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Assessment of Irrigation Potential Utilization in Major Irrigation Project Using Geospatial Data

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***Abstract*— Many irrigation projects were constructed in India post-independence period spending huge resources. However, there is a gap existing between Irrigation Potential Created (IPC) and Irrigation Potential Utilized (IPU). The reliable data on IPU under different irrigation projects is not readily available because of various reasons. Several studies were carried out for mapping of irrigated area at regional and global scale using coarse resolution satellite data but not at project level. Also, to assess IPU in an irrigation project, needs season wise irrigated area. Therefore, in the present study, multi-temporal medium resolution satellite data of Landsat-8 OLI (30m) coupled with other geospatial data of the project command area is used for assessment of IPU in a major irrigation project. The methodology proposed in the present study, can be upscaled to cover all the Major and Medium (M&M) irrigation projects in a river basin / State. This information is useful for taking remedial measures to achieve full I.P. utilization at project, river basin / Sate level.**

***Index Terms*— Geo-spatial data, Irrigation Potential Utilization, Isodata clustering, Normalized Difference Vegetation Index.**

I. INTRODUCTION

Irrigation development played a key role towards food security in India. Expansion of irrigation facilities through creation of new major, medium and minor irrigation projects, along with consolidation of existing systems, has been the main strategy for increasing production of food grains. In India, the irrigation projects are classified into three categories viz. major, medium and minor. Projects which have a Culturable Command Area (CCA) of more than 10,000 ha are termed major projects, those which have a CCA of less than 10,000 ha but more than 2,000 ha are termed as medium projects and those which have a CCA of 2,000 ha or less are known as minor projects. There are about close to 2,000 major and medium irrigation projects [1] in India.

Ultimate Irrigation Potential (U.I.P) of India is estimated as 139.90 mha The massive development of a vast irrigation network has resulted in significant increase in I.P created from 22.6 mha in 1951 to 110.07 mha by the end of March 2009. However, the reliable data on actual I.P utilization under different irrigation projects is not readily available for aggregation at river basin or national level. Wherever available, it lacks either in consistency and / or reliability because of various data collection agencies involved in the process. The problem is compounded because of inter-state and inter-basin issues. In addition, compliance monitoring of irrigation water utilization vis-à-vis allocations and assessment of water resources availability at basin scale requires reliable data on irrigated areas. Therefore, the need of the hour is to quickly generate reliable data on actual I.P utilization in a consistent and unbiased manner using remotely sensed data.

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Several studies were carried out in the past to map irrigated areas at global, country and regional scale using coarse resolution remotely sensed and other data sources. For instance, USGS Global Land Cover Map [2] was developed using 1 km monthly composite of NDVI (Normalized Difference Vegetation Index) obtained from AVHRR (Advanced Very High Resolution Radiometer). The Global Map of Irrigation Areas (GMIA) published by FAO was developed by Siebert, et al [3] using approximate information of total irrigated area from national information and other data sources (irrigated area per national statistical unit, irrigated area from point, polygon, and raster maps of land cover and other satellite data) at a spatial resolution of 5-arc minutes. International Water Management Institute (IWMI) released global irrigated area map for a 10-km grid resolution using methods described in Thenkabail, et al [4]. Zhao and Siebert [5] developed crop class based irrigated area maps for India using net sown area and extent of irrigated crops from the census and land use land cover data at 500 m spatial resolution for year 2005. For the Indian region, coarse resolution (250-1000 m) irrigation map based on MODIS remote sensing data was completed [4]-[6] for the Ganga, Indus and Krishna river basins. Performance evaluation of a major irrigation project using Indian Remote Sensing satellite data was carried out [7]-[9]. It was demonstrated that temporal NDVI is useful for crop type and irrigated area mapping [10] [11].

Emphasis of the above cited studies was on irrigated area mapping at coarse resolution, ranging from 250 m, 500 m, 1km and above at regional and country level. The geographical extent includes irrigation project areas (predominantly irrigated) and outside areas (predominantly rainfed). They essentially indicate the geographical distribution of area clusters that are being irrigated by different sources.

However, considering the average land holding size being small (less than 2 ha) in India, the results from coarse resolution study comprises of mixed pixel inaccuracies, especially at irrigation project level. Also, it does not estimate season wise area irrigated during the same agriculture year, which is required to estimate the actual Irrigation Potential (I.P) Utilization under any Major / Medium irrigation project during any year against I.P created facilitating to assess the Gap in I.P. utilization in that particular project.

The need of the hour is to estimate the Irrigation Potential (I.P) Utilization under each of the Major / Medium irrigation projects and the gap that exists at River basin / National level. This information is very essential to formulate the policies for taking the remedial measures to achieve full I.P utilization, there by not allowing the investments made in the irrigation sector go waste.

Therefore, the purpose of the present study is to demonstrate the use of medium resolution temporal Landsat-8 OLI (30 m) satellite data and other geo-spatial data to assess I.P Utilization under a Major irrigation project. Also, it is proposed that the methodology used in the study is simple and can easily be upscaled to cover all the Major & Medium projects in a river basin consisting of hundreds of such projects, and finally to all river basins in the country.

II. STUDY AREA

Jurala Project is located across river Krishna, near village Revulapally, Mahabubnagar district in Telangana state. The project command area extends between 15^{O} 50' to 16^{O} 30' N latitudes and 77^{O} 40' to 78^{O} 20' E longitudes (Fig. 1). The project has Gross Command Area (GCA) of 63,345 ha and Culturable Command Area (CCA) of 41,360 ha. The I.P created (IPC) is 41,360 ha with an annual irrigation intensity of 100%.

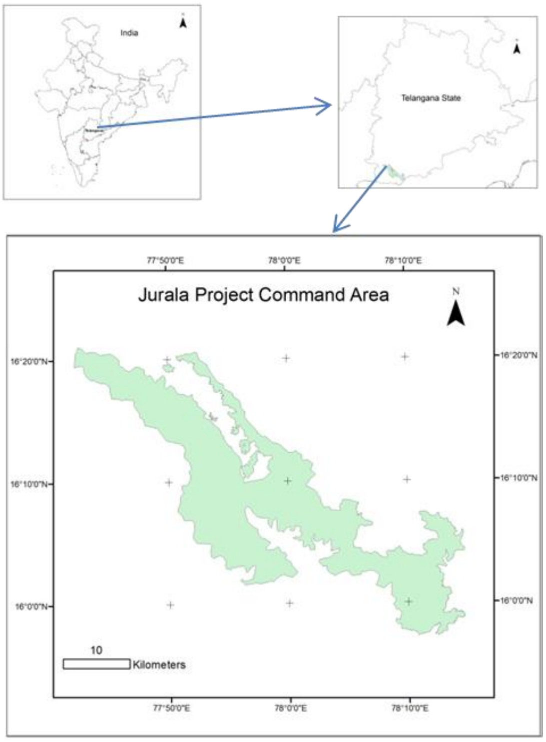

Fig.1: location map of the study area

III. DATA USED AND METHODOLOGY

A. Data Used

Temporal Landsat-8 OLI (Operational Land Imager) satellite data of 30m resolution was downloaded from USGS (United States Geological Survey) earth explorer website. Sample temporal satellite images are shown below (Fig. 2). Monthly cloud free satellite data covering 2014-15 agricultural year was utilized for the study (Table 1).

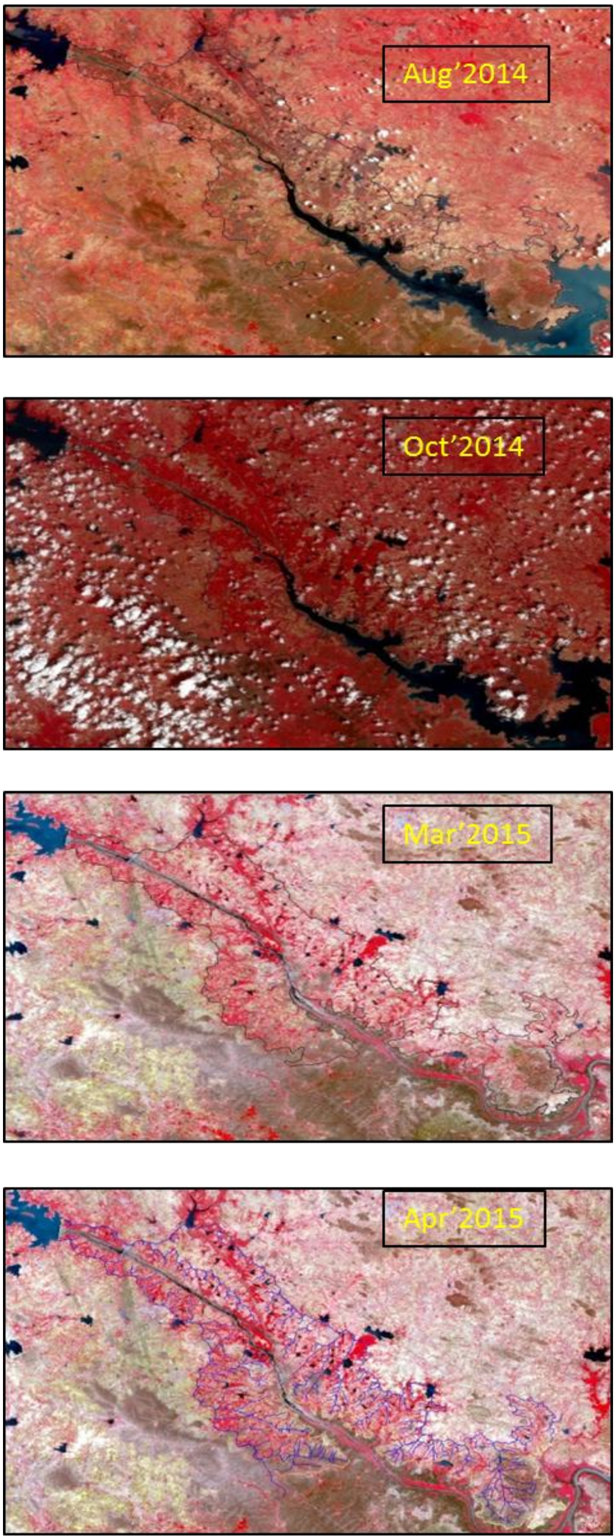

Fig.2: Temporal satellite images

Table 1: Satellite data used

S.No	Satellite data used
1	August 2014
2	September 2014
3	October 2014
4	December 2014
5	January 2015
6	February 2015
7	March 2015
8	April 2015
9	May 2015

Spatial data on project canal network (upto minor canal) and river/ stream network available in India WRIS (Water Resources Information System) portal was used (Fig. 3A & 3B). Also, high resolution 2.5m merged IRS PAN plus LISS-IV data available was made use. Additionally, groundtruth was collected during field visit and basic information about project was collected from Jurala project authority.

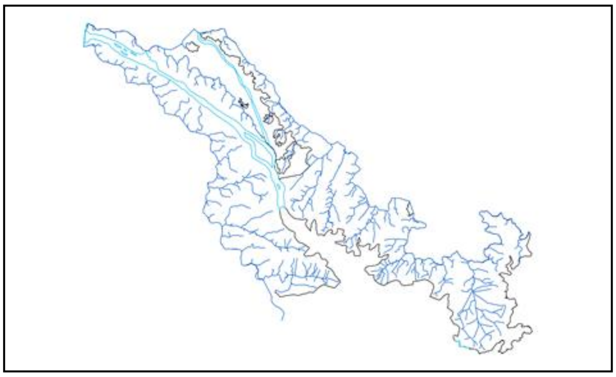

Fig.3A: Canal network

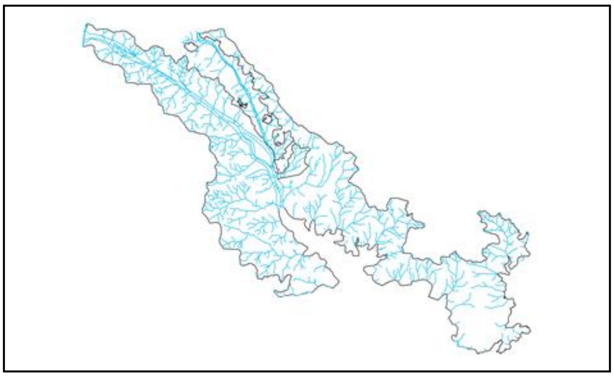

Fig.3B: Drainage network

B. Methodology

In the present study, all the crop area within the irrigation project command that receives full or supplementary irrigation during the crop season and also from different sources i.e., either from canal, bore well or lift from nearby river / stream is treated as irrigated area of the project.

Overall methodology includes elimination of all non-commnad / non-CCA area pockets, associated vegetation with waterbodies / rivers and then delineation of irrigated / rainfed crop area from within total crop area in the project command.

Initially, the exact project command boundary was delineated using the canal network (upto minor canal) and drainage with 2.5m high resolution satellite data of IRS PAN plus LISS-IV as the background. This has facilitated the removal of non-command area (non-CCA area) within the overall project boundary from further analysis, which is the main source of rainfed area getting mixed with project irrigated area. Also, all the water bodies present in the project command were masked out and there was no forest present. Subsequently, all further satellite data processing was confined to this near CCA project command boundary.

NDVI (Normalized Difference Vegetation Index) represents the amount of green biomass and is an indicator of the crop health and its temporal profile indicates crop growth cycle and seasonality. NDVI is defined as follows:

$$NDVI = (NIR-RED) / (NIR+RED)$$

Monthly NDVI images were generated using temporal Landsat-8 OLI satellite data using NIR and Red bands. These monthly NDVI images were thresholded with NDVI equal to or more than 0.2 which has resulted in removal of most of the non-crop vegetation in each of the images and stacked together. This temporal monthly NDVI data set for 2014-15 agriculture year was subjected to unsupervised ISODATA clustering in ERDAS Imagine software. All the clusters from the first level of classification were identified and labeled into different major crop groups and seasons based on the magnitude, monthly variation of NDVI (Fig.4), its seasonality and also groundtruth information. All the clusters were grouped into 9 major crop groups (Table 2) and one non-crop vegetation/ fallow. These 9 major crop groups were again subjected to second level of ISODATA clustering individually to identify and remove any non-native cluster or non-crop vegetation/ fallow in each of the group to form pure crop groups.

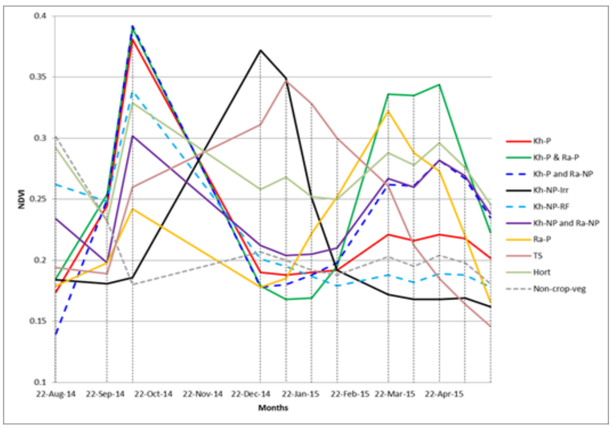

Fig.4 Temporal NDVI of major crop groups

Table 2: Major crop groups

S.No	Major crop group
1	Kharif Paddy
2	Kharif Nonpaddy (Irrigated)
3	Kharif Nonpaddy (Rainfed)
4	Kharif Paddy & Rabi Paddy
5	Rabi Paddy
6	Twoseasonal
7	Horticultural / Annual
8	Kharif Paddy & Rabi Nonpaddy
9	Kharif Nonpaddy & Rabi Nonpaddy

Season wise irrigated area viz. Kharif Irrigated Area (KIA), Rabi Irrigated Area (RIA), Two-Seasonal Irrigated Area (TSIA) and Horticultural Irrigated Area (HIA) classes were then formed based on season during which particular crop group was grown from 9 major crop groups identified earlier excluding kharif nonpaddy (rainfed) crop area. Crop groups 4, 8 & 9 are areas irrigated for two crops in a year (kharif & rabi), whereas crop groups 6 & 7 are areas irrigated for single crop in a year extending from kharif to rabi. Accordingly, seasonwise irrigated areas are estimated as follows:

KIA= 1+2+4+8+9; RIA= 4+5+8+9; TS&HIA= 6+7

Finally, I.P Utilization (IPU) or Gross Irrigated Area (GIA) during 2014-15 is estimated as sum total of KIA, RIA and TS&HIA which considers double irrigated area (4,8,9) twice.

IPU (or GIA) = KIA + RIA + TS&HIA

Net Irrigated Area (NIA) was derived by mosaicking of all irrigated areas of KIA, RIA and TS&HIA which considers double irrigated area (4,8,9) once.

IV. RESULT AND DISCUSSION

The satellite data derived season wise irrigated area and net irrigated area maps (Fig.5) of Jurala project are presented below. The details of season wise irrigated area along with IPU and NIA are provided in Table 3. Irrigated area estimated in this study includes area irrigated from all sources such as project canals, borewells and other sources like river lifting etc. The IPU (or GIA) of Jurala project during 2014-15 year is estimated as 45,195 ha (Fig. 6) and the Irrigation Intensity (I.I) works out to be 109.27%. The Net Irrigated Area (NIA) is estimated as 36,304 ha against a CCA of 41,360 ha which works out to be 87.78% of CCA.

This indicates that there was a gap to an extent of 5,056 ha which was not irrigated at all during the year. At the same time, an area to an extent of 8,891 ha (GIA-NIA) was irrigated during two seasons, compensating for the gap at project level. However, gap area needs to be utilized by better water management practices in the project command. Only then, can we say there is a full utilization of the I.P created under the project command.

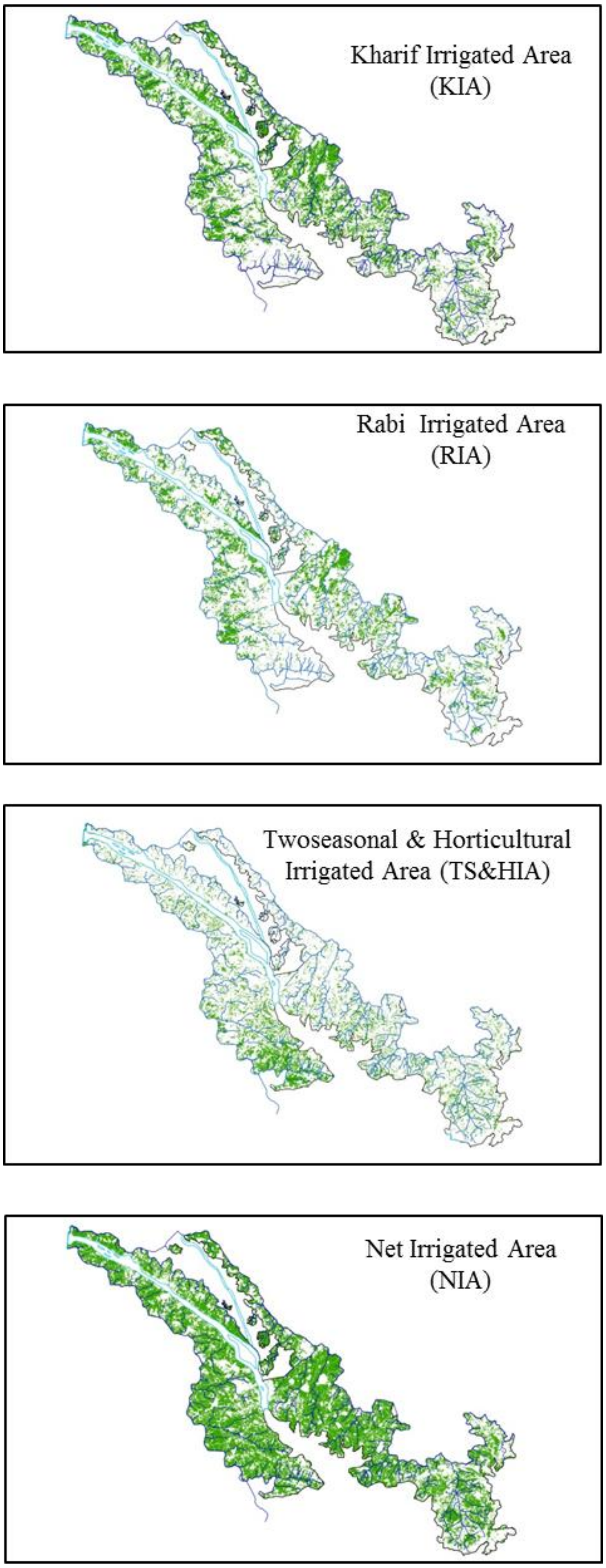

Fig.5: Irrigated area maps

Table 3: Seasonwise irrigated area

S.No	Season wise Irrigated Area (2014-15)	Irrigated Area (ha)
1	Kharif Irrigated Area (KIA)	21,921
2	Rabi Irrigated Area (RIA)	12,660
3	Twoseasonal & Horticultural Irrigated Area (TS&HIA)	10,614
4	Irrigation Potential Utilization (IPU)	45,195
5	Net Irrigated Area (NIA)	36,304

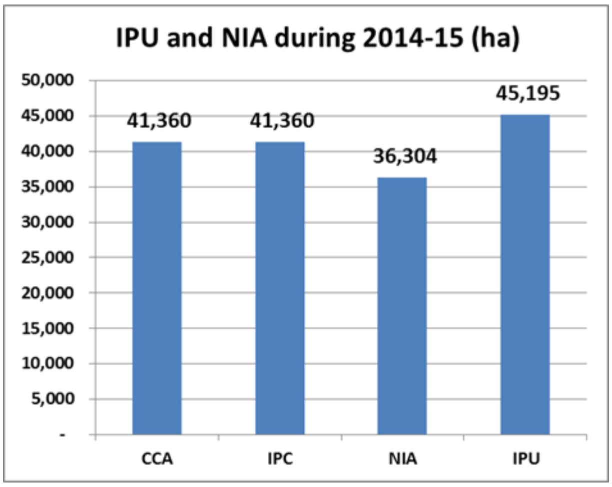

Fig.6: Irrigation Potential Utilization (IPU)

V. CONCLUSION

Medium resolution multitemporal satellite data is useful for assessment of Irrigation Potential Utilization (IPU) in a major irrigation project. Moreover, to assess IPU in an irrigation project, average of atleast 10 years needs to be considered to account for variation in water availability and corresponding IPU. Hence, availability of satellite data for current and historic years, is really useful for assessing IPU of an irrigation project with reliability and consistency. Also, the methodology presented here can be upscaled to cover all irrigation projects in a sub-basin/basin/State. This IPU information, if available, will be ideal for identifying and addressing the gap in IP utilization in a more effective manner.

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REFERENCES

[1] M. Shanker, et al. (2013) "Monitoring of Irrigation projects using high resolution cartosat satellite data", *National Natural Resources Management System Bulletin*, NNRMS (B) – 38, December 2013, pp. 43–50.

[2] Loveland, T.R. et al. (2000) "Development of a global land cover characteristics database and IGBP Discover from 1 km AVHRR data", *International Journal of Remote Sensing*, 21, pp. 1303-1330.

[3] Siebert, S. et al. (2005) "Development and validation of the global map of irrigation areas". *Hydrol. Earth Syst. Sci.* 9, pp.535-547

[4] Thenkabail, P.S., Schull, M. & Turral, H.(2005) "Ganges and Indus river basin land use / land cover (LULC) and irrigated area mapping using continuous stream of MODIS data" *Remote Sensing of Environment*, 95, pp.317-341.

[5] Zhao, G. & Siebert, S (2015), "Season-wise irrigated and rainfed crop areas for India around year 2005", *MyGeoHUB*, Available: http://doi.org/10.13019/M2CC71.

[6] Biggs, T.W. et al. (2006) "Irrigated area mapping in heterogeneous landscapes with MODIS time series, groundtruth and census data, Krishna Basin, India", *International Journal of Remote Sensing*, 27, pp.4245-42466.

[7] A.V.Suresh babu, M.Shanker, V.Venkateshwar Rao, (2012), Satellite derived geospatial irrigation performance indicators for benchmarking studies of irrigation systems", *Advances in Remote Sensing*, 1, June 2012, pp. 1-13.

[8] A.K. Chkraborti, M. Shanker et al. (2002) "Performance evaluation of an irrigation project using satellite remote sensing, GIS & GPS", *5th Annual International Conference on Map India 2002*, New Delhi, February 6-8, 2002.

[9] V.V.Rao, M. Shanker, S.T.Chari and Sanjay Sharma (1997) "Irrigation Status in Tungabhadra project command: Satellite sensing of field realities", *Proc. Workshop on Remote Seinsg and GIS applications in water resources engineering*, Bangalore, September 17-19, 1997, pp. 116-124.

[10] Thenkabail, P.S. et al.(2009) "Global irrigated area map (GIAM), derived from remote sensing for the end of the last millennium", *International Journal of Remote Sensing*, 30, pp.3679-3733.

[11] Ozdogan, M. & Gutman, G. (2008) "A new methodology to map irrigated areas using multi temporal MODIS and ancillary data: An application example in the continental US. *Remote Sensing of Environment*, 112, pp. 3520-3537.

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