

# REMOTE SENSING AND GIS BASED LAND-USE PLANNING IN “SATER MIANAR HOUR” WET LAND ECOSYSTEM IN TRIPURA STATE OF INDIA FOR SUSTAINABLE DEVELOPMENT

Diganta Barman<sup>a,\*</sup>, Jonali Goswami<sup>a</sup>, Kuntala Bhusan<sup>a</sup>

<sup>a</sup> Scientist / Engineer “SC”, NESAC, Department Of Space, Umiam(Shillong), Meghalaya-793103  
[diganta\\_isrol@yahoo.co.in](mailto:diganta_isrol@yahoo.co.in)

## Commission IV, WG-IV/10

**KEY WORDS:** Ground Water Prospect, Watershed Prioritization, Landuse Planning, Remote Sensing

### ABSTRACT:

In the state of Tripura, in India, agriculture contributes about 64 % of the total employment and about 48 % of the state's domestic product. Growing population and decreasing per capita land availability entails that the available land must be utilized effectively. With this broad objective, the study team took up an integrated study of “Sater Mianar Hour”- an erstwhile wetland ecosystem being used for rice cultivation. The study was basically aimed at improving the productivity of the wetland area in catchment level. Major problems of the wetland ecosystem are siltation of the natural drainages locally called charras, gradual rise of the major river bed resulting in back flow into the feeder channels causing water stagnation and flooding, mono-crop agriculture with rice alone as the dominant crop etc. Major objective of the study was to prepare land-use plan for sustainable development of the area in catchment level with inputs from sub-watersheds prioritization and Sub-surface water potential in various landforms and litho-types of the study area, where sub-watersheds were prioritized based both field and remote sensing parameters such as various parameters of drainage morphometry such as drainage density, circularity ratio etc, slope, Soil brightness index (SBI), normalised difference vegetation index (NDVI) etc. Data from LISS III (multispectral) and LISS-IV (mono) of IRS-P6 satellite and soil maps from NBSSLUP were used to map the current land use, geomorphology, ground water prospective zones. The entire rice ecosystem has been delineated into twenty micro watersheds and prioritized into four categories such as very high, high, medium and low for taking up developmental plans on priority. It is found that most of the study area is good to very good in ground water prospect that can be used extensively during Rabi and summer season crop growing periods after carrying out quality check. The recommended package of individual appropriate land use (1:25,000 scale) in each of different priority zones of the catchment is mainly aimed at vegetative and agronomic measures for erosion control, in situ soil moisture conservation and production system. Using the database, several alternatives for water harvesting, cropping pattern, soil conservation, agro-horticulture, afforestation, etc have been suggested. Area statistics have been generated for both existing and recommended land-use pattern. Implementation of suggested land use at watershed level, based on priority, will lead to sustainable development of the rice ecosystem.

### 1. Introduction:

In Tripura, agriculture contributes about 64 % of the total employment and about 48 % of the state's domestic product. Growing population and decreasing per capita land availability entails that the available land must be utilized effectively. Wastelands and wetlands are to be appropriately reclaimed and properly used. With these broad objectives in view, the High Power Committee which was appointed for preparation of the master plan for utilization of Space Technology in the north eastern region and heads and secretaries of departments of Govt. of Tripura sat together and decided to take up the integrated study of Sater Mianar Hour- an erstwhile wetland ecosystem being used for rice cultivation. This project has been taken up to improve the productivity of the land and water resources of Sater Mianar Hour.

### 2. Study area:

The project area (Figure1) is situated at a distance of 15 kilometer south east of Kailasahar town covering mainly the villages of Fultali, Jharultali, Birchdranagar etc. The geographical extent of the actual area to be developed is from 91° 59' to 92° 01' longitude and from 24° 14' to 24° 16' latitude and it having an area of 1750 ha. However the total watershed area contributing water to the wetland system is about 5561 ha. It is having extent from 91° 57' 15'' to 92° 02' 24'' longitude and from 24° 12' 30'' to 24° 18' 15'' latitude. The core waterlogged area of the wetland ecosystem having an area of 1750 ha is covering five revenue villages. The average annual rainfall over the area is 1600 mm with a maximum of 600 mm in the month of July. The area is under flood plain/alluvium, as a result of which it is mostly wet and water logged land. Land irrigability class for the area is '2d'. Rocks are sedimentary. Soils are deep imperfectly or poorly drained, mainly fine loamy in texture. Livelihood of about 2300 families is linked with the development of this area. Another 400 to 500 families in the surrounding will also be partially influenced by this development process in the surrounding of the area.

Major problems in the wetland are

- a. Siltation of the Charras (natural drainages).
- b. Poor drainage requiring deepening, widening and realignment..
- c. Gradual rise of Manu river bed resulting in back flow into the channels thereby causing water stagnation and flooding in the study area.

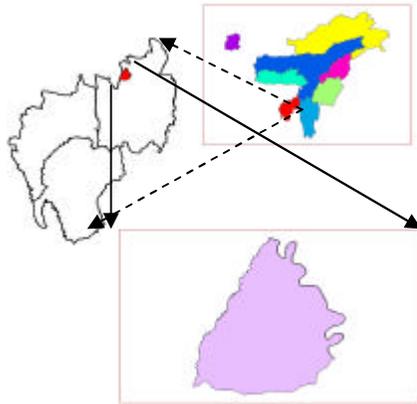


Figure1. Location map of the study area Covering 'Sater Mianar Hour'

### 3. Objectives:

As mentioned above, the main goal of the project is to suggest corrective measures for improving the productivity of the wetland eco-system. Various objectives of the project is to utilize RS and GIS technologies to achieve the following

1. To map the natural drainage course in the wetland and its catchments area.
2. To prepare geo-morphological and ground water prospective map to explore and utilize the sub-surface water potential for irrigation during rabi season.
3. To prepare detailed land-use/ land-cover maps on 1:25000 scale and infer the availability of natural resources.
4. Delineation and prioritization of the micro watersheds of the entire catchments area of the wetland from soil erosion perspective so that the first problem of siltation of the cherras can be mitigated.
5. Finally to prepare a optimum land-use plan in 1: 25,000 scale.

### 4. Data used:

1. IRS-1D/IRS-P6 LISS-III (Multi-spectral) imagery.
2. IRS-P6 LISS-IV (Mono) imagery.
3. Survey of India reference maps of 1:63,360 scale.
4. Soil Map at 1:2,50,000(NBSS & LUP)

### 5. Methodology:

The study involves generation of thematic maps showing current land use/land cover, surface water resources, drainage pattern, geomorphology, geology, soil types, road network etc. using remote

sensing data. Elevation information are extracted from survey of India topographical maps which are used to prepare slope maps. The present study has been carried out under three basic themes of Land-use land cover, Geomorphology & drainage and Slope & watershed prioritization. The entire methodology has been shown in the flow chart given in figure 2. Detailed work has been carried out under three themes as follows.

#### 5.1 Land use land cover:

IRS 1D LISS III digital data of 23.5m spatial resolution has been used for current land use/land cover classification. Digital image analysis techniques have been employed for obtaining different land use / land cover categories. The nearest motorable road and location of villages has been interpreted from the IRS-P6 LISS-IV (Mono) imagery. The boundary of the Sater mianar hour is extracted from topographical maps as well as from remote sensing data based on the boundary map supplied by govt. of Tripura.

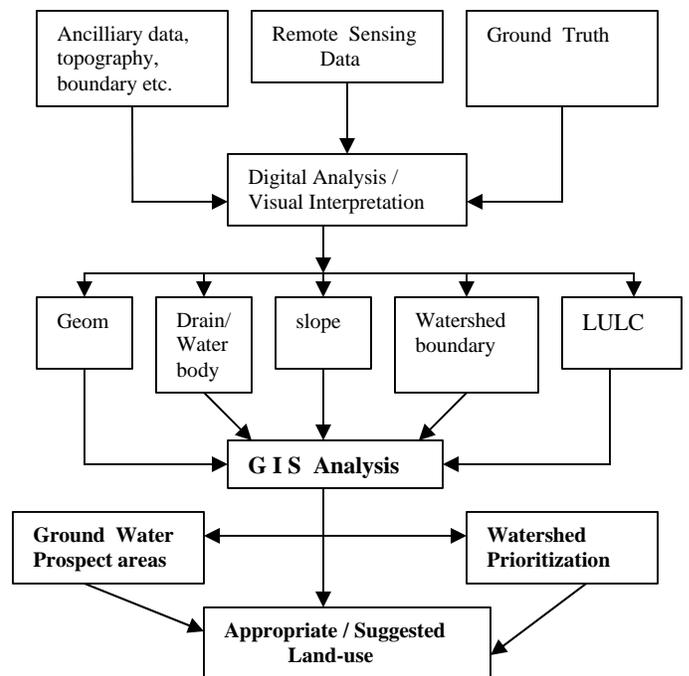


Figure 2. Methodology Flow chart

The study area is predominantly covered by dense as well as open forest followed by agricultural land. Mostly wet and waterlogged land are seen. There is a good natural drainage system but siltation is the main problem. Most of the potential lands for agricultural/horticultural crops are lying vacant as dry fallow. The area under different existing land use land cover (LULC) categories are shown in Table1. And classification of existing LULC is shown in Figure 3.

#### 5.2 Geo-morphology, Ground water prospecting

Hydro-geomorphologic maps depicts the important geomorphic units, landforms and underlying geology so as to provide an understanding of the landforms versus processes, material/lithology, structure and geologic control vis-à-vis groundwater occurrence as well as prospect. Geo-morphologically the area is young

Current	AREA(HA)
---------	----------

LULC	
Agri.Plantation	9.24
Crop Land	952.51
Dense Forest	895.70
Dry Fallow	1021.03
Lakes/Ponds	15.15
Marchy/Swampy Area	20.98
Mixed Forest	1992.58
Riverine Sandy Area	30.75
River	109.47
Urban(Rural)	323.18
Wet Fallow	243.71
<b>TOTAL</b>	<b>5614.31</b>

Table 1. Existing LULC statistics

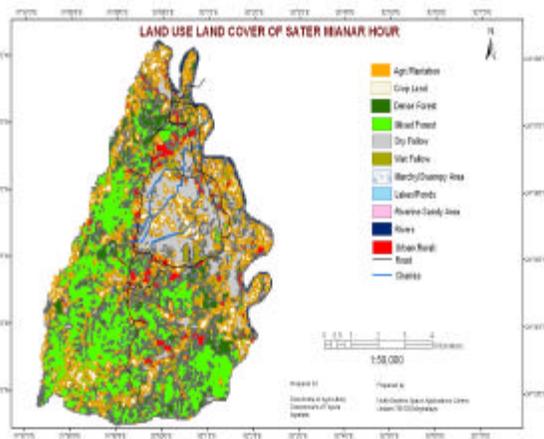


Figure 3. Existing LULC

and immature and landforms are mainly of erosional and depositional origin. The study area is a part of Kailshahar-Chamanu Valley, subsurface geology of this valley as described by CGWB is mainly fine to medium grained sandstone horizon with clay/shale horizon in near surface areas especially on hill tops. Number of Dug wells, shallow tube wells and a few deep tube wells are present in and around the study area namely in

Gaurnagar, Kumarghat, Karamcherra, Tilakpara and in Camanu .Average depth to water level during pre-monsoon is 2.50m bgl and during post-monsoon season is 1.5m bgl. Because of alternate sandstone and shale layers of Dupitila and Tipam Sandstone Formation ground water prospect in this region is very good to moderate. Presence of shale layer in near surface condition created water logging problem in places especially where proper drainage is absent. Also when underlying strata is shaly (impermeable) it favors high runoff and erosion thus groundwater prospect is low in those areas. Various landforms are found in the study area are deep and shallow alluvial plains, pediplain, valley fill deposits, residual hill, river, flood plains, oxbow and serpentine lake, point bar, migrated river course, dry streams, wetlands etc. Ground water prospect map is shown in figure 4 supported by table 2.

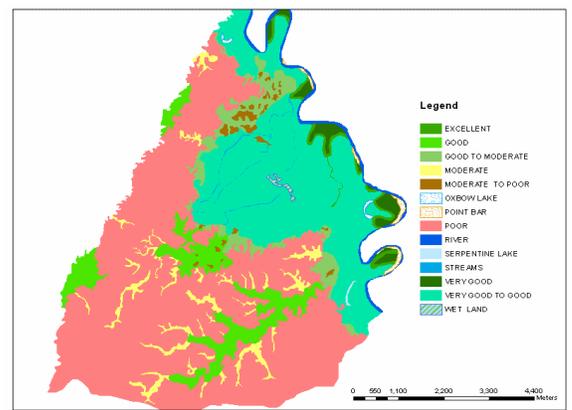


Figure 4. Ground water prospect.

### 5.3 Slope, Watershed delineation and prioritization

The entire job in this theme was carried out in the following major steps:

- 1.slope map, aspect map and DEM for the entire catchment area have been generated in 1:25000 scale.
- 2.The entire watershed area has been divided into twenty nos micro watersheds by considering all 3<sup>rd</sup> order streams as the highest order for each micro watershed. Size wise the smallest area being 118.35 ha and the largest being 517.75 ha.
- 3.All the twenty micro-watersheds were prioritized on the basis of the following parameters:

LANDFORMS	LITHOTYPE	GROUNDWATER PROSPECT
Deep Alluvial Plain (DAP)	Unconsolidated sediments	Very good to good
Deep Alluvial Plain (DAP)	Dupitila Formation	Good to moderate
Pediplain (PP)	Dupitila Formation	Poor
Valley Fill deposit (VF)	Dupitila Formation	Moderate
Residual Hill (RH)	Dupitila and Tipam Sandstone Formation	Moderate to poor
Flood Plain (FP)	Unconsolidated sediments	Very good
Migrated River Course (MRC)	Unconsolidated sediments	Excellent
Dry Streams (DST)	Unconsolidated sediments	Excellent
Shallow Alluvial Plain (SAP)	Dupitila Formation	Good

Table 2. Landforms with litho types for Ground Water prospect.

a. Drainage density 'Dd =  $S L / A_w$ '. Where 'S L' = Total length all the streams in a particular micro-watershed and 'A<sub>w</sub>' = Area of the micro watershed. From soil erosion perspective, higher stream density portrays higher soil erosion potential(channel phase) of the micro-watershed. Hence higher weightage were allotted to micro watersheds having higher drainage density.

b. Circularity ratio 'Cr' =  $4 \pi (A/P^2)$  of the shape of the micro-watersheds where, 'A' = Micro watershed area and 'P' = Perimeter of the of the micro watershed boundary. In watersheds of circular shape, higher intensity of discharge occurs as compared to watersheds elongated in shape which results in higher proportion of soil erosion(channel phase). Hence higher weightage has been allotted to those micro watersheds having circular sort of a boundary on the basis of circularity ratio.

c. Slope is directly proportional to quantum of erosion (both channel and land phase). Hence micro-watersheds which are falling on high slope area, have been allotted higher weightage as compared to micro-watersheds falling in relatively flat terrain.

d. Normalized Difference Vegetation Index has been generated for the entire watershed area. Eroding capacity of water is less in areas with healthy vegetation. On this basis, lower weightage have been allotted to t micro watersheds falling on areas with healthy vegetation as compared to the micro watersheds falling on areas with relatively unhealthy vegetation.

e. Soil Brightness Index has also been generated for the entire study area. Bright areas in SB index indicates soil condition from sparingly covered to totally exposed as well as from dry loose sandy soil to wet cohesive clayey soil. Exposed, dry and sandy soil is more easily eroded as compared to soil under vegetation. Micro watersheds falling on the bright areas in the SBI image have been allotted higher weightage as compared to those falling on relatively darker areas.

Based on all the above parameters, respective weightages for all the twenty micro watersheds were added to get the total weightage for prioritization for each of the micro watersheds. The total weightage range from the minimum to maximum has been divided into four equal parts such as *low priority*, *medium priority*, *high priority* and *very high priority* and accordingly all the twenty

micro-watersheds have been prioritized among themselves (Figure 5 and table 3).

## 6. Results, Conclusions and remedies in terms of suggested land-use planning.

After considering three field parameters such as Slope, Circularity ratio and drainage density as well as two remote sensing parameters such as NDVI and Soil Brightness Index for assigning priority weightages to each of the twenty micro-watersheds. After summation of the all the weightages, SMH 13 & SMH 20 fall in very high priority category. Both these two micro-watersheds are inside cadastral boundary. Most of the human population are in and around these two micro-watershed. Hence water logging problem solution to which in these two micro-watersheds should be the top priority. Widening of the natural streams (charras), improved agricultural practices, exploration of possibilities for diversion channels for expulsion of excess water can be some of the measures for which field studies in micro level can be taken up. Other watersheds in and around the cadastral boundary fall in high priority category. Apart from various vegetative and engineering measures, improved agricultural practices will play important role in overall development of Sater Mianar Hour watershed.

Micro - watershed name	Drainage density	Circularity ratio	Slope	S B Inde	NDVI Inde	Total weight	Priority
SMH 1	6	6	7	7	7	33	High
SMH 2	10	3	7	4	5	29	High
SMH 3	8	1	6	1	1	17	Low
SMH 4	8	2	7	3	2	22	Medium
SMH 5	8	3	6	1	1	19	Low
SMH 6	8	9	6	1	1	25	Medium
SMH 7	6	5	8	3	3	25	Medium
SMH 8	8	8	6	4	4	30	High
SMH 9	6	3	7	3	3	22	Medium
SMH 10	4	10	8	5	5	32	High
SMH 11	6	5	4	8	9	32	High
SMH 12	2	2	4	10	10	28	High
SMH 13	2	10	7	7	10	36	Very high
SMH 14	6	8	7	4	4	29	High
SMH 15	6	10	6	3	3	28	High
SMH 16	8	7	6	3	2	26	Medium
SMH 17	6	9	6	1	2	24	Medium
SMH 18	4	3	4	5	5	21	Low
SMH 19	2	9	5	7	10	33	High
SMH 20	6	9	3	10	10	38	Very high

Table 3. Weightages for prioritization

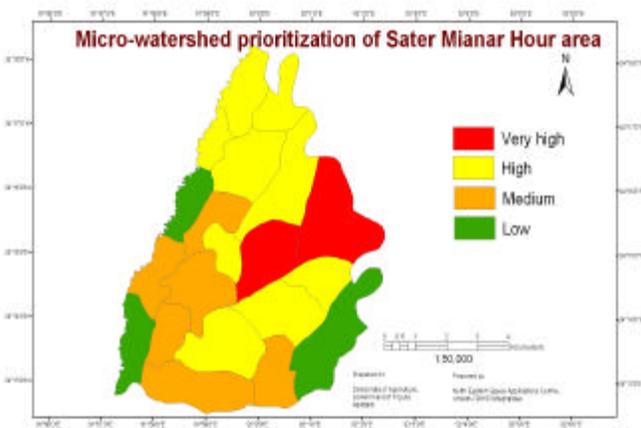


Figure 5. Priority micro-watersheds

Appropriate/suggested plans for land resources has been arrived at by integrating information on various themes viz., geomorphology, geology, soil, slope, surface water availability, ground water prospects, current land use land cover in GIS environment. Detailed maps have been prepared showing suggested land use for all the groups of watershed based on prioritization. Suggested land-use plan for the entire study area has been shown in Figure 6.

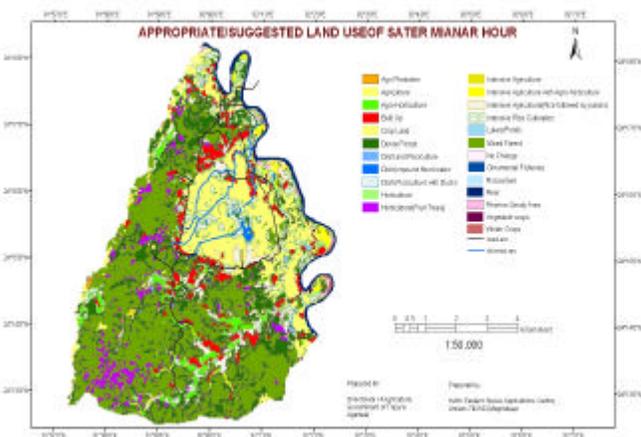


Figure 6. Suggested land-use plan

Final suggestions for converting various current land-uses into new suggested land-uses based on priority, available ground water prospect etc is shown in table 4 followed by Suggested land-uses for the very high priority

Current LULC	Landforms	Ground water prospect	Appropriate LULC
Agri.Plantation	PP	Poor	Agri Plantation
Crop Land	FP	Very Good	Intensive agriculture with Agro-horticulture
Crop Land	PP	Poor	Horticulture(Fruit Trees)
Crop Land	DST	Excellent	Disilt and Pisciculture
Crop Land	WL	Wet Land	Disilt,Pisciculture with Ducks
Crop Land	DAP	Good to moderate	Agriculture
Crop Land	DAP	Good to moderate	Agriculture
Crop Land	PP	Poor	Crop Land
Dense Forest	PP	Poor	Dense Forest
Dry Fallow	DAP	Good to moderate	Agriculture
Dry Fallow	SAP	Good	Agro-Horticulture
Dry Fallow	PP	Poor	Horticulture
Dry Fallow	VF	Moderate	Intensive Agriculture
Dry Fallow	DAP	Very good to good	Vegetable crops
Dry Fallow	MRC	Excellent	Vegetable crops
Dry Fallow	PB	Point Bar	Winter Crops
Lakes/Ponds	PP	Poor	Lakes/Ponds
Mixed Forest	PP	Poor	Mixed Forest
Riverine Sandy Area	SAP	Good	Riverine Sandy Area
Rivers	RV	River	Rivers
Urban(Rural)	PP	Poor	Built Up
Marchy/Swampy Area	DAP	Very good to good	Disilt,Impound flood water
Wet Fallow	SAP	good	Intensive Agriculture (Rice followed by pulses)
Wet Fallow	OL	Oxbow Lake	Disilt and Pisciculture
Wet Fallow	ST	Stream	Ornamental Fisheries
Wet Fallow	PP	Poor	Agrohorticulture

Table 4. Current to suggested land-uses

watersheds(Figure 7) and its corresponding area statistics(Table 5) as a representative sample of the suggested planning for the four priority categories in all the twenty micro-watersheds.

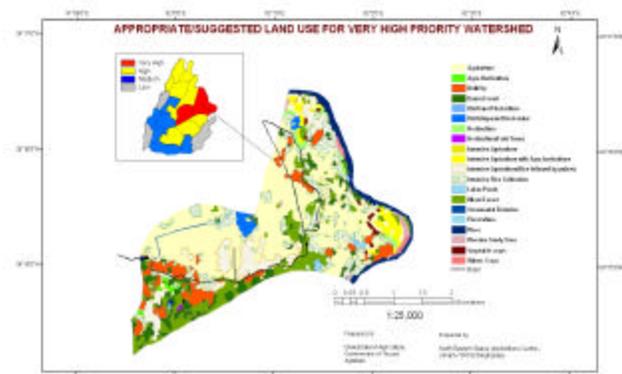


Figure 7. Suggested land-use plan for very high Priority watersheds.

Current LULC	Area(ha)	Suggested LULC	Area(ha)
Crop Land	150.36	Agriculture	353.55
Dense Forest	63.48	Agro-Horticulture	3.27
Dry Fallow	366.19	Built Up	60.75
Lakes/Ponds	4.20	Dense Forest	63.48
Marchy/Swampy Area	10.82	Disilt and Pisciculture	0.55
Mixed Forest	94.56	Disilt, Impound flood water	10.82
Riverine Sandy Area	8.24	Horticulture	8.93
Rivers	29.94	Horticulture(Fruit Trees)	0.49
Urban(Rural)	60.75	Intensive Agriculture	0.02
Wet Fallow	71.06	Intensive Agriculture with Agro-horticulture	25.00
<b>TOTAL</b>	<b>859.60</b>	Intensive Agriculture(Rice followed by pulses)	79.63
		Intensive Rice Cultivation	105.51
		Lakes/Ponds	4.20
		Mixed Forest	94.56
		Ornamental Fisheries	1.91
		Pisciculture	0.50
		River	29.94
		Riverine Sandy Area	8.24
		Vegetable crops	4.69
		Winter Crops	3.56
		<b>TOTAL</b>	<b>859.60</b>

Table 5. Area statistics

## 7. References:

**Anonymous, 1995**, Action plans for sustainable development of Hirisave abd Haranahalli watersheds, Hassan district, Karnataka. Technical report published by ISRO, Bangalore.

**Dutta, D., Sharma, J. R., Adiga, S. 2002** Watershed characterization, prioritization, development planning and monitoring- Remote sensing approach. Technical Report ISRO-NNRMS-TR-103-2002, ISRO, Bangalore

**Gupta, A. K., Nageswara Rao, P. P., Kanasha Raj, K., Dutt, C. B. S. and Chandrasekhar, M. G. 1993**. An integrated Approach for Resource Development Using Remote Sensing – A case study specific to Hill areas. Photonirvachak – Journal of Indian society of Remote sensing, 21 (2): 99-108.

**Naik S. D., 1990**, Watershed Prioritization in Dhansiri Catchment of Assam. SAC, Ahmedabad

**NRSA, 1995**, Integrated Mission for Sustainable Development – Technical Guidelines.

**Raju Prasad P.V.S.P., 1990** Role of remotely sensed data in the evaluation of land capability for agricultural land-use – A geomorphic approach (A case study of Nandayal area, Kunoor district, A. P.); proc. National Symposium on Remote Sensing for Agricultural Applications, New Delhi, pp 48 – 57 .

**Schultz G.A and Engman E.T., 1998**, Remote sensing in hydrology and water management – Springer Verlag Berlin Heidelberg, New York.

**Venkateshwarlu, P., Reddy, M.A., 2002**, Remote Sensing for Natural Resource Management – A case study; proc. ISPRS commission VII symposium on Resource and Environmental Monitoring, Hyderabad, vol. 34: pp 642-644

## 8. Acknowledgements:

The authors want to acknowledge Dr. P.P Nageswara Rao, Associate Director, NESAC for his valuable suggestions during the study.

The authors further express their thankfulness to Er. Debasis Deb, Deptt. of Agriculture, Tripura for providing all ancillary information about the study area.

The author also acknowledge the support from Sri. K.C Bhattacharyya, Director, NESAC for his kind comments and suggestions.

Finally the authors convey their sincere thanks to Dr. V. Jayaraman, Director, EOS, ISRO for encouragement and funding the study under EOAM.