EIA for Ramapada Sagar (Polavaram) Irrigation Project using the Model of RS and GIS

Sreeramulu. Y [1*], Murali Krishna.I.V [2]
1. Associate Professor, Dept.of Civil Engg, KSRM College of Engineering, Kadapa-516003, A.P., India
2. Adjunct Professor, Asian Institute of Technology, Bangkok, Mobile No 09848049624

Abstract
At Global level, Asian countries like India and China have experienced untold environmental degradation and ecological deterioration in the past century, with little or no real solution to alleviate many of these concerns. Poorly planned human interference has been the major cause. Adequate information and appropriate technology are limiting factors for effective environmental management. Hence, efforts to improve, conserve and protect the environment will include not only the resolution of political policies but also the application of a state-of-the-art scientific approach to planning and implementation. The process of Environmental Impact Assessment (EIA) was developed as an effective planning tool. The genuine conduct of this process will go a long way in reducing environmental deterioration. Because of the dynamic characteristics and multivariate nature of the environment, it has often been difficult to collate, analyze and interpret its data sets. However, this great complexity can be overcome with the present research of engineering management system model of Remote sensing and geographical information system and related technology with the ground truth verification.

This Research study deals with the Environmental impact assessment for an irrigation project i.e.Ramapada Sagar (Polavaram) Irrigation project, which has been carried out in parts of West Godavari, East Godavari and Khammam districts of Andhra Pradesh. About 14,400 Sq Kilometer area of remote sensing data have been collected and analyzed for environmental impact assessment by using emerging GIS technology. The prime objective is to study the environmental impact of the project on land use land cover environment, water environment, , submergence area and formulate suitable environmental management plan for minimizing expected adverse impacts during as well as after the implementation of project.

From the land use land cover environment, the crop land covers 79.8% with an area of 3,92,766 ha, plantations 49,505ha, built up land occupies 23,262ha (4.72%), forest occupies a mere 0.38%, tanks and streams occupies 3,819 ha (0.82%) and scrub land occupies 19,680ha (3.37%). The slopes of the catchment mostly range between 1% to 5% (i.e., nearly level to gently sloping). The agriculture is practiced generally in the nearly level to gently sloping areas. In the catchment about 91.55% of the area comes under nearly level to gently sloping category (i.e., 0% - 5% slope). Only 0.45% of the catchment area comes under moderately sloping to strongly sloping (i.e., between 5% - 15% slope). The nearly level, very gently sloping, gently sloping areas are 77.25%, 21.44%, and 0.86% respectively. From the slope map, erosion intensity can be estimated and suitable measures that are required to restrict the siltation of the proposed Reservoir by biotic treatment, engineering treatment and gully control works can be suggested.
It has been observed during water environment analysis; an area of about 50 sq.km is under inundation at low water level +135ft (41.15m), 200 sq.km is under inundation at +140ft (42.67m), and an area of 360 sq.km is under Inundation at +150ft (45.72m) FRL.

Key words: Environmental impact assessment, Ramapada sagar (Polavaram) Project, Remote sensing (RS), Geographic Information system (GIS), Catchment area, land use land cover , water environment , submergence / Inundation

1.0 Introduction
Environmental Impact Assessment (EIA) is a planning and management tool for sustainable development, aimed at providing decision-makers with information on the likely consequences of their actions. Thus EIA can be considered as being anticipatory in nature. EIAs define and assess the potential physical, biological, socio-economic and health effects of the proposed project in a manner that allows for a logical and rational decision to be made about the proposed action (Glasson et al., 1995; Wathern, 1988; Wood, 2003) [32].

Asian countries like India and China have experienced untold environmental degradation and ecological deterioration in the past century, with little or no real solution to alleviate many of these concerns. Poorly planned human interference has been the major cause. Adequate information and appropriate technology are limiting factors for effective environmental management. Hence, efforts to improve, conserve and protect the environment will include not only the resolution of political policies but also the application of a state-of-the-art scientific approach to planning and implementation. The genuine conduct of this process will go a long way in reducing environmental deterioration. Because of the dynamic characteristics and multivariate nature of the environment, it has often been difficult to collate, analyze and interpret its data sets. However, this great complexity can be overcome with the present research of Engineering Management system Model of Remote sensing and Geographic Information System (GIS) and related technology with the ground truth verification. The prime objective is to study the environmental impact of the project on land use land cover environment, water environment and submergence area and formulate suitable environmental management plan for minimizing expected adverse impacts during as well as after the implementation of project.

1.1 Study Area

This study deals with Environmental impact assessment for developmental project i.e.Ramapada Sagar (Polavaram) Irrigation project, which has been carried out in parts of West Godavari, East Godavari and Khammam districts of Andhra Pradesh . The Godavari River originates in the Nasik district of Maharashtra, India and flows through West Godavari district of Andhra Pradesh, India and discharges directly into the Bay of Bengal Sea. The study area is represented in Figure 1.1, located between 81^0-46^1 E longitude and 17^0-13^1 N latitude, and covers parts of the Survey of India topographic sheet numbers 65G/7,8,11,12.

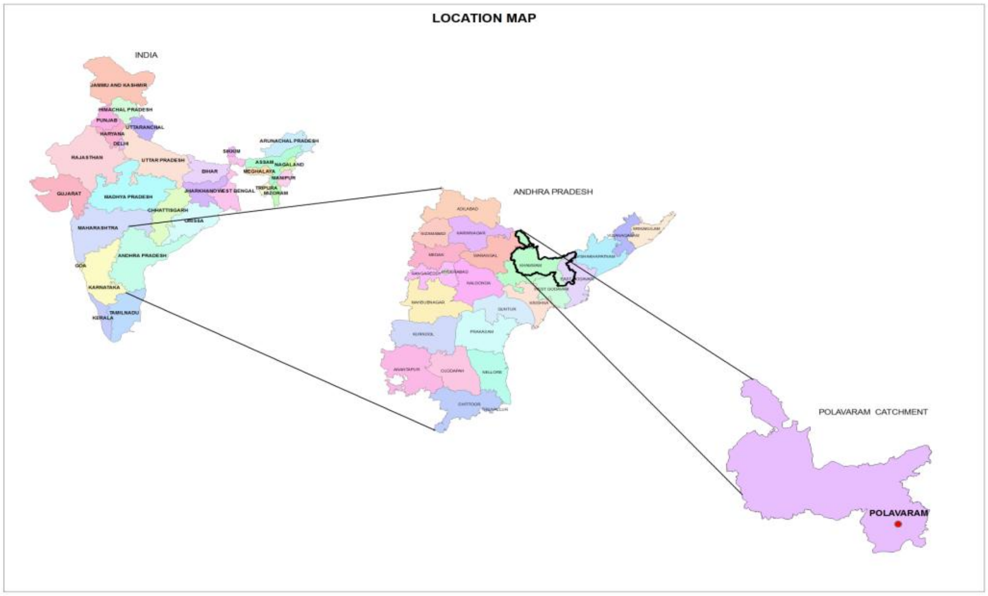

Figure 1.1: Location map of Ramapada Sagar (Polavaram) Project Study area

The proposed project is a multipurpose project benefiting the upland areas of Visakhapatnam, East Godavari, West Godavari, Krishna and Khammam districts. It also supplies drinking water to Visakhapatnam township and villages enroute. The general climate of the command is characterized by hot summer and general dryness which gives copious rainfall. May is the hottest month with a maximum day temperature 44^0C and the minimum temperature is about 22° C. The south-west monsoon season during midst of June and ends by mid October. The annual average rainfall is about 858.65 mm. In the study area the humidity is very high during peak rainy season. Mean humidity generally varies between 62% and 80% as per the data collected for 27 years. Highest humidity of 80% is during June to September. Average wind velocity varies between 4.2 kmph in April and 8.47 kmph in November.The average rainfall in the command area is 859 mm.The finalized project site consists of a zoned Earth-cum-Rockfill dam with an impervious core across the existing river course. The spillway is located in the right flank saddle and power dam on the left flank saddle. The FRL of the reservoir is proposed as +150ft (45.72m).

2.0 Research work Model proposed

Model Name	Description	Major Features	Data Requirements	Out Put
CE – EIPS – RS & GIS [Civil engineering Environmental impact assessment for an irrigation project interms of submergence using Remotesensing and Geographic information system]	2D – Longitudinal, Vertical Reservoir water quantity and quality model for Environmental Impact Assessment using Remote sensing and GIS	- Description of Land use / Land cover - Assessment of Water Environment - Assessment of submergence area under various discharge flows - Allow simulation of most major physical , chemical and biological process and associated water quality constituents	**Primary data :** - Water Quantity , Quality data and coefficients - Physical data , cross section geometry , elevations and locations of nodes; Lateral inflows and tributaries ; control structures **Secondary data :** - River Flows, Depths, spot heights and velocities - Water Quantity and Quality targets at system control points.	- Classification of Land use / Land Cover area and suggestive crops - Submergence / Inundation area due to the Reservoir water quantity (Printed and / or plotted) - Vertical profiles and outflow values for constituents over time (Printed and / or plotted) - Reports of water quality parameter values for drinking and Irrigation purposes - Catchment area treatments - Site selection for Resettlement & Rehabilitation purposes

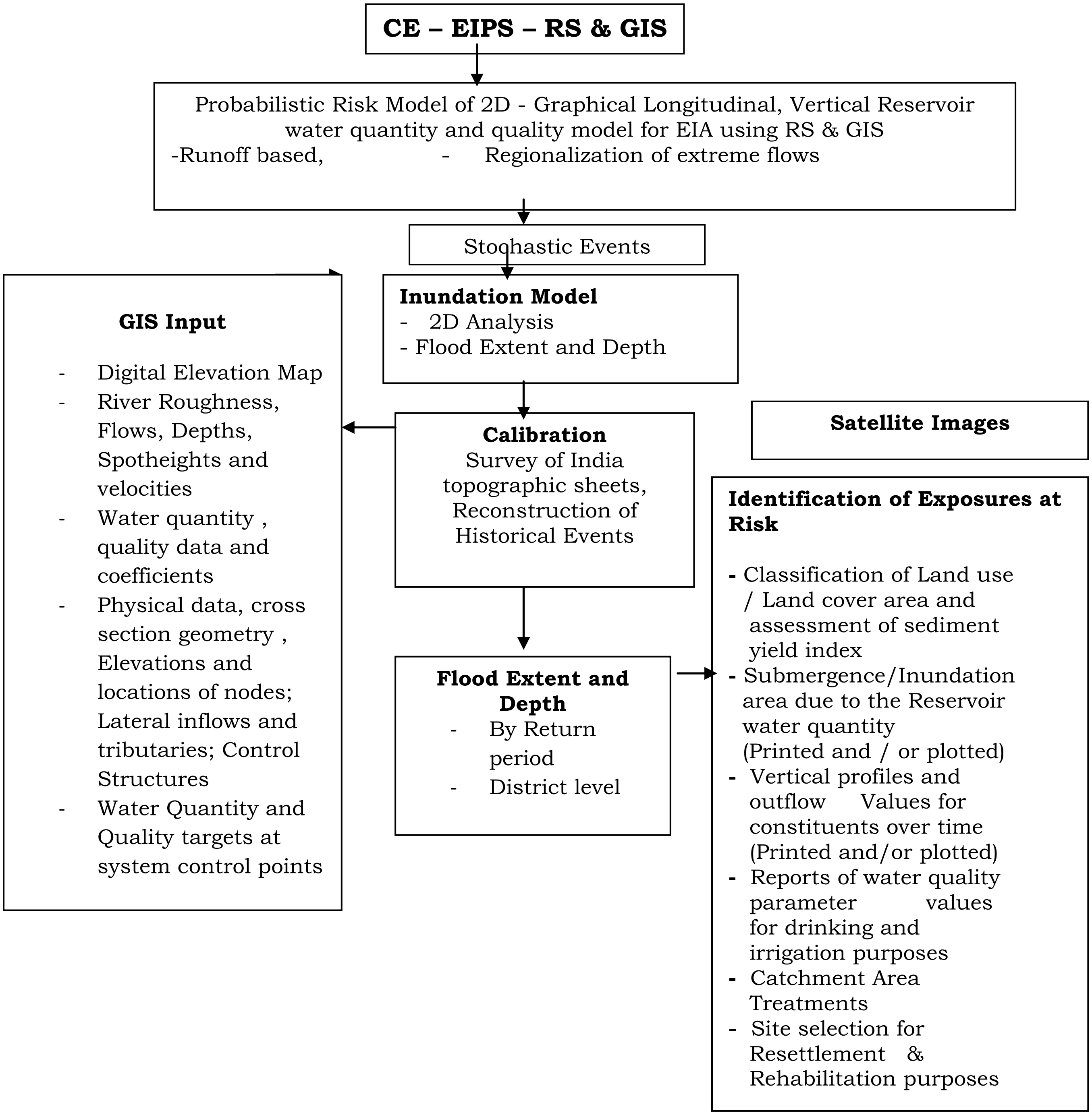

Figure.2.1 Flow chart of Research work Graphical model proposed on Environmental Impact assessment for Ramapada sagar (Polavaram) Irrigation Project using Remote sensing and Geographic Information system with ground truth verification

2.1 Mathematical Expressions involved in the Research work model proposed

Probability Distributions:-

Generalized Pareto Distribution (GPD)

Cumulative Distribution Function when $P [X \leq x]$, CDF $F(x) = 1 - e^{-y}$ where

$$Y = -K^{-1} \log [1 - k (x - \xi) / \alpha]$$

$$Y = (x - \xi) / \alpha \quad \text{for} \quad k = 0$$

Generalized Extreme value distribution [GEV]

CDF ,

$$F_x(x) = \exp \{ - [1 - (kx - \xi) / \alpha]^{1/k} \} \quad \text{for } k \neq 0$$

$$F_x(x) = \exp \{ - \exp[- (x - \xi) / \alpha] \} \quad \text{for } k = 0$$

Runoff Quantity Density Function =

$$\text{Derivative} \quad f(x) = d/dx [f(x)]$$

$$f(x) = d/dx (1-e^{-y})$$

$$= -d/dx \{1-[k(x- \xi)/ \alpha]\}^{1/k}$$

$$= 1/ \alpha \{1 - [k(x- \xi)/ \alpha]\}^{(1-k)/k}$$

X	=	Rainfall
f(x)	=	Runoff
K	=	Slope factor / Velocity
α	=	Time
ξ	=	Infiltration
Y	=	Runoff function coefficient

3.0 Materials and methods

The study utilised the Survey of India toposheets of 1:50,000 scale for studying the catchment area, command area and also the submergence area for identification of land use land cover, slope and soils, etc.The satellite based remote sensing imageries are procured from the NRSA for image analysis and arriving at the land use land cover, slope, soils, surface drainage, etc. and also for preparation of catchment area treatment plan based on Sediment Yield Index method. But in this paper land use / land cover, slope aspect and submergence / inundation are only represented.

The methodology comprises access to Remote Sensing Data and analysis of the same, ground truth verification, collection of primary and secondary data, group discussions etc. The study covers land environment, water environment and submergence area. The data were processed through computers with suitably designed software. The following tasks have been undertaken to meet the study objectives

- Generate thematic maps of various natural resources
- Integrate the thematic maps
- Define the plan of implementation

The input data from all of the above diverse sources are translated into the thematic maps by the methods of: interpretation, classification, manipulation, integration, editing and analysis. The data translation into thematic maps employed the GIS software Arc/Info, Arc View , Arc Map and the remote sensing software ERDAS. The Impact is determined by taking the Spot heights as reference.

4.0 Results

The following Figure 4.1, Figure 4.2 and Figure 4.3 are the output of Research work model proposed:

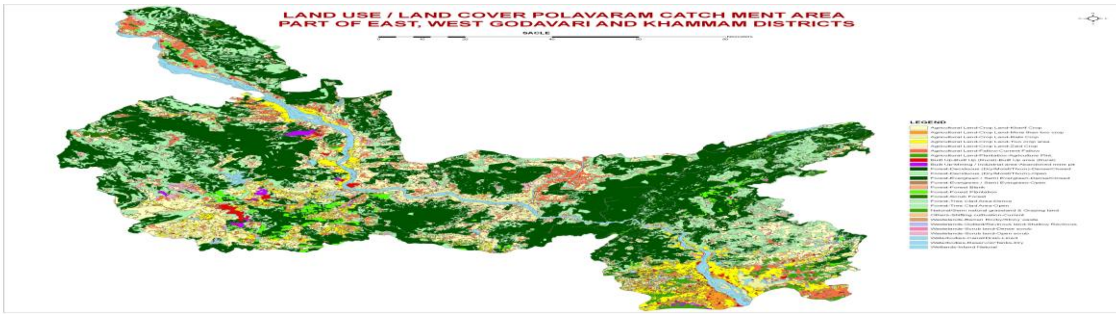

Figure 4.1 shows the Land use / Land cover of Ramapada Sagar (Polavaram) Catchment Area , year 2008-09 (Satillite data: 05.11.2008)

Digital interpretation of IRS LISS-III FCC on 1:50,000 scale is workout in ERDAS for identification of different land use land cover classes based on the image characteristics. The multidate imagery are interpreted for the details of the crop land in the two harvest seasons known as the kharif and Rabi seasons. Based on ground truth verification the boundaries are finalized which synchronizes well with the physiography, slope and soil of the area. The analysis of remote sensing data provided the area under different land use and land cover under different categories of the catchment and this area has been represented in Figure 4.1. The crop land covers 79.8% with an area of 3,92,766 ha, plantations 49,505ha, built up land occupies 23,262ha (4.72%), forest occupies a mere 0.38%, tanks and streams occupies 3,819 ha (0.82%) and scrub land occupies 19,680ha (3.37%). The major soils in the command area are moderately deep gravelly sandy loams and lateritic upland (1,92,308 ha); followed by deep fine sandy loam (1,39,403 ha). The other types of soils are deep sandy loam on undulating land, moderately deep sandy loams on rolling lands, deep clayey soils on gently sloping, very deep fine loamy / clayey soils in valley, etc. The majority of the soil types fall in land irrigability/ classification 2 & 3.

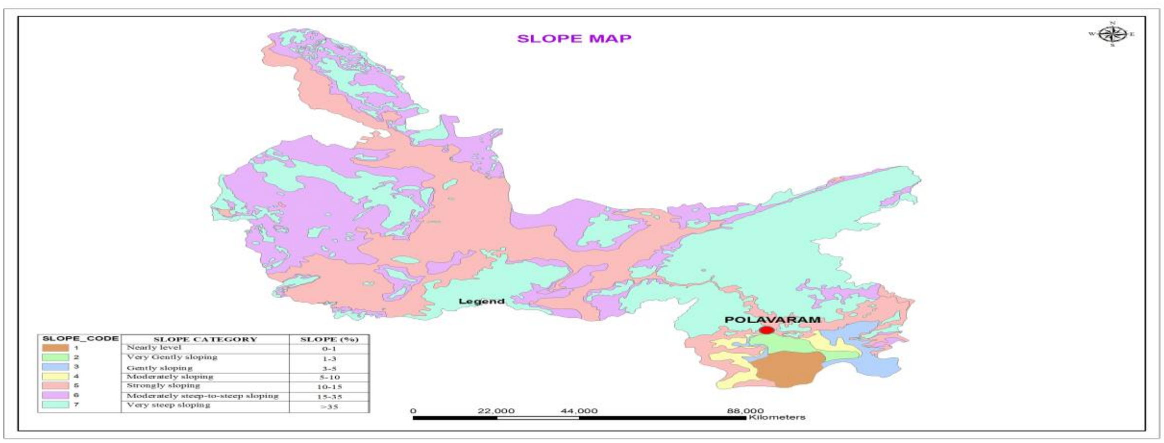

Figure 4.2 Slope Map

The slope map (Figure 4.2) has been prepared for the catchment areas using 1:50,000 scale topographical maps of Survey of India showing contours of 20 m interval using tan method. The different classes of slopes have been categorized as per the guidelines suggested by All India Soil and Land Use Survey (AIS&LUS). The vertical drop is measured from the contour interval and the horizontal distance between the contours is measured by multiplying the map distance with the scale factor. Finally the slope percentage is calculated. From the figure 4.2, the slopes of the catchment mostly range between 1% to 5% (i.e., nearly level to gently sloping). The agriculture is practiced generally in the nearly level to gently sloping areas. In the catchment about 91.55% of the area comes under nearly level to gently sloping category (i.e., 0% - 5% slope). Only 0.45% of the catchment area comes under moderately sloping to strongly sloping (i.e., between 5% - 15% slope). The nearly level, very gently sloping, gently sloping areas are 77.25%, 21.44%, and 0.86% respectively. From the slope map, erosion intensity can be estimated and suitable measures that are required to restrict the siltation of the proposed Reservoir by biotic treatment, engineering treatment and gully control works can be suggested.

Analysis of Water Environment

Surface Water Quality

100 Water samples were collected during the year 2007-08 at the proposed site and got analysed. It is concluded that the Godavari River water at the project site is found to be chemically suitable for irrigation and drinking water purposes.

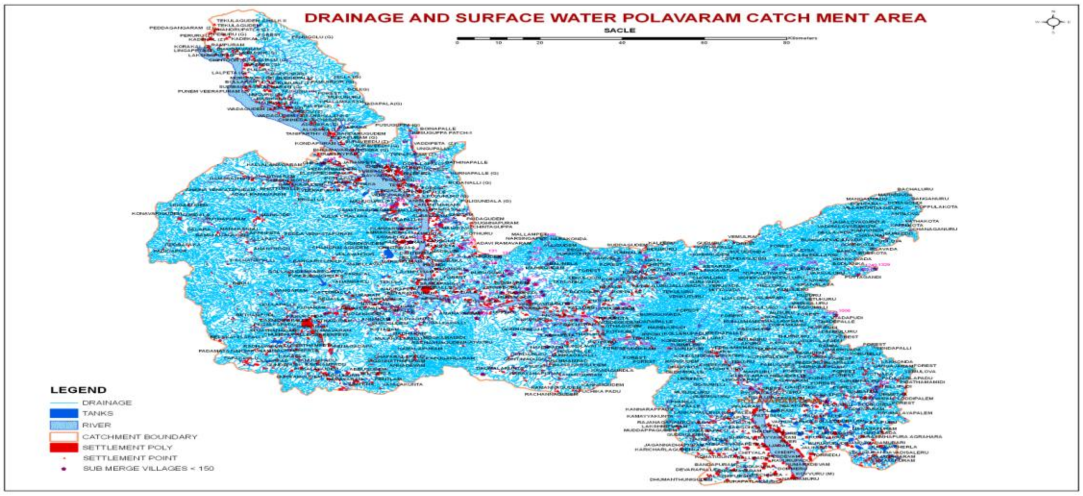

Figure 4.3 Drainage and Surface water of Ramapada Sagar (Polavaram) Catchment Area

From the Figure 4.3 , due to the construction of the Ramapada Sagar (Polavaram) on the Godavari River, an area of about **50** sq.km is under inundation at low water level +135ft (41.15m), **200** sq.km is under inundation at +140ft (42.67m),and an area of **360** sq.km is under Inundation at +150ft (45.72m) FRL.

5.0 Conclusions

The model of Civil Engineering Environmental impact assessment for an irrigation project interms of submergence using Remotesensing and GIS (CE-EIPS – RS&GIS) is developed and successfully worked out. The analysis of remote sensing data provided the area under different land use and land cover under different categories of the catchment and this area has been studied. The model also helps for the preparation of water environment with the representation of submergence / inundation area under different water levels.

The final conclusion is, that this Civil Engineering Management system model using Remote sensing and Geographical information system with ground truth verification is a unique model for assessing results for Environmental impact assessment process interms of, Land use and Land cover environment, Water environment and submergence area etc., . This model help contribute to the resolution of the many environmental problems plaguing in Asian countries.

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