# USING GIS TO EVALUATE ENVIRONMENTAL IMPACTS FOR DAMS CONSTRUCTION

(Final Draft)

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## ABSTRACT

Within recent decades, there has been an increasing concern that human interruption and action have been negatively impacting the environmental and affecting the natural resources. A growing on environmental quality has forced and encouraged many countries to implement legislation and guidelines that will ensure the consideration of natural environment land-use planning and site location processes.

The Dams construction is one of factors influencing the environment including the natural resources. This concern has led to an increased emphasis on environmental studies all over the world. They start looking for powerfully technique to minimize the negative side affect of Dams construction GIS was the best selection technique in this field.

This paper shows how the GIS can be used to reduce the environmental impact by Dams selection. Finally a brief case study has been included to demonstrate the successful role of GIS in Dam construction. An area in Gujarat state in west of India was selected for this study.

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# 1. INTRODUCTION

Nowadays, Dams construction process is very important for economic and social development. A construction new Dam is very critical because of the affect of this project on the environment. The damming of a river will have dramatic consequences on the nature of the environmental both upstream and downstream of the dam. The reservoir waters spill out into the surrounding environmental, flooding the natural habitat that existed before the dam's construction. Also, a dam acts a barrier between the upstream and downstream habitat of migratory river animals threatening to decrease reproduction numbers and reduce the species population. The water temperature will be effect on the plants and animal life present in both the reservoir and river, often creating environmental that are unnatural to the endemic species.

This thought makes the Dam selection process very difficult by minimize the environmental impacts. To achieve this today, Geographic Information Systems (GIS) is being implemented in the following aspects of environmental planning.

| | |
|---|---|
| Environmental Impact Assessment | Environmental Risk Management |
| Environmental Standards | Environmental Monitoring |

Combining GIS and EIA in construction new Dam has significant benefits. One of these benefits is the fast and accurate decision taking by decision makers.

In view of the above, GIS was the best selected software to deal with the construction of new Dam. GIS is software used for storing, retrieving and presenting both spatial and non-spatial data in an efficient, quick, and structured way.

## 2. OBJECTIVE

The main objective and consideration of this paper is to explain and illustrate the effectiveness and the capability of GIS technology in optimal Dam selection for reducing the environmental impacts. It shows how the GIS usefully used in conjunction with other data sources to find the best selection for the new Dam. **The study area of railway is the Gujarat state in west India.**

## 3 REVIEW OF LITERATURE

Several studies have been conducted to show the importance of using the application of GIS in environmental consideration in any developing projects. Abu zeid and Mohammd Wagdy (1999) used GIS to evaluate the environmental impact assessment (EIA) for Dam construction and irrigation system development. They show that GIS can handle large data related to EIA and representing them in accurate way with less time consuming process. They start with EIA definition then they show the advantages of using the GIS with EIA. They conclude that GIS is considered as one of the important technique that can be used for environmental scoping. James Event and Jennifer (2005), shows the GIS is a useful technique that can be implemented to evaluate the environmental impact assessment of constructing a new Dam. This type of projects has a disaster affect on the environment, constructing new dam can be considered as a major source of damage to the surrounding environment. The authors present the benefits of using GIS for EIA of Dams construction projects which can help to select the optimal road location with less impact on the environment.

# 4 CASE STUDIES

The Man river in Gujarat state in west of India  was selected as a case study to show the effectiveness of using GIS in dam selection and environmental consideration in land use and management. The main two reasons behind this selection are the improving the land productivity in the command area. Proper utilization of the irrigation water from the dam is suggested to prevent increase in the land salinity in the command area. The study shall assess the status of erosion and land degradation in the catchment area to prevent siltation and to suggest the future plan of treatment.

The watershed of the Man River has a semi-arid climate. The scarcity of water is acute. In spite of having a rich black cotton soil, the area is backward because of dependency on rain fed agriculture. The increased irrigation potential due to the proposed dam shall have a great impact on the socio-economic upliftment of the region.

The study attempts to assess the present problems of the area and to provide suggestive measures for the watershed improvement of the Man River after the construction of the dam. Various information layers were integrated through the GIS software Arc/Info using overlay methods. Suitable site selection for different types of treatments, using the criteria rules of Arc/Info has also been performed

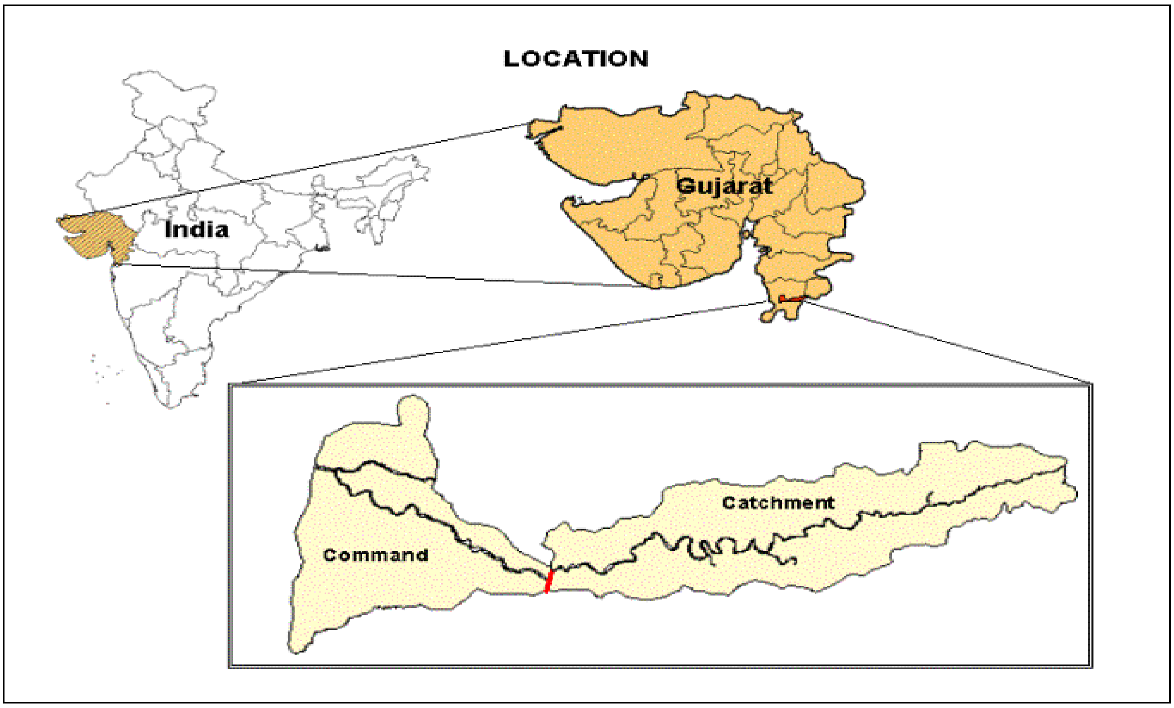



**Figure 1: Location of the study area in India**

# 5 METHODOLOGY OF STUDY

## 5.1 Data Collection

### 1) Physiography and drainage:

The catchment area of the proposed dam consists of *flat topped, highly dissected plateaus* and dyke ridges running in a west to east direction. The Man River in the catchment area flows in incised meanders forming steep 'V' shaped valleys with steep sides.

The command area of the proposed dam is surrounded by *moderately dissected plateaus* and *piedmont* slopes. Along the river valley the *flood plain* consists of good quality soil, suitable for cultivation.

The largest portion of the command area is the *alluvial plain*, which has been formed by the river Man. The alluvial plain is studded with number of *residual hills* with degraded forests.

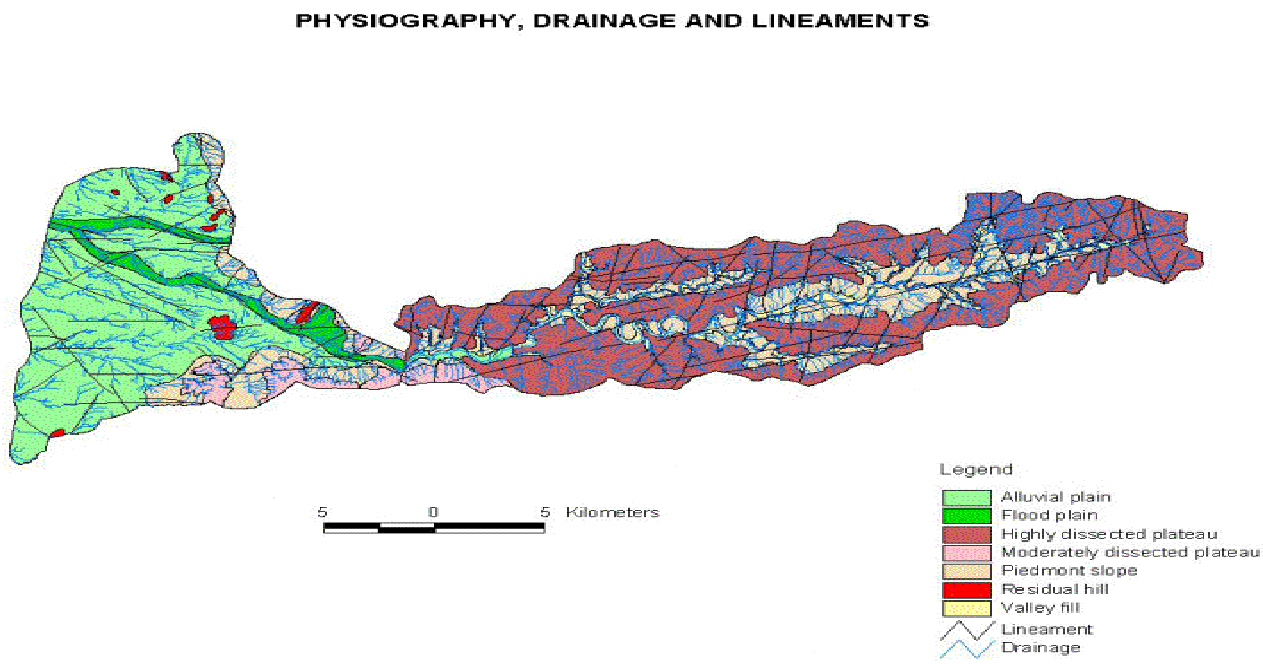



**Figure 2: Physiography and drainage system**

## 2) Geology and structure:

The catchment and command areas are occupied by various Deccan trap lava flows viz. Amygdaloidal basalt and Porphyritic basalt and agglomerate of the Cretaceous – Eocene age. These are traversed by dolerite dykes.

Big cavities filled with secondary quartz are also seen. The agglomerates separate the lava flows and occur in the form of lenses of thickness varying from 1-2m.

Top of the plateaus consists of porphyritic amygdaloidal basalt, which is highly fractured and jointed.

## 3) Climate:

The area has a semi-arid type of climate. It records a maximum temperature of 42$^{o}$c with a mean annual temperature of 27$^{o}$c.April and May are the hottest months. In winter the temperature drops to 7$^{o}$c. January is the coldest month.

About 95% of the rainfall comes from the South-West monsoon. The average annual rainfall is 2465mm is concentrated in a few months and the remainder of the year is dry.

## 4) Soil series:

The area, being of basaltic formation, falls under the broad soil group of red loams and black clayey soils. The transmission of water through similar parent material seems to have influenced the development of different physiographic characteristics of the soils in the area.

Below is given a brief description of the physiographic characteristics of the soils of the area

**SOIL SERIES**

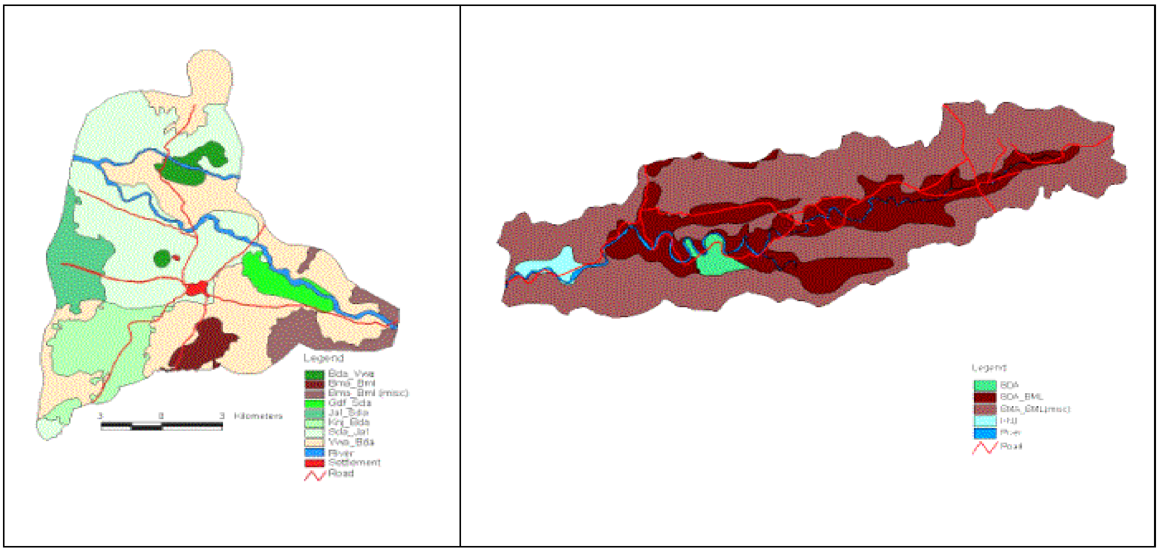



**Figure 2: Soil Series**

<u>Soils of the high lands</u>: The characteristics of the dissected plateau with a slope above 8$^{o}$ have gravelly, shallow to moderate thickness, loamy, non-calcareous soil, which has eroded and derived from intra-trappean basalt rock in situ condition..

<u>Soils of piedmont slopes and river valleys</u>: The relief decreases towards the west and the materials washed out from the upper reaches are deposited in the downstream areas. The area is usually having 3-5% slope gradients. The soils in these areas are of shallow to moderate thickness, dark reddish brown to very dark grayish brown, clay loam to clayey.

Soils of the alluvial plain and flood plain: The piedmont slope gradually merges into the alluvial plains with gently sloping land. The soil becomes deep to very deep, clayey calcareous and non-calcareous, dark grayish brown, very dark grayish brown to dark yellowish. The soil cracks vertically during dry season due to montmorillnitic type of clay. m.

## 5) Land use/ Land cover:

Digital interpretation of IRS LISS-III FCC on 1:50,000scale for two season dates is done in ERDAS for identification of different land use land cover classes based on the image characteristics. Based on ground truth verification the boundaries are finalized which synchronizes well with the physiography, slope and soil of the area.

Twelve land use / land cover classes have been identified in the command area and eight classes have been identified in the catchment area

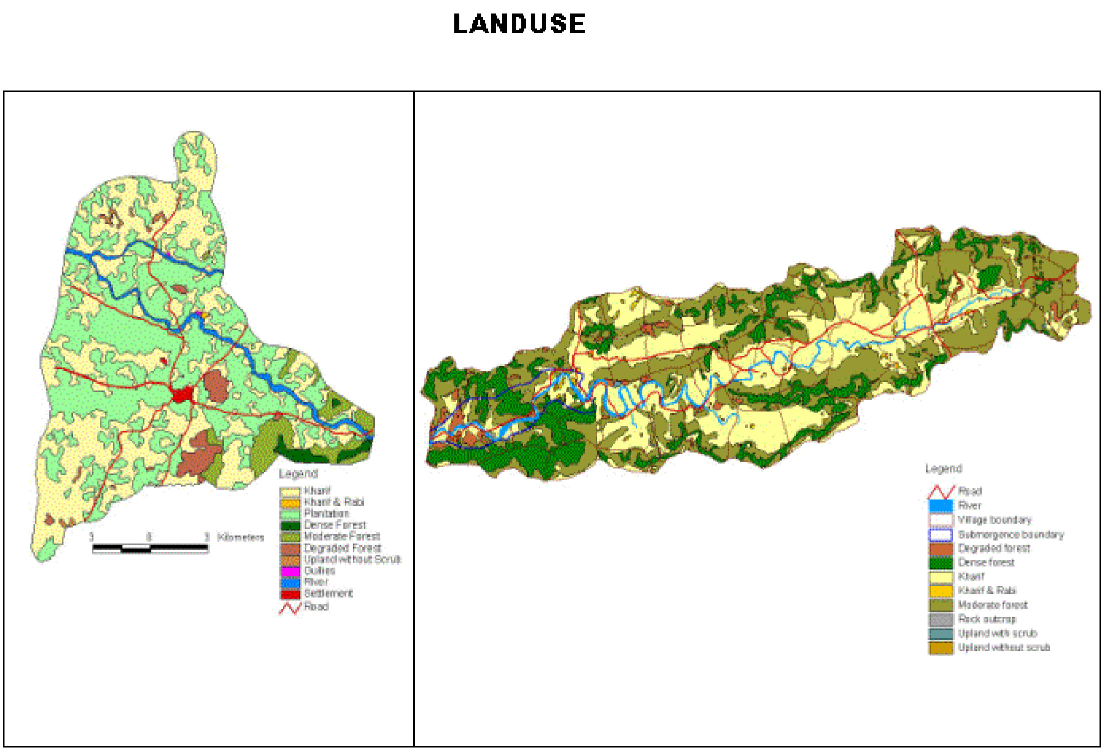



**Figure 3: Land Use**

## 5.2 Analysis and Discussion

The secondary layers are derived from the above datasets in Arc/Info by the various overlay functions. Polygons below a threshold limit eliminated to generate the final layers based on which the decisions can be made.

The slope map is derived by using the GRID and TIN features of Arc/Info. The input data are the contours from the Survey of India topographic sheets. After converting from raster to vector layer it is processed for generating the secondary overlays. In the catchment area, the plateau tops have slopes of 0-3% and the steep hillsides are above 8%. The piedmonts comprise of slopes mainly between 5 – 8%.

The command area, comprising mainly of the alluvial plain and the flood plain, has a slope ranging between 0-3%. In the surrounding dissected plateau and piedmont, the slope varies between 3 – 8%.

Groundwater prospects are assigned to each unit. A total of five classes of groundwater prospect areas have been identified in the catchment area. The groundwater status in most of the area varies between poor to moderate, especially in the dissected plateaus and dyke ridges.

**GROUDWATER PROSPECT**

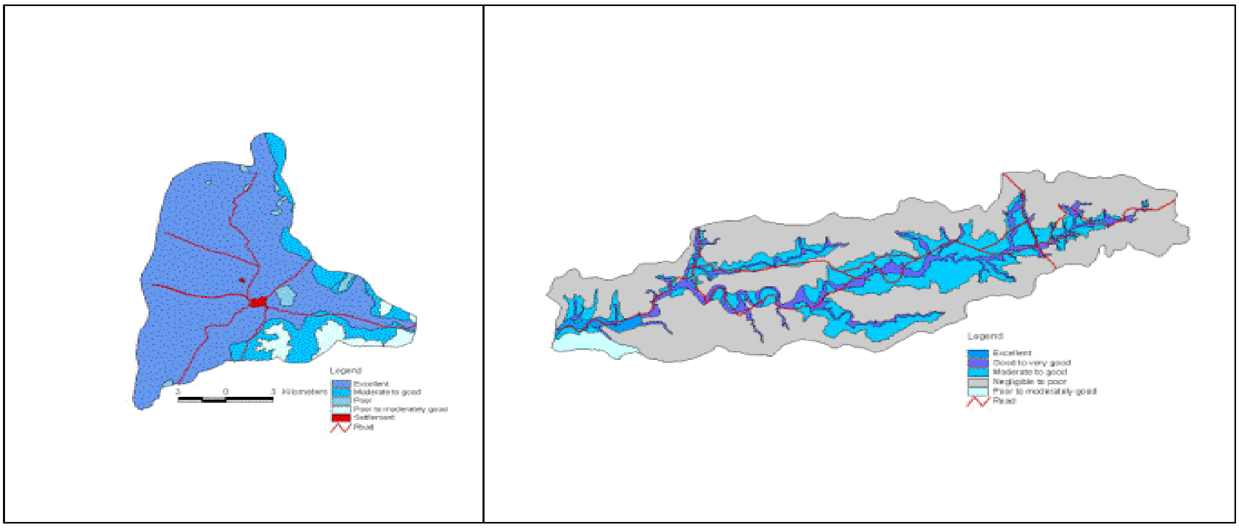


**Figure 4: Groundwater Prospect**

In the command area, based on the texture, structure, permeability, of the soil, soil-irrigability classes are assigned and each type of soil irrigability class is given a unique code. This soil-irrigability layer is unionized with the slope layer to derive the land-irrigability classes.

Based on the percent slope and soil irrigability classes, four land-irrigability classes have been identified.

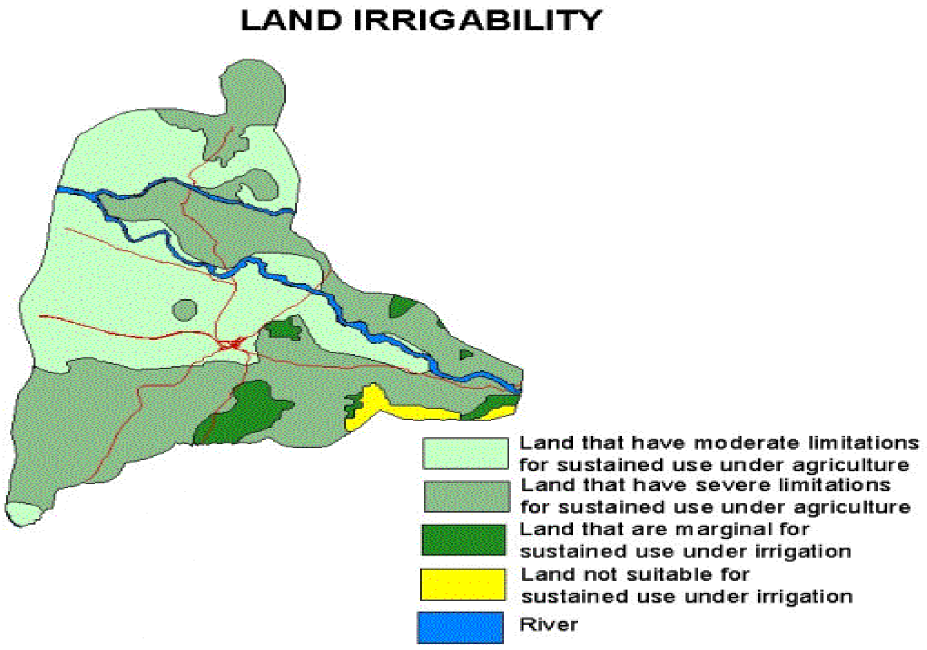



**Figure 5: Soil irrigability**

Overlaying of the slope, soil and land use, in Arc/Info for both the catchment and command areas, has generated the Composite Erosion Intensity Units (CEIU)/Composite Land Development Units (CLDU) respectively.

Total 47 unique CEIU and 42 unique CLDU have been generated for the catchment and the command areas respectively. The area of each unique CEIU is estimated for each sub-watershed. This CEIU/CLDU has been used for decision making.

Overlaying the slope, soil, land use and environmental factors of each CEIU/CLDU, land capability classes are generated. Each land capability class is identified by a unique characteristic, having similar hazards of the soil to various factors, which causes soil damage, decreases soil fertility, and its potential for agriculture.

In the command area the land-capability has been assigned for the development of the area. In the catchment area land capability has been assigned for future treatment.

**LAND CAPABILITY**

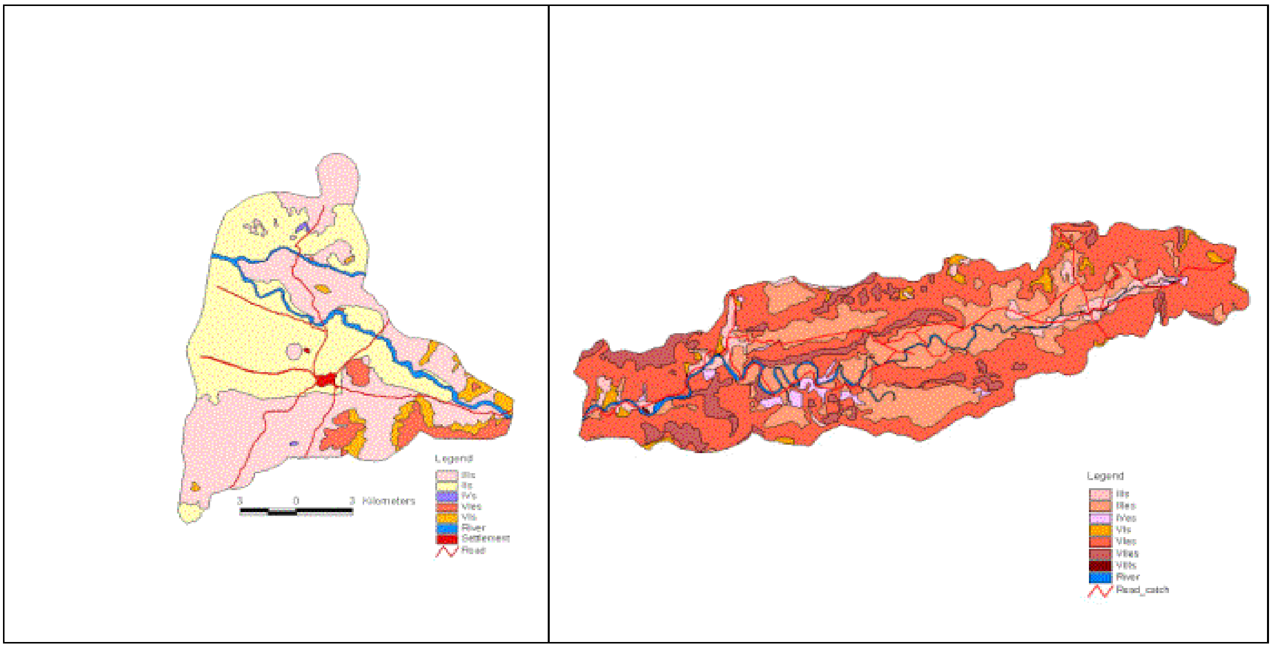
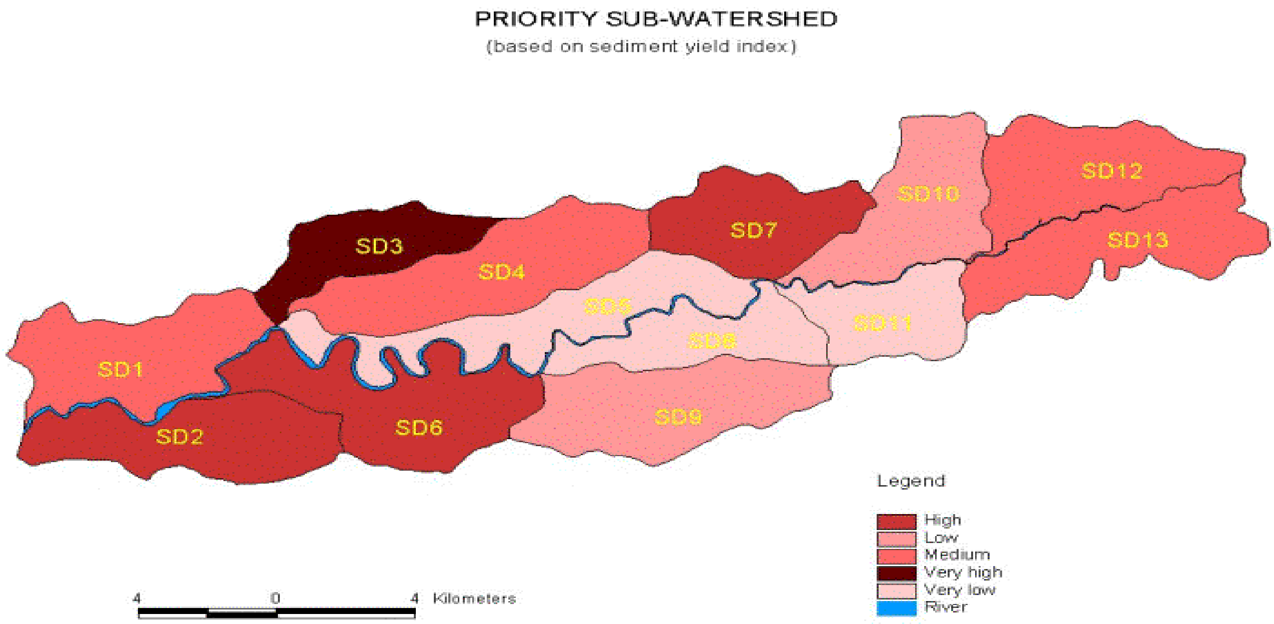



**Figure 5: Land Capability**

The Sediment Yield Index is assigned to each CEIU. The sub-watersheds have been identified based on the area eroding more in time and space and have been prioritized based on the Sediment Yield for future treatment.




.**Figure 6: Priority of Sub-Watershed**

# 6 RECOMMENDATIONS

### i. Development plan for the command area:

Based on the land irrigability of the command area, it has been found that around 176.8 sq.km. of the total command area of 192.6 sq. km or 91.8% is expected to produce better crop by irrigation water from the dam, provided proper drainage facilities are present.

The land capability also shows that approximately 170 sq.km. area of the command area has II and III land capability, which indicates that the area can produce better crops by improving the quality of soil with appropriate treatment of nutrients and fertilizer.

Based on the soil, land use, slope, land irrigability etc. of the command area, suggestions have been made to change the land use pattern and undertake reforestation in some of the areas.

### ii. Treatment plan for the catchment area:

The longevity of the proposed dam can be extended by checking soil erosion in the catchment area. After a detail assessment of the above overlays, it is recommended to treat each sub-watershed from different aspects.

The land capability of the catchment area shows that 16.4 sq.km. of the total catchment area of 261.0 sq. km. can be treated with soil and water conservation methods to increase the moisture retention capacity, thus improving the fertility of the soil. Development measures for the command area have been suggested. The drainage line treatment is also necessary in the catchment area to prevent soil erosion.

## 7 CONCLUSION

The purpose of the paper was to present a practical example of environmental consideration in Dam construction using GIS. Utilizing the GIS in this project apart from direct benefits, GIS has clearly demonstrated its usefulness to find a best location for the Dam.

The entire study was carried out by using, Arc/info, Arc VIEW and ERDAS. The intricate overlays, which are manually impossible to generate, along with the detailed calculation have been successfully performed. Geosoft Topographics (GTIPL) has successfully completed the study suggesting the treatments for the development of the command and the catchment areas, along with some preventive measures for reducing the soil erosion in the catchment.

Due to the construction of the dam on the Man River, an area of 17.55 sq.km is going under submergence. This area consists of parts of five villages. The villages which are most affected are Avdha, Rajpuri jungle and Hanmanthmal. The affected inhabitants can be suitably rehabilitated in the non-submerged part of the villages.

. It shows how the GIS can be used as a source of information to enhance and assist the decision makers in decision making. It was shown clearly in the case study that the human activities, actions and urban developing can be controlled and directed towards the protection of environment

## REFRENCES


- Dibang Multipurpose project ,River Dibang ,Natural Productivity Council, Guwahati
- " Colorado river watershed." Arizona department of water resources(cired october 16,2002)
- Pearce, Fred. the dammed:river,Dams, and the coming World Water crisis. London : Bodley Head 1992
- Shibani. "environmental impact of dams construction using GIS",2001
- Fearbside, Philip M." Hydroelectric Dams in Brazilian, 1996
- Abu zeidand Wagdy,"assessment of environmental impacts for Irrigation Project, decision support system", 1999
- James,Jennifer,"Upstreams channel following Dam construction and Removal Using GIS/ remote sensing approach, 2004