Map Query, Flow Accumulation > 10000 is calculated.

Stream order (Strahler) and Stream Ids were calculated using Map Calculator.

Unique Basis model was prepared using Flow direction and Stream Ids. In all 9 major sub catchments were identified in the study area.

Agriculture and Settlement map was generated from the existing land use map and the same was buffered with a distance of 500m.

Available spring sources were plotted using Infrastructure map, and half a kilometre buffer zone was created for the spring source map. The infrastructure features were identified within the half-kilometre range on the buffered spring source map.

After reclassifying the Unique Basin Map into two classes, i.e., 0-No Data and 1-1, separate maps were generated for each individual basin (Basin1-9).

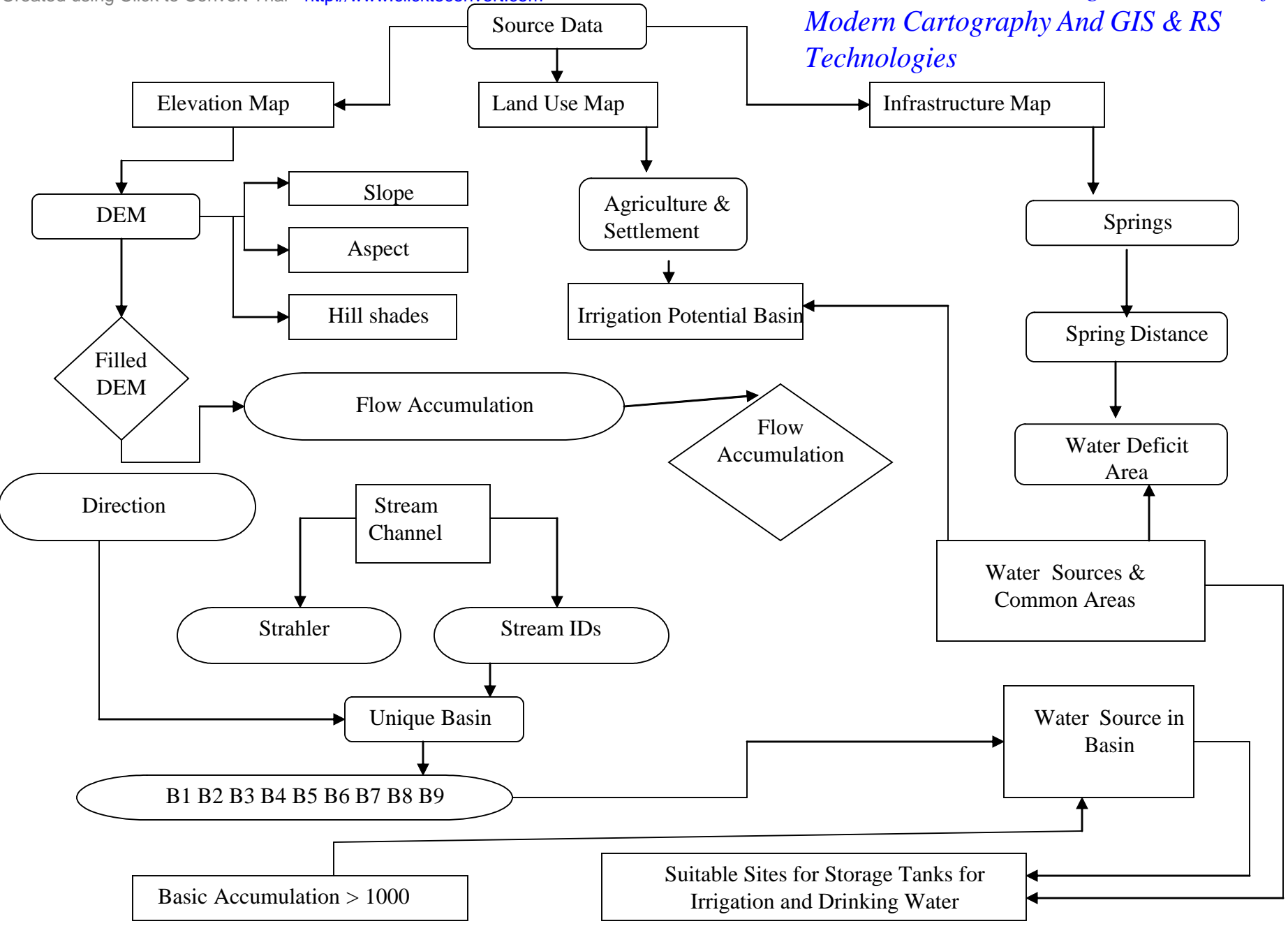
Each basin map was multiplied with Accumulation>10000 map to obtain the water source in that basin.

Less than 500m buffer zone was identified from the water source of the basin to calculate the water source and command area of the individual basin.

Water deficit area in each basin was obtained from the product of water source and command area and the spring distance maps using map calculator.

Irrigation potential of each basin was calculated by multiplying water source and command area and agriculture & Settlement maps.

The flow chart illustrates the aforesaid methodology to achieve the objectives (Figure 1).



## 5.0 RESULTS

The entire watershed area is segregated into nine sub-units, termed as basins or catchments, based on the criteria of elevation, slope, aspect, stream channels, flow direction, etc., Potential water sources along the perennial stream sources in each basin were identified (Figure 2) on the basis of water accumulation (accumulation no.>10000). A total of 40 suitable potential water accumulation sites were identified in the 9 basins ( See Table below ). Basin 6 and 7 having the highest number of potential water accumulation sites of 12 and 11 respectively; are largest in area as well. Basin 3 and 8 having the lowest number of potential water accumulation sites (one each). The basin 9, which is at S-W direction, doesn't have any suitable site for water harvesting.

TABLE 1

Basin No.	Area in Sq. k.m.	No. Of Potential Sites
01	9.46	03
02	7.79	04
03	4.11	01
04	2.87	06
05	1.68	02
06	25.17	12
07	21.54	11
08	0.02	01
09	4.04	0

All the identified potential water accumulation sites are not found within a close proximity to road for easier accessibility (figure 3). Therefore, we have generated a map which depicted potential water accumulation sources located within 100 metres of distance from the road. It is envisaged that such locations are convenient for routine fetching of water for domestic and livestock use. Basin 6, despite having largest number of potential water accumulation sites, has only three potential sources within the stipulated distance criteria in comparison to the 4 with 9 potential sites, and basin 1 with 7 sites. Further, some of the potential water accumulation sites at the peripheral margin of a basin can serve as source to the adjoining basins. Depending on the existing spring sources as well as the identified potential water accumulation along the stream source we presumed they will be able to cater only up to ½ km from the source and assessed the alternate areas within this region (Figure 4). The over lay of existing and proposed water harvest sites are used to calculate the total feeding capacity in terms of area; some of these represented common intersection areas (Figure 5). These sources are expected to cater to the need of about 50.06 km<sup>2</sup> area out of 79.33 km<sup>2</sup> of total watershed area.

## **6.0 CONCLUSION**

In Himalayas, steep slopes cause high runoff of the rain water, which is eventually lost down the stream. It could be useful to tap this water at some higher elevation for either irrigating the terraces or meet other domestic needs.

The GIS and Remote Sensing techniques provided the base information on the land-cover and land use maps, the pattern and placement of villages, forest, agricultural land and road network. The elicitation of drainage map and water accumulation capacity at different locations laid emphasis on identifying suitable sites, and to further identify closer proximity, of some of these sites from road for convenient routine harvesting. This information is required to be strengthened by adequate field studies and on site observation.

In all, 40 sites were identified which could be developed for harvesting runoff water for the purpose of irrigation and other uses. Out of these 21 sites lie within 100m from the road and easily accessible. An additional 27 sq km area was identified; totaling of about 50 sq km area that can irrigate half-km distance from potential source inside the Saidyagad watershed is identified.

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Figure 2

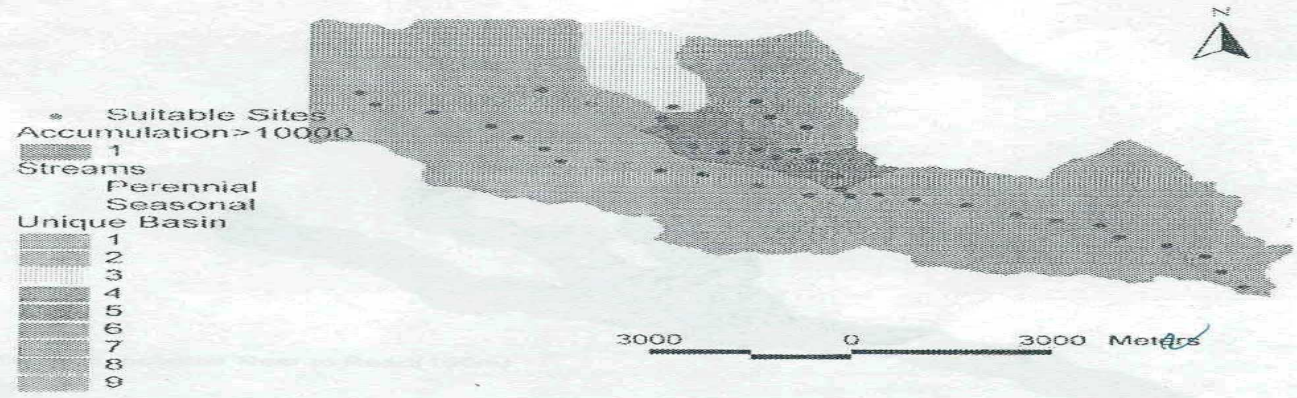
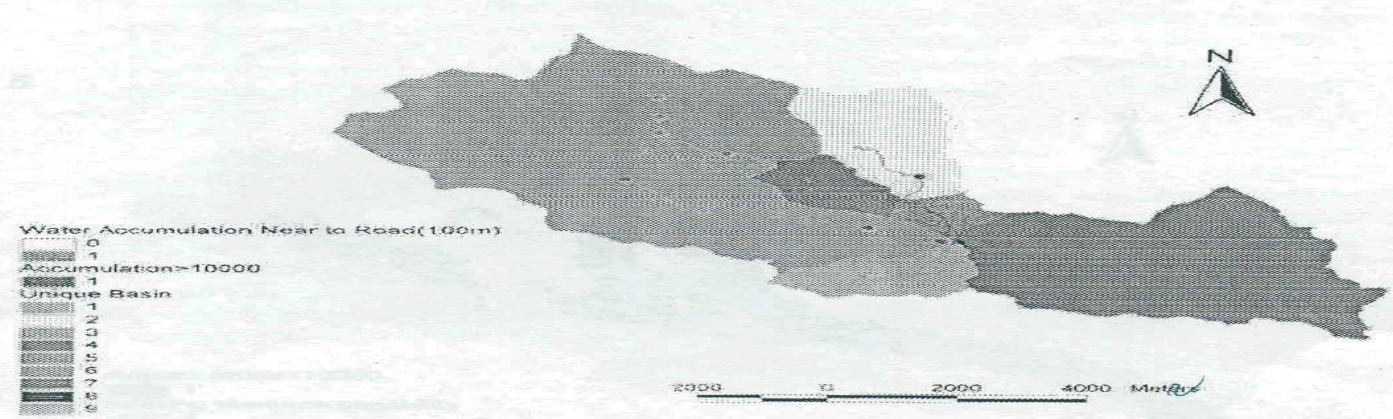
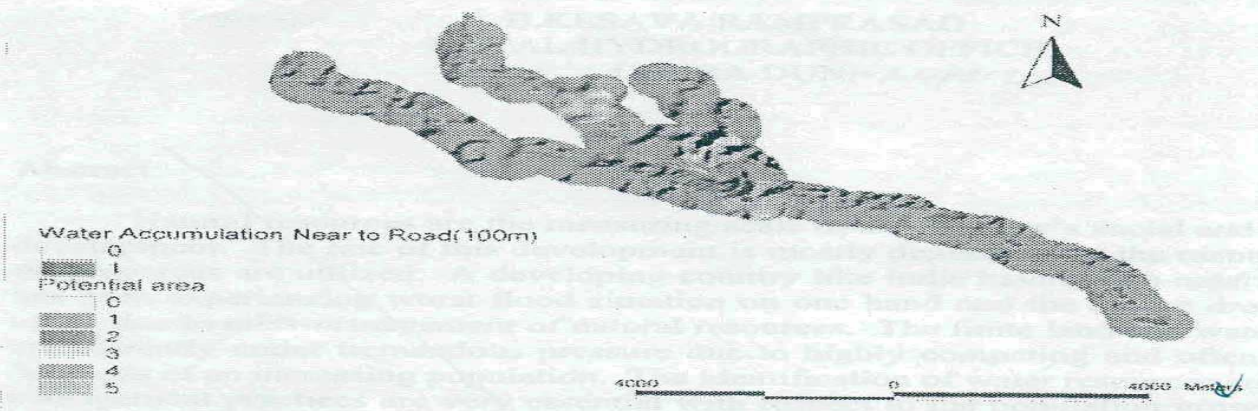


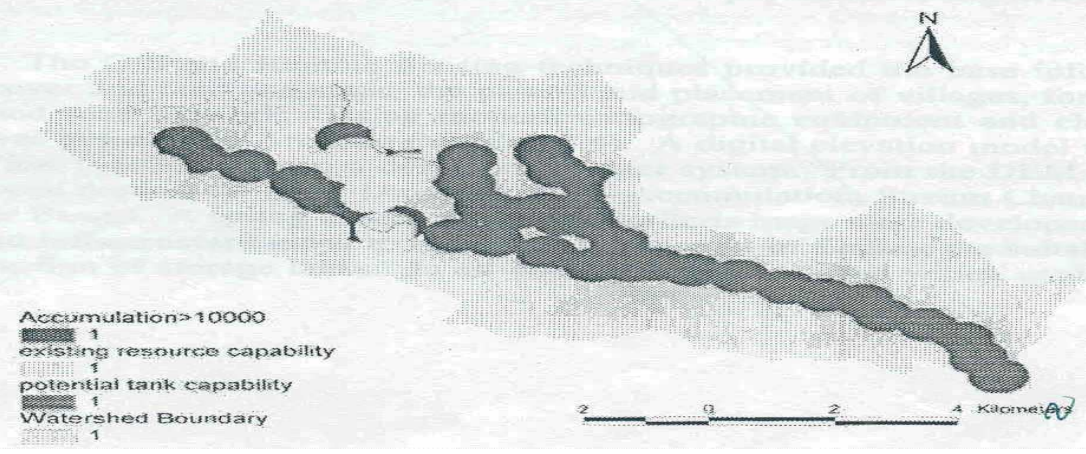
Figure 3



**Figure. 4**



**Figure. 5**



Application of GIS technology for hydrological modelling is still restricted to research labs and projects of academic value only (Meijerink *et al.*, 1994). Their application in development plans and projects is almost unheard in developing countries such as India. Another major problem is lack of data, inaccessibility of data when available as it is not available in digital form or official regulations. If the rainfall and runoff data available for the region we can feed that information to this model to obtain quantitative results. Even the usefulness of present model and prospective sites short listed for water harvesting could not be verified for their authenticity for want of relevant information on water requirements, existing irrigation structures, actual volume of water accumulations etc., However, potentials of water harvesting are already well documented for the region (Kothyari *et al.*, 1991; Dhruva Narayana *et al.*; 1990) in terms increasing agricultural and plantation productivity.

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