GEOSPATIAL INPUTS FOR IRRIGATION EFFICIENCY IN THE COMMAND AREA OF TUNGABHADRA LEFT BANK CANAL

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Abstract –*Irrigation of crops consumes a substantial quantity of water and that must be used judiciously.The study reported here is an attempt to understand the role of satellite remote sensing and GIS in improving the irrigation efficiency of canal irrigation. The main objective of this paper is to identify the gaps between the irrigation potential created and utilised and suggesting new canals to the gap identified areas inorder to increase the irrigation by using high resolution satellite data , SOI toposheets, slope and DEM to the Tungabhadra left bank command area, finding the cropping pattern violations and degraded lands.*

Keywords— High resolution satellite data, Gap identification, Crop Violation, Soil moisture estimation.

1. INTRODUCTION

Management of water in India is a major concern in recent years to improve the crop growth and to sustain the irrigation systems in the country. Identification of areas that are deprived of irrigation, change in cropping patterns, crop identification and predicting the yield, assessment of soil moisture are the main concerns in the command area.

The Tungabhadra project was built to provide water to the area of 5.23 lakh hectares. In that 3.63 lakh hectares is given to Karnataka state and 1.6 lakh hectares is for Andhra Pradesh. To supply water from dam to the croplands downstream, they have constructed various canals, distributaries, sub-distributaries, field canals, etc. The water is released through four canals, viz., Left bank low level canal, Left bank high level canal and Right bank low level canal, Right bank high level canal.In Tungabhadra project command area, as per the recent reports, water utilization is more than the crop requirement.

Due to the effect of frequent droughts, failure of monsoons and excess utilization of water at upper reaches of the command area, managing the water has become a difficult task. Another major reason is that not following the localized cropping pattern and discharging the water more than recommended as seen in the monthly canal withdrawal statement. Soil moisture conditions in the Tungabhadra command area are highly fluctuating and the tail-enders are the worst affected. The soil moisture is an important component in finding out the amount of water present in the soil and it is calculated to irrigate the crops for the particular soil suitable for the land in dry season.

Due to increase in population, the demand for higher levels offload production and productivity of food crops is increasing. Inequitable supply of water in the command area and lack of awareness among the farmers about the land degradation, not adopting the recommended cropping patterns (violation of cropping systems), the irrigated croplands are not able to give expected productivity. Irrigated lands are experiencing degradation (salinity, alkalinity, etc...) leading to lack of nutrition in soils, harmful use of pesticides, the soil is losing its biodiversity, and organic matter of the soil is being depleted.

Hence, there is a need for regular monitoring of the status of supply of water, crop productivity and cropping patterns, land degradation and suggest the ways to improve the benefits of irrigation to the land and income levels of farmers. The present study is an attempt made in that direction using the modern tools of Geoinformatics.

2. MATERIALS AND METHODOLOGY

2.1 DATA COLLECTION

The various satellite images and secondary data except canal networks given below was obtained from the KSRSAC department. The existing canal network was obtained from Advanced Centre for Integrated Water Resource Management.

Table 1: The satellites and sensors used in the present study

SATELLITES	SENSORS	DATES
Resourcesat-2	LISS-III	Jan / Feb 2005 Jan / Feb 2015
Resourcesat-2	LISS-IV	Feb-May 2011/12
Cartosat-1	PAN	Feb-May 2011/12
Resourcesat-2	AWIFS	17th OCT 2016, 7TH JAN 2017, 15th FEB 2017

2.2 Secondary Data: Thematic Layers

Thematic layers are the collection of geodatabases, which can be overlayed on the satellite imagery. Geographic data such as point, line, polygon and attributes are stored and organized in a spatial geodatabases, which are modelled in real world entities. Some of the thematic layers used in this study are as follows:

- Digital Elevation Model (DEM)
- Existing canal network
- Land degradation
- Land use map
- Geomorphology map
- Soil map
- Slope map

2.3 Survey of India (SOI) Toposheets:Some of the Toposheets used in this study are as follows:
56H04, 57A 09, 57A 10, 57A 13, 57A 14, 57D16, 56H04, 56H8, 57E01, 57E05

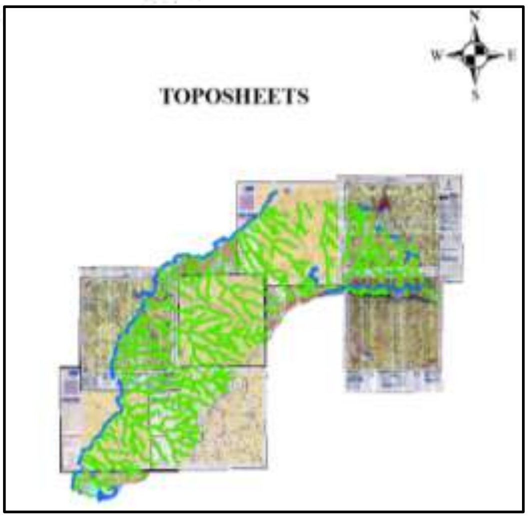

Figure.1: Some of the ground truth points collected in the study area and the Toposheets used for the TLBC Command area

2.4 STUDY AREA

Tunga and Bhadra are the two distribuaries where the name "Tungabhadra" is derived which rise in the hill "Varaha Parvata" in the Kuduremuka mountain ranges in Western Ghats. The length of the river is 640kms and joins the river Krishna at Sangameshwaram near Kurnool in Andhra Pradesh. Second largest river in South India is the river Krishna and Tungabhadra is one of the tributary to it. Tungabhadra dam is built across the Tungabhadra river at Mallapuram which is 2441m long and 49.39m high dam in Bellary district of Karnataka to store 133 tmcft capacity of water. Due to siltation in the place, storing capacity of the reservoir is reduced to 104.34 tmc.

The study area for the present work is Tungabhadra Left Bank Canal (TLBC) command area. The total command area is 2,44,000 ha. The total length of the canal is 226.91kms. There are 87 distributaries in this command area.The satellites and sensors used in this study are shown in Table 1.

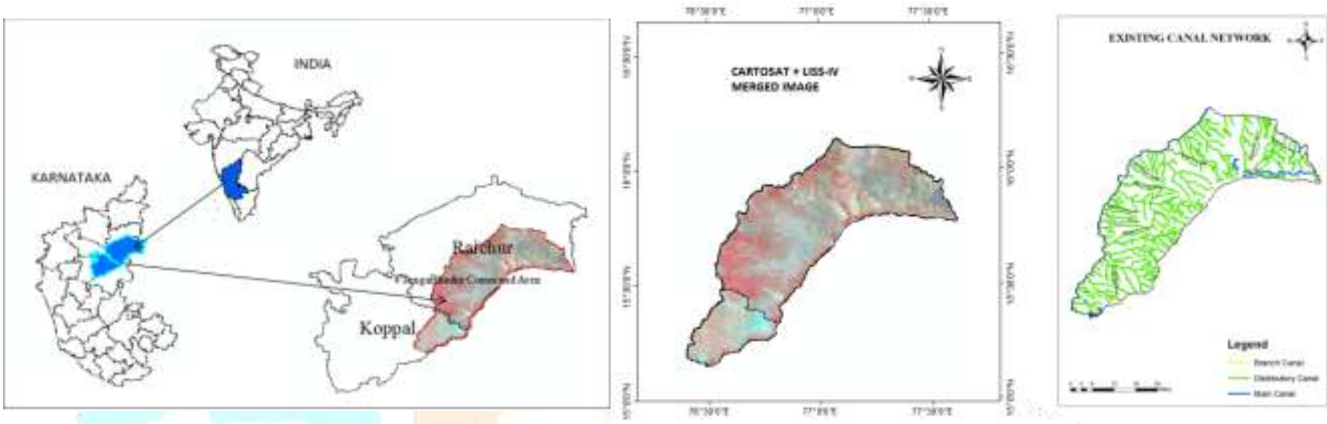

Figure.2: Location map of the study area,merged satellite image of CARTOSAT-1 Pan and LISS-4, existing canal network for the TLBC command area respectively

3. METHODOLOGY

3.1 Gap identificationin the TLBC command area

Cartosat-1 and LISS-IV merged data is used to analyze the canal gap identification. The procedure carried out is given in steps involved in the flowchart shown in Fig.3. Using Toposheets, basic information about the study area were visualized and the existing canal network interpreted.

(a) (b)

(a) shows sample image of LISS-4 merged withCartosat-1+PAN indicating Canal network in the command area.
(b) The gap in the canal (Cyan colour line) identified on the satellite image.

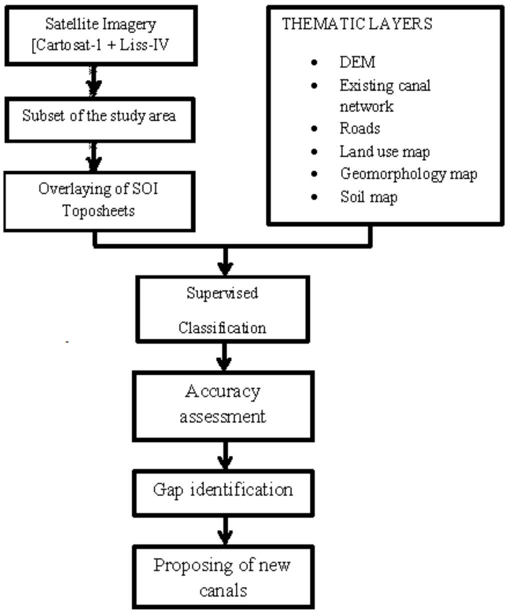

Figure.3: The flow chart showing methodology for proposing of new canals

The gaps are identified in the areas where the canals have stopped half the way and not reached to all the crop lands because of insufficient funds provided by the government.To Identify the gaps and suggest a new canal, Tungabhadra left bank boundary and satellite data i.e. the spatial data (Cartosat-1) and spectral data (LISS-IV) merged image was used which is shown in Fig.2. The image was projected into WGS 84, UTM projection.

4. Crop Violation

To plan the cropping pattern to the Tungabhadra Command area, extensive soil survey was conducted for the entire area. The main objective in preparing cropping pattern was to maximize the benefits to farmers. Depending on the soil characteristics, soil condition was to be improved. The steps carried out in finding the crop violation is given in the Flowchart shown in Fig.4.

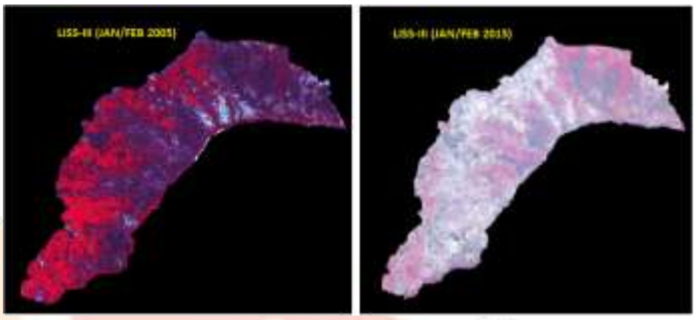

Figure.5: The Multidate LISS-III Image

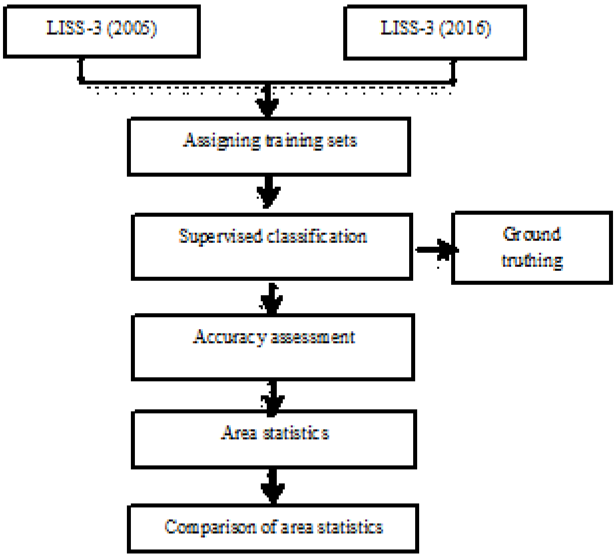

Figure.4: The flow chart of the methodology for Calculating cropping violation

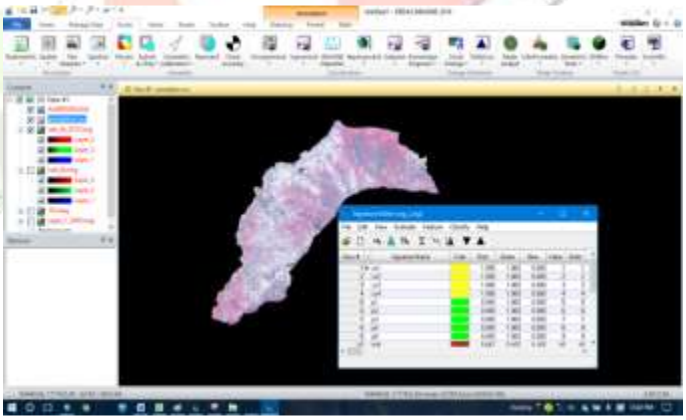

Figure.6: Assigning of Training sets and the signature files in ERDAS imagine

Table 2: Landcover types in TLBC command area using LISS-III data of 2005

Sl.No	Crops	L.B.C	L.B.H.L.C	R.B.L.L.C	RB HLC	Total
1	Paddy	21099	352	7581	-	29032
2	Sugarcane	8436	-	6230		14666
3	Garden	6345	-		80910	87255
4	Light irrigated Kharif	89304	74	-	-	89378
5	Light irrigated Rabi	88761	35	23693	-	112489
6	Rabi Cotton	29967	8	-	-	29975
	Total	**243912**	**469**	**37504**	**80910**	**362795**

Source: Annual report of Command Area Development Authority (CADA) 2015-16, Tungabhadra Project, Munirabad.

5. Soil moisture estimation

The main objective of finding the soil moisture is to find the amount of water holding capacity of the Soil in the TLBC. This was done to know the crops suitable for the area during the deficiency in water. The flow chart of the methodology carried out in assessment of soil moisture estimation for the TLBC is shown in Fig. 10.

Figure.7: The Normalized Difference Vegetation Index (NDVI) for different months

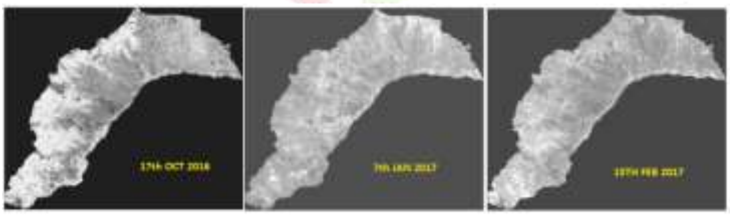

Figure.8: The Normalized Difference Moisture Index (NDMI) for different months

Figure.9: The Normalized Difference Moisture Index (NDDI) for different months

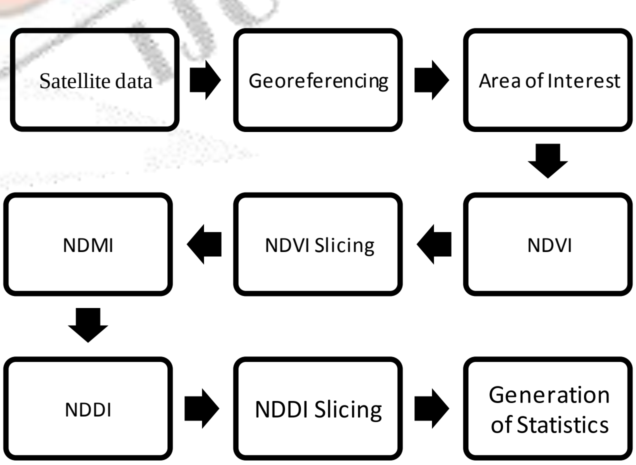

Figure.10: shows the flowchart of the methodology carried out in soil moisture assessment

The formulae for calculating NDVI, NDMI, NDDI is given below:

NDVI = NIR – RED / NIR +RED
NDMI = NIR-SWIR / NIR + SWIR
NDDI = NDVI – NDMI / NDVI + NDMI

6. RESULTS AND DISCUSSIONS

6.1 Canal Gap Identification in Irrigation Infrastructure: There are four main canals in the Tungabhadra project namely

1) Left bank canal (TLBC)
2) Right bank canal
3) Left bank low level canal
4) Right bank low level canal

Out of four canals in the Tungabhadra Project area, TLBC command area has been considered for canal gap identification. The canal gaps include the places where the canals have not reached the crop lands in command area due to the insufficient funds.

6.2 Tungabhadra Left bank canal

The main canal takes off from the Tungabhadra reservoir and the total length of the canal is observed to be 226.41km where almost all the canals are completed. There are distributaries and minors taking off from TLBC. The laterals, sub laterals and field canals can be seen in satellite imagery. Most of the distributaries are completed whereas secondary and tertiary canals are left with gaps. Canal network in the GIS platform and to find the gaps in the TLBC area, supervised classification map generated to classify the different category and to find the slope in the TLBC command area, the slope map was generated using DEM data and to know the landforms of the command area, the Geomorphology map was generated which is shown in Fig.11 respectively.

The proposed canal in the satellite imagery of the TLBC and zoomed image of the proposed canals is shown in Fig.12.respectively. There are 87 distributaries in the TLBC, in which the gaps were identified in 15 distributaries. The total length of the canals proposed in the study area is 40.96km.

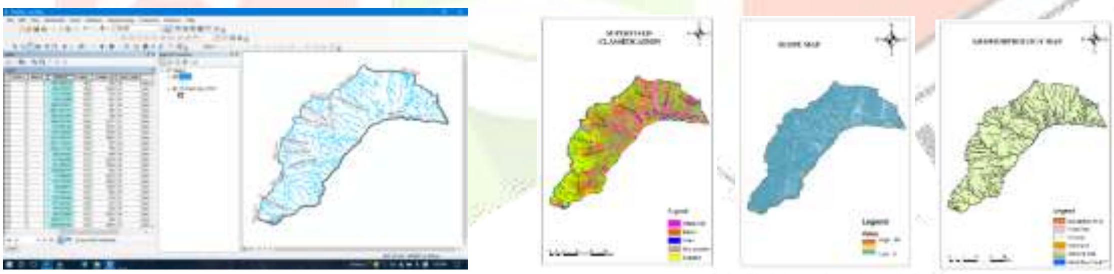

Figure.11: shows the canal networks in GIS platform, the supervised classification of the TLBC command area, slope map generated for the study area and the Geomorphology map generated for the study area respectively.

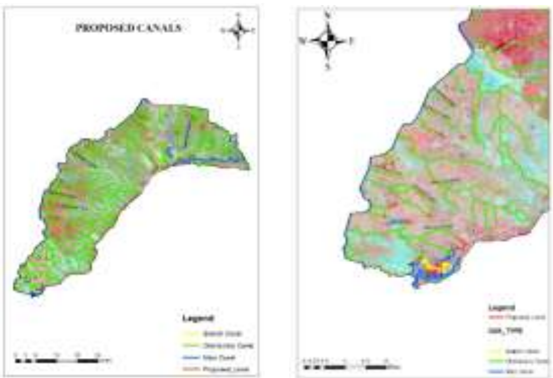

Figure.12: The Proposed canals in the gap identified area and
Zoomed canal networks suggested in the gap identified areas in the TLBC

The total length of the existing canals is 1873.14km and the length of the proposed canals is 40.96km is shown in Table 3.

Table 3: Proposed different types of canals in TLBC command area.

Sl.No	Canal type	Existing canal (Km)	Proposed canal (Km)
1	Main canal	217.74	4.41
2	Distributary canal	1645.11	35.42
3	Branch Canal	10.29	1.13
Total		**1873.14**	**40.96**

6.3 CROP VIOLATION

Crops grown during the year 2005 and 2015 were identified and area estimated using supervised classification, the same were compared with the localised cropping pattern of the TLBC command area. The crops suggested in the localised pattern were 8% under paddy, 4% under sugarcane, 73% under light irrigated Kharif and Rabi crops and 8.3% under Rabi cotton. However, the results obtained in the year 2005 shows that 21% of the area was under paddy and 7% under sugarcane which are high water demanding crops requiring release of more water during their growth period. The results obtained in the year 2015 shows that 18% of the area was under paddy and 1.5% under sugarcane and 36% under non- crop land. It appears that due to the inadequate supply of water to the lower reaches, 36% of the land is left un- irrigated. The area of the Landcover types generated for the year 2005 and 2015 is shown in Table 4 and supervised classification carried out for the two dates is shown in Fig.13 respectively.

Table 4: Landcover types in TLBC command area using LISS-III data of 2005 and 2015 respectively.

Jan / feb 2005 Scenario of crops in TLBC based on LISS-III			
Sl.no	**Crop / land cover type**	**area (in hectare)**	**%**
1	Paddy	141279	21.21
2	Sugarcane	43443	6.52
3	Degraded land	25020	3.76
4	Waterbody	2267.25	0.34
5	Wasteland/fallow land	164628	24.72
Total		**3,76,691**	
Total area of the TLBC =		**665944**	

Jan/feb 2015 Scenario of crops in TLBC based on LISS-III			
Sl.no	**Description**	**area (in hectare)**	**%**
1	Paddy	120823	18.14
2	Sugarcane	10011.9	1.50
3	Degraded land	7140.9	1.07
4	Waterbody	1610.02	0.24
5	Wasteland/fallow land	237087	35.60
Total		**3,76,691**	
Total area of the TLBC =		**665944**	

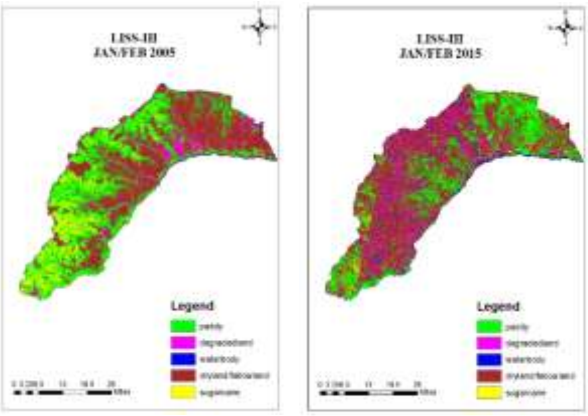

Figure.13: shows the supervised LU/LC classification for TLBC command area for the year 2005 and 2015 respectively

6.4 Assessment of Soil Moisture Estimation:

In this study, Assessment of soil moisture stress has been done for October 2016, January 2017 and February 2017 of Tungabhadra command area. The estimation of soil moisture which is normal, mild, moderate and severe is shown in Table 5. The soil moisture stress map found that in the month of October 2016, 91% of the TLBC command area was under mild soil moisture stress and it changed to 27% moderate and 72% severe condition in Jan 2017. In Feb 2017, 64% of the TLBC command area was under moderate condition and 23% under severe condition shown in Fig.14 respectively.

Table 5: The soil moisture condition for different months in TLBC command area.

Periodic Soil moisture Assessment for TLBC Command area									
Year	Total GA(ha)	Normal (ha)	%	Mild(ha)	%	Moderate (ha)	%	Severe (ha)	%
17Oct16	1039240	665.4	0.06	946319	91.06	1788.1	0.17	90467.01	8.71
7Jan17	1039240	379.1	0.04	1824.8	0.18	289297.3	27.84	747739.1	71.95
15Feb17	1039240	158.3	0.02	135233.4	13.01	663792.4	63.87	240056.1	23.10

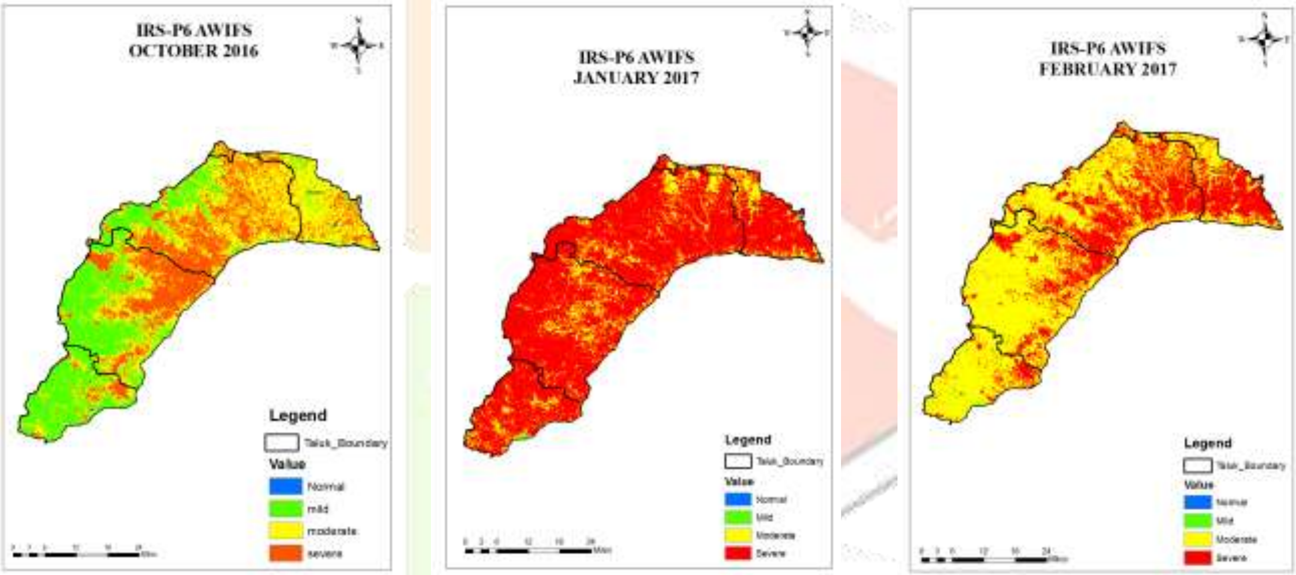

Figure. 14: The surface soil moisture stress in TLBC as on 17th October 2016, 7th January 2017 and 15th February 2017

CONCLUSION

Irrigation efficiency depends on i) reducing the losses during transport through the canal network (conveyance efficiency) and ii) optimum use of water in the fields. The present study is an attempt to provide a few geospatial inputs for improving the irrigation efficiency. The study was conducted in the TLBC command area using satellite remote sensing and GIS. Cartosat-1, LISS-III and LISS-IV, AWiFS sensors of RESOURCESAT-2 were used in this study.

Gaps in the canal network in the TLBC command area was estimated using CARTOSAT-1(Pan) and LISS-IV merged data and thematic layers such as existing canal networks, road map, land use map, land degradation map, geomorphology map, slope map and DEM were used.

Identification of crops grown in the TLBC command area and their acreage estimations were done using LISS-III sensor data. Change in cropping patterns and violation of recommended crops in the TLBC command area was done using Multidate LISS-III sensor for the year 2005 and 2015 for Rabi season only. Kharif season crop identification and estimation of area was not done due to cloud cover and bad data quality.

Assessment of soil moisture stress in the TLBC was calculated using AWiFS sensor of three dates i.e. for 17th Oct 2016, 7th Jan 2017 and 15th Feb 2017. NDVI, NDMI and NDDI were generated using near infrared, shortwave infrared and red spectral bands of AWiFS.

The total length of the TLBC command area was observed to be 226.61km. The major gaps in the TLBC were identified and 40.96km length of new canals was suggested. Thus high resolution satellite data from Cartosat-1+LISS-IVmerged product was successfully used for inventory of canal network facilitating objective assessment of physical status. The satellite inventoried data on status of canals can be used not only to prepare canal wise percent progress but also to identify gaps if any. It will also assist in identifying the critical areas requiring field verification thus significantly reducing the period of visit by the officials of the Water Resources Department, Government of Karnataka.

The study showed that the command area under TLBC is predominated by high water demanding paddy and sugarcane crops during 2005 and the area under these crops is gradually reducing by 2015. In both the years the area under major crops was found out to be against the cropping patterns suggested at the time of project approval. Thus this study shows clearly that the farmers of the TLBC command are violating the recommended cropping patterns.

In assessing the soil moisture, normal, mild, moderate and severe soil moisture conditions were estimated. The results showed that during the month of October 2016, 91% of the TLBC command area was under mild soil moisture stress and it gradually changed to 27% under moderate and 72% under severe stress condition in the month of Jan 2017. In the month of February 2017, 64% of the area was under moderate condition. This type of monitoring surface soil moisture status would help in identifying the areas that need immediate water supply and in prioritizing such areas.

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