PRESENTATION

THE ASIA CHALLENGE

The document identifies each region's key challenges; options for addressing them; and level of risk from warming of either 2°C or 4°C by 2100 compared to pre-industrial levels. This risk is calculated on the basis of present policies for adapting to climate change.

FLOOD DAMAGE TO HOMES, INFRA

RISK: High at 2°C, very high at 4°C
OPTIONS: More resilient buildings, selective relocation

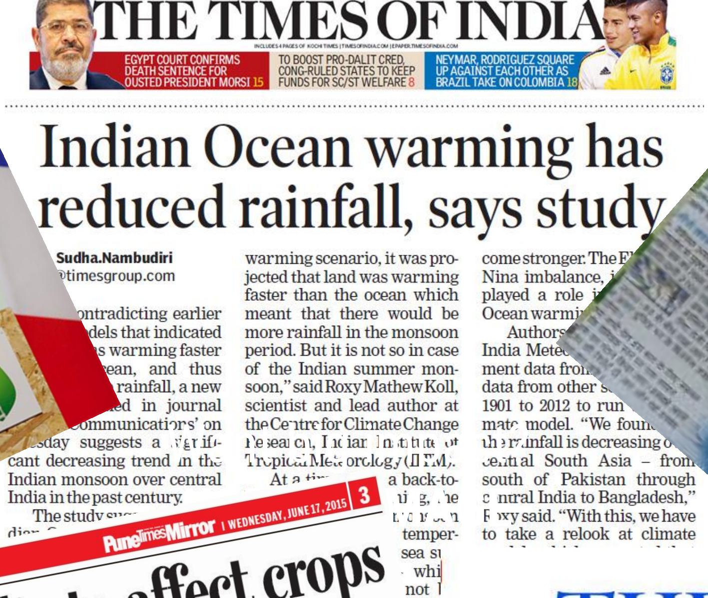
DEATHS FROM EXTREME HEAT

RISK: Very high at 2°C and 4°C
OPTIONS: Strengthen health systems, improve city planning to reduce urban heat build-up

MALNUTRITION AND DROUGHT

RISK: Medium high at 4°C
OPTIONS: Beef up vigilance on food supplies, improve disaster preparedness AFP

Source: The Indian Express



THE TIMES OF INDIA

EGYPT COURT CONFIRMS DEATH SENTENCE FOR OUSTED PRESIDENT MORSI 15 | TO BOOST PRO-DALIT CRED, CONG-RULED STATES TO KEEP FUNDS FOR SC/ST WELFARE 8 | NEYMAR, RODRIGUEZ SQUARE UP AGAINST EACH OTHER AS BRAZIL TAKE ON COLOMBIA 18

Indian Ocean warming has reduced rainfall, says study

Sudha.Nambudiri @timesgroup.com

...ontradicting earlier ...dels that indicated ...s warming faster ...ean, and thus ...rainfall, a new ...ed in journal ...ommunications' on ...sday suggests a significant decreasing trend in the Indian monsoon over central India in the past century.

The study ... dian ...

warming scenario, it was projected that land was warming faster than the ocean which meant that there would be more rainfall in the monsoon period. But it is not so in case of the Indian summer monsoon," said Roxy Mathew Koll, scientist and lead author at the Centre for Climate Change Research, Indian Institute of Tropical Meteorology (IITM).

At a ti... a back-to-... temper- sea s... whi... not l...

come stronger. The El ... Nina imbalance, i... played a role i... Ocean warmi...

Authors ... India Mete... ment data fro... data from other s... 1901 to 2012 to run ... mate model. "We foun... the rainfall is decreasing o... central South Asia – from south of Pakistan through central India to Bangladesh," Roxy said. "With this, we have to take a relook at climate ...

जलवायु परिवर्तन समझौता भारत को बना सकता है दुनिया का ...

भारत सहमत नहीं हुआ तो धराशायी हो...

कहीं देर न हो जाए

राष्ट्रीय/अंतरराष्ट्रीय

बाढ़ और ...

CITY www.punemirror.in/city

Pune Times Mirror | WEDNESDAY, JUNE 17, 2015 | 3

Low rainfall in central India to affect crops

IITM study finds that increasing El Niño effect over Indian Ocean will disrupt southwest monsoon this year; agri ministry continues to believe monsoon could be good

Sandip.Dighe @timesgroup.com
TWEET @ThePuneMirror

The crucial southwest monsoon may experience interferences this year, according to the findings of a recent study conducted by a group of young scientists from the Indian Institute of Tropical Meteorology (IITM), eventually impacting agriculture. Research has found that at least six central Indian states may get "deficit rainfall" due to the well-documented El Niño effect over the Indian Ocean.

The study also points to a significant decrease in summer monsoon rainfall over the central Indian subcontinent during the past century—scientists suggest that the observed rapid warming over the Indian Ocean is play...

The young IITM team that conducted the research along with foreign counterparts

MAHENDRA KOLHE

fected in Madhya Pradesh, Chhattisgarh, Jharkhand, Bihar, Uttar Pradesh and Uttarakhand. They observed data dating from the 1870s for the summer monsoon, procured from the Indian Meteorological Department (IMD) and other sources.

Lead author and IITM scientist Roxy Mathew Koll said, "Using data from 1901-2012, we found that rainfall has been decreasing over central South Asia. The decrease is highly sig...

culture is still mostly rain-fed. A reduction of up to 10-20 per cent in mean rainfall can be seen. Land over the subcontinent has not been heating up as much as the ocean. Besides, temperatures—particularly along the west of the ocean—have increased by 1.2 degrees Celsius. This is quite significant. It will affect the progress of the monsoon towards the central regions."

Koll elaborated, "We also found there were only seven El Niño events reported from 1900-1950. But this has changed—thereafter, 12 El Niño events were reported so far, with high intensity." The study was part of the Indo-French collaboration under the National Monsoon Mission, set up by the ministry of earth sciences. Koll conducted the research in collaboration with other IITM scientists Ritika Kapoor, Ashok Karumuri and B N Goswami. The study also included Raghu Murtugudde from the University of Maryland in the US, and French scientist Pascal Terry from the Sorbonne University.

Meanwhile, agricultural scientists and officials from the ministry of agriculture still believe sowing time is the most crucial for productivity in rain-fed areas; although sowing begins from June, they believe there is still time to do so, as the monsoon rains have not yet fully spread across the country. Dr N Chattopadhyay, deputy director general of Agromet, said, "We cannot ignore that the present monsoon is progressing well and has already covered Maharashtra, south Gujarat and Odisha. Now, we are expecting that it will cover central India, too. Thereafter, we can talk about further developments. At this juncture, it is mere prediction."

An official from the agriculture ministry said, "Since there is a poor monsoon forecast, some states have already been asked to prepare contingency plans to reduce the impact of erratic rains on kharif crops. These plans have been kept ready for 580 districts; similar ones are being prepared for other states as well."

Ministry sources added, "Since the sowing of kharif crops normally begins with the onset of the monsoon in June, harvesting starts from October. If the IITM scientists' prediction is correct, production of rice, pulses and soybean, along with oil seeds, will be severely affected. Eventually, it will disturb demand and supply chains in those states."

DELHI, WEDNESDAY, DECEMBER 2, 2015

THE HINDU

INDIA'S NATIONAL NEWSPAPER SINCE 1878

Dirt in our minds, not on streets, says Pranab Mukherjee Page 12 | Judicial custody of Peter Mukerjea extended Page 13 | Climate action an economic 'imperative', says Barack Obama Page 14 | Raghuram Rajan keeps repo rates unchanged Page 15

FLOOD WARNING ALONG ADYAR

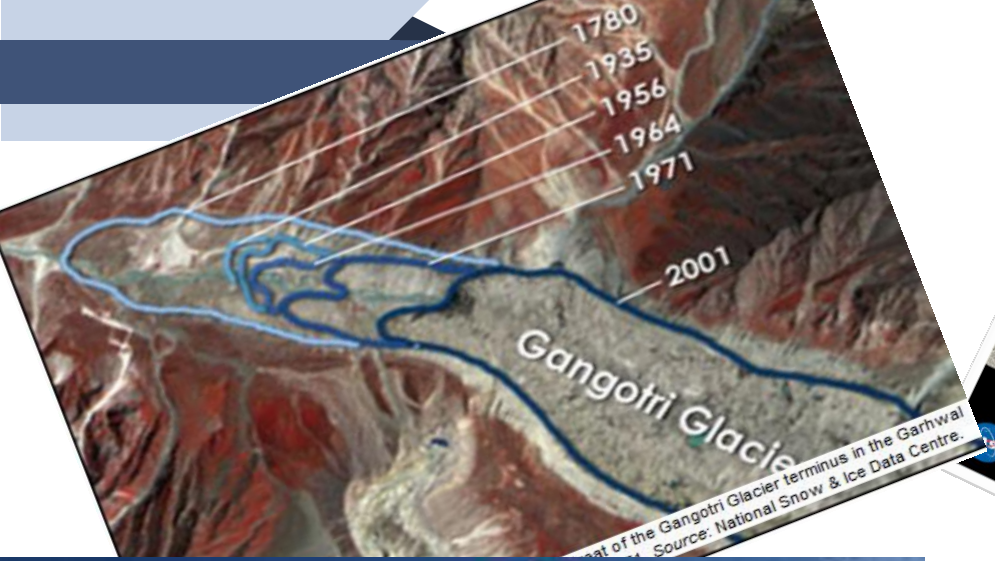
Heavy rain torments coastal T.N., brings life to a halt in Chennai

Army columns, boats deployed to rescue those stranded

Amid beef row, buffalo tallow export booms

Centre quietly eases curbs after 32 years; price spurts

BEEFING UP FOREIGN TRADE

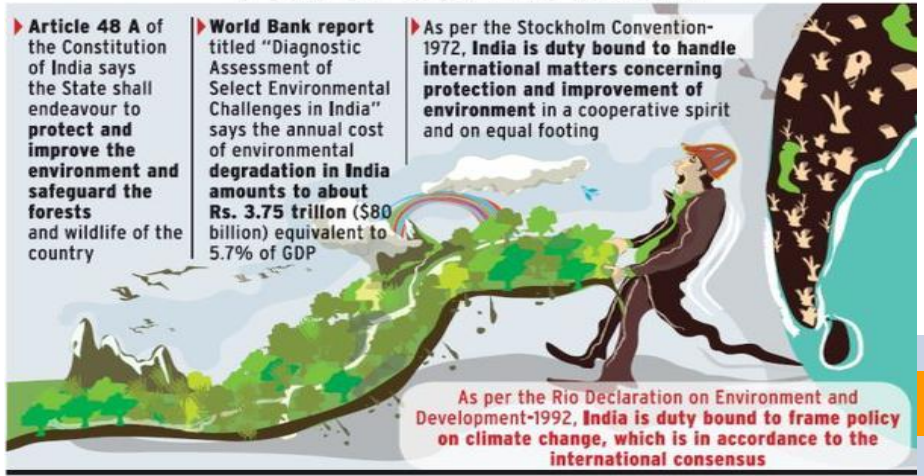


FOR A GREEN INDIA

Article 48 A of the Constitution of India says the State shall endeavour to **protect and improve the environment and safeguard the forests** and wildlife of the country

World Bank report titled "Diagnostic Assessment of Select Environmental Challenges in India" says the annual cost of environmental **degradation in India amounts to about Rs. 3.75 trillion** ($80 billion) equivalent to 5.7% of GDP

As per the Stockholm Convention-1972, **India is duty bound to handle international matters concerning protection and improvement of environment** in a cooperative spirit and on equal footing



As per the Rio Declaration on Environment and Development-1992, **India is duty bound to frame policy on climate change, which is in accordance to the international consensus**

Satellite based study of climate change impact on local weather elements along N-S transect across Jharkhand, Bihar & Eastern Nepal

SHANTI SHWARUP MAHTO (M.Tech. Student CLRM, CUJ)
&
Prof. A.C PANDEY (HoD, Professor CLRM, CUJ)

INTRODUCTION

The impacts of human activities on global climate change are mainly attributed to **greenhouse gases, aerosols**, and land use activities *(IPCC, 2014)*

CLIMATE CHANGE

Change in the long term weather event & phenomenon (solar insolation, albedo, temperature, rainfall, pressure etc.) on a particular region over a period of time.

Land use land cover change (LU/LC)*, which could affect surface climate and environment by changing the surface process (deforestation, soil erosion, albedo change) is crucial on global climate change *(Claussen et al., 2001; Pielke Sr, 2005)*

The **climate variability** has led to increased evapotranspiration rates, decline in soil moisture, and socio-economic consequences with longer dry periods *(Cruz et al., 2007; Ramos et al., 2012)*

Higher or lower rainfall or changes in its spatial and seasonal distribution influences the spatial and temporal distribution of runoff, soil moisture and groundwater reserves, and thereby affects the frequency of droughts and floods *(Kumar et al., 2010; Jhajharia and Singh, 2011)*

There is a consistent warming trend which is clearly reflected by the increasing occurrence of **extreme climate events** like droughts, floods and heat waves, sea level rise, glacier melting *(Meehl et al., 2007)*

In India context, climate change is largely affecting the agriculture, water demands, and more rapid melting of glaciers *(IPCC, 2013)*

* More sensitive to local climate change

OBJECTIVES

(1)

Preparation of thematic maps to analyze the changing pattern of rainfall and temperature (2000 – 2015) for the study area.

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(2)

Establishing a correlation between the rainfall distribution and above normal temperature zone in the pre monsoon season .

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(3)

Retrieval of the net surface radiation & evapotranspiration of the study area in order to observe the correlation with the seasonal rainfall pattern.

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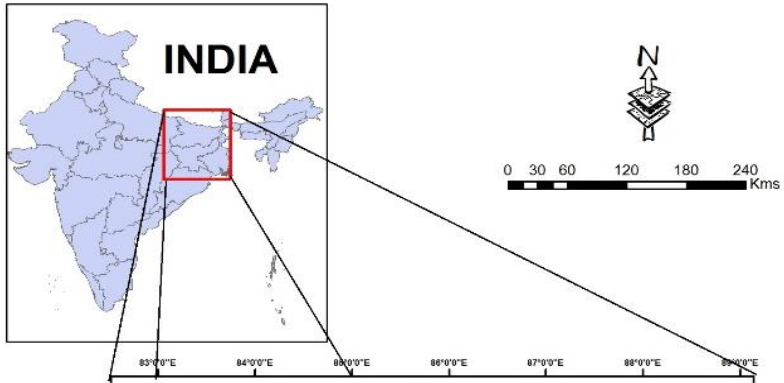
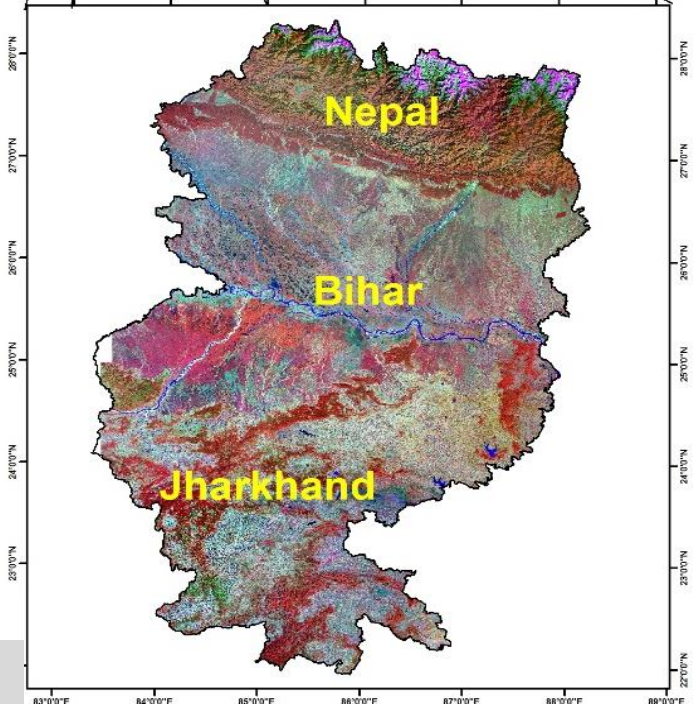
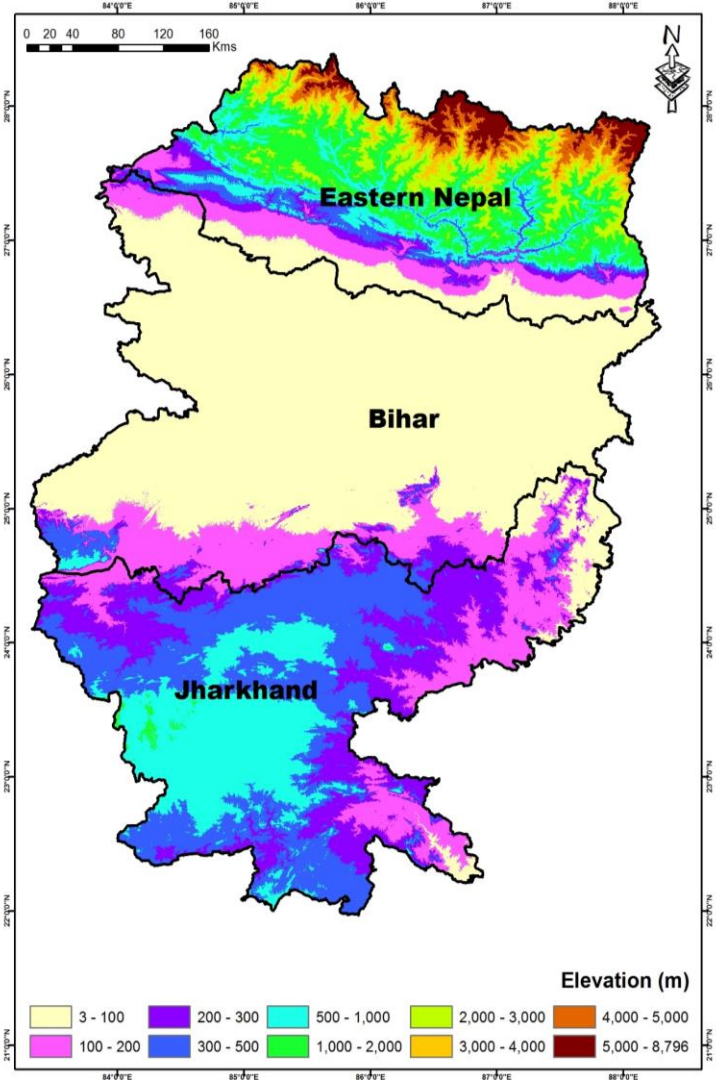
STUDY AREA







0 30 60 120 180 240 Kms

It consists of Jharkhand, Bihar, Eastern Nepal

(Along North-South transect across Himalayan-Gangetic Plain and Chota Nagpur Plateau)

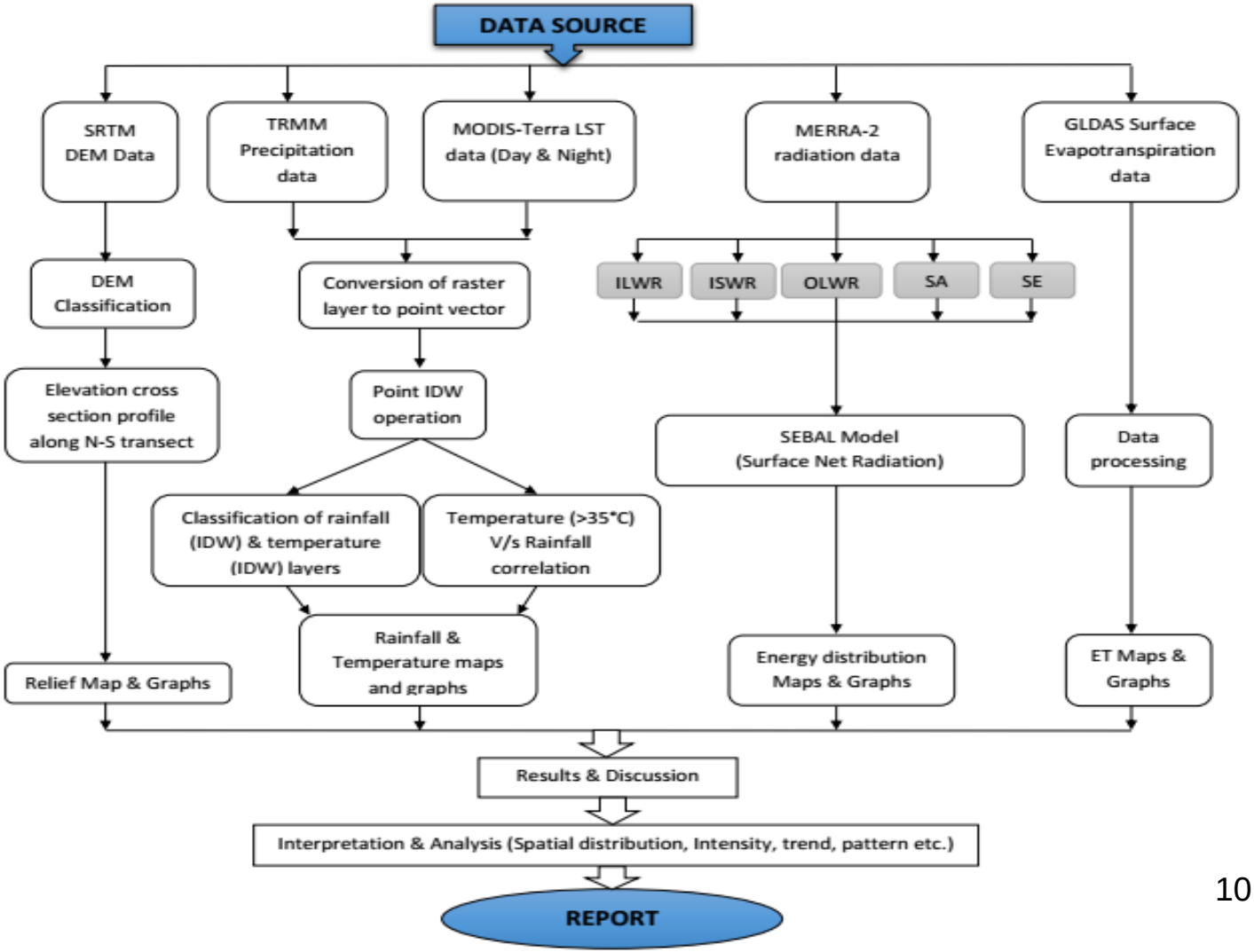
Total area: 230204 km2
Total Perimeter: 4137km

LANDSAT-5 TM (8 FEB 1988), SRTM DEM (90M)

DATA USED

TRMM PRECIPITATION	• 0.25°X0.25° monthly 3B43v7 • Rainfall analysis • http://www.geovanni.nasa.gov
MODIS-Terra LST	• 1km X1km, 8 day average • Temperature analysis • http://www.geovanni.nasa.gov
GLDAS EVAPOTRANSPIRATION	• 0.25°X0.25°, monthly average • Radiation analysis • http://disc.sci.gsfc.nasa.gov/mdisc/
SRTM DEM	• 90m • Relief analysis • http://www.jpl.nasa.gov/srtm/
MERRA-2 RADIATION	• 0.625°×0.5° monthly • Radiation analysis • http://gmao.gsfc.nasa.gov

METHODOLOGY



SURFACE RADIATION BALANCE EQUATION

$$Rn = (1 - \alpha)\, RS\downarrow + RL\downarrow - RL\uparrow - (1-\varepsilon o)\, RL\downarrow$$

Where,

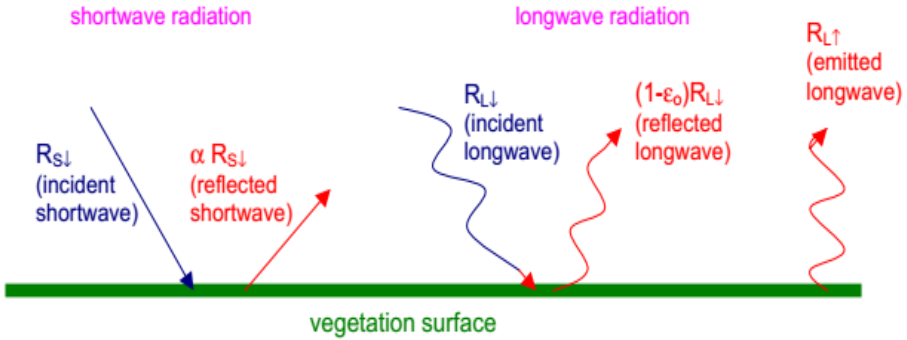
RS↓ is the incoming short wave radiation (W/m2),

α is the surface albedo (dimensionless),

RL↓ is the incoming long wave radiation (W/m2),

RL↑ is the outgoing long wave radiation (W/m2), and

ε_o is the surface thermal emissivity (dimensionless).

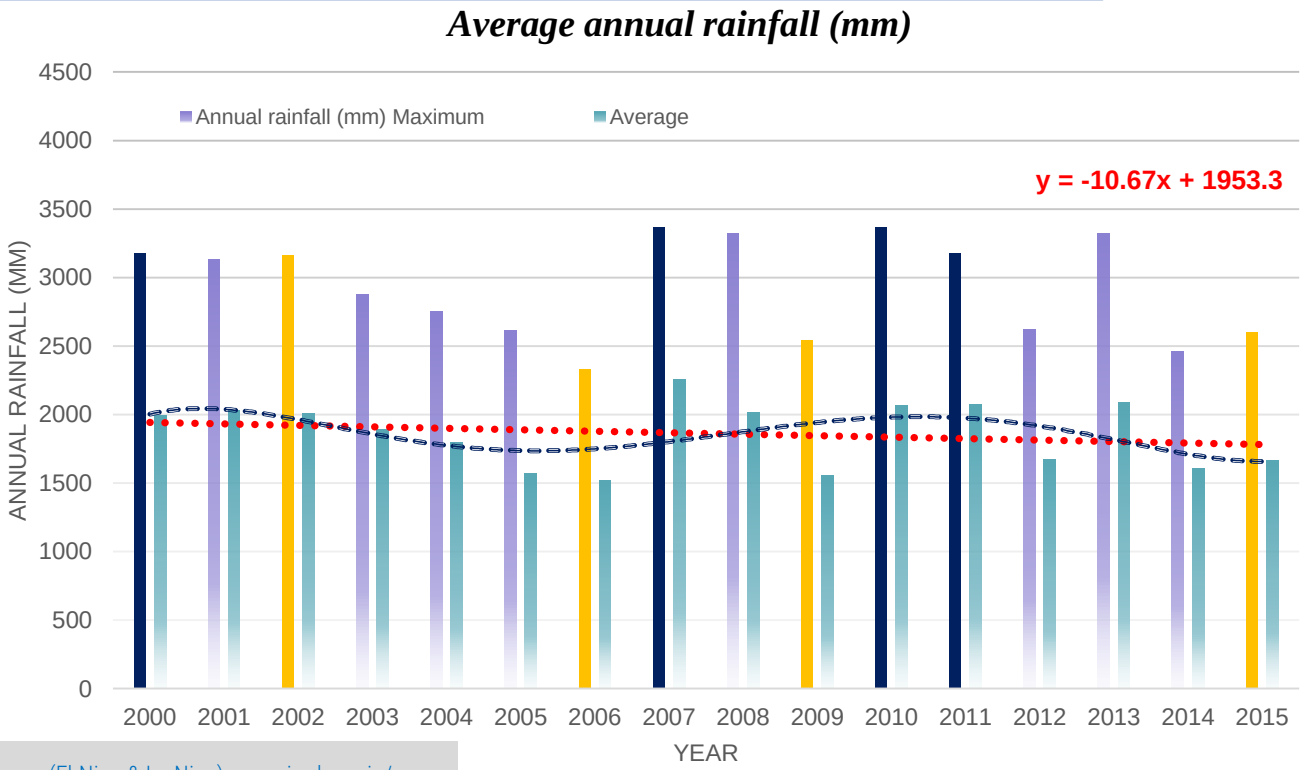


Net surface radiation = gains – losses

RESULTS & DISCUSSION

Let’s start with the first set of slides

RAINFALL ANALYSIS



Source (El-Nino & La-Nina): www.imd.gov.in/

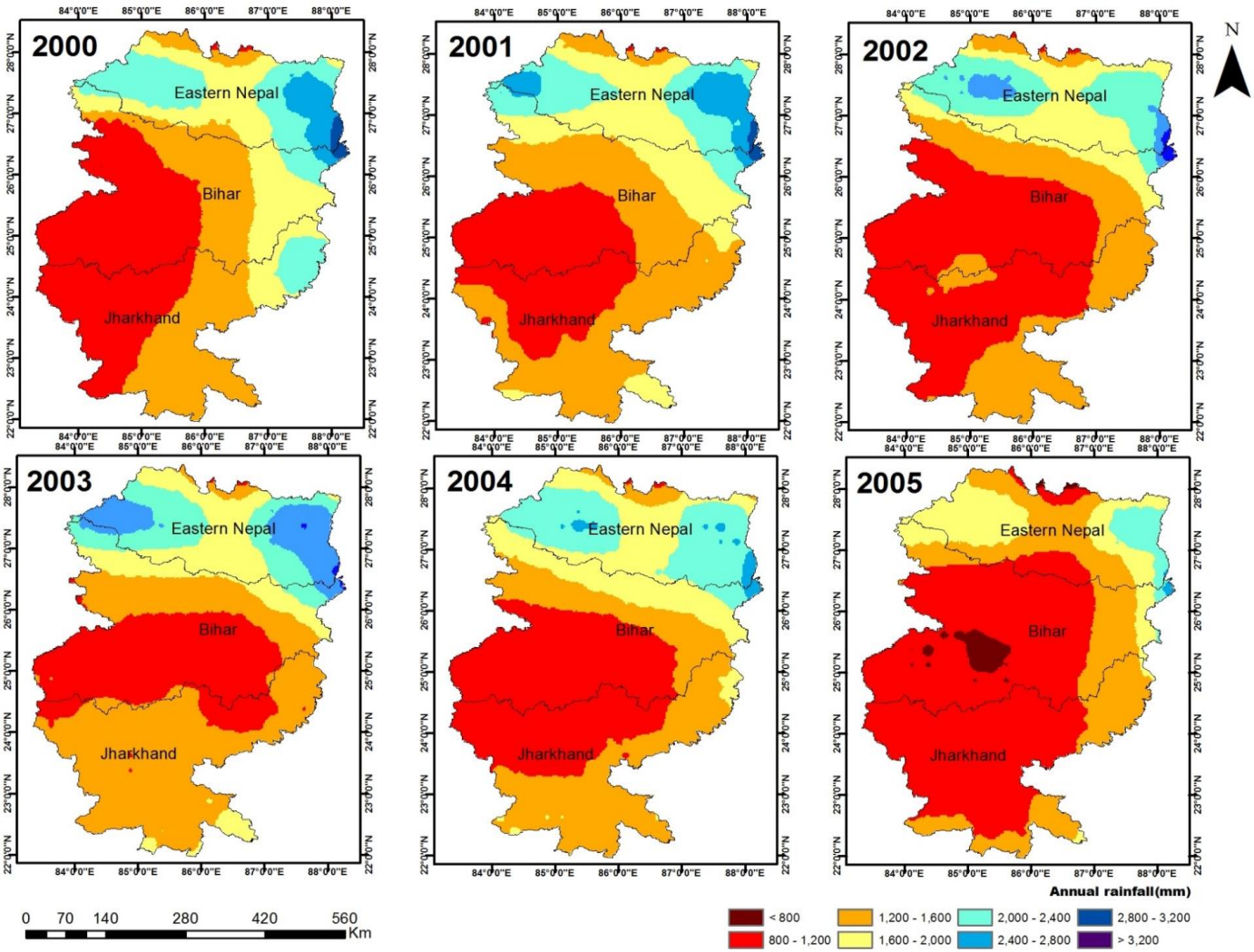
The average annual rainfall of the study area is showing a gradual decreasing trend in the past three pentad

Although the long term trend is showing a negative linear curve of the rainfall but it is following a curve of sine function having a wavelength of 3 to 5 years

Yellow Bars: El-Nino Years
Dark Blue Bars: La-Nina Years

RAINFALL

- The rainfall intensity and amount received over the E-E Nepal and N-E Bihar region has decreased over the last 15 years (except year 2007).
- The western Bihar-Jharkhand region receives the least annual rainfall within the study area, nearly 900 to 1000 mm.
- The east of eastern (E-E) Nepal receives the highest annual rainfall within the study area including the north east (N-E) Bihar region i.e. greater than 2000 mm



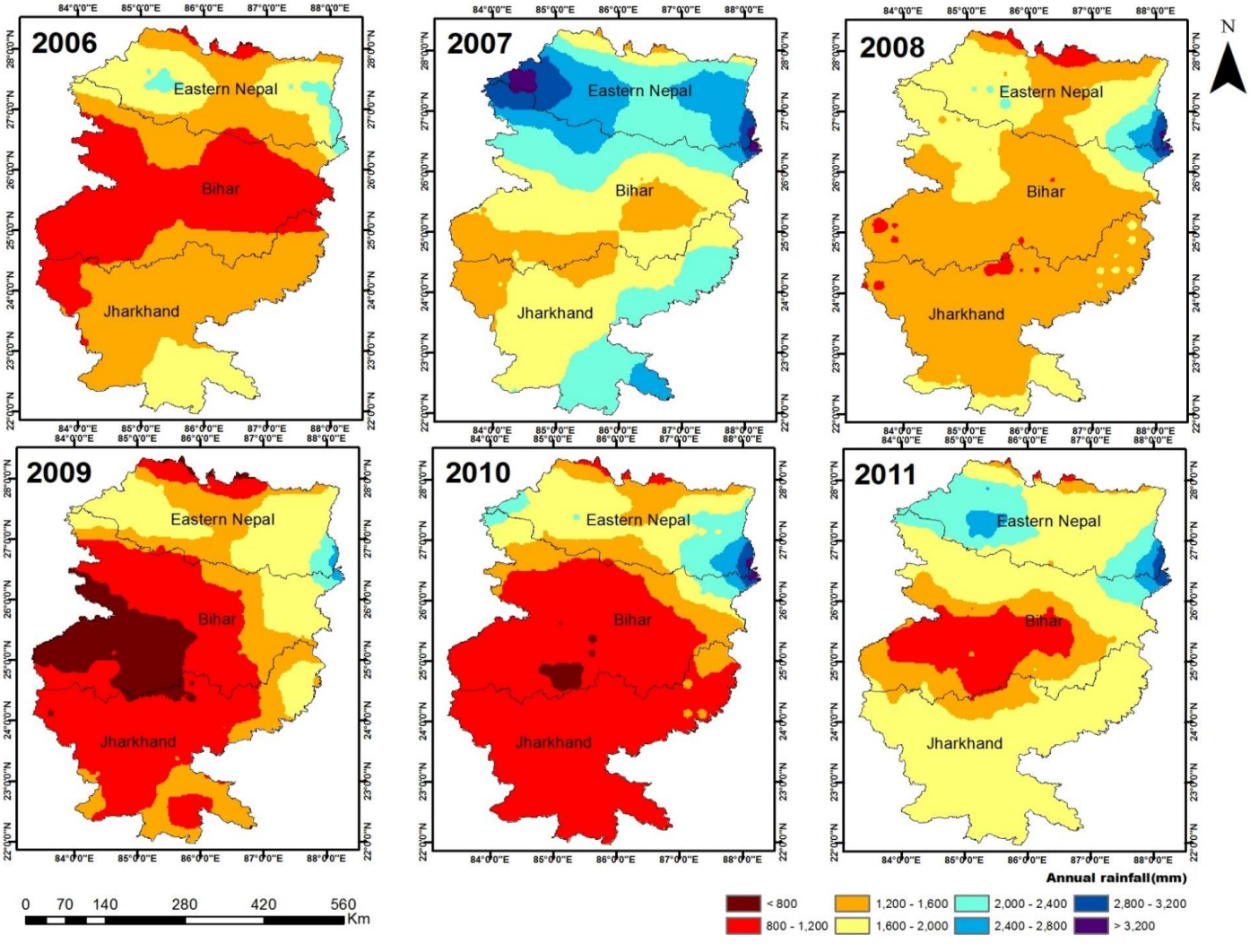
RAINFALL

Bihar flood 2007

- More than 100 people died, 4822 villages and 10,000,000 hectares of farm land were affected.

Bihar flood 2008

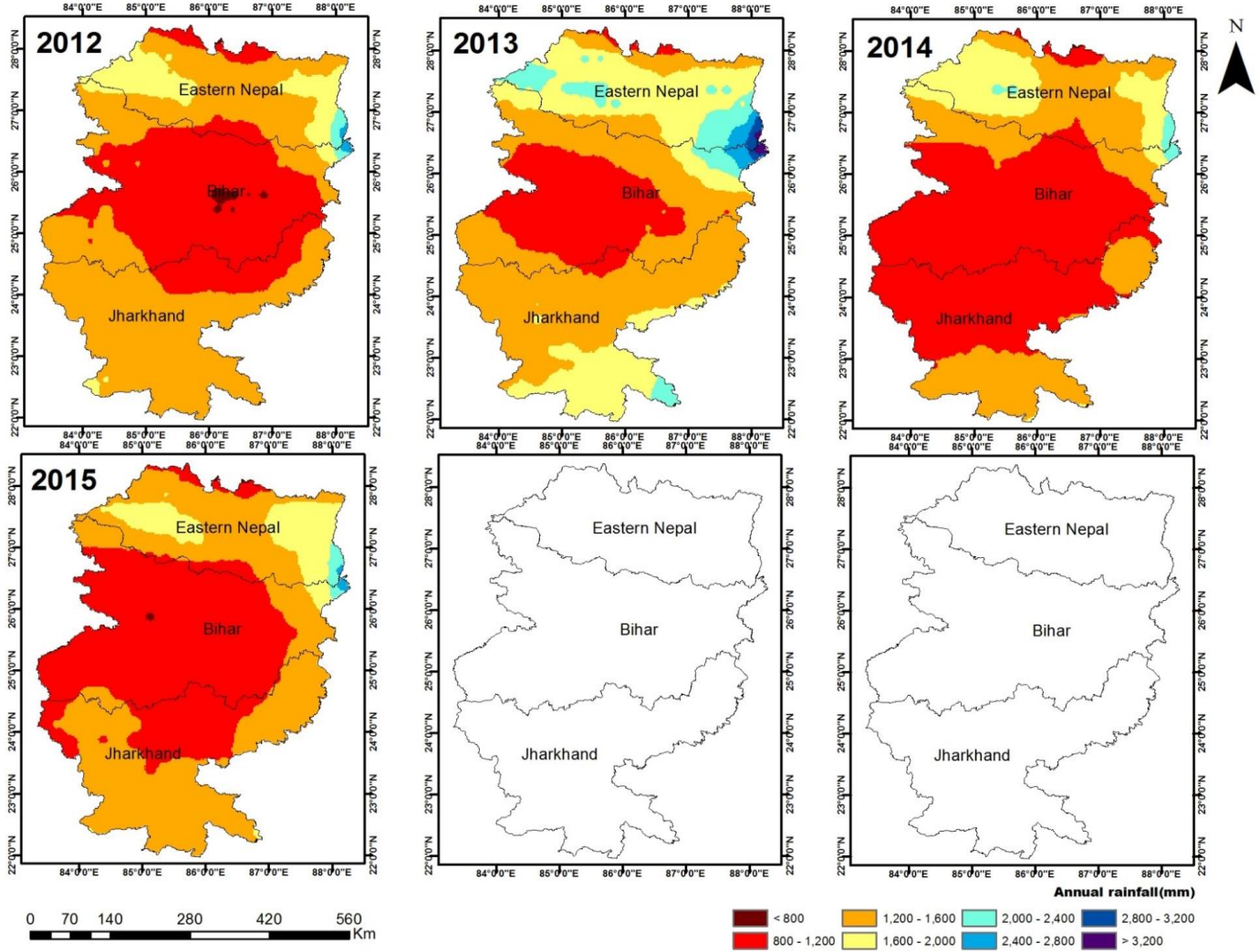
- The flood killed 250 people and forced nearly 3 million people from their homes in Bihar. More than 300,000 houses were destroyed and at least 340,000 hectares (840,000 acres) of crops were damaged.



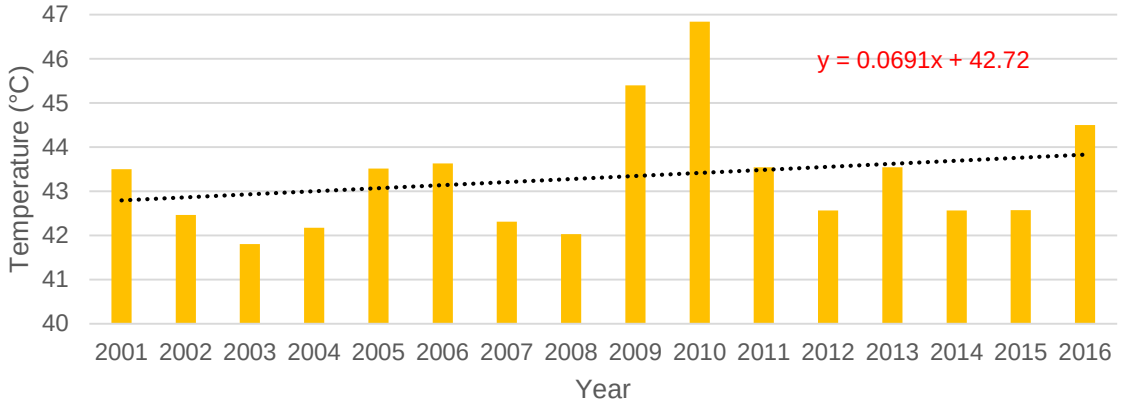
Source: http://actintl.org/news/dt-nr-2007; North India inundated". Hindustan Times. 3 August 2007. Last accessed 3 August 2007.

Michael Coggan in New Delhi (29 August 2008). "Death toll rises from Indian floods – Just In – ABC News (Australian Broadcasting Corporation)"

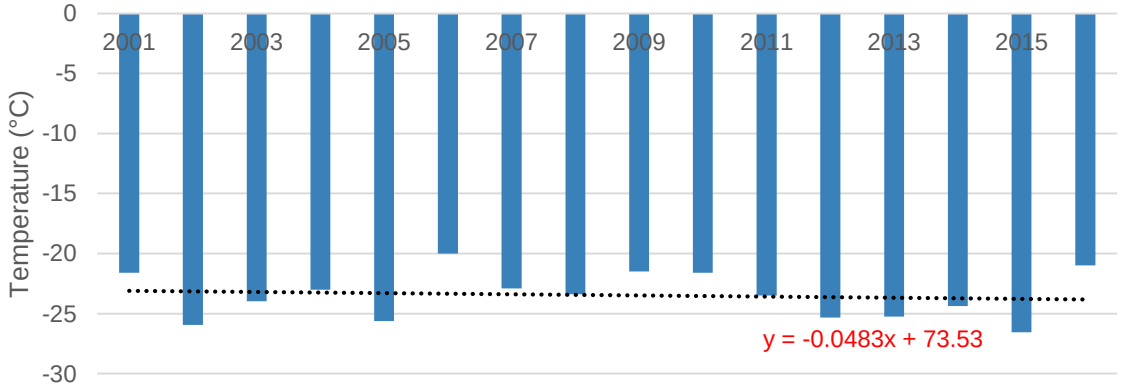
RAINFALL


2012
2013
2014
2015
Eastern Nepal
Bihar
Jharkhand
N
0 70 140 280 420 560
Km
Annual rainfall(mm)
< 800
800 - 1,200
1,200 - 1,600
1,600 - 2,000
2,000 - 2,400
2,400 - 2,800
2,800 - 3,200
> 3,200

TEMPERATURE ANALYSIS



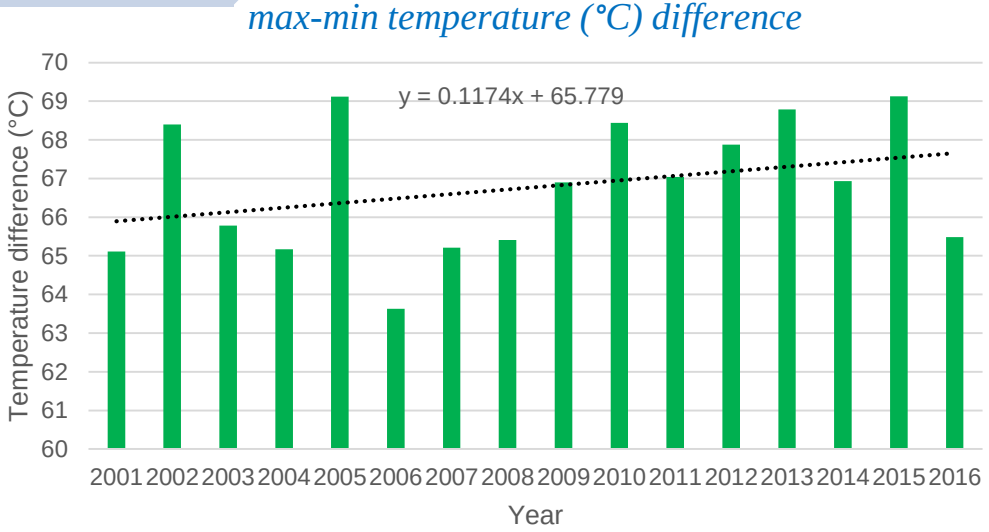
Trend of maximum temperature (°C)



Trend of minimum temperature (°C)

TEMPERATURE ANALYSIS

Year	Day time maximum temperature (°C)	Night time minimum temperature (°C)	Temperature difference (°C)
2001	43.5	-21.61	65.11
2002	42.46	-25.94	68.4
2003	41.8	-23.98	65.78
2004	42.17	-23	65.17
2005	43.51	-25.61	69.12
2006	43.63	-20	63.63
2007	42.31	-22.9	65.21
2008	42.03	-23.38	65.41
2009	45.4	-21.5	66.9
2010	46.84	-21.6	68.44
2011	43.54	-23.5	67.04
2012	42.56	-25.32	67.88
2013	43.54	-25.25	68.79
2014	42.56	-24.37	66.93
2015	42.57	-26.56	69.13
2016	44.5	-20.98	65.48

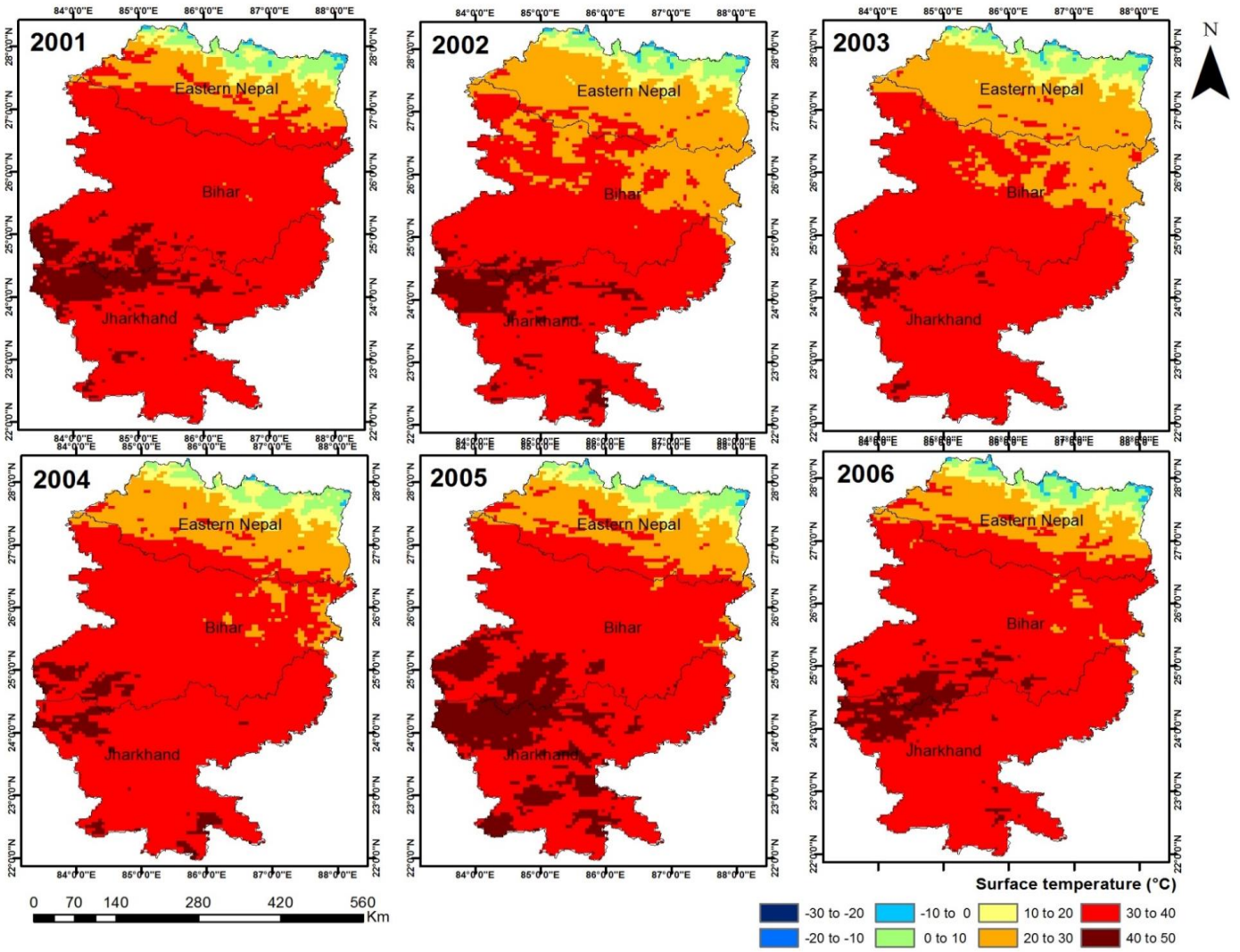


The temperature difference is increasing at the rate of 1°C per five years

TEMPERATURE

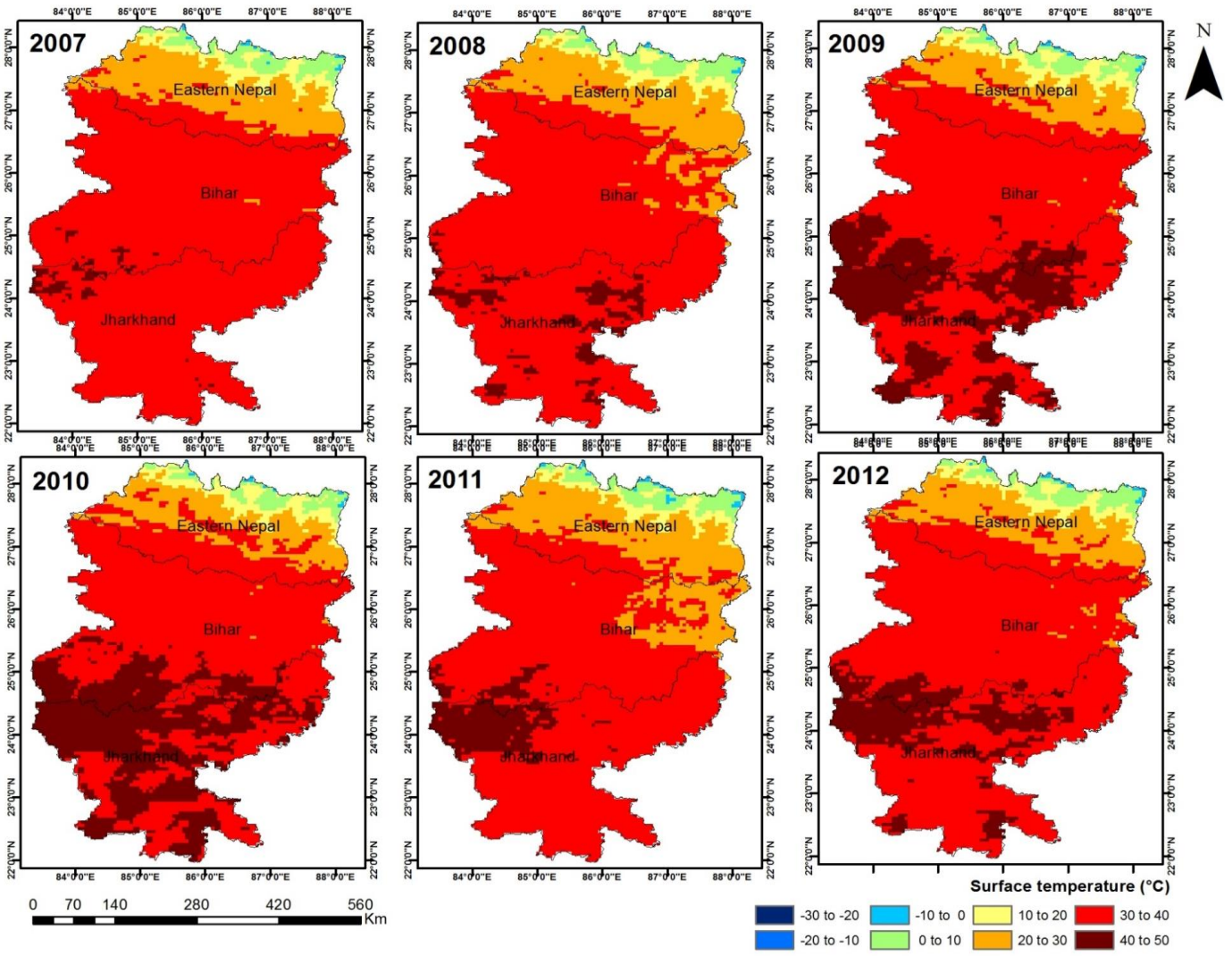
- South western region of the study area in the water deficit region which theoretically suggests that the temperature should be higher than the other areas.

i.e. higher temperature has a positive correlation with rainfall deficit region

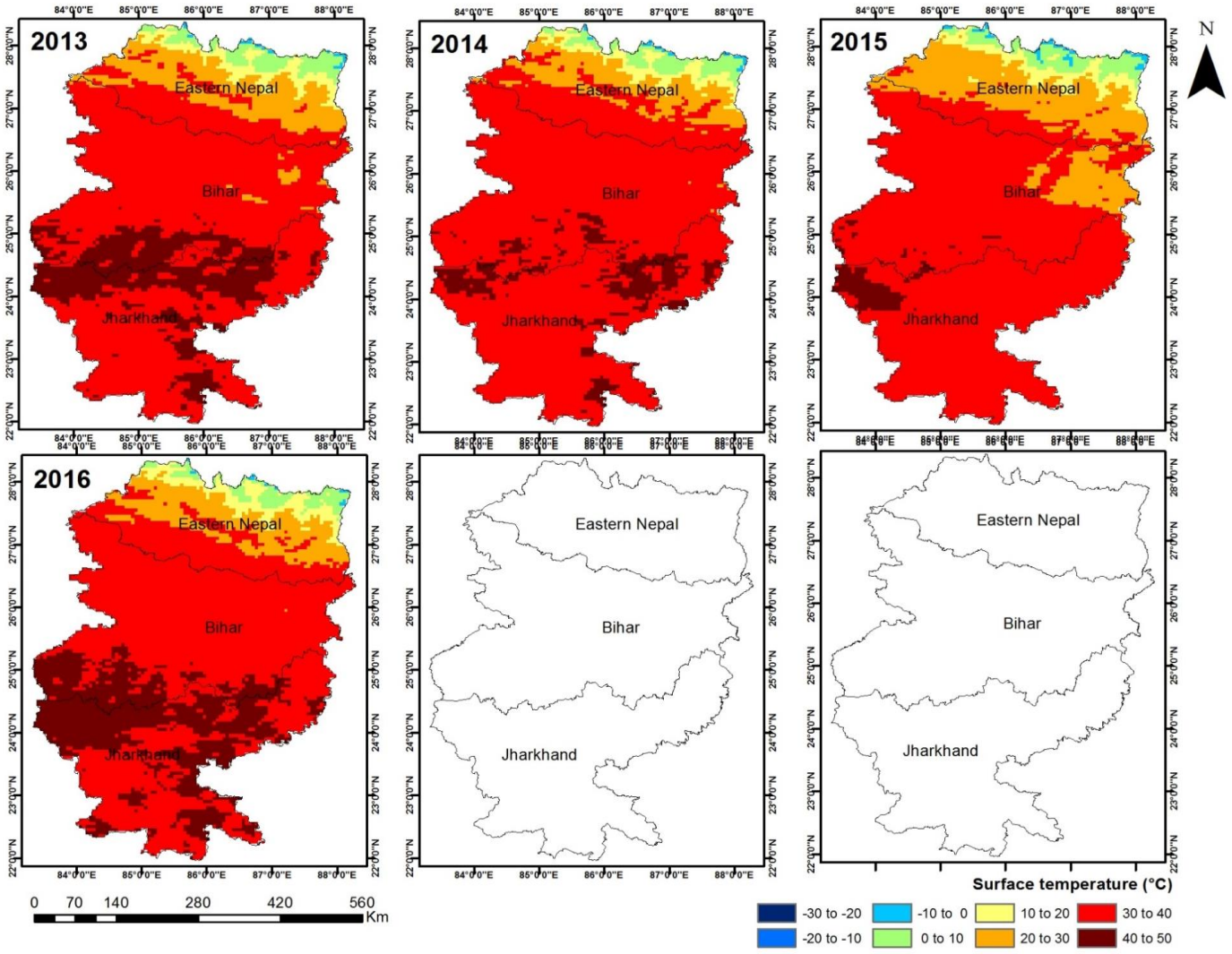


TEMPERATURE

The Jharkhand region will be effected by more intense heating then Bihar and hence water shortage in near future.

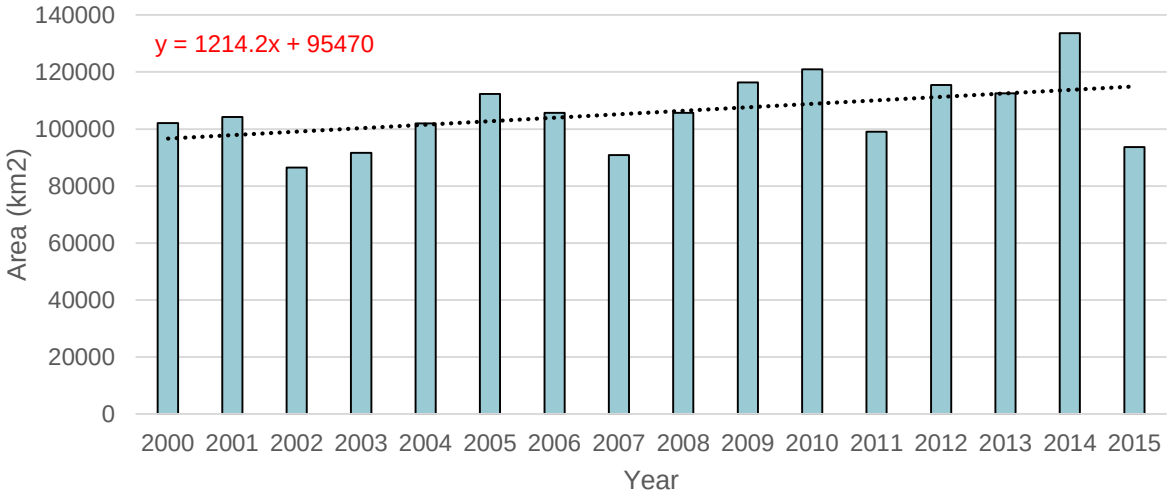


TEMPERATURE



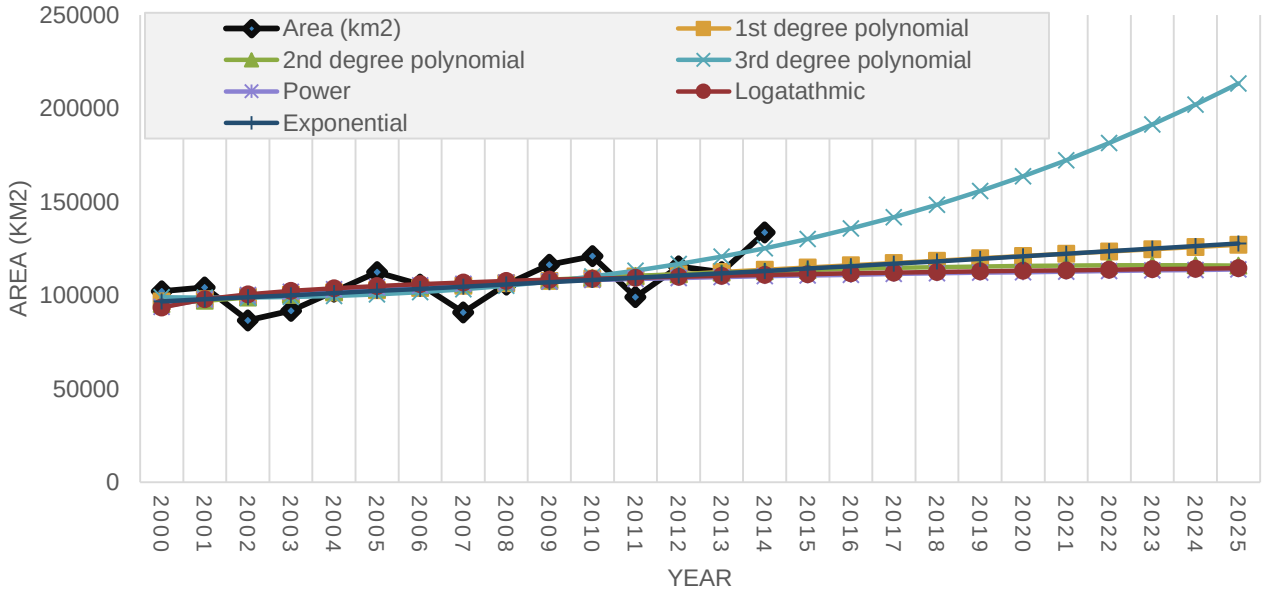
TEMPERATURE V/s RAINFALL ANALYSIS

Trend of area having temperature >=35°C in summer



A threshold value of 35°C and more has been fixed for the day time maximum temperature and the regions has been identified and located in the map and classified the rainfall under the threshold value.

TEMPERATURE V/s RAINFALL



It has been found that the 3rd degree polynomial curve (cubic) sets the highest threshold area value up to which it can reach in the nearby future whereas all the other curves shows the actual and lower values of the desired area (greater than or equal to 35°C) which will reach in the nearby future.

First degree polynomial curve (linear)

$y = 1214.2x + 95470$

Second degree polynomial curve (parabolic)

$Y = -39.21x^2 + 1880.8x + 93470$

Third degree polynomial curve (cubic)

$Y = 3.73x^3 + 88.975x^2 - 444.86x + 99219$

Power curve

$Y = 93871x^{0.0591}$

Logarithmic curve

$Y = 6475.4\ln(x) + 93377$

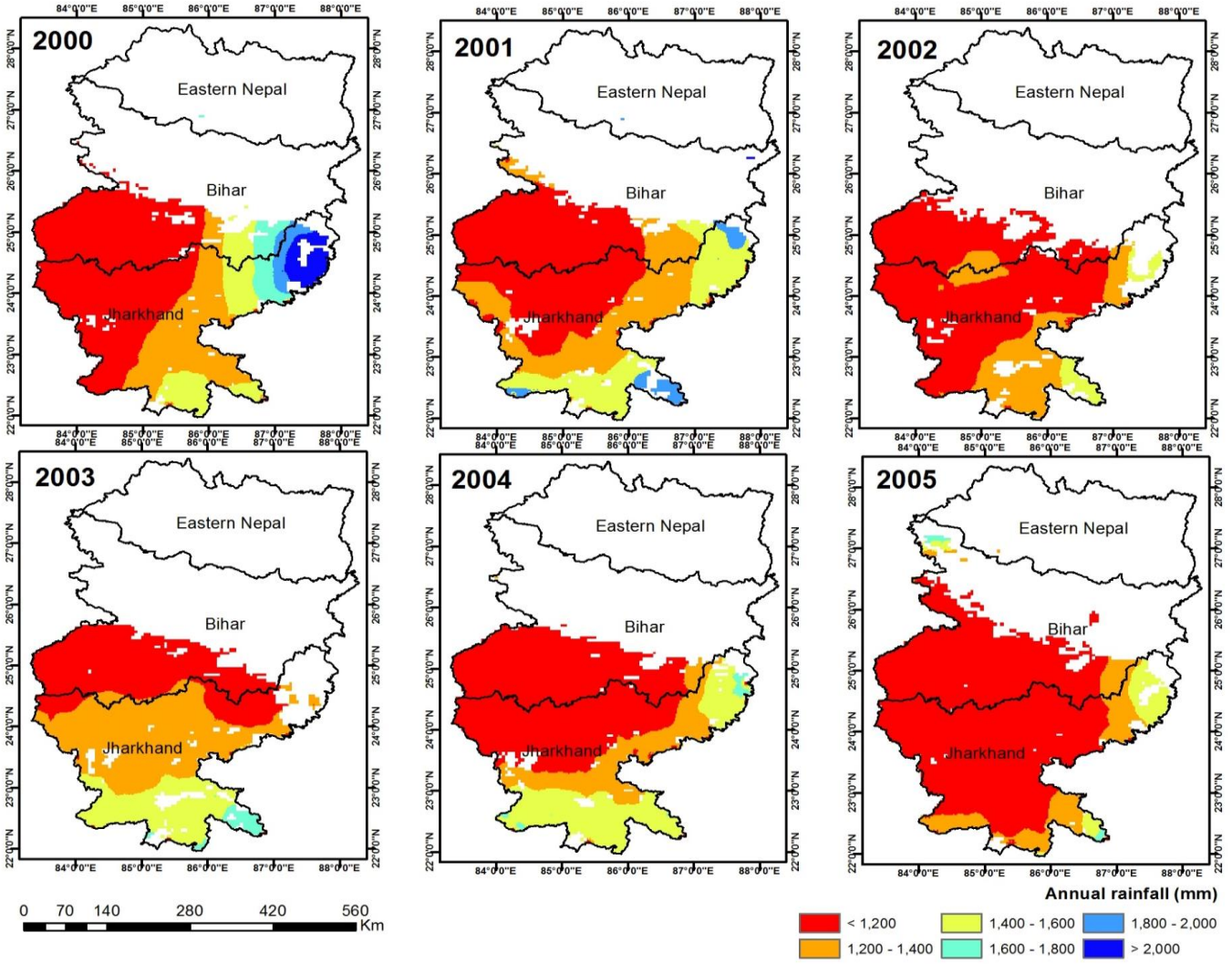
Exponential curve

$Y = 95696e^{0.0111xq}$

Year	Area (km2)	1st degree polynomial	2nd degree polynomial	3rd degree polynomial	Power	Logarithmic
2000	102115.30	96684.20	95311.59	98866.85	93871.00	93377.00
2001	104170.10	97898.40	97074.76	98715.02	97796.28	97865.41
2002	86535.30	99112.60	98759.51	98785.91	100168.07	100490.95
2003	91659.20	100326.80	100365.84	99101.88	101885.69	102353.81
2004	101959.20	101541.00	101893.75	99685.33	103238.24	103798.75
2005	112337.20	102755.20	103343.24	100558.62	104356.66	104979.36
2006	105704.60	103969.40	104714.31	101744.15	105311.73	105977.55
2007	90852.90	105183.60	106006.96	103264.28	106146.11	106842.22
2008	105704.60	106397.80	107221.19	105141.41	106887.56	107604.91
2009	116394.80	107612.00	108357.00	107397.90	107555.21	108287.16
2010	120894.50	108826.20	109414.39	110056.15	108162.76	108904.33
2011	99072.10	110040.40	110393.36	113138.52	108720.40	109467.76
2012	115458.40	111254.60	111293.91	116667.41	109235.93	109986.07
2013	112467.20	112468.80	112116.04	120665.18	109715.41	110465.95
2014	133613.40	113683.00	112859.75	125154.23	110163.68	110912.71
2015	Nil	114897.20	113525.04	130156.92	110584.67	111330.62
2016	Nil	116111.40	114111.91	135695.65	110981.60	111723.19
2017	Nil	117325.60	114620.36	141792.78	111357.14	112093.31
2018	Nil	118539.80	115050.39	148470.71	111713.53	112443.42
2019	Nil	119754.00	115402.00	155751.80	112052.70	112775.56
2020	Nil	120968.20	115675.19	163658.45	112376.27	113091.50
2021	Nil	122182.40	115869.96	172213.02	112685.65	113392.74
2022	Nil	123396.60	115986.31	181437.91	112982.08	113680.58
2023	Nil	124610.80	116024.24	191355.48	113266.62	113956.17
2024	Nil	125825.00	115983.75	201988.13	113540.21	114220.51
2025	Nil	127039.20	115864.84	213358.22	113803.70	114474.48

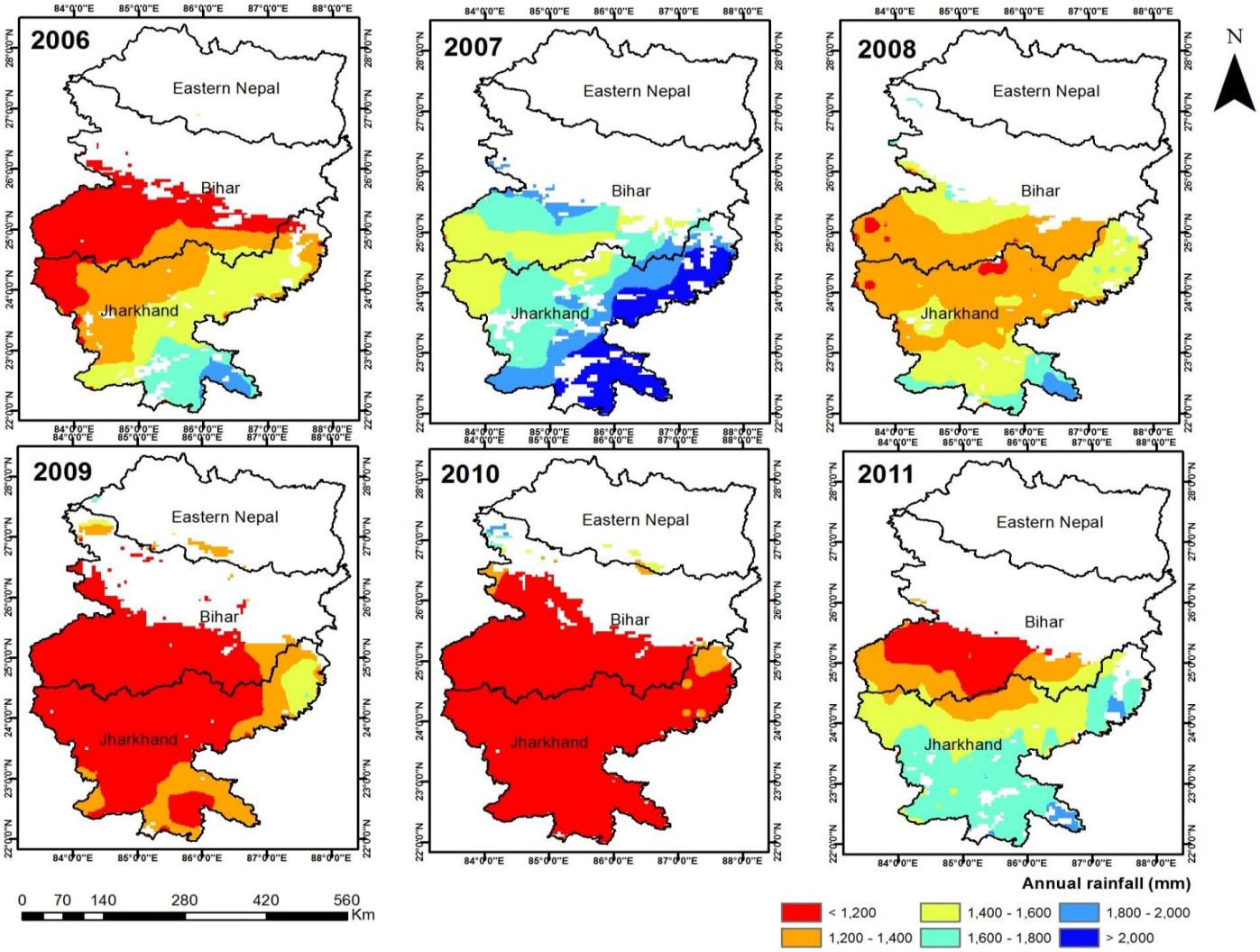
TEMPERATURE V/s RAINFALL

It has been found that the East-West central line passing through the center of the Bihar region (say the river Ganga) is the dividing line or zone for the threshold temperature.



TEMPERATURE V/s RAINFALL

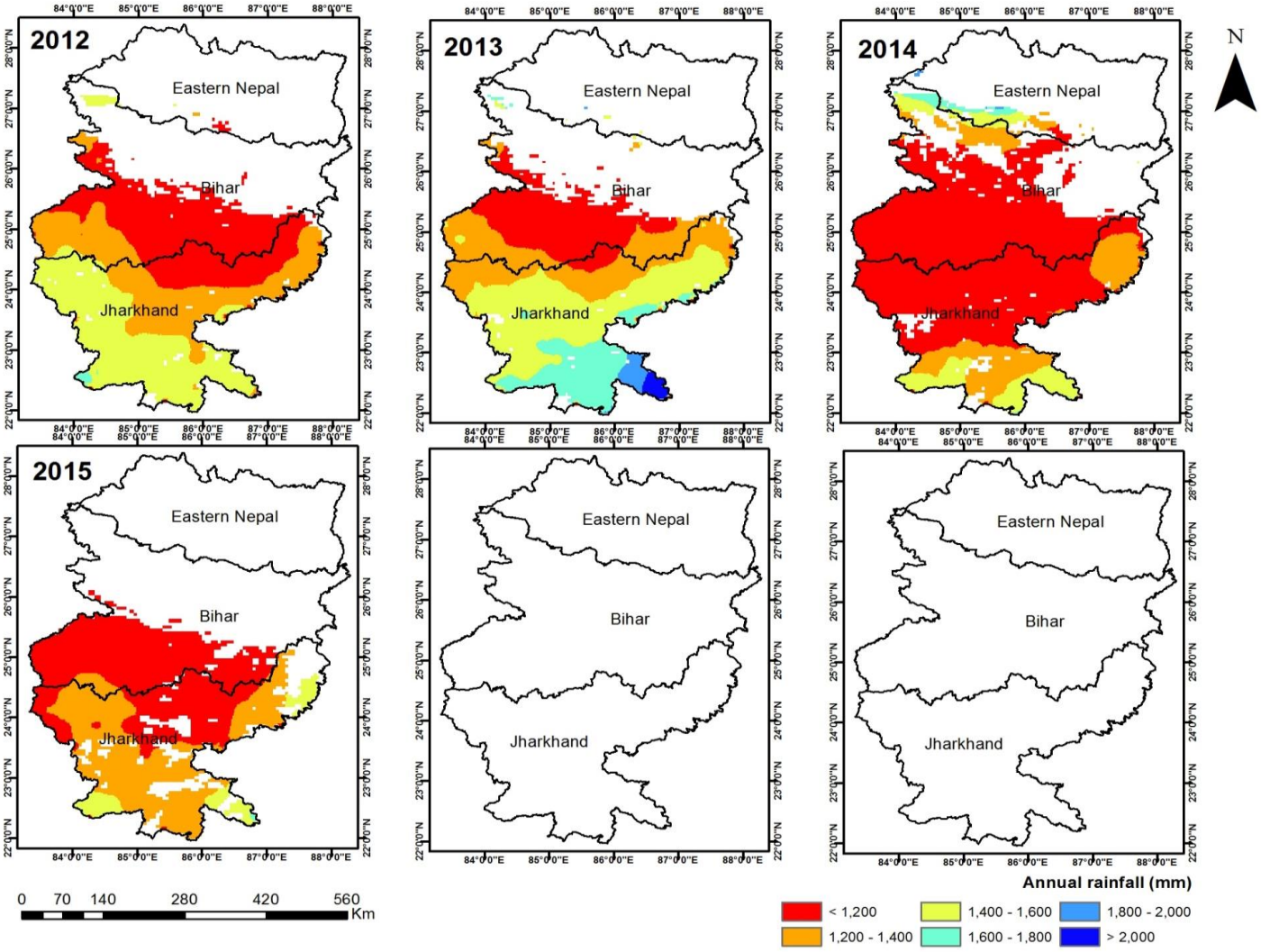
Below this line (i.e. towards the Jharkhand) the entire area witnesses a temperature greater than or equal to 35°C whereas on the other hand as we move upward (i.e. towards Nepal) there is a very few areas which witnesses temperature greater than or equal to 35°C and witnesses a comparatively cooler temperature than the lower ones.



TEMPERATURE V/s RAINFALL

This correlation suggests that the Jharkhand region is widely effected with this dry condition including the lower Gangatic half of Bihar region (southern Bihar)

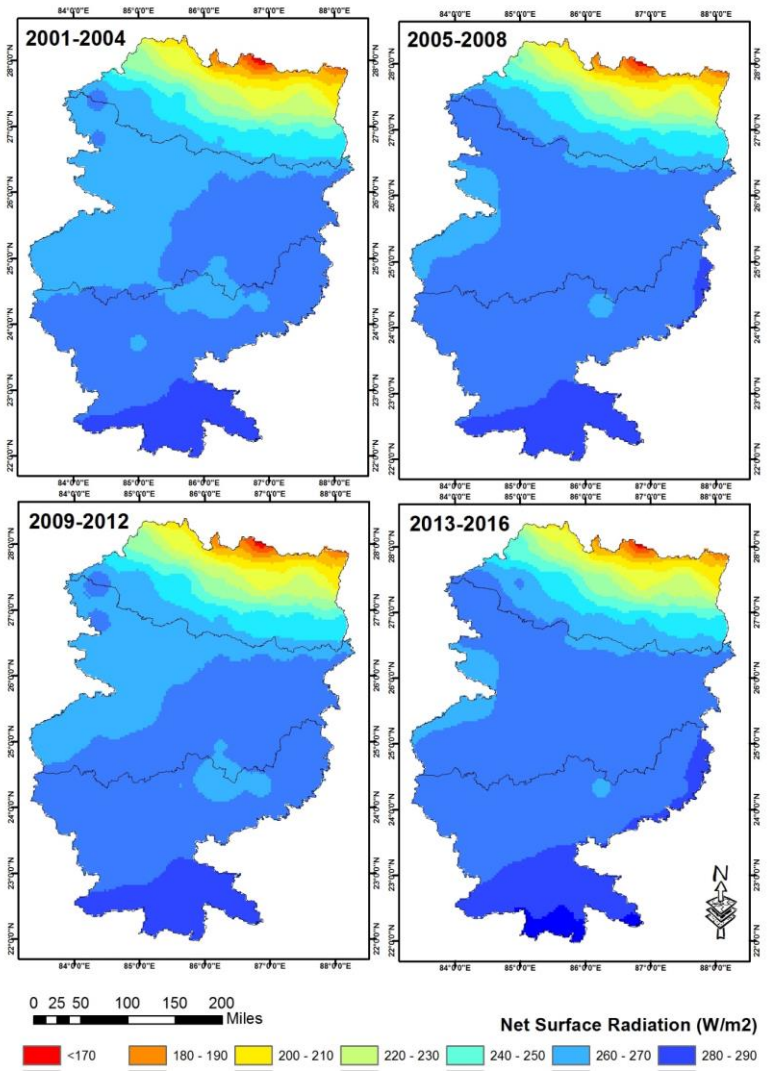
NOTE: The northern Bihar somehow witnesses the similar heat index to the nearest southern Bihar due to the high relative humidity but low temperature



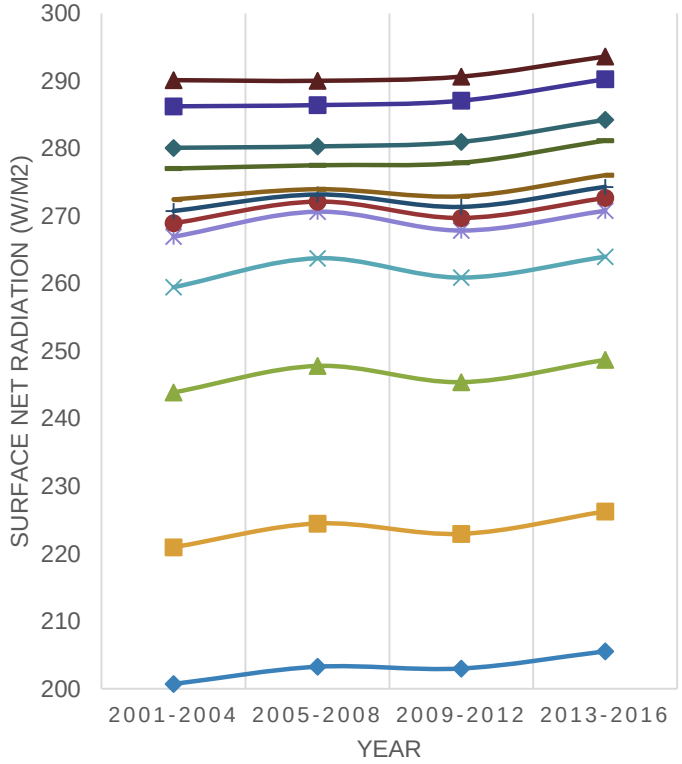
> *Since, the main natural driving force behind the climate variability is the Sun, i.e. the solar radiation/energy which the Earth's surface actually retains.*

NET SURFACE RADIATION (NSR) ANALYSIS

- The NSR has an overall increasing trend during the period of years.
- The surface over the Bihar & Jharkhand are absorbing and retaining more heat than the higher latitude Nepal.



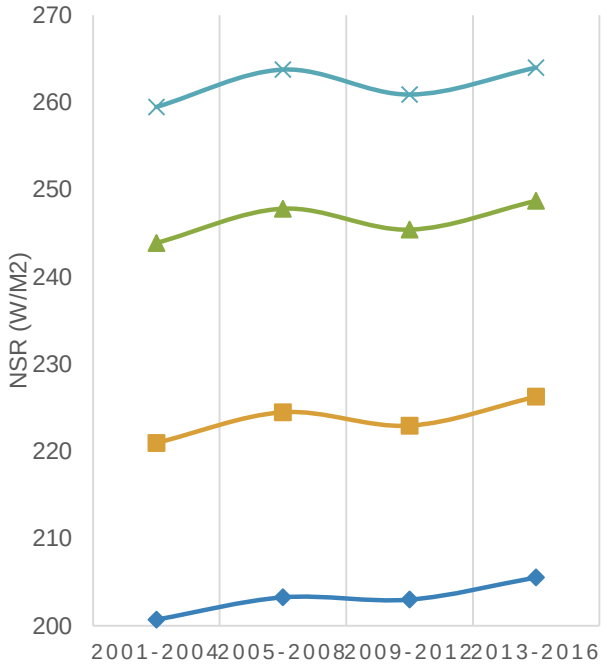
Latitudinal variation in NSR



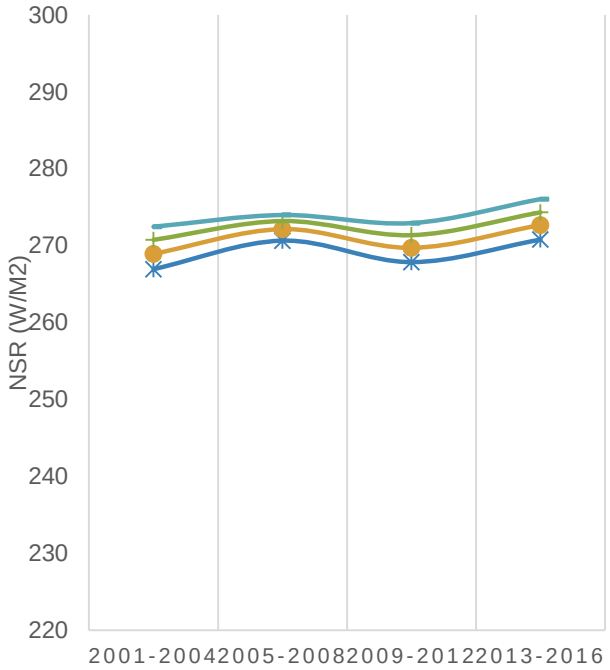
Latitudinal distribution of Net Surface Radiation (NSR), W/m^2

The curves are plotted on the basis of average NSR in each four year duration on an interval of 0.5° latitude difference ranging from 22°N latitude (top most curve) to 29°N latitude (bottom most curve).

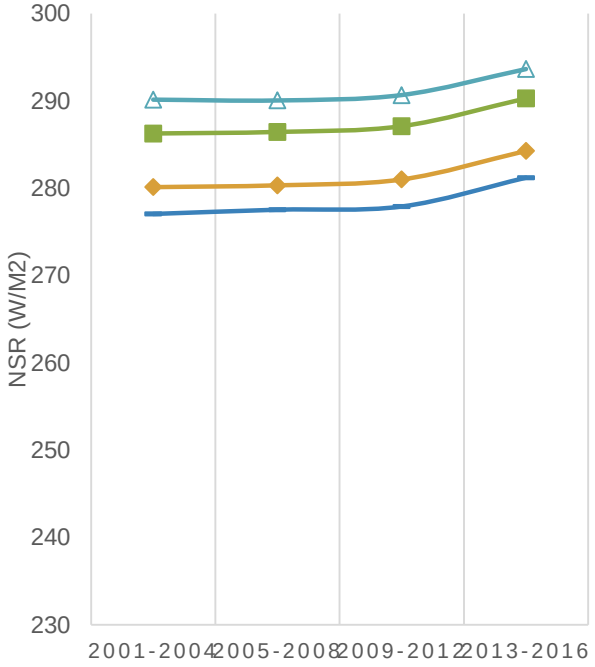
Latitudinal variation in NSR



With respect to Nepal, W/m2



With respect to Bihar, W/m2



With respect to Jharkhand, W/m2

Latitudinal variation in NSR

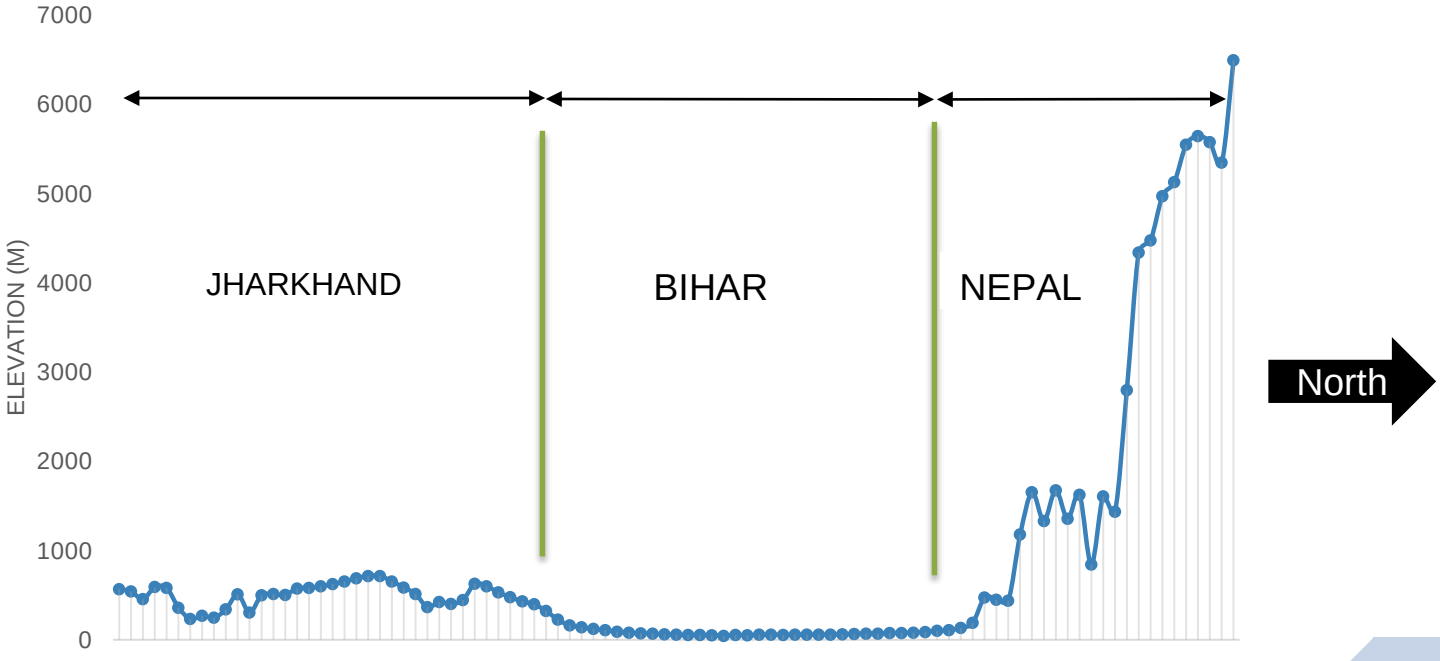
- The Nepal region has the wider range of NSR which ranges from 200 W/m^2 to 270 W/m^2 (difference of 70 W/m^2). This is basically due to the huge variation in the surface topography (i.e. entire mountain range) ranging from 500m to more than 6000m.

- Moving down from Nepal, the Bihar has the least stretch of NSR ranging from 265 W/m^2 to 275 W/m^2 (difference of 10 W/m^2). This may due to the very less variation in the topography, (i.e. entire plain region) ranging from 50m to 200m.

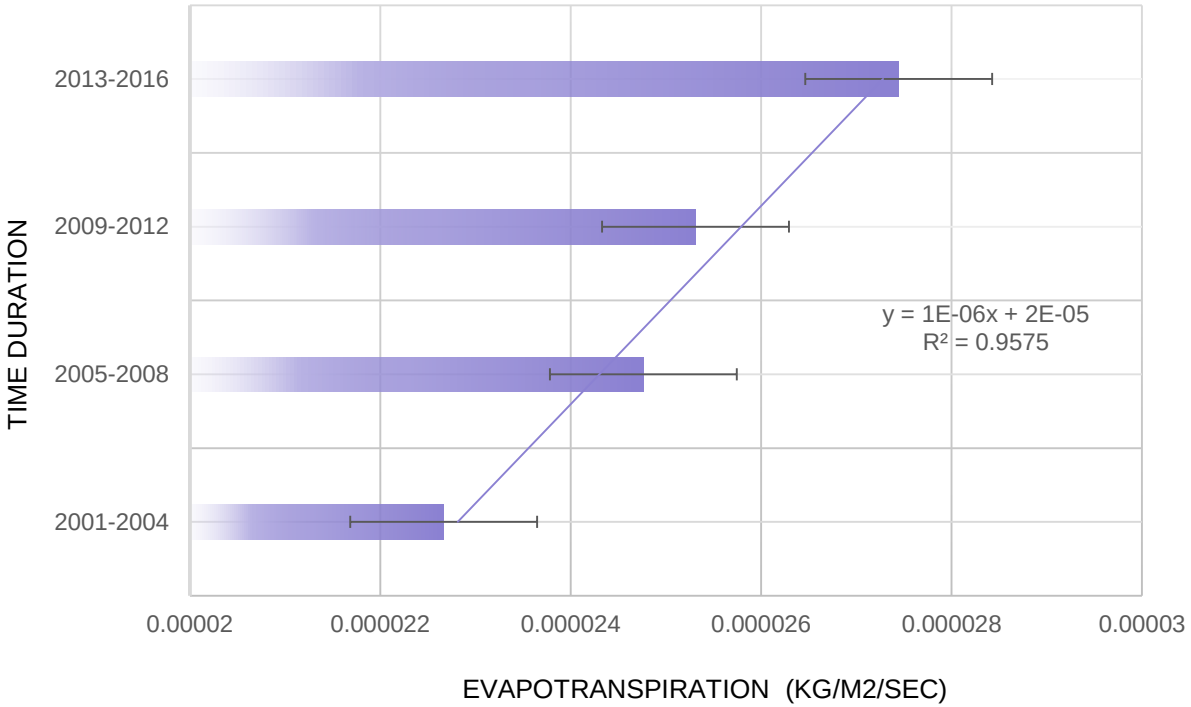
- Whereas, the Jharkhand region has the moderately less stretch of NSR ranging from 275 W/m^2 to 300 W/m^2 (difference of 70 W/m^2). This may due to the moderate surface topographic variation (i.e. some plains and Plateau) ranging from 300m to 700m.

Region covering	2001-2004	2005-2008	2009-2012	2013-2016
Nepal	200.6976	203.2524	202.9907	205.529
	220.9535	224.4686	222.9363	226.253
	243.8741	247.8062	245.4034	248.7051
	259.4631	263.7531	260.8902	263.9788
Bihar	266.9422	270.6496	267.8581	270.7812
	268.9364	272.1446	269.7178	272.6803
	270.7523	273.1983	271.3614	274.3268
	272.4577	273.9811	272.928	276.0516
Jharkhand	277.0411	277.5293	277.8956	281.1949
	280.1121	280.3219	280.9931	284.2599
	286.257	286.4363	287.0927	290.2748
	290.1319	290.0393	290.66	293.6338

DEM cross-section profile along N-S transect



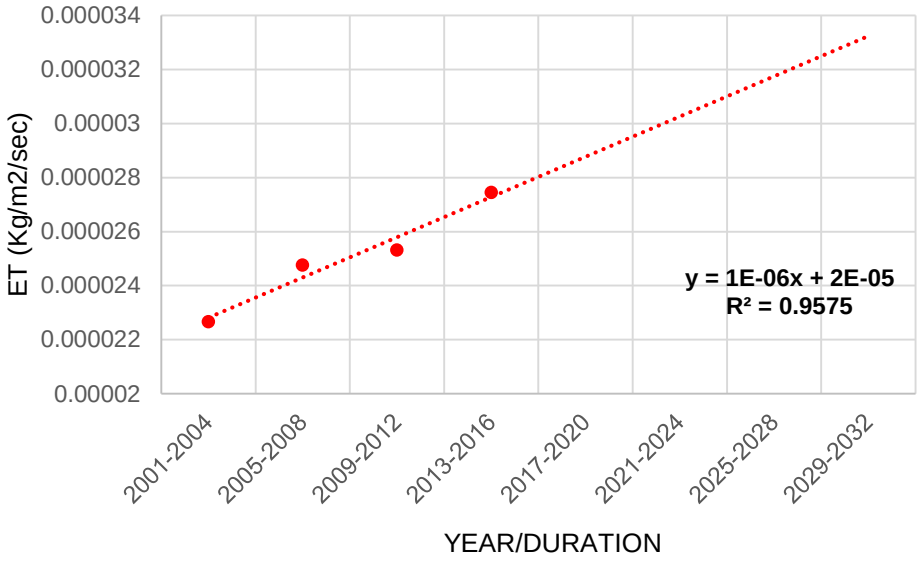
SURFACE EVAPOTRANSPIRATION (ET) ANALYSIS

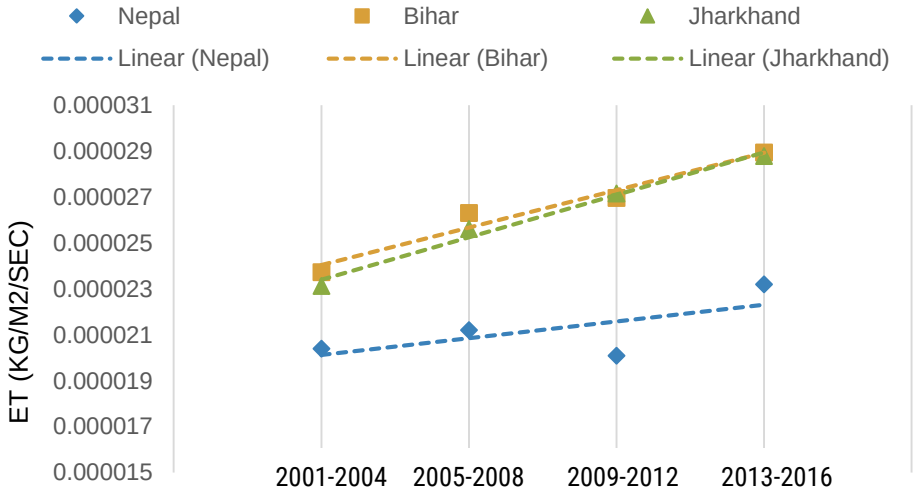


The rate of evaporation & transpiration is showing an increasing trend over the period of time.

The western Bihar- Jharkhand region has the significant increase (an increase of 8 x 10^{-5} Kg/m^2/sec) in the rate of evapotranspiration

Future trend of average surface ET for the study area, up to 2032





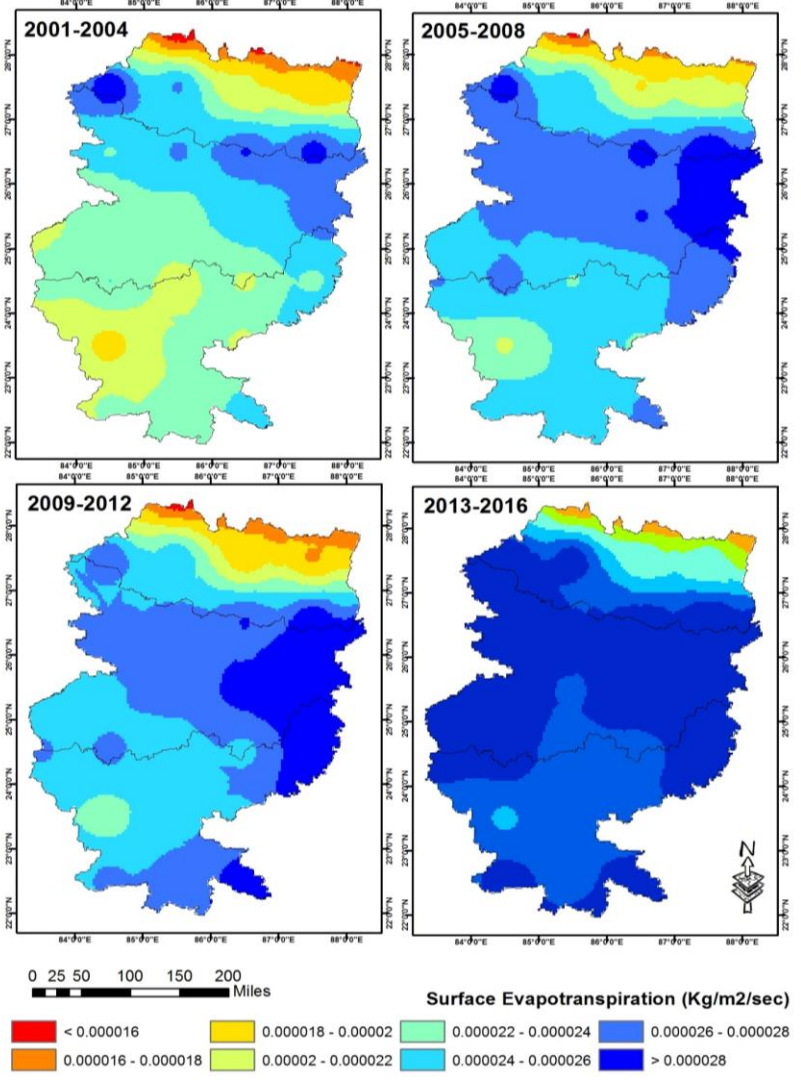
Trend of surface ET for Jharkhand, Bihar & Nepal, 2001-2016

Latitudinal variation in NSR

According to the previous graphs & maps,

It has been found that the trend of ET is approximately the same for the Bihar and Jharkhand whereas Nepal has the slightly different trend with lower ET values.

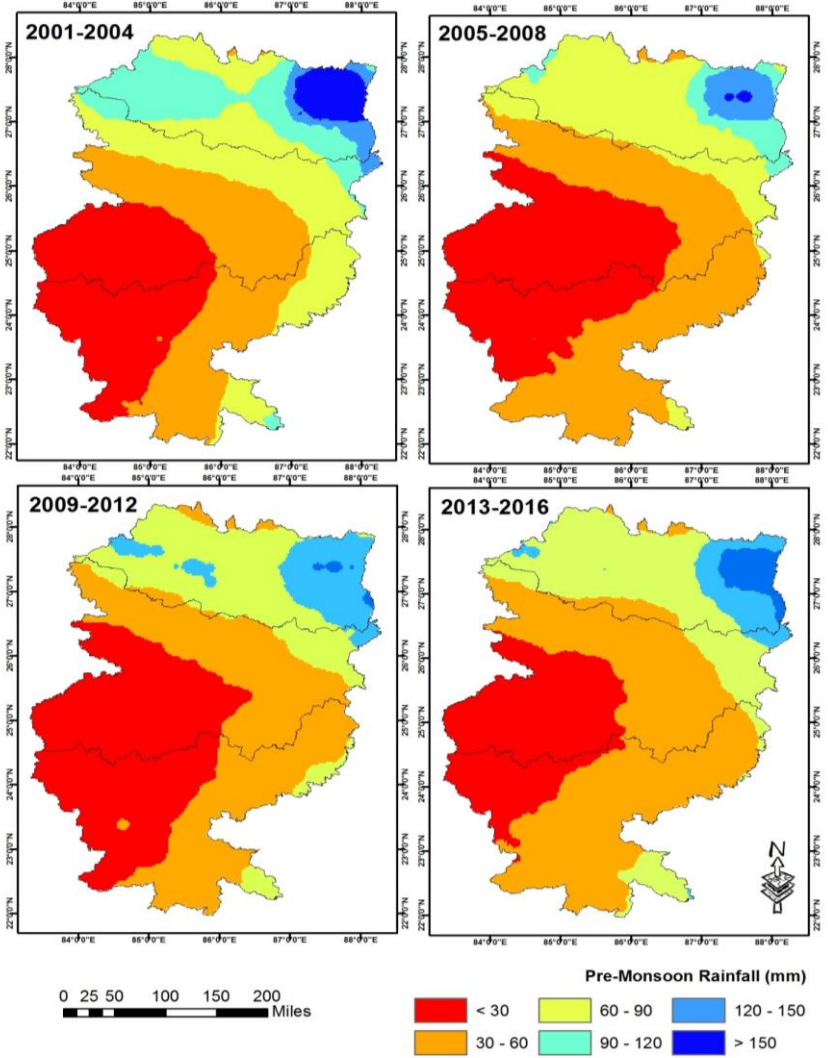
The ET values for the Bihar and Jharkhand ranges from 0.000023 to 0.000029 Kg/m^2/sec whereas this is from 0.000019 to 0.000022 Kg/m^2/sec for Nepal

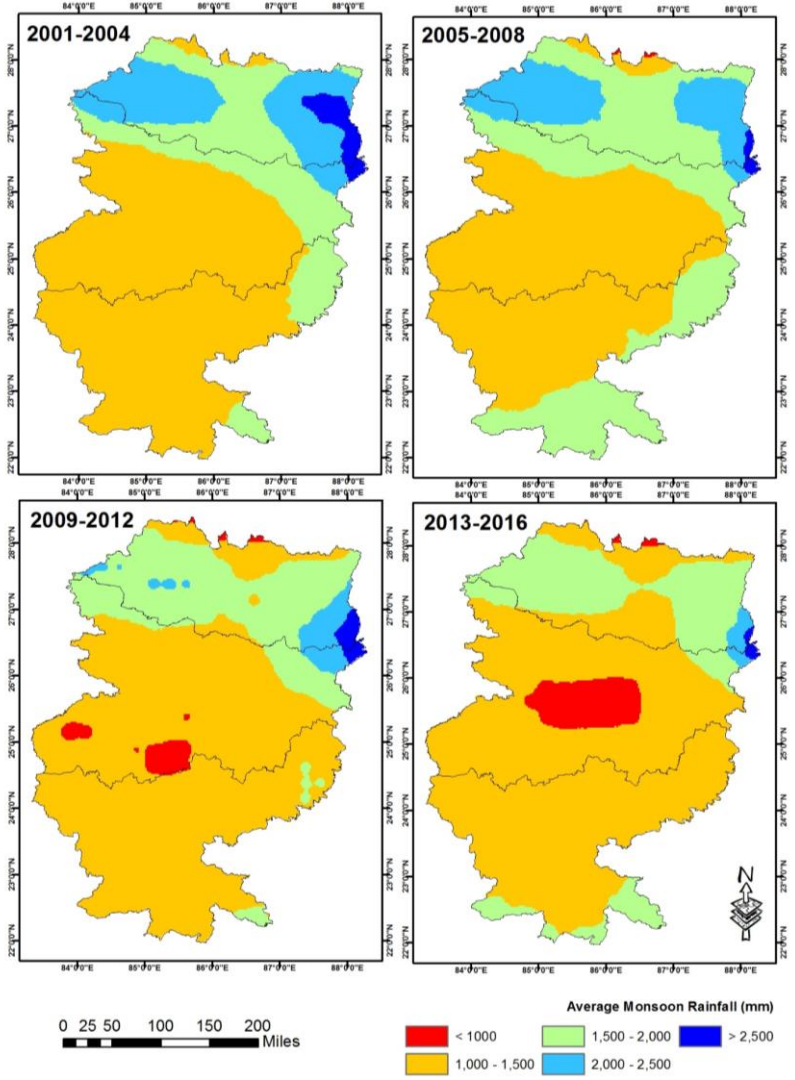


“To analyze the effect of continuous NSR receiving and an increasing trend of ET w.r.t seasonal & spatial rainfall

Pre-monsoon & Monsoon Rainfall Analysis w.r.t Net Surface Radiation (NSR) & Evapotranspiration (ET)

- There is an upward latitudinal shifting in the low rainfall bands in both the pre-monsoon & monsoon condition.
- With consideration last 3 durations i.e. 2005-2008, 2009-2012 and 2013-2016, the trend of pre-monsoon average rainfall has shown an increasing trend of rainfall. This may be due to the high surface evapotranspiration during pre-monsoon season (summer season).
- Whereas during the monsoon period, this region has received less rainfall (especially in central Bihar) over the period of time.
- As the monsoon clouds are developed globally, there must be some other factors which are governing the decrease in monsoon rainfall including net surface radiation and evapotranspiration.


2001-2004
2005-2008
2009-2012
2013-2016
0 25 50 100 150 200
Miles
Pre-Monsoon Rainfall (mm)
< 30
30 - 60
60 - 90
90 - 120
120 - 150
> 150


2001-2004
2005-2008
2009-2012
2013-2016
0 25 50 100 150 200
Miles
Average Monsoon Rainfall (mm)
< 1000
1,000 - 1,500
1,500 - 2,000
2,000 - 2,500
> 2,500

CONCLUSION

- It results after the correlation with temperature (>35°C) that the regions with low rainfall (<1000mm) have to witness warmer temperature conditions (>43°C).
- The difference in maximum and minimum temperature is increasing at the rate of 1°C per five years.
- The east-west central line of the Bihar, along the river Ganga is found to be the line of division i.e. almost 80-90% of the area which witness >35°C temperature lies below this line and few 10-20% lies above it.
- The results for NSR have shown that the NSR has an overall increasing trend over the period of time.
- The Nepal has a wider stretch of NSR due to its highly undulating topography (mountain) followed by the Jharkhand (plateau) and Bihar (plain).

CONCLUSION

- The surface ET has also an increasing trend over the period of time and the results are noticeable for western Bihar-Jharkhand.
- The rainfall results have shown that there is an upward latitudinal shifting of the low rainfall bands in both the pre-monsoon and monsoon conditions.

THANKS!