Geospatial Analysis of Wetlands in Jharkhand Using Multi-temporal Satellite Data

Neeraj Sharma
Jharkhand Space Application Centre

Nishi Kullu
Jharkhand Space Application Centre

Ayyemperumal THILLAI Jeyaseelan
National Remote Sensing Centre

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Geospatial Analysis of Wetlands in Jharkhand Using Multi-temporal Satellite Data

N. K. Sharma[1]*, N. J. Kullu[2], P. K. Swain[3], A. T. Jeyaseelan[2]
[1]Scientist, Jharkhand Space Applications Center, Department of IT, Government of Jharkhand, Ranchi-834004, India
[2]Scientific and Technical Assistant, Director, Jharkhand Space Applications Center, Department of IT, Government of Jharkhand, Ranchi-834004, India
[3]Geospatial Associate, Geospatial Delhi Limited, Vikas Bhawan-II, New Delhi-110054, India

ABSTRACT

The present study was carried out to study the wetlands of Jharkhand using pre-monsoon and post-monsoon satellite data. Different indices were used to quantify the seasonal extent of wetlands, aquatic vegetation and turbidity levels of wetlands. Wetlands occupying an area smaller than 2.25 ha were identified separately as small wetlands. The total number of wetlands identified in Jharkhand was 2436 covering an area of 1568.27 sq. km. Small wetlands were 13327 in number. Rivers/streams and reservoirs occupied more than 90% area of total wetland area. Wetlands mostly exhibited moderate turbidity. Spatial geodatabase generated in the present study will be useful for the planning and monitoring of wetlands for their continued ecosystem services to the society. Major wetlands may be further developed as the prime sites of tourist attraction.

Keywords: *Aquatic vegetation, LISS III, reservoirs, river, turbidity*

****Author for Correspondence*** E-mail: sharmank@rediffmail.com

1. INTRODUCTION

A wetland is an ecosystem that arises when water inundation causes anaerobic conditions in soils giving rise to biota which is adapted to flooded environment [1]. Wetland delivers a wide range of services to humans such as flood control, groundwater replenishment, shoreline stabilization, nutrient retention, water purification, biodiversity reservoir, recreation, cultural values, fish and fiber, climate change mitigation with an economic upper value of $ 15 trillion [2]. Inventory and monitoring of wetlands is important for management of wetland resources [3]. Satellite remote sensing and GIS has been proved as a necessary tool for monitoring of wetland resources especially in large geographical areas and in inaccessible areas [4–6].

In India, wetland mapping has been carried out earlier at different scale using moderate resolution and coarse resolution satellite data [7, 8]. In the present study, baseline information on wetland type, extent, turbidity and aquatic vegetation has been generated for Jharkhand state, India. This study is a part of a national-level study for mapping the wetlands at 1:50,000 scale.

2. STUDY AREA

The Jharkhand state is one of the newly established states of the Indian Union carved out of the State of Bihar in November 2000. The total geographical area 79,714 km^2 lies between 21^{o} $58^{/}$ and $25^{o}20^{/}$ north latitude and 83^{o} $20^{/}$ and 87^{o} $57^{/}$ east longitude (Figure 1). There are 211 community blocks and 32,615 revenue villages. Jharkhand has three main seasons, viz., (i) The summer season (March to May), (ii) rainy season (June to October) and (iii) winter season (November to February). About 9% of the area in the state is irrigated. The state receives rainfall 1200–1600 mm/annum, of which 82.1% is received during the period June to September and the rest 17.9% in the remaining months. Major rivers of the state are Swarnarekha, Sone, Barakar, Damodar, Ajay, South Koyal, Shankh river, North Koyal, Brahmani and Bansloi.

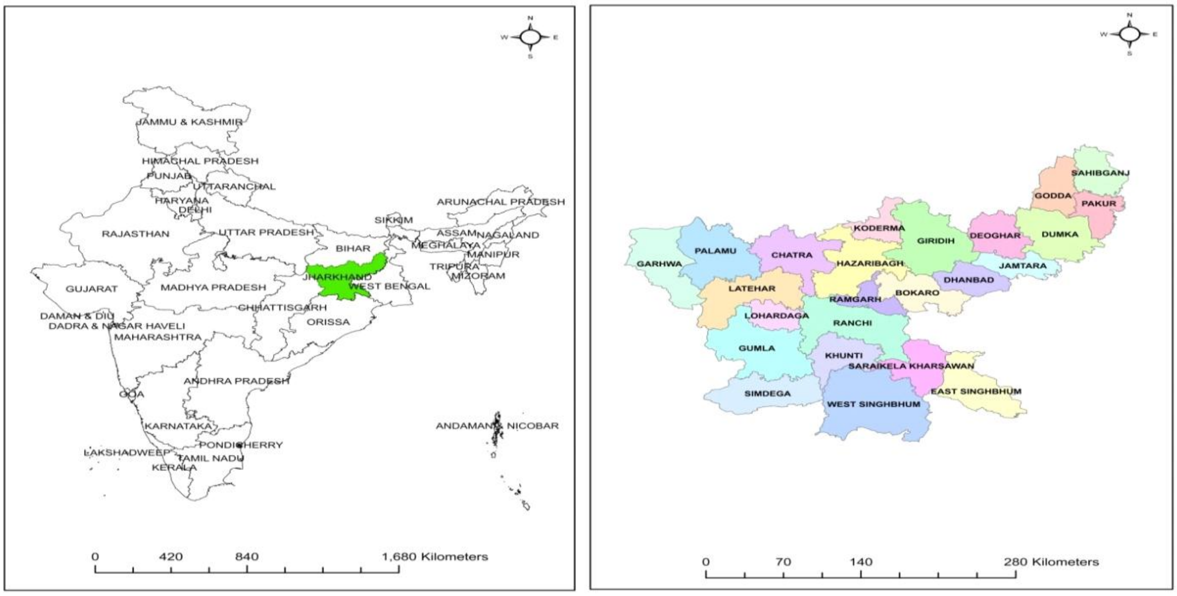


Fig.1: *Location Map of Jharkhand.*

3. MATERIALS AND METHODS

IRS P6 LISS III satellite data was used to map the wetlands. Satellite data has four spectral bands; two in visible and two in Infra Red region with 23.5 m spatial resolution and 24-day temporal resolution. Two date data, one acquired during March–May 2007 and another during September–December 2006, were used to record the pre-monsoon and post-monsoon hydrological variability of the wetlands, respectively. Satellite data received from National Remote Sensing Centre was geo-referenced and a mosaic of Jharkhand was prepared. Different base layers were prepared using Survey of India (SOI) topographic maps and satellite data. False Color Composite (FCC) was generated using infra red, red and green bands by assigning them red, green and blue colors, respectively.

Detailed methodology and wetland classification scheme was followed as per Garg and Patel [7]. Wetlands mapping was carried out through digital classification and onscreen visual interpretation. A minimum mapping unit was set as 2.25 ha. Water bodies smaller than 2.25 ha were identified and mapped as point features separately. Ground truth was carried out using global positioning system (GPS) during March–May and September–December 2008. Field photographs were taken to record the water quality (subjective), status of aquatic vegetation and water spread. Wetland put to agriculture use in any of the two dates is not included as wetland class. Different wetland layers generated for each inland wetland were wetland extent, water spread, aquatic vegetation spread, and turbidity level of open water. Wetland extent included open water and aquatic vegetation. Water spread was delineated using post-monsoon and pre-monsoon satellite data. Turbidity was evaluated for lakes, reservoirs, barrages and other large wetlands.

Different indices for quantification of wetland characteristics used were normalized difference water index (NDWI), modified normalized difference water index (MNDWI), normalized difference vegetation index (NDVI), normalized difference pond index (NDPI), and normalized difference turbidity index (NDTI) developed by different researchers [9–13]. Details of these indices are given below. These indices were generated using ERDAS Imagine image processing software and stacked as layers. Various combinations of the indices/spectral bands were used to identify the wetland features.

NDWI = (Green−NIR)/(Green + NIR)
MNDWI = (Green−MIR)/(Green + MIR)
NDVI = (NIR−Red)/(NIR + Red)
NDPI = (MIR−Green/MIR + Green)
NDTI = (Red−Green)/(Red + Green)

MNDWI, NDPI and NDVI images were used to extract the wetland boundary through suitable hierarchical thresholds. MNDWI was also used within the wetland mask to delineate the water and no-water areas. NDPI and NDVI images were used to generate the vegetation and no-vegetation areas within a wetland using a suitable threshold. MNDWI image were used to generate qualitative turbidity level (high, moderate and low) based on signature statistics and standard deviations. In the FCC, turbidity levels appear in different hues such as dark blue or blackish for low turbidity, medium blue for moderate turbidity and light blue or whitish blue for high turbidity. District wise wetland statistics were generated by overaling the district boundary layer over state wetland layer.

4. RESULTS AND DISCUSSION

A total of 2436 wetlands have been delineated using GIS layers of wetland boundary, water-spread, aquatic vegetation and turbidity (Figure 2). In addition, a total of 13327 wetlands were identified smaller than 2.25 ha in size.

Wetland area statistics have been presented in Table I. Total wetland area estimated is 156827 ha, which accounts for about 2% of geographical area of Jharkhand. The major wetland types are river/stream (97746 ha), reservoirs (48177 ha), tanks/ponds (5688 ha), lakes (3204 ha), riverine wetlands (1629 ha), waterlogged-natural (231 ha), ox-bow lakes (83 ha), waterlogged-man-made (61 ha) and aquaculture ponds (8 ha).

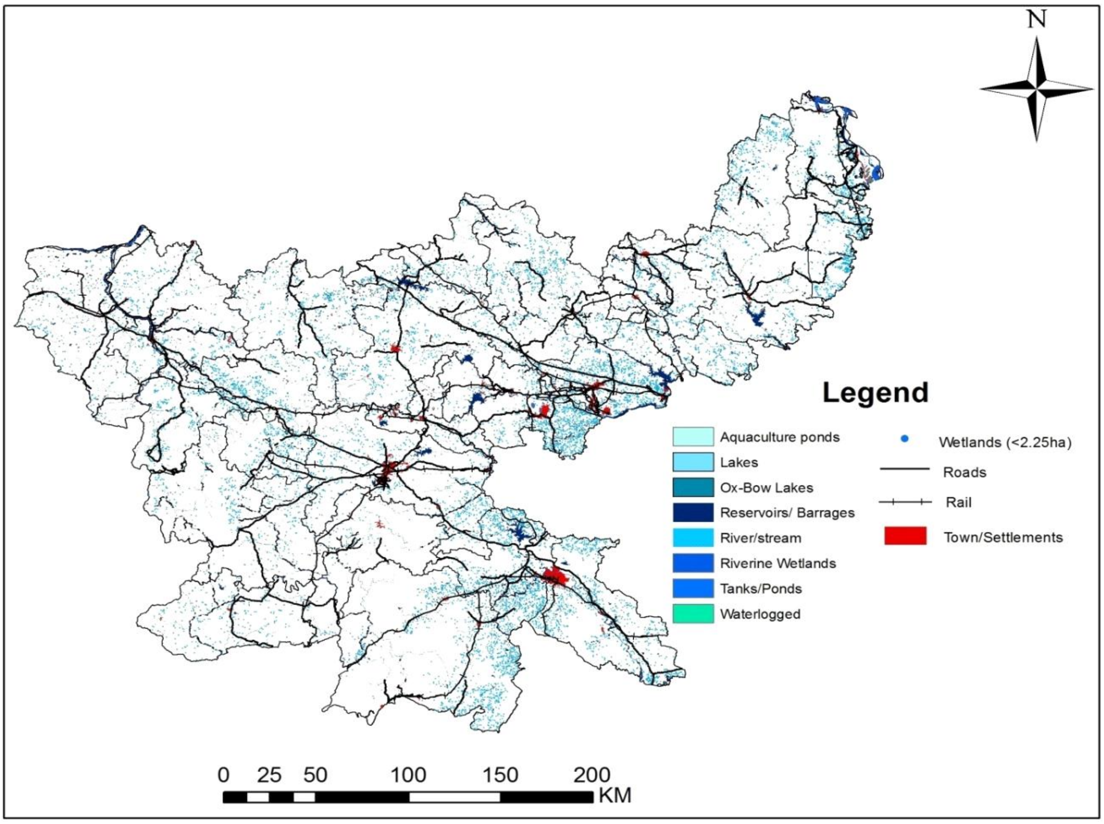
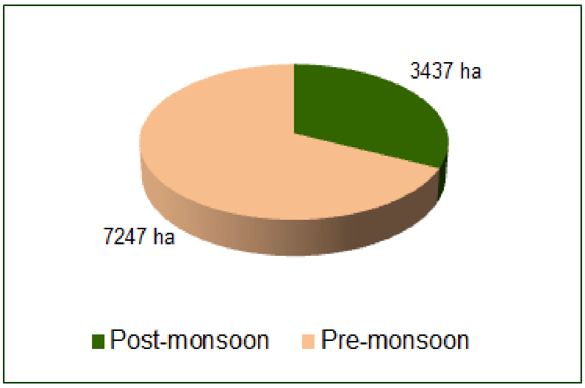


Fig. 2: *Wetland Map of Jharkhand.*

Table I: *Wetland Statistics of Jharkhand.*

Wetland Category	**Numbers**	**Total Wetland Area (ha)**	**Open Water Area (ha)**	
			Post-monsoon	**Pre-monsoon**
Inland Wetlands – Natural				
Lakes	16	3204	1344	385
Ox-bow lakes/Cut-off meanders	18	83	71	70
Riverine wetlands	42	1629	781	552
Waterlogged	58	231	232	16
River/Stream	317	97746	97744	63442
Inland Wetlands – Man made				
Reservoirs/Barrages	1062	48177	47387	34476
Tanks/Ponds	910	5688	5255	4241
Waterlogged	11	61	50	35
Aquaculture ponds	2	8	8	8
Total	2436	156827	152872	103225
Wetlands (< 2.25 ha)	13327			

Area under aquatic vegetation in pre-monsoon season was 7247 ha which was more than the aquatic vegetation area in post-monsoon season which was 3437 ha indicating submergence or reduction in growth of aquatic vegetation during post-monsoon season (Figure 3a). Wetlands in Jharkhand mostly exhibited moderate turbidity; which was 88410 ha in post-monsoon and 64127 ha in pre-monsoon season. Wetlands showing low turbidity cover 21015 ha and 12774 ha in post monsoon and pre-monsoon season, respectively (Figure 3b). Jharkhand state has shown a drastic reduction in the extent of open water from pre-monsoon (103225 ha) to post-monsoon (152872 ha), which amounts to approximately 32%.



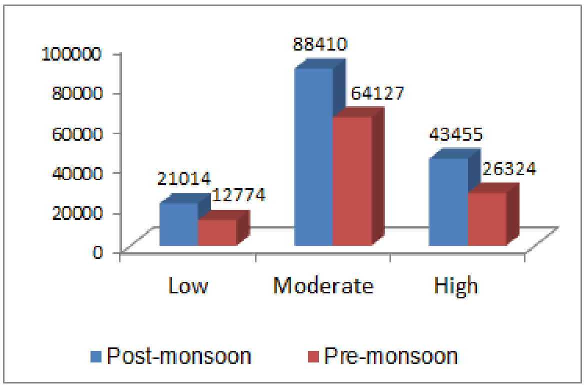


Fig. 3a: *Aquatic Vegetation Statistics of Wetlands* ***Fig. 3b:*** *Turbidity Variation Statistics of Wetlands.*

In district wise analysis, Sahibganj ranked first in terms of wetland area (15636 ha) followed by Seraikela-Kharsawan (11325 ha), Hazaribag (10718 ha), Bokaro (10284 ha) and others (Figure 4). In Sahibganj, Saraikela-Kharsawan and Dhanbad districts, the area under wetland category was 9.8%, 4.2% and 4.1% respectively of the total geographical area. Post-monsoon and pre-monsoon open water extent has been shown in Figure 5. Minimum seasonal variation (2%) in open water extent is observed in Ramgarh district while it was maximum in Lohardaga (68%) (Figure 6). On an average, the state has shown a decrease of 33% of open water extent.

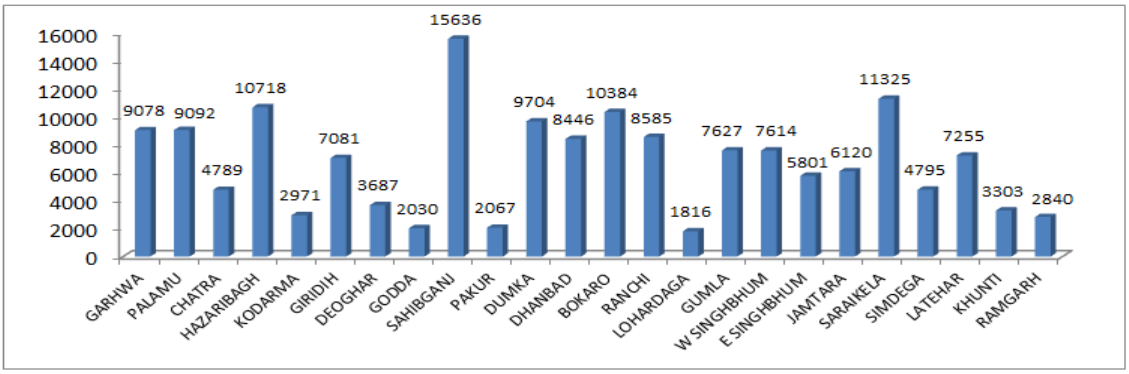


Fig. 4: *Areal Statistics of Wetlands in Different Districts of Jharkhand.*

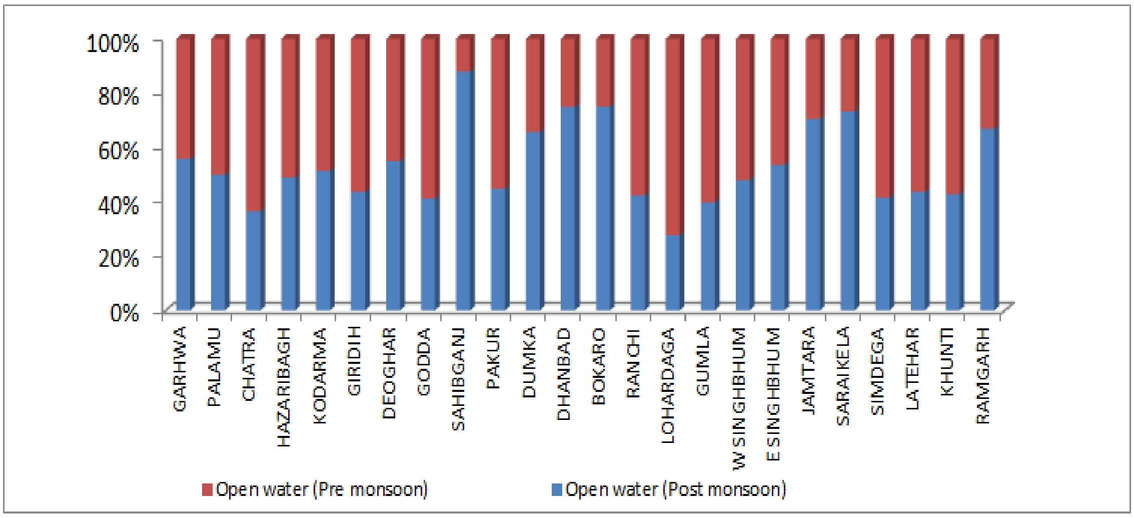


Fig.5: *Pre-monsoon and Post-monsoon Area under Open Water in Wetlands of Different Districts.*

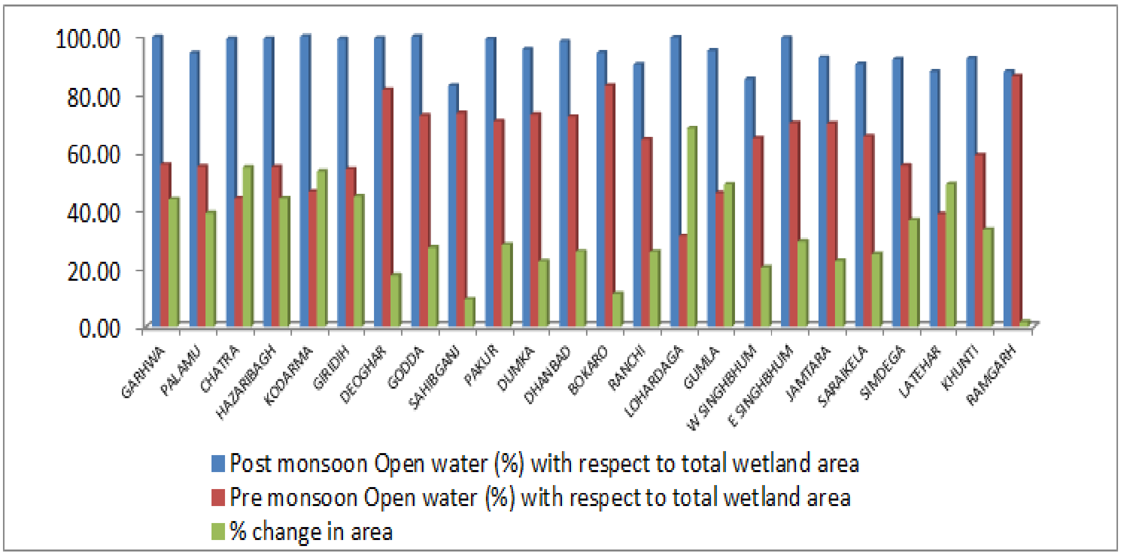


Fig.6: *Seasonal Change in Areal Statistics of Open Water in Wetlands of Different Districts.*

Udhwa lake (Bird Sanctuary), Getalsud, Tenughat, Panchet, Konar, Tilaiya, Maithon, Masanjore, Malay, Kansjore, and Hatia reservoirs are most important wetland areas of Jharkhand state. Pre-monsoon and post-monsoon satellite images of some of the important wetlands with details of aquatic vegetation and turbidity are shown in Figure 7. Two water bodies namely Pataura and Barhale form Udhuwa Lake Bird Sanctuary which is the only bird sanctuary of Jharkhand situated in Sahibganj on the bank of Ganges. This bird sanctuary presents a model of nature conservation under wetland environment [14]. The sanctuary provides natural habitat to a variety of birds including Brahminy kites, fishing eagles, house swifts and palm swifts apart from a large variety of migratory birds from Europe and Siberia arriving during winter [15].

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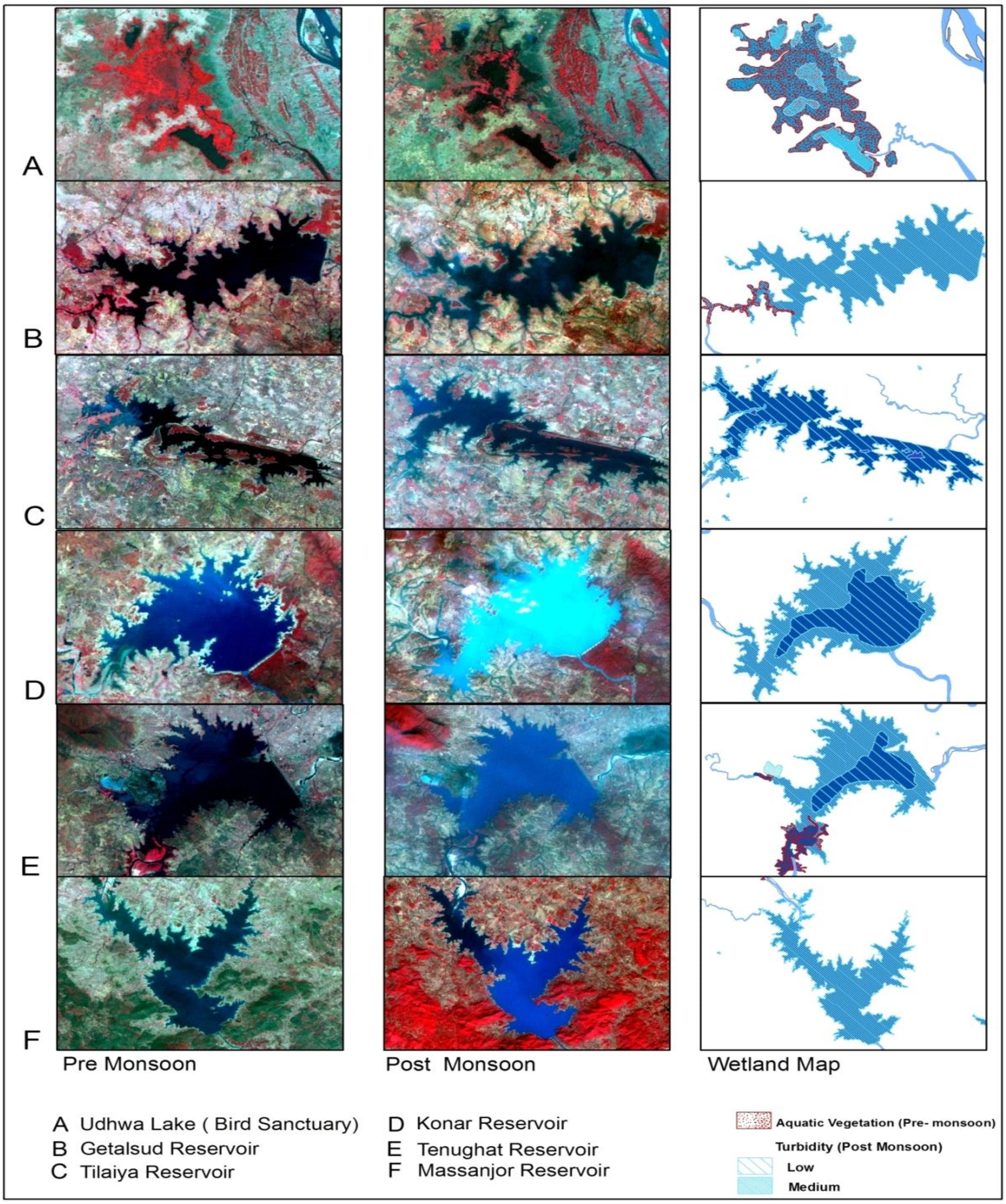

Fig. 7: *Important Wetlands of Jharkhand.*

Reservoirs play most important role in irrigation and drinking water supply as agriculture in Jharkhand is rain dependent. At present, there are many poorly maintained tourist spots in Jharkhand that need to be developed for enhancement of eco-tourism for the employment generation of local people. Wetlands in Jharkhand are playing major role in fish production. However, the state lags far behind (1600 kg/ha/year) the national level of fish production (2150 kg/ha/year) due to heavy siltation and weed infestation of the tanks [16].

Therefore, construction of new reservoirs for rainwater harvesting and to meet the demands of water for various purposes is the need of the time.

5. CONCLUSIONS

Spatial information generated on wetland area, open water dynamics and turbidity in the present study will provide the basic information to planners for better management and sustainable use of water resources. Most of the wetlands exhibited moderate turbidity. Wetland attributes quantified in the present study need to be studied further in relation to the different stress factors causing depletion of ecosystem services and their biodiversity value.

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REFERENCES

1. Keddy P. A. *Wetland Ecology: Principles and Conservation.* Cambridge University Press, New York. 2010.
2. Millennium Ecosystem Assessment. *Ecosystems and Human Wellbeing: Wetlands and water Synthesis*. World Resources Institute, Washington, DC. 2005.
3. Prasad S. N. et al. *Tropical Ecology*. 2002. 43(1). 173–186p.
4. Finlayson C. M. et al. *Marine and Freshwater Research*. 1999. 50(8). 717–727p.
5. Ozesmi Stacy L. and Bauer Marvin E. *Wetlands Ecology and Management.* 2002. 10. 381–402p.
6. Rebelo L. M. et al. *Journal of Environmental Management*. 2009. 90(7) 2144–2153p.
7. Garg J. K. and Patel J. G. *National Wetland Inventory and Assessment, Technical Guidelines and Procedure Manual.* SAC/EOAM/AFEG/NWIA/TR/01/2007. 2007.
8. SACON. *Inland Wetlands of India: Conservation Atlas*. Salim Ali Centre for Ornithology and Natural History, Vedams eBooks (P) Ltd., New Delhi. 2004.
9. McFeeters S. K. *International Journal of Remote Sensing*. 1996. 7. 1425–1432p.
10. Xu Hanqiu. *International Journal of Remote Sensing*. 2006. 27. 3025–3033p.
11. Townshend J. R. and Justice C. O. *International Journal of Remote Sensing*, 1986. 7. 1435–1445p.
12. Tucker C. J. and Sellers P. J. *International Journal of Remote Sensing*. 1986. 7. 1395–1416p.
13. Lacaux J. P. et al. *Remote Sensing of Environment*. 2007. 106. 66–74p.

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14. Mandal R. B. Ed. *Water Resources Management*. Concept Publishing Company, New Delhi, India. 2006.
15. http://www.wildlifeinindia.in/images/udhwa.html accessed on 5th September 2012.
16. http://www.jharkhand.gov.in/New_Depts/ap201011/FISHERIES.pdf accessed on 25th August 2012.