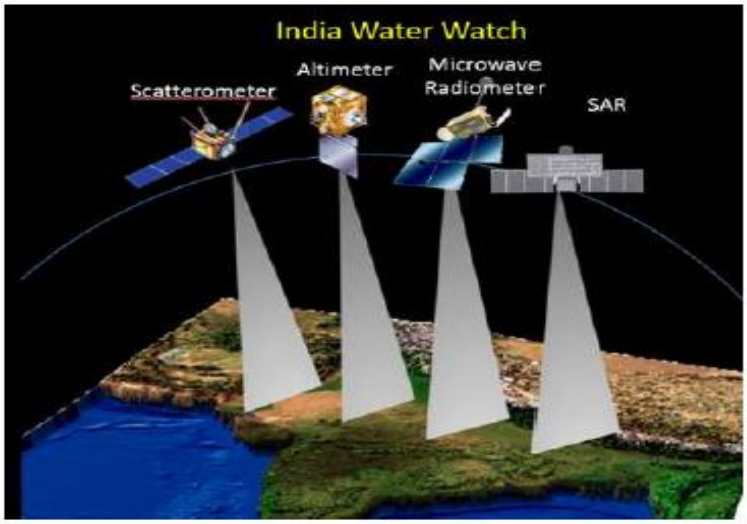
National Wetland Inventory and Assessment (NWIA) Phase-II
(under SARITA programme)

WORK PLAN – Jammu & Kashmir



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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 Jammu & Kashmir 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 Jammu & Kashmir 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.

- Hydro-ecological pilot level study for Wular Lake.

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.

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.

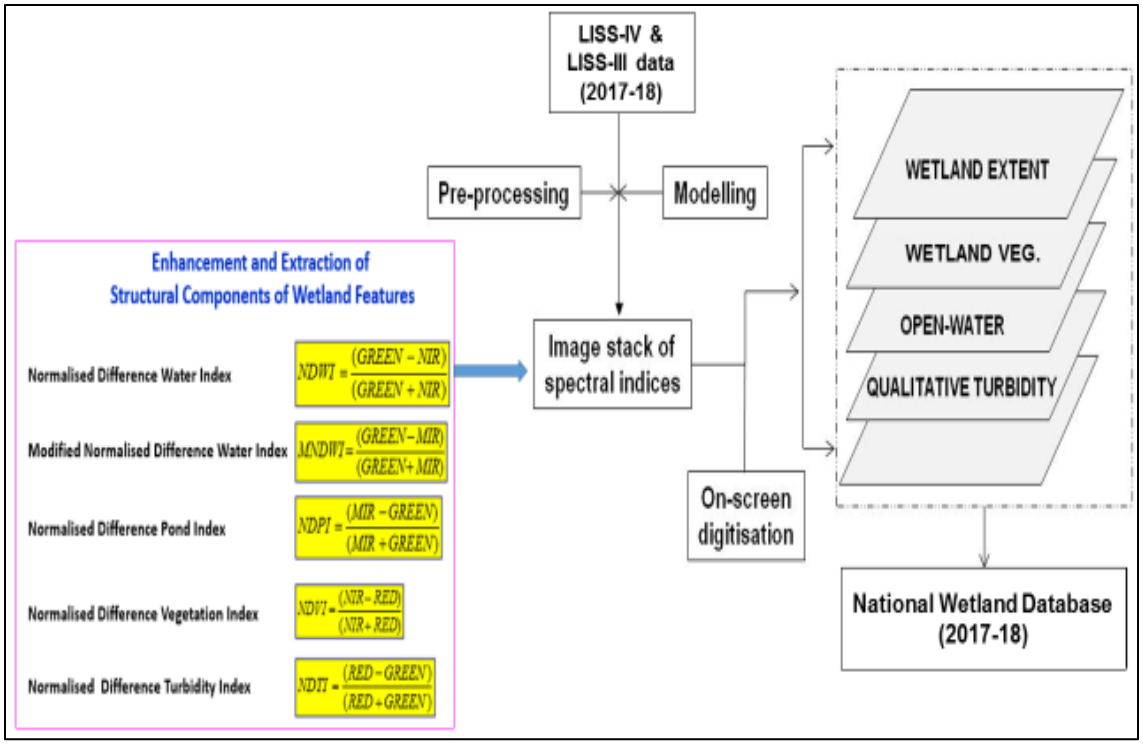

Figure 1: Steps in the extraction of wetland components

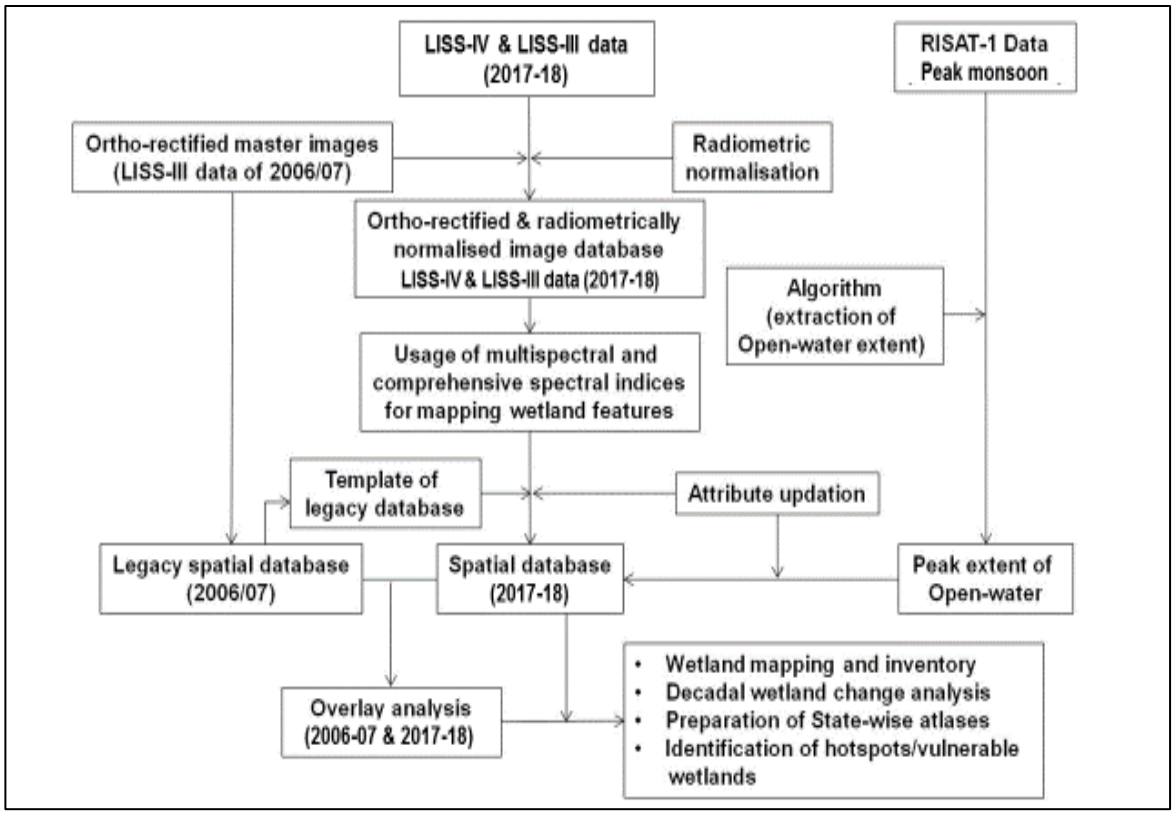

Fig. 2: Schematic showing spatial wetland mapping/inventory and change analysis

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 1:50 000 scale
- Geodatabase of State Wetland Inventory and Assessment on 1:25 000 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 1537 maps of 7.5" x 7.5" grids on 1:25 000 scale cover the state. Out of these ~ 20 % grids have partial coverage. So work of about 1350 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-Jammu & Kashmir work total funds earmarked are Rs. 2599000. Details are given below.

Budgetary Details

Sl. No	Budget Head	Ist Year (in Rs)	IInd Year (in Rs)	Total (in Rs)
1.	Satellite data (To be provided by SAC)	-	-	-
2.	Services (Salary of manpower : 2 nos., data analysis, other services)	780000	780000	1560000
3	Material	100000	100000	200000
4.	Travel and Ground Truth data collection	200000	200000	400000
5.	Contingency	50000	50000	100000
6.	Institutional overhead charges @ 15%	169500	169500	339000
	Total	**1299500**	**1299500**	**2599000**

** 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 University of Jammu.

8. DURATION: 24 months

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

Schedule/milestones – Jammu & Kashmir

Sl. No	Activity	Responsibility	Period	
			Start	End
1	Preparatory work	CA*	Feb 19	Feb 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	CA	Feb 19	June 19
3	Quality Check	SAC and CA	June 19	July 19
4	Change Analysis report and database	SAC and CA	Jul 19	Sep 19
	1:25,000 scale work using LISS-IV data			
5	Analysis of satellite data/ Wetland Inventory	CA	Oct 19	Apr 20
6	Field Verification/GT	CA	Nov 19	Jan 20
7	Creation and Organisation of GIS database	CA	Oct 19	Apr 20
8	Quality Check	SAC and CA	Nov 19 May 20	Nov 19 May 20
9	Final geodatabase of wetlands and other themes	CA	Jun 20	Oct 20
10	Preparation/finalisation of statistics, maps and atlas	CA	Oct 20	Jan 21
11	Report/Atlas	SAC and CA	Jan 21	Mar 21
	Hydro-ecological pilot study			
12	Remote Sensing & GIS data analysis	CA + SAC	June 19	May 20
13	Field data collection	CA + SAC	Aug 19 May 20	Aug 19 May 20
14	Modeling and analysis	CA + SAC	June 19	Dec 20
15	Salient findings and report	CA + SAC	Jan 21	March 21

* CA – Collaborating Agency

10. 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.

- Garg, J.K., Singh, T.S. and Murthy, T.V.R. (1998). Wetlands of India. Project Report: RSAM/SAC/RESA/PR/01/98, June 1998, 240 p. Space Applications Centre, Ahmedabad.
- 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	
19/02/19 **Project Coordinator,** **(NWIA-Phase-II, SAC)** डॉ. प्रवीण कुमार / Dr. Praveen Kumar प्रधान, एचटीडीडी/ एएमएचटीडी/ ईपीएसए Head, HTDD/AMHTD/EPSA अंतरिक्ष उपयोग केंद्र (इसरो) Space Applications Centre (ISRO) भारत सरकार / Government of India अहमदाबाद/Ahmedabad-380015	5/2/19 **Dr. Avtar Singh Jasrotia** **Principal Investigator** Prof. & Head Deptt. of Remote Sensing & GIS University of Jammu, Jammu
19/02/19 **Principal Investigator,** **(SARI.TAV Programme/SAC)** डॉ. आर.पी. सिंह / Dr. R.P. Singh प्रधान, एलएचडी/जीएचसीएजी/ईपीएसए Head LHD/GHCAG/EPSA अंतरिक्ष उपयोग केंद्र Space Applications Centre (ISRO) भारत सरकार / Government of India अहमदाबाद/Ahmedabad-380015	**Registrar,** **University of Jammu. Jammu (J&K)** REGISTRAR University of Jammu (A.M.)
Deputy Director, EPSA, **(SAC, Ahmedabad)** डॉ. राज कुमार / Dr. Raj Kumar उप निदेशक / Dy. Director ईपीएसए / EPSA	

Project Report

National Wetland Inventory and Assessment (NWIA) Phase-II (under SARITA programme), Space Application Centre (ISRO), Ahmedabad

Important aspects & progress made so far: On a scale of 1:50000, total 256 Lakes/Ponds (Natural), 555 High Altitude Wetlands, 8 Waterlogged Wetlands, 4 Reservoirs/ Barrages and 164 Tanks/Ponds (man-made) were monitored using LISS III datasets, having total area 540040.79 ha during the year 2017-18 for Jammu & Kashmir Himalayan region. On the other hand, in 2006-07 total 273 Lakes/Ponds (Natural), 549 High Altitude Wetlands, 15 waterlogged wetlands, 3 Reservoirs/ Barrages and 91 Tanks/Ponds (man-made) were monitored covering total area of 519483.59 ha. Total increase in area was found to be 20557.20 ha during 2017-18 as compared to 2006-07. 31 polygons and 104 points of wetlands disappeared in 2017-18 having area of 255.18 ha and 104 ha, respectively. 25 new polygons and 122 new points of wetlands were found to be in 2017-18 having area of 136.13 ha and 122 ha, respectively.

Total area of natural inland wetlands in 2017-18 was found to be 517891.23 ha, whereas in 2006-07 were found to be 497437.85 ha. On the other hand, area of man-made inland wetlands in 2017-18 was found to be 22148.51 ha, whereas in 2006-07 were found to be 22045.74 ha.

The same work has been executed on a scale of 1:25000 using LISS IV datasets.

R&D work done: Project completed and submitted successfully. The information was generated in the above said project are available in the Jammu University portal
Geoportal: https://www.jammuuniversity.ac.in/node/2285

DEPARTMENT OF REMOTE SENSING AND GIS
UNIVERSITY OF JAMMU

PROF. A. S. JASROTIA
Head

No: PGD/RS&GIS/22/ 5237
Dated: 30. 08. 2022

UNIVERSITY OF JAMMU
STATEMENT OF EXPENDITURE

Statement of expenditure incurred in connection with the research project entitled "**National Wetland Inventory and Assessment (NWIA) Phase-II (under SARITA programme)**" sanctioned by the SAC in favour of **Prof. A.S. Jasrotia, Department of Remote Sensing and GIS, University of Jammu, Jammu** w.e.f. November, 2021 to March, 2022.

Head	Unspent balance B/F from FY 2021	Grant received for FY 2021-22	Total grant available for FY 2021-22	Expenditure incurred during FY 2021-22	Balance	Grant required for FY 2022-23
Satellite data	-					
Services (Salary of Manpower)	665	3,62,215	3,62,880	3,62,880	Nil	
Material	Nil	-	-	-	-	
Travel and Ground Truth Data collection	58,821	-	58,821	58,821	Nil	
Contingency	14,000	62,785	76,785	76,785	Nil	
Overheads	Nil	75,000	75,000	75,000	Nil	
Total	73,486	5,00,000	5,73,486	5,73,486	Nil	

Principal Investigator
(Dr. A.S. Jasrotia)
Prof. & Head
Deptt. of Remote Sensing & GIS
University of Jammu
Jammu

Joint Registrar (Finance)
University of Jammu
Joint Registrar
University of Jammu

Registrar
University of Jammu
Registrar
University of Jammu

DEPARTMENT OF REMOTE SENSING AND GIS
UNIVERSITY OF JAMMU

PROF. A. S. JASROTIA
Head

No: PGD/RS&GIS/22/ 5236
Dated: 30.08.2022

EXPENDITURE REPORT

Project: **National Wetland Inventory and Assessment (NWIA) Phase-II (under SARITA programme),**

Name of Participating Agency: **Space Application Centre (SAC), ISRO, Ahmedabad and Department of Remote Sensing and GIS, University of Jammu, Jammu**

Expenditure report for the period: November, 2021 to March, 2022

Certified that an amount of Rs. 5,00,000 received from SAC for the work connected with the **"National Wetland Inventory and Assessment (NWIA) Phase-II (under SARITA programme),** project to Department of Remote Sensing and GIS, University of Jammu, Jammu has been spent for the purpose for which it was sanctioned as under:

S.No.	Expenditure head	Amount (Rs.)
1.	Expenditure upto beginning of the quarter	5,50,255
2.	Expenditure during the quarter (Nov., 2021 to Mar., 2022)	
	Satellite data	-
	Services (Salary of Manpower)	3,62,880
	Material	-
	Travel and Ground Truth Data collection	58,821
	Contingency	76,785
	Overheads	75,000
	Total Expenditure	5,73,486
3.	Opening balance as at beginning of the quarter (November 2021)	73,486
4.	Expenditure during the quarter (Nov., 2021 to Mar., 2022)	5,73,486
5.	New balance	Nil

The expenditure as above has been incurred as per rules and procedures of **University of Jammu** and has been properly accounted for in the books of accounts. The relevant records are retained in this organization and are audited/subject to audit by our auditors.

Principal Investigator
(Dr. A.S Jasrotia)
Prof. & Head
Deptt. of Remote Sensing & GIS
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