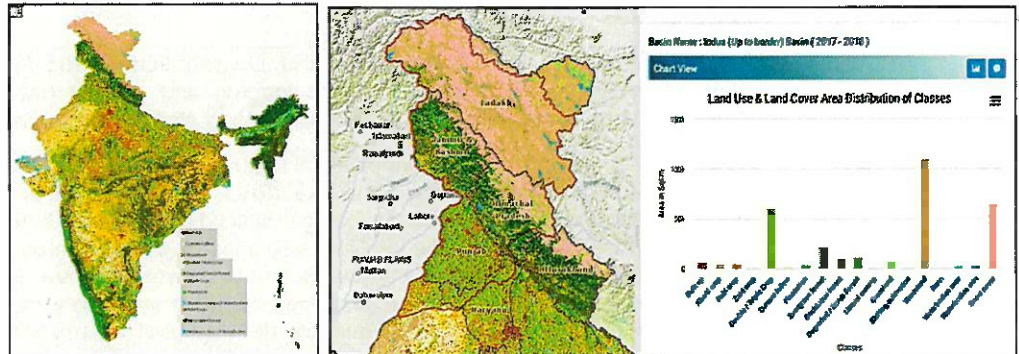


Business Specific Requirements	
Theme	Master Information System
Application	WRIS-Land Resources
Use Case	Land Use – Land Cover
Use Case ID	WRIS-MIS-07
Other linked Use Case	Forest/Tree Cover (WRIS-MIS-05), Land Degradation (WRIS-MIS-06), Wasteland Study (09), Wetland Inventory (WM-UC-01), Water logging and salinity (IM-UC-11), Crop Yield Estimation (CWM-UC-11), Land resources-allied themes and also usefull as important model parameter
Description	Land Cover is defined as observed physical features on the Earth's Surface. When an economic function is added to it, it becomes Land Use. (FAO, 2005) Land use is a very human-centric term. This is mainly the focus on the activity that is being practiced on a piece of land. Changes in LULC do not always have to be driven by humans; the land can also undergo changes through the forces of nature. Therefore, it is necessary to timely monitor the changes in land use/land cover pattern for a particular area or the whole. The detection of such changes gives planners and policy makers answers to some important questions which is essential for sustainable development. Information on land use/land cover and the changes over a period of time attain prominence because of its primary requirement in all the planning activities.
Used by	Planners, Decision makers, administrators, academicians, farmers, and the public in general
Priority	<p>High Priority: Land use serves as base for many applications and also as a model parameter required in many thematic studies. Land use land cover mapping addressing Kharif, Rabi and Zaid crops, greening of wastelands, seasonality of wastelands, surface water bodies, forest vegetation and other high temporal land use practices using satellite remote sensing data can provide a reliable database.</p> <p>The LULC maps and database should be used at broad level for the following purposes:</p> <ul style="list-style-type: none"> • Scientific research involving carbon cycle, hydrologic cycle, energy budget studies, weather/climate prediction; • Siting of industries, SEZs etc.; • Land improvement programmes; • Watershed management; • Coastal zone management; • Water resource management • Agricultural productivity improvement etc.
Phase	Phase-1 Subsumed
Business Problem	<p>Issue: Land resource related queries such as, what type of land is more severely under threat, where do forests need protection, which direction is an urban Centre growing, and is that posing any dangers to the natural environment, how is the changing land use affecting the atmosphere and nearby water resources, where do we have the best opportunity to exploit land as a natural resource, and so on are always asked and requires timely updated spatial database to answer and assess the situation.</p> <p>Approach: NRSC Land use division finalised a threefold classification system and adopted the same for Nationwide LULC analysis at various scale mapped every year. NWIC receives classified outputs on both 50k & 250K scale. To generate LULC using High resolution satellite data and Google earth engine, NRSC classification system can be adopted followed with intense ground checks. Both raster and vector based mapping approach is considered to get most out of optical and microwave imageries.</p>
Output	Land use land cover on desired scale/resolution
Outcome	LULC classified data on 50k (vector) & 250K (raster) scale. Temporal changes of LULC over Indian administrative and hydrological regions with maps, chart/graph and statistics and also based upon user specific query. Updated LULC information from various agencies within single frame

Visualization

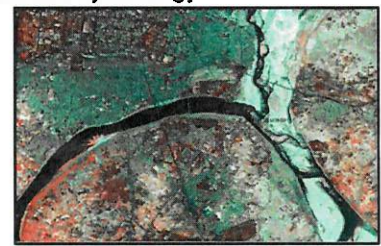
- Map** – LULC map at country to State/district/Basin/Sub-Basin level from IRS LISS-III (23.5m) data on 1:50K scale and from IRS P6 AVHRS (56m) data on 1:250K scale (NRSC)



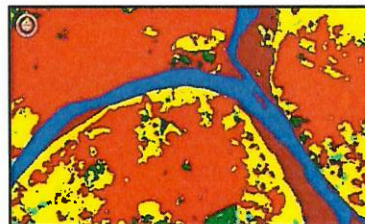
High Resolution LULC Map: LULC data can also be prepared for the area of interest using high resolution satellite images (*IRS-L4, RISAT SAR, Sentinel-2 etc.*) with required ground checks and disseminated with finer details and standard symbology



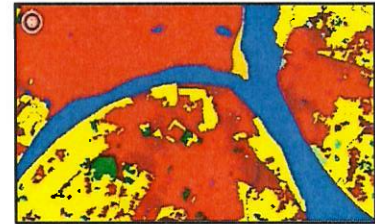
ERS Copernicus Sentinel-2 Image (10m)



IRS R2 LISS-IV Image (5.8m)



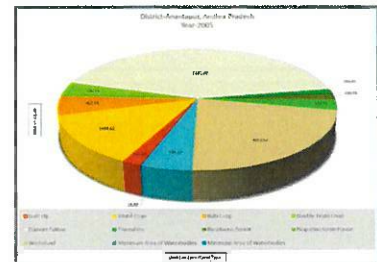
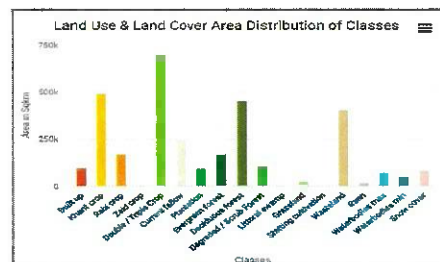
Sentinal-2 Image(10m) Classified LULC

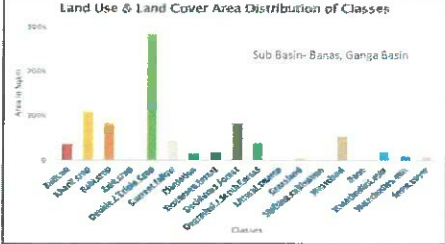
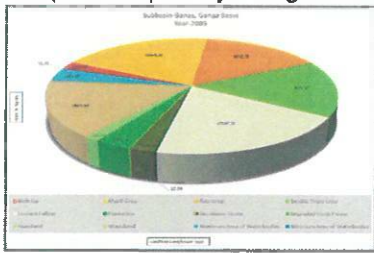
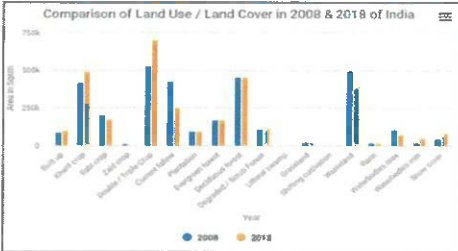


LISS-IV Image (5.8m) Classified LULC

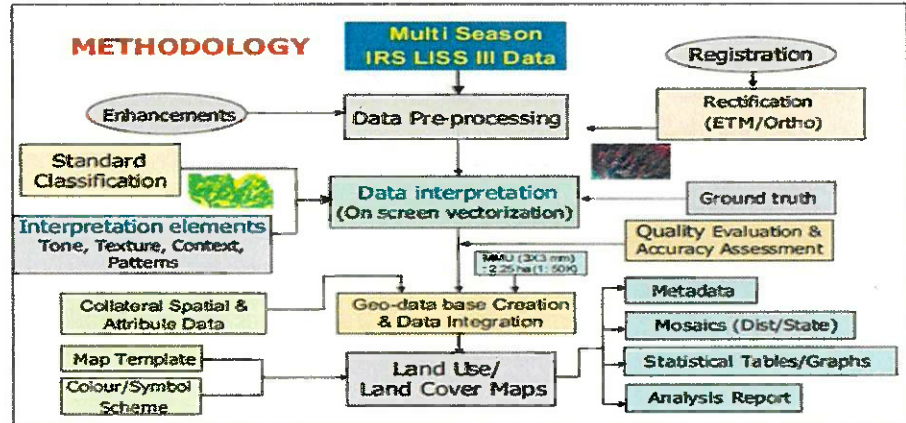
- Graph / Charts:** Various Pie/Bar charts can be drawn based upon administrative/hydrological setup indicating Land use land cover classes

(a) Class wise distribution of Land use land cover area (Based upon administrative setup)



	<p>(b) Class wise distribution of Land use land cover area (Based upon Hydrological setup)</p> <div><div><p>Land Use & Land Cover Area Distribution of Classes</p></div><div><p>Sub-Basin- Banas, Ganga Basin</p></div></div> <p>(c) Comparison between two consecutive year or decadal LULC cycle</p> <div><div><p>Comparison of Land Use / Land Cover in 2008 & 2018 of India</p></div><div><table><tr><th>LULC Classes</th><th>Area in Sqkm of 2008</th><th>Area in Sqkm of 2018</th></tr><tr><td>Built up</td><td>84456.46</td><td>93673.04</td></tr><tr><td>Kharif crop</td><td>414913.80</td><td>489509.39</td></tr><tr><td>Rabi crop</td><td>200062.63</td><td>169900.77</td></tr><tr><td>Zaid crop</td><td>7988.24</td><td>5594.08</td></tr><tr><td>Double / Triple Crop</td><td>529998.03</td><td>696009.69</td></tr></table></div></div> <p>3. Output in tabular format: – State/District-wise, Basin/Sub Basin wise Land use land cover status can be provided in the form of table and as per the time selection (yearly). Comparison between two LULC cycle can also be provided to assess positive and negative changes over the period of time.</p> <div><table><tr><th>S.No</th><th>Classes</th><th>Area Sq. Km</th></tr><tr><td>1</td><td>Built up</td><td>6472.468</td></tr><tr><td>2</td><td>Kharif crop</td><td>5102.306</td></tr><tr><td>3</td><td>Rabi crop</td><td>5007.584</td></tr><tr><td>4</td><td>Zaid crop</td><td>366.658</td></tr><tr><td>5</td><td>Double / Triple Crop</td><td>60826.903</td></tr><tr><td>6</td><td>Current fallow</td><td>3035.140</td></tr><tr><td>7</td><td>Plantation</td><td>3396.768</td></tr><tr><td>8</td><td>Evergreen forest</td><td>21522.462</td></tr><tr><td>9</td><td>Deciduous forest</td><td>9845.986</td></tr><tr><td>10</td><td>Degraded / Scrub Forest</td><td>11150.989</td></tr><tr><td>11</td><td>Grassland</td><td>6671.953</td></tr><tr><td>12</td><td>Wasteland</td><td>109916.107</td></tr><tr><td>13</td><td>Waterbodies</td><td>5204.985</td></tr><tr><td>14</td><td>Snow cover</td><td>65419.638</td></tr></table><table><tr><th>S.No</th><th>Category</th><th>2007-2008</th><th>2017-2018</th><th>Change</th><th>Percent</th></tr><tr><td>1</td><td>Built up</td><td>4732.268</td><td>6472.468</td><td>1745.200</td><td>36.88</td></tr><tr><td>2</td><td>Kharif crop</td><td>4608.048</td><td>5102.306</td><td>494.259</td><td>10.73</td></tr><tr><td>3</td><td>Rabi crop</td><td>3433.095</td><td>5007.584</td><td>1574.488</td><td>45.86</td></tr><tr><td>4</td><td>Zaid crop</td><td>87.385</td><td>366.658</td><td>279.273</td><td>319.59</td></tr><tr><td>5</td><td>Double / Triple Crop</td><td>57496.634</td><td>60826.903</td><td>3330.269</td><td>5.79</td></tr><tr><td>6</td><td>Current fallow</td><td>8041.278</td><td>3035.140</td><td>-5006.138</td><td>-62.26</td></tr><tr><td>7</td><td>Plantation</td><td>3381.336</td><td>3396.768</td><td>15.432</td><td>0.46</td></tr><tr><td>8</td><td>Evergreen forest</td><td>21518.962</td><td>21522.462</td><td>3.500</td><td>0.02</td></tr><tr><td>9</td><td>Deciduous forest</td><td>9853.639</td><td>9845.986</td><td>-7.652</td><td>-0.08</td></tr><tr><td>10</td><td>Degraded / Scrub Forest</td><td>11150.274</td><td>11150.989</td><td>0.715</td><td>0.01</td></tr><tr><td>11</td><td>Wetland/swamp</td><td>0.003</td><td>0.003</td><td>0.000</td><td>0.00</td></tr><tr><td>12</td><td>Grassland</td><td>6214.436</td><td>6671.953</td><td>457.517</td><td>7.36</td></tr><tr><td>13</td><td>Wasteland</td><td>152529.947</td><td>109916.107</td><td>-42613.840</td><td>-27.94</td></tr><tr><td>14</td><td>Waterbodies</td><td>5200.209</td><td>5204.985</td><td>4.776</td><td>0.09</td></tr><tr><td>15</td><td>Snow cover</td><td>25712.848</td><td>65419.638</td><td>39706.790</td><td>154.42</td></tr></table></div> <p>4. Predefined Text Report: The report may be generated at various level such as country/ state/district/basin/sub basin. If the user is interested in one region, then the detailed LULC information and temporal change (year) may be provided with graph/charts and relevant statistics. Comparative analysis for changes may be included with facts and ground references in the report.</p>	LULC Classes	Area in Sqkm of 2008	Area in Sqkm of 2018	Built up	84456.46	93673.04	Kharif crop	414913.80	489509.39	Rabi crop	200062.63	169900.77	Zaid crop	7988.24	5594.08	Double / Triple Crop	529998.03	696009.69	S.No	Classes	Area Sq. Km	1	Built up	6472.468	2	Kharif crop	5102.306	3	Rabi crop	5007.584	4	Zaid crop	366.658	5	Double / Triple Crop	60826.903	6	Current fallow	3035.140	7	Plantation	3396.768	8	Evergreen forest	21522.462	9	Deciduous forest	9845.986	10	Degraded / Scrub Forest	11150.989	11	Grassland	6671.953	12	Wasteland	109916.107	13	Waterbodies	5204.985	14	Snow cover	65419.638	S.No	Category	2007-2008	2017-2018	Change	Percent	1	Built up	4732.268	6472.468	1745.200	36.88	2	Kharif crop	4608.048	5102.306	494.259	10.73	3	Rabi crop	3433.095	5007.584	1574.488	45.86	4	Zaid crop	87.385	366.658	279.273	319.59	5	Double / Triple Crop	57496.634	60826.903	3330.269	5.79	6	Current fallow	8041.278	3035.140	-5006.138	-62.26	7	Plantation	3381.336	3396.768	15.432	0.46	8	Evergreen forest	21518.962	21522.462	3.500	0.02	9	Deciduous forest	9853.639	9845.986	-7.652	-0.08	10	Degraded / Scrub Forest	11150.274	11150.989	0.715	0.01	11	Wetland/swamp	0.003	0.003	0.000	0.00	12	Grassland	6214.436	6671.953	457.517	7.36	13	Wasteland	152529.947	109916.107	-42613.840	-27.94	14	Waterbodies	5200.209	5204.985	4.776	0.09	15	Snow cover	25712.848	65419.638	39706.790	154.42
LULC Classes	Area in Sqkm of 2008	Area in Sqkm of 2018																																																																																																																																																														
Built up	84456.46	93673.04																																																																																																																																																														
Kharif crop	414913.80	489509.39																																																																																																																																																														
Rabi crop	200062.63	169900.77																																																																																																																																																														
Zaid crop	7988.24	5594.08																																																																																																																																																														
Double / Triple Crop	529998.03	696009.69																																																																																																																																																														
S.No	Classes	Area Sq. Km																																																																																																																																																														
1	Built up	6472.468																																																																																																																																																														
2	Kharif crop	5102.306																																																																																																																																																														
3	Rabi crop	5007.584																																																																																																																																																														
4	Zaid crop	366.658																																																																																																																																																														
5	Double / Triple Crop	60826.903																																																																																																																																																														
6	Current fallow	3035.140																																																																																																																																																														
7	Plantation	3396.768																																																																																																																																																														
8	Evergreen forest	21522.462																																																																																																																																																														
9	Deciduous forest	9845.986																																																																																																																																																														
10	Degraded / Scrub Forest	11150.989																																																																																																																																																														
11	Grassland	6671.953																																																																																																																																																														
12	Wasteland	109916.107																																																																																																																																																														
13	Waterbodies	5204.985																																																																																																																																																														
14	Snow cover	65419.638																																																																																																																																																														
S.No	Category	2007-2008	2017-2018	Change	Percent																																																																																																																																																											
1	Built up	4732.268	6472.468	1745.200	36.88																																																																																																																																																											
2	Kharif crop	4608.048	5102.306	494.259	10.73																																																																																																																																																											
3	Rabi crop	3433.095	5007.584	1574.488	45.86																																																																																																																																																											
4	Zaid crop	87.385	366.658	279.273	319.59																																																																																																																																																											
5	Double / Triple Crop	57496.634	60826.903	3330.269	5.79																																																																																																																																																											
6	Current fallow	8041.278	3035.140	-5006.138	-62.26																																																																																																																																																											
7	Plantation	3381.336	3396.768	15.432	0.46																																																																																																																																																											
8	Evergreen forest	21518.962	21522.462	3.500	0.02																																																																																																																																																											
9	Deciduous forest	9853.639	9845.986	-7.652	-0.08																																																																																																																																																											
10	Degraded / Scrub Forest	11150.274	11150.989	0.715	0.01																																																																																																																																																											
11	Wetland/swamp	0.003	0.003	0.000	0.00																																																																																																																																																											
12	Grassland	6214.436	6671.953	457.517	7.36																																																																																																																																																											
13	Wasteland	152529.947	109916.107	-42613.840	-27.94																																																																																																																																																											
14	Waterbodies	5200.209	5204.985	4.776	0.09																																																																																																																																																											
15	Snow cover	25712.848	65419.638	39706.790	154.42																																																																																																																																																											
Frequency	Once in five years, updated as provided by concerned mapping agency (NRSC)																																																																																																																																																															
Measures of Success (KPIs)	To generate spatial and change database on land use/land cover. Major change areas will be specifically identified. This will enable planners and administrators to initiate the appropriate measure for preventing / arresting the degradation and development of natural resources.																																																																																																																																																															
Input Data Required	Various medium to high resolution satellite sensor images, legacy data and SOI toposheets																																																																																																																																																															
	<p>Geospatial Time Series Data:</p> <ul style="list-style-type: none">•Frequency: Yearly<ol style="list-style-type: none">1. Monsoon Season – Kharif: August - October2. Post-Monsoon – Rabi: December - March3. Pre-Monsoon – Zaid: April – May•Resolution:<ol style="list-style-type: none">1. IRS R2 LISS III (23.5m) at 50k scale2. IRS P6 AWiFS (56m) at 250K scale3. ESA Sentinel-2 (10-15m)4. IRS R2 LISS IV (5.8 m) at 25k scale5. RISAT EO4 SAR FRS-2(3m), CRS (50m)•Extent of Coverage: Whole country																																																																																																																																																															
Process																																																																																																																																																																
Algorithm/Tool	The major steps involved in Land use land cover mapping are data preparation by selection of image, interpretation to identify change area, ground truthing and post classification correction, followed by generation of output. The approach involves two methods for classification (i) Vector based on-screen visual interpretation of satellite images and (ii) raster-based image classification.																																																																																																																																																															

- (i) On-screen visual interpretation can be applied on to the terrain corrected Resourcesat-2 LISS III & LISS IV imagery. The methodology essentially is based on editing the previous year digitized layers for updation with reference to current year images. The output generally is good fit at 50k scale mapping for LISS-III and at 25k scale for LISS-IV image. This creates an advantage to assess changes over the period of time.



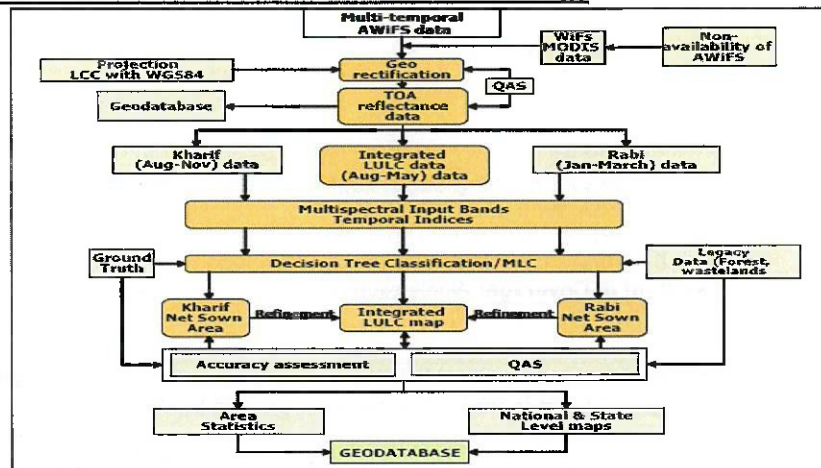
LULC classification scheme and brief description of classes are as given hereunder:

Sl.	Description-1	Description-2	Classes from NRC LULC50K Mapping Project
1	Builtup	Urban	Residential, Mixed builtup, Public / Semi Public, Communication, Public utilities / facility, Commercial, Transportation, Reclaimed land, Vegetated Area, Recreational, Industrial, Industrial / Mine dump, Ash / Cooling pond, Rural
2	Agriculture	Rural	Mine / Quarry, Abandoned Mine PE, Land fill area
		Mining	Kharrif, Rabi, Zaid, Two cropped, More than two cropped
		Crop land	Plantation - Agricultural, Horticultural, Agro Horticultural
		Plantation	Current and Long Fallow
		Fallow	Current Shifting cultivation
3	Forest	Evergreen / Semi evergreen	Dense / Closed and Open category of Evergreen / Semi evergreen
		Deciduous	Dense / Closed and Open category of Deciduous and Tree Cid Area
		Forest Plantation	Forest Plantation
		Scrub Forest	Scrub Forest, Forest Blank, Current & Abandoned Shifting Cultivation
4	Grass/ Grazing	Swamp / Mangroves	Dense / Closed & Open Mangrove
5	Barren/unculturable/Waterlands	Grass/ Grazing	Grassland/ Alpine / Sub-Alpine, Temperate / Sub Tropical, Tropical / Desertic
		Salt Affected Land	Slight, Moderate & Strong Salt Affected Land
		Gullied / Ravinous Land	Gullied, Shallow ravine & Deep ravine area
		Scrub land	Dense / Closed and Open category of scrub land
		Sandy area	Desertic, Coastal, Riverine sandy area
		Barren rocky	Barren rocky
		Rann	Rann
6	Wetlands / Water Bodies	Inland Wetland	Inland Natural and Inland Manmade wetland
		Coastal Wetland	Coastal Natural and Coastal Manmade wetland
		River / Stream / canals	Perennial & Dry River/stream and line & unlined canal/drain
		Water bodies	Perennial, Dry, Kharrif, Rabi & Zaid extent of lake/pond and reservoir and tanks
7	Snow and Glacier		Seasonal and Permanent snow

Classification System for LULC mapping


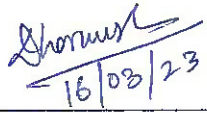
- (ii) IRS P6 AWIFS satellite data can be used for LULC mapping at 1:250K scale. Raster based digital image classification approach is successfully applied for country level mapping by NRSC/ISRO. For identification of agriculture, forest and water Normalised Difference Indices method are very popular and result oriented.

Flow chart of raster based LULC classification methodology



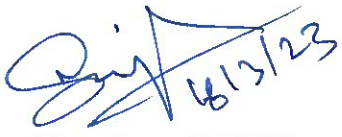

	<p><u>Process involved in data integration & development:(by NWIC)</u></p> <p>Step 1: LULC classes Sync with existing/designed Schema 1. Reprojection of classified LULC raster data received from NRSC into India WRIS Projection (LCC) 2. LULC is then bifurcated as per classification Schema based on threefold classification system (Attribute table) 3. Joining LULC Schema table with LULC Raster file based on primary key (LULC web code) 4. Cleaning LULC Raster by removing null values and extra unwanted fields 5. Import Raster LULC in new Geodatabase and create area field to calculate the area (in Sq.km) of Raster LULC</p> <p>Step 2: LULC area statistics – Administrative & Hydrological setup Wise & Data Publishing 1. Calculate LULC class area for all Districts/Sub Basin using Tabulate Area tool in ArcGIS (Table) 2. Calculate area Sq. m to Sq.km in newly created blank Master Table for LULC classes 3. Publish web map service and appropriate data table for final GUI development</p> <p>Note* Other agencies are working in line with NRSC but with limited ground truthing and varying mapping scale. NRSC is also mapping LULC under SIS-DP project through visual interpretation on IRS LISS-IV Pan & Carto merge data to produce output at 1:10k scale</p>
Data Validations	Initial screening is required before integrating data received from various mapping agencies for its completeness and accuracy. Checking of figures/stats quoted in published reports with geographical raster/vector data layer provided/generated for particular mapping year. LULC classification and mapped area should also justify statistics, surveyed by department of Economics and Statistics
Software Requirement (specific if any)	ARC GIS/PRO, ERDAS Imagine, Hydro tools, QGIS
Dependencies & Risks	Non-availability of appropriate season data sometimes put constraints on the interpretation of the features owing to poor reflectance of data, cloud conditions/images and other phenological changes. Incomplete or manipulated data (Interpretational errors). Registration errors when using old SOI toposheet for reference purpose. Unmatched GIS layer feature area with published statistics. Generally raster and vector classification output doesn't match due to difference in mapping approach. Software solutions and trainings are highly required in working with High Resolution Microwave Image.
User Acceptance Testing (UAT) By	NWIC
Development Responsibility	NWIC
Reference material	<ol style="list-style-type: none"> 1. ISRO/NRSC: NRSA/RSGIS-AA/NRC/NLULC- AWiFS/PROJREP/R01/JUN07, 2. NRSC (2014), Land Use / Land Cover database on 1:50,000 scale, Natural Resources Census Project, LUCMD, LRUMG, RSAA, National Remote Sensing Centre, ISRO, Hyderabad 3. Ranganath R. Navalgund, Remote sensing applications: An overview, Current Science, Vol. 93, No. 12, 25 December 2007 4. Manual - Preparation of Geo Spatial Layers using High Resolution (Cartosat-1 PAN + LISS-IV Mx) Orthorectified Satellite Imagery, RS & GIS AA, NRSC, ISRO, March-2012

For any communication/clarification on the BSR, the following Officer may be contacted.

Nodal Officer Name & Designation:	Dr. Rakesh Singh, Deputy Director	Signature : 
Organization:	National Water Informatics Centre	
Contact No.: Email id:	9006150281 dd-services-nwic@gov.in	
BSR prepared by Subject Matter Expert (SME), Name & Designation:	Dr. Dharmesh Singh Hydrologist	Signature : 
Organization:	NWIC	
Contact No.: Email id:	8447025987 hydrologist.nwic@gmail.com	

This is to certify that the above BSR has been vetted and found satisfactory.

Details of Domain Organization SPOC and SME for Verification and Approval of above BSR

 (Signature of SPOC) SPOC Name: Dr. Rakesh Singh SPOC Designation: Deputy Director Organization: NWIC	 (Signature of SME) SME Name: Sh. Karthic S.R. SME Designation: Deputy Director Organization: NWIC
--	--