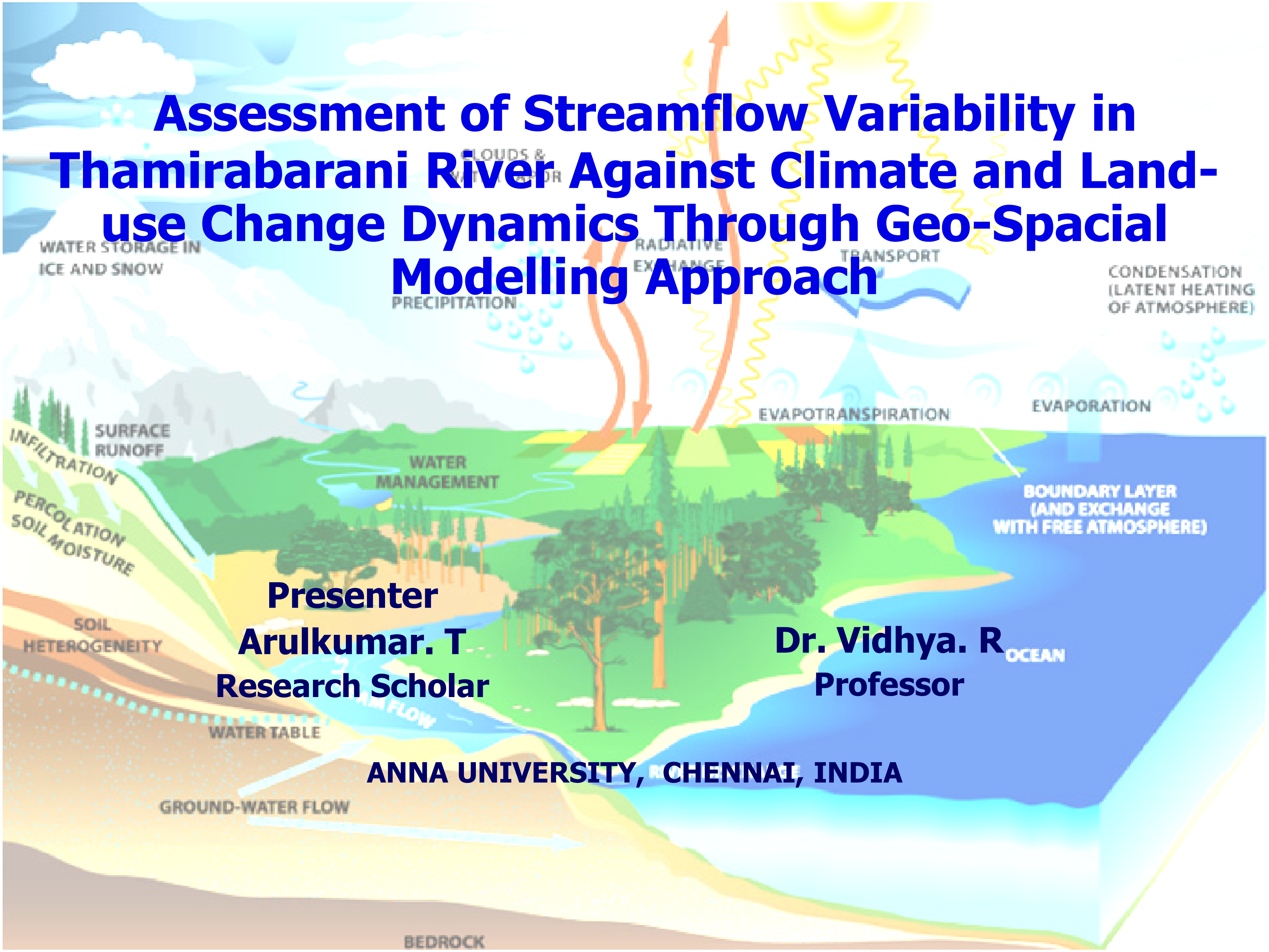

Assessment of Streamflow Variability in Thamirabarani River Against Climate and Land-use Change Dynamics Through Geo-Spacial Modelling Approach

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Presentation Outline

- Introduction
- Motivation for the study
- Research Objectives
- Study Area and Data Description
- Methodology
- Results and Discussion
- Conclusion

Introduction

- Water resources of Tamiraparani River Basin is an important factor which influences economy development of Southern Districts of Tamilnadu.

- Scarce resources, poor quality, unfavourable temporal and spatial distribution characterizes the water resources in this region

- It is required to model water resources at river basin scale in order to quantify the effect of different land use changes and hydrological and climatic conditions on water resources availability.

- This will be done to demonstrate water resource availability under different hydrological and climatic conditions and the implications on water resource availability.

Motivation for the study

- In the Thamirabarani river basin, water resources are stressed by rising demand, likely declining rainfall, and the impact of land use and Climate changes on hydrology.

- Current water resources only meet demand in the Tirunelveli Districts in good rainfall years.

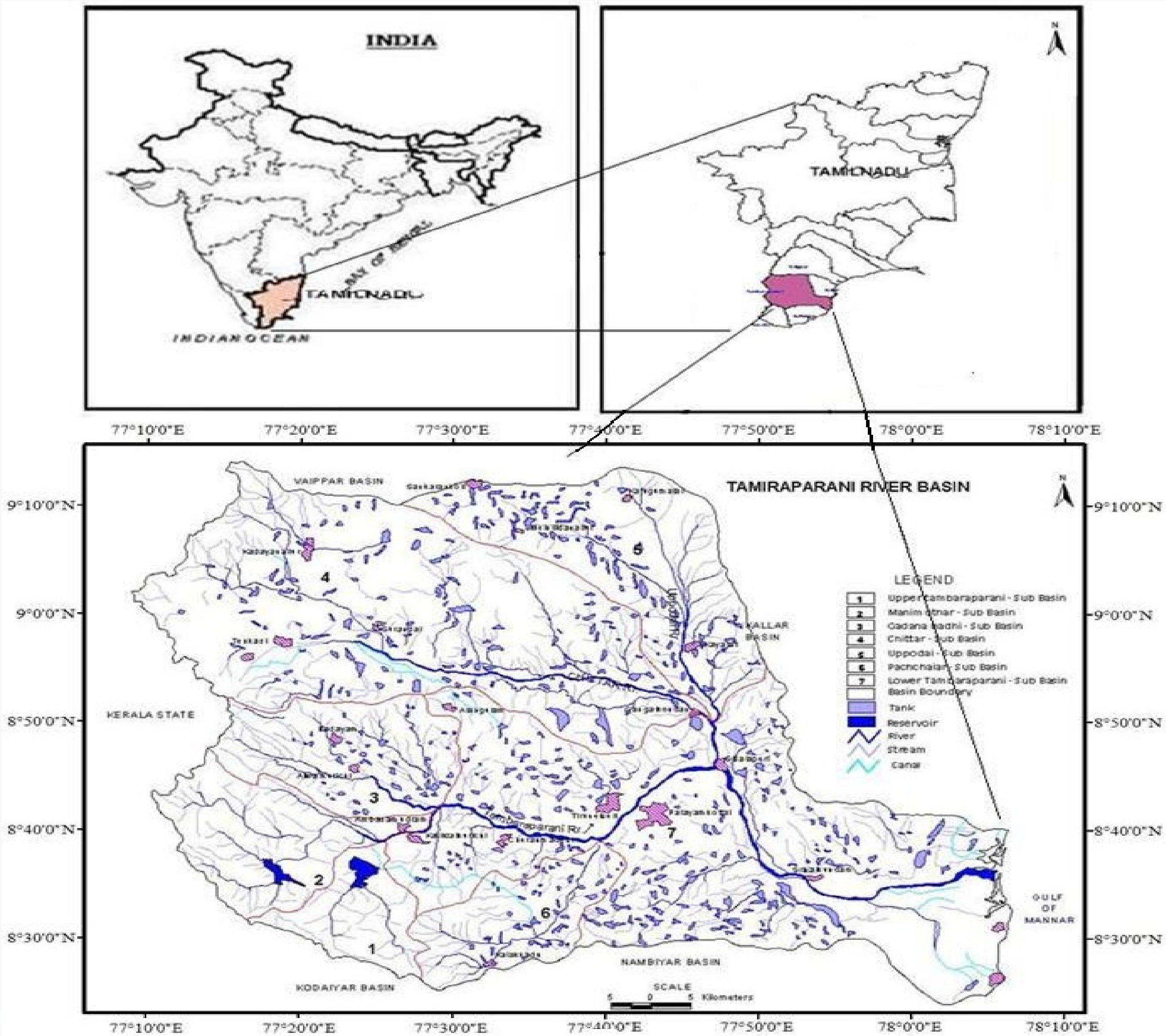
- Water resources modelling is thus needed to support integrated water resources management planning.

- This study explores an integrated approach that combines SWAT for assessing stream flow, with ARIMA trend analysis for climate change and CLUE-s for land use change prediction.

Research Objectives

- To predict rainfall and temperature using ARIMA trend analysis in Thamirabarani river basin from 2003 to 2020
- To simulate the land use change from 2003 to 2020 using CLUE-S model and to determine the impact of land use change on water flux
- To model, with monthly and daily time steps, the water balance and the water resources of catchments.
- To assess the impacts of land use and climate change on stream flow of Thamirabarani River using the SWAT model.

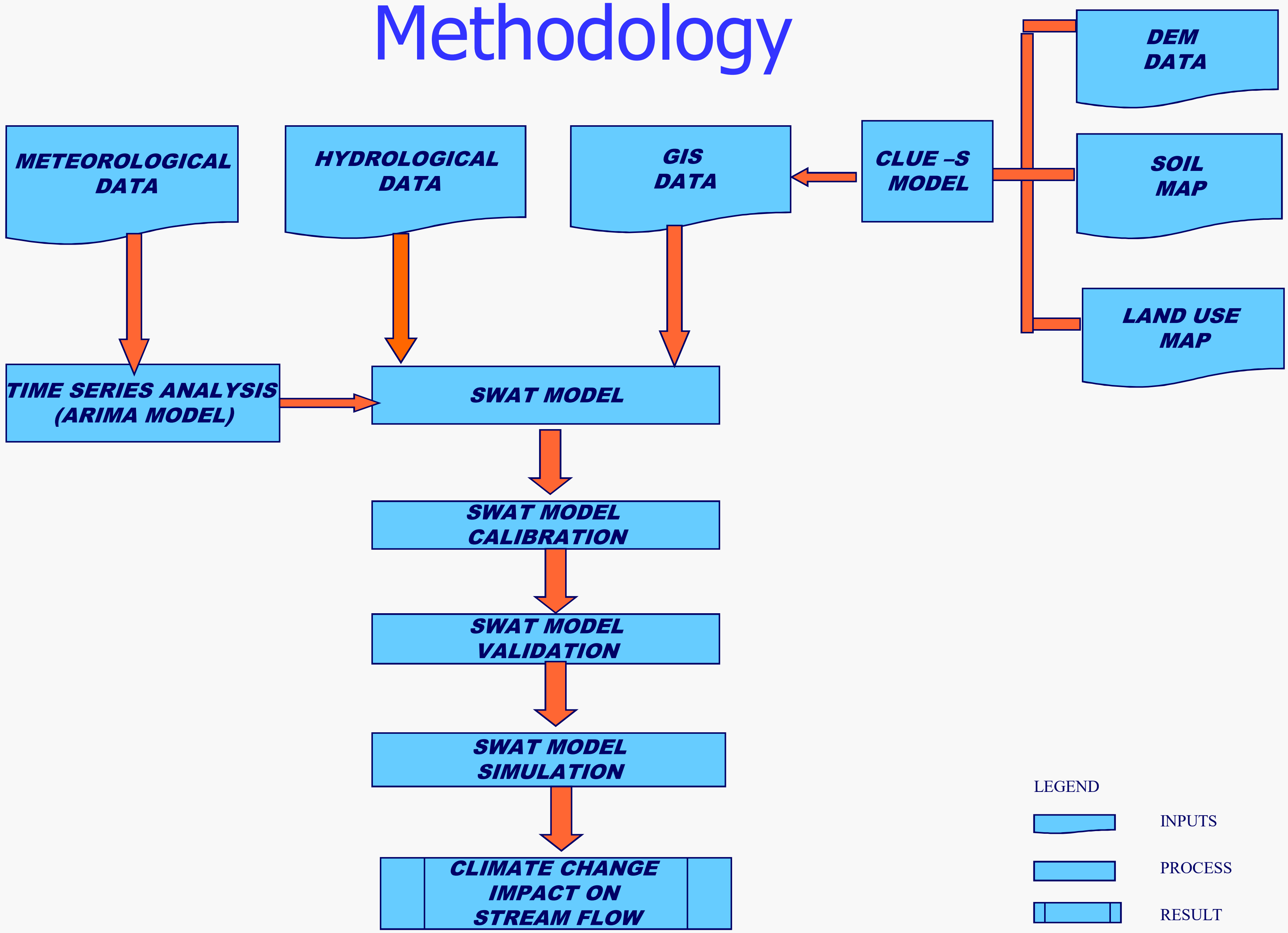
Study Area


INDIA
TAMILNADU
INDIAN OCEAN
TAMILNADU
TAMIRAPARANI RIVER BASIN
LEGEND
Upper Tambaraparani - Sub Basin
Manimuthar - Sub Basin
Gadana Nadhi - Sub Basin
Chittar - Sub Basin
Uppodai - Sub Basin
Pachchaiar - Sub Basin
Lower Tambaraparani - Sub Basin
Basin Boundary
Tank
Reservoir
River
Stream
Canal
VAIPPAR BASIN
KALLAR BASIN
KERALA STATE
KODAIYAR BASIN
NAMBIYAR BASIN
GULF OF MANNAR
SCALE
5 0 5 Kilometers
77°10'0"E
77°20'0"E
77°30'0"E
77°40'0"E
77°50'0"E
78°0'0"E
78°10'0"E
9°10'0"N
9°0'0"N
8°50'0"N
8°40'0"N
8°30'0"N

Study Area Description

- The area of the river basin is 5942 sq.km.
- The major rainy season is from October to middle of January.
- The average annual rainfall prevails over the study area is 815 mm.
- The total length of River is 120km of which 75km runs in Tirunelveli district.
- It is fed both by monsoons and by its tributaries.
- The relative humidity during the year is between 55 - 65%.
- It flows roughly east and enters the Gulf of Mannar of the Bay of Bengal near Palayakayal.

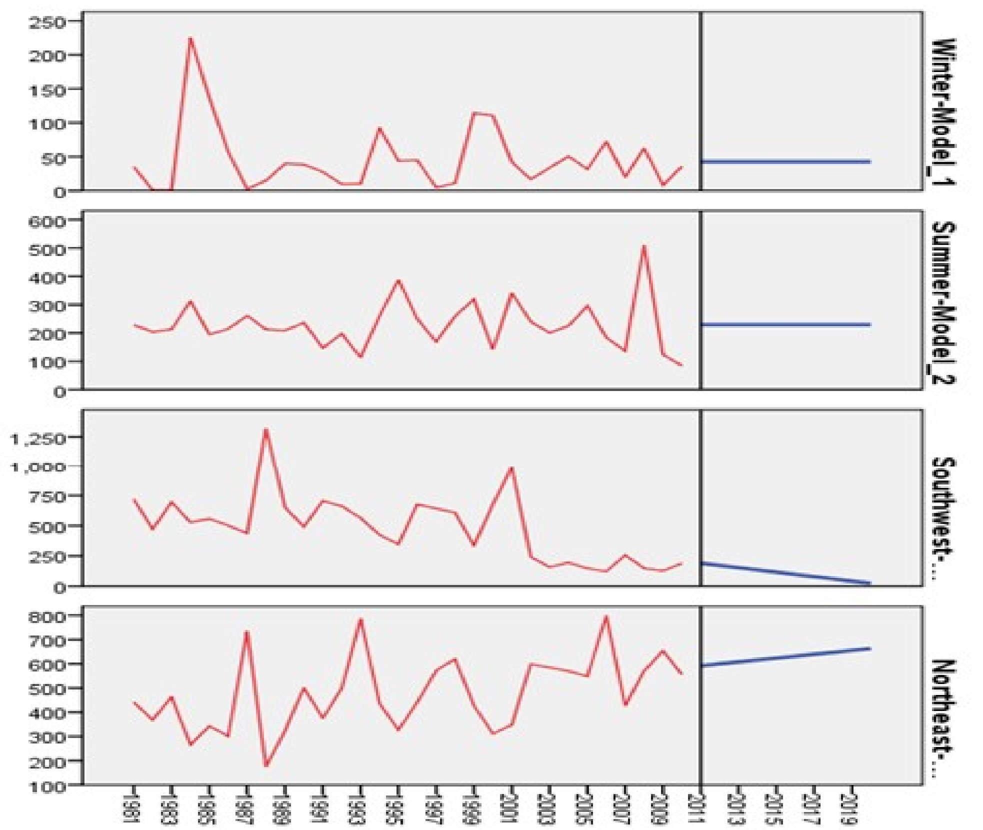
Methodology

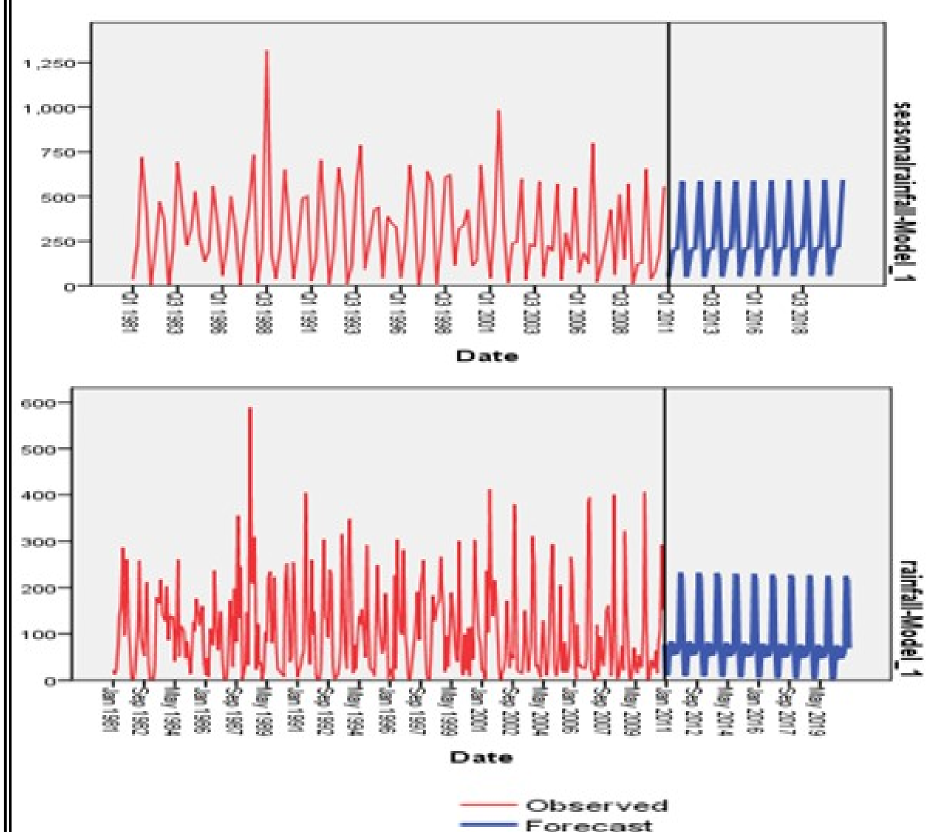


Data used in the Study

VARIABLES	DATA SOURCE
Land use/land cover map	**LANDSAT, LISS 3 and LISS 4 Satellite images (1996-2012)**
Soil map	**Soil Terrain Database**
Digital Elevation Model	**Shuttle Radar Topography Mission (SRTM)**
Measured Stream flow	**Central Water Commission**
Measured rainfall	**State Ground and Surface Water Resources Data Centre (PWD)**
Measured temperature	**State Ground and Surface Water Resources Data Centre (PWD)**

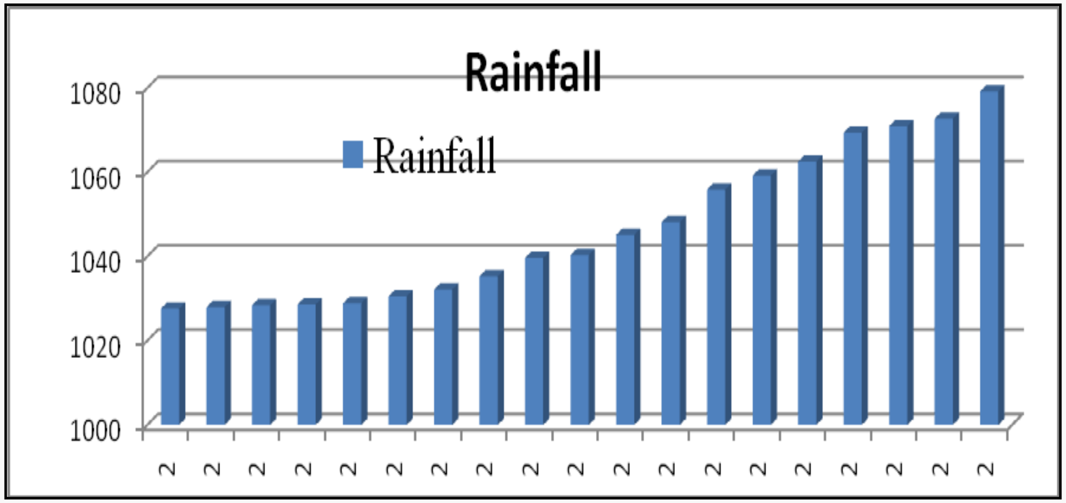
ARIMA seasonal & monthly trend - Precipitation (1981-2020)





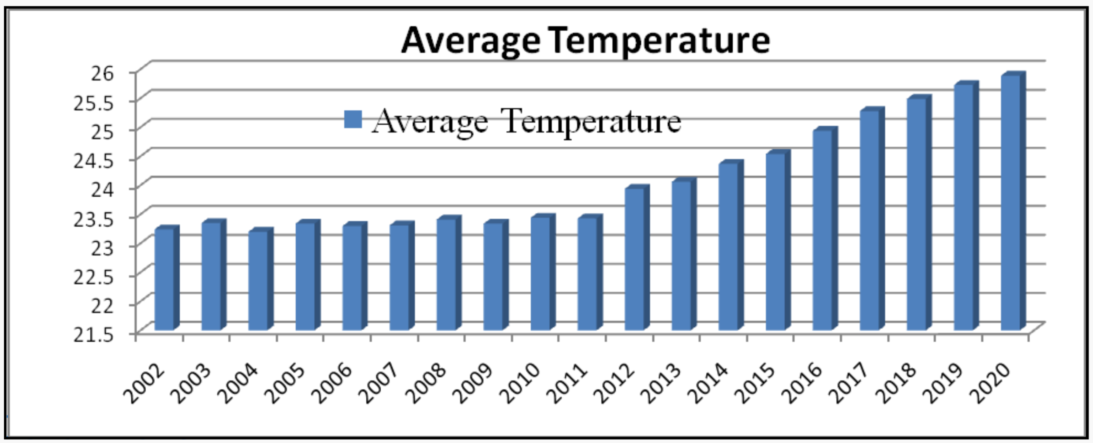
Monthly precipitation has been predicted an increase in NE monsoon and decrease in SW monsoon.

ARIMA Precipitation predicted results (2002-2020)



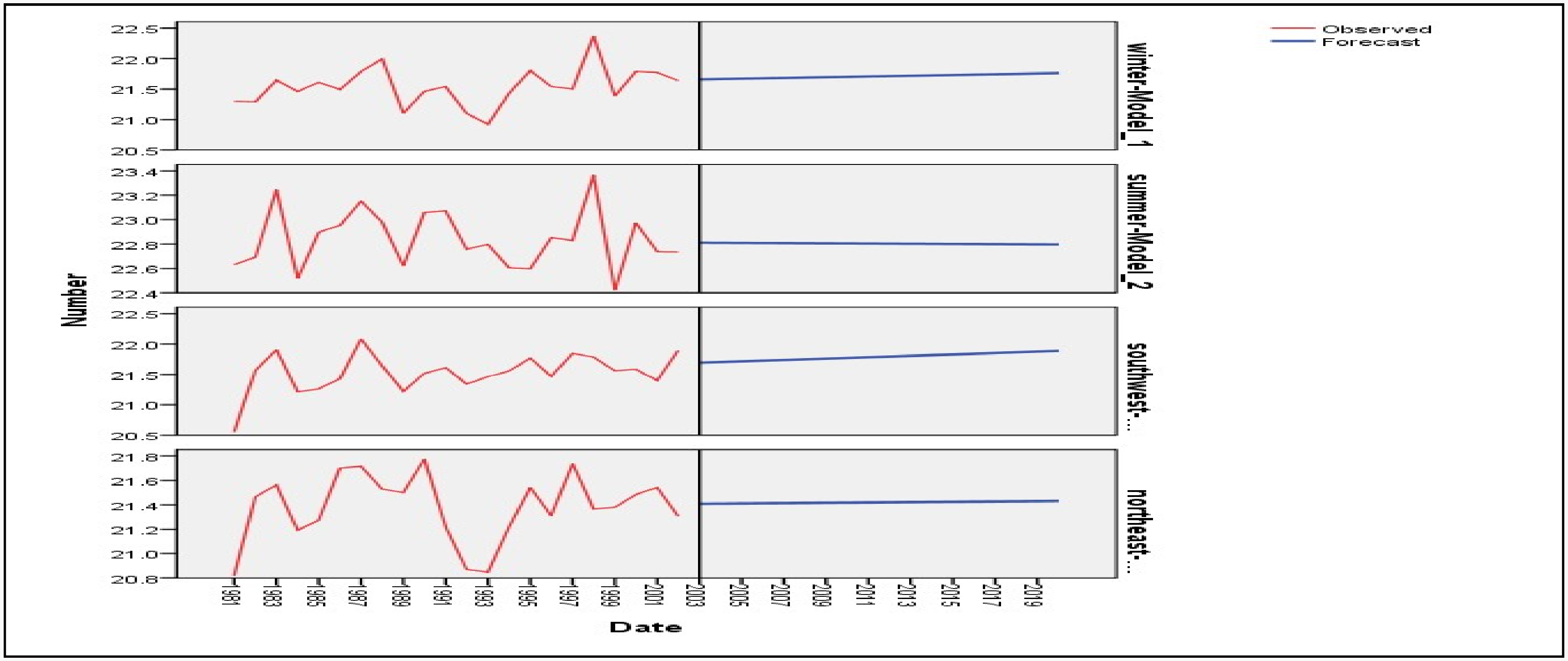
The future 2013-2020 annual rainfall trend increase from 1030mm to 1080mm.

ARIMA Average temperature predicted results (2002-2020)



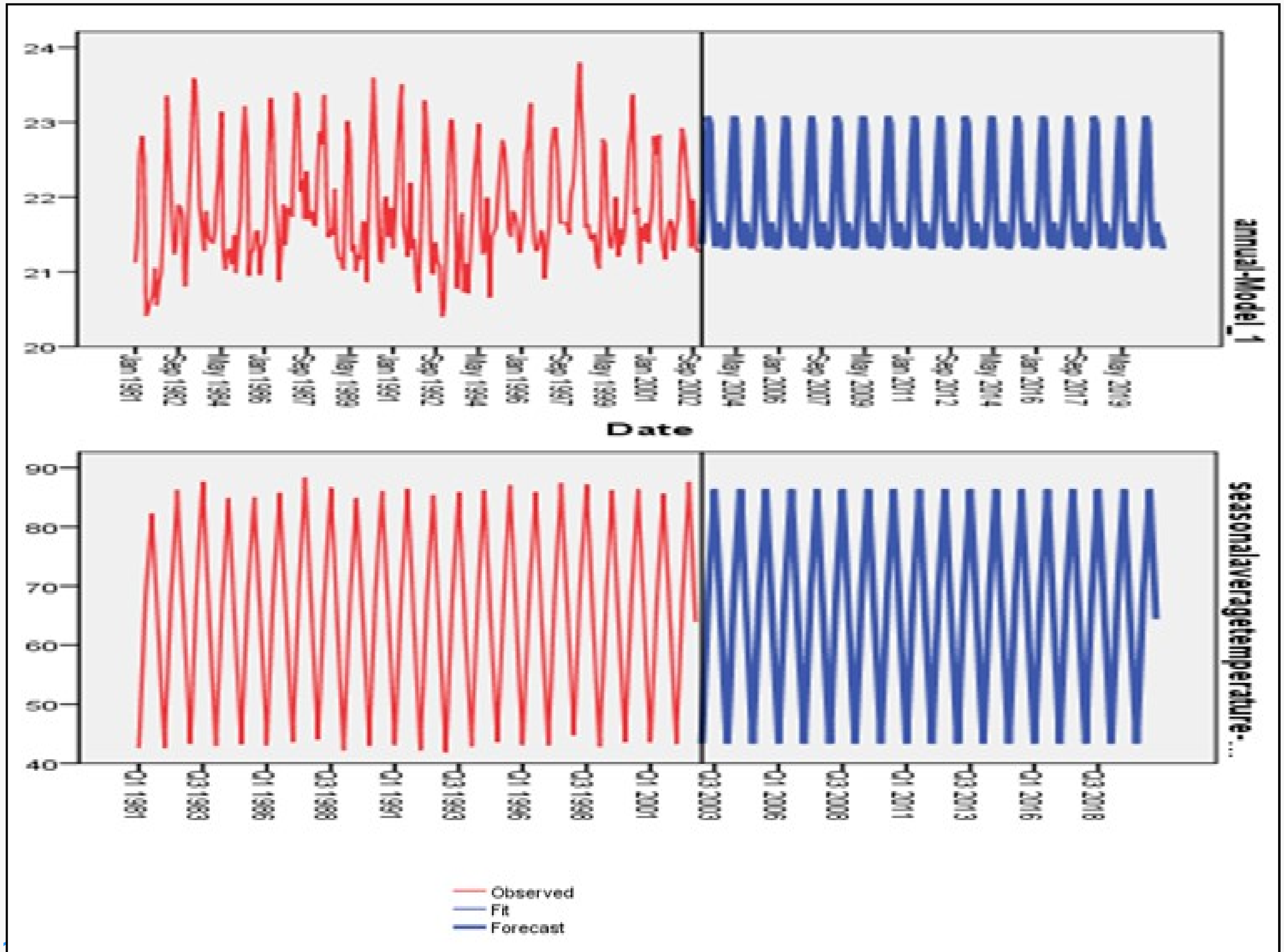
In the future period from 2013 to 2020 average temperature trend will increase from 23° C to 25° C.

ARIMA seasonal trend - Average temperature (1981-2020)

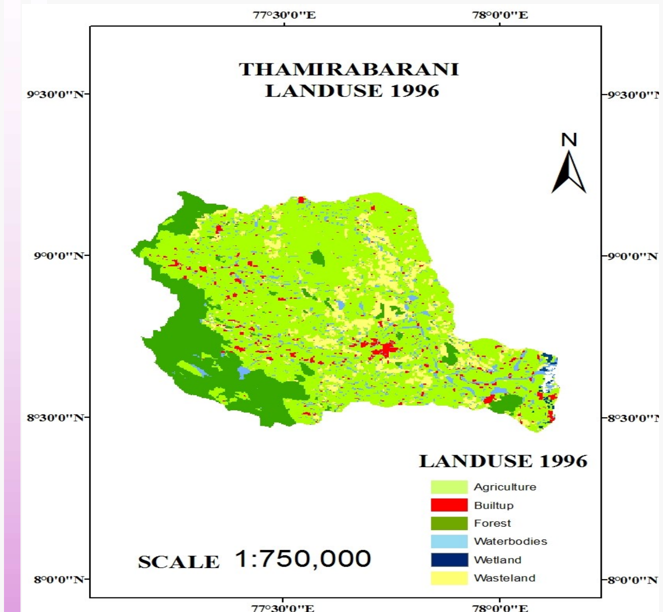


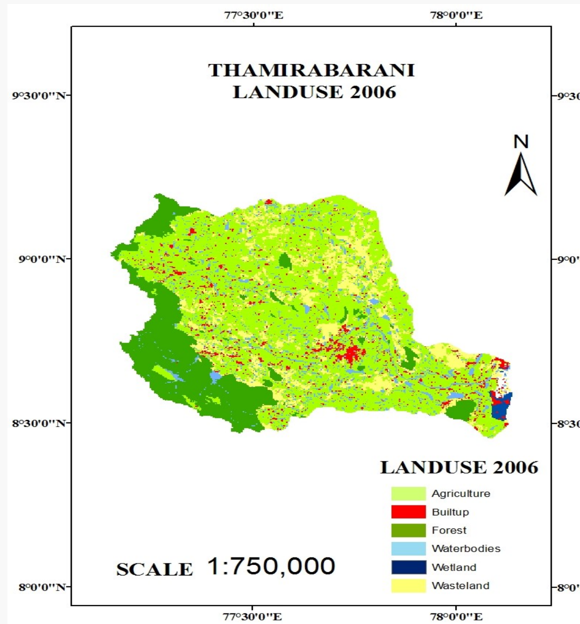
Monthly average temperature would decrease during NE monsoon and increase in SW monsoon as predicted.

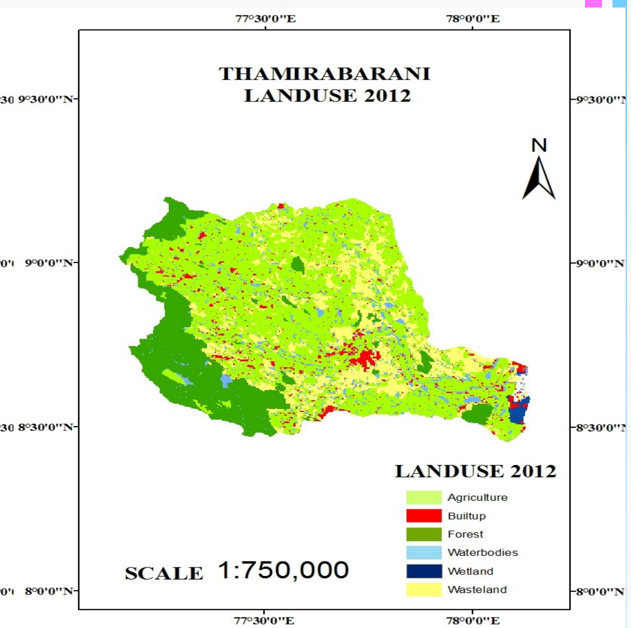
ARIMA monthly trend - Average temperature (1981-2020)



Landuse Map Preparation (1996, 2006 & 2012)







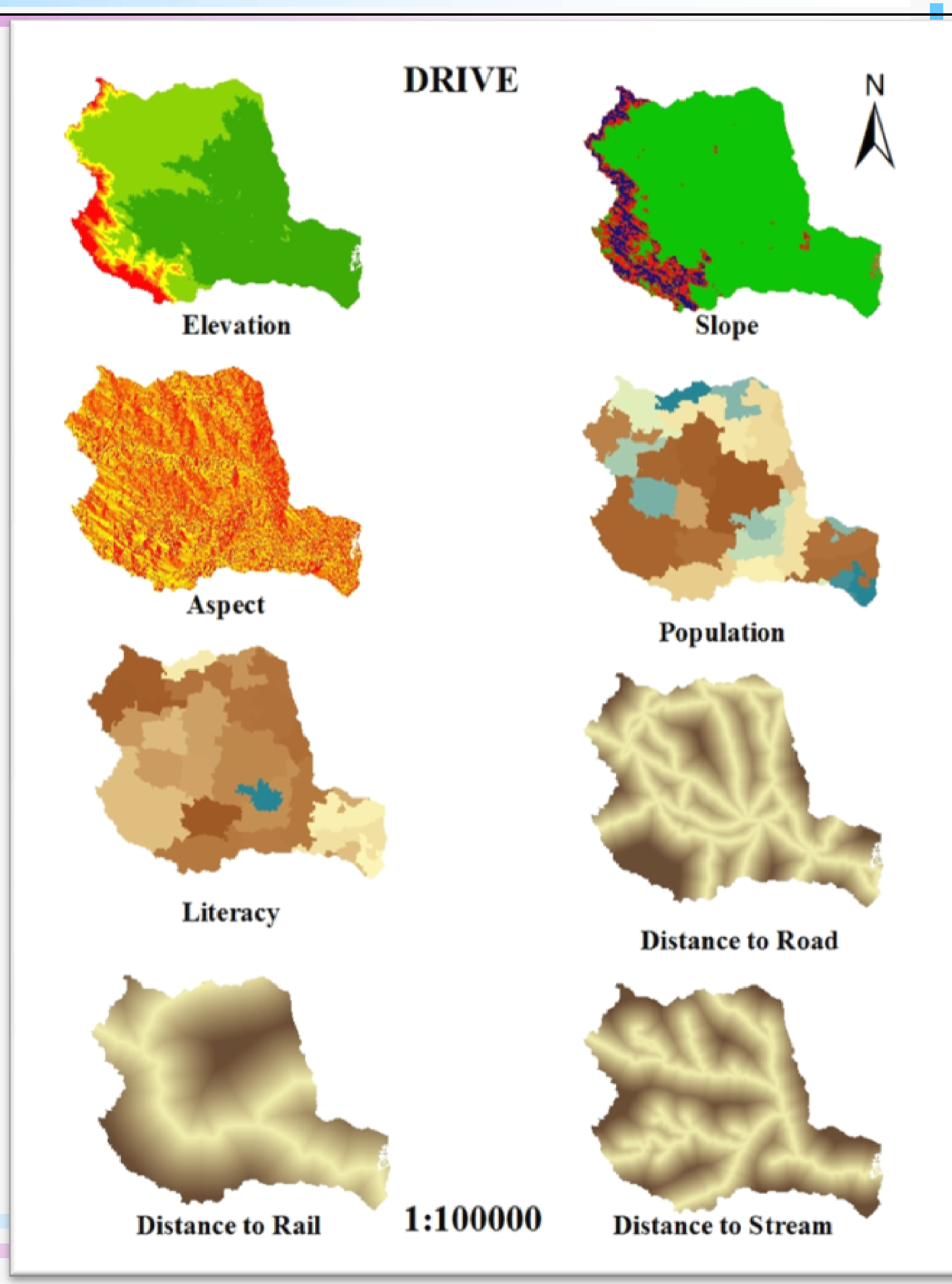
- The land use map has been prepared using LANDSAT, LISS 3 and LISS 4 Satellite images.
- First level classification such as Agriculture, Water bodies, Wet land, Built-up and Forest has been done.
- The area for each land use type has been calculated and the corresponding demand files have been prepared.
- The study area is mostly occupied by the agricultural lands and waste lands.

Land Use Prediction by CLUE-S model

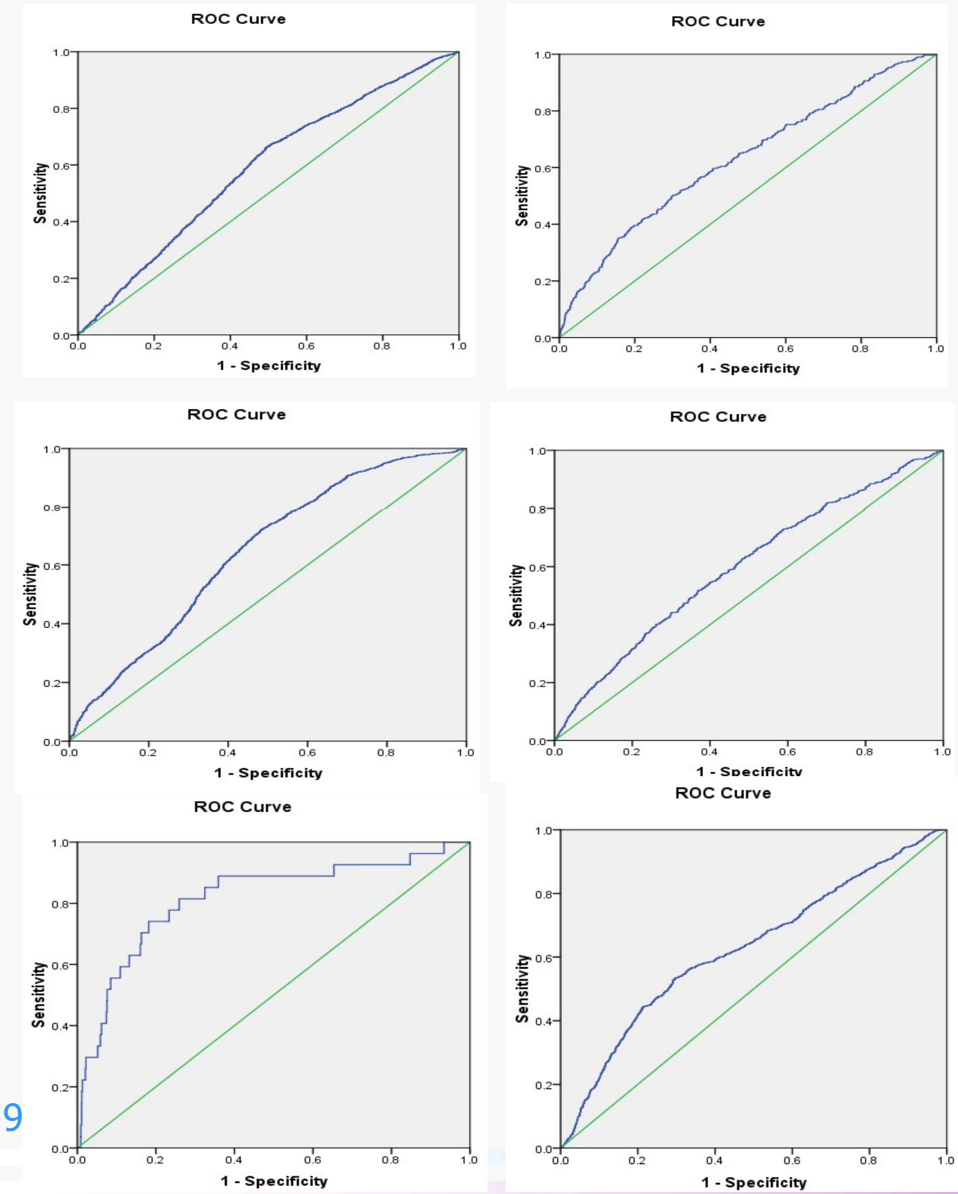
- The Conversion of Land Use and its Effects at Small regional extent (CLUE-S) model is a scale dynamic model with multi-scale characteristics based on system theory.
- The factors or drivers considered are elevation, slope, aspects, population, Iliteracy, distance to river, distance to stream and distance to rail.
- The area for each land use type has been calculated and the corresponding demand files have been prepared.

Driving factors

(a) Elevation
(b) Slope
(c) Aspects
(d) Population
(e) Literacy
(f) Distance to Rail
(g) Distance to Stream
(h) Distance to Stream



Logistic Regression



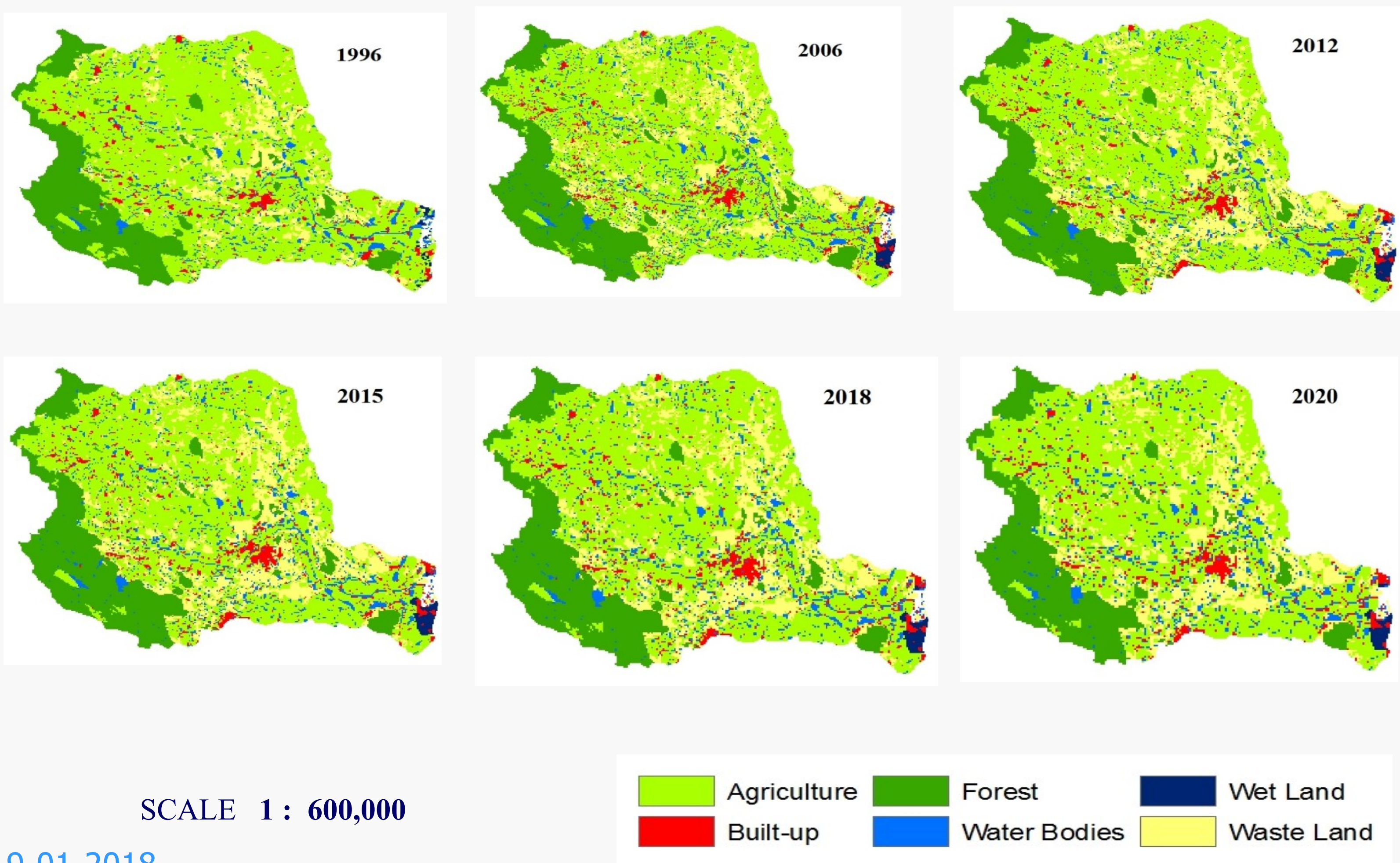
Validation of logistic regression analysis has been tested by using Receiver Operating Characteristic (ROC) method.

S.No	LANDUSE TYPE	ROC CURVE
A	Agriculture	0.688
B	Built up	0.631
C	Forest	0.645
D	Water	0.598
E	Wetland	0.817
F	Waste Land	0.626

Predicted Land use Map

- The databases for land use of the specific year (1996,2006 and 2012) have been generated with the help of ArcGIS.
- The land use data for the specific year was necessary for the prediction of land use of the years 2015, 2018 and 2020.
- The entire database has been created, then the parameters and the drivers have been identified to develop the model which predicts the land use change in the study area using CLUE-S model.

Predicted Land use maps - 1996 to 2020



SCALE **1 : 600,000**

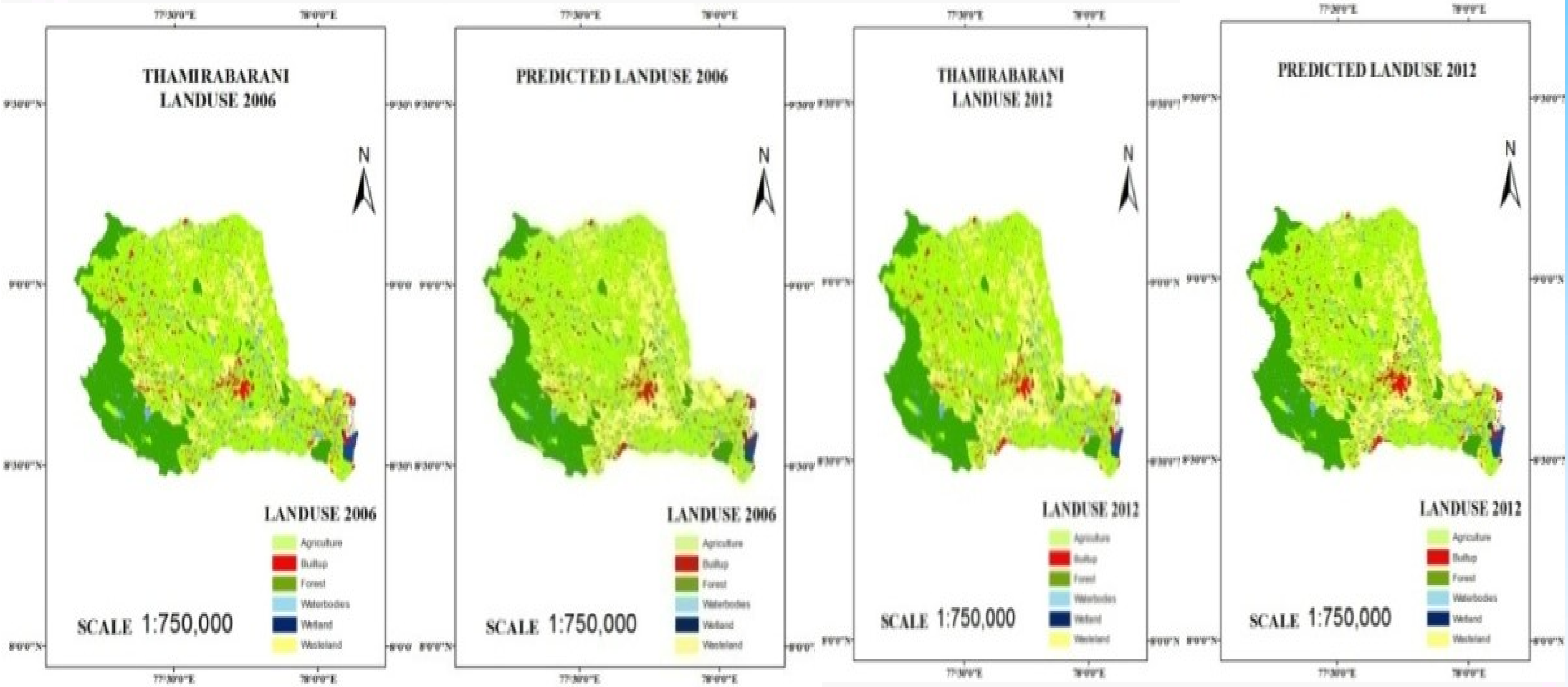
CLUE-S Model validation

Land use type	2006 (%)			2012 (%)		
	Area	Predicted Area	Error	Area	Predicted Area	Error
Agriculture	54.64	55.69	-1.05	50.52	51.57	-1.02
Built-up	4.47	4.60	-0.12	4.81	4.93	-0.19
Forest	18.30	18.30	0.00	18.30	18.30	0.00
Water Bodies	14.66	14.66	0.00	18.43	18.43	0.00
Wetlands	0.55	0.59	-0.04	0.56	0.60	-0.09
Waste Land	7.36	6.15	1.21	7.39	6.18	1.81

- In order to achieve a valid predicted land use, the validity of this model was examined by using the actual land use map of years 1996, 2006 and 2012, which has been created from image interpretation.

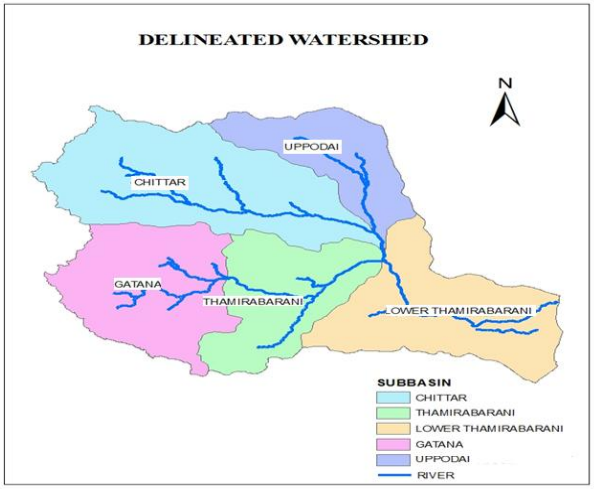
- Land use map of years 2006 and 2012 resulted from predicted land use is compared to the actual land use map of years 2006 and 2012 to measure area of each land use type in both maps.

Comparison of predicted and actual land use map (2006 and 2012)



In the predicted land use maps from 2012 to 2020, agriculture area were predicted to decrease by 4.27%, while waste land, built-up and wet land were predicted to increase by 1.93%, 1.84 and 0.5% respectively, based on 1996 base line.

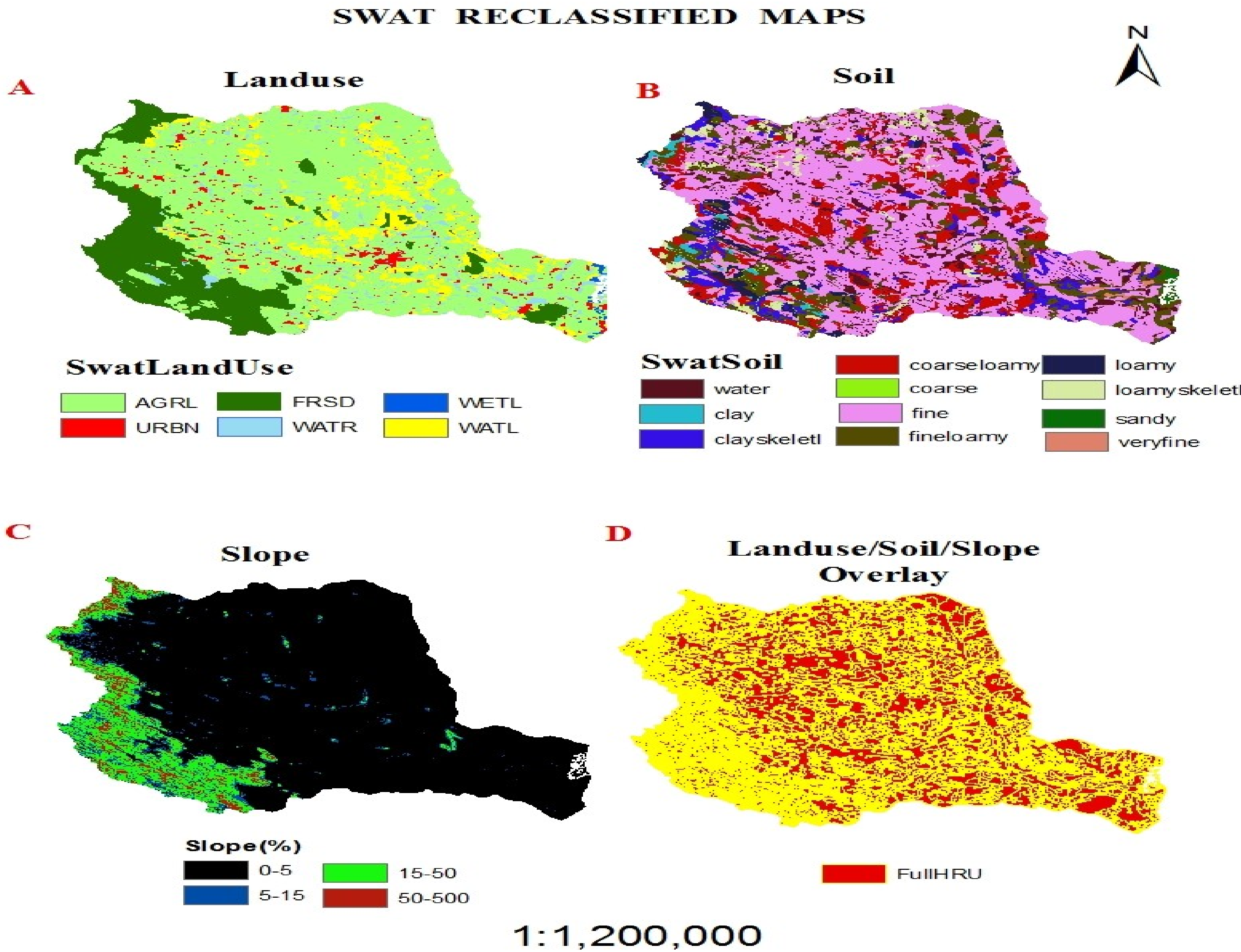
Stream Flow Estimation by SWAT



S.No	Sub basin	Area(Sq.km)
1	CHITTAR	1659.24
2	UPPODAI	704.27
3	THAMIRABARANI	1160.01
4	GATANA	931.41
5	LOWER THAMIRABARANI	1253.44

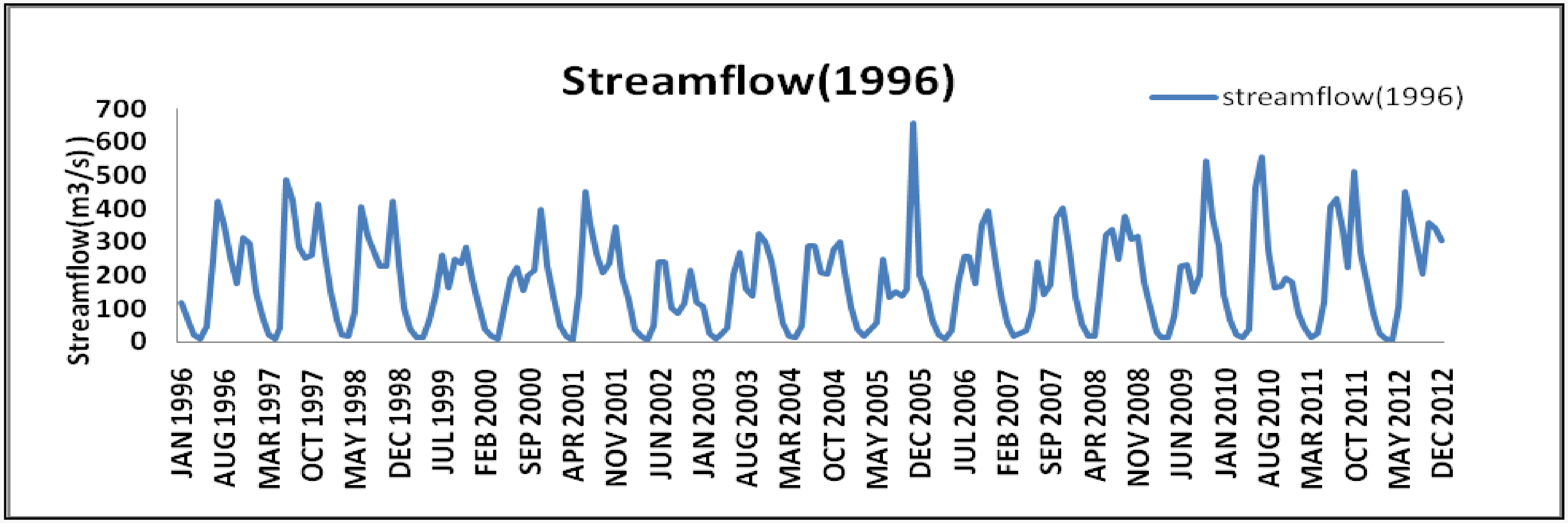
- The output of SWAT model gives the precipitation and stream flow of each and every watershed on daily basis with respect to precipitation, temperature, land use, soil and slope data.

- As Thamirabarani River Basin is divided into 5 sub watersheds, the mean monthly rainfall and stream flow in whole watersheds have been calculated.



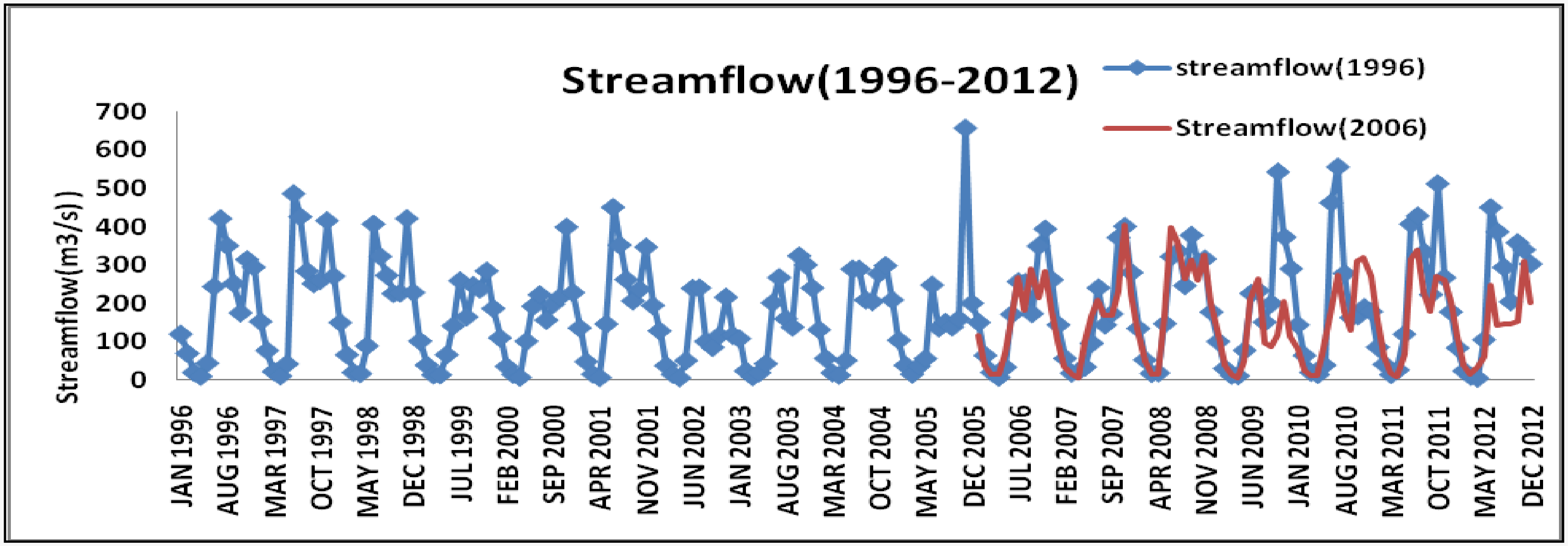
SWAT RECLASSIFIED MAPS
N
A
Landuse
B
Soil
SwatLandUse
AGRL
FRSD
WETL
URBN
WATR
WATL
SwatSoil
water
clay
clayskeletl
coarseloamy
coarse
fine
fineloamy
loamy
loamyskeletl
sandy
veryfine
C
Slope
D
Landuse/Soil/Slope Overlay
Slope(%)
0-5
5-15
15-50
50-500
FullHRU
1:1,200,000

Stream flow results for land use 1996

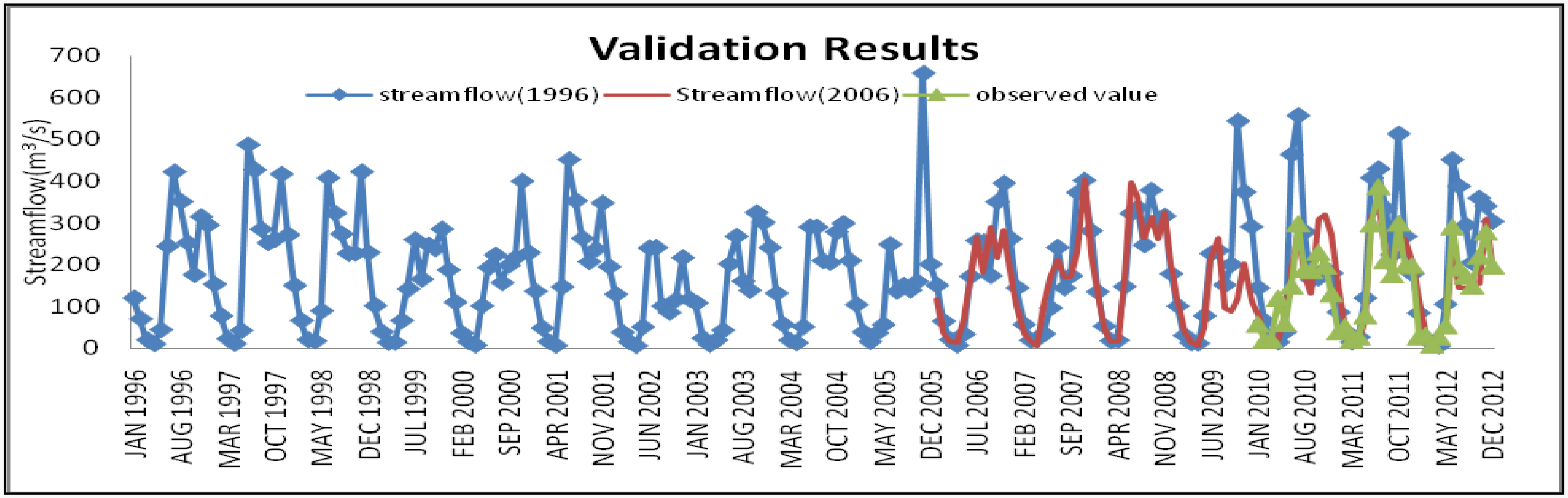


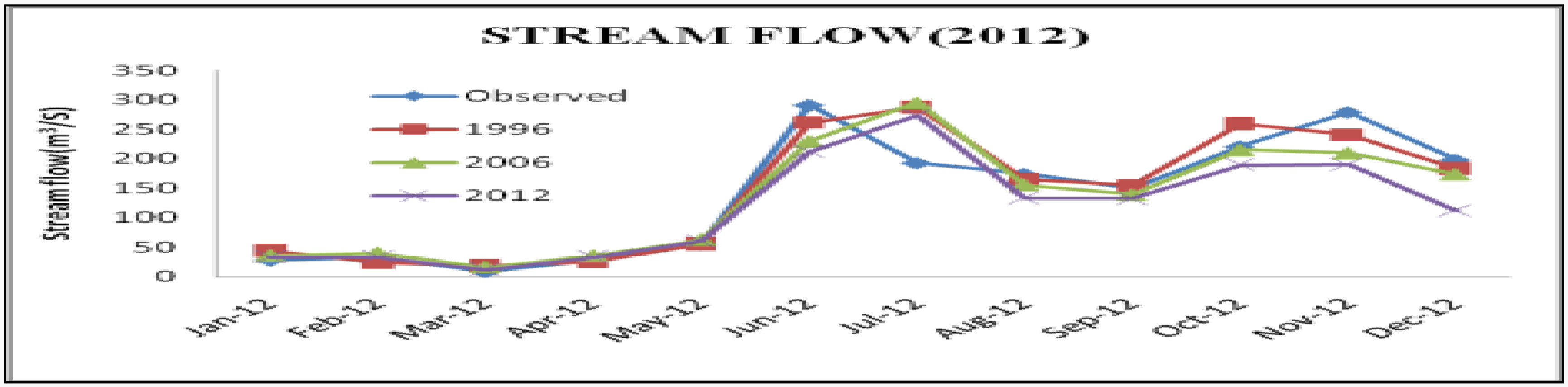
By using the land use data of year 1996 and soil, slope, precipitation and temperature data of years (1996 to 2012), stream flow of whole watershed has been evaluated initially.

Stream flow results for land use 2006



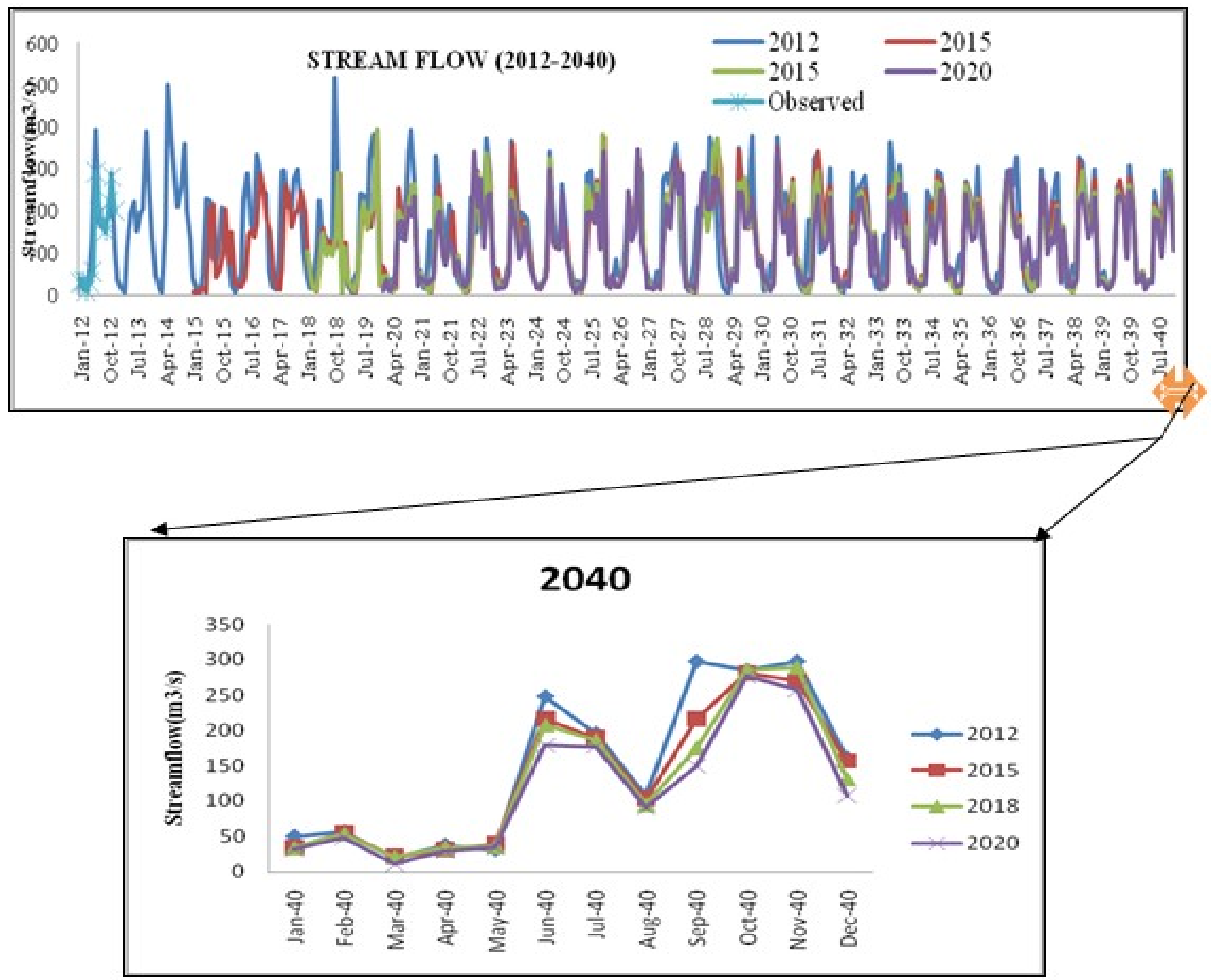
- Similarly by using the land use data of year 2006 and soil, slope, precipitation and temperature data of years (2006 to 2012), stream flow of whole watershed has been evaluated again.
- By comparing 1996 and 2006 land use, stream flow trend will be decreasing because land use will be changed.



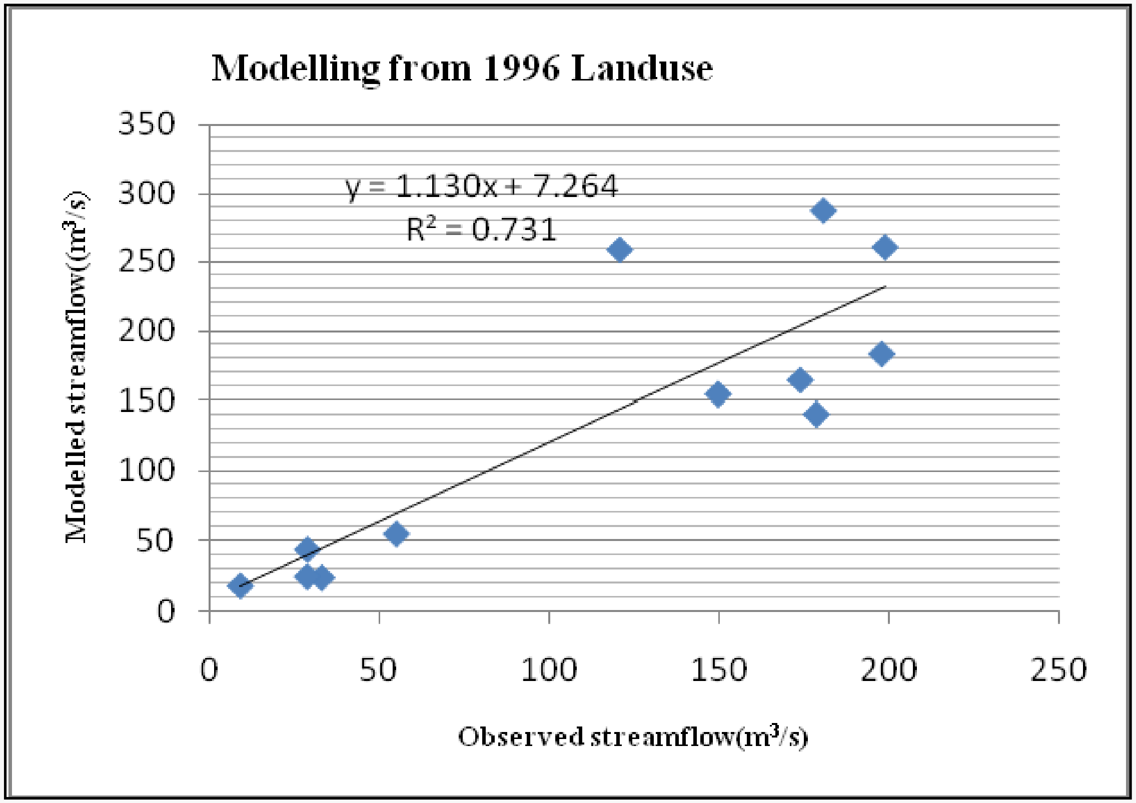


The results are validated with observed stream flow data for the year 2010-2012.

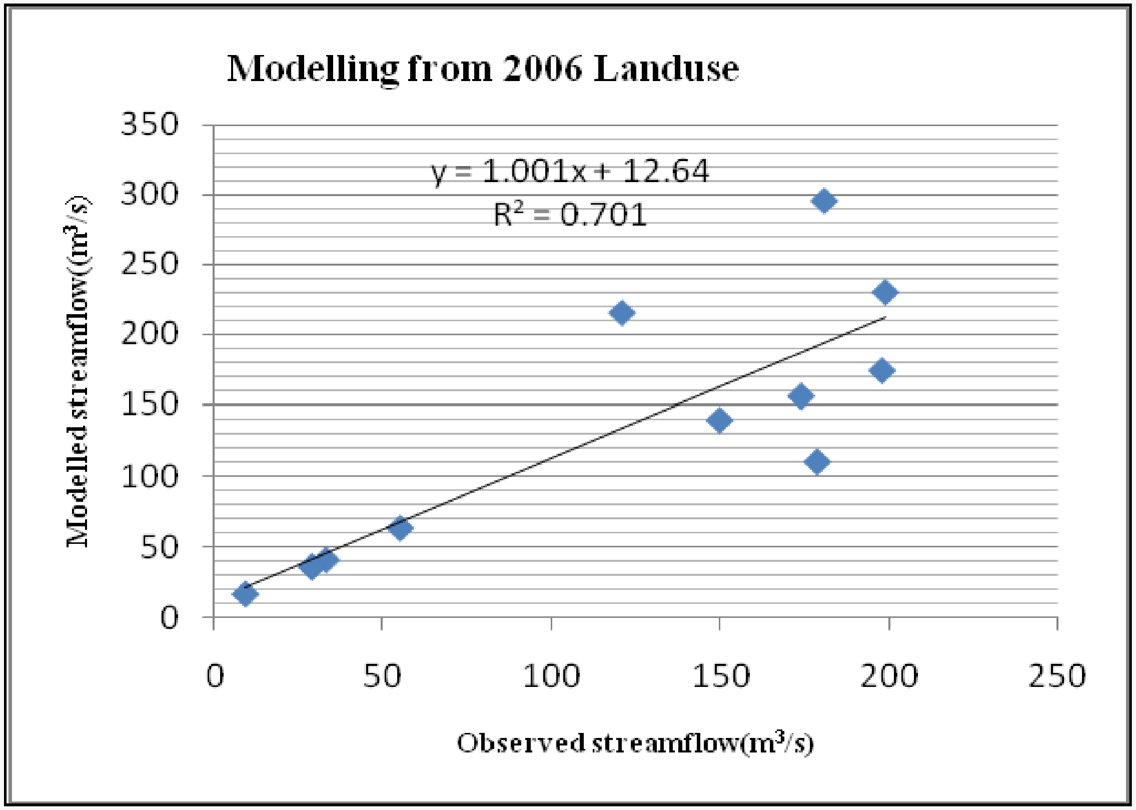
Time plot of predicted stream flow results from 2013 to 2040 using predicted land use, predicted precipitation and temperature data of years 2012, 2015, 2018 and 2020



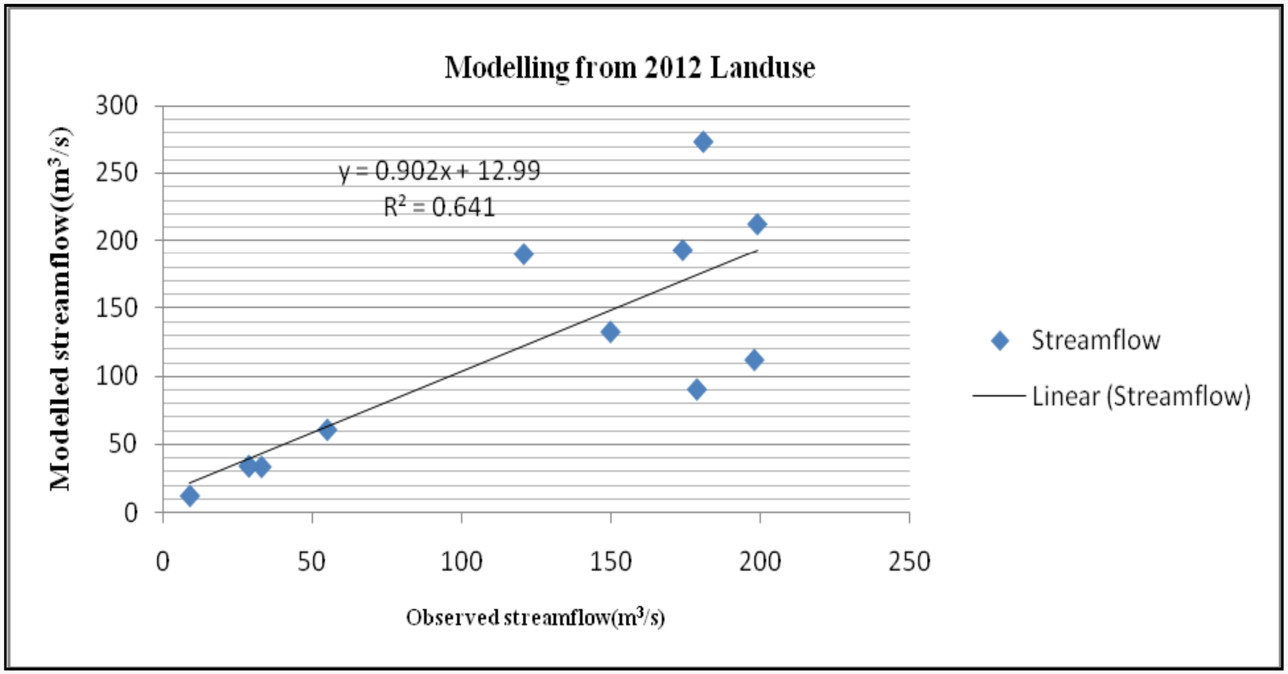
Scatter plot comparison of the observed and model simulated stream flow using 1996 land use



Scatter plot comparison of the observed and model simulated stream flow using 2006 land use



Scatter plot comparison of the observed and model simulated stream flow using 2012 land use



Conclusion

- The results show that stream flow for 2013-2040 has an increase of 10.8% due to climate change only, but a decrease of 12.4% due to climate change and land use changes.
- From the analysis of model results, it was also noticed that predicted increase in precipitation will have a greater impact on watershed hydrology than the predicted land use changes, but land use change also plays a vital role because it can magnify these impacts at several aspects.
- The result shows that the man-made land use change has a greater influence on the stream flow of the river basin.
- Therefore, to lessen the gravity of negative hydrologic impacts and use positive impacts, both land use/cover and climate changes should be considered in water resource planning for the Thamirabarani river basin.

Thank You