

*Research Article*

## INVENTORY OF SATHANUR COMMAND AREA FOR MANAGEMENT OF IRRIGATION SYSTEM USING REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEM

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### **Abstract**

Water management practices in India have major concern in recent years to aid sustainable irrigation system in the country. The application of Remote Sensing and Geographic Information System has been increased to study and address the various issues relevant to the management of irrigation systems and the agricultural information derived from the satellite data forms the basic input for the study. In this paper a work has been taken up for inventorying and monitoring the irrigated agriculture land in Sathanur command area is explained. An attempt has been made in this study to assess the moisture stress of major crops in the command area using the satellite data. The agricultural conditions were analyzed over time and space using satellite data and ground truth data collection. The major crops in the command area were identified using visual and digital analysis and the based on that the cropped areas were estimated. Then qualitative assessment of moisture stressed crops is done using Normalized Difference Vegetation Indices (NDVI) and the crops in the input image is classified in to healthy crop area, moderately moisture stressed area and severely moisture stressed area. This study would hopefully lead to more operational use of this information in the management of irrigation system.

**Keywords:** Command area, Digital analysis, Moisture stressed crops, NDVI, Visual analysis.

### **INTRODUCTION**

Data on agricultural situation in irrigated command areas at desired spatial level remains unavailable which is today's major problem in evaluating the performance of irrigation systems. Crop identification and prediction of yield are the main concern of remote sensing application in agriculture. Various studies have demonstrated the usefulness of satellite remote sensing data for generating the information on total irrigated area and area under different crops (Estes et al., 1978; Kenneth and Lee, 1984; Nageswar Rao and Mohan Kumar, 1994), condition of crops (Williamson, 1989; LLoyd 1989; Thomas et al., 1994) and crop production (Pinter 1981; Hatfield 1983;

Murthy et al., 1996). Researchers have investigated different spectral bands and for water sensitivity. The spectral bands at 950-970, 1150-1260, 1450, 1950, and 2250 nm have shown promise in estimating water content in certain species (Sims and Gamon, 2003). Crop canopies are dynamic entities influenced by many management practices including cultivars, seed rate, soil moisture, fertilizers and disease, etc in addition to architecture of the crop (Rao et al., 1997). The water management in command area has become a challenging task because of the reasons like failure of monsoons, frequent droughts, excess utilization of irrigation water at upper reaches of the command area and not following the recommended cropping pattern. Information on crop types grown and

their acreage estimation in any given geographical area is needed for a variety of purpose like yield prediction, agricultural planning, irrigation management etc. Such information is more valuable for any command area because of the fact that the precious natural resource that is 'water' if used properly contributes to the increase in productivity and if improperly used leads to land degradation, problems like salinity, alkalinity, water logging etc.

If water is not distributed as per designed pattern, the tail end farmers will be affected and have to keep their lands fallow due to insufficient availability of water. Normally the farmers at the upper reaches draw more water and resort to growing crops that are irrigation intensive like paddy, sugarcane etc. due to ignorance, some farmers over irrigate their fields, which in due course of time leads to water logging and salinity problems. Hence, management of irrigation water in command areas has become top most priority in the context of environmental degradation. Information on the types of crop grown, total cropped area and actual amount of water available in the reservoir is needed for efficient management of water in the command area. Conventional methods of collecting such information by ground surveys are cumbersome, often influenced by personal bias and sampling errors. Remote Sensing Technology is becoming a powerful medium for such resource surveys, mapping and regular monitoring because of the advantages like synoptic view, repetitive coverage and reliability. Once the cropped area in any particular region is estimated in one season, crop monitoring in subsequent years become easy. This study was taken up for inventorying and monitoring the irrigated agriculture in Sathanur command area with the objectives that includes identifying the major crops in the command area, estimating the cropped area in the command area and identifying the area of moisture stress qualitatively in the command.

## MATERIAL AND METHODS

### Study area

The Sathanur command area lies approximately between latitudes of 11° 55' to 12° 05' N and longitudes of 78° 55' to 79° 00' E covering a total geographical area of about 18,217 ha. The Sathanur dam is located across the Ponnar river near Sathanur village about 32 Km from

Thiruvannamalai town in Thiruvannamalai district of Tamil Nadu.

The catchment area of the river at the Sathanur dam site is 10,835 Sq.Km. The study area map is shown in the Figure 1. September, October and November are peak rainfall months, with a decline setting in from mid November. Temperatures remain fairly constant, ranging from 29.5°C to 38.4°C (maximum) and 20.4° to 26.5° (minimum). The south-west monsoon lasts from mid June to end of September, followed by the north-east monsoon from October to December with the two monsoons contributing roughly equal amount of 420 mm of rainfall. There are two types of soil in Sathanur command area namely Edathanur series and Mudiyanur series. While the Mudiyanur series are heavy soils, the Edathanur series are light soil. The soils available in the command areas are free from saline and alkaline problems. The main sources of irrigation in the command area are Sathanur Left Bank Canal (SLBC), Sathanur Right Bank Canal (SRBC), tanks and wells. All these sources mainly depend upon the south-west monsoon (mid June to end September) and the north east monsoon (October to December). The major crops found in the Sathanur command area are paddy, sugarcane and groundnut.

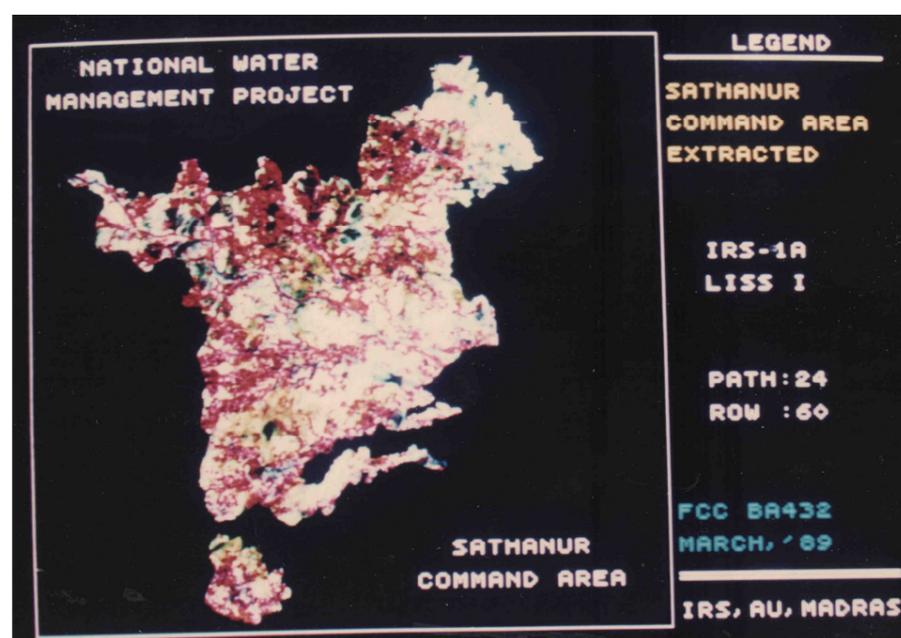


Figure1: Satellite image of the study area

There are three types of lands available for cultivation in Sathanur command.

1. Land wholly depend on reservoir water
2. Land commanded by reservoir and wells
3. Land commanded by reservoir through tanks and wells

## Data used

The details of the remotely sensed data products used in the study are given in the Table 1. Digital data products in the form of Computer Compatible Tapes (CCT's) were used. Satellite data were selected based on the crop calendar of the command areas.

Table 1: Details of Data Products

Satellite*	Sensors <sup>#</sup>	Path- Row	Date/Mon/Year	Data type <sup>§</sup>
IRS 1A	LISS I	24-60	20 MAR'89	CCT
IRS 1A	LISS I	24-60	07 MAR'90	CCT
IRS 1A	LISS I	24-60	08 SEP' 91	CCT

\*IRS - Indian Remote sensing Satellite

<sup>#</sup>CCT - Computer Compatible Tape

<sup>§</sup>LISS - Linear Imaging Self Scanner

## Methodology

Digital analysis was carried out for this study. The computer compatible tapes were analyzed on VAX11/780 computer linked Pericolor 2001 image processing workstation.

### Ground truth data collection

Field visits were made for the ground truth collection for Sathanur command area so as to correlate the tones and textures of different crops and other land use/land cover categories with the image interpretation key. In the predetermined test sites on toposheets, detailed information of different crops grown and other ancillary information were collected. The major crops found in the Sathanur command are paddy, groundnut and sugarcane.

### Digital analysis

#### Supervised classification

Figure 2 shows the functional flowchart of digital image processing. The standard FCC image was displayed on Pericolor 2001 by passing bands 4, 3, 2 through red, green and blue guns respectively. Training sets were given to different land use/land cover classes like crops, forest/scrub, fallow land, water bodies etc., and statistical parameters like mean, standard deviation etc. were generated for these categories. From the study of statistical parameters of crop category, two or three major crop classes could be identified. Preliminary digital analysis was carried out by using maximum likelihood

classification. The training sets given during preliminary digital analysis were purified with the available ground truth for different crops and other land use/land cover classes. Once again signature sets were generated for the above mentioned classes. Subsequently maximum likelihood classification program was run for classifying the data.

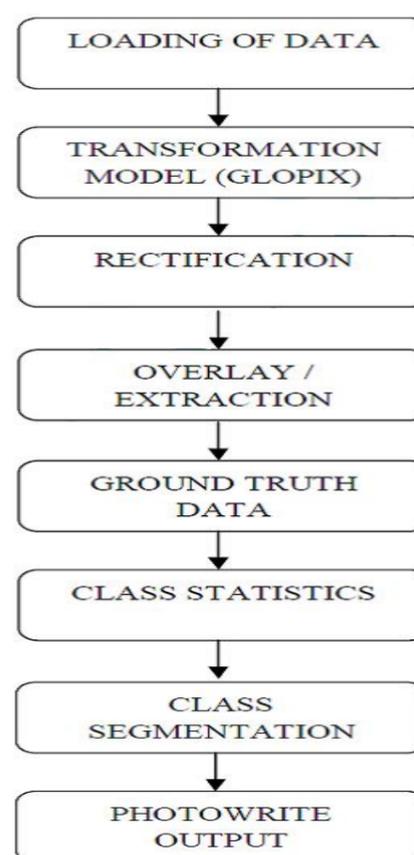


Fig .2 Functional Flow Chart of Digital Image Processing

#### Color coded classified output

The Photo-write Compatible Tape (PCT) was generated from the final output of Rabi (March, 1989 and March, 1990) and Kharif (September, 1991) seasons of Sathanur command. The PCT's have been generated at a scale of 1: 50,000 for Sathanur command.

#### Moisture stress study

Inadequate supply of nutrients, water, insect/pest attack, disease outbreak and abnormal weather conditions are the main factors which adversely affect the crop growth and restricts the potential yield of the crop. Whenever plant growth is retarded by less than optimum conditions, the plant is said to be 'stressed'. The word 'stress' although difficult to define from physiological point of view, is commonly used to signify any effect on plant growth that is detrimental. An attempt has been made to assess the moisture stress of major crops in Sathanur command qualitatively. For the assessment of moisture stress qualitatively, a mask scene containing the

interested crop pixels was generated and using this mask corresponding pixels were extracted from the raw scene which was subsequently subjected for the generation of Normalized Difference Vegetation Indices (NDVI). The NDVI is defined as

$$\text{NDVI} = (\text{NIR} - \text{Visible Red}) / (\text{NIR} + \text{Visible Red})$$

Where, NIR = Near Infra Red

Occurrence of moisture stress in the crops usually results into the reduction in plant canopy cover. Higher NDVI values are associated with greater density, larger leaf area and larger green biomass of the canopy. Gaussian post normalization is used in bringing the NDVI in the range of 0 to 255. It has been inferred from the NDVI values that the area closer to the tank and canal has higher NDVI values than that of the area away from the tank and canal. This has been divided in to three equal ranges. Red, yellow and Green colors have been assigned to the lower, middle and higher ranges of NDVI respectively. The pixels assigned green color is having no moisture stress i.e., healthy crop and pixels assigned yellow color and red color are moderately and severely moisture stressed crops.

## RESULTS AND DISCUSSION

### Digital analysis

In the Sathanur command area three major crops such as paddy, sugarcane and groundnut have been identified and their acreage was estimated. The image of classified scene of IRS 1A LISS I data for observed period are analyzed. Because of unavailability of cloud free data only two only one data of September 1991 was used for the analysis. Cropped area under paddy, sugarcane and groundnut crops in Rabi season obtained by digital analysis of IRS IA LISS I data in Rabi season is listed in Table 2. The lesser the figure obtained for sugarcane crop is due to early stage of the crop. The land use distribution in Sathanur command area during Rabi season of 1989 and 1990 and Kharif season of 1991 are shown in the Figures 3, 4 and 5. The mean spectral response of paddy, sugarcane, groundnut, fallow, scrub, water body and wasteland in the command area in terms of mean DN values are presented in Table 3. From the Table 3 we can see even though the spectral values in the bands 4, 2 and 1 are more or less same for both paddy and groundnut, they differ largely in band 3. Despite the spectral values in the bands 3, 2 and 1 are more or less same for both paddy and

sugarcane, their existence large difference in band 4. Hence, they could be separated out distinctly.

### Moisture stress study

An attempt has been made to assess the moisture stress of different crops in Sathanur command. The assessment of moisture stressed area has been done for Kharif (September 1991) and Rabi (March 1989 and March 1990) seasons of Sathanur command. Table 4 shows the area of healthy crops; moderately moisture stressed crops and severely stressed crops in Sathanur command area. The image of moisture stress map in the area is shown in the figures 6 to figure 4. It has been inferred from the moisture stress scene that the crops nearer to tank and canal is classified as a healthy crop and the crops away from the tank and canal classified as a moderately moisture stressed and severely moisture stressed area.

Table 2: Area under major crops in Sathanur command from digital analysis of IRS 1A data (unit in ha)

S. No.	Crops	Mar'89		Mar'90		Sep'91	
		RSE*	R <sup>#</sup>	RSE*	R <sup>#</sup>	RSE*	R <sup>#</sup>
1	Paddy	1138	1256	547	576	509	-
2	Sugarcane	302	2724	411	3003	1604	-
3	Groundnut	3904	2860	3108	3142	9768	-
Total Cropped Area		5,844	6,840	4,066	6,729	11,881	-

\*RSE – Remote Sensing Estimation; R- Reported

Table 3: Spectral response of major crops and other land use in Sathanur command

S. No.	Category	Mean DN Values			
		B4	B3	B2	B1
1	Paddy	53.55	27.44	25.22	44.22
2	Sugarcane	64.18	24.81	25.18	42.93
3	Groundnut	56.84	33.89	28.89	47.81
4	Fallow land	44.26	42.94	32.39	54.64
5	Water body	19.33	20.97	19.66	40.19
6	Scrub	56.09	49.23	35.53	57.51
7	Waste land	63.00	61.74	39.91	60.38



Figure 3: Land Use Land Cover map of Sathanur Command area for the year a) 1989 b) 1990 c) 1991

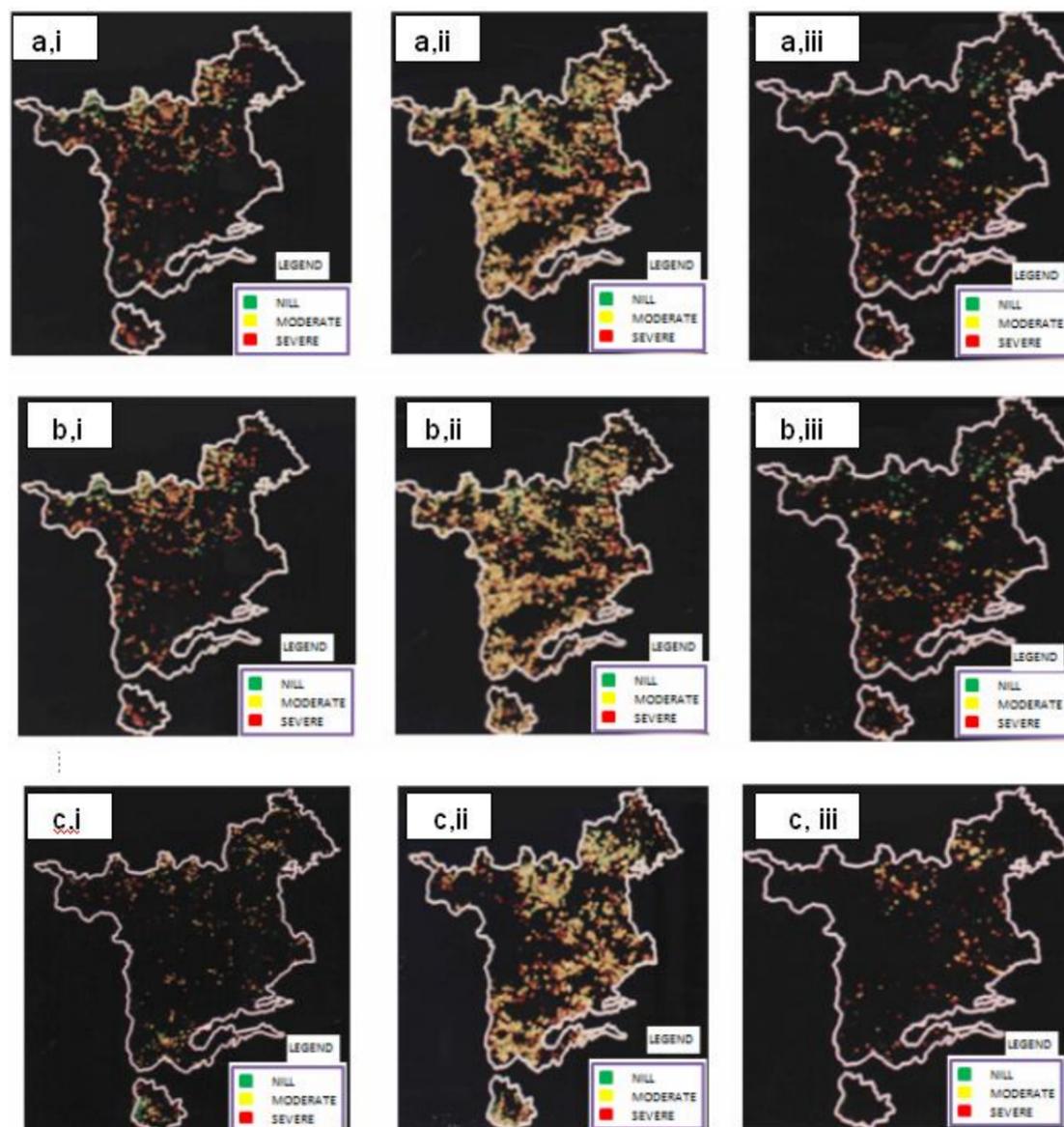


Figure 4: Moisture stressed area for Sathanur command area of the year a) 1989 b) 1990 and c) 1991 for i) Rice ii) Sugarcane iii) Groundnut

Table 4: Area of moisture stress in Sathanur command in both Kharif (Sep'91) and Rabi (Mar'89 and Mar'90)

S. No	Crop	Moisture stressed area in ha.		
		Healthy crop	Moderately Stressed crop	Severely Stressed crop
Rabi season				
1.	(Mar'89)			
2.	Paddy	260 (22%)	348 (31%)	529 (47%)
3.	Groundnut	975 (25%)	2047(52%)	901 (23%)
	Sugarcane	257 (32%)	324 (40%)	223 (28%)
Rabi season				
1.	(Mar'90)			
2.	Paddy	148 (27%)	227 (41%)	174 (32%)
3.	Groundnut	880 (28%)	1362 (44%)	866 (28%)
	Sugarcane	173 (42%)	152 (37%)	88 (21%)
Kharif season				
1.	(Sep'91)			
2.	Paddy	72 (14%)	81 (16%)	357 (70%)
3.	Groundnut	2508 (26%)	5867 (60%)	1394
	Sugarcane	976 (61%)	280 (17%)	(14%) 348 (22%)

In Rabi season (March 1989) most of the crops in the Left Bank Canal (LBC) of Sathanur command is classified as a healthy crop, where as in the Right Bank Canal (RBC) most of the crop is classified as moderately moisture stressed area and severely moisture stressed area. These shows, at this season crops under LBC might have received more amount of water than the crops under RBC.

It is concluded that, Remote Sensing Estimation (RSE) of acreage of paddy and groundnut are comparable with the reported data of Sathanur command in Rabi season (March 1989 and March 1990). But the acreage of sugarcane is less than that of the reported figure. This is because the growth of sugarcane crop at the time of date of pass was about two months old which resulted in lesser manifestation. In the moisture stress analysis it has been found that the area closer to tank and canal have been classified as healthy crop and the crops away from the tank is classified as moisture stressed crops which is generally representative of the true situation of the ground. The lower moisture level indicates the presence of weeds in the crop. In case of higher stress level, it is clear that plants become more affected by the lack of water content with increase in time. However, this relationship has to be strengthened quantitatively with real time ground surveys.

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