SPATIAL DROUGHT MONITORING IN THAR DESERT USING SATELLITE BASED DROUGHT INDICES AND GEO-INFORMATICS TECHNIQUES

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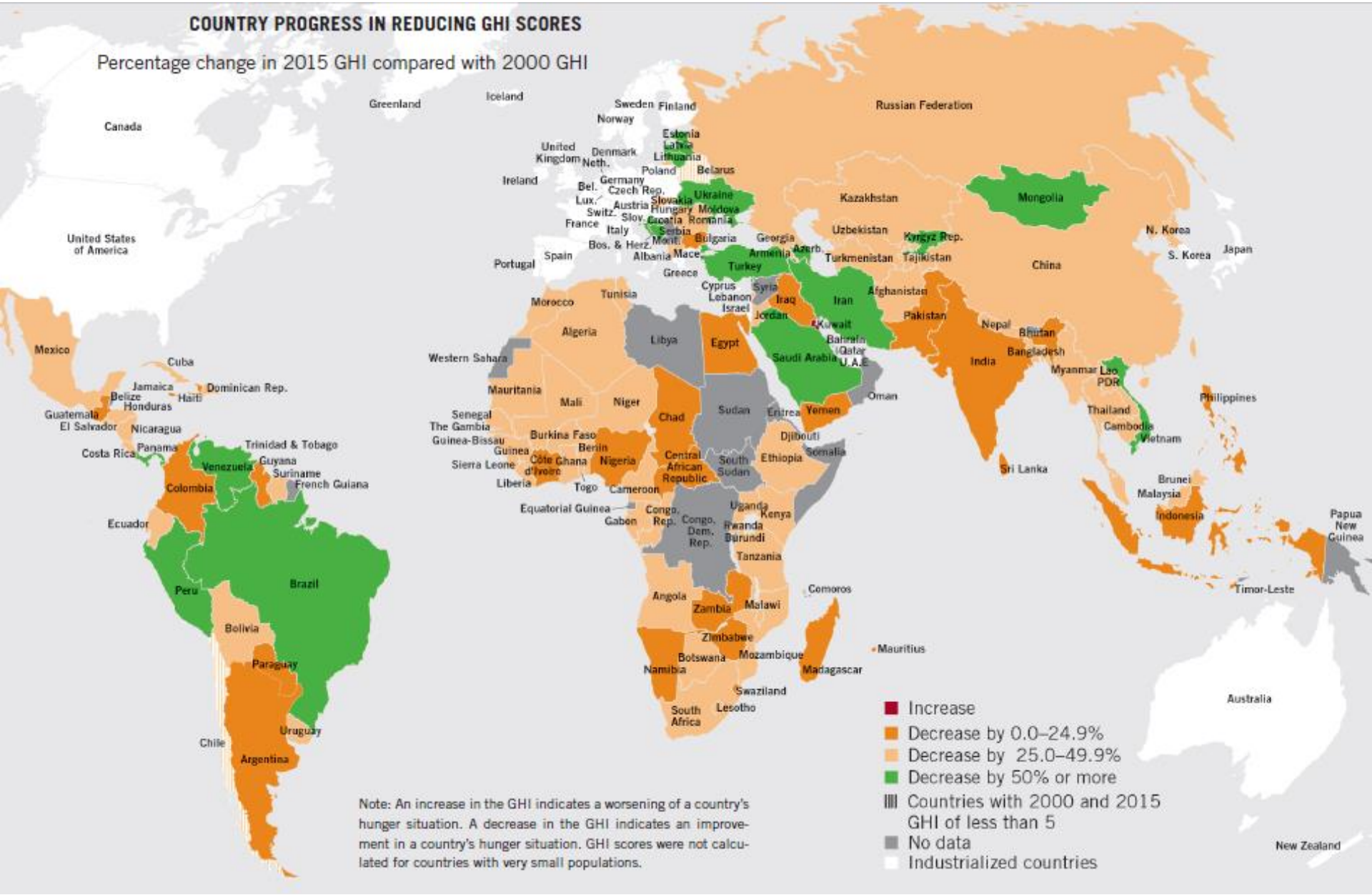
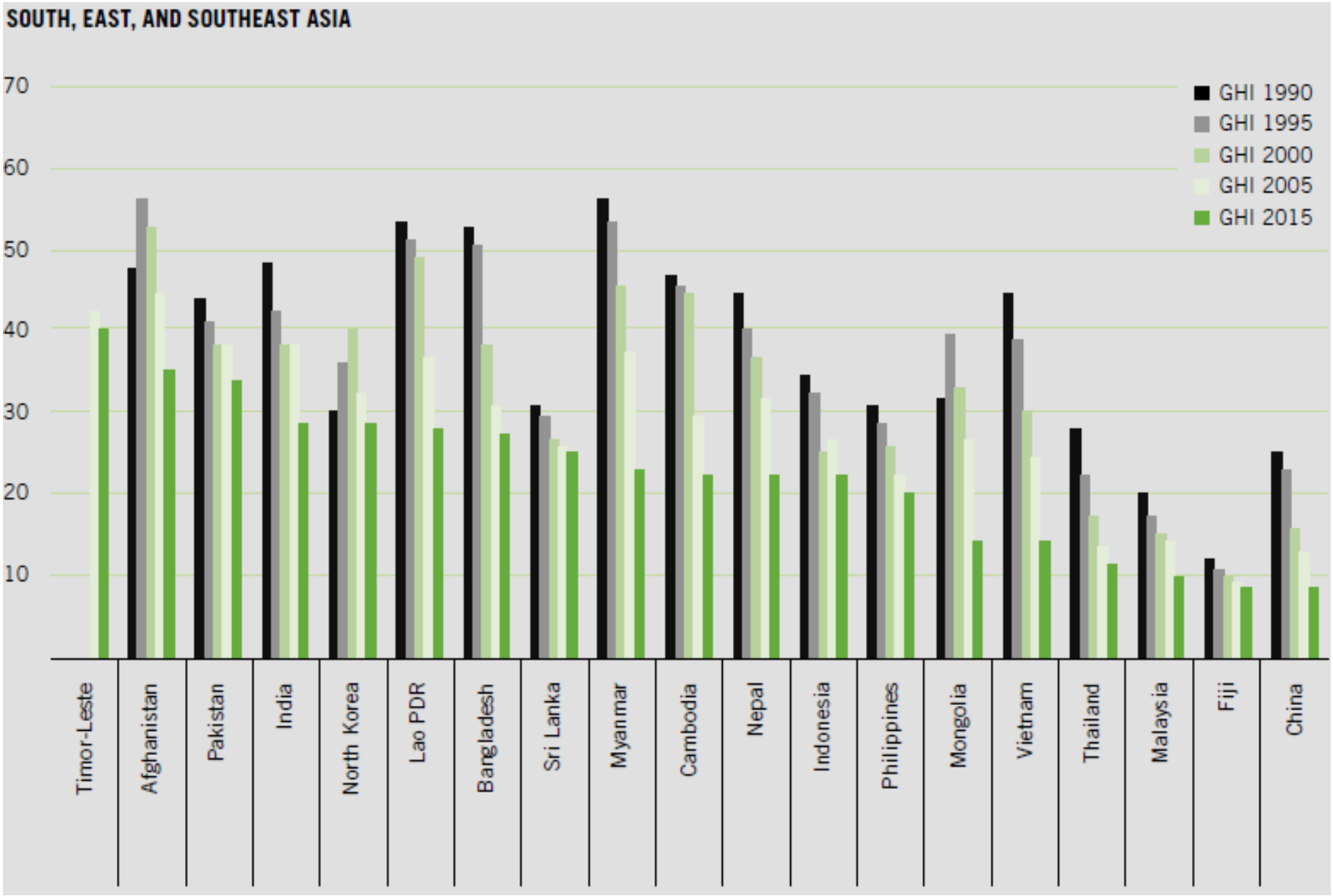
Introduction

- Droughts is a natural phenomenon which can be caused due to many factors like insufficient precipitation, high temperature, high evapo-transpiration, depletion of ground water and exploitation of water resources etc.
- Drought has become a recurrent phenomenon in our country due to rapid increase in population and continuous climatic changes.
- According Global Hunger Index (GHI) report 2015 issued by IFPRI, there are still more than 795 million people falling under hunger lines all over the world.
- GHI report ranked Pakistan at number 93 out 104 countries with a total score of 33.9, depicting an increase in Pakistan's Hunger index.
- The present work is focused on examining influence of drought on vegetation of Thar area by making an attempt to understand the nature of drought persisting in the Thar region, the affects of less rainfall and high temperature on the land cover/vegetation.



World map showing Progress made by countries in reducing GHI



Graphical representations of GHI scores of different Asian Countries

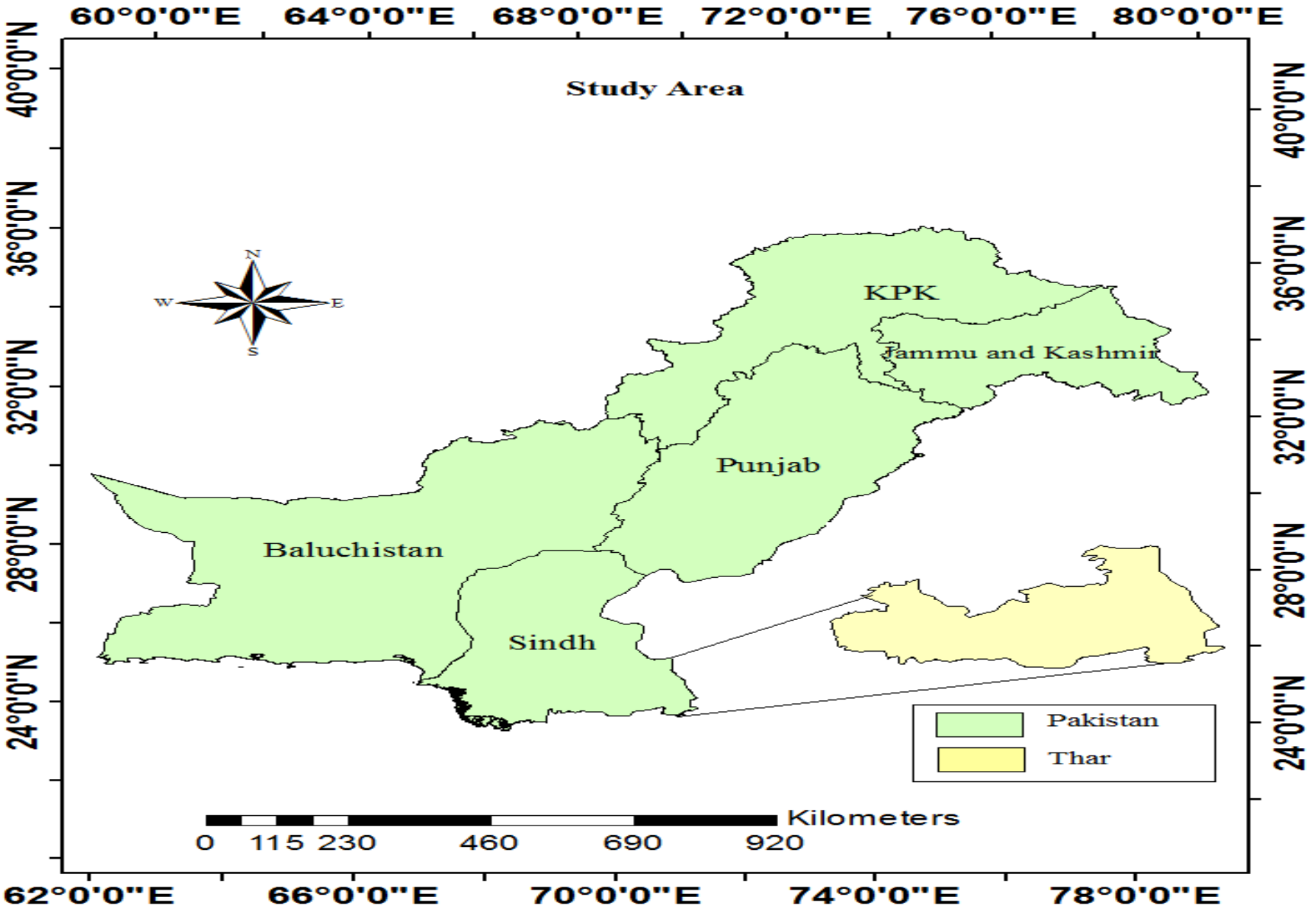
Background of Study& Objectives

- Various indices have been used by various researchers all over the world in order to estimate and access drought existence.
- There are more than 20 drought indices used by researchers. Selection of proper Index for a study is based on the type of research being done and Data Availability in an area.
- The application of geographic information system (GIS) and remote sensing for Drought evaluation and assessment has been popular topic of research.

Objectives:

- To study spatial distribution of drought in Thar desert using satellite based drought Indices
- To study the effect of drought on land use change within the Thar desert

Study Area


Study Area
60°0'0"E
64°0'0"E
68°0'0"E
72°0'0"E
76°0'0"E
80°0'0"E
40°0'0"N
36°0'0"N
32°0'0"N
28°0'0"N
24°0'0"N
62°0'0"E
66°0'0"E
70°0'0"E
74°0'0"E
78°0'0"E
N
W
E
S
KPK
Jammu and Kashmir
Punjab
Baluchistan
Sindh
Pakistan
Thar
Kilometers
0 115 230 460 690 920

Data Acquisition

Data Type	Data Products	Data Source	Data Specification
Satellite Data	MODIS 250m resolution	http://www.glovis.usgs.gov	30m spatial resolution
Climatic Data	Precipitation data, Temperature Data (minimum & maximum	Pakistan Meteorological Department	Monthly data of five complete years (2002, 2005, 2008, 2011 & 2014)

Vegetation Indices

1. Normalized Difference Vegetation Index (NDVI)

- Normalized Difference Vegetation Index (NDVI) is a numerical indicator which can be used in remote sensing in order to analyze the targeted area whether it contains vegetation or not.
- Generally, visible and near-infrared bands of electromagnetic spectrum are used for this purpose. The NDVI can be calculated using the following formula:

$$\mathbf{NDVI = (NIR - VIS) / (NIR + VIS)}$$

Where NIR and VIS represents the spectral reflectance measurements acquired in the near-infrared regions and visible (red) regions, respectively.

- The result of this calculation always gives a number that ranges from -1 to +1.
- Value close to +1 indicates highest density of vegetation and close to zero means no vegetation.

Vegetation Indices (Contd.)

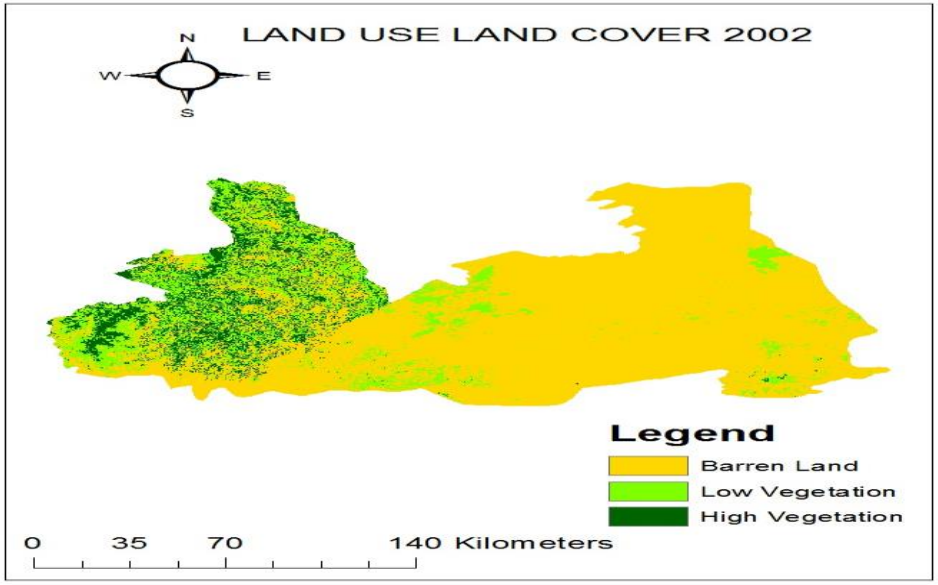
2. Standard Precipitation Index (SPI)

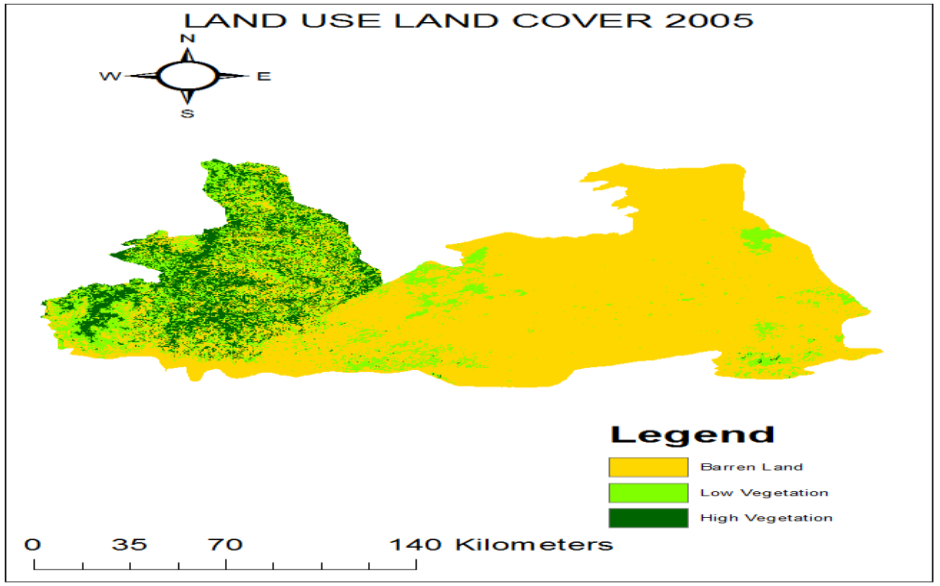
- Standard Precipitation Index (SPI) developed by American scientists McKee, Doesken and Kleist in 1993 is a simple and statistically relevant index which gives an understanding of impacts of precipitation deficiency on reservoirs, ground water, soil moisture etc.
- It is a flexible and powerful probability index which is used to quantify the precipitation deficit.
- It is calculated for different time scale with precipitation as the only input parameter. SPI is given as the ratio of difference between the normalized seasonal precipitation and its long-term seasonal mean to the standard deviation.

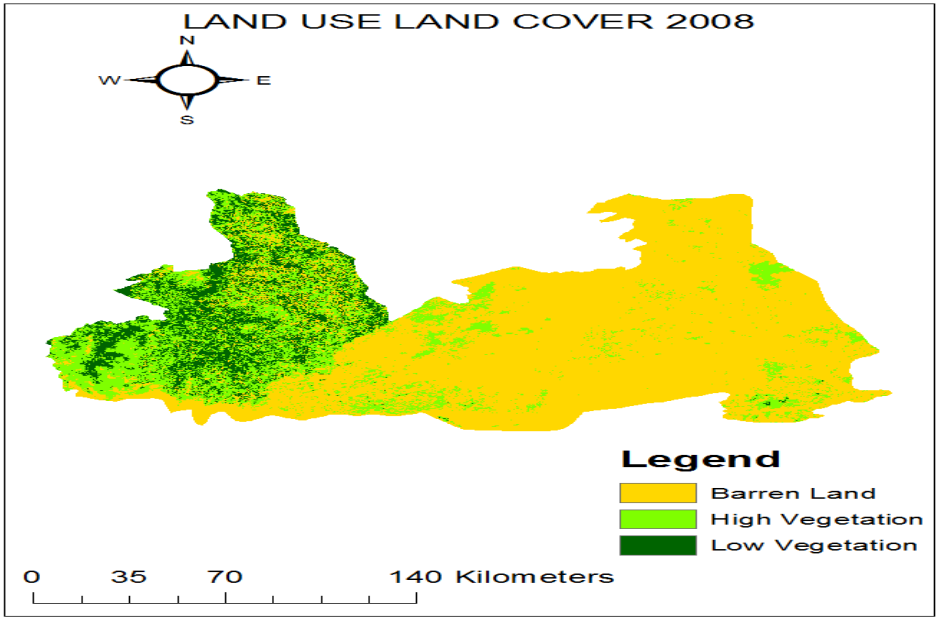
$$SPI = \frac{X_{ij} - X_{im}}{\sigma}$$

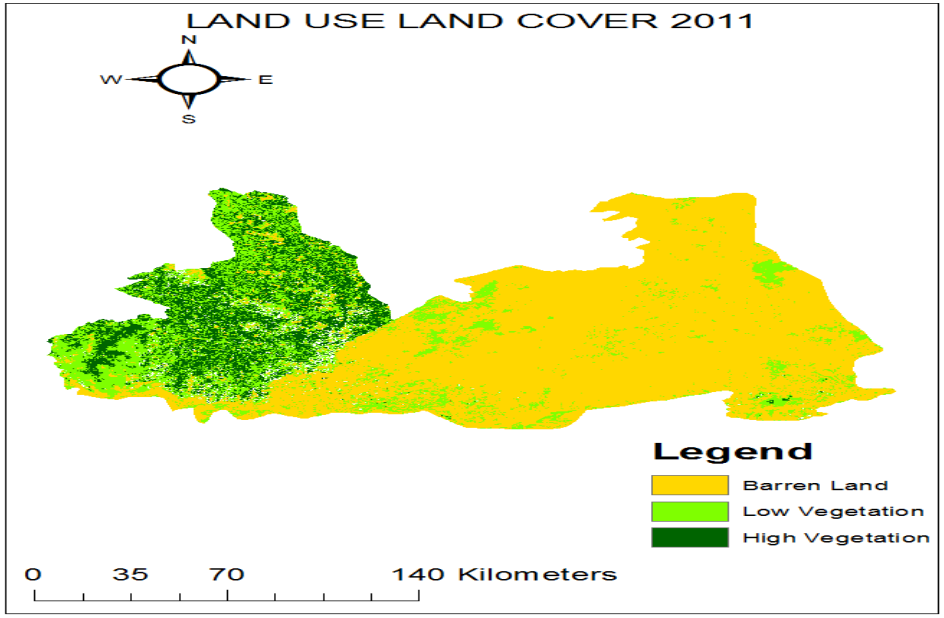
Where X_{ij} is the seasonal precipitation at the rain is gauge station and j^{th} observation, X_{im} is the long-term seasonal mean and is its standard deviation.

Results: Land Use Land Cover Classification









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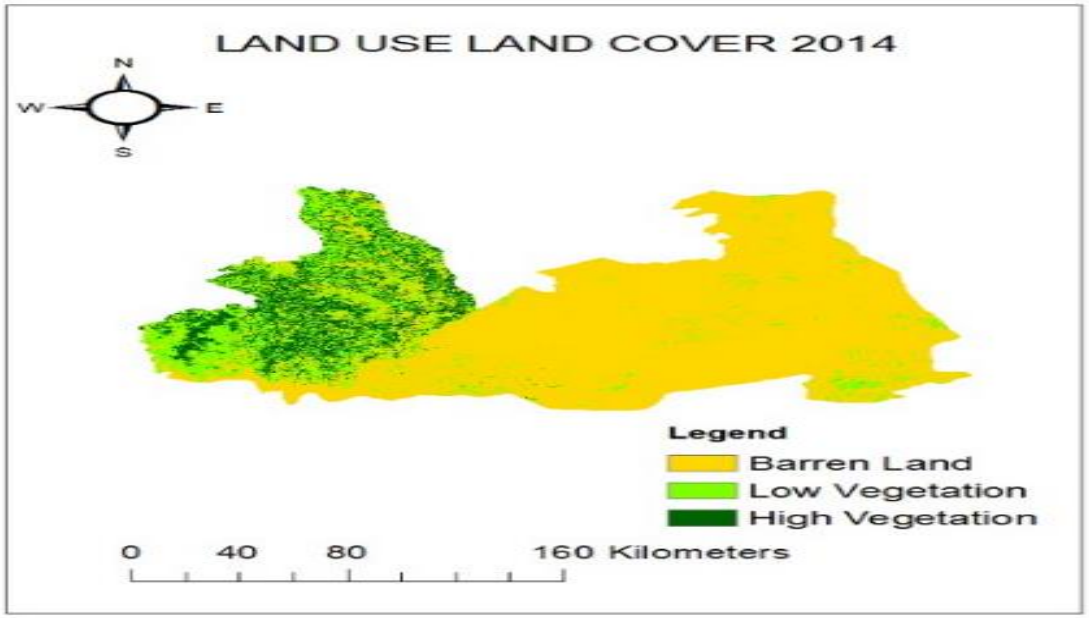
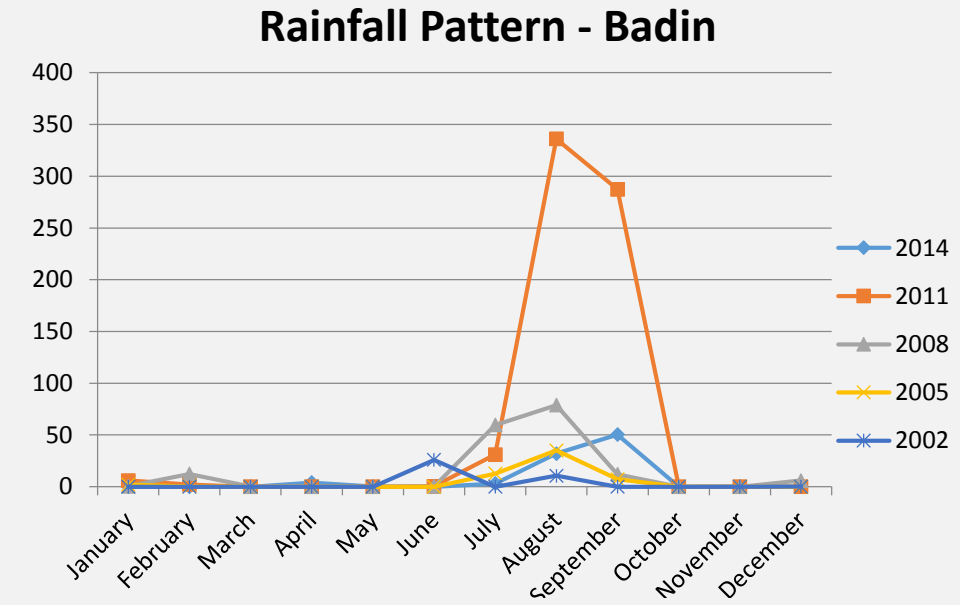
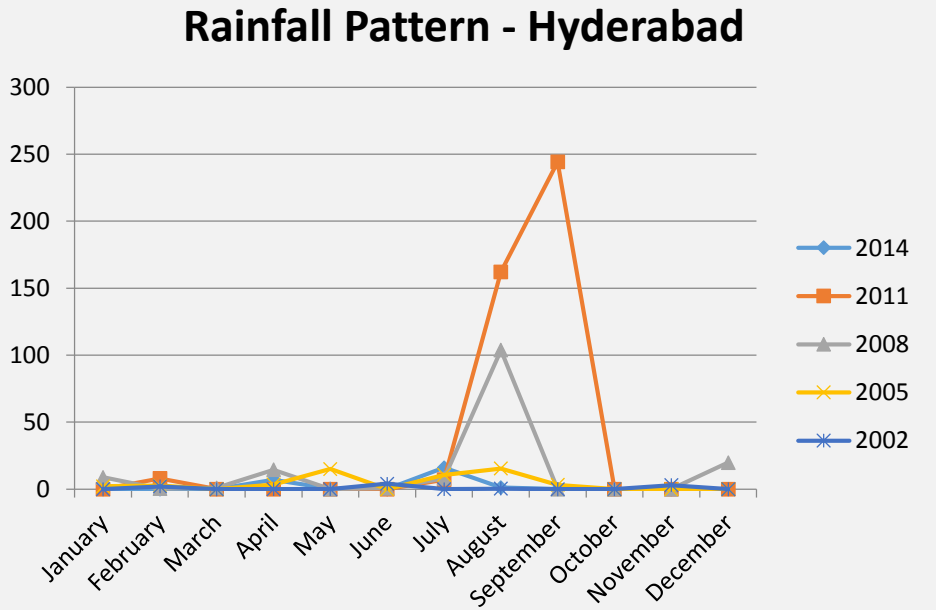
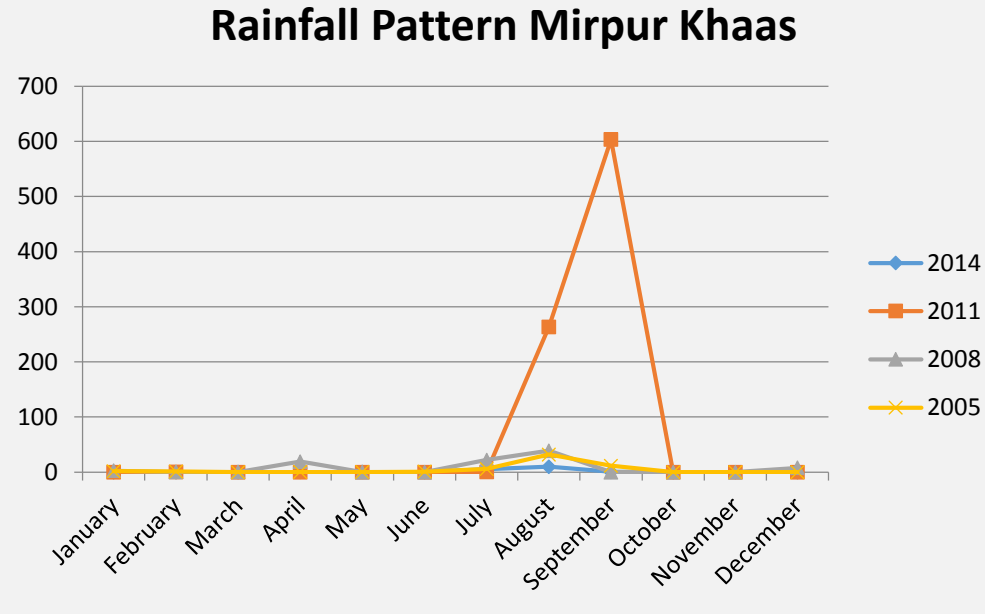


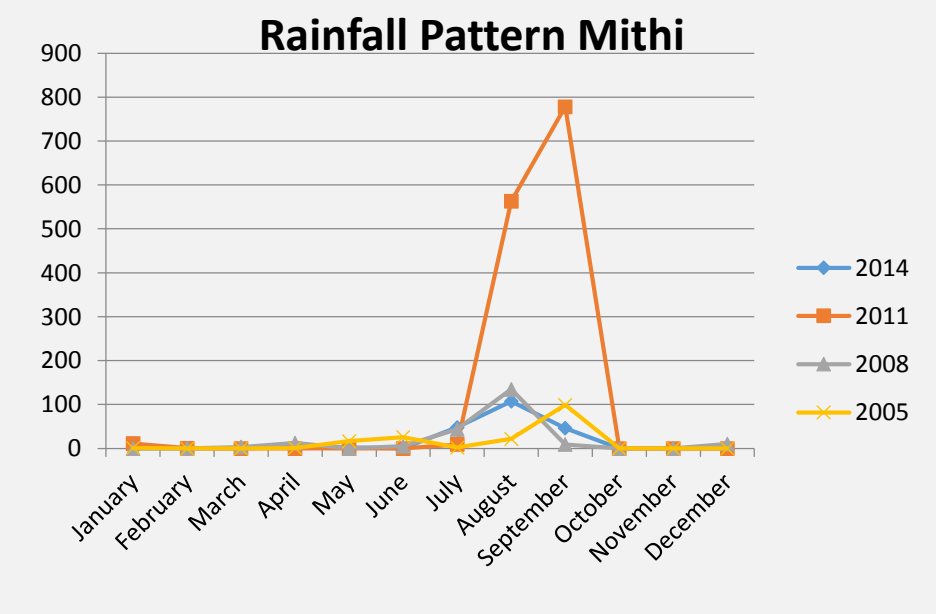
Year	Area (Million Hectare)		
	Barren Land	Moderate Vegetation	High Vegetation
2002	2.736	0.595	0.379
2005	2.667	0.597	0.445
2008	2.476	0.789	0.445
2011	2.350	0.791	0.570
2014	2.638	0.649	0.423

Results: Rainfall Pattern of Thar

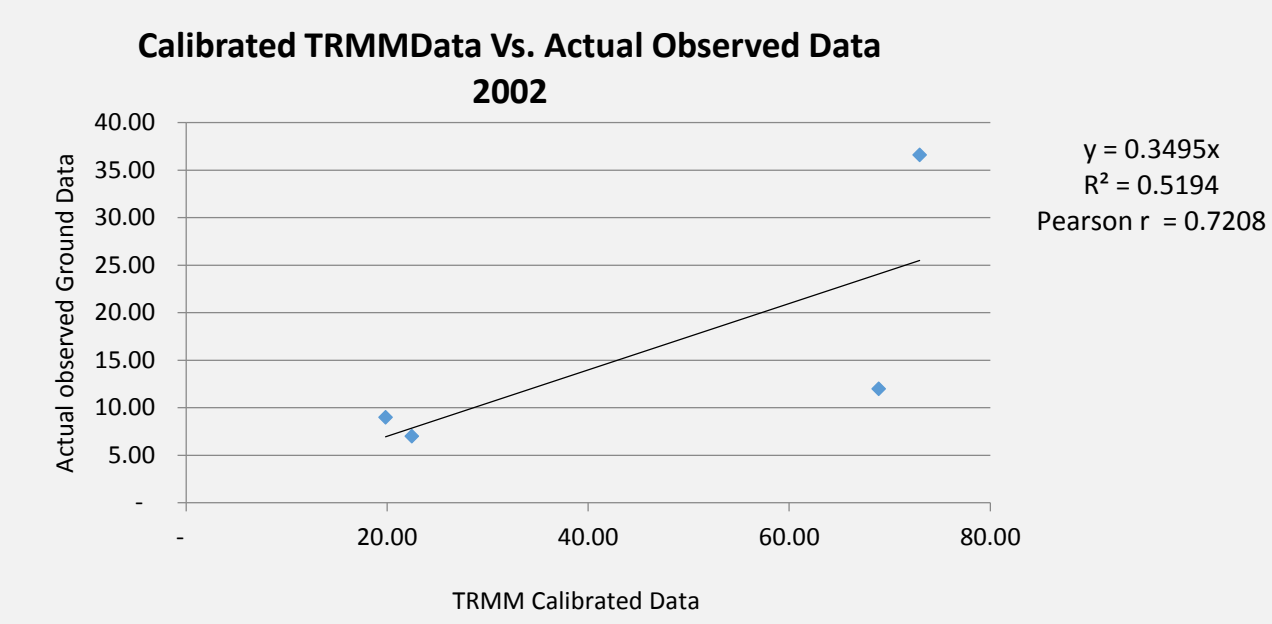






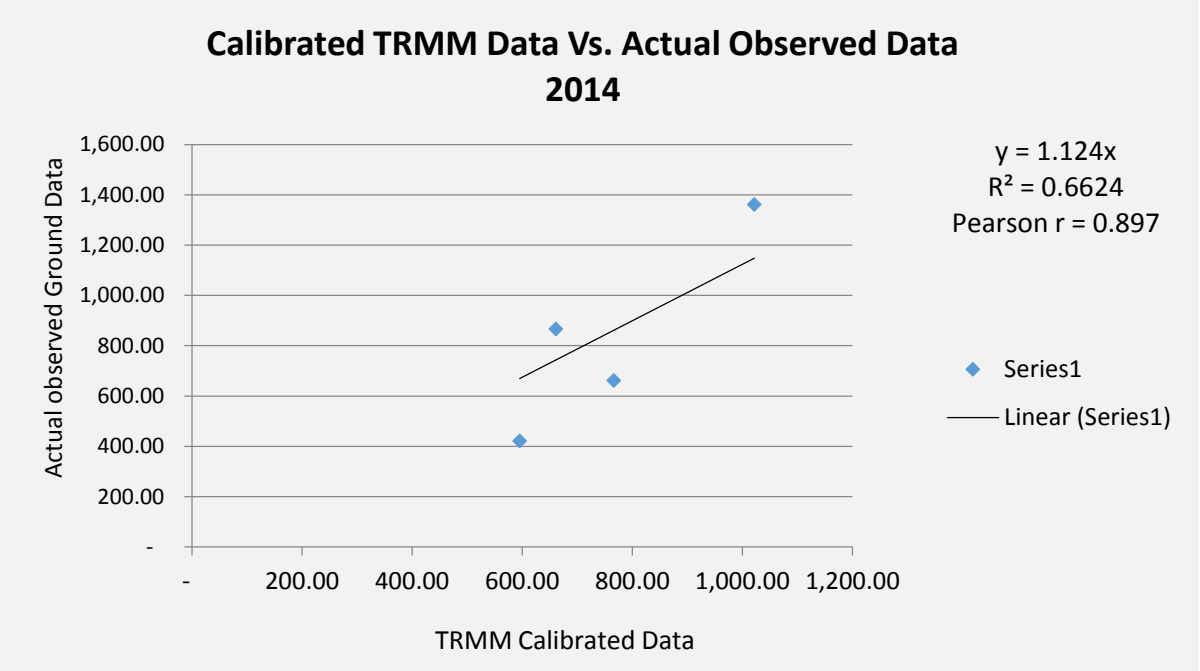


Results: Rainfall Data Validation - 2002



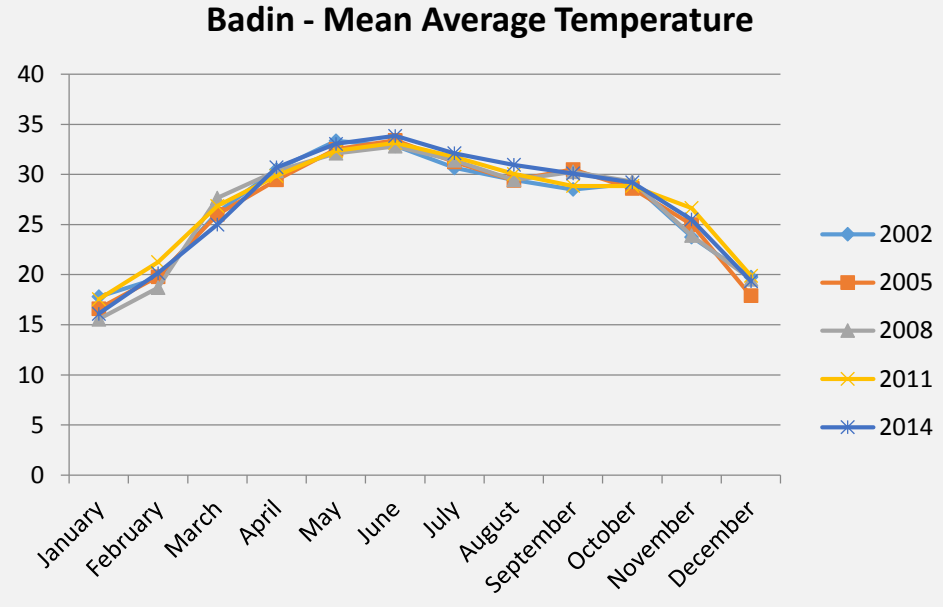
Station Name	Latitude	Longitude	Elevation	TRMM Calibrated Rainfall	Observed Rainfall
Badin	24.63	68.90	9.00	72.96	36.60
Hyderabad	25.38	68.42	30.00	19.84	9.00
Mirpur Khas	25.51	69.00	15.00	22.45	7.00
Mithi	24.75	69.80	30.00	68.89	12.00

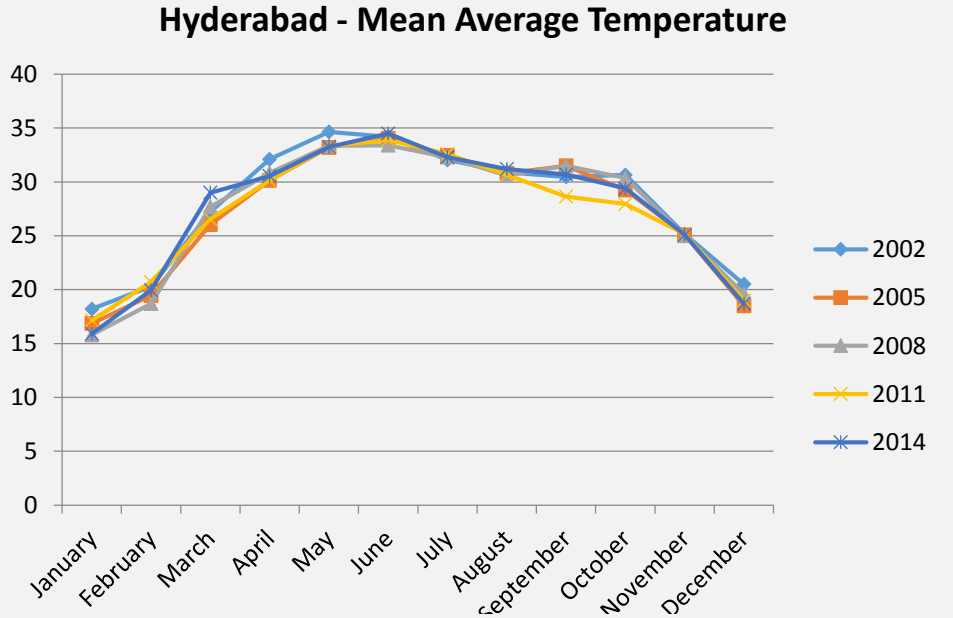
Results: Rainfall Data Validation - 2011

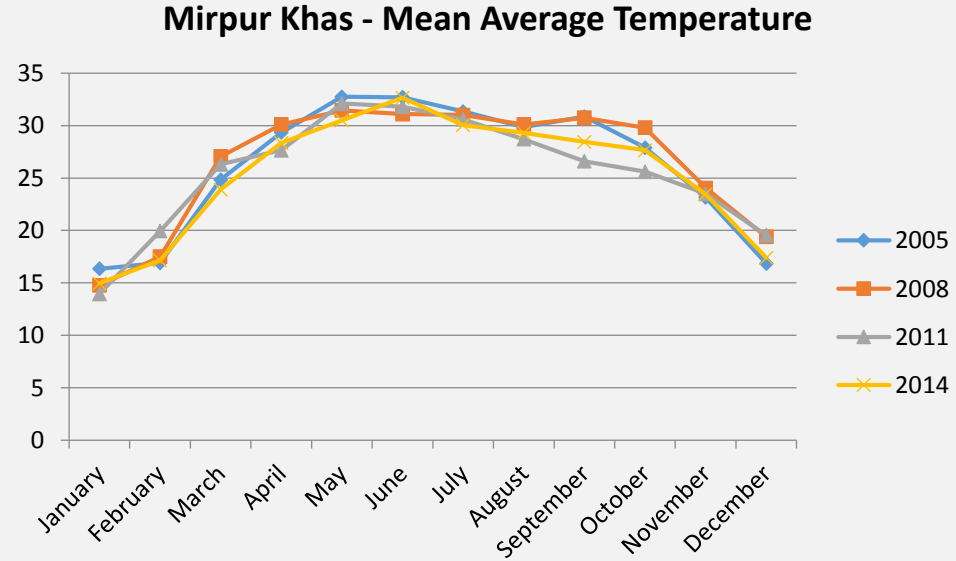


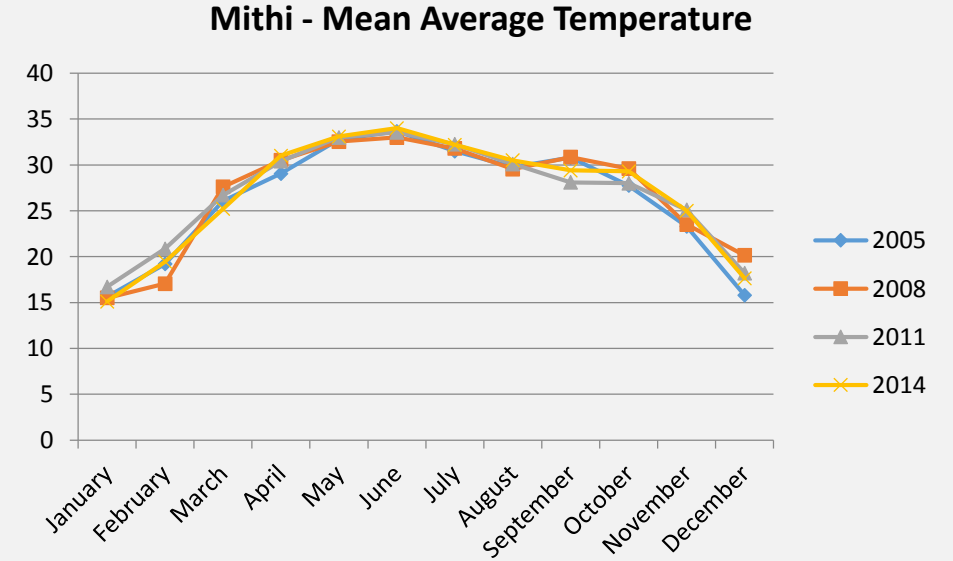
Station Name	Latitude	Longitude	Elevation	TRMM Calibrated Rainfall	Observed Rainfall
Badin	24.63	68.90	9.00	766.20	662.50
Hyderabad	25.38	68.42	30.00	595.25	421.40
Mirpur Khas	25.51	69.00	15.00	661.00	867.10
Mithi	24.75	69.80	30.00	1,021.67	1,361.30

Results: Average Temperature of Thar









Conclusions

- The Land use land cover maps indicate that vegetation cover in Thar Desert showed as improving trend from 2002 to 2011 and then again declined in the year 2014. This indicated the presence of drought in Thar till date.
- The precipitation data obtained from PMD showed that in each year the precipitation occurred at below average level accept for the year 2011, which was a drought year. The values of SPI were also calculated to be negative which indicated absence of adequate rainfall in Thar.
- The actual precipitation data of each year was compared with TRMM satellite data. The results revealed over-estimation of TRMM in calculating the rainfall data. Coefficient of determination R^2 and Perason correlation coefficient r were calculated for each year. The best results were obtained for the year 2008 in which R^2 was 0.670 and Pearson Correlation Coefficient was 0.897.
- Temperature data obtained from PMD showed that there is a rise in average temperature of Thar by almost 1 ^{0}C in the past decade. It indicates above normal temperature in Thar indicating occurrence of drought.

Recommendations

❖The further more research will be required on drought indices by incorporating other factors like soil condition, temperature and fertility of land and ground water level.

❖The higher resolution data of SPOT 2.5 m and Global View with 30 cm resolution will provide accurate and reliable results according to field conditions of Pakistan.

❖The availability of field data is a big hurdle as it does not represents actual precipitation occurred. Therefore, Government should make a strategy for correct collection of meteorological data.

Thank You!