Journal of Natural Sciences Research
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.4, No.13, 2014 – Special Issue

Environmental Challenge due to Climate Change in Bihar, Developing State of India

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Abstract

As detailed in the Vulnerability Atlas of India, 27 districts in Bihar are fully affected by high-speed winds of 47 m/s intensity due to climatic change. The area of districts—Banka, Jahanabad, Arwal, and Nalanda is nearly 90 percent affected. Other districts of South Bihar except Nawada are partly affected by high-speed winds of 44 m/s. In all 86 percent of the total area of Bihar is prone to high-speed winds of 47 m/s intensity and only 14 percent of the area prone to high-speed winds of lesser intensity.

The five major district, in all 21.1 % of Bihar fall under seismic zone-V. The Himalayan tectonic plate near the Bihar-Nepal Border is having six subsurface fault lines penetrating through its Gangetic planes in four directions, Bihar is vulnerable to the worst kind of disaster caused by earthquake.

Available evidence shows that there is high probability of increase in the frequency and intensity of climate related natural hazards due to climate change and hence increase in potential threat due to climate change related natural disasters in India, and Bihar is no exception to this. It is highly vulnerable to hydro-meteorological natural disasters, with North Bihar in general being highly flood-prone, and South Bihar being highly drought prone due to the recent climatic change.

***Keywords*:** Climatic change, Natural Disaster, Earthquake, Flood, Drought, Cyclone.

1 Introduction

Developing States including Bihar and other states of India that tend to share similar sustainable development challenges, including small but growing populations, limited resources, remoteness, susceptibility to natural disasters, vulnerability to external shocks, excessive dependence on international trade, and fragile environments. Their growth and development is also held back by high communication, energy and transportation costs, irregular international transport volumes, disproportionately expensive public administration and infrastructure due to their small size, and little to no opportunity to create economies of scale.

Climate change will have wide-ranging effects on the environment, and on socioeconomic and related sectors, including water resources, agriculture and food security, human health, terrestrial ecosystems and biodiversity and coastal zones. Changes in rainfall pattern are likely to lead to severe water shortages and/or flooding. Melting of glaciers can cause flooding and soil erosion. Rising temperatures will cause shifts in crop growing seasons, which affects food security, and changes in the distribution of disease vectors putting more people at risk from diseases such as malaria and dengue fever. Temperature increases will potentially severely increase rates of extinction for many habitats and species (up to 30 percent with a 2° C rise in temperature). A rise in extreme events will have effects on health and lives as well as associated environmental and economic impacts.

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2 Background

Future vulnerability depends not only on climate change but also on the type of development path that is pursued. Thus adaptation should be implemented in the context of national and global sustainable development efforts. The international community is identifying resources, tools and approaches to support this effort. Adapting to climate change entails taking the right measures to reduce the negative effects of climate change (or exploit the positive ones) by making the appropriate adjustments and changes. There are many options and opportunities to adapt. These range from technological options such as increased sea defences or flood-proof houses on stilts, to behaviour change at the individual level, such as reducing water use in times of drought and using insecticide sprayed mosquito nets. Other strategies include early warning systems for extreme events, better water management, and improved risk management, various insurance options and biodiversity conservation.

2.1 The National Context

India's economy and a majority of its population are highly dependent on climate sensitive sectors such as agriculture, animal husbandry, fisheries, tourism, etc. Since climate change is expected to impact natural and human systems adversely by inducing changes these systems, India can be considered highly vulnerable. Climate change is only likely to exacerbate India's already high physical exposure to climate-related disasters (65 percent of India is drought prone, 12 percent flood prone and 8 percent susceptible to cyclones). As a consequence, climate change is highly likely to impact livelihoods by disrupting social, cultural, economic, ecological systems, physical infrastructure, and human assets, accentuating health risks, and as such, posing severe risks to the development of the country. Since climate change impacts are felt at multiple levels from the global to the local, responses to climate change too need to be at multiple levels, calling for strategic Interventions at local, sub-national, national, and global levels.

2.2 The Bihar Context

Available evidence shows that there is high probability of increase in the frequency and intensity of climate related natural hazards due to climate change and hence increase in potential threat due to climate change related natural disasters in India, and Bihar is no exception to this. It is highly vulnerable to hydro-meteorological natural disasters, with North Bihar in general being highly flood-prone, and South Bihar being highly drought prone. In the (relative) absence of state level climate models and/or vulnerability studies, as well low community awareness, Bihar is potentially more sensitive and vulnerable to the climate change and its impacts

3.0 Climate Condition of Bihar

The term climate change is often used interchangeably with the term global warming, but climate change is preferred to global warming because it helps convey that there are other changes in addition to rising temperatures. Climate change refers to any significant change in measures of climate such as temperature, precipitation, or wind lasting for an extended period (decades or longer). Climate change may result from:natural factors, such as changes in the sun's intensity or slow changes in the Earth's orbit around the sun;natural processes within the climate system (e.g. changes in ocean circulation);human activities that change the atmosphere's composition (e.g. through burning fossil fuels) and the land surface (e.g. deforestation, reforestation, urbanization, desertification, etc.)

3.1 Floods

Bihar is endowed with rich water bodies consisting of glacial rivers, rain-fed rivulets and tals and ground water. The whole of North Bihar is a courtyard of Himalayan Rivers and the whole of South Bihar the backyard of rivers flowing from south. Together they divide the State in seven river zones as if, bracketed between two major rivers, the rich land falling in-between is held in ransom by them. Most of these rivers namely Ghaghra, Gandak, Burhi Gandak, Bagmati, Kamla, Adhwara group of rivers, Kosi and Mahanada have Himalayan origin and have considerable portion of their catchment in the glacial region falling in Nepal and Tibet. They are, therefore, positioned to receive very copious rainfall during monsoon when discharge of these rivers is 50 to 90 times larger than fair weather flow. This causes frequent and large scale flooding of North Bihar. As such, 73.63 percent of the geographical area of North Bihar is considered to be prone to floods.

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The southern part of Bihar, on the other hand, is drained by rivers that are largely rain fed, having their origins either in the Vindhyachal Hills or in the Hills of Chotnagpur and Rajmahal. These rivers are either dry or have scanty discharges in non-monsoon months. Karmanasa, Sone, Punpun, Kiul, Badua, Chandan are the important rivers of this region. Falling between the Ganga and Indo-Nepal border, North Bihar having a geographical area of around 50,000 sq.km has a general slope from northwest to southeast. The geographical area of South Bihar is around 44000 sq.km and has a general slope of south to north.

If the rivers of North Bihar, due to their large catchment area in the Himalayas, cause floods in around 74 percent of its geographical area, then the rivers of South Bihar drain their water of the tract and accumulate them behind the high southern Bank of the Ganges which has resulted in the formation of a number of tals viz, Fatuha Tal, Bhaktiyarpur Tal, Barh Tal, More Tal, Mokamah Tal, Barahiya Tal and Singhual Tal These tals also receive backwater of the Ganges when it is in high spate. These tals, therefore, get submerged during monsoon and affect the kharif cultivation in most of the area. The area, thus, affected by tals is around 36 percent of the total South Bihar area.

Thus, the total geographical area affected by flood, water logging in tals etc. amount to 56 percent of the total geographical area of Bihar. Floods in large parts of the plains of Bihar, especially North Bihar, are recurring features and cause havoc destroying crops and the quality of land and threatening the conditions of life and livestock due to largescale displacement. Out of these the area of Sitamarhi, Supaul and Kishanganj are 90 percent affected by flood, five districts- Bhagalpur, Darbhanga, Khagaria, Madhepura, Saharsa get around 70 percent affected and in the rest of the districts, the flood-affected areas vary from 55 percent to 25 percent. In all 56 percent of the total area of Bihar is affected by flood.

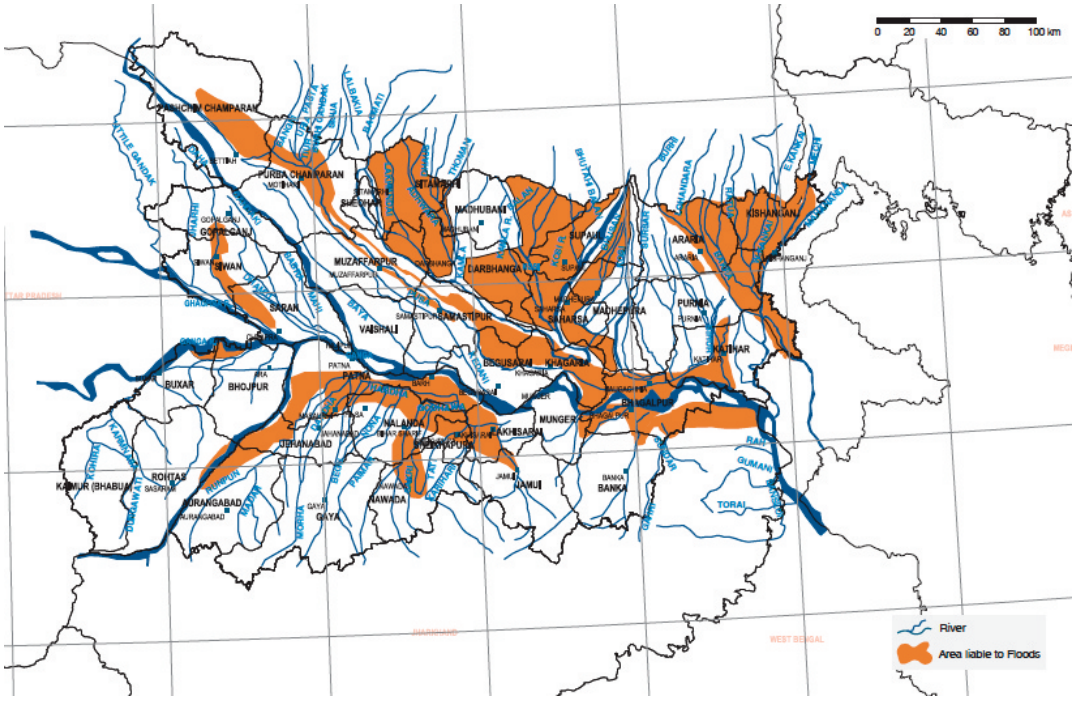

Figure 1: Flood affected area of Bihar

A study of the flood stages in various river systems revealed that early flood takes place during the month of May-June in River Bagmati, Kosi, and Kamla. Thereafter, floodgenerally comes in River Burhi Gandak in the month of mid July. During these months River Ganga generally remains low but by September, the master drain, the Ganges, also rises making the flood-problem very acute. Thus, from the month of May to September, for five months, Bihar has to suffer through the ravages of floods of one kind or another, the impact of which was perhaps not felt to the same extent in the past as is felt now. It is so because of the ever-increasing encroachments on the flood plains by the growing population to meet its requirements of food and fibre. The

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destruction of forests forreclaiming areas for occupation and for obtaining fuel for domestic requirements have also contributed in intensifying floods.

From 2001 to 2010, the number of districts affected ranged from 9 to 25, number of blocks affected, from 6 to 269, number of panchayat fully affected, from 10 to 2235, number of panchayats partially affected from 237 to 1581 and the number of villages affected ranged from 679 to 18,832. The number of human life affected ranged from 7.18 lac to 244.42 lakh, livestock affected ranged from 0.1 lac to 86.86 lakh. The total area affected ranged from 1.81 lakh ha to 19.69 lakh ha out of which agriculture land ranged from 1.6 lakh ha to 14.4 lakh ha, and non-agricultural land ranged from 0.39 lakh ha to 9.3 lakh ha. The total crop loss ranged from those sown in 0.1 lakh ha to 10.6 lakh ha.

The recorded impact of flood reveals that it is not the number of districts or blocks or panchayats affected by flood that matter. It is the area covered that determines the loss of life and property -- in the year 2004, a death toll of 885 human lives and 3272 animals were reported. Crop damage was worth ` 522.06 crore and loss of public property to the tune of ` 1030.49 crore were reported, in addition to 9.3 lakh houses that were damaged.

In the year 2007, 650 people and 615 animals were reported to be dead, 59610 houses were damaged, and 11.9 lakh hectare areas covering 10215 villages were adversely affected. Damages of crop and public property were estimated as ` 781 crore and ` 643 crore respectively. In the year 2008 in the Eastern Afflux Embankment near Kusaha Village in Nepal at nearly 12 km upstream of Kosi Barrage a breach happened which increased to nearly two km. Through this long breach, the Kosi took a new course nearest to where the river flowed in 1926 and caused widespread destruction – around 806 villages were washed away and about 23.13 lakh people lost their property. Around seven lakh persons had to be evacuated. In all, 16 districts, 86 blocks, 1678 village, 18.36 lakh of population, and 1.139 lakh of animals were affected by flood in 2008.

Crops worth ` 1704.09 lakh, houses worth ` 379 lakh and public property worth ` 321.9 lakh were either lost or damaged.

3.2 Drought

It is a paradoxical situation that a state so rich in water bodies, also suffers from severe droughts. Bihar often faces drought situation of different scales/levels that intrinsically lead to famine situations. This situation necessarily occurs when the summer monsoon gets weak and which causes percentage departure of seasonal rainfall from the normal.

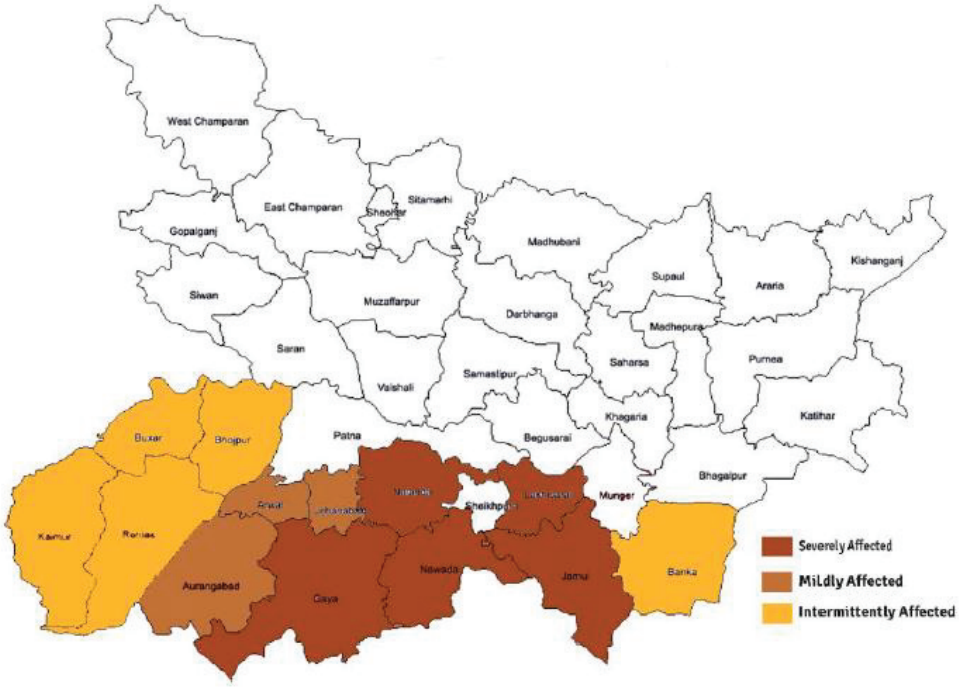

Figure 2: Drought affected area of Bih

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Climatically, the state of Bihar lies on the crossroads of the wet eastern coastal regions and the relatively dry continental region of the western plains. Being on the threshold of transition zone there happens regional variations in rainfall distribution as well as rainfall variability. Although, the average rainfall in Bihar is 1120 mm, but considerable variations occur with 2000 mm in the extreme eastern and northern part and less than 1000mm in the western and south-western part of the state. As a result 33 percent of the State receives less than 750 mm rainfall, making the southern part of Bihar vulnerable to drought. Even the 35 percent of northeastern part of Bihar that receives around 1120 mm rainfall suffers drought once in four to five years due to scanty rains.

Although the North Bihar plain receives plenty of rainfall, but when the annual rainfall is even 25 percent less than the normal, drought situations prevail. Quite often the problem of drought and floods prevails simultaneously. Apart from deficiency in rainfall prime reasons of recurring drought in Bihar is the nature of soil with low mineral and humus-contents besides extremely poor water holding capacity. Recurrent rainfall variability and sustained departure from the normal rainfall vis-a-vis low reliability, fluctuating both surface and underground water resources and extremely poor water holding capacity of the major soil group appear to have clubbed together to cause frequent droughts in Bihar. Beside, there is a relationship between reducing forestland and the increasing rainfall variability and the phenomenon is well manifested in Bihar scenario of recurrent droughts.

4.0 Causes of Climate Change

We see climate changing rapidly now as the general warming of the earth has been characterized as "global climate change" meaning the general weather everywhere isn't going to "be like it used to" in the near future. Climate may change in a single region or across the whole planet. There are various causes of change which can be brought about by a variety of factors. These include natural external factors, such as changes in solar emission or slow changes in the earth's orbit; or natural internal processes of the climate or earth system such as volcanic activity; or, as has occurred recently, human-induced (anthropogenic) factors.

In the past the conversion of most of the temperate forest zones into agricultural land changed the ecology and the local climate. After the Industrial Revolution, industrialization, urbanization and population growth have caused the spread of enormous pollutants effecting the deliberate modification of the climate. Combustion of a great amount of fossil fuels has caused an increase in the concentration of greenhouse gases resulting in global warming and climate change. This has altered the wind, cloud and precipitation pattern. The land use has also an effect on the climate such as deforestation, agricultural work and urbanization.

4.1 Climate Profile and Vulnerability and Climatic Conditions in Bihar

The cold weather commences early in November and comes to an end in the middle of March. The climate in the cold weather is pleasant. The days are bright and warm and the sun is not too hot. As soon as the sun sets the temperature falls and the heat of the day yields a sharp bracing cold. The mean temperature in Bihar varies from 10 C to 18 C. January is the coldest month in Bihar. Light fog occurs occasionally during daytime especially in the month of January. Some times Bihar gets light winter showers in December-January. The hot weather sets in the end of March and lasts until the middle of June.

The highest temperature is often registered in May, which is the hottest month in the state. Like the rest of the northern India, Bihar also experiences dust storms, thunder-storms and dust raising winds during the hot season. Dust storms having a velocity of 48–64 km/Hour are most frequent in May and with second maximum in April and June. The hot winds (loo) of Bihar plains blow during April and May with an average velocity of 8–16 km/hour.

This hot wind greatly affects human comfort during this season. Soon after Mid June the monsoon season commences and continues till the end of September, the beginning of this season occurs when a storm from the Bay of Bengal passes over Bihar. The commencement of monsoon begins as early as the last week ofMay or as the first or second week of June. The rainy season begins in June. The rainiest months are July and August. The rains are the gifts of the southwest monsoon. There are two distinct areas in Bihar where rainfall exceeds 1800mm. These lie on northern and north-western wings of the State. The southwest monsoon normally withdraws from Bihar in the first week of October.

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An important feature of the retreating monsoon season in Bihar is the invasion of tropical cyclones originating in the Bay of Bengal at about 120 N latitude. Bihar is also influenced by the typhoons originating in the South China Sea. The maximum frequency of the tropical cyclones in Bihar is during September-November especially during the asterism called hathiya. These cyclones are essential for the maturing of paddy, and are required for the moistening of the soil for the cultivation of rabi crops.

Table-1

	Winter (Jan – Feb)		Summer (Mar – May)			Monsoon (Jun – Sep)				Post-monsoon (Oct – Dec)			Year-round
City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
Patna	16	19	25	30	31	31	29	15	28	26	22	17	26
Arrah	16	18	24	30	31	30	29	28	29	26	21	17	25
Darbhanga	16	18	23	28	29	29	29	28	28	26	21	17	25

Table-2

	Winter (Jan – Feb)		Summer (Mar – May)			Monsoon (Jun – Sep)				Post-monsoon (Oct – Dec)			Year-round
City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
Patna	16	19	25	30	31	31	29	15	28	26	22	17	26
Arrah	16	18	24	30	31	30	29	28	29	26	21	17	25
Darbhanga	16	18	23	28	29	29	29	28	28	26	21	17	25

5.0 Earthquake in Bihar

Being located in the high seismic zone perched on the boundary of the tectonic plate joining the Himalayan tectonic plate near the Bihar-Nepal Border and having six subsurface fault lines penetrating through its Gangetic planes in four directions, Bihar is vulnerable to the worst kind of disaster caused by earthquake of near maximum intensity.

In all 21.1 percent of the total area of Bihar falls in Zone V. Thus, Bihar has suffered ten earthquakes in a span of 247 years. Earthquakes ranging from 5.5 to 8.3 on the Richter scale has rocked and wrecked Bihar. The latest earthquake was reported on 18th Sept. 2011 at 6.12 pm on 6.8 Richter scale with epicentre being in Sikkim – Nepal region. Only 10 deaths were reported in the state.

The worst of these was in 1934, one in which more than 25,000 persons lost their lives. Bhatgaon in Nepal and Munger in Bihar were completely ruined. Large part of Patna and Kathmandu in Nepal and Motihari, Muzaffarpur and Darbhanga in Bihar were also destroyed along with innumerable villages in between.

One noteworthy phenomenon of this earthquake was that sand and water vents appeared throughout the central vents of earthquake area. The ground around these sand fissures subsided, causing more damage. Extensive liquefaction of the ground took place over a length of 300 km (called the Slump Belt) during 1934 Bihar-Nepal earthquake in which many structures went afloat.

An M6.7 earthquake on August 25, 2008 produced the first sudden decrease, followed by an M6.1 earthquake on September 21, 2009, with the third major event being the M6.9 event on September 18, 2011. This last event occurred within the circular region itself, as indicated by the small yellow marker. This mountainous region is one of the most seismically active continental areas on earth. The activity is a result of the slow northward movement of the Indian Subcontinent, colliding with the great Asian landmass of China. Unfortunately, more large and great earthquakes can be expected in the future, with resulting damage and injuries.

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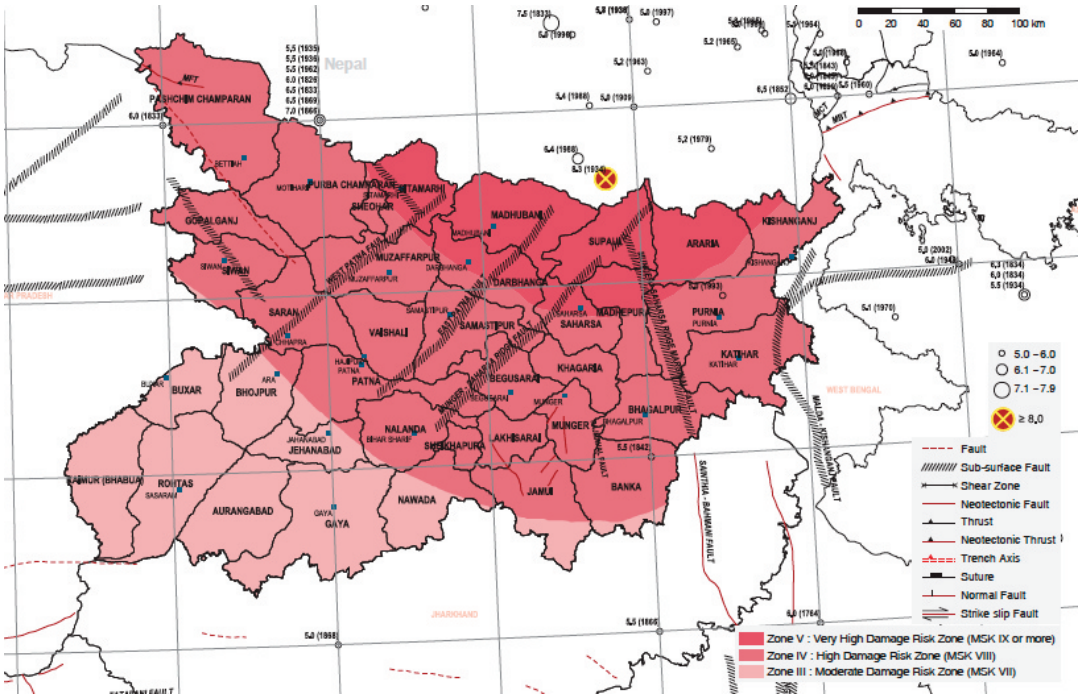

Figure 3: Earthquake vulnerability zone-wise.

6.0 Cyclonic Storms (High Speed Winds)

Among the natural hazards of the surface cyclones (High Speed Winds) are by far the most devastating both by causing loss of life as well as loss in terms of socio-economic development.

As detailed in the Vulnerability Atlas of India, 27 districts in Bihar are fully affected by high-speed winds of 47 m/s intensity. The area of districts—Banka, Jahanabad, Arwal, and Nalanda is nearly 90 percent affected. Other districts of South Bihar except Nawada are partly affected by high-speed winds of 44 m/s. Nawada In all 86 percent of the total area of Bihar is prone to high-speed winds of 47 m/s intensity and only 14 percent of the area prone to high-speed winds of lesser intensity.

Figure 4: Cyclonic storm vulnerability zone-wise

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7.0 Conclusion

Climatic change of Bihar and adjoin developing state of India compelled us to mitigate the issues relating to disasters in the State include the recurring nature of the main event categories – Earthquake, floods and droughts. The Kosi River is the main cause of recurrent floods in north Bihar. The river runs through a steep gradient in Nepal. Rainfall in the Kosi catchment in Nepal overloads the barrage compelling release from the Barrage, which causes floods and waterlogging in north Bihar. The heavy discharge from the Barrage causes downstream Bagmati, Burhi Gandak, and Ganga rivers to inundate. In addition, the discharge carries enormous amounts of sandy silt that gets deposited over arable land and renders it fallow.

Additionally, disasters, as and when they occur, are exacerbated by a number of factors; some of these include:

- High population decadal growth rate;
- Illiteracy in general and Female illiteracy in particular, and therefore, low awareness levels;
- Low per capita income;
- Rural roads in poor condition;
- Scarce health infrastructure;
- Sand casting and changes in land use due to sand casting;
- Lack of adequate tree/green cover and resultant soil erosion;
- Debris disposal;
- Damage to water management resources;
- Damage to plantations;
- Increasing salinity due to poor drainage;
- Pressure on environmental resources in areas receiving the out-migration; and
- Environmental degradation due to pollution caused by reconstruction

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