Climate Change Impacts Studies for Rajasthan (Areas of Inland Drainage and Mahi Basin)

By

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With

IIT Delhi and CU Rajasthan

Project Team

Principal Investigator

- Dr. Mahender Choudhary, Professor Department of Civil Engineering, Malaviya National Institute of Technology Jaipur

Co- Investigators

- Dr. Y. P. Mathur, Professor Department of Civil Engineering, Malaviya National Institute of Technology Jaipur
- Dr. M. K. Jat, Professor Department of Civil Engineering, Malaviya National Institute of Technology Jaipur
- Dr. Rohit Goyel, Professor Department of Civil Engineering, Malaviya National Institute of Technology Jaipur
- Dr. Sudhir Kumar, Professor Department of Civil Engineering, Malaviya National Institute of Technology Jaipur
- Dr. Gunwant Sharma, Professor Department of Civil Engineering, Malaviya National Institute of Technology Jaipur
- Dr. Urmila Brighu, Professor Department of Civil Engineering, Malaviya National Institute of Technology Jaipur
- Dr. B. R. Chahar, Professor Department of Civil Engineering, IIT Delhi New Delhi
- Dr. Devesh Sharma, Department of Environmental Science, Central University of Rajasthan, Kishangarh, Ajmer .

Institutes Involved

Research Station/Institute

- Malaviya National Institute of Technology Jaipur, J.L.N. Marg, Jaipur-302017.

Partner Institute

- Indian Institute of Technology Delhi, Hauz Khas, New Delhi-110017

- Central University of Rajasthan, Kishangarh, Ajmer

Manpower Requirement

S. No.	Activity	Responsible Expert & Station	Manpower required	Appointed	Duration (Year)
1	Literature Review & Data Collection	Complete Project Team	RA (01), JRF (04)		1
2	Trend Analysis	Dr. Devesh Sharma CURAJ	RA (1) JRF (1)	1 JRF appointed	2 3
3	Hydrological Modelling : Calibration, validation and generation of hydrologic responses and adaptation measures in allocation/use of water resources	Dr. Mahesh K Jat Dr. Mahender Choudhary & Dr. Rohit Goyal MNIT	RA (2) JRF (2)	1 RA & 2 JRF appointed	2 3
4	Development of crop production function and impact analysis, Adaptation of climate change in agriculture sector	Dr. Mahender Choudhary & Dr. Gunwant Sharma	RA (1) JRF (2)		1 2
5	Soil erosion responses under different scenarios	Dr. Mahesh K Jat & Dr. Mahender Choudhary	RA (1)		1
6	Adaptation measures in reservoir/canal operation	Dr. Y.P.Mathur & Dr. Gunwant Sharma	RA (1)	1 JRF appointed	1
7	Water quality assessment	Prof. Sudhir Kumar and Dr. Urmila Brighu MNIT	JRF (1)		2
8	Drainage studies	Prof. B.R.Chahar IITD	JRF (1)		2
9	Water demand management options for different sectors	Dr. Mahesh K .Jat & Dr. Mahender Choudhary	RA (1)		1
10	Mitigation strategies for extreme hydrological events i.e., flood and droughts	Dr. Mahender Choudhary Dr. Mahesh K. Jat & Dr. Devesh Sharma	RA (1)		1

JRF and RA

MNIT, Jaipur

- Five JRF were appointed in the project from which Two JRF are dropped out from the project. Currently Three JRF are working in the project.
- JRF are getting the salary of Rs 25000 + 20% HRA per month.
- One RA has been appointed.
- RA is getting the salary of Rs 38000+20% HRA per month.

CU, Rajasthan

- One JRF has been appointed in the project.

❖ Process for recruitment of other required JRF and RA is ongoing.

PhD Registered JRFs

- Mr. Ankan Jana

  PhD Topic: Impact of climate change and Adaptation measures of a river basin (tentative)

- Mr. Mithun Chaudhary

  PhD Topic: Hydrologic modelling and climate change using SWAT (tentative)

- Mr. Biltu Pal

  PhD Topic: Dam Break analysis (tentative)

Introduction

- The impact of Climate Change (CC) is being felt around the globe.
- Central Water Commission (CWC) has taken up basin level hydrological study under National Water Mission and PM's NAPCC
- The proposed project consists of the Area of Inland Drainage of Rajasthan & Mahi River Basin.
- First basin is part of The Thar Desert with its unique hydrological characteristics.
- Mahi Basin lies between east longitudes 72^0 15' to 78^0 15' and north latitudes 22^0 0' to 22^0 40' N respectively.

Study area (Area of Inland Drainage)

- It has an Arid Climate and slopes gently towards West – Southwest towards Indus River system.
- Annual rainfall is 100-400 mm with Natural recharge only 0–2% of precipitation.
- Rainfall is received mainly during monsoon season.
- The region receives water from Indira Gandhi canal system from which water is mainly used for drinking purpose and irrigation of Rabi crops.
- The soil formation consists of a thin veneer of Dune Sand of zero to few meters in thickness underlain by an impervious clay layer.


Punjab
Haryana
Rajasthan
INDIA
Indus (Up to border) Basin
Ghaggar and others Sub Basin
Luni Upper Sub Basin
Banas Sub Basin
Yamuna Mid
Ganga
Firozpur
Bathinda
Kurukshetra
Mansa
Patiala
Kaithal
Sirsa
Fatehabad
Jind
Ganganagar
Hanumangarh
Hisar
Sonipat
Rohtak
Bhiwani
Jhajjar
Gautam Bu
Bikaner
Churu
Mahendragarh
Jhunjhunun
Gurgaon
Alwar
Jaisalmer
Sukhri
Nagaur
Jaipur
Dausa
Jodhpur
Ajmer
Tonk
Karauli
Barmer
Pali
Sheopur
Jalor
Rajsamand
Bhilwara
Bundi
Kota
200 km

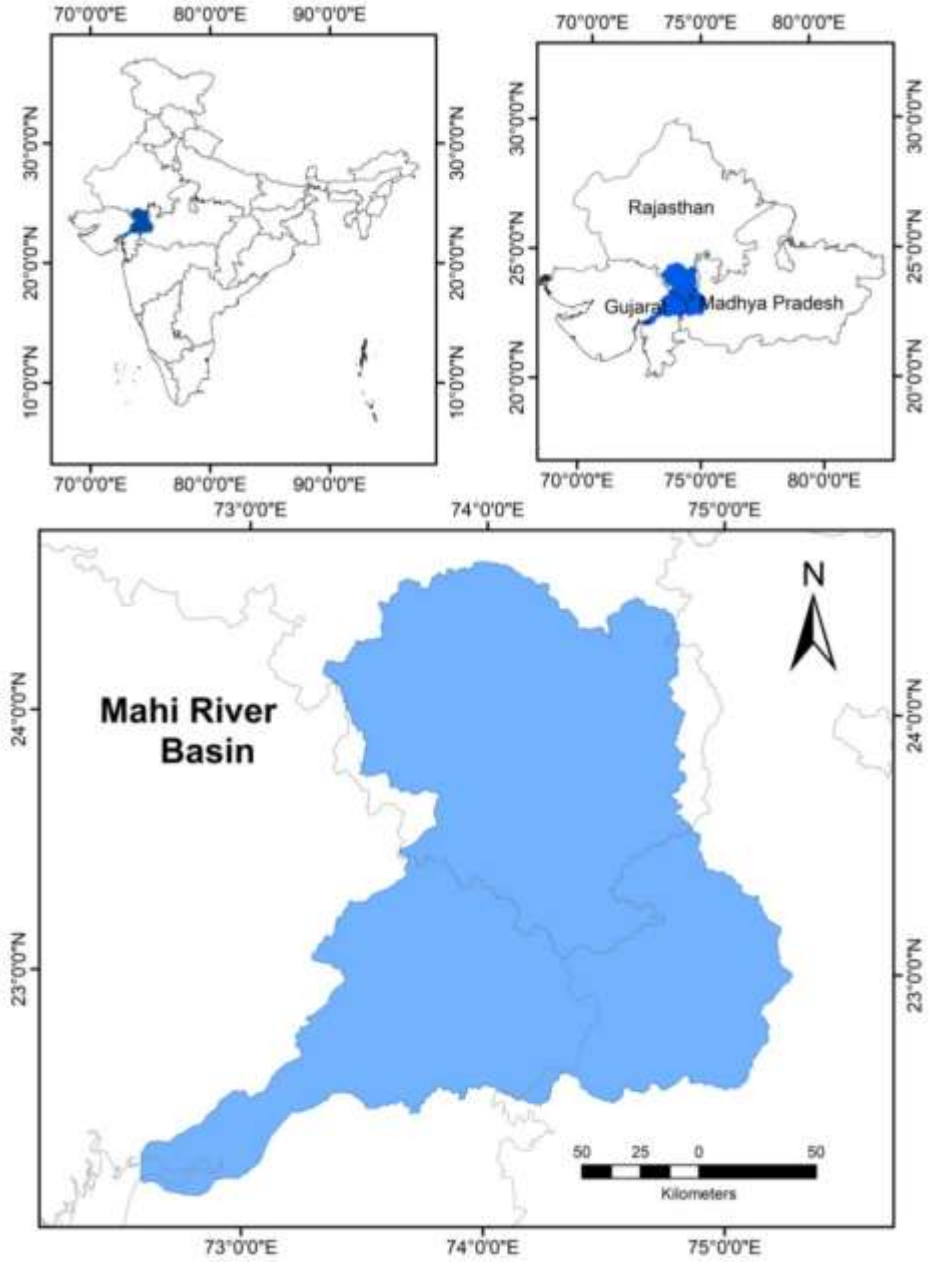
Study Area cont.

- At a few places subsurface paleo-channel containing fresh water or perched aquifers have been reported.
- Traditionally RWH was the only source of water.
- In the recent past there have been few instances of flooding due to high rainfall intensity, no drainage and low percolation rate.
- Many development schemes(CAD, lift irrigation and drinking) and Industrial projects (solar, wind & thermal power, cement, mining, gas and petroleum) are coming up.

Study area (Mahi)

- The Mahi basin extends over an area of 34,842 sqkm
- The basin lies in the States of Rajasthan, Gujarat and Madhya Pradesh.
- The upper part of the basin in Rajasthan and Madhya Pradesh comprises mostly hills and forests.
- The central part lying in Gujarat consists of developed lands and the lower part lying in Gujarat is flat and fertile and well developed alluvial tract.
- Important soil types in the basin are red and black soils. The culturable area of the basin is about 2.21 Mha which is 1.1% of the total culturable area of the country.

Mahi River Basin



Study Area cont..

- The Mahi River originates in the Mahi Kanta hills in the Vindhyachal range and joins Gulf of Khambat.
- The principal tributaries of the Mahi River are Som, Jakham, Moran, Anas, and the Bhadar.
- Major projects on the River Mahi are Jakham Reservoir, Panam Dam, Mahi Bajaj Sagar Project and Kadana
- Climate-change can have a serious impact on the effectiveness of policies, availability of new resources and efficient utilization of the existing resources.

Objectives

- Collection of baseline data for both the Basins.
- Hydrological modelling of the two Basins using SWAT model.
- Study the impact of Climate Change on various Hydrological parameters.
- Identification of hotspots/extreme phenomenon with respect to hydrological parameters.
- Suggesting suitable adaptation/mitigation policies for water use, cropping patterns, calamity management, resource allocation etc.

Methodology

A systematic study of the basins required to achieve above mentioned objective. Methodology will comprises of following steps.

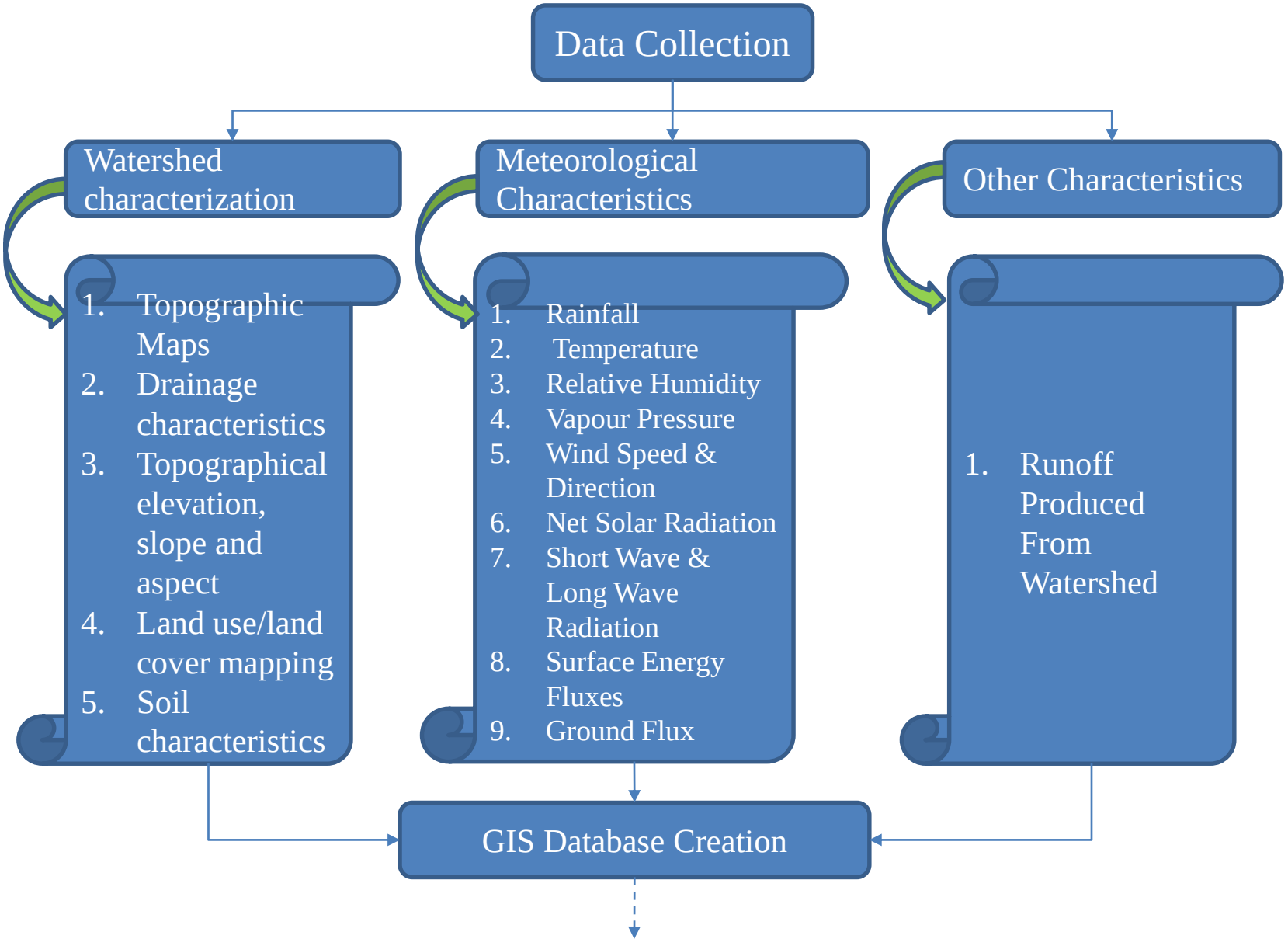
- Detailed data collection related to each aspect of a Basin for its characterization, which includes –

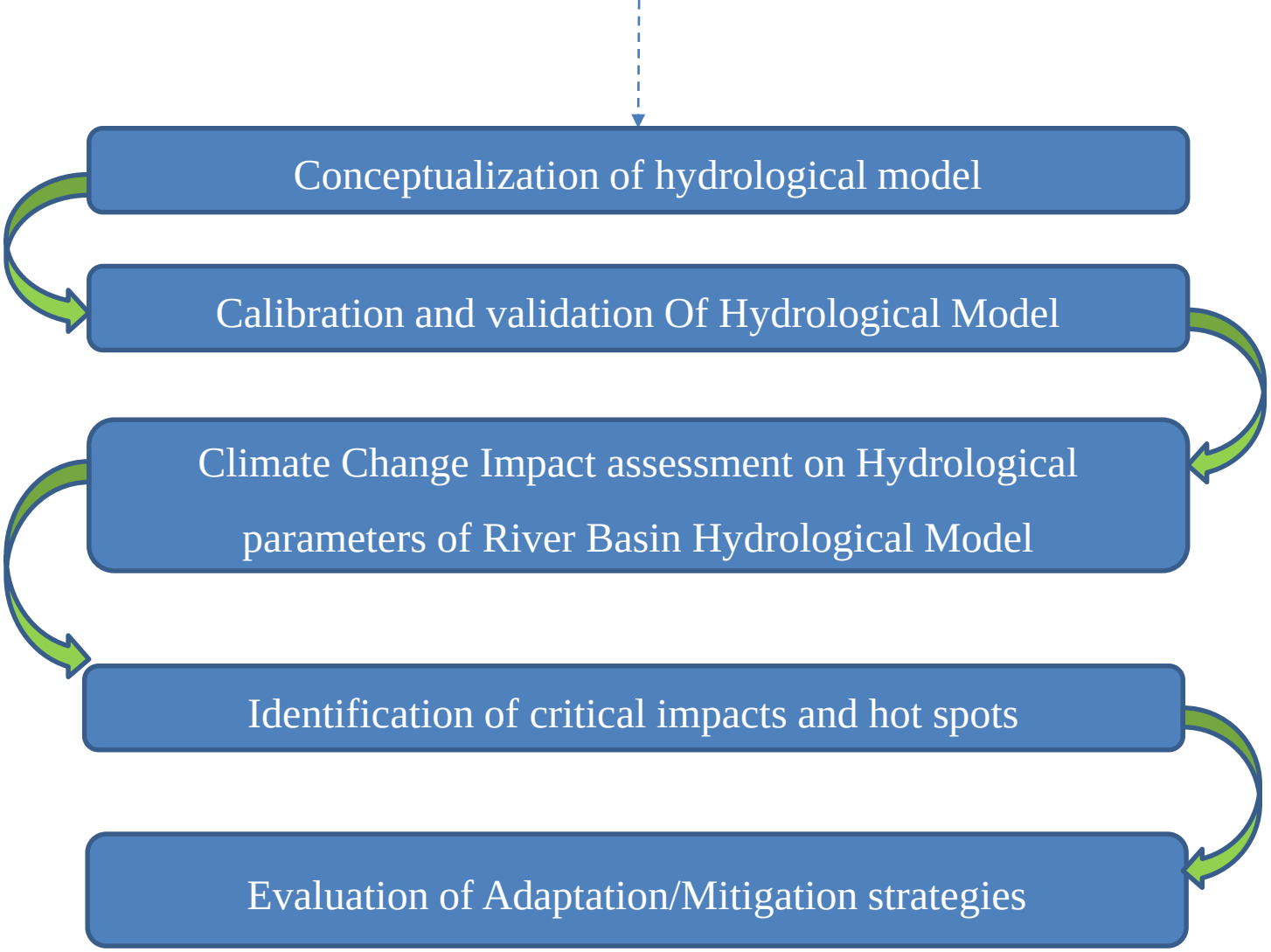
- Basin extent from topographic maps
- Drainage characteristics (morphometry of drainage; length, size, section, slope, surface type etc.)
- Topographical elevation, slope and aspect
- Land use/land cover mapping (multi-temporal data)
- Soil characteristics (C, phi values, suction pressure, soil moisture at different depths, texture etc.)
- Meteorological information (temporal information of meteorological parameters like rainfall, temperature, relative humidity, vapour pressure, wind speed & direction, net solar radiation, short wave & long wave radiation, surface energy fluxes, ground flux etc.)

Methodology Contd...

- Data collection for runoff produced from watersheds (multi-temporal surface runoff measurement)
- Creation of suitable GIS database
- Conceptualization of hydrological model
- Calibration of hydrological model
- Validation of models
- Generation of meteorology in different Climate Change Scenarios and analysis of extreme weather phenomenon
- Development of Adaptation strategies to the climate change in the form of water distribution for Municipal and Irrigation uses, Reservoir operation, crop cycling.
- Mitigation strategies for extreme events like flood, drought, heat wave and cold wave etc.

Flow Chart


Data Collection
Watershed characterization
Meteorological Characteristics
Other Characteristics
1. Topographic Maps
2. Drainage characteristics
3. Topographical elevation, slope and aspect
4. Land use/land cover mapping
5. Soil characteristics
1. Rainfall
2. Temperature
3. Relative Humidity
4. Vapour Pressure
5. Wind Speed & Direction
6. Net Solar Radiation
7. Short Wave & Long Wave Radiation
8. Surface Energy Fluxes
9. Ground Flux
1. Runoff Produced From Watershed
GIS Database Creation


Conceptualization of hydrological model
Calibration and validation Of Hydrological Model
Climate Change Impact assessment on Hydrological parameters of River Basin Hydrological Model
Identification of critical impacts and hot spots
Evaluation of Adaptation/Mitigation strategies

Data Collection

Toposheet

- A number of toposheet has been procured from SOI.

Topographic sheet no	
G43T	4,7,8,11,12,14,15,16
G43U	2,3,4,6,7,8,11,12,15,16
F43B	5,6,7,8,9,10,11,12,13,14,15,16
F43C	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16
F43D	3,4,8
F43G	11,12,14,15,16
F43H	1,2,3,4,5,6,7,8,9,10,11,13,14
F43I	1,2,3,5,6,7,9,10,11,13,14,15,
F43J	1,2,5
F43M	9,10,13,14
F43N	1,5,9

Cont..

Satellite Data

Year	Satellite/Sensor	Radiometric Resolution	Spatial Resolution (m)	Spectral Resolution	season	Path	Row	Date of acquisition
1977	Landsat MSS 1-5	6 bit	60	Band 4 Band 5 Band 6 Band 7	FEB-MAR (Rabi Season)	158	43	23-03-1977
							44	23-03-1977
						159	43	10-03-1977
							44	28-03-1977
							45	28-03-1977
1980	Landsat MSS 1-5	6 bit	60	Band 4 Band 5 Band 6 Band 7	OCT-NOV (Kharif Season)	158	43	22-10-1980
							44	22-10-1980
							45	22-10-1980
						159	43	05-10-1980
							44	05-10-1980
							45	05-10-1980
						160	43	29-11-1980
							44	29-11-1980
							45	18-09-1980
1987	Landsat MSS 1-5	6 bit	60	Band 4 Band 5 Band 6 Band 7	OCT-NOV (Kharif Season)	148	43	27-10-1987
							44	27-10-1987
							45	27-10-1987
1990	Landsat TM	8 bit	30	Band 1 Band 2 Band 3 Band 4 Band 5	FEB-MAR (Rabi Season)	147	43	18-03-1990
							44	14-02-1990
						148	43	09-03-1990
							44	09-03-1990
							45	09-03-1990
				Band 6 Band 7	OCT-NOV (Kharif Season)	147	43	31-12-1990
							44	31-12-1990
						148	43	23-01-1991
							44	23-01-1991
							45	23-01-1991

Cont..

1995	Landsat TM	8 bit	30	Band 1 Band 2 Band 3 Band 4 Band 5 Band 6 Band 7	FEB-MAR (Rabi Season)	147	43	12-02-1995
							44	12-02-1995
						148	43	23-03-1995
							44	23-03-1995
							45	23-03-1995
					OCT-NOV (Kharif Season)	147	43	02-11-1995
							44	02-11-1995
						148	43	11-11-1995
							44	11-11-1995
							45	11-11-1995
2000	Landsat TM	8 bit	30	Band 1 Band 2 Band 3 Band 4 Band 5 Band 6 Band 7	FEB-MAR (Rabi Season)	147	43	10-02-2000
							44	10-02-2000
						148	43	16-01-2000
							44	16-01-2000
							45	16-01-2000
	Landsat ETM	9 bit	30	Band 1 Band 2 Band 3 Band 4 Band 5 Band 6 Band 7 Band 8	OCT-NOV (Kharif Season)	147	43	15-10-2000
							44	15-10-2000
						148	43	22-10-200
							44	23-11-2000
							45	22-10-2000

2009	Landsat TM	8 bit	30	Band 1 Band 2 Band 3 Band 4 Band 5 Band 6 Band 7	OCT-NOV (Kharif Season)	147	43	17-11-2009
							44	17-11-2009
						148	43	24-11-2009
							44	24-11-2009
							45	24-11-2009

Cont..

2015	Landsat OLI	12 bit	30	Band 1 Band 2 Band 3 Band 4 Band 5 Band 6 Band 7 Band 8 Band 9 Band 10 Band 11	FEB-MAR (Rabi Season)	147	43	23-03-2010
							44	23-03-2010
						148	43	30-03-2015
							44	30-03-2015
							45	30-03-2015
					OCT-NOV (Kharif Season)	147	43	18-11-2015
							44	18-11-2015
						148	43	09-11-2015
							44	09-11-2015
							45	09-11-2015
2018	Landsat OLI	12 bit	30	Band 1 Band 2 Band 3 Band 4 Band 5 Band 6 Band 7 Band 8 Band 9 Band 10 Band 11	FEB-MAR (Rabi Season)	147	43	31-03-2018
							44	31-03-2018
						148	43	22-03-2018
							44	22-03-2018
							45	22-03-2018
					OCT-NOV (Kharif Season)	147	43	25-10-2018
							44	25-10-2018
						148	43	01-11-2018
							44	01-11-2018
							45	01-11-2018
	Sentinal 2	12 bit	10	Band 1 Band 2 Band 3 Band 4 Band 5 Band 6 Band 7 Band 8 Band 8a Band 9 Band 10 Band 11	FEB-MAR (Rabi Season)			31-03-2018
					OCT-NOV (Kharif Season)			25-10-2018

Cont..

Rainfall Data

Types of data	Area	Temporal Resolution	Data Range
Rainfall	Station Wise in Rajasthan	Daily	1957-2016
Rainfall	Station Wise in Madhya Pradesh	Monthly Mean	1970-2014
Rainfall	District wise Whole Basin	Monthly Mean	1901-2002

Temperature Data

Types of data	Area	Temporal Resolution	Data Range
Average Temperature	District wise Whole Basin	Monthly Mean	1901-2002
Minimum Temperature	District wise Whole Basin	Monthly Mean	1901-2002
Maximum Temperature	District wise Whole Basin	Monthly Mean	1901-2002

Gauge Discharge data

Types of data	Area	Temporal Resolution	Data Range
Ground water level	Block wise Whole Basin	Yearly	1996-2018

Ground water data

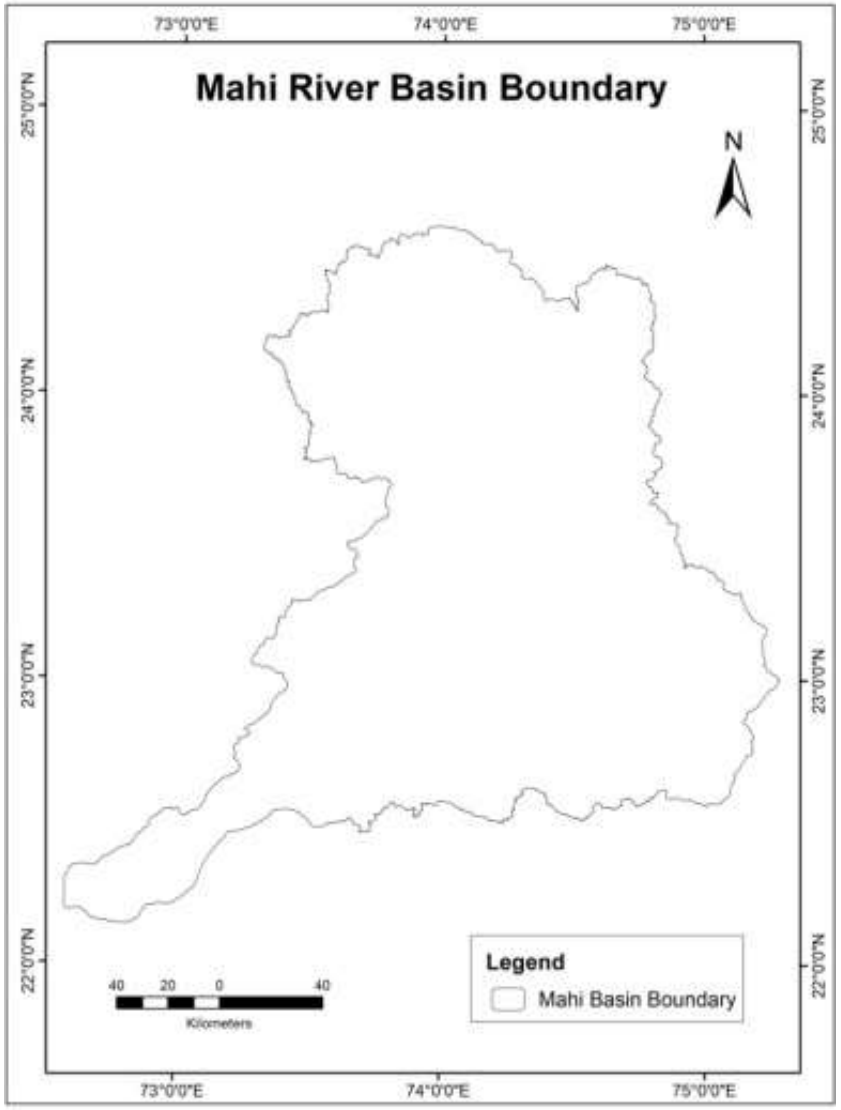
Types of data	Area	Temporal Resolution	Data Range
Gauge Discharge	Station Wise in Rajasthan	Monthly (Monsoon)	1962-1992
Gauge Discharge	Station Wise in Madhya Pradesh	Daily	1988-2016

Potential Evapotranspiration

Types of data	Area	Temporal Resolution	Data Range
PET	District wise Whole Basin	Monthly Mean	1901-2002

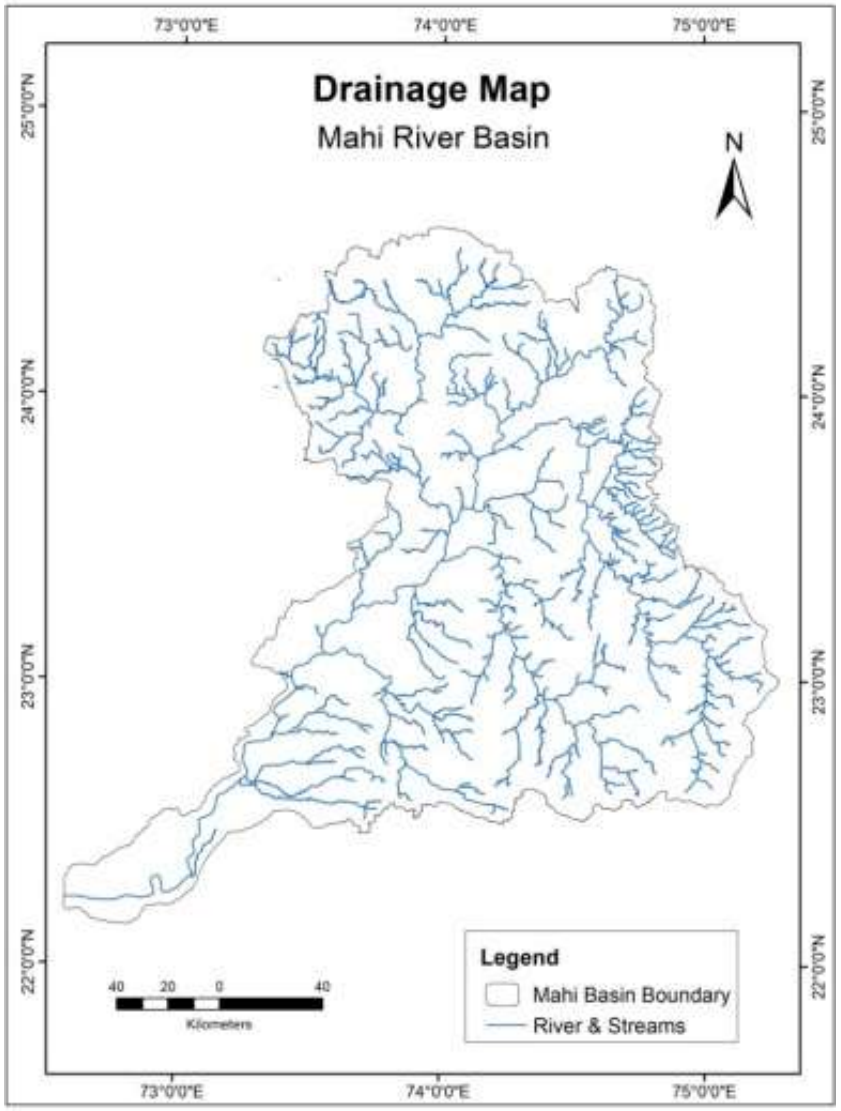
GIS Database Creation

- Mahi river basin boundary has been delineated using DEM and topographic maps.



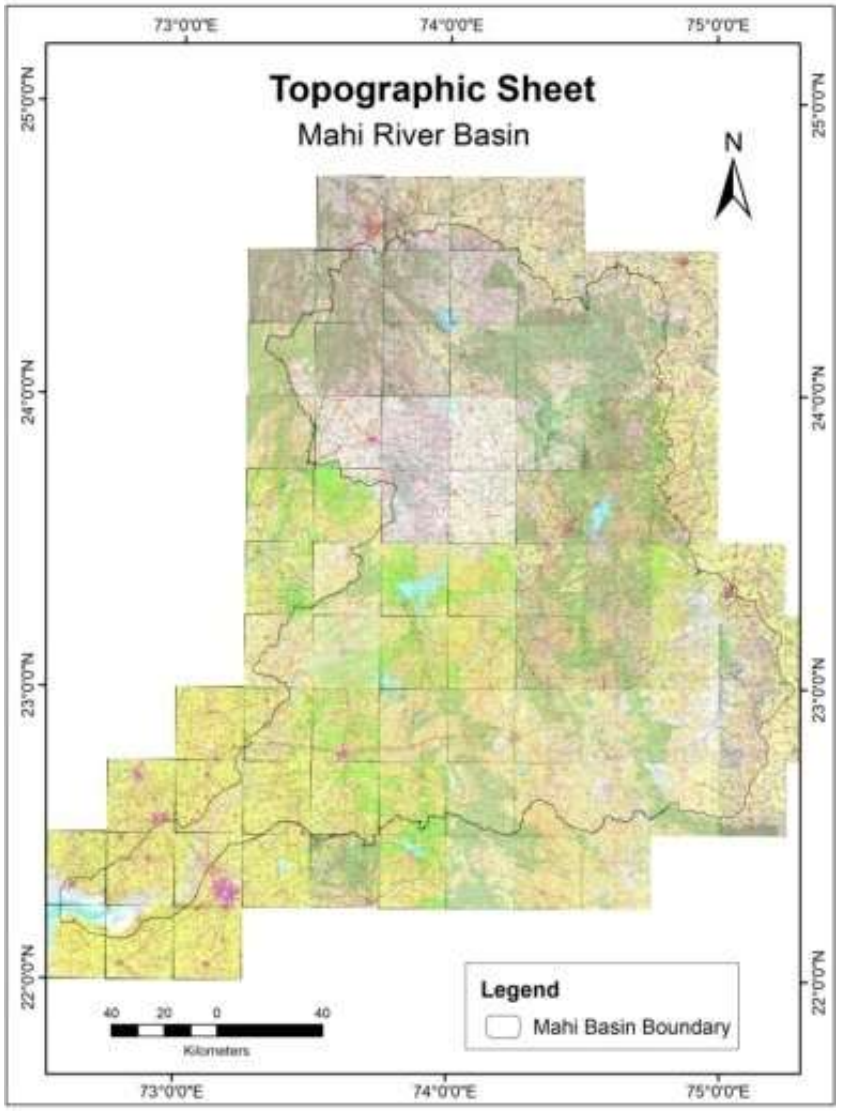
Cont..

- The drainage network has been prepared for Mahi river basin.



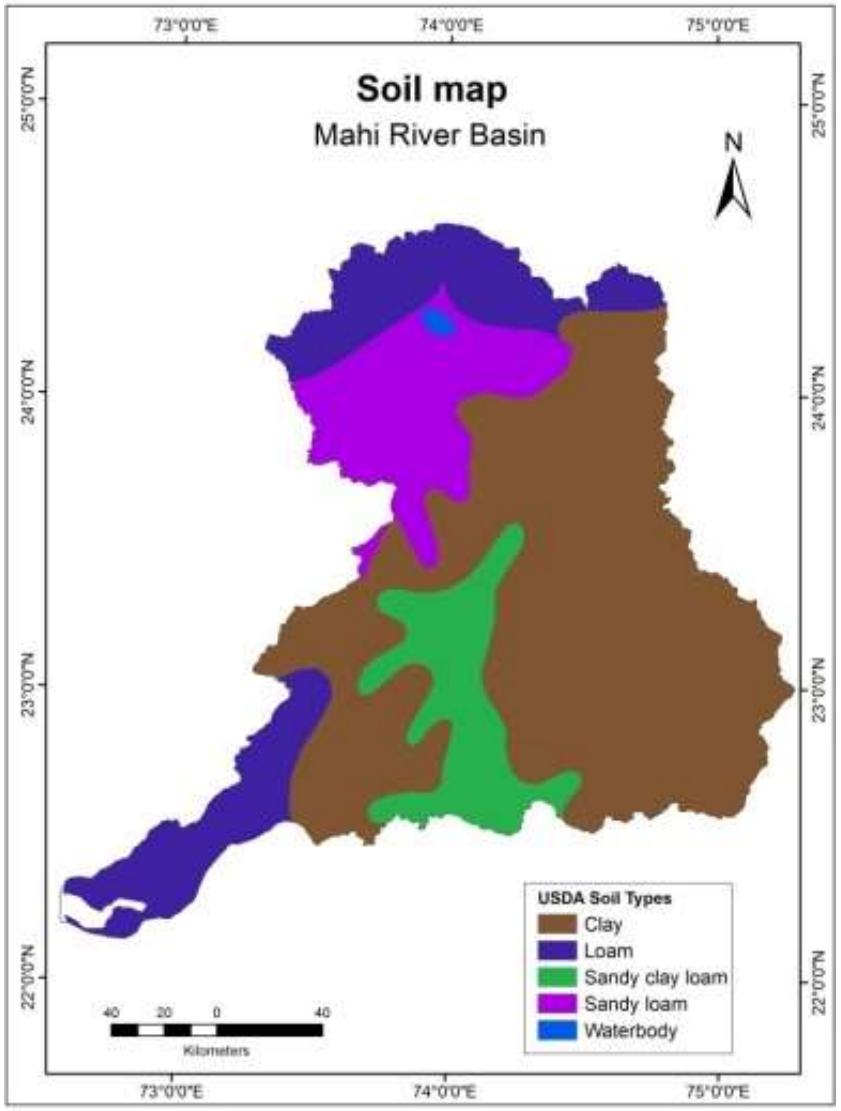
Cont..

- All the toposheet are geo-referenced in UTM WGS84 43N projection and coordinate system with an acceptable range of RMS error.



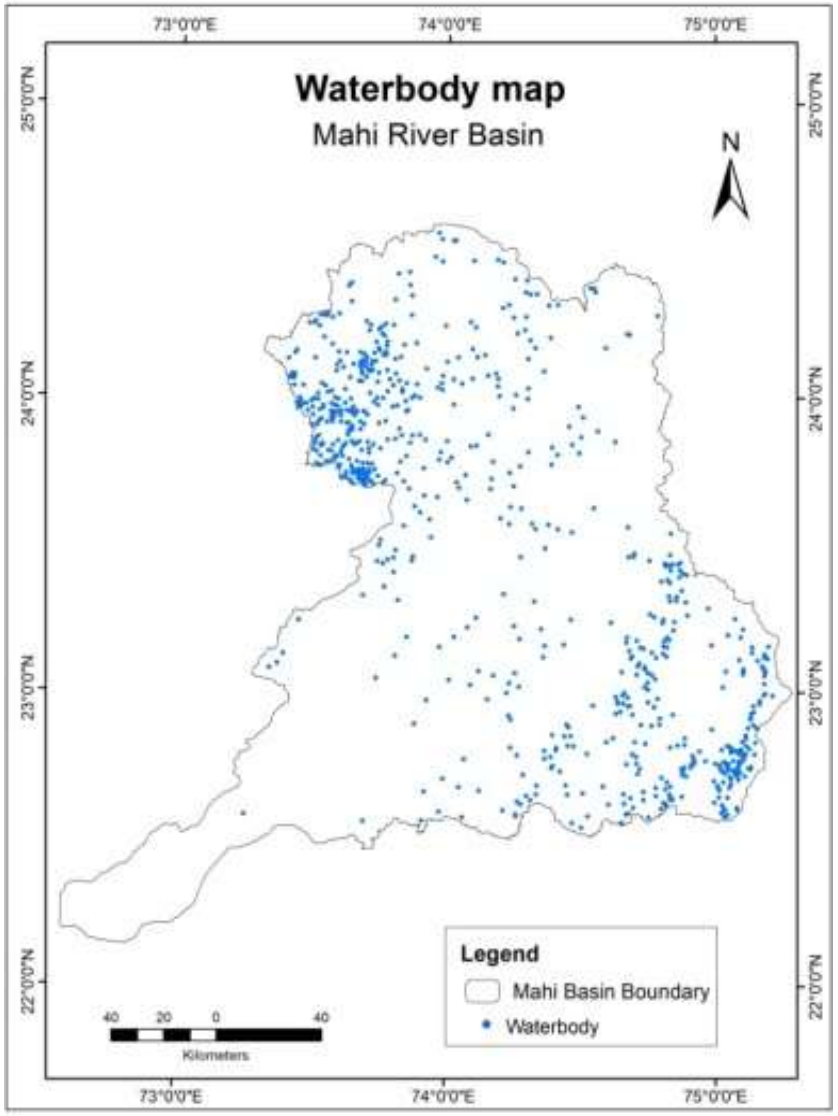
Cont..

- The soil map has been characterized with the help of FAO (Food and Agriculture Organization of the United Nations) based information.



Cont..

- The important waterbodies contributing to the catchment of Mahi River basin has been digitized.



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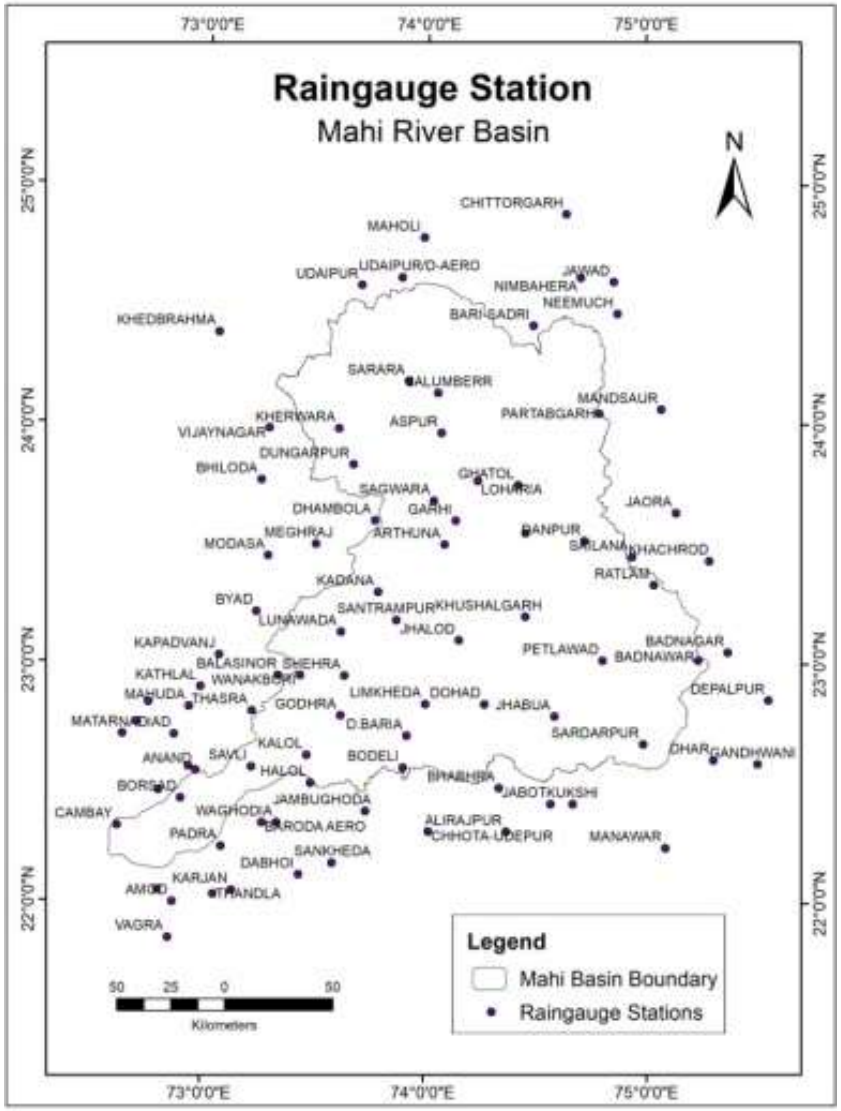
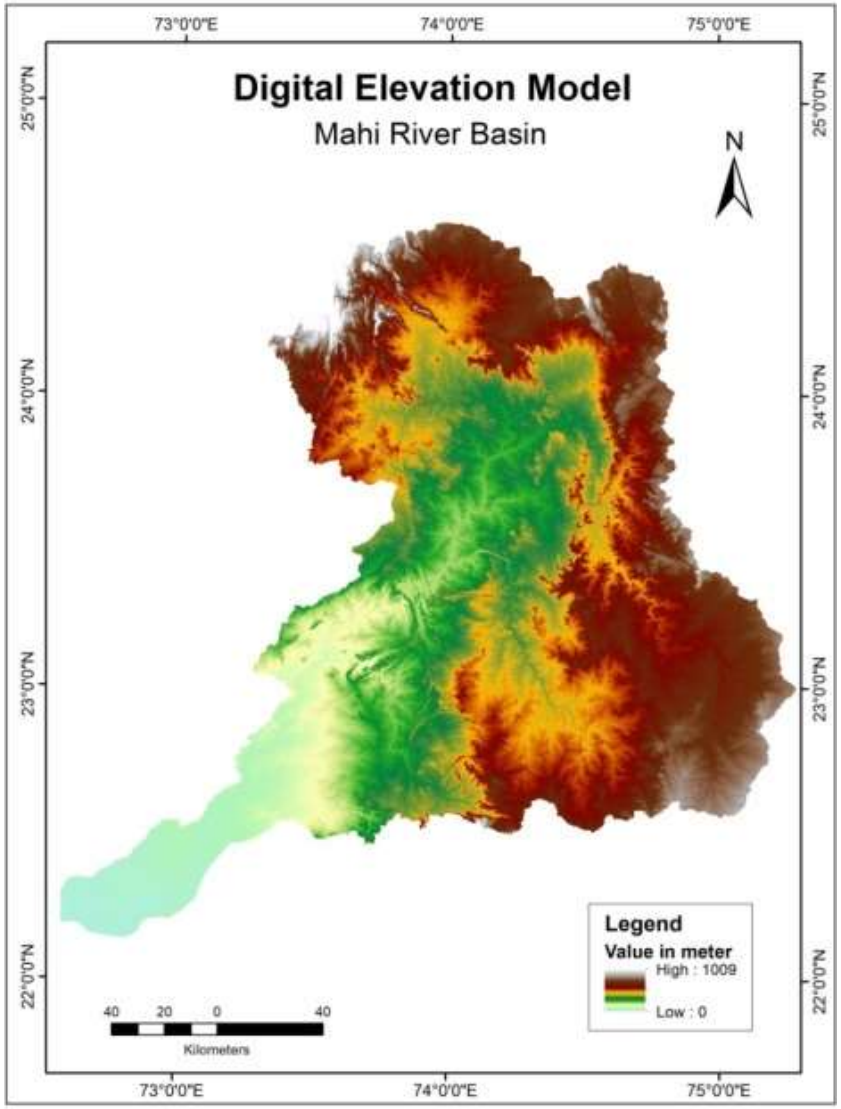
- The raingague stations have been digitized for Mahi river basin.



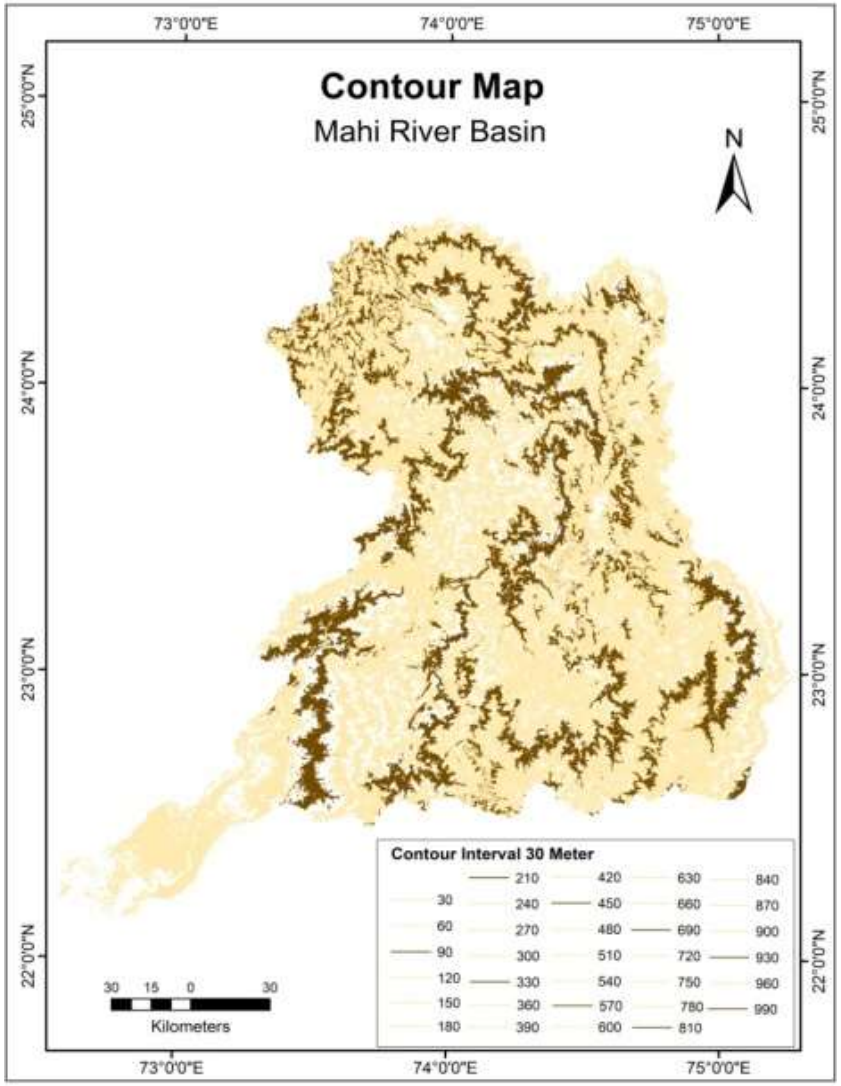
Cont..

- The DEM (Digital Elevation Model) has been prepared for Mahi river basin.
- The range of elevation is 0-1009(m).



Cont..

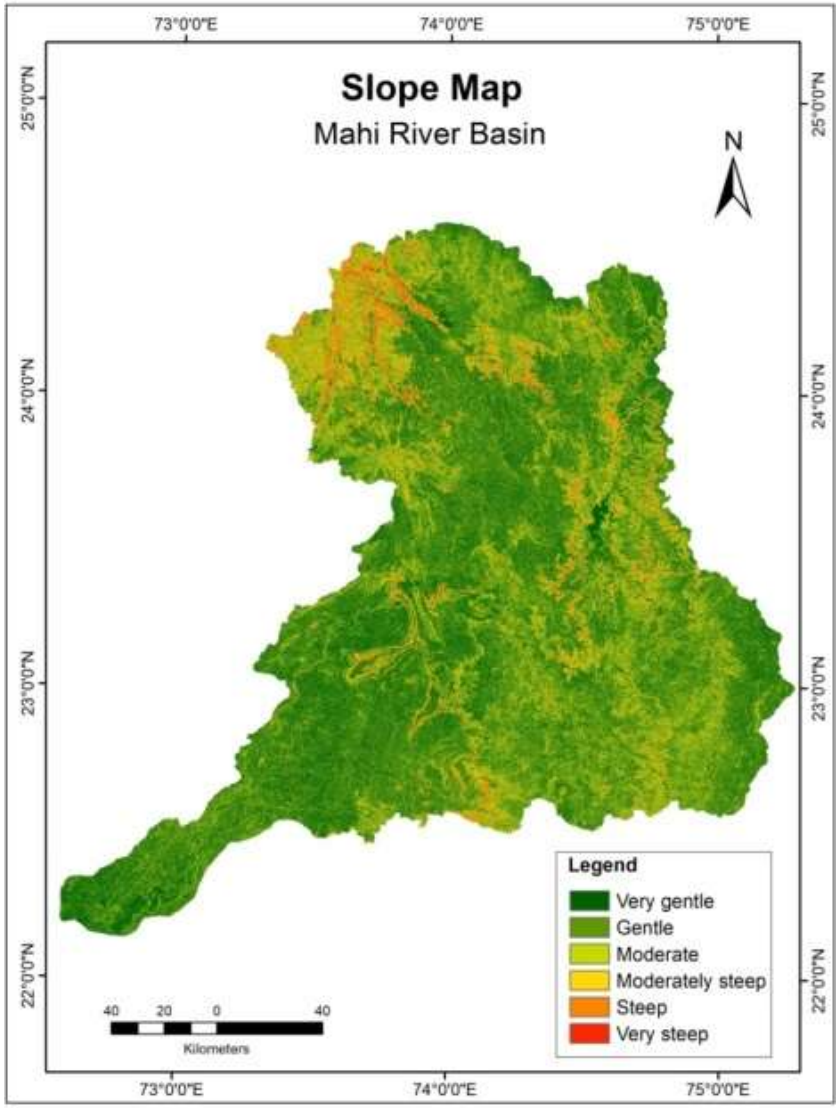
- The contour map (30m resolution) has been prepared for Mahi river basin.



Cont..

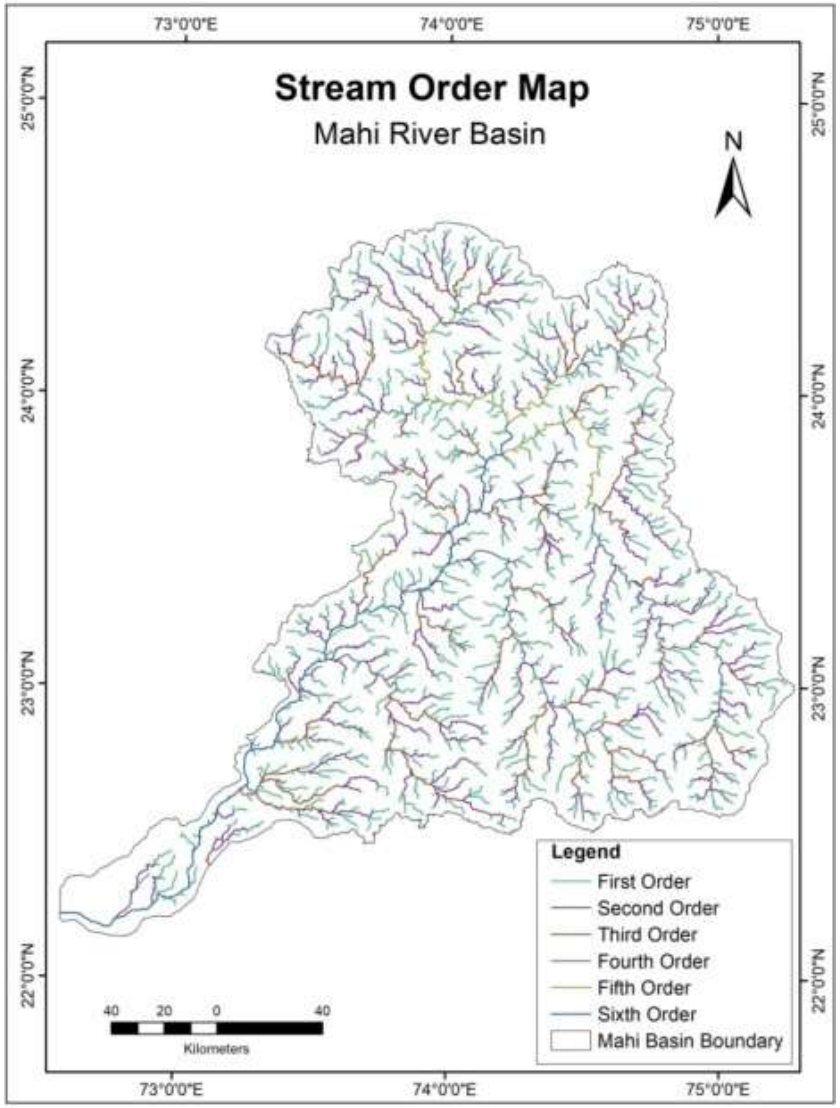
- The slope map has been prepared for Mahi river basin.
- It has been classified into six categories i.e. Very gentle, Gentle, Moderate, Moderately steep, Steep and Very steep (Sikandar et al., 2004).

S.no.	Range (in degrees)	Category
1	0 to 5	Very Gentle
2	5 to 10	Gentle
3	10 to 15	Moderate
4	15 to 25	Moderately Steep
5	25 to 35	Steep
6	>35	Very Steep

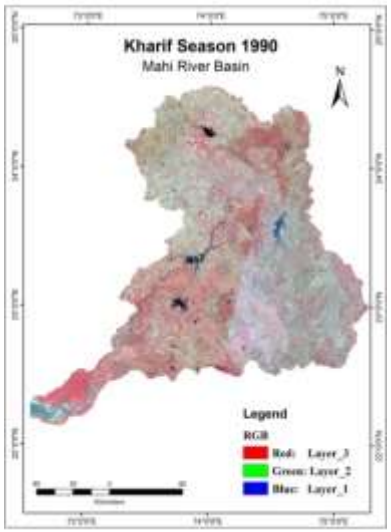


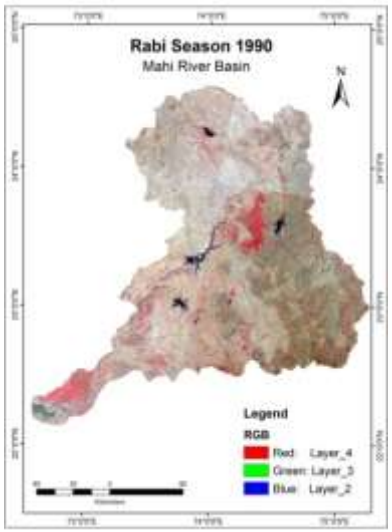
Cont..

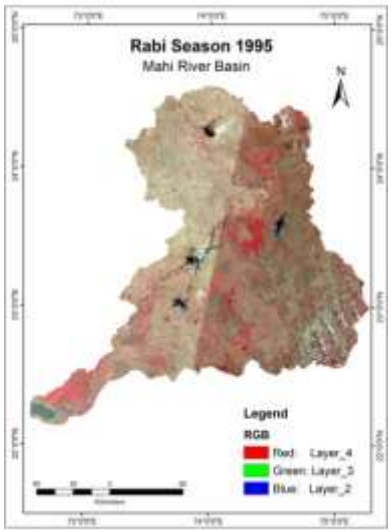
- The stream order map has been prepared which contains the information of first, second, third, fourth, fifth and sixth order drains for Mahi river basin.

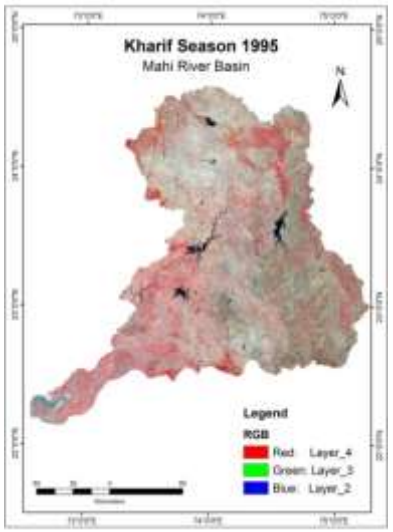


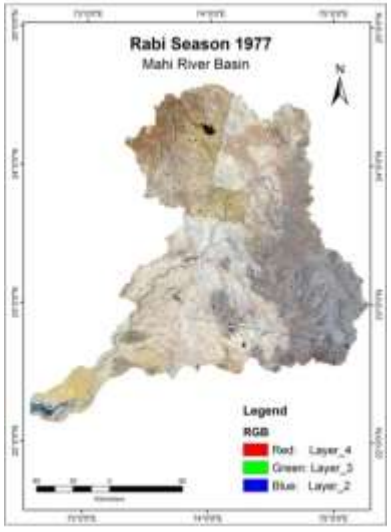
Preparation of FCCs of Satellite images

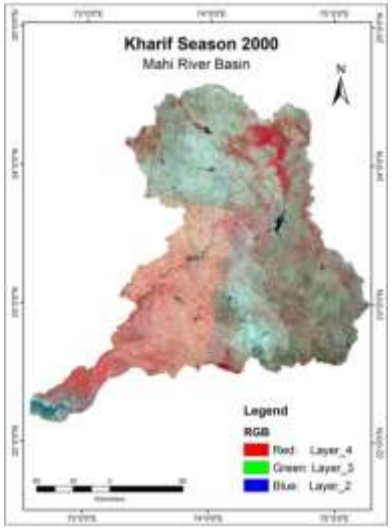


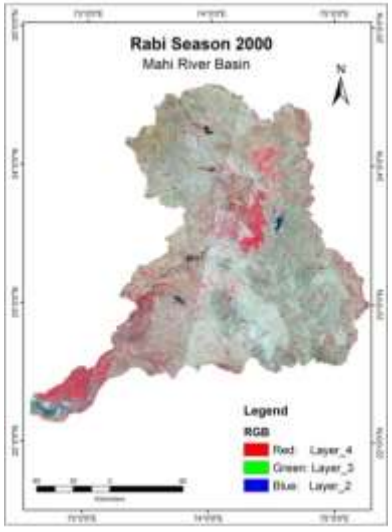


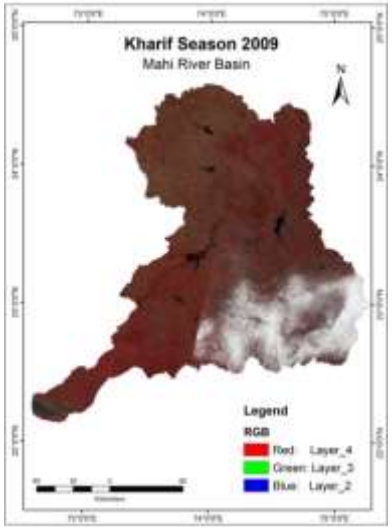












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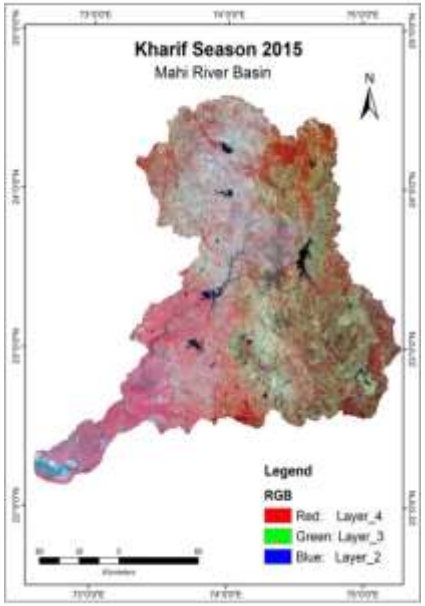
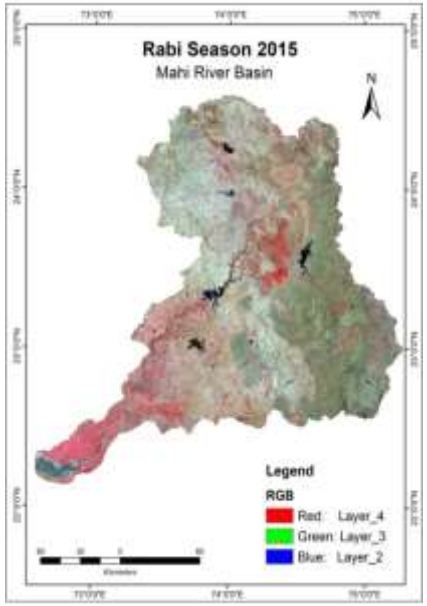
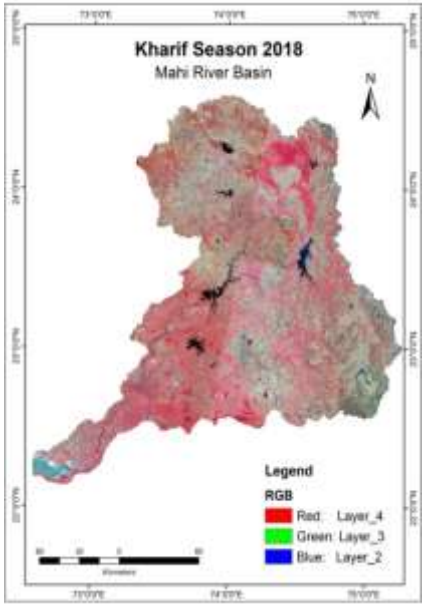
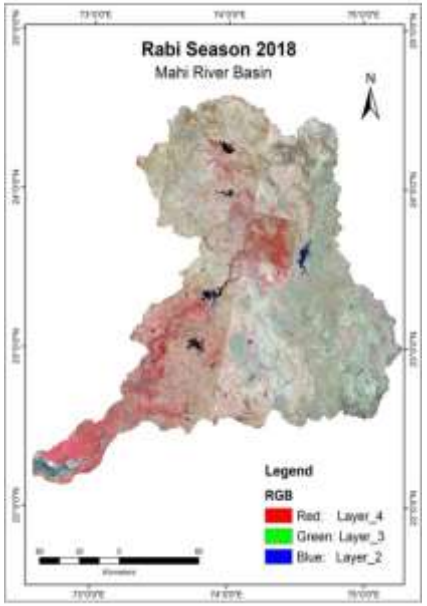
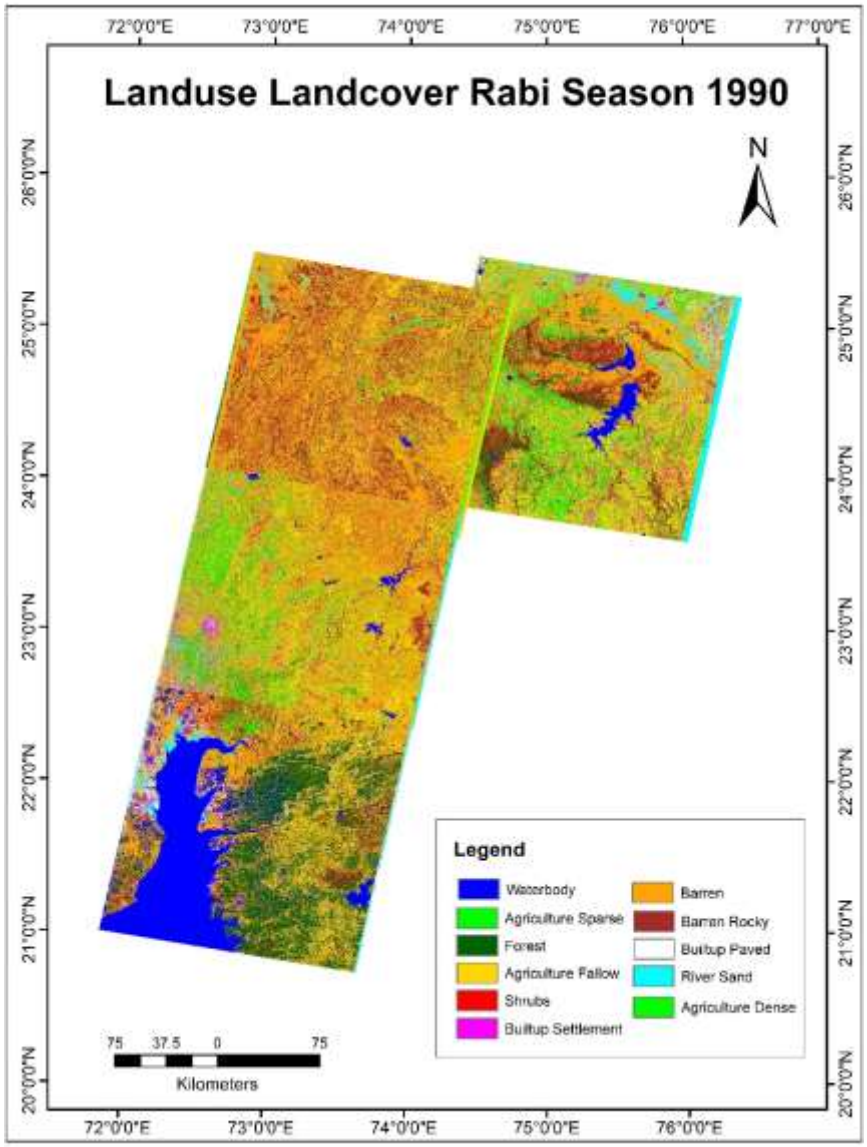


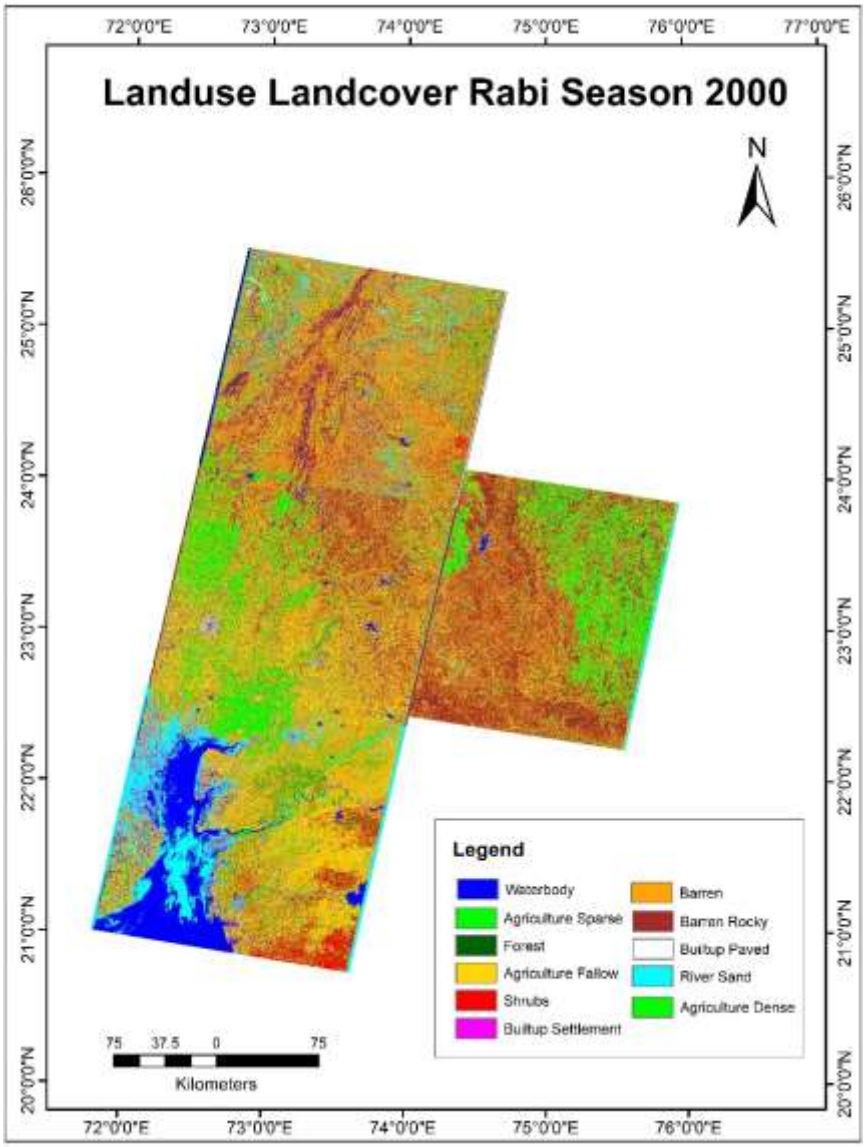






Preparation of Land use/ Land Cover Maps





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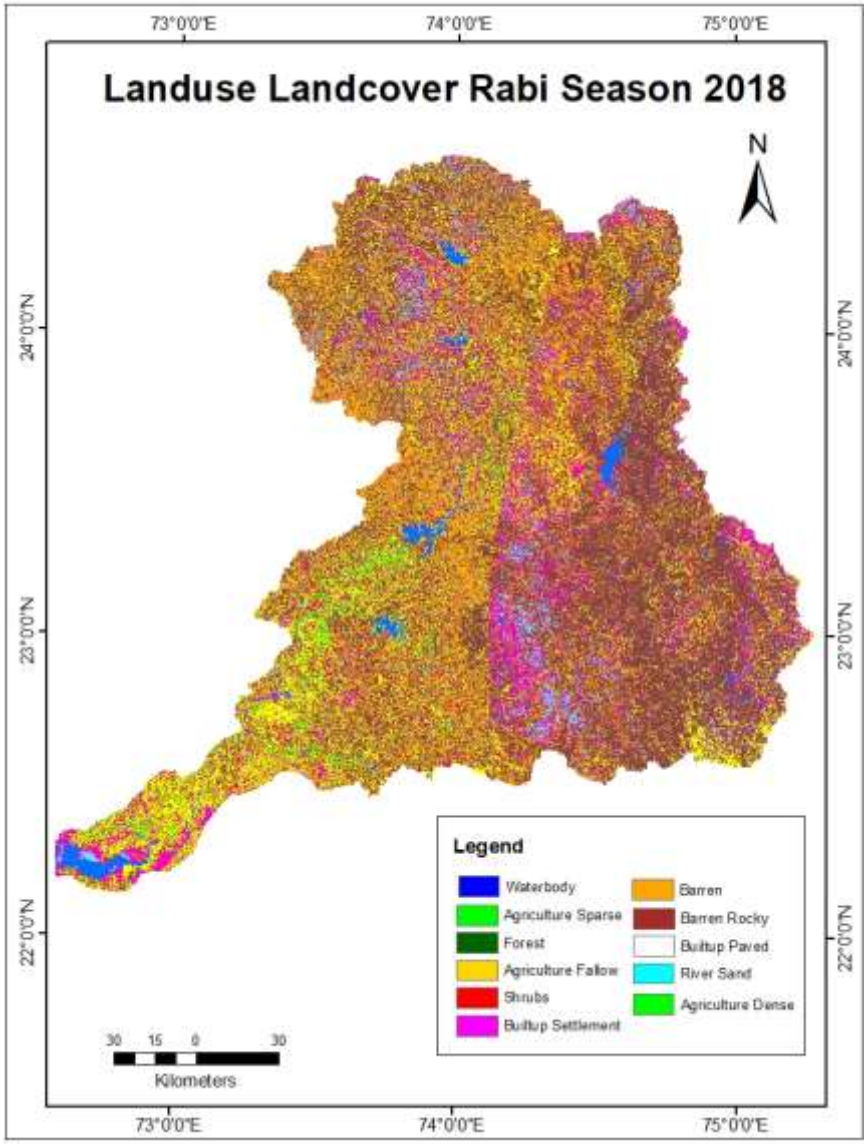
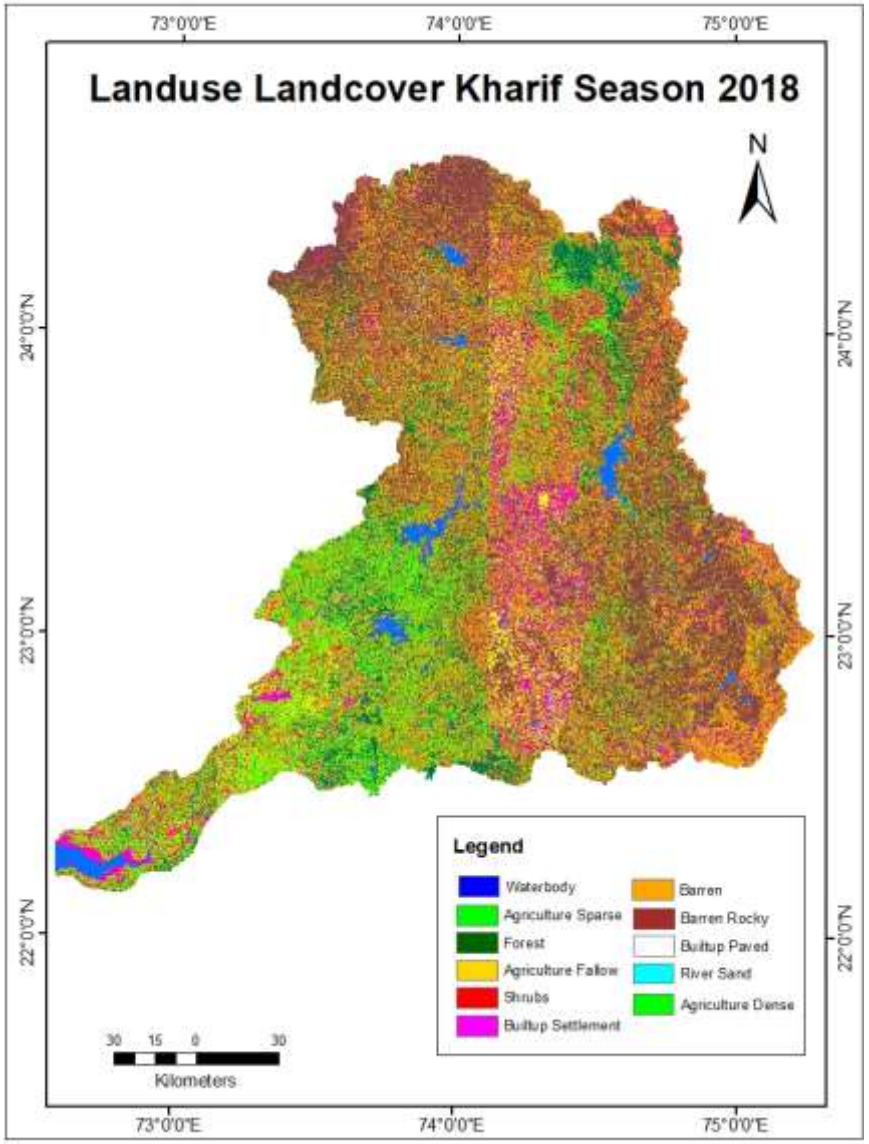
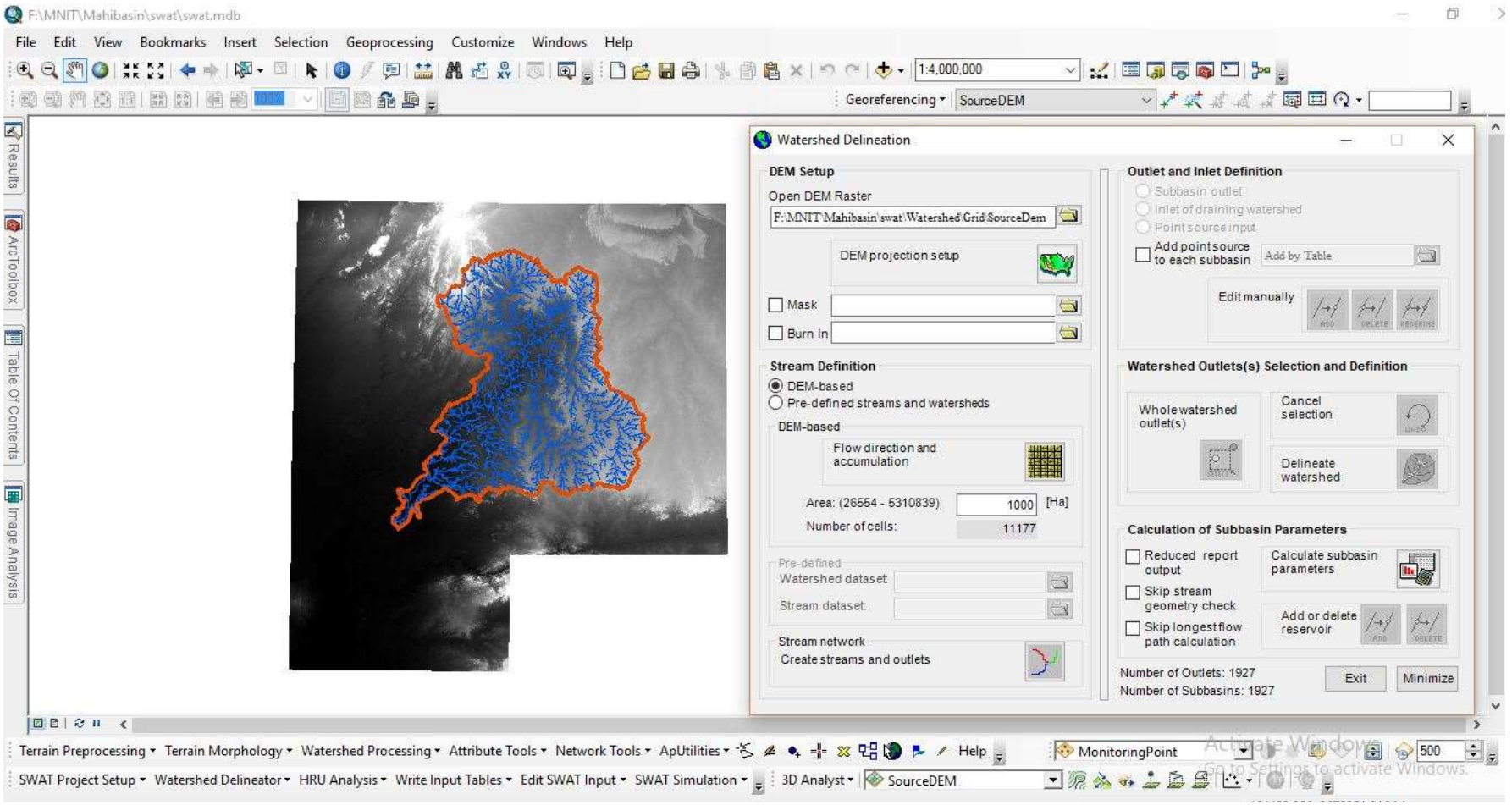
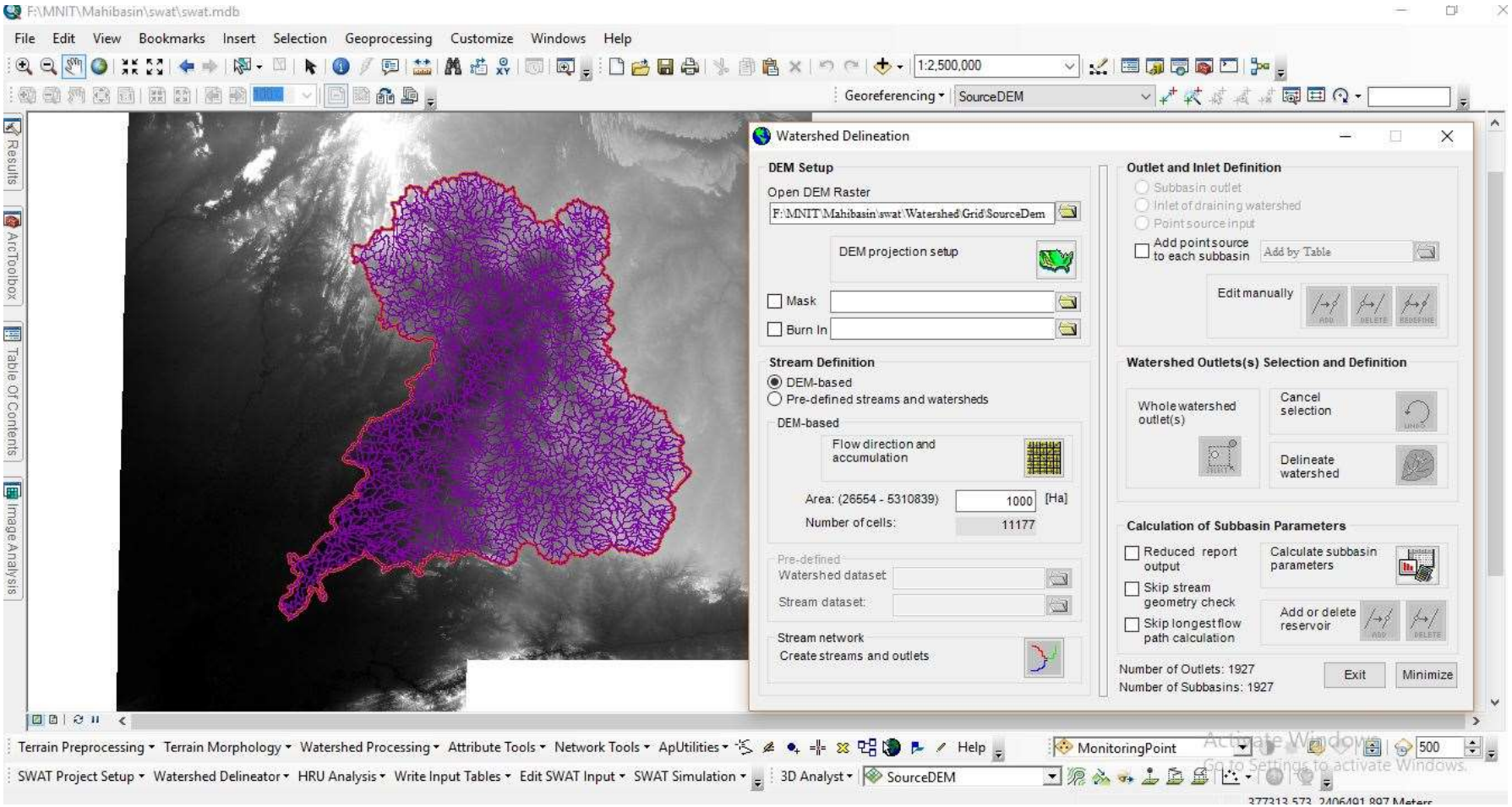




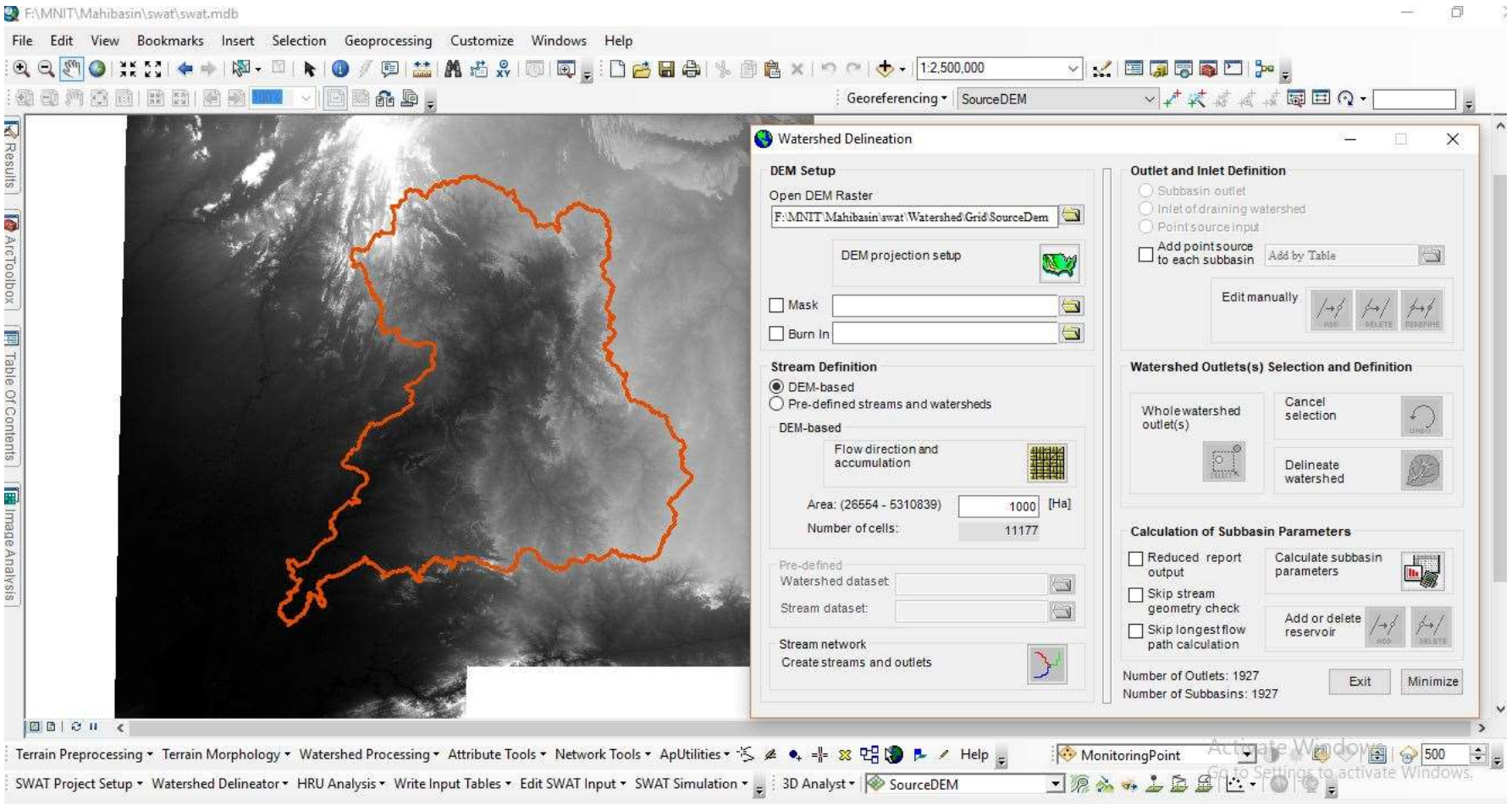
Development of SWAT model for study area



Development of SWAT model for study area



Development of SWAT model for study area



Salient points of work progress

MNIT Jaipur

1. One PhD on Climate Change impact assessment of India (Temperature) using cordex data is near completion.
2. Another candidate working on High resolution Climate Change Impact on Rajasthan using WRF model and CMIP 5/6 data.
3. Three JRF and One RA have been appointed and recruitment process for remaining staff is going on.
4. Procurement of computers and equipment has been initiated.
5. Literature review and data collection is under progress.
6. Preparation of LULC maps using satellite image classification and conditioning of DEM is going on.
7. A thorough study on SWAT model has been made and the development of SWAT model for the study area is initiated.

Cont..

IIT Delhi

1. Literature review and data collection is in progress.
2. Recruitment of 1 JRF will be done soon.

Cont..

Central University of Rajasthan

1. One Student completed M.Sc. thesis entitled “Intercomparision of TRMM 3B42 V7 and Rain gauge Data using SWAT Hydrological Model Over the Upper Mahi Basin” in the period January-May 2018.
2. This study is useful for project considering the study area and collection of datasets for hydrological model (SWAT) like DEM, soil, LULC, Climate data (TRMM and IMD), and discharge. Model was calibrated and validated at Paderdibadi gauge station and also sensitivity analysis was performed. This study will help in overall development of hydrological model in Mahi Basin.
3. Recently, there is acceptance of manuscript entitled “Spatio-temporal Trends and Projections of Climate Indices in the Banas River Basin, India” in the Journal Environmental Processes (Springer). This publication is useful and will provide support to study the hydrological and meteorological trend analysis and extreme indices in the project study area.

Budgetary information

- Total Cost of the project including overhead charges (if any) Rs 265.73 lakhs

Subhead	**Amount MNIT**	**Amount CURAJ**	**Amount IITD**
Salary	113.76	22.75	11.23
TE	14.60	3.00	1.50
Infrastructure /Equipments	61.35	1.60	0.00
Experimental Charges	6.00	1.50	1.50
Sub Total	195.71	28.85	14.23
Add Contingency 5 %	9.79	1.44	0.71
Total Rs in lakhs	205.5	30.29	14.94
Institutional over heads 20 % (With limit of R 15.00 lakh maximum)	9.75	3.00	2.25
Grand Total Rs in lakhs	215.25	33.29	17.19

Budgetary information

Identifiable Milestones of progress	**Months from start**	**Amount to be released Rs in Lakhs**
Start	0	Equipment and first year budget = Rs 120.76 Lakhs
Data collection, literature review and calibrated and validated hydrological model	12	As per second year budget except equipment = Rs 46.17 Lakhs
Trend analysis, crop production function, ground & surface water quality data collection, generation of future hydrological responses	24	As per third year budget = Rs 36.48 Lakhs
Climate change impact analysis, adaptation measures on water resources, agriculture and soil erosion, water allocation, demand management and mitigation measures of climate extremes (flood & drought). Report preparation and submission	36	

Work Plan

Task	0-6 months	6-12 months	12-24 months	24-36 months
Knowledge review and issue identifications	√	X		
Setting up of laboratory and field data collection	√	X	X	
Induction of staffs/research scholars	√			
Experimental and mathematical modelling works an identified issues		X	X	X
Annual progress report submission		X	X	X
Final report submission				X

Notes:

a) The work should be divided into milestones 3 to 6 months apart.

b) The milestones are mainly for the purpose of monitoring of progress and release of funds. The funds to be released on achieving various milestones should be indicated.

c) Normally there may be only one release of funds in a financial year.

Line of Action

- Collection of data
- Purchasing of Satellite images and toposheet.
- Purchasing of equipments and computers.
- Recruitment process of project staff.
- Literature survey
- GIS database creation
- Preparation of Land use Land cover maps.
- Development of SWAT model for the study area.

Abbreviations used

- FCC- False Color Composite
- SWAT- Soil and Water Assessment Tool
- UTM- Universal Transverse Mercator
- WGS- Word Geodetic System
- LULC- Land use/ Land Cover
- RWH- Rain Water Harvesting

Thank you