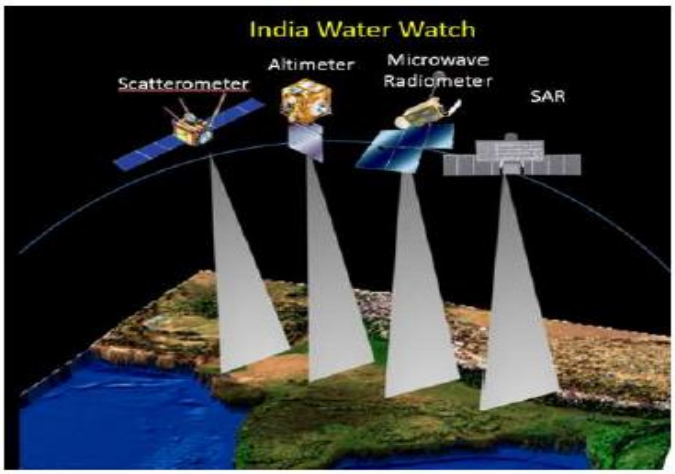
# National Wetland Inventory and Assessment (NWIA) Phase-II

**(under SARITA programme)**

***WORK PLAN***

***WORK PLAN- Bihar***




**Earth, Ocean, Atmosphere, Planetary Sciences and Applications Area (EPSA)**
**Space Applications Centre, ISRO**
**Ahmedabad 380015**

**and**

**Birla Institute of Technology, Mesra Ranchi, Jharkahnd**

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## 1. INTRODUCTION AND BACKGROUND

Wetlands played a major role in human history. It is only wetlands, whether perennial rivers or large water-bodies have always been the sites of sources of water and consequently the development of civilisations. Wetlands are among the most productive ecosystems of the world although they account only about 4 per cent of the earth's ice-free land surface. Wetlands usually occur in depressions or along rivers, lakes, and coastal waters where they are subjected to periodic flooding. Some wetlands also occur on slopes associated with the ground water seeps. Conceptually, wetlands lie between well-drained upland and permanently flooded deep waters of lakes, rivers and coastal embankments. Wetlands are among the most productive ecosystems besides being a rich repository of biodiversity, and are known to play a significant role in carbon sequestration.

Space Applications Centre (ISRO), Ahmedabad, at the behest of the Ministry of Environment, Forests and Climate Change (MoEF&CC), Government of India, carried out first scientific inventory of wetlands for India using IRS LISS-I/II data (of 1992-93 timeframe). This inventory of wetlands was carried out partly on 1: 250, 000 and partly on 1: 50, 000 scales with an estimated wetland extent to about 8.26 million ha (Garg et al, 1998). These estimates (24 categories) do not include rice paddies, rivers, canals and irrigation channels etc. Subsequently, a need was felt for creation of wetland database in GIS environment for monitoring, conservation and planning in the 16th Meeting of SC-B. In pursuance of the decision of the 16th SC-B (Standing Committee on Bioresources and Environment) of NNRMS (National Natural Resources Management System) meeting, Space Applications Centre (ISRO), Ahmedabad was entrusted to formulate a project proposal for creating a digital database of wetlands in the country and to develop a wetland information system. Consequently, a pilot project for development of GIS based wetland information system (WINSYS) for West Bengal was funded by MoEF&CC and executed by Space Applications Centre, Ahmedabad. Like-wise, a wetland information system for Loktak Lake (Loktak Resources Information System) was also developed.

In view of the increasing importance of wetlands worldwide, Ministry of Environment, Forests and Climate Change, Govt. of India has given responsibility to SAC to formulate a proposal for 1:50, 000 scale wetland inventory in India using 2006-07 timeframe satellite data. A peer review has suggested for a minor change in the classification system adopted earlier (1992-92) resulting 19 wetland categories/classes while keeping identical hierarchy. Subsequently, "National Wetland Inventory and Assessment" (NWIA) project was carried out by SAC on 1: 50 000 scale that resulted into a digital database and state-wise, and national wetland atlases based on Resourcesat-1 LISS-III data of 2006-07 timeframe. The estimated extent of wetland in the country was about 15.26 million ha (Panigrahy et al., 2011).

Over a period of time, the database of wetlands has been widely used in developmental activities that require environmental clearances etc. Since, almost a decade has been passed;

it is worthwhile reassessing the current status of wetlands at national level in comparison with the database of 2006-07. During discussion with MoEF&CC officials it has been suggested to formulate programme on wetland inventory and assessment on 1:25,000 scale for entire country using Resourcesat-2 LISS-IV data of post-monsoon and pre-monsoon seasons of 2017-18.

Satellite technology has evolved over the years and currently being used to retrieve information on various hydrological parameters. Methods are being developed and experimented to measure water level, river width, flood inundation, soil moisture, water quality, evapotranspiration and ground water. There is need to develop an integrated technique towards National level water watch system to address quantity and quality of water resources. SAtellite based RIver basin hydrological Technique and Applications (SARITA) programme formulated at SAC aims for following objectives;

1) Retrieval of hydrological variables with past 20 years' time series analysis from suite of Indian and globally available satellites.
2) Development of indigenous satellite input driven hydrological model and its calibration and validation in the selected river basins.
3) Wetland Inventory and Change Detection.
4) Hydrological experiment and establishment of hydrology lab.

The SARITA program will be carried out covering whole Indian region including southerly flowing Himalayan rivers contributing water to India with specific analysis to address the issues of transboundary rivers. A cell based hydrological system model will be developed at 5x5 km cell size for simulations of various water balance components integrating satellite derived inputs. Also, site specific measurements and modelling will be carried out at more than 100 locations in different river basins. The SARITA program consists of two major projects (1) River Hydraulics and (2) Wetland inventory and change analysis. The project on river hydraulics will deal retrieval of hydrological variables and modeling whereas proposed project on National wetlands inventory and Assessment will cover updation of wetlands of India at 1:25000 scales and change detection from the reference NWIA 2006-07-time frame.

## 2. OBJECTIVES

- Updation of Wetland Inventory of Bihar at 1:50,000 scale using Resourcesat LISS-III data of timeframe 2017-18, using the existing Wetland Inventory of timeframe 2006-07 as base layer. Creation of Wetland Inventory GIS Database for year 2017-18. Change analysis between Wetland Inventory of timeframe 2017-18 and 2006-07 and report preparation.

- Preparation of Wetland Inventory of Bihar at 1:25,000 scale using Resourcesat LISS-IV data of timeframe 2017-18. Creation of Wetland Inventory GIS Database for year 2017-18. Preparation of state level project report and Atlas.

## 3. WETLAND CLASSIFICATION SYSTEM

In the present wetland inventory of India, National Wetland Classification system will be used for wetland delineation and mapping (Table 1). The Wetland Classification System besides including all wetlands incorporates deep-water habitats and impoundments. Main criteria followed in this system are:

- Wetland hydrology, *i.e*. manifestation of water on the satellite imagery.
- Wetland vegetation -- mainly hydrophytes and other aquatic vegetation in a part or whole of the water body as observed on satellite data.

**Table 1: Wetland Classification System**

| Wettcode | Level I | Level II | Level III |
|---|---|---|---|
| **1000** | **Inland Wetlands** | | |
| **1100** | | **Natural** | |
| 1101 | | | Lakes |
| 1102 | | | Ox-Bow Lakes/ Cut-Off Meanders |
| 1103 | | | High altitude Wetlands |
| 1104 | | | Riverine Wetlands |
| 1105 | | | Waterlogged |
| 1106 | | | River/stream |
| **1200** | | **Man-made** | |
| 1201 | | | Reservoirs/ Barrages |
| 1202 | | | Tanks/Ponds |
| 1203 | | | Waterlogged |
| 1204 | | | Salt pans |
| 1205 | | | Aquaculture ponds |
| **2000** | **Coastal Wetlands** | | |
| **2100** | | **Natural** | |
| 2101 | | | Lagoons |
| 2102 | | | Creeks |
| 2103 | | | Sand/Beach |
| 2104 | | | Intertidal mud flats |
| 2105 | | | Salt Marsh |
| 2106 | | | Mangroves |
| 2107 | | | Coral Reefs |
| **2200** | | **Man-made** | |
| 2201 | | | Salt pans |
| 2202 | | | Aquaculture ponds |

(Ref: Garg J.K. and Patel J. G., 2007)

i. The extent of vegetation, if present, in the inland wetlands will be indicated on the maps.
ii. Wetlands put to regular agriculture use have not been included.

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Classification system for 1:25K will be separatly provided based on discusions held during meeting

with partner institutes

## 4. METHODOLOGY ENVISAGED

### 4.1 Change analysis (2006-07 and 2017-18)

During the course of the time the developments have enabled mapping of wetlands along with certain information on their structural components in a semi-automated to automated way. There are various methods for extraction of water information from remote sensing imagery, which according to the number of bands used, are generally divided into two categories, i.e. Single-band and multi-band methods.

In single-band method usually involves choosing a band from multi-spectral image to differentiate land from water by subjective threshold values while multi-band methods take advantage of reflective differences of each involved band. Certain spectral indices compatible to LISS-III and LISS-IV data will be used to enhance the structural components of wetlands in the present study. They are:

1) Normalised difference water index (NDWI) was suggested by Mcfeeters, 1996. The bands chosen are green and NIR. Selection of these wave lengths was done due to: a) maximise the typical reflectance of water features by using green light wavelength; b) minimise the low reflectance of NIR by water features; and c) take advantage of the high reflectance of NIR by terrestrial vegetation and soil features. The open water futures will have positive values while soil and terrestrial vegetation features will have zero or negative values. It is expressed as $\frac{(Green-NIR)}{(Green+NIR)}$

2) The reflectance pattern of built-up land in green and NIR is similar to water i.e. they both reflect green light more than they reflect in NIR. The average reflectance of built-up land in MIR is greater than that of green. Therefore, if a MIR band is used instead of NIR as used in the NDWI, the built-up land should have negative values. Based on this, a remedy is given as Modified normalised difference water index (**MNDWI**), as suggested by Hanqiu xu, 2006 using MIR instead of NIR. It is expressed as $\frac{(Green-MIR)}{(Green+MIR)}$

3) Normalised difference vegetation index (**NDVI**) as used by Townshend and Justice, 1986; Tucker and Sellers, 1986 takes advantage of the condition where the presence of features that have higher NIR reflectance and lower red reflectance (e.g. Terrestrial vegetation) will be enhanced, while those with low red reflectance and very low NIR reflectance (e.g. Water) will be suppressed or even eliminated. Vegetated surfaces tend to have positive values, bare soils may have near zero and open-water features have negative values. The results of this index range from -1 to +1. It is expressed as $\frac{(NIR-Red)}{(NIR+Red)}$

4) Lacaux *et al*, 2007 observed that the classic NDVI did not perform well for vegetation within the wetland. The behaviour vegetation inside and outside of wetlands cannot be distinguished. Thus the latter can not be used for detecting the vegetation within the wetland. Reflectance of water is higher (narrow difference) in green and compared vegetation while reverse (large difference) in MIR. Thus a new index named as Normalised difference pond index (**NDPI**) is suggested to exploit the advantage of difference at green and MIR. It is expressed as $\frac{(MIR-Green)}{(MIR+Green)}$

5) Pure water has a specific radiometric response: its reflectance is weak in green (less than 10 %), becomes very small in red and quasi-null in NIR. The increase in turbidity and its associated radiometric responses make the open water features (ponds) behave like bared soil (Guyot, 1989). Since the values of the red radiometric responses are much larger than that of the green ones, the relationship between the green and red wavelengths is reversed (Campbell, 1996; verbyla, 1995). To meet the turbidity sensing of open-water of wetlands, Lacaux *et al*, 2007 suggested Normalised difference turbidity index (**NDTI**). It is expressed as $\frac{(Red-Green)}{(Red+Green)}$

Comprehensive usage of multispectral as well as spectral indices and SAR data, it envisaged to map/inventory of wetlands along with peak open-water, open-water and vegetation besides qualitative turbidity. An example of utility of the spectral indices in delineation of structural components of a wetland is given in Fig. 2.

Legacy database of national wetland inventory is available comprising spatial eight layers based on 2006 (post-monsoon) and 2007 (pre-monsoon) LISS-III data.

The legacy database was prepared in GIS domain following the NNRMS guidelines. With the aid of the existing digital database, legacy transfer approach would be followed. Current data set will be pre-processed for geometric correction followed by radiometric normalisation. The spatial database prepared under NWIA project will be used as legacy and the current satellite data will be used to update the current status of the wetlands. Subsequently, the spatial databases of the 2006-07 and 2017-18 will be subjected to overlay analysis in GIS domain and change area statics and spatial layers will be prepared. Main steps of the methodology are given in Fig. 1 and 2.

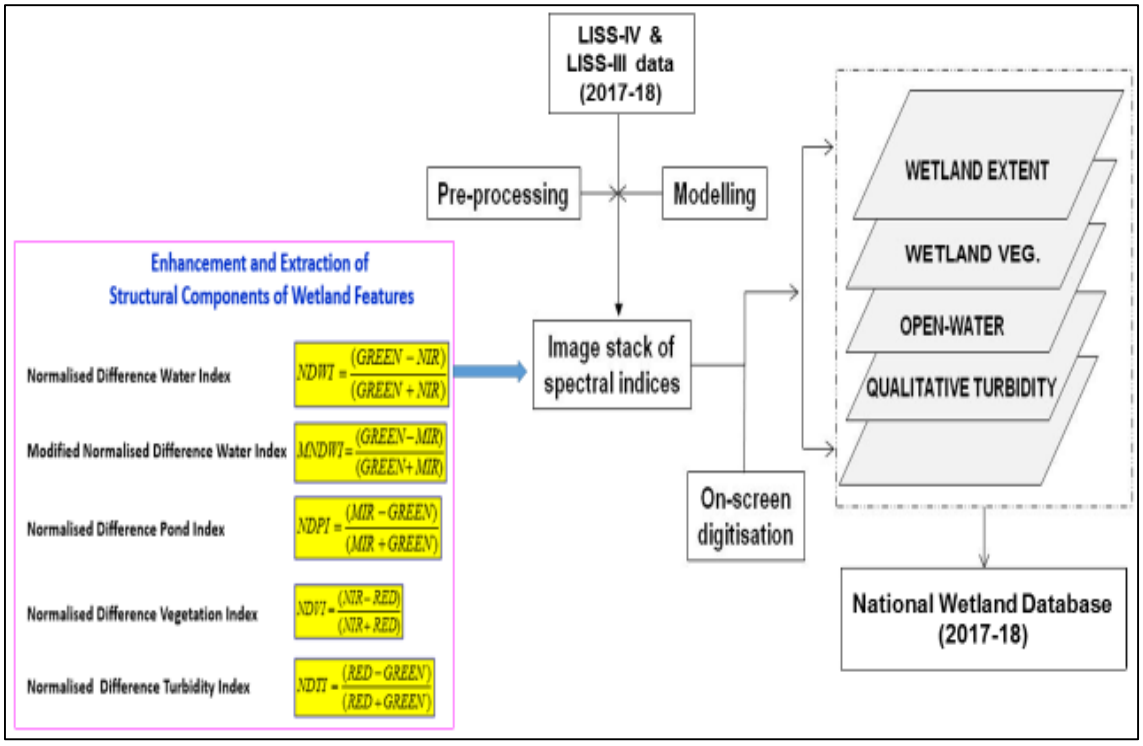


Figure 1: Steps in the extraction of wetland components

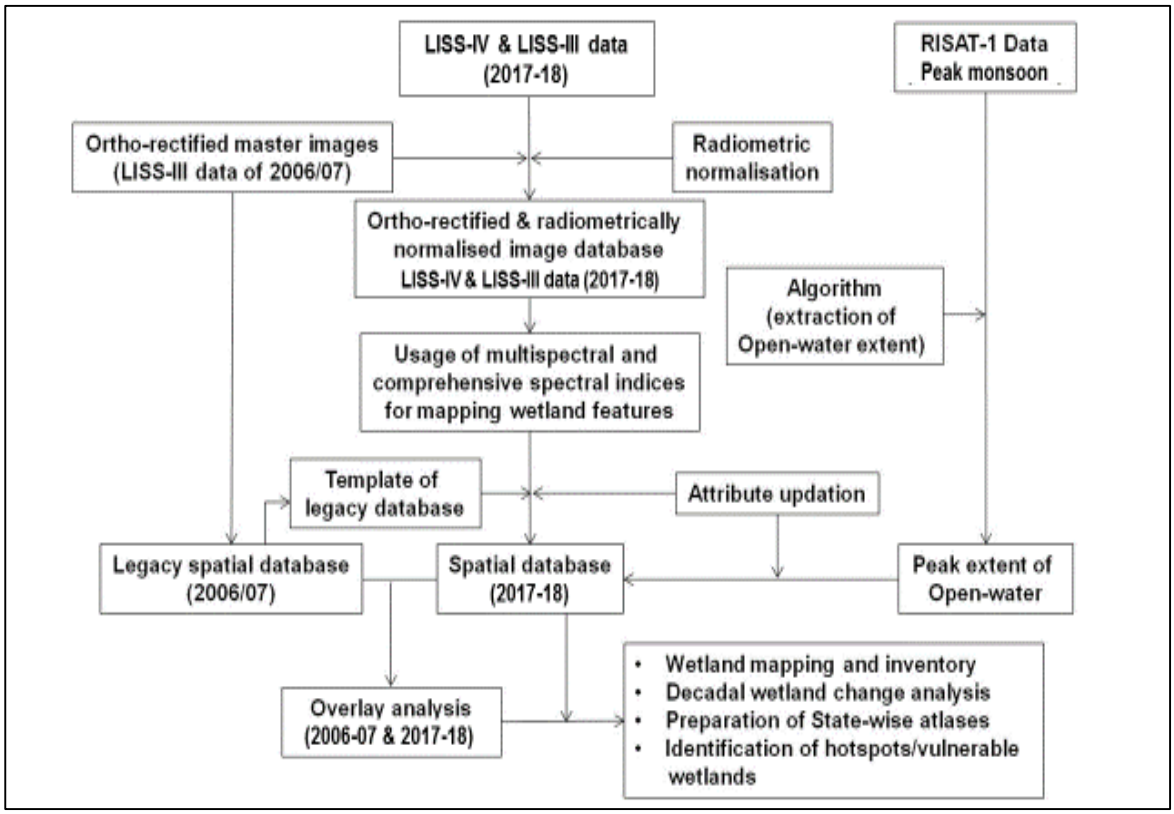


Fig. 2: Schematic showing spatial wetland mapping/inventory and change analysis

### 4.2 Wetland Inventory on 1:25,000 scale

Inventory of wetlands on 1:25 000 scale will involve analysis of Resourcesat LISS-IV post-monsoon and pre-monsoon) data of 2017/18. Salient features of overall methodology to be adopted are as under:

- Wetland inventory and assessment of the state using satellite data. Inventory/mapping as per technical guidelines and database standards.
- Ground truth data collection. This includes field data collection for all the major wetlands as per data collections proforma provided in manual.
- Creation/procurement of base layers (rail, road network, settlements (including names), drainage, administrative boundaries) in digital format
- State level seamless geodatabase of wetlands and base layers.
- Map composition at map sheet, taluka, district and state level using standard templates.
- State level report

***Satellite Data Analysis***

Wetland maps (7.5' X 7.5') on 1: 25 000 scale will be prepared using Resourcesat LISS IV satellite data. Mapping will be done for entire state. Latest LISS IV digital data (2017-18) will be analysed for delineation of boundary of wetlands, assessing water spread during post-monsoon and pre-monsoon seasons, assigning qualitative turbidity levels and distribution of vegetation (in wetlands). Besides satellite data, NWIA-I database, SOI topographical maps, ground truth information along with collateral data will also be used while delineating wetland categories.

***Ground Truth Data Collection***

Ground truth data will be collected for geotagged GT database and also accuracy assessment. Representative wetlands of all types shall be visited for field data collection (minimum 10% of the total specific types, as per the proforma of GT collection). Information on structural components/ hydrological parameters will also be collected during field data collection. For urban areas all the wetlands having area > 2 ha will be visited for field data collection.

***Outputs***

As mentioned earlier, wetland database including base layers will be organised as per Technical Guidelines. This will lay foundation for periodic monitoring of wetlands. Subsequently, a seamless digital database on 1: 25,000 scale wetland inventory at state level will be generated. Information system module will be developed under VEDAS portal at SAC for facilitating data retrieval at the desired level. Outputs will be in the form of digital database, digital maps, atlases and information system.

***Quality Checking and Accuracy Assessment***

Quality checking will be in two stages i.e. stage 1 – internal QC and stage 2 – external QC. External QC team shall be inter-centre. Desired accuracy standards are provided in the technical guideline document provided by SAC. Accuracy assessment involves determination of thematic (classification) as well as locational accuracy. In addition GIS database(s) contents will also be evaluated for accuracy. Thematic, locational and database accuracy tags will be attached as per the requirement.

## 5. DELIVERABLES

- Geodatabase of State Wetland Inventory and Assessment on 1:50000 scale
- Geodatabase of State Wetland Inventory and Assessment on 1:25000 scale
- Groundtruth database as per proforma.
- Digital maps at various levels (district/ state/ map sheet level) in geo-pdf format.
- State wetland report and atlas.

## 6. WORK QUANTUM

A total of 637 maps of 7.5" x 7.5" grids on 1:25000 scale cover the state. Out of these ~ 20 % grids have partial coverage. So work of about 540 full size grids has been considered for budget and other resources requirement purpose. SAC will provide all the satellite data, legacy databases required for project work. Following layers will be required for preparation of wetland maps and generation of database.

- Wetland boundary
- Pre-monsoon water spread
- Post-monsoon water spread
- Aquatic Vegetation during post-monsoon
- Aquatic Vegetation suring Pre-Monsoon
- Turbidity - post-monsoon
- Turbidity - Pre-Monsoon
- Wetlands/waterbody (< 0.5 ha)
- Transportation network – Road
- Transportation network - Raiway
- Drainage
- Canal
- Settlements

Layer-wise standards and other details **are given in "National Wetland Inventory and Assessment on 1:25,000 scale – Technical Guidelines and Procedure Manual".**

## 7. BUDGET

To carry out NWIA-II-Bihar work total funds earmarked are Rs. 2050000. Details are given below.

| | | Bihar | | |
|---|---|---|---|---|
| **Sl. No** | **Budget Head** | **Ist Year (in Rs)** | **IInd Year (in Rs)** | **Total (in Rs)** |
| 1 | Satellite, legacy and other collateral data (To be provided by SAC) | - | - | - |
| 2 | Salary of Manpowers | 600000 | 600000 | 1200000 |
| 3 | Travel, Ground Truth (Field) data collection and Quality Check | 281000 | 281000 | 562000 |
| 4 | Contingency | 50000 | 50000 | 100000 |
| 5 | Overhead (~10%) | 94000 | 94000 | 188000 |
| | **Total** | 1025000 | 1025000 | 2050000 |

** Money under 'Services' can be utilised for Project Staff.

1. Ortho-rectified satellite data will be provided by SAC.
1. Any publication resulting out of this work will be brought jointly by SAC and RRSC-E.

## 8. DURATION: 24 months

## 9. FUNCTIONARIES AND CONTACT ADDRESS, PHONE, EMAIL, ETC

### 9.1. RRSC -East, NRSC

| Sl. No. | Name | Contact Address | Phone | Email |
|---|---|---|---|---|
| 1. | Shri Y.K. Srivastava | Sci/Eng. SF, RRSC-East, NRSC/ISRO, Dept. of Space, Govt. of India, Kolkata - 700156 | 033-23410021 | srivastava_yk@nrsc.gov.in |
| 2. | Dr. S. Bandyopadhyay | Head(Applications), RRSC- East, NRSC/ISRO, Dept. of Space, Govt. of India, Kolkata - 700156 | 033-23410001 | bandyo_s@nrsc.gov.in |

### 9.2. Partner Institute

| Sl. No | Name | Contact Address | Phone | Email |
|---|---|---|---|---|
| 1. | Dr. C. Jeganathan<br>Professor | Department of Remote Sensing, Birla Institute of Technology, Mesra, Ranchi, Jharkhand | 8979630041<br>7763859236 | jeganthanc@bitmesra.ac.in |
| 2. | Dr A. P Krishna<br>Professor | Department of Remote Sensing, Birla Institute of Technology, Mesra, Ranchi, Jharkhand | 9431100447 | apkrishna@bitmesra.ac.in |
| 3. | Dr. V. S. Rathore<br>Assistant Professor | Department of Remote Sensing, Birla Institute of Technology, Mesra, Ranchi, Jharkhand | 9431382641 | vsrathore@bitmesra.ac.in |
| 4. | Mr. Nitish Kumar Sinha<br>System Analyst | Department of Remote Sensing, Birla Institute of Technology, Mesra, Ranchi, Jharkhand | 9470368588<br>9955002266 | nitish@bitmesra.ac.in |

**10. SCHEDULE:** Project is to be completed as per the schedules given below

| Sl. No | Activity | Responsibility | Period | |
|---|---|---|---|---|
| | | | Start | End |
| 1 | Preparatory work | BIT | Aug 19 | Aug 19 |
| | **1:50,000 scale work using LISS-III data** | | | |
| 2 | Wetland database updation using LISS-III data of 2017-18 with respect to 2006-07 database | BIT | Sept 19 | Dec 19 |
| 3 | Quality Check | SAC, RRSC-East & BIT | Dec 19 | Jan 20 |
| 4 | Change Analysis report and database | SAC, RRSC-East & BIT | Feb 20 | Mar 20 |
| | **1:25,000 scale work using LISS-IV data** | | | |
| 5 | Analysis of satellite data/ Wetland Inventory | BIT | Dec 19 | July 20 |
| 6 | Field Verification/GT | BIT | Jan 20 | Mar 20 |
| 7 | Creation and Organisation of GIS database | BIT | Dec 19 | July 20 |
| 8 | Quality Check | SAC, RRSC-East & BIT | Aug 20 | Aug 20 |
| 9 | Final geodatabase of wetlands and other themes | BIT | Sept 20 | Jan 21 |
| 10 | Preparation/finalisation of statistics, maps and atlas | BIT | Jan 21 | May 21 |
| 11 | Report/Atlas | SAC, RRSC-East & BIT | May 21 | July 21 |

**11. References**


- Garg J.K. and Patel J. G., 2007. National Wetland Inventory and Assessment, Technical Guidelines and Procedure Manual, Technical Report, SAC/EOAM/AFEG/NWIA/TR/01/2007, June 2007, Space Applications Centre, Ahmedabad.
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- Panigrahy, S., T. V. R. Murthy, J. G. Patel and T. S. Singh, 2012. Wetlands of India: inventory and assessment at 1: 50,000 scale using geospatial techniques. Current Science, Vol. 102, No. 6, 25.
- National Wetland Atlas : India, SAC/EPSA/ABHG/NWIA/ATLAS/34/2011, Space Applications Centre, ISRO, Ahmedabad


**Signatures**

**Project Coordinator,**
**(NWIA-Phase-II, SAC)**

**Principal Investigator,**
**(BIT, Mesra)**

**Principal Investigator,**
**(SARITA, Programme)**

**Registrar,**
**(BIT, Mesra)**

Birla Institute of Technology
Mesra, Ranchi

**Deputy Director, EPSA,**
**(SAC)**

डॉ. राज कुमार / Dr. Raj Kumar
उप निदेशक / Dy. Director
ईपीएसए / EPSA

**Principal Investigator**
**(RRSC-East)**