ICAR-NAHEP- Center for Advanced Agricultural Science and Technology
COLLEGE OF AGRILCULTURAL ENGINEERING
JNKVV, JABALPUR
Progress Report Second Quarter (July to Sept 2021)

A center for Spatial Data Application in Agriculture (CSDA)

Title : "Skill Development to use spatial data for natural resources management in Agriculture"

Objectives:

- To build basic capacity for using RS & GIS techniques applied for betterment of Natural Resource Management particularly in Agriculture and allied sectors.

  Activities

  1. Awareness program for students
  2. Introductory program for administrator
  3. Executive learning for executives
  4. Capacity building for Scientists, Teachers, officials, students and Young Professionals

- To identify appropriate techniques for integration of spatial and ground data to realize problems related to land, water and vegetation.

  Activities

  1. Problem identification in realizing process with satellite and ground data techniques available.
  2. Making the spatial data maps more precise and accurate using fine resolution data available with present satellite systems.
  3. Students undergoing master and doctoral degree program shall be involved to undertake research project on related aspects. They shall be provided research fellowship for the same.

- To develop user friendly spatial data products using identified technologies for policy makers, researchers, field workers and farmers.

  Activities

  1. Preparation of Theme based maps
  2. Preparation of Integrated maps for decision making.

1. Administrative Activities

1.1 Creation of Facilities

i. National competitive bid invited for Hyper spectral Spectroradiometer
ii. Specification was made for server with software, 10KVA UPS, Drone and Thermal imaging camera.
iii. RFQ invited of large format Plotter A0 size, Digital Terminals, Digital Planimeter & Chartometer.
iv. Quotation were received on 29/09/2021.
v. Received Spectra radiometer, Line Quantum, PAR sensor with logger, Chlorophyll SPAD meter.
vi. Development of computer lab and training hall is in progress. Civil work for renovation of labs is 80-90% completed. Electrical connectivity and networking work is in progress.
vii. Training of staff on Line Quantum PAR sensor with logger and Chlorophyll SPAD meter.

1.2 Training schedule planned

Training schedule for online/offline training for students and faculty of various department is prepared as below:

Training schedule

S.No	Date		Training
	From	To	
1	22.6.21	12.7.21	Application of RS & GIS in NRM for Outgoing Students
2	24.7.21	24.7.21	Food Safety- a Shared Responsibility
3	25.7.21	25.7.21	Impact of Climate change on Insect Pests
4	26.7.21	26.7.21	Good Laboratory practices for safety & estimation procedure of pesticides residues, nutrients in soil & plants
5	29.7.21	29.7.21	Online Awareness programme on Grievance Redressal Mechanism
6	29.7.21	19.8.21	Hands-on training on Remote Sensing & GIS using QGIS. (For Faculty) (Batch- I)
7	11.08.21	11.08.21	Management in organic farming
8	25.8.21	15.9.21	Hands-on training on Remote Sensing & GIS using QGIS. (For Faculty) (Batch- II)
9	29.09.2021	29.09.21	Integrated Disease Management.
10	24.09.2021	24.09.21	Awareness programme on National service scheme (NSS)

2. Capacity Building Programme

2.1 Application of RS & GIS in NRM for Outgoing Students

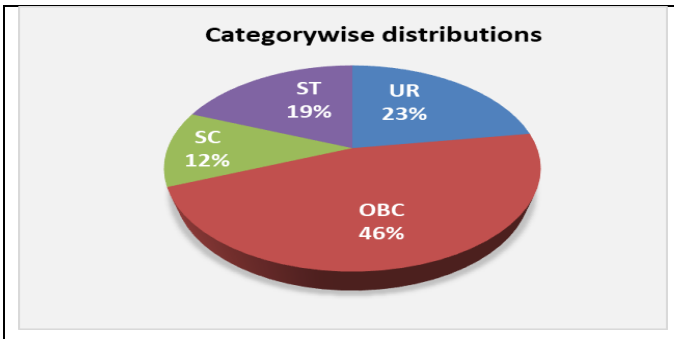
"Twenty-one days training program on Application of RS & GIS in NRM has been organized from 22.6.2021 to 12.7.2021 for outgoing student Agricultural Engineers. During first week of training program, students were exposed to structures design, soil sample analysis and different irrigation methods. Second week of the training program was devoted to information about remote sensing process, GIS and its functionalities, image interpretations, RS and GIS application in field of Agriculture, use of different types of thematic maps i.e. weather, road, Human, physical geography, landforms, physical features, land use and land cover (LULC), soil, slope, drainage and temperature map. Useful apps prevailing in NRM domain and different types of open source GIS software like QGIS plugins, gvSIG, GRASS GIS, ILWIS, SAGA GIS and GeoDa were also exposed. Surveying and levelling and area identification through open source GIS software has been covered in third week of the training program. 84 participants registered for program out of which 62% were male and 38% were female. They belong to UR (23%), OBC (46%), SC (12%) and ST (19%) categories. The detailed training schedule is listed below.

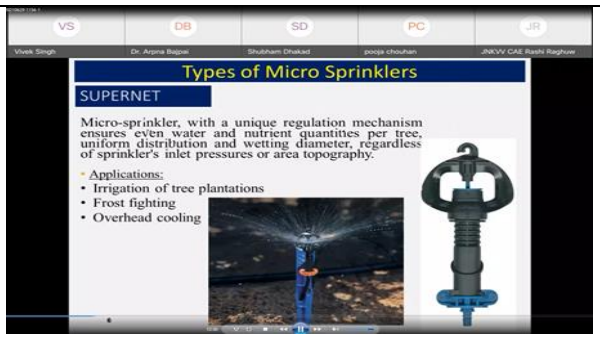
Training schedule

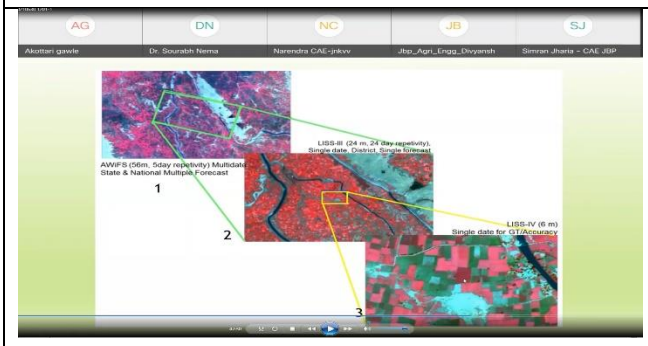
Date	Topic
22.06.2021	Common structures and load distributions and force analysis
23.06.2021	Analysis of soil sample – sand, silt, clay, sieve analysis, and Hydrometry
24.06.2021	Determination of soil mechanical properties.
25.06.2021	Types of drippers, laterals and filters and their layout in drip design.
28.06.2021	Maintenance against clogging and fertigation techniques.
29.06.2021	Design, layout and evaluation of a sprinkler Irrigation system.
30.06.2021	Common satellites, resolutions, supplying agencies and data acquisition.
01.07.2021	Thematic maps its preparation and use.
02.07.2021	Introduction to open source software
05.07.2021	Useful apps prevailing in NRM domain.
06.07.2021	Working out area of an irregular field
07.07.2021	Levelling exercise
08.07.2021	Working and use of Total station
09.07.2021	Measurement and estimation of quantities of work.
12.07.2021	Costing for quantities SOR for PWD and SOR for WK

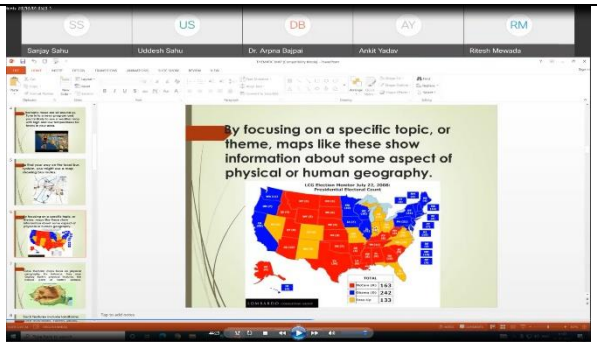
Table 2.1 Participants on Application of RS & GIS in NRM

Number of Students						Percentage of participation of Category			
Gender	UR	OBC	SC	ST	Total	UR	OBC	SC	ST
Male	7	32	5	8	52	13	62	10	15
Female	12	7	5	8	32	38	22	16	25
Total	19	39	10	16	84	23	46	12	19









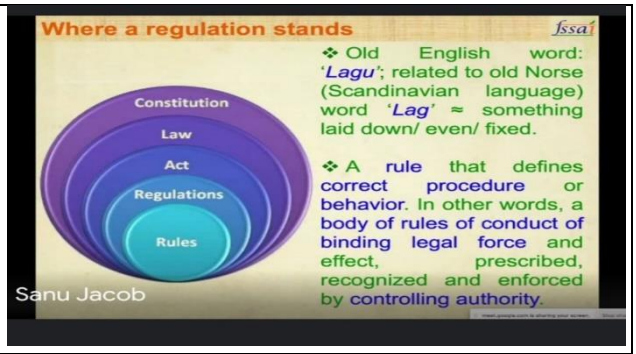
2.1 Glimpses of training program on Application of RS & GIS in NRM

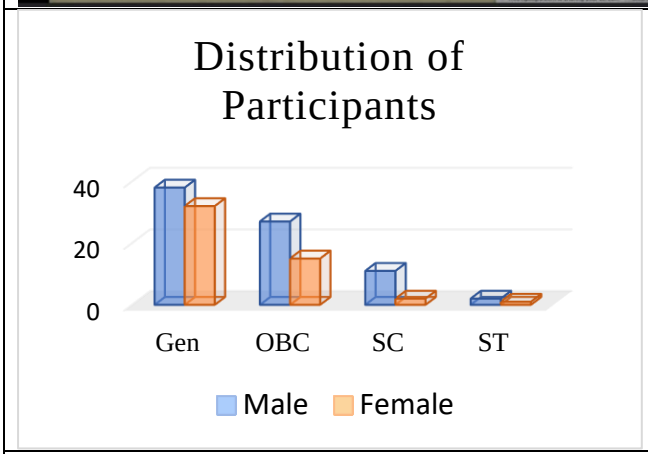
2.2 Food Safety a Shared Responsibility

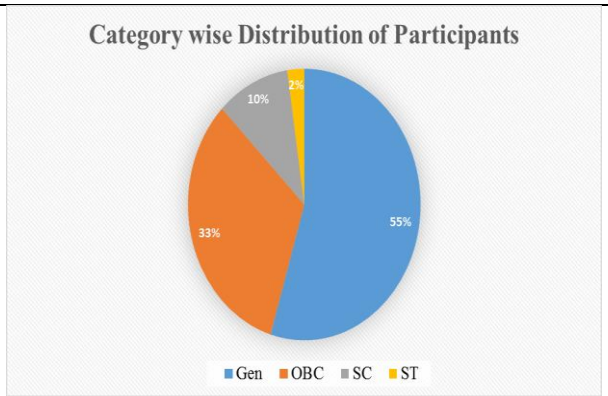
One day training program on "Food-Safety a Shared Responsibility "was organized on 24th July 2021 Dr. Sanu Jacob, Director FSSAI New Delhi, discussed about the FSSAI's, definition of food, food science as an interdisciplinary subject and food safety challenges. He also elaborated about various food fraud activities, importance of food safety and how it can be ensured using different laws and regulations of FSSAI, timeline and changes done in old FSSA laws since 2006 to till date. Export Inspection Council (EIC) of India, its working, notified commodities and regulations for different consumer operators was also explained. 128 participants registered for program out of which 61% were male and 39% were female. They belong to UR (54.68%), OBC (40.62%), SC (10.15%) and ST (2.34%) categories.

Table 2.2 Participants on Food Safety a Shared Responsibility

Number of Participants						% of participants in different category			
Gender	Gen	OBC	SC	ST	Total	Gen	OBC	SC	ST
Male	38	27	11	2	78	48.71	34.61	14.10	2.58
Female	32	15	2	1	50	64.00	30.00	4.00	2.00
Total	70	52	13	3	128	54.68	40.62	10.15	2.34







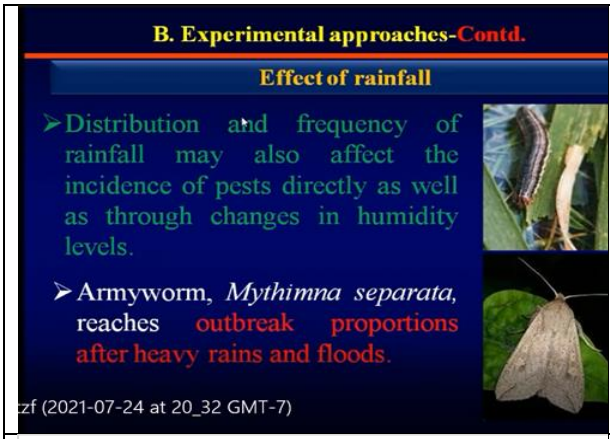
2.2 Food Safety a shared responsibility by Dr. Sanu Jacob

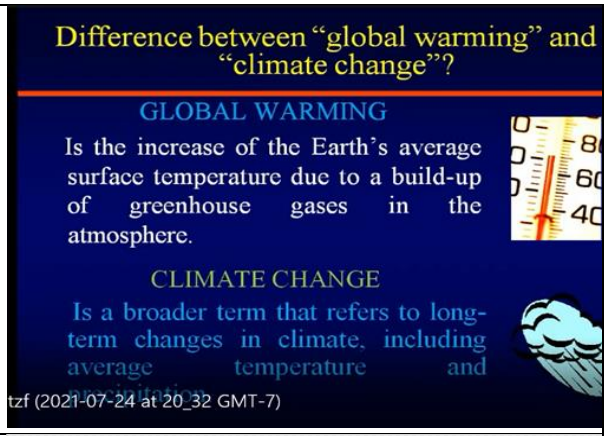
2.3 Impact of Climate change on Insect Pests

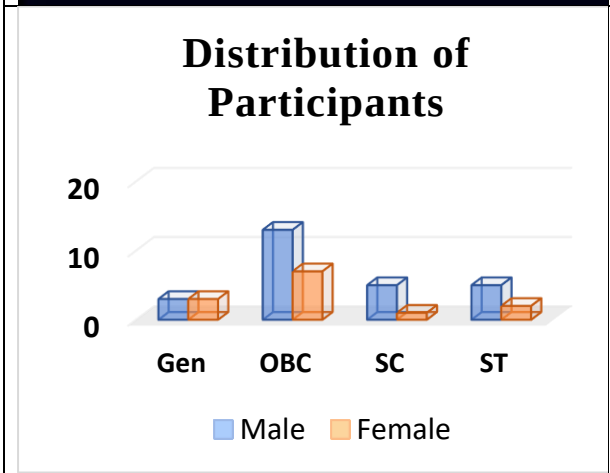
An online training program entitled "Impact of Climate Change on Insect Pests" Impact of higher CO2 Concentration, and Precipitation Pattern was discussed by Dr.S.B. Das. Details on how insects Response to increased temperature, and to Increased CO2 Concentration was also explained. Total 39 students attended the program out of which 66.67% were male and 33.33% were female. They belong to UR (15.4%), OBC (51.3%), SC (15.4%) and ST (17.8%) categories.

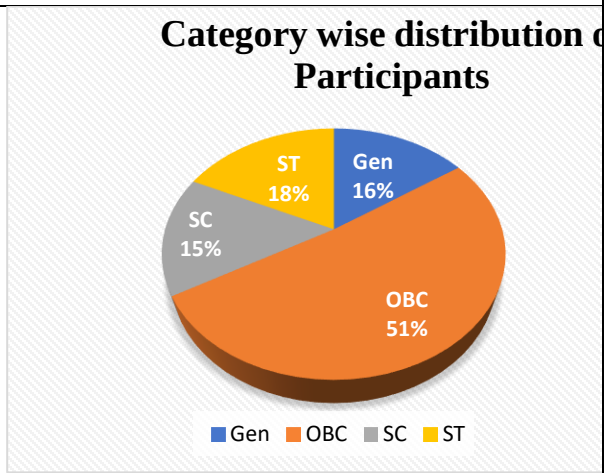
Table 2.2 Participants attended training on impact of climate change on insect pests

Number of Participants						% of participants in different category			
Gender	Gen	OBC	SC	ST	Total	Gen	OBC	SC	ST
Male	3	13	5	5	26	11.5	50.0	19.2	19.2
Female	3	7	1	2	13	23.1	53.8	7.7	15.4
Total	6	20	6	7	39	15.4	51.3	15.4	17.8









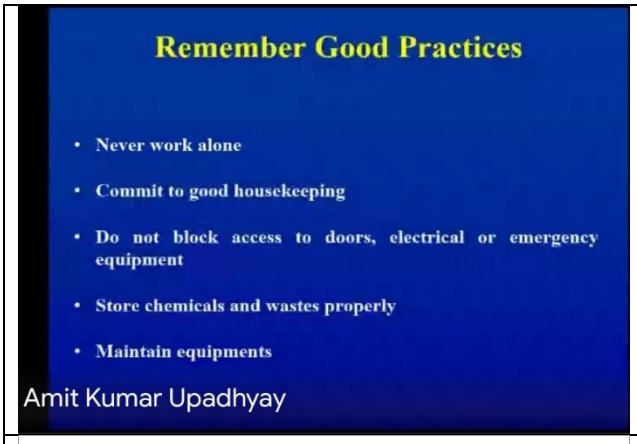
2.3 Impact of climate change on insect pests

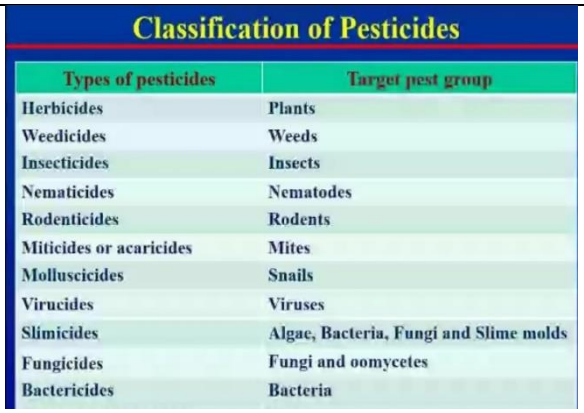
2.4 Good Laboratory Practices for safety & estimation procedure of pesticides residues and nutrient in soil & plants

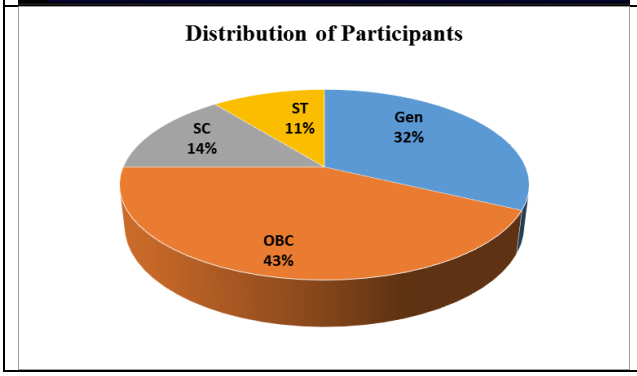
An online training program on "Good Laboratory practices (GLP) for safety & estimation procedure of pesticides residues and nutrients in soil & plants". The Lecture was delivered by Dr. Amit Kumar Upadhyay Scientist, Department of Soil Science and Agricultural Chemistry, JNKVV Jabalpur. He elaborate the basic principles of GLP, test facilities for organisation and personnel, quality assurance programmes, Apparatus, material and reagent facilities test system and control item standard operating procedure, statistically procedure for data evaluation, storage and retention. Total 39 students attended the program out of which 57.15% were male and 42.85 % were female. They belong to UR (32.1%), OBC (42.9%), SC (14.3%) and ST (10.7%) categories.

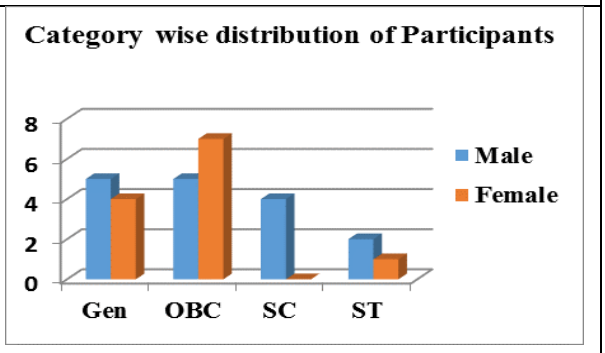
Table 2.4 Participants on Good Laboratory Practices

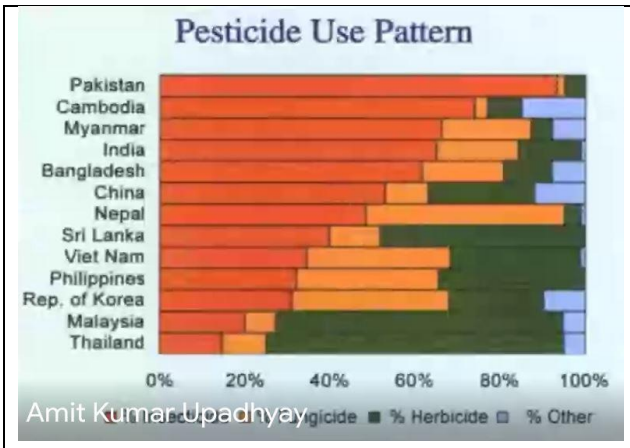
	Number of Participants					% of participants in different category			
Gender	Gen	OBC	SC	ST	Total	Gen	OBC	SC	ST
Male	5	5	4	2	16	31.3	31.3	25.0	12.5
Female	4	7	0	1	12	33.3	58.3	0.0	8.3
Total	9	12	4	3	28	32.1	42.9	14.3	10.7









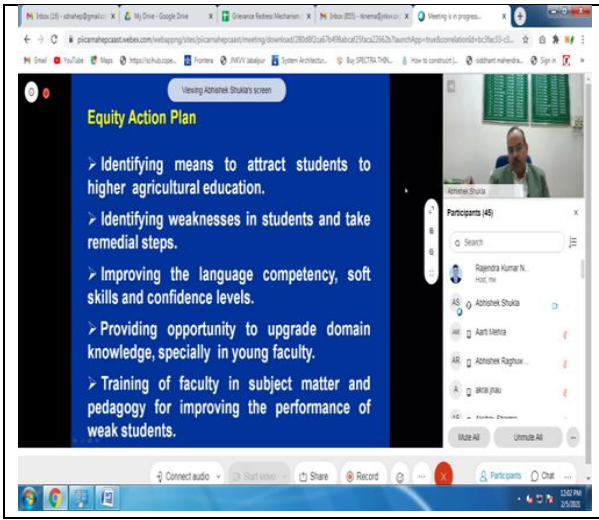


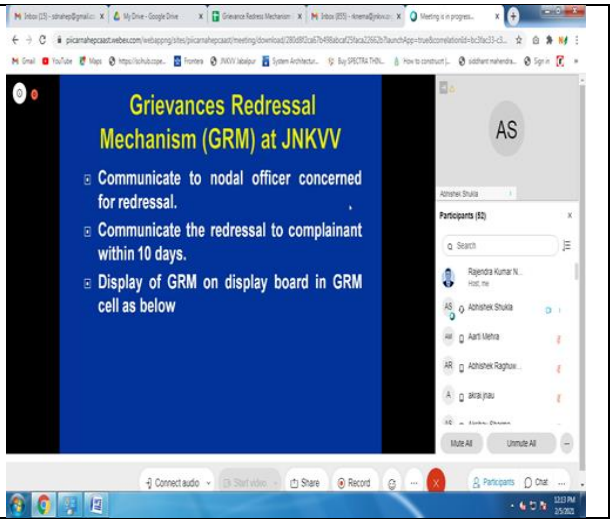
2.4 Glimples of Good Laboratory practices by Dr Upadhyay

2.5 Online Awareness programme on Grievance Redressal Mechanism

Online awareness program entitled "On Grievance Redressal Mechanism (GRM)" was held on 29th July 2021. The lecture was delivered by Dr. Abhishek Shukla, Nodal officer GRM cell. The point raised in front of redressed forum and how they mechanized was discussed in awareness program. 201 students and faculties registered for program out of which 61.7% were male and 38.3% were female. They belong to UR (37.8%), OBC (36.3), SC (14.9%) and ST (10.9%) categories.

2.5 Awareness Program on Grievance Redressal Mechanism (GRM)									
Number of Participants					% of participants in diff. category				
Gender	UR	SC	ST	OBC	Total	UR	SC	ST	OBC
Male	44	21	13	46	124	35.5	16.9	10.5	37.1
Female	32	9	9	27	77	41.6	11.7	11.7	35.1
Total	76	30	22	73	201	37.8	14.9	10.9	36.3





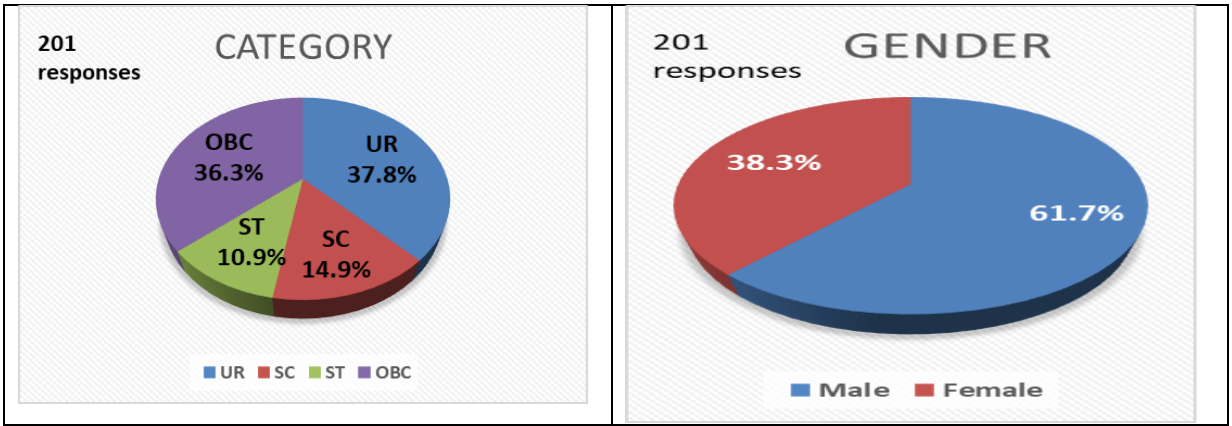


Plate 2.5 : Awareness programme on Grievance Redressal Mechanism (GRM)

2.6 Faculty training on Remote Sensing & GIS using QGIS.

21 days "Hands on Training on Remote Sensing and GIS Using QGIS" was organised from 29th July to 19th August 2021 for faculty from Agriculture colleges i.e. Jabalpur, Tikamgarh, Ganjbasoda, Powarkheda, Balaghat, Rewa and Chhindwara, JNKVV Jabalpur. The main aim of this training was to initiate participants to use RS and GIS software, especially concerning the domains- Introduction to Remote Sensing and its applications in Agriculture, Download and installation of QGIS software, Processing and analysis of satellite image. The different geoportals and availability of remote sensing data at various online platforms such as Google Earth, Earth on AWS, NASA Worldview, NOAA, INDIA WRIS, Sentinel Hub, Copernicus Open Access Hub, Bhuvan and USGS Earth Explorer. The basics of GIS covered the topics i.e. components of GIS, elements of GIS based analysis, coordinate systems, scale, resolution, map projection, GIS data types (raster and vector data), GIS software's and how remote sensing and GIS together can be used in various field. The training was attended by forty-three (43) participants includes 34 Assistant professor, 3 Associate professor, 3 Professor and 3 technical staff. The detailed schedule of 21 days training programme is as under:

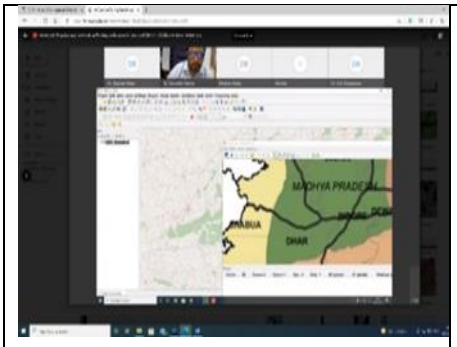
Training Schedule:

Date	Topic
29/07/2021	Inauguration, Pre-Training Test, Introduction to Remote Sensing and applications in Agriculture, Specialized learning Videos.
30/07/2021	Satellites, Sensors, and Resolution, Visual Interpretation of Satellite Imagery. Specialized learning Videos
31/08/2021	Different Geoportals (Earth explorer, Bhuvan, Copernicus ESA etc.), Specialized learning, Introduction to GIS, Specialized learning Videos
2/08/2021	Introduction of QGIS open-source software, Downloading & Installation of QGIS Software Overview, Specialized learning Videos
03/08/2021	Georeferencing of Map, Generation of vector features such as Point, Line and Polygone, Specialized learning Videos

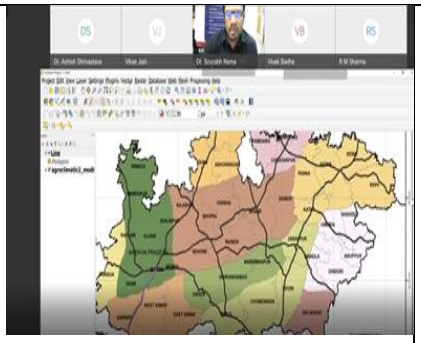
04/08/2021	Features (Point, Line and Polygon) digitization, filling data in attribute table and area calculation.
05/08/2021	Downloading of Landsat-8 satellite dataset and about bands information. Specialized Learning
06/08/2021	Layer stacking of different bands and clipping of Area of Interest (AOI)
07/08/2021	Layer stacking of bands and clipping of Area of Interest (AOI).
09/08/2021	Band combinations for agriculture applications using False Colour Composite (FCC).
10/08/2021	Introduction in QGIS and Pre-Processing of Landsat 8 using SCP
11/08/2021	Region of Interest (ROI) and Creating Training Dataset
12/08/2021	Introduction of Classification Supervised classification using Minimum distance algorithm
13/08/2021	Supervised classification using Minimum distance algorithm
14/08/2021	Area Calculation of LU/LC classified data
16/08/2021	Map Layout Creation
17/08/2021	Presentation by Participants on LU/LC (as prepared during exercise)
18/08/2021	Presentation by Participants on LU/LC (as prepared during exercise)
19/08/2021	Post Training Assessment & Valedictory Function

Table 2.6 Participants on Hands on training on Remote Sensing & GIS using QGIS.

	Number of Participant					Percentage of participation of Category			
Gender	UR	OBC	SC	ST	Total	UR	OBC	SC	ST
Male	23	3	0	1	27	85	11	0	4
Female	11	1	1	0	13	85	8	7	0
Total	34	4	1	1	40	85	10	2	3

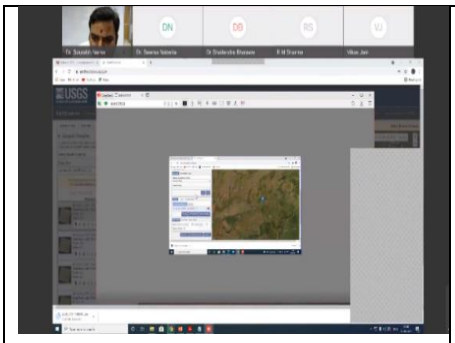


Georeferencing of map
Digitization of vector feature

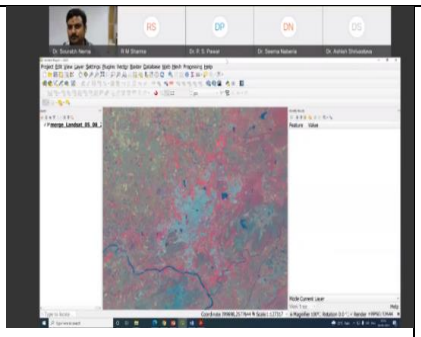


Georeferencing of map
Digitization of vector feature

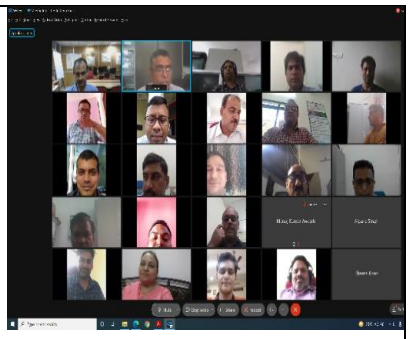
Inaugural Function



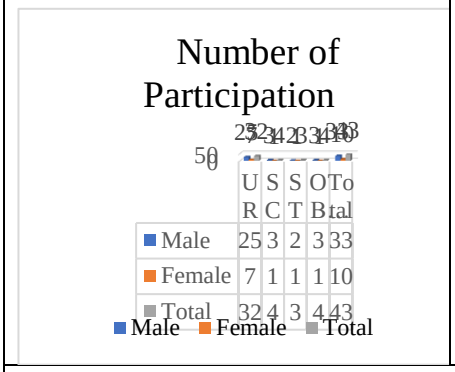
Downloading of satellite data from USGS Earth Explorer

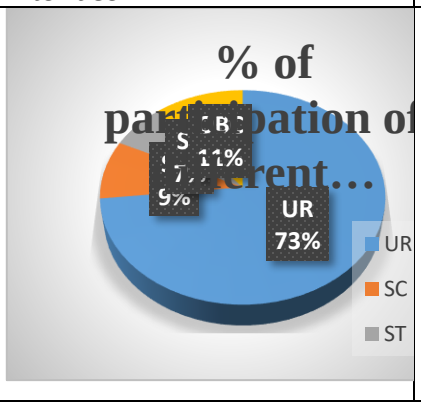


Formation of FCC in QGIS interface



Valedictory function





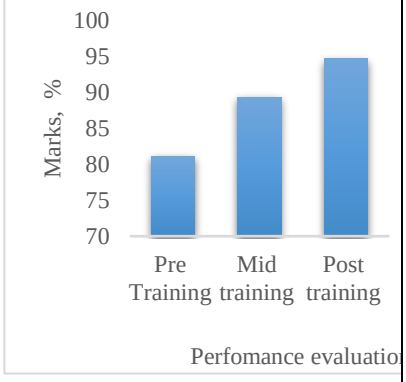


Plate 2.6 Participants attended 21 days training and details of lectures

2.7 Management in organic farming

One day training program on "Management in organic farming" was organized on 11th August by Dr. Pratap Bhanu Sharma, Scientist Agronomy, JNKVV. The basic of principles of organic Agriculture and its essential components i.e. Enrichment of Soil, Management of temperature, conservation of soil and rain water, harvesting of sun energy etc. Were exposed. Various measures that can be taken for nutrient management, its sources like green manure, vermicomposting, Non-edible oil cakes Poultry manure Azolla and bio fertilisers were discussed. Total 51 students attended the program out of which 68.63% were male and 31.37% were female, belong to UR (33.3%), OBC (43.1%), SC (13.7%) and ST (9.8%) categories.

Table 2.7 Participants of Management in organic farming

Number of Participants						% of participants in different category			
Gender	Gen	OBC	SC	ST	Total	Gen	OBC	SC	ST
Male	9	16	5	5	35	25.7	45.7	14.3	14.3
Female	8	6	2	0	16	50.0	37.5	12.5	0.0
Total	17	22	7	5	51	33.3	43.1	13.7	9.8

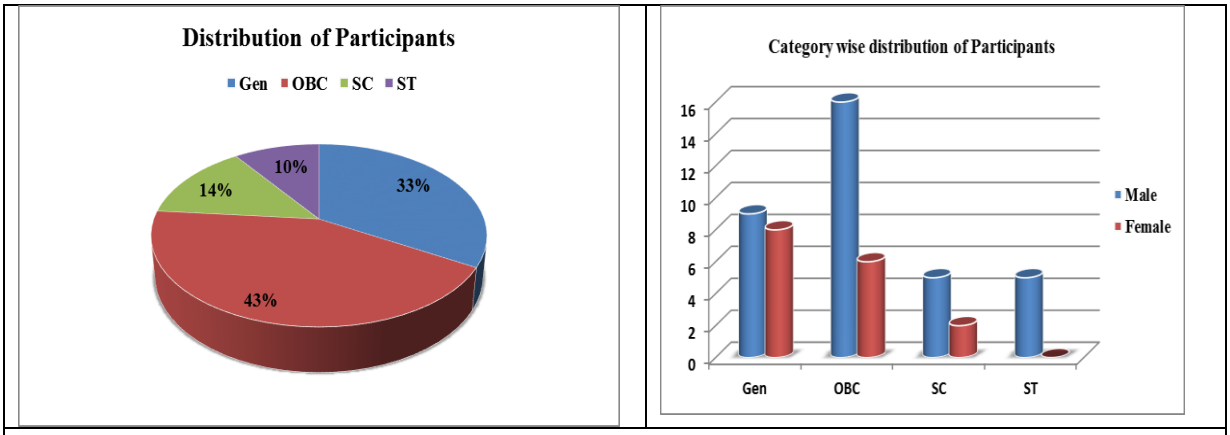


Plate 2.7 Graphical representation of attended Participants

2.8 Faculty training on Remote Sensing & GIS using QGIS

21 days "Hands on Training on Remote Sensing and GIS Using QGIS" was organised from 25th August to 15th September 2021 for faculty from Agriculture colleges i.e. Jabalpur, Tikamgarh, Ganjbasoda, Powarkheda, Balaghat, Rewa and Chhindwara, JNKVV Jabalpur. The training was attended by forty (40) participants includes 19 Assistant professor, 3 Professor, 6 scientist, 6 technical staff and 6 NAHEP staff. Introduction to Remote Sensing and its applications in Agriculture, Satellites, Sensors and Resolution. Visual Interpretation of Satellite Imagery, Different Geoportals and introduction to GIS, Introduction, acquiring and installation of QGIS software. Georeferencing of map and generation of vector features, acquiring satellite data, basics of image, bands information, band combination, FCC formation and clipping of Area of Interest (AOI), Pre-Processing of Landsat 8 using SCP plugin. Creating training dataset, Satellite image classification, LULC area calculation and map layout creation. The detailed schedule is as under:

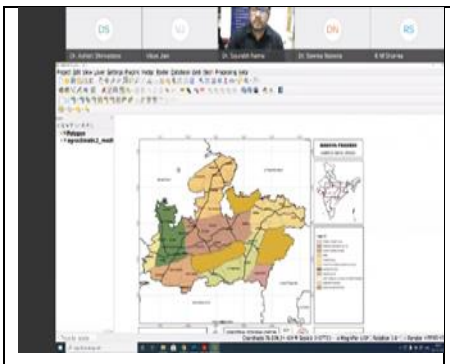
Training schedule

Date	Topic
25/08/2021	Inauguration, Introduction to Remote Sensing and applications in Agriculture, Pre-Training Test, Specialized learning
26/08/2021	Satellites, Sensors, and Resolution, Visual Interpretation of Satellite Imagery, Special Lecture
27/08/2021	Different Geoportals (Earth explorer, Bhuvan, Copernicus ESA etc.). Introduction to GIS, Special Lecture
28/08/2021	Introduction of QGIS open-source software, Downloading & Installation of QGIS Software Overview, Practice Session
31/08/2021	Georeferencing of Map. Generation of vector features such as Point, Line and Polygon. Practice Session.
01/09/2021	Features (Point, Line and Polygon) digitization, filling data in attribute table and area calculation, Practice Session

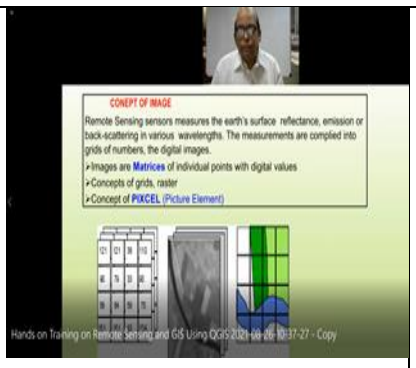
02/09/2021	Downloading of Landsat-8 satellite dataset and about bands information. Practice Session
03/09/2021	Layer stacking of different bands and clipping of Area of Interest (AOI), Practice Session
04/09/2021	Layer stacking of bands and clipping of Area of Interest (AOI), Practice Session
06/09/2021	Band combinations for agriculture applications using False Colour Composite (FCC), Practice Session
07/09/2021	Introduction in QGIS and Pre-Processing of Landsat 8 using SCP, Practice Session
08/09/2021	Region of Interest (ROI) and Creating Training Dataset, Practice Session
09/09/2021	Introduction of Classification, Supervised classification using Minimum distance algorithm, Practice Session
10/09/2021	Supervised classification using Minimum distance algorithm, Practice Session
11/09/2021	Area Calculation of LU/LC classified data, Practice Session
13/09/2021	Map Layout Creation, Practice Session
14/09/2021	Presentation by Participants on LU/LC (as prepared during exercise)
15/09/2021	Post Training Assessment &Valedictory Function

Table 2.8 Participants attended Hands on training of Remote Sensing & GIS using QGIS.

Number of Participant						Percentage of participation of Category			
Gender	UR	OBC	SC	ST	Total	UR	OBC	SC	ST
Male	23	3	0	1	27	85	11	0	4
Female	11	1	1	0	13	85	7	8	0
Total	34	4	1	1	40	85	10	2	3

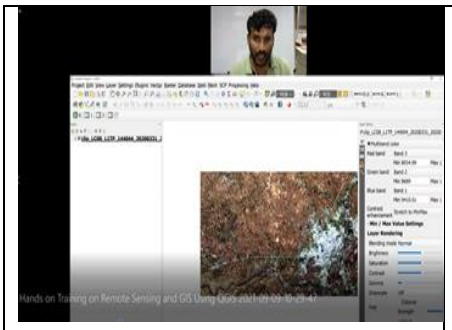


Digitization of Agroclimatic zone

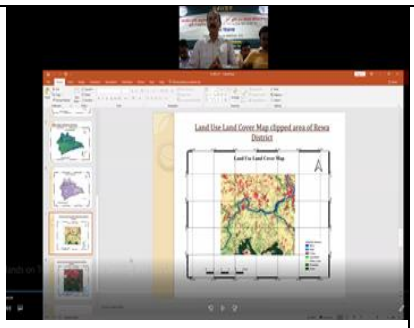


Concept of Image

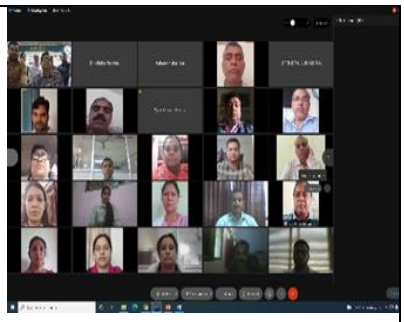
Inaugural Function



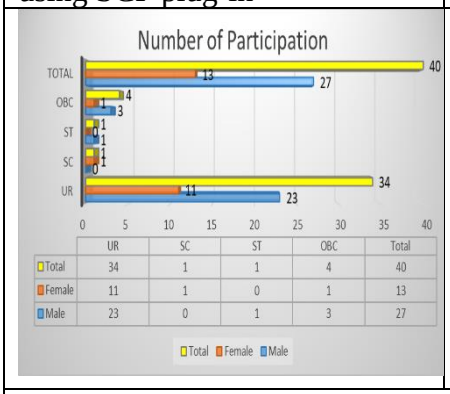
Preparation of virtual stack using SCP plug-in

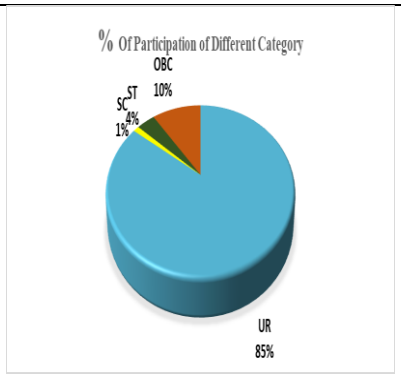


Presentation by participants



Valedictory function





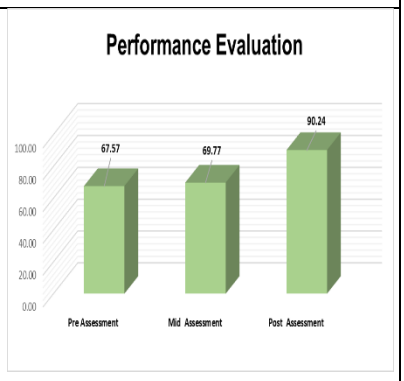


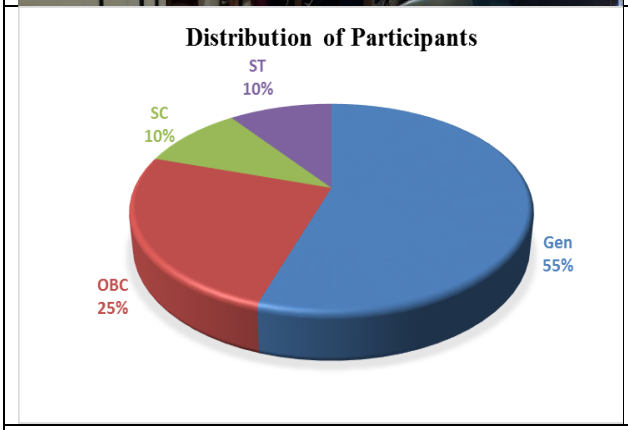
Plate 2.8 Participants attended 21 days training and details of lectures

2.9 Integrated Disease Management:

A training on "Integrated Disease Management" was organised on 29.09.2021 for students at Bio control Research & Production Centre (ELP). Different Disease Management Practices in crops and their importance, central idea behind IDM, Criteria of Priority for various crops, and various phases i.e. single tactic, multiple tactic, biological monitoring, modelling, management and acceptance. Total 20 students had attended the program out of which 50% were male and 50 % were female. They belong to UR (55%), OBC (25%), SC (10%) and ST (10%) categories.

Table 2.9 Participants attended Integrated Disease Management.

	Number of Participants					% of participants in different category			
Gender	Gen	OBC	SC	ST	Total	Gen	OBC	SC	ST
Male	6	2	1	1	10	60	20	10	10
Female	5	3	1	1	10	50	30	10	10
Total	11	5	2	2	20	55	25	10	10



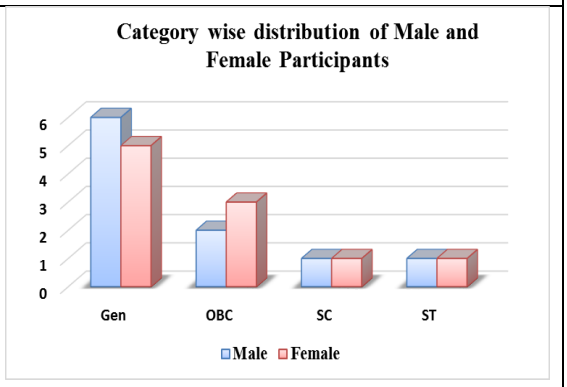


Plate 2.9 : Glimpses of training on Integrated Disease Management.

2.10 Awareness programme on Environmental Safeguard Measures

Awareness program entitled on Environmental Safeguard measures was held on 24th September 2021, under the guidance of Dr. R. N. Shrivastava on the auspicious day of NSS. Dr. P. K. Bisen enlightened about the aim of NSS that is to provide hands on experience to young students in delivering community services and the motto of NSS "NOT ME BUT YOU" and Awareness of Environmental Conservation. Dr. Amit Kumar Sharma, Dean student welfare had shared about inception of the scheme in the year 1969 and the student's strength till date. Students also presented their presentation and shared the experience of NSS camp and distributed certificates to the students.

3. Techniques for integration of spatial and ground data

3.1 Problem Identification: The following problems were identified earlier in realizing process with satellite and ground data with techniques available

- Watershed prioritization
- Fall Army Worm infestation in maize crop
- Assessment of soil quality index
- Yellow stem borer infestation in paddy
- Variation of spectral finger prints of major Rabbi crops
- Ground Water potential zoning
- Carbon sequestration evaluation of Orchards
- Characterization of Orchards
- Groundwater estimation for river revival
- High temperature stress in Chickpea
- Surface water body dynamic analysis using GEE
- Land use land cover change detection

3.2 Precision and Accuracy of satellite data maps:

3.2.1 Assessment of Classification on Sentinel-2 and Landsat-8 Data for Land Cover / Use Mapping

This study aims to compare classification accuracies of land cover/use maps created from Sentinel-2 and Landsat-8 data. Jabalpur District (Fig 1) was selected as study area, falls between latitudes 22.49 N to 24.08 N longitudes 75.25 to 80.53 E. The total geographical area of the district is 5046.51 sq. km According to the 2011 census. Water, forest, agricultural, transport network, urban, and open land cover/use were used as classes to identify. February 2020 Sentinel-2 and Landsat-8 images of Jabalpur (Table 1) were obtained and image pre-processing steps like atmospheric and geometric correction were employed. Both Sentinel-2 and Landsat-8 images were resampled to 30m pixel size and similar spectral bands for both satellites were selected to create a base for these multi-sensor data. Maximum Likelihood supervised classification methods was applied to identify the different classes.

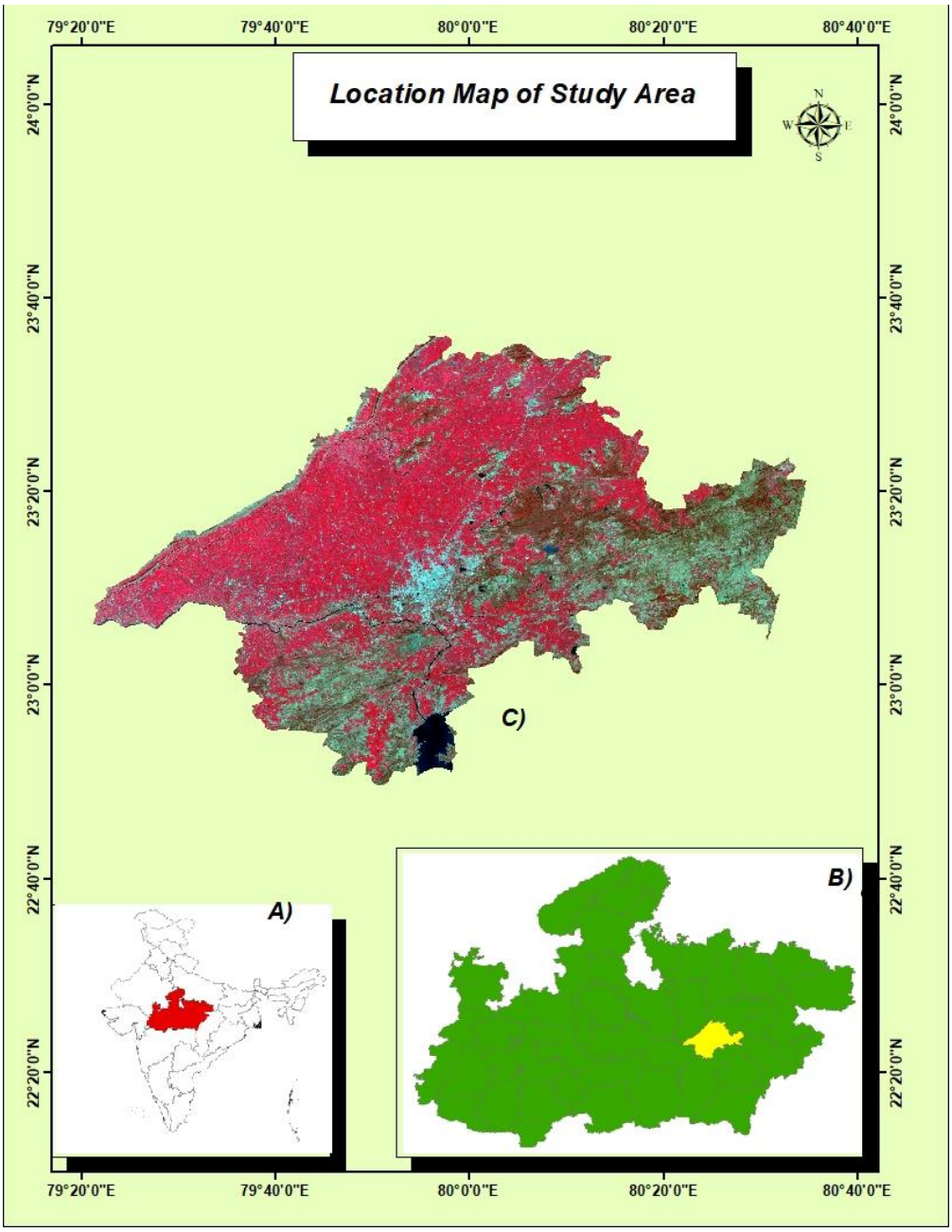


Fig.1 Location map of the study area

Landsat 8 satellite, launched on 11.02.2013, with 11 bands and spatial resolution from 30 m to 100 m via the Operational Land Imager (OLI) sensor with 16 days temporal resolution. Sentinel-2 mission, launched on 23.06.2015, is a land monitoring constellation of two satellites (Sentinel- 2a and Sentinel- 2b) providing global optical imagery with 13 spectral bands using Multispectral Imager instrument. Temporal resolution of Sentinel-2 is 10 days with one satellite and 5 days with 2 satellites, with a spatial resolution from 10 m to 60 m.

Table 1: Spectral bands and spatial resolution of satellite data used.

Landsat 8 satellite			Sentinel 2 satellite		
Band	**Particular**	**Spatial Resolution, m**	**Band**	**Particular**	**Spatial Resolution, m**
1	Ultra-Blue (coastal/aerosol)	30	1	Coastal aerosol	60
2	Blue	30	2	Blue	10
3	Green	30	3	Green	10
4	Red	30	4	Red	10
5	NIR	30	5	Vegetation red edge	20
6	SWIR 1	30	6	Vegetation red edge	20
7	SWIR 2	30	7	Vegetation red edge	20
8	Panchromatic	15	8	NIR	10
9	Cirrus	30	8A	Narrow NIR	20
10	Thermal 1	100* (30)	9	Water vapour	60
11	Thermal 2	100* (30)	10	SWIR – Cirrus	60
			11	SWIR	20
			12	SWIR	20

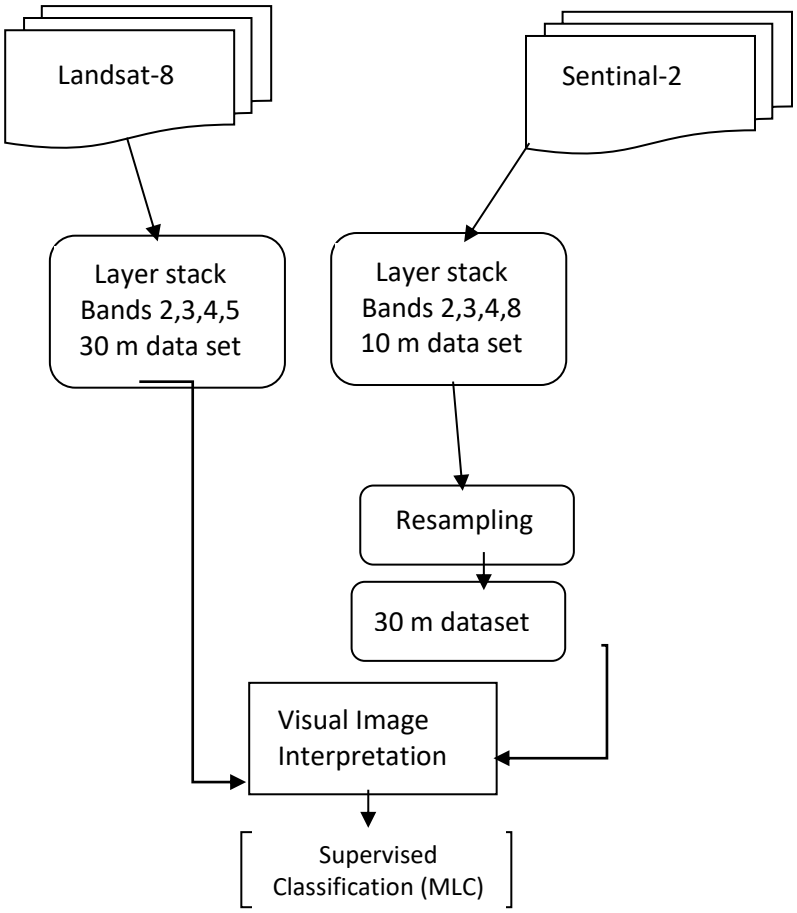


Figure 2. LULC classification using two set of data

Similar spectral bands of Landsat-8 and Sentinel-2 were obtained and layers stacked. Band 2, band 3, band 4, band 5, having 30 m spectral resolution for landsat 8 and band 2, band 3 and band 4 and band 8 having 10 m spectral resolution for Sentinel-2 were stacked. 10 m spectral resolution bands of Sentinel-2 image were resampled to 30 m and 4 multispectral band image with 30 m spatial resolution was obtained using layer stacking. Common spatial resolution data set of similar spectral band range has been created (Fig. 2). Maximum Likelihood method was used for classification of images.

Land cover maps of the study region was prepared through supervised classification with six classes namely water, forest, agricultural, transport network, urban area and open areas classes (Figure 3 and 4).

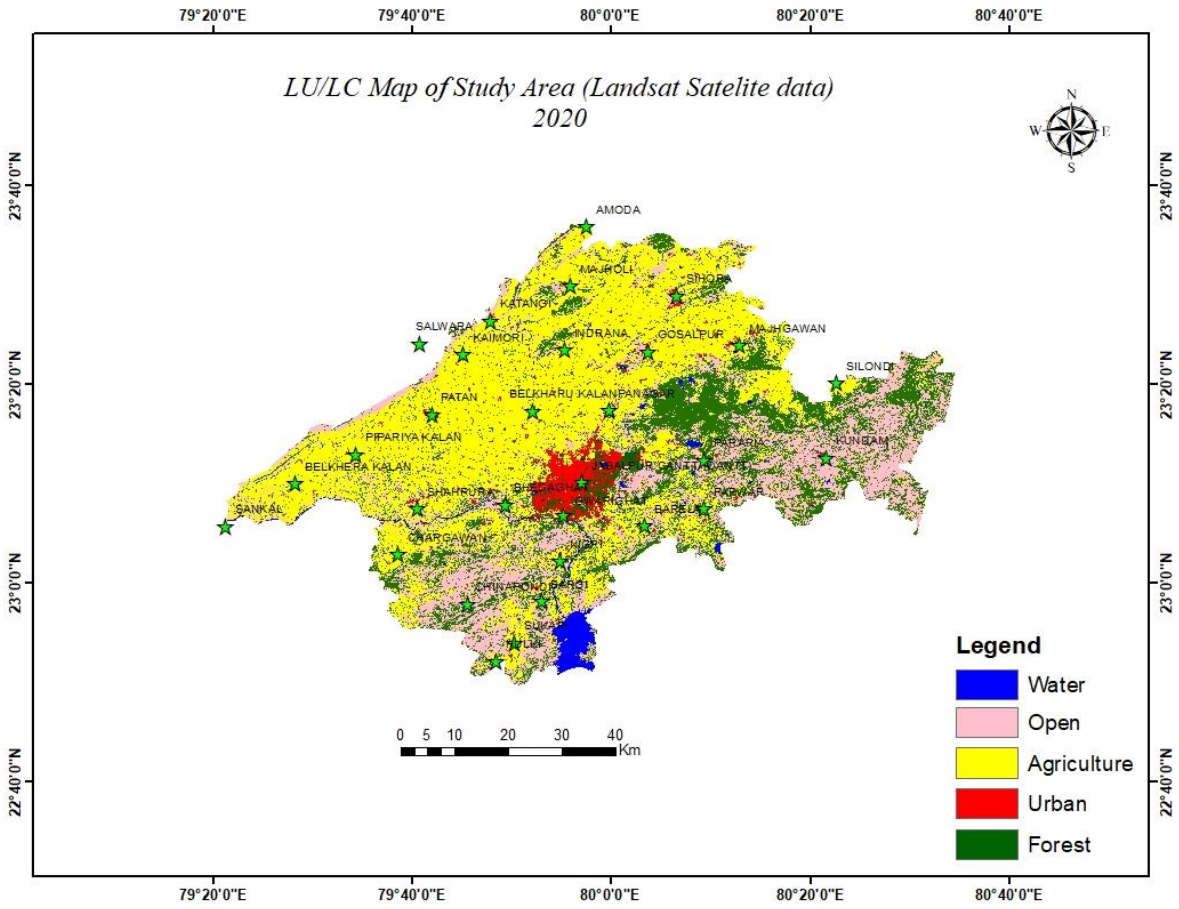


Fig. 3 Land use/land cover map of Jabalpur district (Landsat8) February, 2020

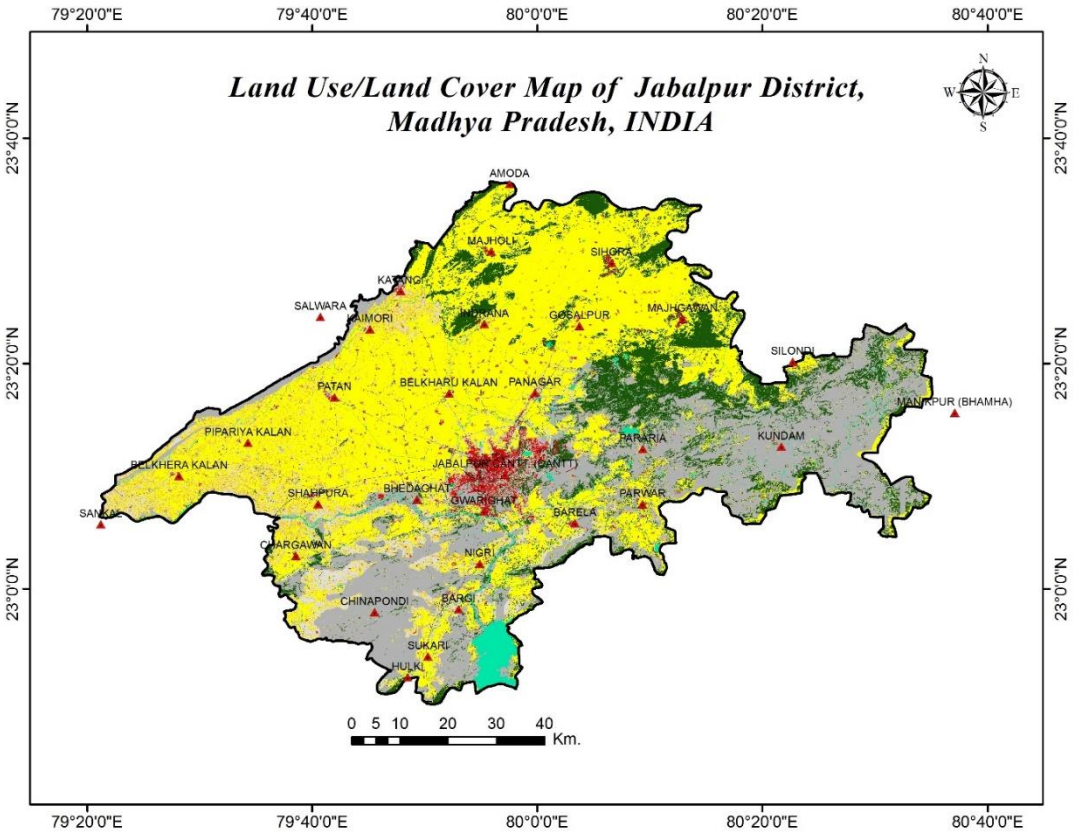


Fig. 4 Land use/land cover map of Jabalpur district (Sentinel 2) February, 2020

Table 2. Area under different classes as estimated through two satellite data set

Estimated area under different classes as estimated through two satellite data set is presented in Table 2. Total area under Agriculture is estimated as 234351 ha which 46.48 percentage of the total geographical area as Landsat 8 data set. The same class is classified in 281011.57 ha by Sentinel2 satellite data set, which is 55 .69 percentage of total geographical area. The difference in estimation also reflectance in other classes and therefor the estimated area has to be relooked and necessary modification are to be made for expected accuracy of classification through ground truth verification for the same.

Classes	**Landsat – 8 data Area (ha)**	**Landsat – 8 data Area (%)**	**Sentinal-2 data area (ha)**	**Sentinal-2 data area (%)**
Water	8947.17	1.77	11026.9	2.19
Forest	117890.72	23.38	187735.5	37.20
Open	122033	24.20	13424.5	2.66
Agriculture	234351	46.48	281011.57	55.69
Urban	18007.5	3.57	8868.09	1.76
Road	3000	0.59	2553.66	0.51
Total Area	**504229.39**	**100**	**504620.22**	**100**

3.3 Students Research Projects: Students of undergoing master and doctoral degree program have been involved to undertake research project on related aspects. Research fellowship have

been provisioned for students working on relevant research problems of this particular objective. These activities will continue in the following years. The details of research topic student involved, advisor for guidance, objectives and progress of work are presented below.

Table 3.3.1 Involvement of students for Post graduate and Doctoral research under NAHEP theme

S. No	Topics	Student	Department	Advisor	Course
1	Characterization of the efficacy of plant growth regulators for high-temperature stress mitigation in chickpea (*Cicer arietinum* L.) through ground based proximal remote sensing.	Supriya Debnath	Department of Plant Physiology	Dr. R. Shiv Ramakrishnan	Ph. D.
2	Computation of carbon sequestration of mango (*Mangiferaindica* L.) orchards of Jabalpur district using geoinformatics.	Shreesty Pal	Fruit Science, Department of Horticulture	Dr. S. K. Pandey	Ph. D.
3	Spatial mapping and characterization of Mango *(Mangiferaindica*L.) orchards using Remote Sensing and GIS in Jabalpur District of Madhya Pradesh.	Govind Madariya	Fruit Science, Department of Horticulture	Dr. S. K. Pandey	M.Sc.
4	Characterization of Fall Army Worm (FAW) Infestation in Maize Crop through Ground Based Hyperspectral Remote Sensing	Kumari Pragya	Department of Entomology	Dr. S. B. Das	Ph. D.

	Under Field Conditions.				
5	Diagnostic Analysis and Planning of Rejuvenation of Kanari River in Jabalpur District.	Ayushi Trivedi	Department of Soil and Water Engineering	Dr. M. K. Awasthi	Ph. D.
6	Identification of Suitable Sites for Artificial Groundwater Recharge Using Geoinformatics in Ken River Basin, India.	Deepak Patle	Department of Soil and Water Engineering	Dr. M. K. Awasthi	Ph. D.
7	Demarcation of Groundwater Potential Zones of Tons Basin using Geoinformatics.	Neelam Bunkar	Department of Soil and Water Engineering	Dr. R. K. Nema	Ph.D.
8	Study on Prioritization of Sub-watersheds through Integration of Land Use Land Cover Factors with Morphometric Parameters.	J Himanshu Rao	Department of Soil and Water Engineering	Dr. S.K. Sharma	Ph. D.
9	Deciphering the Mechanism of Resistance for Dry Root Rot and Terminal Heat Stress Resistance in Chickpea applying Genetic, Genomic and proximal remote sensing based phenomics approaches.	Deepak Katkani	Department of Plant Breeding and Genetics	Dr. Anita Babbar	Ph. D.
10	Characterization of the plant growth regulators for alteration of growth,	Rohit kumar kumawat	Department of Plant physiology	Dr. Gyanendra Tiwari	Ph. D.

	physiology and high temperature stress tolerance mechanism in wheat (*Triticumaestivum*L.) through ground based proximal remote sensing.				
11	Application of proximal remote sensing elicited from plant phenomics approaches and characterization of chilli genotype for heat stress.	Ms. Shweta Tiwari	Department of Plant Breeding and Genetics	Dr. Kanchan Bhan	Ph. D.
12	Morphometric study for prioritization of sub-watersheds using Principal Component Analysis: A Geospatial Technique based approach.	Suruchi Vishwakarma	Department of Soil and Water Engineering	Dr. M. K. Hardaha	M. Tech.
13	Land use and land cover classification of Betwa basin using spatial data	Vipin Kumar Mishra	Department of Soil and Water Engineering	Dr. M. K. Awasthi	M. Tech.
14	Characterization of yellow stem borer (YSB) infestation in rice crop through ground based hyperspectral remote sensing under field conditions.	Salil Dwivedi	Department of Entomology	Dr. S. B. Das	Ph. D.

Table 3.3.2 Progress work in Post Graduate and Doctoral Research

S. No	Title	Objective	Progress
1	Characterization of the efficacy of plant growth regulators for high-temperature stress mitigation in chickpea (*Cicer arietinum* L.) through ground based proximal remote sensing.	1. To quantitatively assess the high temperature stress in chickpea plants using hyperspectral remote sensing. 2. To test the possibility of application of some bioregulators in improving growth, Leaf Area Index, biomass partitioning and yield under high temperature stress condition. 3. To analyze physio-biochemical alterations to gain insight into the mechanisms of bio-regulators induced high temperature stress tolerance. 4. Spectral Characterization of plant growth regulators mediated high temperature stress mitigation in chickpea through ground-based hyperspectral remote sensing.	• Estimation of stress and physio-biochemical tolerance traits in lab. • Research paper mining. • Data compilation of the 1st trial.
2	Computation of carbon sequestration of mango (*Mangiferaindica* L.) orchards of Jabalpur district using geoinformatics.	1. To identify carbon sequestration potential of mango orchards. 2. To estimate the above ground carbon sequestration of mango orchards using satellite data. 3. To analyze the relationship between the amount of above ground carbon sequestration and vegetation indices obtained from remotely sensed data.	• Survey of mango orchards of village Nanakheda (Jabalpur block), village Gurupipriya and Madwa (Patan block) of Jabalpur district. • Acquisition of field data (ground truth data). • Estimation of carbon sequestration through conventional method.

S. No	Title	Objective	Progress
3	Spatial mapping and characterization of Mango *(Mangiferaindica*L.) orchards using Remote Sensing and GIS in Jabalpur District of Madhya Pradesh.	1. To study about total area of mango orchards in Jabalpur block. 2. Assessment of spatial mapping of mango orchards.	• Survey of mango orchards of village Nanakheda (Jabalpur block), village Gurupipriya and Madwa (Patan block) of Jabalpur district. • Acquisition of field data (ground truth data). • Theses writing (Introduction and Review of literature)
4	Characterization of Fall Army Worm (FAW) Infestation in Maize Crop through Ground Based Hyperspectral Remote Sensing Under Field Conditions.	1. To characterize spectral signatures of FAW infested maize. 2. Derive hyperspectral vegetation indices to assess FAW damage levels in maize with spectral bands sensitive to the pest infestation. **3.** To establish a relationship between FAW infestation gradient with changes in leaf chlorophyll, nitrogen & relative water content and spectra in maize.	• Field preparation • Net installation in field • Maize sowing • Crop maintenance • Fall Armyworm Population dynamics observations • Mass rearing of Fall Armyworm • Mass rearing of predator lady bird beetle
5	Diagnostic Analysis and Planning of Rejuvenation of Kanari River in Jabalpur District.	1. Diagnostic study for flow retardation in Kanari river. 2. To analyse rainfall-runoff-recharge interaction for river watershed. 3. To plan measures to rejuvenate the river.	• Groundwater recharge rate and runoff was estimated coupling the SWAT model with meteorological data. • National atlas on aquifer systems of India was geo-referenced and the type of aquifer was extracted for the kanari river watershed using various tools of ArcGIS. • Groundwater storage volume was calculated by considering the saturated thickness and specific yield. • Domestic water demand, agriculture water use, pumping and livestock water demand was estimated for water budgeting.

6	Identification of Suitable Sites for Artificial Groundwater Recharge Using Geoinformatics in Ken River Basin, India.	1. To prepare spatial maps on different themes contributing to availability of groundwater. 2. To demarcate the groundwater potential zones and validation. 3. To identify suitable sites for augmentation of groundwater recharge in critical areas.	• Geomorphology map of Ken River Basin has been prepared. • Depth to water level data has been collected from Madhya Pradesh State Ground Water Data Centre, Bhopal and from Uttar Pradesh Ground Water Department, Luknow and processed. • Permanent Observation Wells (POWs) location map of Ken River Basin has been prepared. • Depth to water level map (Pre-monsoon and Post-monsoon of year 2020) of Ken River Basin has been prepared.
7	Demarcation of Groundwater Potential Zones of Tons Basin using Geoinformatics.	1. To prepare spatial map of different themes contributing to availability of groundwater. 2. To develop decision making criteria for groundwater potential zones based on thematic maps. 3. To demarcate the groundwater potential zones, Interpretation, analysis and verification.	• Methodology and Results of different prepared maps viz geology, geomorphology, lineament density, rainfall maps were written. • Details of different methods used to demarcate groundwater potential zones were written. • Review research papers regarding collection of secondary data for validation of groundwater potential map.
8	Study on Prioritization of Sub-watersheds through Integration of Land Use Land Cover Factors with Morphometric Parameters.	1. To derive morphometric parameters of sub-watersheds through geoinformatics. 2. To analyse land use land cover classes in the study area. 3. To prioritize sub-watersheds using integrated approach of morphometric parameters and land use land cover classes.	• Sentinel 2B satellite images T44QMK, T44QML, T44QNK and T44QNL 18th January 2021 was utilized for LULC mapping. • Pre-processing techniques were applied and unsupervised classification method was used for preparing the broad categories of LULC. Satellite image was classified by on screen visual interpretation technique, based on the available

			ancillary data, prior knowledge using image processing software. • Six major classes were used namely agricultural land, forests, wasteland, fallow land, habitation (built-up) and water bodies for LULC map. • Accuracy obtained for LULC map was 80%.
9	Deciphering the Mechanism of Resistance for Dry Root Rot and Terminal Heat Stress Resistance in Chickpea applying Genetic, Genomic and proximal remote sensing based phenomics approaches.	1. Spectral characterization of dry root rot infected and high temperature stressed plants. 2. Identification of spectral signature and suitable chickpea genotypes under different environments. 3. Characterization of chickpea genotypes for high temperature stress tolerance and dry root rot resistance and its association with morphological, physiological and proximal remote sensing based spectral data. 4. Mapping QTLs/genomic regions responsible for resistance to Rb and terminal heat stress.	• Morphological characterization of chickpea done based on various morphological and post-harvest data. • Quantitative data collection done in all the three dates of sowing. • Sowing of chickpea in nursery trays for pathogenicity test of Dry root of disease. • Isolation of fungus from previously collected sample and make pure culture. • Preparing various chemical solution for isolation of DNA. • Searching the research paper related to signature of diseased plants, remote sensing and heat stress. • Ranking of genotypes based on suitability under all micro environments.
10	Characterization of the plant growth regulators for alteration of growth, physiology and high temperature stress tolerance mechanism in wheat (*Triticumaestivum*L.)	1. To quantitatively assess the high temperature stress in wheat using proximal remote sensing 2. Spectral Characterization of plant growth regulators mediated high temperature stress mitigation in wheat through ground-based hyper spectral remote sensing.	• Analysis of different stress related biochemical traits viz; Peroxidase, SOD, • Seed quality attributes • Test of Seed germination and seed vigour test • Data analysis of first year trial.

	through ground based proximal remote sensing	3. To adjudge the possibility of application of some bio-regulators in alteration of phenology, growth analytical traits, biomass partitioning and productivity under high temperature stress condition. 4. To analyze physio-biochemical alterations to gain insight into the mechanisms of bio-regulators induced high temperature stress tolerance.	
11	Application of proximal remote sensing elicited from plant phenomics approaches and characterization of chili genotype for heat stress	1. Spectral characterization and identification of spectral signature of chilli genotype collected from different region of Madhya Pradesh 2. Validation of protocol for screening of high temperature stress tolerance through multispectral and hyper spectral imaging technologies. 3. Screening of chilli genotypes for high temperature stress tolerance on the basis of physiological, cytological and biochemical traits. 4. To study association among heat tolerant and yield contributing traits. 5. To assess genetic diversity of identified genotypes for traits under study. 6. To identified putative genotypes for yield traits under thermal stress condition and are widely adaptable and stable over environments.	• Two nursery preparation and transplanting of chili had been done with interval of almost one month. • The morphological assessment of chili genotypes at vegetative stage had been completed • Canopy Temperature determination at control environment was been done.

12	Morphometric study for prioritization of sub-watersheds using Principal Component Analysis: A Geospatial Technique based approach.	1. To derive morphometric parameters of sub-watersheds in GIS environment. 2. To determine inter-correlation amongst the morphometric parameters. 3. To prioritize sub-watersheds of Banjar river for soil conservation.	• Derived morphometric parameters of sub-watersheds. • Principal component analysis for inter correlation among the 14 morphometric parameters. • Prepared decision making criteria. • Prioritized sub-watersheds based on both compound parameter & PCA approach.
13	Land use and land cover classification of Betwa basin using spatial data	1. Identification of Betwa basin and its characteristics. 2. Land use land cover mapping of the Betwa basin. 3. To estimate irrigated land based on land use land cover mapping and spatial data in Betwa basin.	• LULC classification of Betwa river basin is done and LULC map is prepared. • MODIS NDVI time series data of study area is procured from USGS earth explorer.
14	Characterization of yellow stem borer (YSB) infestation in rice crop through ground based hyperspectral remote sensing under field conditions.	1. To characterise spectral signatures of YSB infested rice 2. Derive hyperspectral vegetation indices to assess YSB damage levels in rice with spectral bands sensitive to the pest infestation 3. To establish a relationship between YSB infestation gradient with changes in leaf chlorophyll, nitrogen & relative water content and spectra in rice.	• Preparation of nursery • Field preparation • Transplanting of paddy (Kranti variety) • Crop maintenance • Contingency sowing of paddy for feeding material YSB • Mass rearing of yellow stem borer

4. Preparation of spatial products containing information on special theme

4.1 Preparation of theme based map for preparing groundwater potential zone map of Jabalpur district

4.1.1 Rainfall Map

The annual mean grid rainfall data (0.25^0 x 0.25^0) from the year 1990 to 2019 of 21 grids obtained from the Indian Meteorological Department (IMD) website and these data are interpolated spatially using the inverse distance weighting method (Fig. 4.1.1). The annual average rainfall of study area was categorized into five classes which were; (i) 1207-1260 mm, (ii) 1261-1297 mm, (iii) 1298-1327 mm, (iv) 1328-1362 mm and (v) 1363-1424 mm.

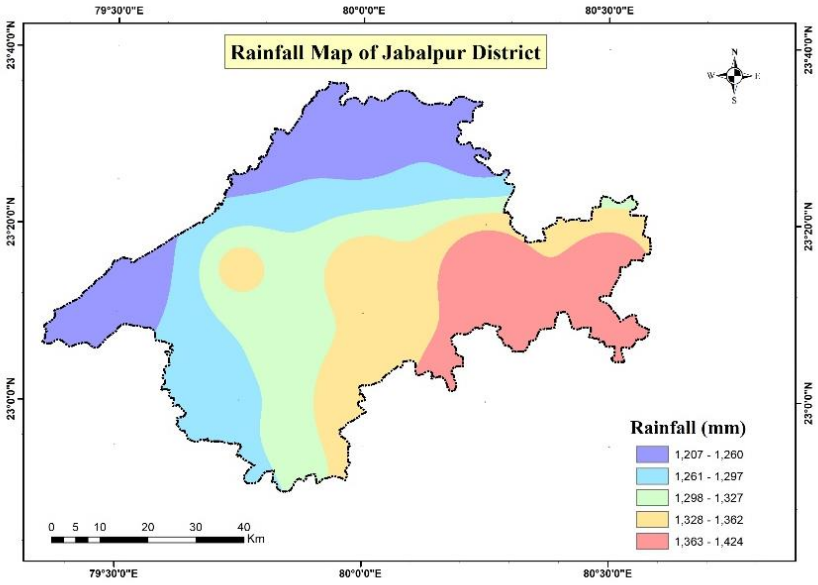


Fig. 4.1.1 Rainfall map of Jabalpur district

4.1.2 Lithology Map

The published geological map of the Geological Survey of India was used for digitizing different lithological units of the study area. Various types of lithological unit namely Dolomite, Banded jasper fractured (BJF), Quartzite, Metalava, Phyllite, Sandstone and Orthoquartzite, Laterite, Basalt, Granite, clay with caliche concretion, Sandstone, Conglomerate, Limestone, Shale, and Amphibolite found in study area (Fig. 4.1.2). Mainly, 37% of the total area in Jabalpur district, basalt is higher than another lithological unit.

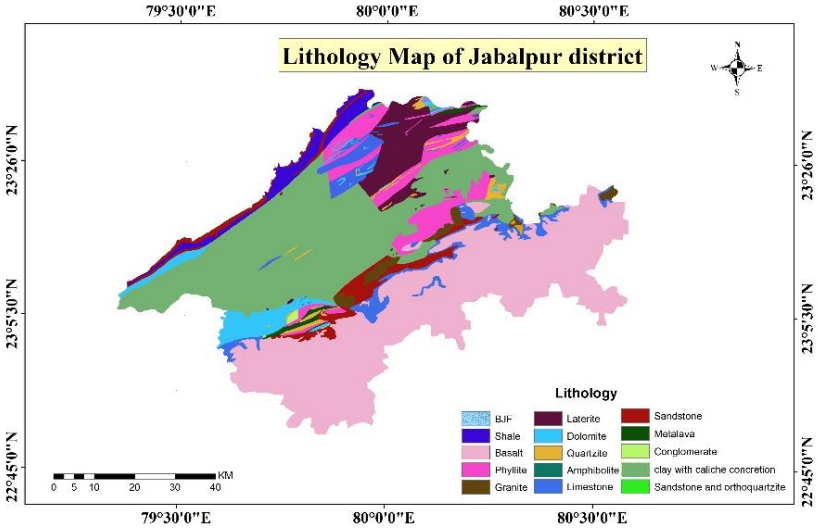


Fig. 4.1.2 Lithology map of Jabalpur district

4.1.3 Lineament Density Map

The lineament density map was prepared using line density in GIS software with the help of Bhuvan geoserver thematic layer and is depicted in Fig. 4.1.3. The data were reclassified into five categories - Very low (0–0.050 km/km^2), Low (0. 050–0.152 km/km^2), Moderate (0.152–0.283 km/km^2), High (0.283–0.464 km/km^2) and Very high (0.464–0.811 km/km^2). The lineament density map shows a low density in most of the area of the study area.

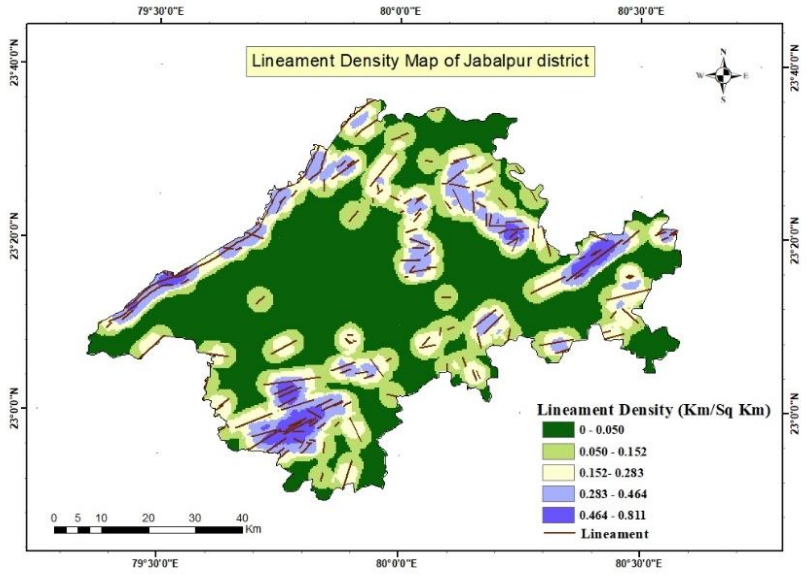


Fig. 4.1.3 Lineament Density map of Jabalpur district

4.1.4 Geomorphology Map

Geomorphology of the Jabalpur district is divided into various types of landforms viz., pediment–pediplain complex (32.8%), low-to-high dissected hills and valleys (8.37%), flood plains (0.79%), Alluvial plain (36.14%), Other waterbodies (1.81%), Active Quarry (0.01%), Dam and Reservoir (0.07%), Piedmont slope (0.22%), River (1.10%) and low to high dissected plateau (18.70%). Jabalpur district is mostly covered by Alluvial plain (Fig. 4.1.4).

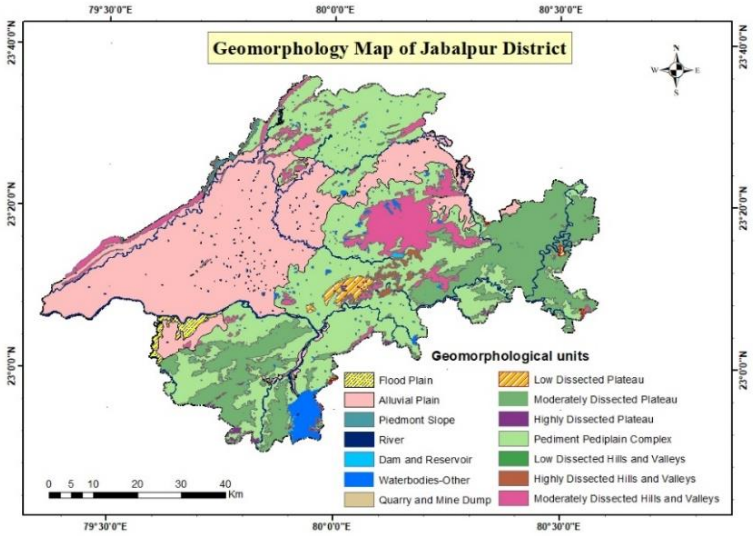


Fig. 4.1.4 Geomorphology map of Jabalpur district

4.2 Preparation of integrated map for decision making

4.2.1 Ground water potential zone map for Jabalpur district

Groundwater potential zone map for developmental blocks of Jabalpur district has been prepared using integrated remote sensing, geographic information system, and multi influencing factor (MIF) technique (Fig. 4.2.1).

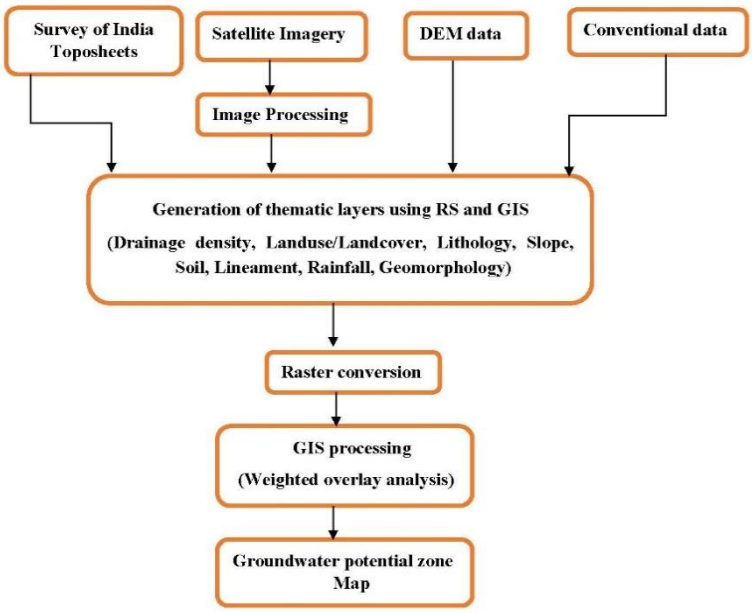


Fig. 4.2.1. Flowchart for delineating the groundwater potential zone

The generated groundwater potential zone of this study area was categorised into five zones, namely Very good, Good, Moderate, Poor and Very poor (Fig. 4.2.2). About 18.28 % of the study area has very good ground water potential zone and 21.90 % falls in the good zone category, as shown in Table 4.2.1. About 23.22 % of study area falls in the poor and 11.40 % in very poor ground water potential zone category. The results of the present study can serve as guidelines for planning future artificial recharge projects in the study area in order to ensure sustainable groundwater utilization. This is an empirical method for the exploration of groundwater potential zones using remote sensing and GIS, and it succeeds in proposing potential sites for groundwater zones.

Table 4.2.1. Area under various groundwater potential zone in Jabalpur district

Sr. No.	**Class Name**	**Area, km^2**	**Area, %**
1	Very Poor	576.46	11.40
2	Poor	1174.12	23.22
3	Moderate	1274.01	25.20
4	Good	1106.82	21.90
5	Very good	924.36	18.28
Total		5055.76	100.00

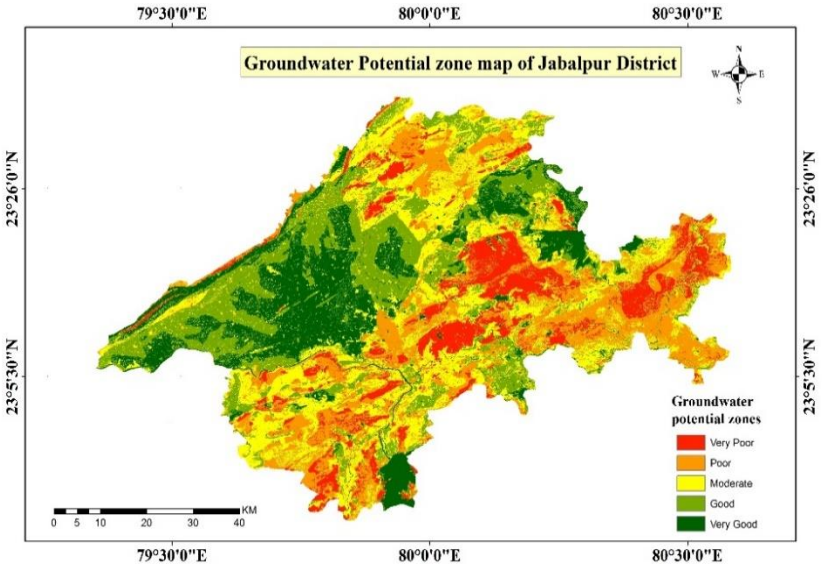


Fig.4.2.2 Groundwater potential zone map of Jabalpur district

4.3 Surface Water Dynamics Analysis Using Landsat 8 OLI Imagery and Google Earth Engine Cloud Platform: A Case Study of Madhya Pradesh, India

Landsat 8 OLI imagery (2014-2020) from GEE database were used to monitor changes of surface water extent in the Madhya Pradesh state from 2014 to 2020. Figure 4.3.1a shows that the study area is completely covered with 26 tiles according to the Earth Resources Satellite Worldwide Reference System (WRS-2). All available surface reflection data set of Landsat 8 OLI images (3690) was used on the GEE platform for the study area and for the period 1 January, 2014 to 31 December, 2020. These data sets were processed to mask the cloud and cloud shadow by the code based on the Function of Mask algorithm (CFMASK) before the water detection. The detail methodology for surface water body detection is shown in Fig. 4.3.2

After identifying the water pixel by the decision tree rule, the water frequency for each pixel was calculated by taking a ratio of the total number of water observations to the total number of good observations using all Landsat8 images within one year and multi-year. The unmasked pixels were treated as good observations whereas the masked pixels were defined as bad observations. Figure 4.3.1 (c and d) shows the total number of landsat8 observation (good observations + bad observations) and total number of good landsat8 observation from 2014 to 2020.

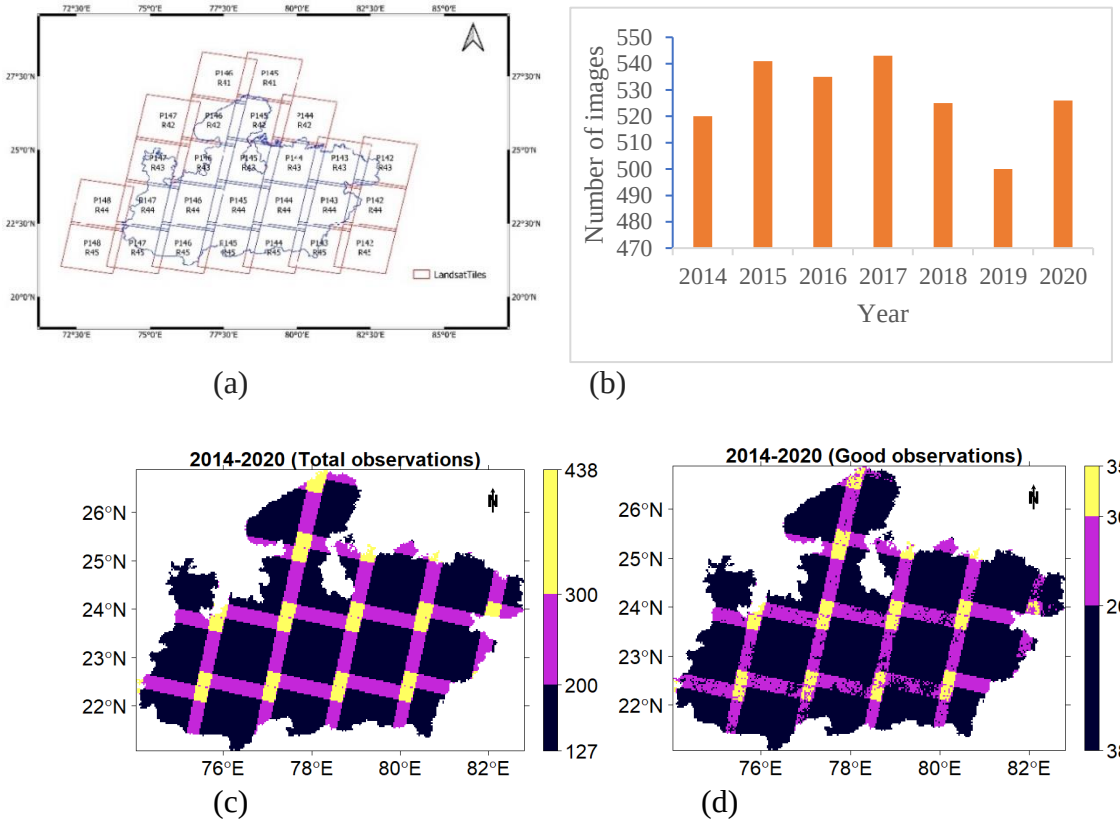


Fig. 4.3.1. (a) Spatial distribution of Landsat tiled with path and row over the study area; (b) Total number of Landsat8 images from 2014 to 2020; (c)Total number of landsat8 observation; (d)Total number of good observation for the study area.

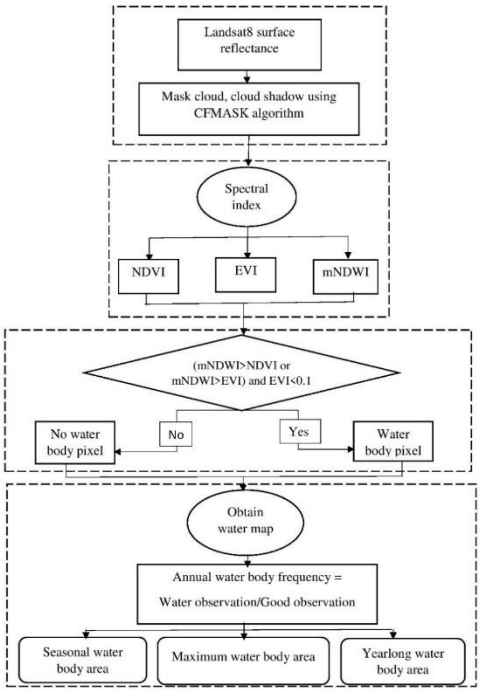


Fig. 4.3.2 Flowchart of the overall methodology of surface water mapping using Landsat 8 images and Google Earth Engine (GEE).

Spatial distribution of surface water body in Madhya Pradesh

The spatial distribution of water pixels in Madhya Pradesh state based on 2014 to 2020 Landsat 8 images is shown in Figure 4.3.3. In general, the seasonal and yearlong waterbody were 2858.2 km^2 and 2657.6 km^2, accounting 51.81% and 48.18% of the total surface water bodies in Madhya Pradesh state, respectively. The pixels area with $wf \geq 0.25$ accounted for 1.79 % of the total area of the Madhya Pradesh state. The water pixel frequency distribution with 8 water frequency levels from 2014 to 2020 is shown in Figure 4.3.4. It has been observed that, the maximum water pixel lies in the frequency range of 0.95 to 1. The number of water pixel in the frequency range of 0.25 to 0.35 is more in 2019 and the other water frequency levels are more or less. The spatial distribution of annual water frequency at different levels indicates that 63%, 53%, 42%, 61%, 47%, 43% and 64% of the water pixel have frequency greater than or equal to 0.75 in 2014, 2015, 2016, 2017, 2018, 2019 and 2020 respectively. These water pixels consist of the interior of a reservoir, a large lake and a river, which are the prime sources of water and can maintain water throughout the year. The seasonal water body were characterized by the water pixel of shallow water body and the water pixel at the edges of streams, pond & large water body which exists in the wet season and may dry up in the dry season.

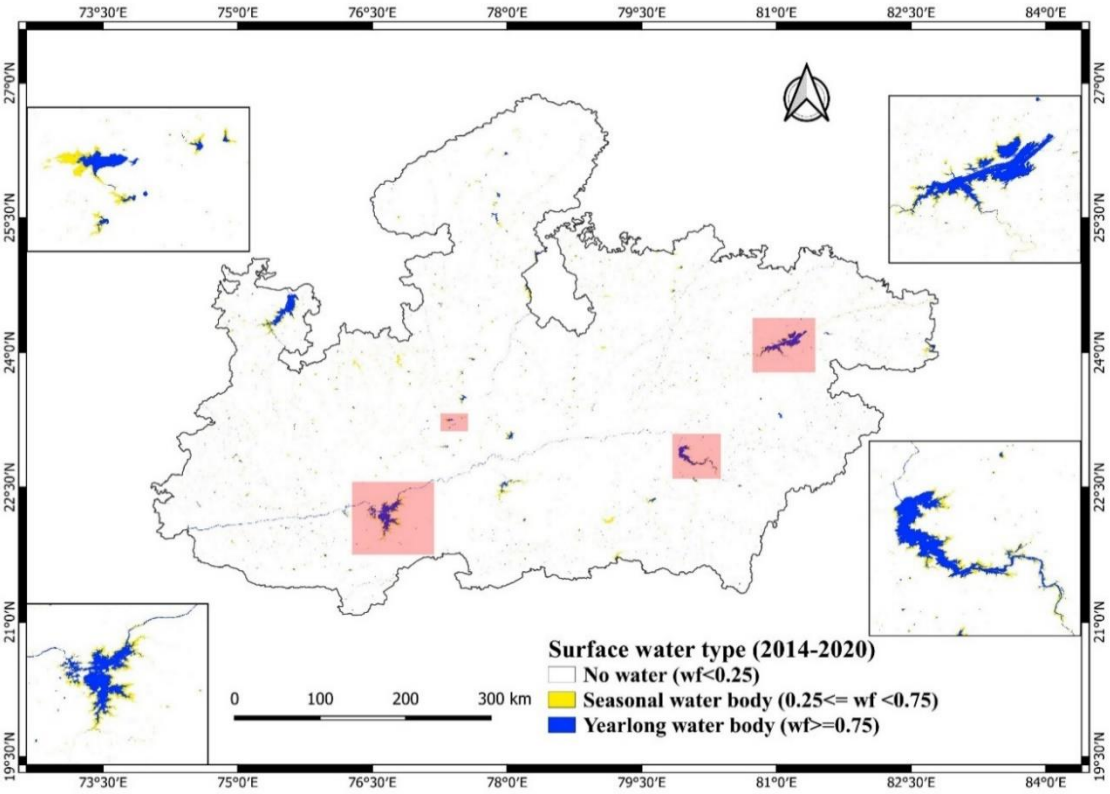


Fig. 4.3.3 The spatial distribution of surface water in Madhya Pradesh state based on 2014 to 2020 Landsat 8 images.

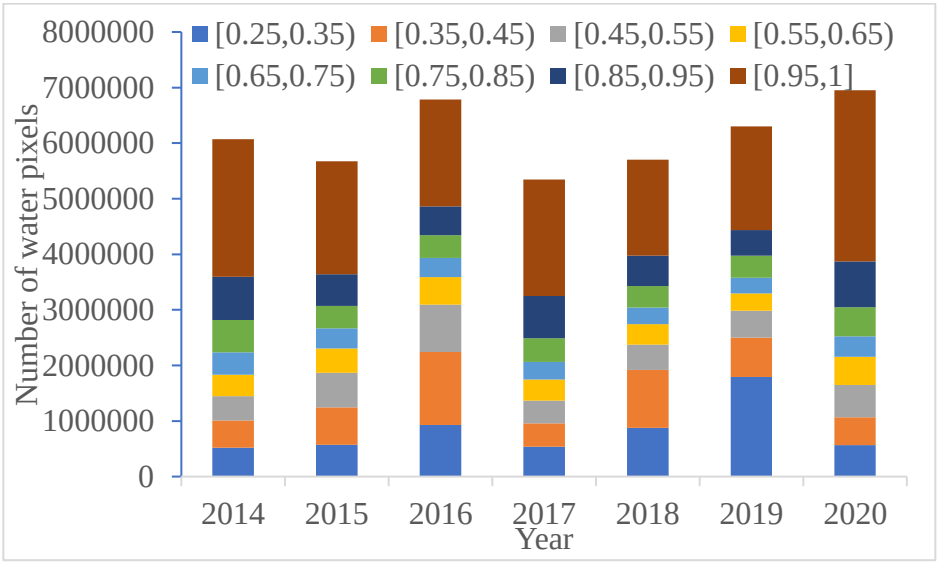
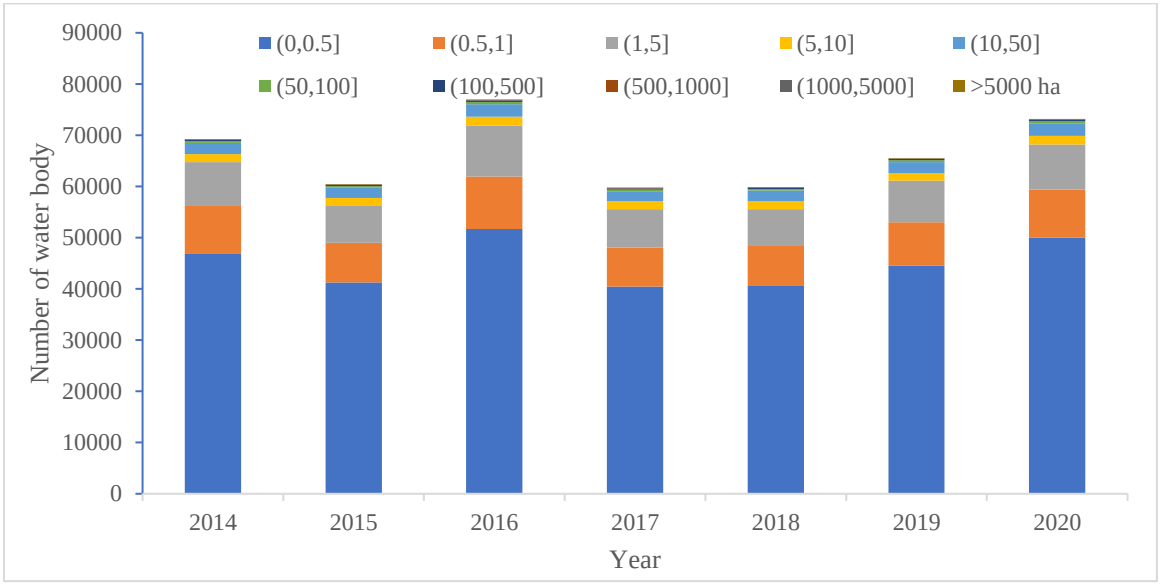


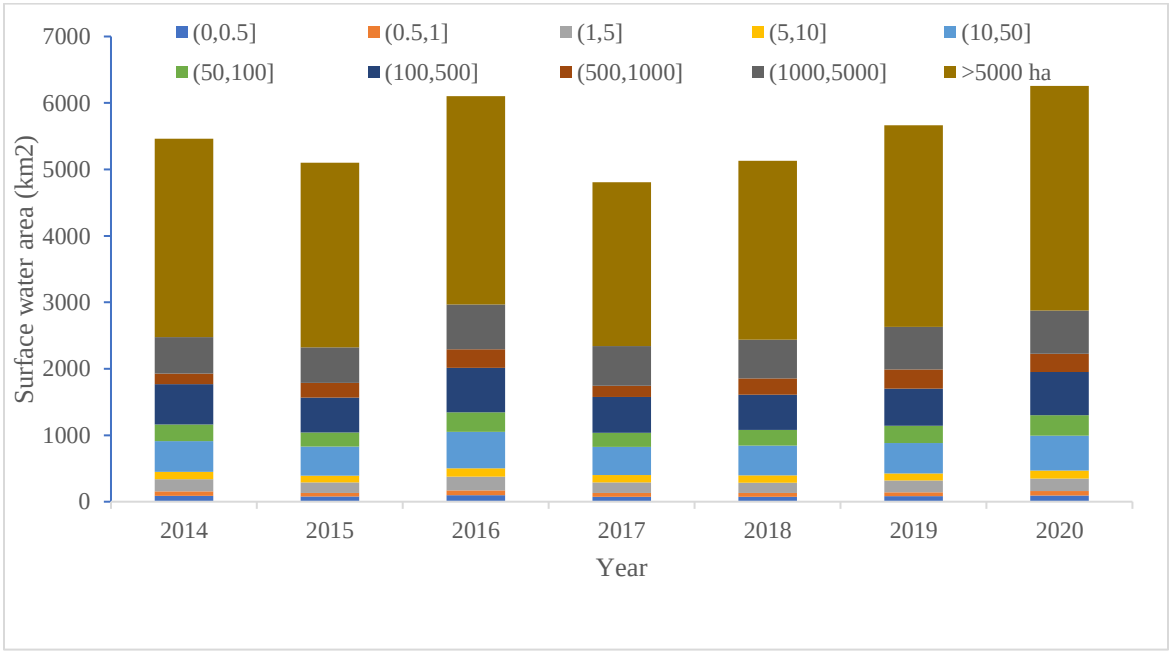
Fig. 4.3.4 Number of water pixels distribution at different frequency levels with a bin of 0.1 during 2014-2020.

The number and area distribution of open surface water bodies at different size levels are shown in Figure 4.3.5. The water bodies are divided into ten categories based on the size. During 2014 to 2020,

the maximum water bodies having surface area greater than 100 ha accounts 0.54% the total number of maximum water body and accounted for 73.53% of the total maximum water body area.



(a)



(b)

Fig. 4.3.5 The numbers and area distribution of the maximum surface water body at different size levels during 2014-2020; (a) the number of maximum surface water body, (b) the area distribution of maximum surface water body

The number of surface water bodies of surface area larger than 500 ha accounted 0.11% of the total number of surface water bodies and accounted for 60.33% of the total maximum water body area. However, the maximum water bodies which have area less than 0.5ha accounted for 67.86% of the total number of surface water bodies and accounted for 1.34% of the total maximum water body area. These results indicated that the change of water body number in Madhya Pradesh state is mainly influenced by small water bodies, while the change of water body area is influenced by large water bodies.

Temporal variation of surface water in Madhya Pradesh from 2014 to 2020.

The year wise surface water extent in Madhya Pradesh from 2014 to 2020 is given in Table 4.3.1. The highest maximum surface water area (6258.8 km^2) was observed in 2020 and lowest (4811.7 km^2) was observed in 2017. The seasonal surface water area varied from 1858.1 km^2 (2017) to 3541.7 km^2 (2016). The yearlong surface water area was found higher in the year 2020 (3984.9 km^2) and lower in 2018 (2396.8 km^2). The ratio of yearlong water body area to seasonal water area was found greater than 1 except in the year 2016, 2018 and 2019.

Table 4.3.1: The dynamics of surface water area in Madhya Pradesh from 2014 to 2020

Year	Area (km^2)		
	Maximum surface water	Seasonal surface water	Yearlong surface water
2014	5465.9	2013.1	3452.8
2015	5105.0	2399.1	2705.9
2016	6108.6	3541.7	2566.9
2017	4811.7	1858.1	2953.6
2018	5134.8	2738.0	2396.8
2019	5669.7	3221.6	2448.2
2020	6258.8	2273.8	3984.9
2014-2020	5515.8	2858.2	2657.6

Relationship between precipitation and surface water area in Madhya Pradesh

Table 4.3.2: Statistical summary of the linear correlation between the monsoon rainfall and surface water body area from 2014 to 2020.

Surface water body type	Monsoon rainfall	
	r	*p*-value
Maximum surface water	0.33	0.47

Seasonal surface water	0.86*	0.014
Yearlong surface water	-0.60	0.15

During the period of 2014-2020, the seasonal surface water area showed the significant positive correlation with the monsoon rainfall (Table 4.3.2). At the same time, the maximum surface water area and yearlong surface water showed the non-significant positive and negative correlation with monsoon rainfall respectively. The result indicated that rainfall was the important factor that influence the seasonal surface water area in study area.

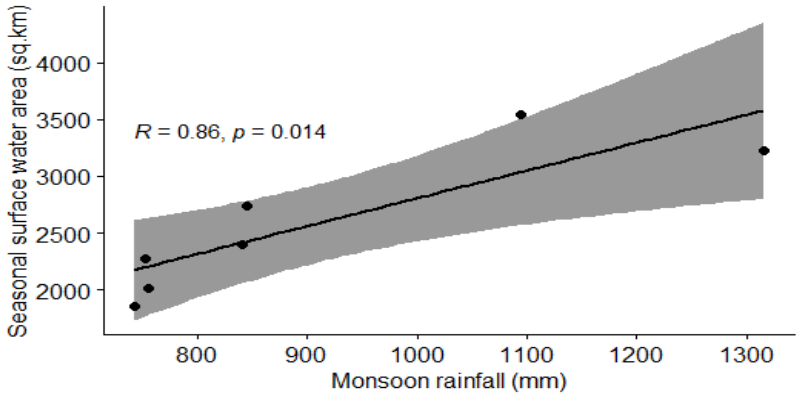


Fig.4.3.6 Scatter plot between monsoon rainfall and seasonal surface water area.

The combined use of indices and GEE reduced the burden of manual classification, and it increased productivity, accuracy, and quality for water surface monitoring and assessment.

4.4 Change detection pattern for investigating land cover dynamics using multispectral satellite data in Jabalpur district

A study has been undertaken with the aim to find "change detection pattern of land use/land cover in Jabalpur district using multispectral satellite data". For this analysis, Landsat-7 (28-03-2000), Landsat-7 (28-03-2010) and Landsat-8 (28-03-2020) satellite data of different years were used to investigate the LU/LC change detection of Jabalpur district over 20 years.

LULC of Jabalpur district in 2000

The LULC map layout generated from the Landsat -7 data set is displayed in Figure 4.4.1. The land categories for the year 2000, and their statistics are listed in Table 4.4.2. According to the results, the largest category was agriculture land (40.40% of the total area), followed by open land (35.73% of the total area). The remaining land use categories were forest (20.75% of the total area), waterbody (1.77% of the total area) and settlements (1.33% of the total area).

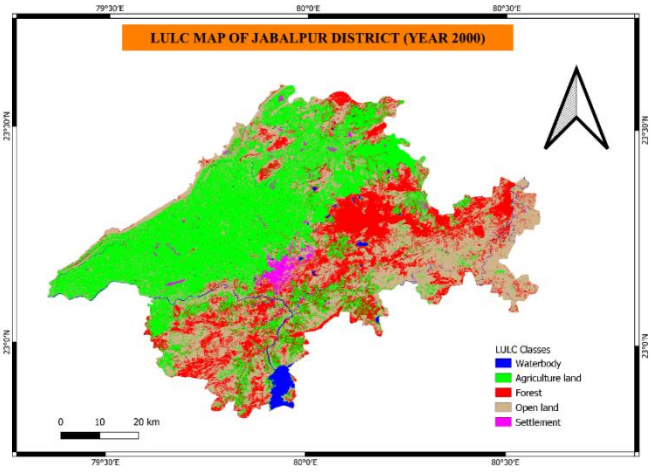


Fig. 4.4.1 LULC map of Jabalpur district for the year 2000

LULC of Jabalpur district in 2010

The LULC map layout generated from the Landsat -7 data set is displayed in Figure 4.4.2. The land categories for the year 2000, and their statistics are listed in Table 4.4.2. According to the results, the largest category was agriculture land (43.56% of the total area), followed by open land (35.92% of the total area). The remaining land use categories were forest (17.67% of the total area), waterbody (1.42% of the total area) and settlements (1.40% of the total area).

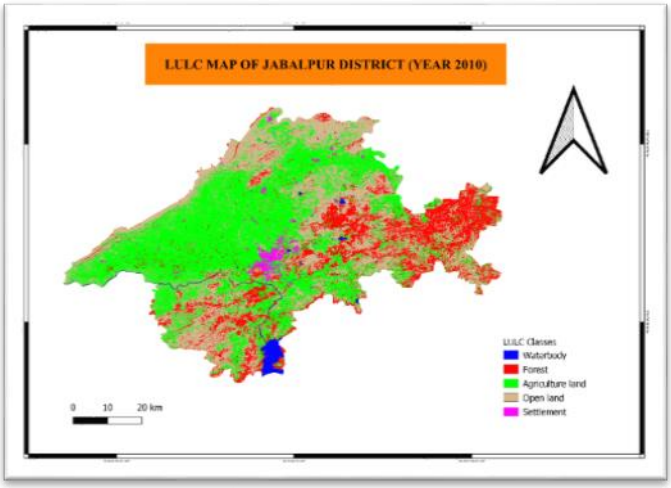


Fig. 4.4.2 LULC map of Jabalpur district for the year 2010

LULC of Jabalpur district in 2020

The LULC map layout generated from the Landsat -7 data set is displayed in Figure 4.4.3. The land categories for the year 2000, and their statistics are listed in Table 4.4.2. According to the results, the largest category was agriculture land (48.08% of the total area), followed by open land (30.36% of

the total area). The remaining land use categories were forest (17.61% of the total area), waterbody (2.11% of the total area) and settlements (1.89% of the total area).

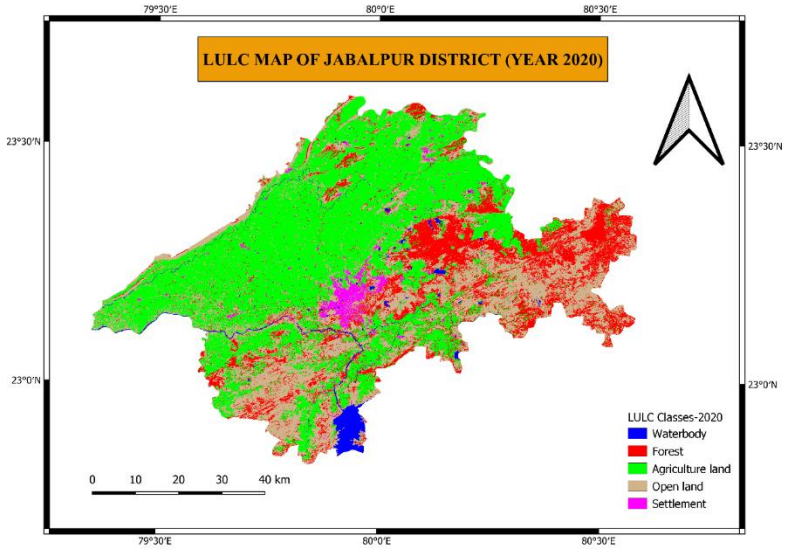


Fig. 4.4.3 LULC map of Jabalpur district for the year 2020

Table 4.4.1. Area in ha under different classes

LAND USE LAND COVER OF JABALPUR DISTRICT			
	Area in ha		
CLASS	JBP-2000	JBP-2010	JBP-2020
1.WATERBODY	8976.6	7197.12	10682.6
2.FOREST	104845	89310.08	88903.2
3.AGRICULTURE	204124	220105	242773
4.OPEN LAND	180522	181505.6	153286.9
5.SETTLEMENT	6747	7096.86	9568.98
TOTAL	505215	505214.66	505214.7

Table 4.4.2. Area in percentage under different classes

LAND USE LAND COVER OF JABALPUR DISTRICT		
CLASS	Area in percentage	

	JBP-2000	JBP-2010	JBP-2020
1.WATERBODY	1.77	1.42	2.11
2.FOREST	20.75	17.67	17.61
3.AGRICULTURE	40.40	43.56	48.08
4.OPEN LAND	35.73	35.92	30.36
5.SETTLEMENT	1.33	1.40	1.89
TOTAL	100.00	100.00	100.00

ERDAS software's was used to identify the changes. The classification has been done using five land cover viz. water body, Agriculture, forest, open land, and residential land classes. Pre-processing and classification of the images had analyzed carefully and accuracy assessment was tested separately. The results showed that overall accuracy in the Jabalpur district was 82.50%, 83.99% and 86.96 % for the years 2000, 2010 and 2020 respectively. The result of the study indicated that in the last 20 years period, the most extensive land cover category of the District in 2000, 2010 and 2020 is agricultural land i.e. 40.40%, 43.57% and 48.09% respectively. The second most extensive land cover category is open land i.e. 35.73%, 35.92% and 30.29% in the year 200, 2010 and 2020 respectively. Forest area shows significant difference in all three map. The major change (+7.69%) identified, in the study, was in Agricultural area from 2000 to 2020.

4.5 Spatiotemporal Ground water trend analysis in Tons basin of Madhya Pradesh, India

Understanding the spatial-temporal distribution and change in ground water trend is a primary and critical requirement for effective water resource planning and management. It also has several international summits, excessive exploitation of ground water are increasing day by day. The Tons river is a tributary of the Ganga river, originating at Tamakund in the Kaimur Range in Madhya Pradesh (M.P.) at an elevation of 610 m. Belan, Mahana, Beehar Simrawal, Karihari and Nar are some of the tributaries of the Tons. The geographical extent of the basin lies between 80^0 20` E to $83^0$ 25` E longitudes and 23^0 57` N to $25^0$ 20` N latitudes with total catchment area is approximately more than 17,441 km2, out of which 12,165 km2 (70%) lies in Madhya Pradesh and the remaining area of 5276 km2 (30%) lies in Uttar Pradesh (Fig. 4.5.1). The current study looks into non parametric statistical methods for identifying trends in groundwater levels in the blocks of Satna and Rewa districts which lies on Tons Basin.

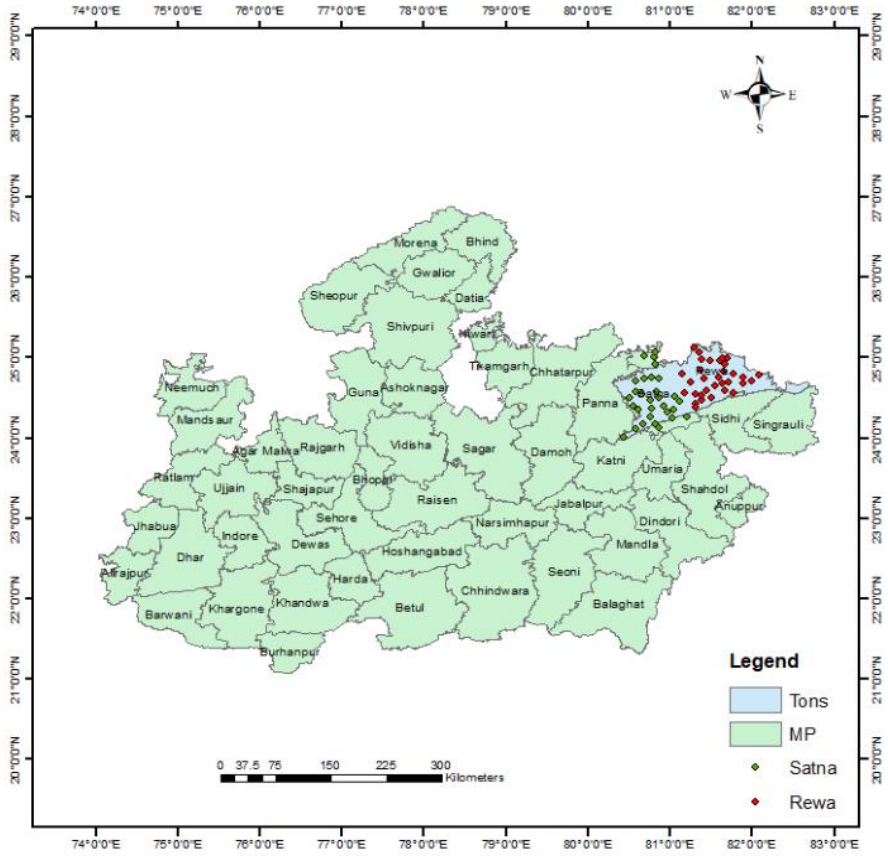


Fig.4.5.1. Location map of observation wells in various blocks of Satna & Rewa districts under Tons basin.

The groundwater level data for various blocks of Rewa and Satna district during the winter (i.e. Rabi session), Pre-monsoon, Monsoon and Post-monsoon seasons for a period of 18 to 26 years have been used in the analysis. The average ground water level of Tons basin for Pre Monsson, Monsoon, Post Monsoon and Winter session were assessed and their spatial distribution were presented in the Figure 4.5.2. The average premonsoon depth to ground water level found to be ranging between 4.59 m to 18.68. The stations especially in Rewa district are showing greater depth to ground water level as compared to Satna District. The Post Monsson depth of Tons basin found to be in range of 2.05 m to 16.9 m. Based on an analysis of seasonal groundwater levels, the nonparametric Mann Kendal and Sens slope estimator tests were used to detect trends. Kendal's test was used to identify the trend that persisted in the data, and the Sen slope estimator test was used to determine the magnitude of the slope.

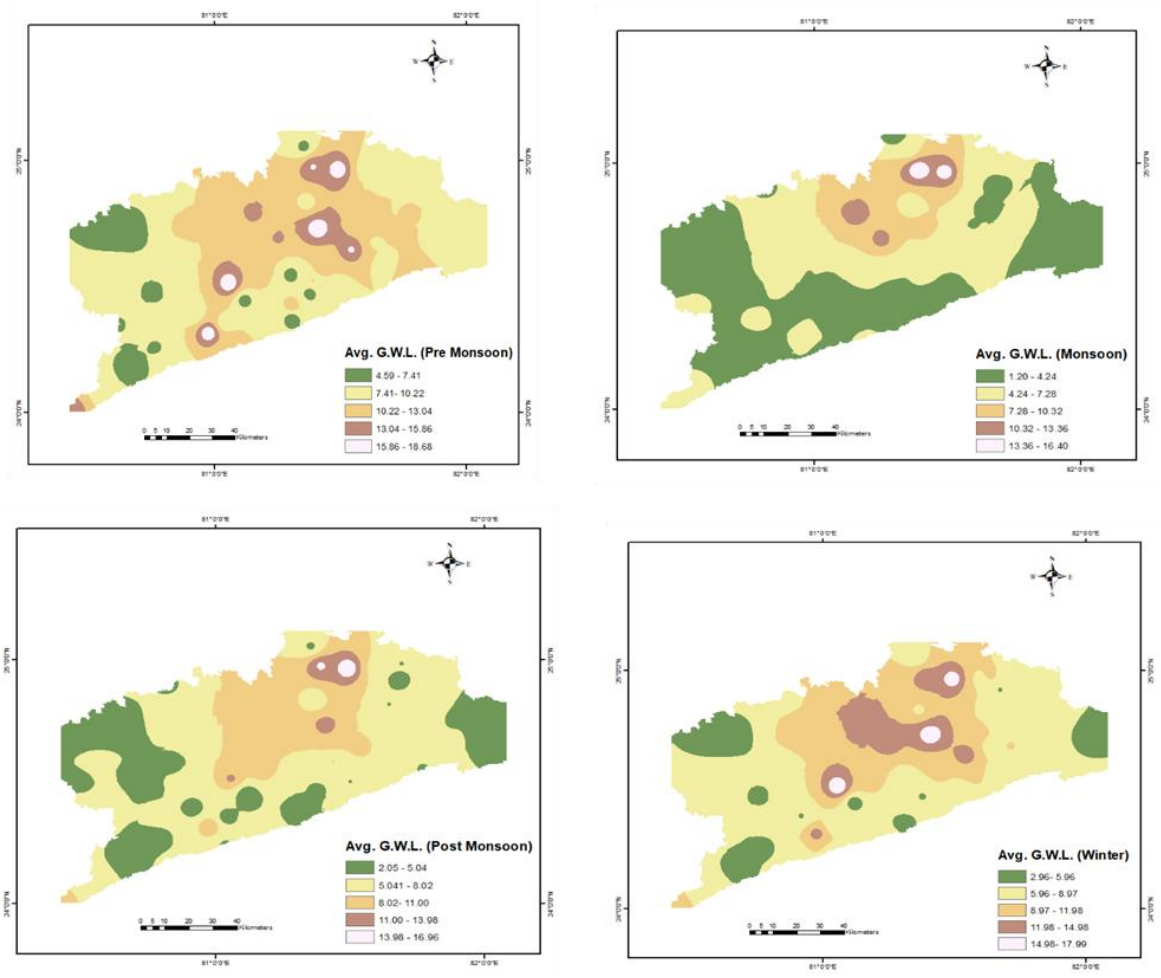


Fig. 4.5.2. The spatial distribution of average ground water level of Tons basin

Based on results, the spatial trend values have been plotted for Tons basin (Figure 4.5.3) and it has been revealed that Majority of the stations in Rewa and Satna are showing the increasing trend. However some of the stations showing the downtrend as well especially in Satna District. There were significant increasing trend changes were observed in Gangeve, Jawa, Mauganj, Naigarhi, Rewa in Rewa district. Similarly Sohawal, Unchahara blocks in Satna also showed significant positive trend change which means depth to ground water significantly increased in these blocks. On contrast Maihar and Ramnagar blocks of Satna District showed the significant decreasing trend over the 22 years of selected period. It can also be revealed that there is variability of trend change in different sessions but few area's especially in Rewa district in quite prominent and showing the trend change in mostly all the sessions

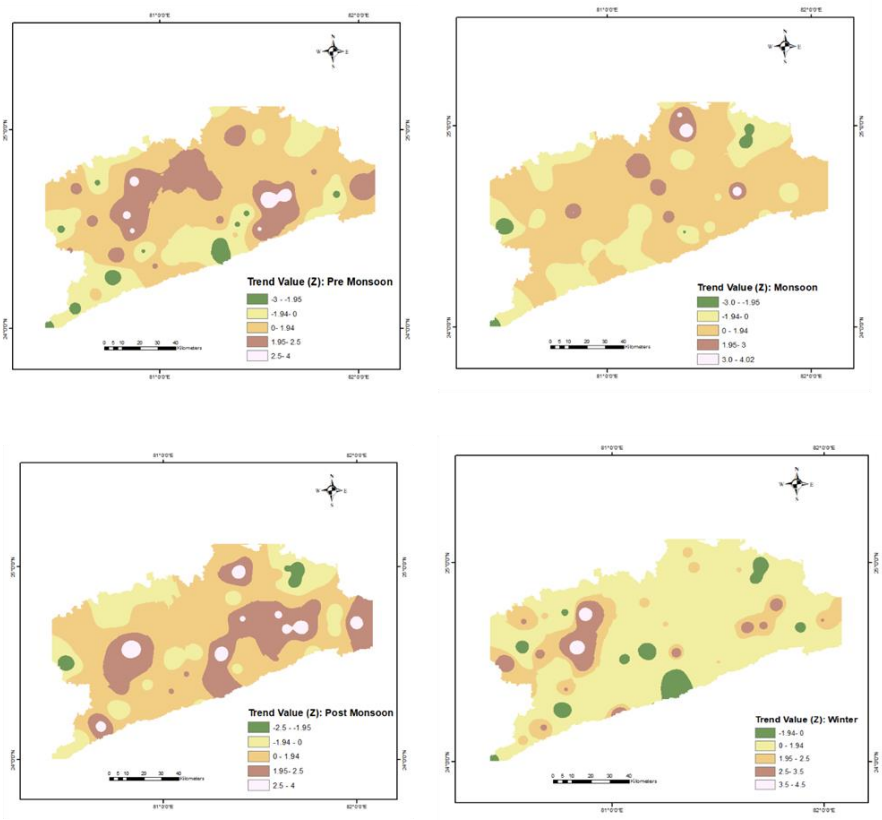


Fig. 4.5.3 Spatial trend of average groundwater level of Tons basin

Despite the fact that there was a lot of variation in the trend and magnitude of ground water trend. Overall, it can be seen that from 1996 to 2018, 14 satiation out of 75 stations had a statistically positive annual ground water trend. The rest of the stations have shown no discernible trend. The analysis shows that the groundwater level time series are cyclical, with seasonal variation in all blocks and a ground water declining trend were identified in few blocks. As a result, future ground water trends and magnitudes may be significantly greater than what has been observed thus far.