Bihar : Climate Change Risk Assessment

(Geospatial Impacts and Vulnerability Analysis with Focus on Women & Children)

Contents

Abbreviations

BSAPCC	Bihar State Action Plan on Climate Change
BSDMP	Bihar State Disaster Management Plan
CEEW	Council on Energy, Environment and Water
CGWB	Central Ground water Board
CSO	Civil Society Organizations
CVI	Composite Vulnerability Index
DST	Department of Science and Technology
GOI	Government of India
ICDS	Integrated Child Development Services
IMD	Indian meteorological Department
IQ	Intelligence Quotient
LPA	Long Period Average
MDM	Mid-day meals
MDMS	Midday Meal Scheme
MGNREGA	Mahatma Gandhi national rural employment guarantee act
MME	Multi-Model Ensemble
NFHS	National Family Health Survey
PDS	Public distribution system
PRI	Panchayati raj Institution
SBM-G	Swachha Bharat Mission-Gramin
SD	Standard deviation
SFDRR	Sendai Framework for Disaster Risk Reduction
SHG	Self-help group
TCVI	Total composite vulnerability index
UNICEF	United Nations International Children's Emergency Fund
VI	Vulnerability Index
WASH	Water, Sanitation and Hygiene
WHO	World Health Organization

Section 1

Bihar : Disasters and Climate Risk

Bihar, divided into four agro-climatic regions and 38 districts, is one of the most disaster-prone state of India, facing calamities of various kinds and varying magnitude. Over the past few decades, the state has faced differential impacts of the changing climate on its people and the state of development. Almost all the districts are prone to major climate-induced hazards like floods, droughts, cyclonic storms, and fires (Fig. 1&2). Cold and heat waves are another major threat, as are geo-tectonic hazards. During the 1934 earthquake more than 25,000 people lost their lives, while the 2015 earthquake in Nepal rocked Bihar, killing 58 and injuring 200 individuals. In 2020, thunderstorm/ lightning hazards (25 February, 13 & 14 March, 26 April, 5 May, 3 July and 15 September resulted in 280 deaths in the state.

But, amongst the various kinds of climate-induced disasters, it is the floods and droughts that are the most common in Bihar; with the state thereby commonly termed as 'India's flood state'. Around 73 percent of north Bihar is flood-prone due to monsoon rains and an increase in the average discharge of river water. In 2008, more than half of Bihar was submerged under water, with 16 of its districts reeling under the deluge. That year the state witnessed its worst floods ever, affecting more than 30 lakh people in about 1500 villages. In the year 2014, nearly 33,200 people were displaced due to floods, and shifted to the 146 relief camps set up by the Bihar government. The flood situation of 2016 and 2019 was serious in the urban areas, again putting at risk millions of people in the state, followed by several fatalities. However, the districts south of River Ganga which account for 25.75 % of the total area, are prone to severe drought. These include 17 districts, which receive less than 730 mm of rainfall, making this part of Bihar vulnerable to regular droughts.

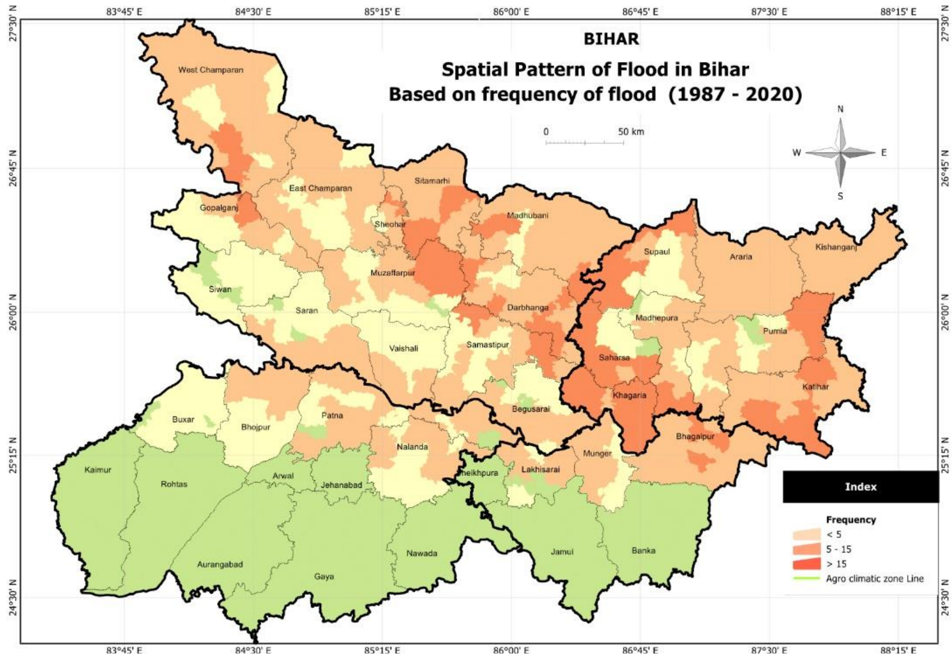


Fig.1

Also, climate change has added a new dimension in altering the nature, frequency and magnitude of natural disasters and calamities over the last few decades. The effects of climate change and climate-induced risks in the state are being noticed in the form of a shift in the average temperature and rainfall pattern, as well as an increasing frequency of extreme events like heavy rainfall in a short span of 24 hours, rising average temperature at day & night, cyclonic storms, heat waves, and droughts.

Especially in the nature of floods and droughts, a unique paradox is being witnessed in the last few years, due to climate change. Both these events occur in the same year, and sometimes even in the same district. An analysis by the Council on Energy, Environment and Water (CEEW 2020) at the national level suggests that three out of four districts in India are extreme event hotspots, with 40 percent of the districts exhibiting a swapping trend, i.e., traditionally flood-prone areas witnessing more frequent and intense droughts, and vice-versa (Mohanty, 2020). Bihar is no exception to this. For example, in 2013, the state witnessed both floods in the beginning of the year and drought towards the end. Then, in 2016, some of the districts of the state faced the worst flood in almost three decades on one hand while some had deficit rainfall in the monsoon (Watwani et 2016). Further, in 2020 and 2021, besides the usual climate calamities mentioned above, the state along with other parts of the country was severely affected by the COVID-19 pandemic. As per official records of the Bihar Government, 1.53 lakh cases were recorded and 785 people lost their lives to this corona virus (till 11 September 2020).

All the above-mentioned disasters have impacted the social and economic development scenario of the state, as well as the quality of life of its people. This long-rooted history of recurrent disasters (natural and human-induced), aided by endemic poverty, and a caste-ridden society in Bihar, are major setbacks to achieve development goals in the state.

However, despite all these hurdles, the state has made impressive strides on the economic front, as well as in bring out visionary policies and rules to mitigate the impact of natural and manmade disasters, in the recent decades. In a short gap of six years (from 2015-16 to 2021-22), the government's investment in disaster management has increased more than 9 times, from Rs 3,475 lakh to Rs 32,832 lakh. In terms of policy development, the state has been a pioneer in dealing with disaster risks. In alignment with the global DRR Frameworks (SFDRR,2015), it has developed a comprehensive roadmap for a disaster risk reduction plan. The first Indian state to do so, Bihar's Road Map on Disaster Risk Reduction outlines the strategy to manage disasters, and build the resilience of at-risk communities living in its disaster-prone areas. It also lays emphasis on the inherent traditional knowledge that the people have utilized historically in a bid to become even more resilient.

Level of Exposure to different disasters and its Spatial Pattern

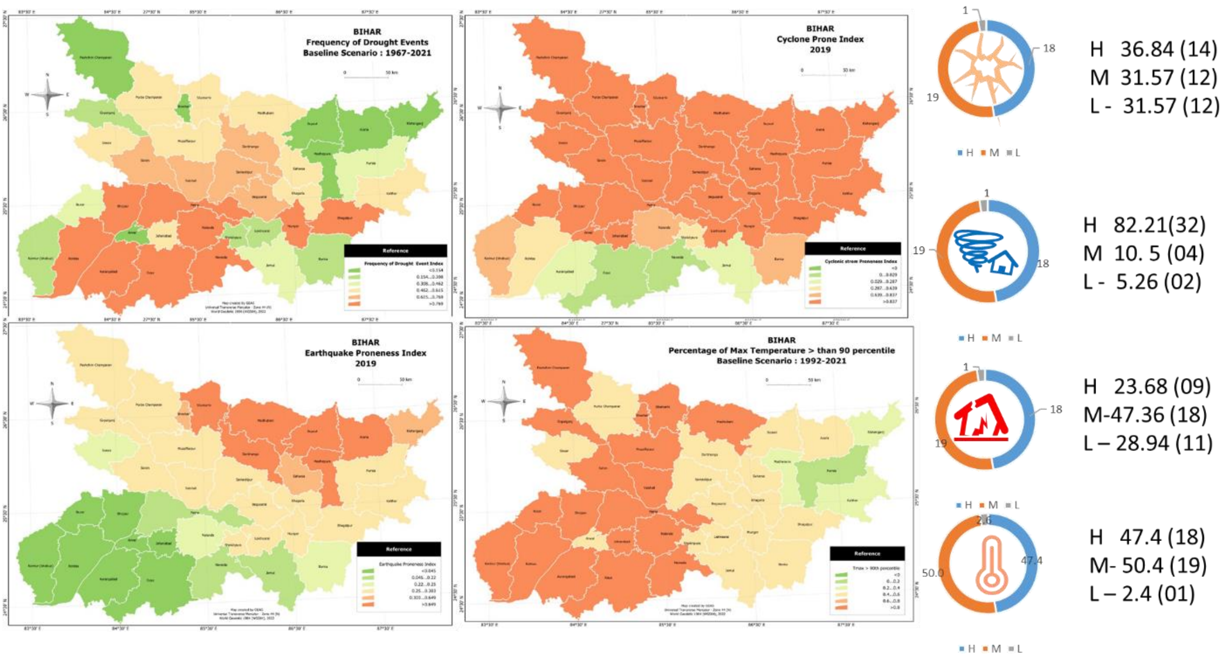


Fig.2

The Roadmap recognizes the changing climate and stresses its impact on the risk of floods and droughts, which are on a continuous rise with every passing year, enhancing the vulnerabilities of the marginalized and less-resourceful farmers, specifically impacting women and children in the households.

The different climatic models developed for the region also clearly estimate that such climatic changes in the state will further increase the vulnerability of the state's 50 million children (Census, 2011). Considering the current economic situation and capacity to respond to minimize the risks of disasters and climate change, it seems that the state is not in a position to combat, withstand or equip itself against the adverse impacts of climatic shifts, be it an increase or decrease in rainfall, a decrease, or change in the seasonal and geographic distribution of rain or changing temperature and humidity regimes. There is no doubt, that this will have a wide-range impact on human beings, particularly children and women who are differentially impacted by such incidents.

Aim & Objectives of the study

This study seeks to assess the current and future trends of climate change district-wise, and conduct a state and district-level vulnerability analysis. It also focuses to comprehend the impact of climate change or climate-induced risks on key sectors related to child development.

Why children and women matter in the climate risk assessment?

Bihar is the fifth-most vulnerable state with respect to climate-induced risks (CEEW 2021). High population growth, widespread poverty, and a large proportion of the population below 20 years of age are detrimental to the state in its bid to tackle disasters and climate change impacts. The average age of the population is 25; of which there are 497.9 lakh children, where the proportion of the 0-6 age population is more than 38 percent.

Being a highly disaster-prone state, with a large part of its territory exposed to natural and man-made disasters, thus, the large number of children in Bihar are even more susceptible to the adverse effects of disasters. It is also to be noted that the proportion of children is even higher in the more disaster-prone districts of the state. It is widely acknowledged that children, especially in the younger age group, are in a stage of rapid development and are less equipped to deal with extreme climate shocks and stresses. Their exposure to various climate risks is also more likely to have long-term consequences, as compared to adults.

Disasters affect a child's survival and development. Thousands of reports have repeatedly stressed that disasters like- floods, earthquakes, and wind storms exert a direct impact on children, which includes injuries or death. The 2008 flood in the Koshi basin is an example where many children were washed away as they lacked the strength to stay on their feet in the surging currents, sometimes even in shallow waters. Beyond the immediate risks of death and injury, disasters induced by climate change also pose a grave risk to children's overall development. For instance, in the 2008 Koshi floods, due to prolonged water logging for several months, diarrhea outbreaks, induced dropout from school, forced migration for livelihood and vulnerable children and women caught in the trap of traffickers were explicitly noticed (Need Assessment report, 2010, GoB). Such disasters also damage sanitation facilities, contributing to water contamination and undermining the sustainability of sanitation behaviors. Additionally, damage to housing endangers a child's well-being, particularly if the emergency shelter is either scarce or inadequate.

Thus, the present study tries to comprehend the impact of climate change on the implementation of the developmental plans and sectoral performance of key line departments like health, education, water and sanitation, nutrition, and child protection; along with district-level vulnerabilities to climate change. It attempts to identify the key driving factors which influence the sectoral performance, and contribute to the vulnerabilities of children and women. In the end, the study provides recommendations for the vulnerable areas to sensitize government departments and other stakeholders on appropriate actions to mitigate climate change risks.

Section 2

Approaches & Methodology for Climate Risk Assessment and Vulnerabilities

The study adopted an integrated approach for collecting current and future climate data and thematic information, and carried out analysis at the district level for identifying vulnerable districts and key sectors. It also focused to identify key indicators of thematic sectors relevant to child development, and how their functioning and targets are impacted by climate change.

Conceptual Framework

The focus of this study was to understand the current (1992-2021) trends, and envision future climate change scenarios (RCP 4.5 and RCP 8.5 of 2050). A vulnerability analysis at the state and district levels, and its impact on sectors focused on the five main domains of child development, i.e., Health; Education; Nutrition; Water, Sanitation and Hygiene and Child Protection. These domains are the primary lenses through which children's vulnerabilities were assessed in Bihar.

Health: Climate change has altered the frequency, timing, intensity, and duration of extreme weather events. These include floods, heat waves, storms, and droughts; all of which have a differential impact on children as they are more vulnerable than adults in climate-induced disaster situations because they rely on others to care for them. They need specialized medical care during and after disasters because of their specific vulnerabilities related to bodily systems and psychology. Climate change affects the growth and survival of disease-causing organisms related to water- and foodborne illnesses. The incidence of water and food borne illnesses, such as gastroenteritis and infectious diarrhea, is known to increase when outdoor temperature increases, or immediately following storms or floods. Extreme weather can result in the breakdown of sanitation and sewer systems or enhance inadequacy to cook food, increasing the likelihood of water and food-borne illness. Children are especially susceptible to this, due to their lesser developed immune systems.

Education: Proper schooling and education are closely linked with access, equity, and quality for rural, poor children. In the wake of changing weather patterns, this is influenced by declining livelihood opportunities, migration, inaccessibility to schools, health-related problems, etc. Climate-induced disasters hit poor communities harder, who are then forced to discontinue their children's schooling. Displacement due to disasters thus adversely impact a child's education.

Nutrition: Children in their growth period, are vulnerable and need proper food and nutrition for their overall development. Nutritional inadequacies result in hampering the development of their body. If this nutritional inadequacy persists for a longer period, it results in improper growth manifested in the form of low weight, stunted height, low IQ, etc. Scientific evidence shows that beyond the age of 2-3 years, the effects of chronic malnutrition are irreversible. Also, child malnutrition is the single biggest contributor to under-five mortality due to their greater susceptibility to infections and slow recovery from illness.

Water, Sanitation and Hygiene (WASH): Water, sanitation and hygiene are the foundations of child survival and development. When children have access to safe water and sanitation close to their homes and schools, they have a better chance to grow up healthy and receive access to education with dignity. Access to safe water, sanitation and good hygiene are essential components for other areas of development including health, nutrition, and education. The effects of climate change are often experienced through water as climate-induced disasters severely affect the infrastructure and services related to drinking water, sanitation, and hygiene. For example, floods inundate tube wells, ponds and water bodies and contaminate natural sources of fresh water, thereby forcing affected communities to use unsafe water. Toilets are generally inadequate, fragile, and mostly unsuitable to withstand high floods or cyclones. This leaves people with no other option but to follow the unsanitary practice of open defecation. Such a crisis in safe water supply and sanitation service severely disrupts hygiene practices. Because of water contamination, the public health situation often deteriorates, spreading water-borne diseases like diarrhea, cholera, typhoid, and hepatitis.

On the other hand, climate change also leads to less rainfall and drought. This affects the amount of water available, how water is stored, as well as the quality of water. It also reduces the base flow of rivers, which leads to an increase or a concentration of pollutants in water, which can spread diseases. When water is scarce, the water supply needs to be managed to avoid conflict. Without enough safe water, and in the absence of sanitation and good hygiene, many children suffer from diarrhea and impaired physical and cognitive growth. Also, in many areas affected by drought and water stress, children usually girls, need to walk long distances to fetch water for daily use.

Child protection: Climate change impacts the physical safety and protection of children. It also plays a role in children's psycho-social well-being. During disasters like floods and droughts, children experience emotional distress, including fear of being separated from their families, mounting tensions and pressures within households, a lack of emotional support at the family level, and increased workloads. Floods can displace thousands of people, temporarily or for extended periods before houses and infrastructure, such as roads, power and communication links are rebuilt. Children are highly vulnerable during population displacements. When a catastrophe occurs, parents or relatives can die and child protection systems become disrupted, increasing children's susceptibility to abuse, child labor, trafficking, and exploitation.

Methodology for Climate Risk Assessment

Climate risks arising out of climate change are multi-dimensional and interlinked. They vary across locations, sectors, communities, households, and individuals (gender). The report adopts the following steps for climate risk assessment, with focus on women and children's vulnerability:

Step 1: Desk based research of secondary data and information

In order to get information about the existing policies of the state on child development, climate risks, impact of climate change on development, climate risk-informed development planning, studies related to children and their vulnerabilities, governance frameworks, history of disasters, and the current status service level gaps, a thorough review of the existing literature and previously conducted vulnerability assessments was undertaken. For this study, several GoB reports/ studies were reviewed including the Bihar State Action Plan on Climate Change (BSAPCC), Bihar State Disaster Management Plan (SDMP), Roadmap of Disaster Risk Reduction, NITI Aayog indicators report on multi-dimensional poverty index, Mapping India's Climate Vulnerability developed by CEEW, 2021 and Climate Vulnerability Assessment for Adaptation Planning in India using a Common Framework developed by DST.

Step 2: Compilation of quantitative data

A detailed list of variables related to historic and future climatic phenomena (temperature, precipitation, and extreme climate events), socio-economic and biophysical factors (such as multi dimension Poverty Index, proportion of small and marginal farmers, forest coverage, gross irrigated areas, share of income from agriculture, dependency ratio and road density) for all the 38 districts of Bihar was compiled. The historic daily gridded climate data of rainfall and temperature of all districts for the recent 30 years (1992-2021) was sourced from the authentic web portals of the Indian meteorological Department (IMD). For the future climatic scenario and extreme events of rainfall and temperature, Multi-Model Ensemble (MME) data of two different scenarios (Low Emission Scenario) RCP 4.5 and (High Emission Scenario) RCP 8.5 of mid-century (2050) was compiled from the GIZ web portal (http://climatevulnerability.in). The variables related to biophysical and socio-economic parameters data was sourced from various published reports and authentic websites of the state government. Sectoral variable data related to health, education, water & sanitation, nutrition, and child protection were sourced from HMIS, NFHS-5, UDISE-plus and NCRB reports.

Step 3: Identification of suitable indicators in terms of climate exposure, sensitivity, and adaptive capacity

Selection of an appropriate and comprehensive set of variables in terms of climate hazards and exposure, sensitivity and adaptive capacity to climate change risks are critical for climate risk assessment. Hence, the variables under the three indicators were first identified by reviewing the published literature and subsequently finalized in consultations with experts. An important characteristic of a variable is to understand its "functional relationship" with vulnerability. For example, if its relation is positive then an increase in the value of the variable increases vulnerability, and vice versa. In addition, to avoid complexities in vulnerability assessment, a balanced weight is assigned to each variable for computing the composite value of the indicator. To arrive at the composite vulnerability, an addition of the composite values of each thematic indicators is carried out, wherein all these indicators are the assigned the same weight.

The variables selected are as follows:

- **Variables related to climate hazards & exposure and functional relationship:** Climate hazards and exposure is the nature and degree to which a system is exposed to hazards induced by climate change. Table 1 details the climate hazards and exposure variables, the baseline data, sources of information and their functional relationship to the climate vulnerability impact of the districts/ regions.

Table 1: **Climate hazards and exposure indicators and their functional relationship**

Theme	**Indicator**	**Baseline**	**Source**	**Relation with climate vulnerability impact**
Climatic Hazards and exposure	Coefficient of variation of Annual Rainfall	1992-2021	IMD daily Gridded data	Exposure (Positive)
	Frequency of heavy rainfall event	1992-2021	IMD daily Gridded data	Exposure (Positive)
	Consecutive dry days	1992-2021	IMD daily Gridded data	Exposure (Positive)
	Coefficient of variation of maximum temperature	1992-2021	IMD daily Gridded data	Exposure (Positive)
	Percentage of days when Max temperature is above 90 percentile	1992-2021	IMD daily Gridded data	Exposure (Positive)
	Average population affected by floods during last 5 years	2016-2021	Disaster Management Department, Bihar	Exposure (Positive)
	Percentage of area prone to floods	2019	Vulnerability Atlas of India, 2019 BMTPC	Exposure (Positive)
	Earthquake proneness index	2019	Vulnerability Atlas of India, 2019 BMTPC	Exposure (Positive
	Cyclonic storm proneness index	2019	Vulnerability Atlas of India, 2019 BMTPC	Exposure (Positive)
	Heat wave index	2019	Bihar Heat Action Plan, BSDMA	Exposure (Positive)
	Frequency of drought events	1967-2021	Disaster Management Department, Bihar	Exposure (Positive)

- **Variables related to development scenario and functional relationship:** In this set of variables, indicators are related to socio-economic development which indicate sensitivity and adaption relationship to climate change impacts. For assessing the development scenario and its impact on climate change, the following variables are considered (Table 2):

Table 2: **Socio economic development and bio-physical scenario and functional relationship**

Theme	**Indicator**	**Baseline**	**Source**	**Relation with climate vulnerability impact**
Development Scenario	Multi dimension Poverty Index	2020	NITI Aayog report 2021 National MPI report	Sensitivity (Positive)
	Proportion of marginal and small land holders	2011	Census of India, 2011	Sensitivity (Positive)
	% of Forest area coverage to gross area	2020-21	Bihar Economic survey report, 2020-21	Adaptation (Negative)
	Total gross irrigated areas	2020-21	Bihar Economic survey report, 2020-21	Adaptation (Negative)
	% of people's income shares from agriculture sector	2011	Census of India, 2011	Sensitivity (Positive)
	Dependency ratio	2011	Census of India, 2011	Sensitivity (Positive)
	Road density	2020-21	Bihar Economic survey report, 2020-21	Adaptation (Negative)

- **Variables related to Sectoral development and its relation with vulnerability impacts:** In sectoral variables, only those indicators were selected that have a direct or indirect relationship in increasing or decreasing vulnerabilities due to climate change (Tables 3, 4, 5,6, and 7).

Table 3: **Variables related to health sector and functional relationship with vulnerability impacts**

Sector	Indicator	Baseline	Source	Relation with climate vulnerability impact
Health	Health infrastructure per 1,00,000 population	2020	HMIS, 2020	Adaptation (Negative)
	HH with any member covered under a health and insurance/ financial scheme	2019-20	NFHS, 2019-20	Adaptation (Negative)
	No. of cases of vector and water borne diseases	2020	HMIS, 2020	Sensitivity (Positive)
	Total number of reported still births	2020	HMIS, 2020	Sensitivity (Positive)
	Number of morbidity cases (1-5 years)	2020	HMIS, 2020	Sensitivity (Positive)
	Children age 6-59 months who are anemic (%)	2019-20	NFHS, 2019-20	Sensitivity (Positive)
	Children aged 12-23 months fully vaccinated based on information from vaccination card (%)	2019-20	NFHS, 2019-20	Adaptation (Negative)

Table 4: **Variables related to Education sector and functional relationship with vulnerability impacts**

Sector	Indicator	Baseline	Source	Relation with climate vulnerability impact
Education	Female Literacy Rate	2011	Census of India	Adaptation (Negative)
	Average instructional days in schools (primary to Higher secondary)	2020	UDISE Plus	Adaptation (Negative)
	Average student teacher ratio	2020	UDISE Plus	Sensitivity (Positive)
	Average dropout rate from primary to secondary level	2020	UDISE Plus	Sensitivity (Positive)
	Schools with functional toilet for girls (%)	2020	UDISE Plus	Adaptation (Negative)
	Schools with functional drinking water facilities (%)	2020	UDISE Plus	Adaptation (Negative)
	Secondary schools with functional electricity (%)	2020	UDISE Plus	Adaptation (Negative)

Table 5: **Variables related to water, sanitation and hygiene sector and functional relationship with vulnerability impacts**

Sector	**Indicator**	**Baseline**	**Source**	**Relation with climate vulnerability impact**
Water, sanitation, and hygiene	HH with tap water supply (%)	2021	JJM dashboard 2021	Adaptation (Negative)
	Proportion of HH that has use of improved sanitation facilities	2019-20	NFHS-5	Adaptation (Negative)
	State of ground water utilization	2020	Bihar Economic Survey 2021	Sensitivity (Positive)
	Ponds/canal/ Ahar/pyne/other encroached to the total, identified in JJHM secondar (%)	2021	Jal Jiwan Hariyali Mission Dashboard	Sensitivity (Positive)
	Changes in ground water table during 2018-19	2020	Central Ground water Board	Sensitivity (Positive)

Table 6: **Variables related to Nutrition sector and functional relationship with vulnerability impacts**

Theme	**Indicator**	**Baseline**	**Source**	**Relation with climate vulnerability impact**
Nutrition	Coverage of MDMS	2020-21	Bihar Economic survey Report	Adaptation (Negative)
	Children under 5 years who are stunted	2019-20	NFHS -5 Report	Sensitivity (Positive)
	Children under 5 years who are wasted	2019-20	NFHS -5 Report	Sensitivity (Positive)
	Children under 5 years who are underweight	2019-20	NFHS -5 Report	Sensitivity (Positive)
	All women age 15-49 years who are anemic	2019-20	NFHS -5 Report	Sensitivity (Positive)

Table 7: **Variables related to child protection sector and functional relationship with vulnerability impacts**

Theme	Indicator	Baseline	Source	Relation with climate vulnerability impact
Child Protection	Women age 20-24 years married before 18 years	2020	NCRB report 2020	Sensitivity (Positive)
	Number of children labor cases	2020	NCRB report 2020	Sensitivity (Positive)
	Crime cases against children	2020	NCRB report 2020	Sensitivity (Positive)
	No of children (5-14 yrs) missing cases	2020	NCRB report 2020	Sensitivity (Positive)
	No of crime cases against women	2020	NCRB report 2020	Sensitivity (Positive)

Step 4: Normalization of indicators

Normalization is based on the indicators' functional relationship with vulnerability. There are several methods of data normalization. For this assessment, the variables are normalized by applying the Min-Max method. This method transforms all values to scores ranging from 0 to 1 by subtracting the minimum score and dividing it by the range of the indicator values.

For the indicators having a positive functional relationship with their respective vulnerability index, the normalization is done with the following equation.

Normalization = (Actual Value – Minimum Value) / (Maximum Value – Minimum Value)

On the other hand, if negative functional relationship occurs, then the following equation is used for normalization

Normalization = (Maximum value – Actual Value)/ (Maximum Value – Minimum Value)

Step 5: Cluster analysis for categorizing districts based on the computed vulnerability index:

The districts in Bihar were categorized as high, moderate, and low using mean and standard deviation (SD) norms. The categorization is as follows:

- High = Index > (Mean + 0.5 SD) ………………………………………………. (3)
- Moderate = (Mean – 0.5 SD) < Index < (Mean + 0.5 SD) …………….(4)
- Low = Index < (Mean – 0.5 SD) ……………………………………………… (5)

Section 3

Changing Climate context of Bihar- Historic and Projected Scenario

Bihar is one of the most climate-sensitive states of India with a unique vulnerability to hydro- met and geophysical risks. Though the state's average rainfall (1068.86 mm) is much higher than many other states of India, half of its area is prone to drought due to scanty rainfall. Northern districts (North of river Ganga) of the state from east to west like Kishanganj, Araria, Supaul, Madhubani, East and West Champaran receive heavy rainfall while the districts south of the river Ganga get less rainfall annually on an average. Such spatial differences in the availability of rainfall is one of the key reasons for economic losses due to excessive and/or scarcity of water and poor development.

Not only the rainfall, but the state is also vulnerable to excessive heat and cold during the summer and winter seasons. Variabilities in temperature are also ultimately responsible in influencing the abiotic component of ecosystems of the state like the annual rainfall amount, level of humidity in the air, heat index, soil moisture etc. The state's average annual temperature is around 26^{o} Centigrade but spatially it varies between a maximum of 48^{o} C during the summers to 5^{o}C in the winters.

The above-mentioned features of rainfall and temperature variabilities in the state has changed remarkably during the last few decades due to climate change. This has impacted the hydrological cycle and consequently the available water resources, flood and drought frequencies, natural ecosystems, society, and economy. (Ramos, 2001). This has not only been evidenced in academic and official discourses, but is being sensed and observed by ordinary people, at their individual level. Thresholds fixed empirically by common people, and those in the official documents based on previous records, for both rainfall and temperature have been overshot. Studies related to climate change conducted in academic pursuits, as also the government reports in the state have confirmed the 'highly conformity' that the state may likely experience more extreme climatic events. Such predictions, of course, would have significant consequences (positive and negative) on the nature of climate-induced hazards like the occurrence of floods, and droughts, the severity of cyclonic storms on the development and more important the growth and yield of different crops. (Patel et al., 2008). Though efforts and consensus on climate change at every level viz national, state, district and to some extent at the village has increased, but still more concerted efforts are required.

The scientific analysis of historic rainfall and temperature data (minimum of 30 years) procured from the IMD and future projection of model data clearly show that there is a high probability of an increase in the frequency and intensity of climate-related natural hazards in India due to climate change; and Bihar is no exception to this. In the absence of state-level climate models and/or vulnerability studies (relative to other states), as well as low community awareness, Bihar is potentially more sensitive and vulnerable to climate change impact. Apart from this, it is also seen that the available studies on the observed trends and variability of rainfall and of extreme rainfall events in Bihar are based on old data. They have not taken cognizance of the recent data and variabilities (Warwade et al, 2018; Guhathakurta et al, 2015; Guhathakurta et al, 2011; Guhathakurta & Rajeevan, 2008 etc.).

The present research report acknowledges the gaps in previous studies and analyzes the recently observed rainfall patterns, trends, and variabilities of 30 years of data (1992-2021). The findings of the research report will help key stakeholders obtain updated knowledge on the changing weather phenomena altered by climate change, reexamine existing autonomous mitigation and adaptation measures related to child development, and most importantly support the creation of risk-informed development plans by the state and district authorities.

Hazards and climate change analysis

Historic Rainfall: Trend, Seasonal Variation and Spatial Pattern

Climate change has altered the weather phenomena and historic behavior of the key components of climate, i.e., rainfall, temperature, and humidity features of the atmosphere in Bihar. Changes in climatic components are not a new phenomenon; they are cyclic and vary from season to season, and most often annually. However, it is the rate of variability in the last 30 years that is important. The state has experienced a continuous change in rainfall amount, intensity and duration, frequency of storms with heavy rainfall, changes in the arrival date of the south-west monsoon, and the number of rainy and dry days; confronting several side effects like changes in flood events, extended waterlogging in agriculture fields, intermittent drought etc.

In this section, the historic rainfall trends, seasonal variation, and spatial pattern are analyzed based on daily gridded rainfall data from IMD between 1992 to 2021 at the district level. In this analysis, the focus is to:

- Identify the trend and spatial pattern of the mean annual rainfall at the state level
- Understand district-wise annual rainfall trend and season-wise variability (winter, pre-monsoon, monsoon and post-monsoon)
- Assess the dispersion (coefficient of variation) of rainfall from mean, at state and district levels
- Identify the trend of extreme events of heavy rainfall and consecutive dry days during the last 30 years

Average rainfall, variability, and its trend

The average rainfall of the state is 1068.86 mm. Two thirds of its total annual rainfall is received from southwest monsoon, while the remaining comes in the form of western disturbances in winter and some amount through pre-monsoon outbreaks in April and May. Table 8 shows the mean rainfall (mm) and the variation of rainfall from the mean i.e., the monthly and annual coefficient of variation of the state for the period 1992-2021. It is seen that the state gets the highest rainfall i.e., 286 mm (26.98% from southwest monsoon rainfall) in the month of July, while August receives 242 mm (22.1% of the southwest monsoon rainfall). June and September receive 15.16% and 17.64% of southwest monsoon rainfall, respectively. Thus, more than 82.6% of the annual rainfall is confined within four months (June to September) during the southwest monsoon season only. The leftover amount i.e., 17.4 % of rainfall is distributed within the remaining eight months.

Table 8: **Month wise Average Annual Rainfall and Coefficient of variation (1992-2021)**

Month	Jan	Feb	Mar	April	May	June	July	August	Sept	Oct	Nov	Dec	Annual
Mean	9.47	11.86	11.19	20.91	65.05	161.17	286.85	242.56	187.58	55.94	5.58	4.96	1068.86
CV	101.40	111.00	119.45	69.79	71.40	54.43	29.25	23.94	41.02	84.48	193.21	181.18	18.2

Fig. 3 show the average rainfall (mm) for the last 30 years as well as displays the trend line.

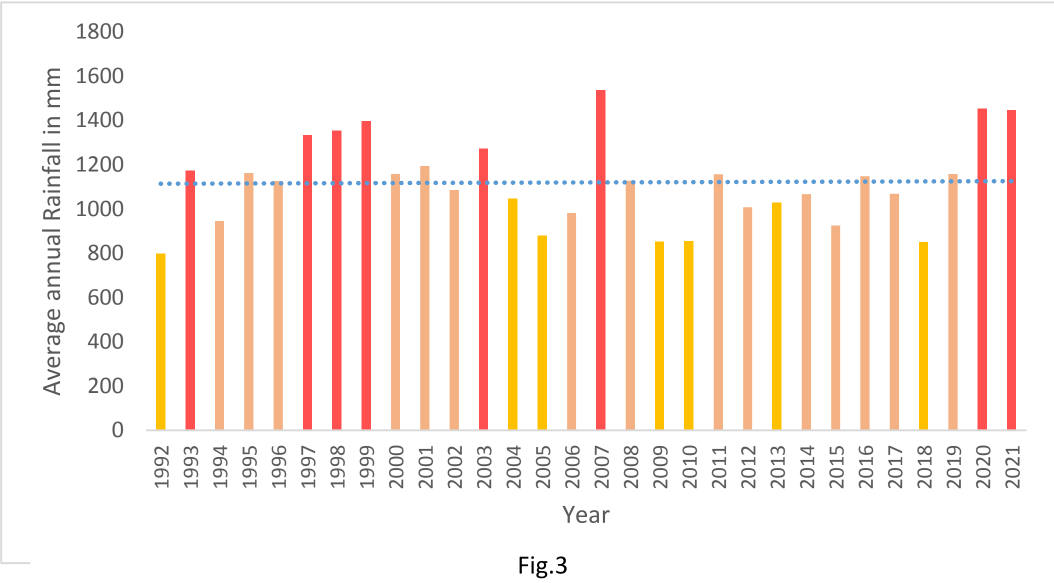


Fig.3

The average annual rainfall of the state is about 1068.86 mm The trend line shows that no significant change in average annual rainfall is observed over the last 30 years. A decreasing trend is observed in all the southwest monsoon months; 14 years out of the recorded 30 years show rainfall below the normal. Amongst them 6 years have been declared officially as drought years. Besides this, 8 years have been noted as record rainfall above normal and 8 years are at par with normal.

During the last 30 years, the highest rainfall of June, July, August, and September was received in the years 2006 (1,019 mm), 2007 (1,117.79 mm), 2008 (1,266 mm), 2020 (1,258 mm), and 2021 (1,266 mm) respectively; while the lowest rainfall of June, July, August and September occurred in the years 1992 (684.01 mm), 2002 (693.45 mm), 2018 (673.42 mm) respectively. The highest southwest monsoon rainfall of 1,266.92 mm (2008) and annual rainfall of 1,754.86 mm was received in the year 2021 and the lowest southwest monsoon rainfall of 684.01 mm and annual rainfall of 799.71 mm in 1992.

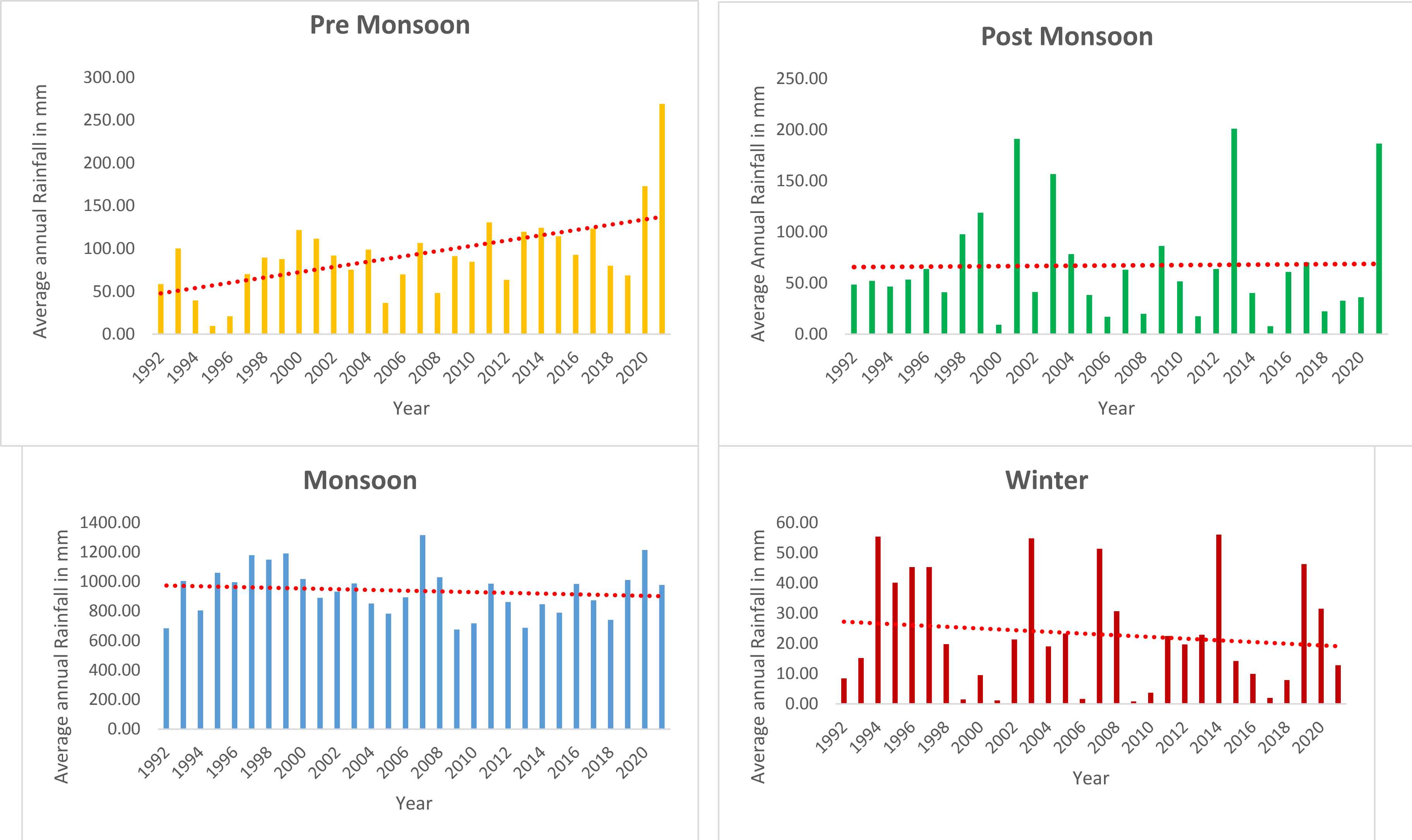

Pre Monsoon
Average annual Rainfall in mm
300.00
250.00
200.00
150.00
100.00
50.00
0.00
1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020
Year
Post Monsoon
Average Annual Rainfall in mm
250.00
200.00
150.00
100.00
50.00
0.00
1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020
Year
Monsoon
Average annual Rainfall in mm
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020
Year
Winter
Average annual Rainfall in mm
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020
Year

Fig.4

District wise variation of monsoon and annual rainfall

Spatially, the rainfall statistics in different parts of Bihar have shown different features. Table 9 gives the district-wise rainfall statistics of Bihar for the four monsoon months as well as the annual rainfall. Fig 5 shows the spatial pattern of these statistics. Three districts in the northeast viz. Kishanganj, Arariya and Purnia and one in the northwest viz. West Champaran, receives relatively higher rainfall than other districts during all the southwest monsoon months. Rainfall received over these districts is around 150-350 mm in June, 350-600 mm in July, 300-450 mm in August, 200-400 mm in September, and annually 1300-2100 mm. In general, districts over the southwest of Bihar received less rainfall during the southwest monsoon season (698-897 mm) as well as annually (780-1029 mm). The highest mean southwest monsoon rainfall (1,694.1 mm) and annual rainfall (2,023.2 mm) is observed over the Kishanganj district, while the lowest mean southwest monsoon rainfall (697.9 mm) and annual rainfall (780.1 mm) over Arwal district.

Annually, the districts exhibiting maximum and minimum coefficient of variation of mean rainfall are Saharsa (35.05) and Rohtas (17.52) respectively. The districts which have a very high degree of annual rainfall variability are West Champaran, Madhubani, Supaul ,Saharsa, Araria, Purnia and Kisanganj. The districts Kaimur Bhabua, Rohtas, Aurangabad and Lakhisarai experienced the least variation in annual rainfall variation. (Fig 5)

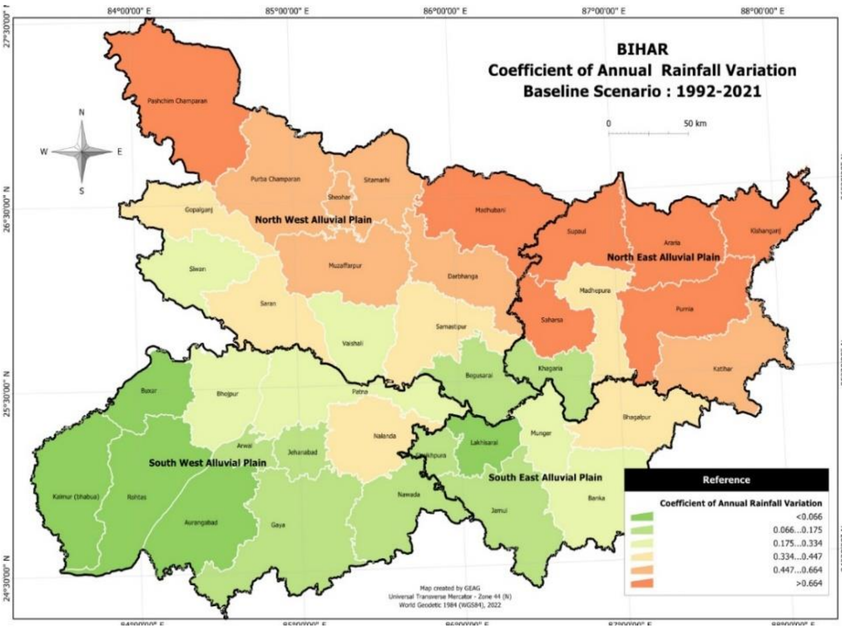


Fig.5

Table 9**: District-wise mean rainfall statistics and coefficient of variation (1992-2021)**

DISTRICT	JUNE		JULY		AUGUST		SEPTEMBER		MONSOON		ANNUAL	
	MEAN (mm)	CV	MEAN (mm)	CV	MEAN (mm)	CV	MEAN (mm)	CV	MEAN (mm)	CV	MEAN (mm)	CV
ARARIA	258.4	39.8	447.2	41.8	324.8	46.2	281.1	53.7	1311.6	30.5	1569.4	29.16
AURANGABAD	138.3	64.4	280.4	40.1	257.7	33.1	179.6	47.5	855.9	33.0	958.7	18.2
BANKA	148.7	51.2	293.8	43.4	247.8	26.5	206.8	56.0	897.0	22.2	1070.2	22.8
BEGUSARAI	148.5	62.0	295.3	47.7	259.9	44.1	218.9	61.2	922.6	37.8	1065.9	20.59
BHABUA	110.1	73.9	279.4	40.6	291.2	55.5	193.2	51.4	873.9	25.9	956.7	17.93
BHAGALPUR	161.5	48.3	301.7	36.8	258.8	38.9	225.5	56.8	947.6	21.4	1167.3	23.38
BHOJPUR	123.9	70.9	298.0	57.3	253.5	39.9	179.9	52.1	855.4	36.3	958.9	20.72
BUXAR	114.1	92.4	288.7	56.2	251.1	40.3	159.8	50.7	813.6	30.4	900.1	18.28
CHAMPARAN.EAST	175.4	54.0	322.6	47.8	287.1	52.7	182.1	60.6	967.2	30.5	1144.8	27.42
CHAMPARAN.WAST	197.3	62.4	399.1	37.4	358.9	47.2	212.4	59.4	1167.6	24.8	1374.7	31.07

DARBHANGA	159.4	75.9	293.8	38.1	242.3	44.9	178.5	59.5	874.0	27.3	1025.1	25.65
GAYA	133.2	71.4	256.3	48.0	231.6	31.7	165.9	59.0	787.0	27.5	888.5	19.15
GOPALGANJ	144.9	58.4	314.4	49.1	261.1	39.1	193.4	61.2	913.9	21.9	1069.0	25.15
JAHANABAD	116.0	70.0	267.1	54.2	243.1	39.8	166.2	59.6	792.4	29.0	888.9	19.07
JAMUI	140.6	57.2	297.1	47.4	237.0	31.4	216.2	63.0	890.9	31.5	1033.8	18.67
KATIHAR	212.8	46.7	329.2	35.0	248.4	43.6	276.4	64.5	1066.9	30.9	1326.7	27.54
KHAGARIA	165.0	63.5	271.1	45.0	247.1	44.7	223.6	62.1	906.8	32.0	1085.1	20.43
KISHANGANJ	330.4	38.6	567.5	41.7	444.0	46.5	352.2	54.6	1694.1	26.4	2010.5	30.21
LAKHISARAI	122.4	51.0	287.7	49.1	208.8	30.1	175.8	54.6	794.7	26.9	922.9	18.64
MADHEPURA	196.3	41.3	295.6	35.9	257.1	43.0	235.3	55.4	984.4	23.8	1203.8	24.75
MADHUBANI	166.5	48.8	325.4	46.1	251.8	52.9	168.8	55.5	912.4	29.9	1071.1	31.39
MUNGER	142.6	55.2	313.9	58.3	242.1	37.0	229.3	54.8	928.0	31.8	1079.6	20.77
MUZAFFARPUR	160.3	59.7	298.0	40.1	257.3	48.1	187.4	69.5	903.0	32.6	1062.2	25.39
NALANDA	114.2	61.6	275.8	50.0	223.5	35.1	182.4	48.9	795.9	27.4	903.3	24.05
NAWADAH	117.9	68.9	269.7	49.3	229.7	35.3	173.5	50.9	790.8	24.9	921.8	18.79
PATNA	128.3	67.2	273.1	52.1	222.2	26.6	169.7	49.3	793.3	27.6	911.4	23.12
PURNEA	268.3	40.1	419.6	40.9	334.9	43.5	296.2	51.6	1319.0	27.7	1623.3	29.39
ROHTAS	120.7	71.3	281.3	49.3	255.2	28.8	153.1	53.6	810.3	24.2	903.4	17.52
SAHARSA	165.7	45.0	315.9	46.4	250.6	39.0	203.8	55.6	936.0	26.6	1122.4	35.05
SAMASTIPUR	155.4	54.3	303.4	45.4	254.2	46.8	199.2	55.8	912.3	28.4	1091.1	25
SARAN	134.7	65.1	275.5	52.8	250.9	36.1	172.7	52.3	833.8	27.4	950.8	25.30
SITAMARHI	169.4	73.8	303.0	57.9	264.6	54.4	164.2	59.1	901.2	38.7	1042.5	28.56
SHEIKHPURA	126.8	60.7	286.7	52.7	203.4	40.6	170.5	58.8	787.4	42.1	908.3	20.44
SHEOHAR	173.1	77.3	308.3	66.3	260.9	64.9	183.4	68.3	925.7	47.3	1076.2	26.79
SIWAN	130.1	64.7	273.9	45.4	233.8	44.1	176.2	58.6	814.0	25.1	957.9	21.85
SUPAUL	202.7	49.7	357.3	58.3	258.4	40.2	211.0	49.7	1029.3	29.6	1253.2	34.91
VAISHALI	115.1	76.5	276.4	70.9	214.4	50.0	154.7	74.6	760.4	52.2	856.9	22.96
ARWAL	97.9	70.1	246.0	69.4	231.0	61.4	158.3	65.9	733.3	38.3	816.9	17.58

Average mean, maximum and minimum temperature, and its variation

The climate of the state is tropical in nature, and its average maximum and minimum temperature is about 32.5^o and 20.27^o Centigrade respectively. But over the last few decades, its surface temperature has altered due to climate change. These changes in temperature have created new challenges of uncertain intensity in rainfall and created significant implications for the agriculture and water sectors.

In this section, the surface air temperature of the last hundred and twenty years (1901-2021) and the immediate last 30 years (1992-2021) have been analyzed. This clearly depicts that the state's average annual mean land surface air temperature during 2021 was -0.82^{0}C cooler than its immediate Long Period Average (LPA,) for the period between the years 1992-2021. The annual maximum and minimum temperature averaged over the state during the year 2021 was cooler than the LPA average with anomalies of -1.5^{0}C and -0.12 ^{0}C respectively.

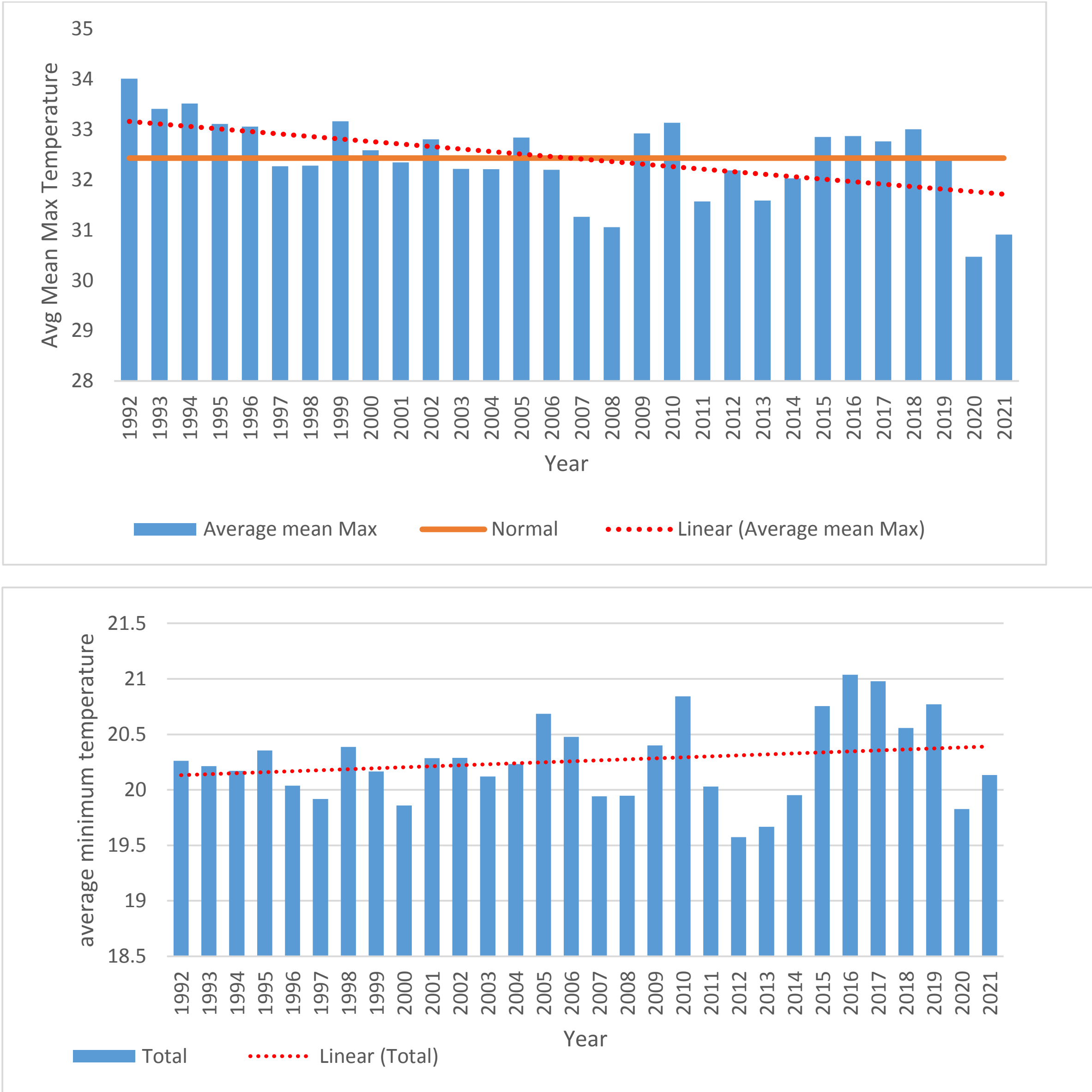


Fig.6

Conversely, during the year 2021, the annual mean land surface air temperature of Bihar was 25.52^{0}C with an anomaly +0.1^{0}C warmer than the average (1901-2021). No significant trend is observed in the state averaged annual mean temperature during 1901-2021. The annual maximum temperature averaged over the state during the year 2021 was cooler than the average with an anomaly of -0.3^{0}C while the annual minimum temperature averaged over the state was warmer than average by 0.4^{0}C. But it is important to note that during the period 1901-2021, the state averaged maximum temperature showed a significant increasing trend (0.54^{0}C/100 years) while the state averaged minimum temperature showed a significant decreasing trend (-0.53^{0}C/100 years).

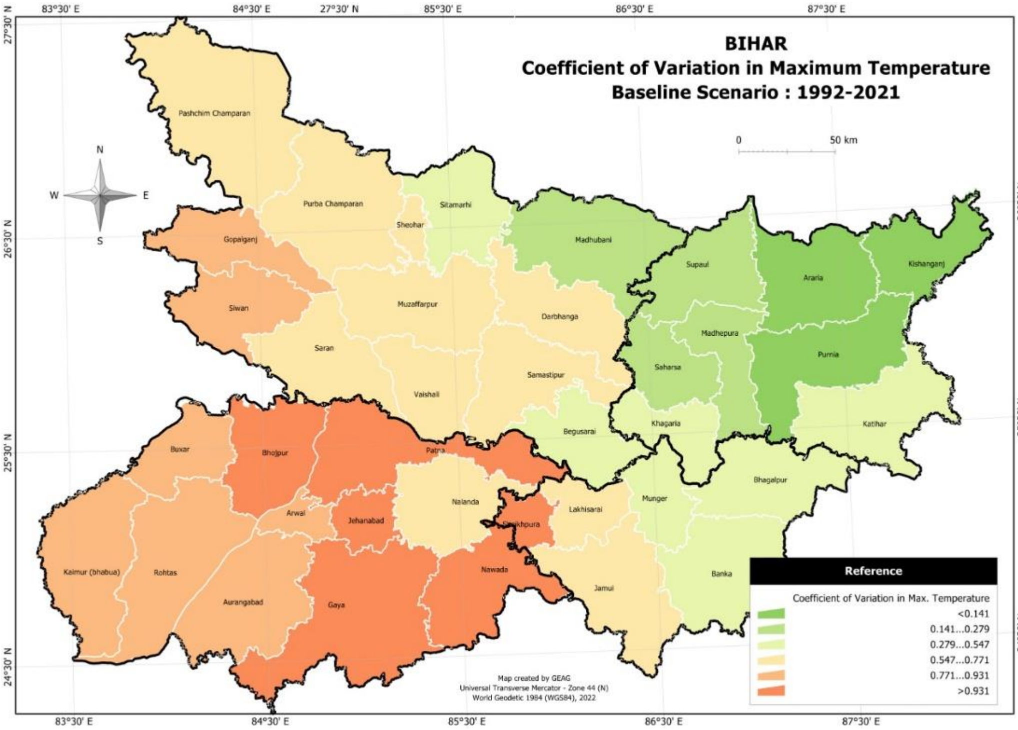


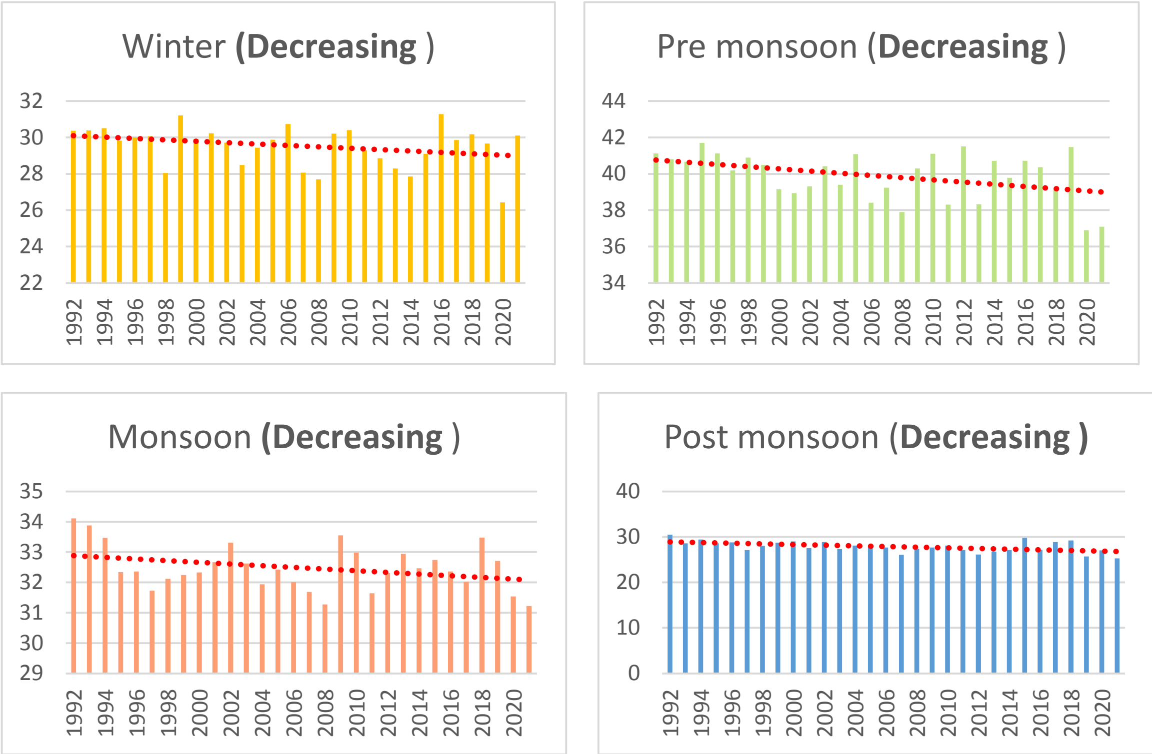
Fig.7

Fig. 7 shows the coefficient of variation in maximum temperature of the immediate last 30 years average. The high coefficient of variations in maximum temperature is prominently noted in south east alluvial plain regions like Bhojpur, Patna, Gaya, Jahanabad, Nawada and Sheikhpura.

Seasonal variations in maximum and minimum temperature

The seasonal analysis of the maximum and minimum temperature of 30 years' data depicts micro changes. The maximum temperature is declining in all seasons. But the rate of declination in winter and pre-monsoon is more prominent than during monsoon and post-monsoon season (Fig. 8), and the mean minimum temperature in the state is increasing. The rate of increase in minimum temperature is noticed in winter, monsoon, and post-monsoon seasons, but is more significant during the monsoon period.

Seasonal Variation of Maximum Temperature



Seasonal Variation of Minimum Temperature

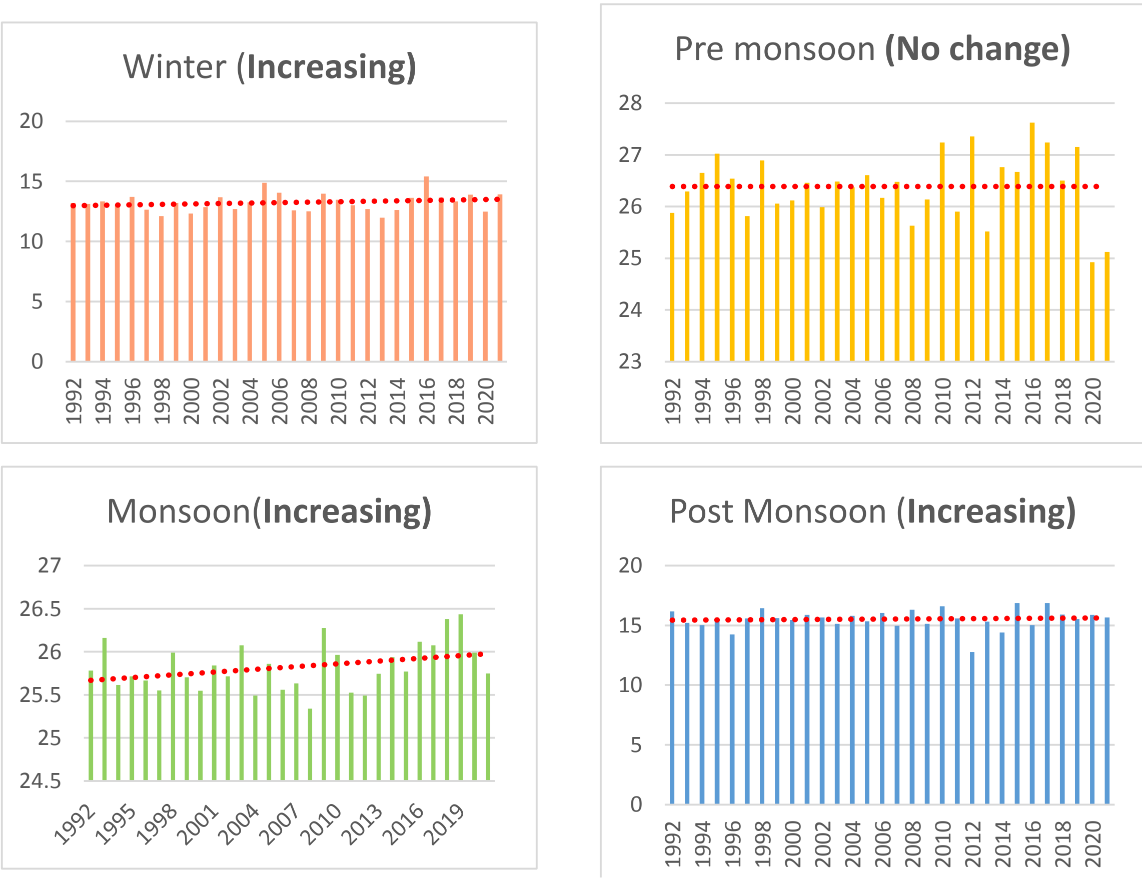


Fig.8

Extreme Climate Events: Trend and spatial pattern of heavy rainfall

The state is experiencing more extreme rainfall climatic events. In the last three decades (1992-2021), the frequency of heavy rainfall days (> 64.5 mm in 24 hours) has increased significantly. The year 2021 experienced the highest heavy rainfall events (56 days) and it is more pronounced in the districts of Kishanganj, Saran, Araria, Purnia, East Champaran, Sheohar, Patna and Samastipur. The average annual frequency and trends of heavy rainfall days in Bihar for the last 30 years are given in Fig. 9

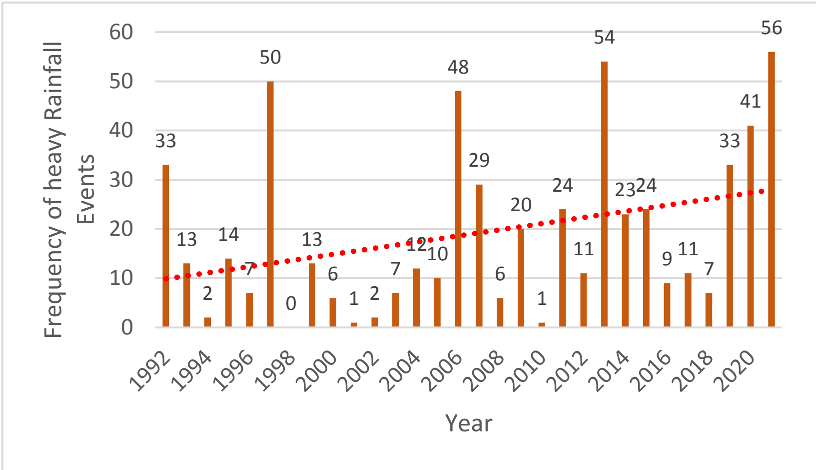


Fig.9

During the southwest monsoon, the maximum frequency of heavy rainfall days is in the range of 4.3-5 days in Kishanganj and in some parts of Purnia, Bhagalpur and West Champaran, while the minimum frequency is in the range of 1-2.4 days in Siwan, Saran, Vaishali, Patna, Nalanda, Nawada, Sheikhpura, Gaya, Jahanabad, Arwal, Bhojpur, Buxar, Rohtas and Kaimur districts. (Fig 10) The remaining parts of the state have a frequency in the range of 2.4-4.3 days. Thus, in general, it is noted that the frequency of heavy rainfall days' decreases from the foothills of the Himalayas (north) to the plateau regions (south) in Bihar. The ranking of districts as per the experiences of heavy rainfall events is given in Fig 11.

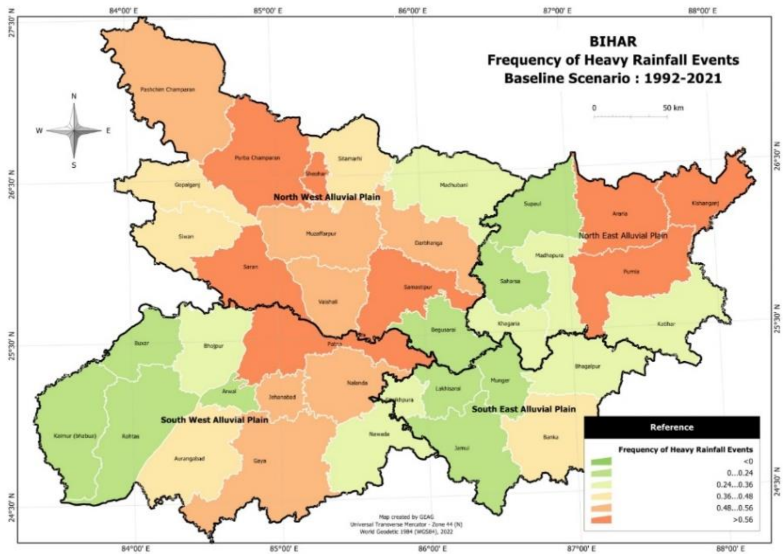


Fig.10

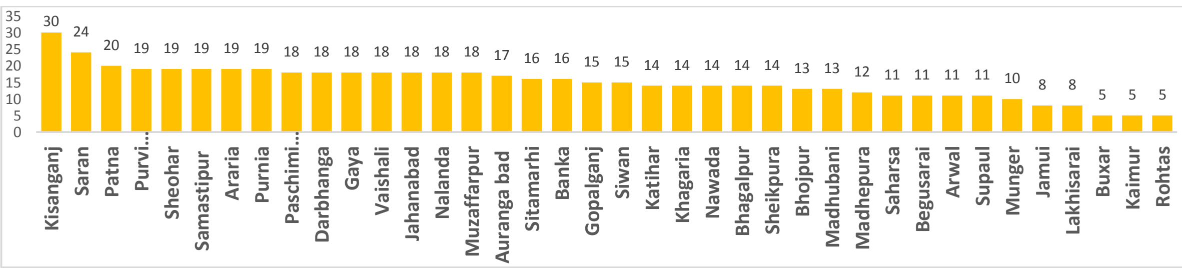


Fig.11

Spatial Pattern of Composite Hazard and Exposure Index

The Composite Vulnerability Index (CVI) of climatic hazards and exposure of all 38 districts of the state is derived from the summation of normalized scores of hazard variables divided by the total number of variables selected under the climate hazard category (Annexure 1). The average CVI of the state is 0.48. Out of 38 districts, 11 have been recognized under the very high to high category, 14 under the moderate to moderate high, and 13 under the low to very low segment. (Fig 12). The spatial pattern of hazard CVI at the district level indicates that the lowest climatic hazard is observed in Jamui district (0.35), followed by Banka (0.38) and Kaimur (0.40), while the highest exposure is noticed in Darbhanga (0.66), followed by Sitamarhi (0.61), Patna (0.59) and Nalanda (0.58) and Saran (0.57) as shown in Fig 13. The districts like Vaishali, Khagaria, Supaul, Madhubani, West Champaran, Bhagalpur, Katihar etc. are moderately vulnerable to climate hazards.

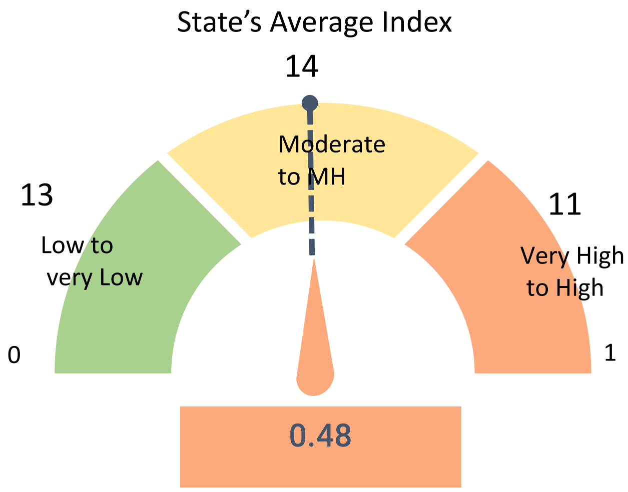


Fig.12

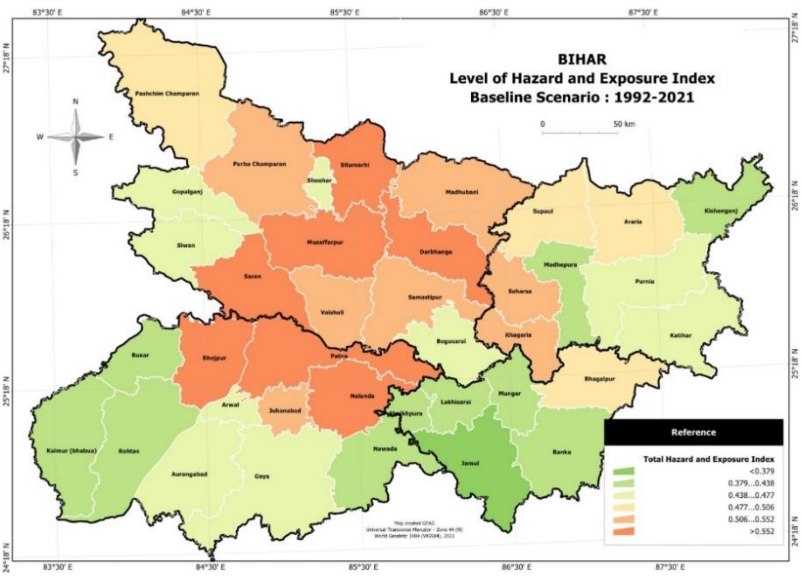


Fig.13

The figures 13 and 14 point to an important inference; that climate change has changed the traditional boundaries of vulnerability. Districts like Supaul, Katihar, Araria, Kisanganj Purnia, etc. were traditionally recognized as vulnerable districts in terms of floods, but now it is the central

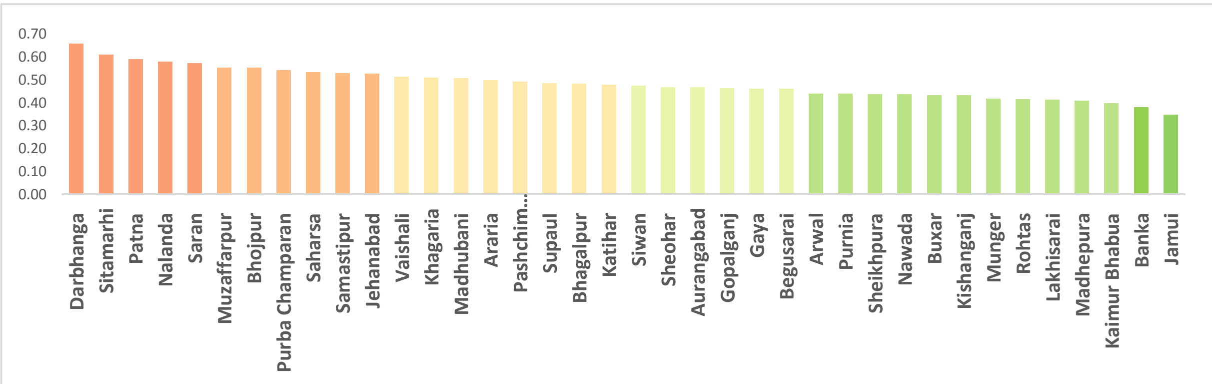


Fig.14

part of Bihar that is becoming more vulnerable. It is very critical to understand that this part of Bihar is densely populated (population density above 1000 persons/sqkm) and is also comparatively more urbanized than the rest of Bihar. If this phenomenon of shifting of vulnerable areas continues, then the exposure to climate risk will increase and the state will face more disasters in the days to come. An example of this is the 2019 floods in Patna, which indicate this shifting trend.

Projected scenario (2021-2050)

Changes in Annual and Seasonal Rainfall Amounts

A projection of rainfall during the forthcoming 30 years (2021-2050) under the two RCPs (4.5 and 8.5) indicates an increase in annual and seasonal totals across Bihar. The annual total rainfall in the baseline period (1992-2021) ranges between 816 mm to 2,010 mm across the districts, with an average value of 1,068.86 mm. The average annual total rainfall across the state is projected to increase by 12% in 2050.

The seasonal total rainfall (4-month period) in the baseline period (1992-2021) ranges from 54–215 mm, 882–1,305 mm and 66–120 mm, with an average seasonal total of 117 mm, 1,020 mm and 87 mm for the seasons of February– May (FMAM), June–September (JJAS) and October–January (ONDJ), respectively. The average seasonal total rainfall is projected to increase by 12–16%, 11–12% and 9–15% respectively, in 2050. Although the absolute increases are very small compared to the JJAS season, the relative increases in seasonal rainfall are higher in the FMAM season followed by the ONDJ season. Moreover, unlike the JJAS and ONDJ seasons, the increase in seasonal rainfall in the FMAM season is higher under RCP 4.5 than RCP 8.5 in 2050. This indicates that the low-emission scenario (RCP 4.5) could trigger high-rainfall conditions during the hottest part of the season. And, although the results indicate a general increase in projected annual and seasonal rainfall amounts over the baseline, the increase shows strong spatial and temporal variations. For example, the absolute rainfall increase in 2050 is lower at Saran, Gaya and Supaul, but higher in Darbhanga, Motihari, Patna and Purnia districts.

Changes in Daily Rainfall Intensity

The projected changes in daily rainfall intensity show strong variability. The daily rainfall intensity is projected to increase for the months of July, August, September, and October ranging between 1–20 % in 2050, while the daily rainfall intensity is projected to decrease in the months between December to April and June in 2050.

Projected Change in Maximum Temperature (Tmax)

Under the future climate change envisioned, the mean annual Tmax is expected to increase across Bihar by 1.6–2.2 ˚C in 2050 depending on the emission scenario with the highest (1.9–2.5 ˚C) and lowest (1.3–1.9 ˚C) increases observed in the FMAM and JJAS seasons, respectively. Both past and future mean monthly maximum temperatures are high (above 35 ˚C) between April and June and will remain close to 35 ˚C from July to September.

Section 4

Impacts of climate change on thematic sectors of child development

Climate risk and its impacts on children and women

The risk induced by climate change will have wide-ranging impact on human beings, particularly children and women, who are differentially impacted. Sometimes, it is a leading killer of children. (Burt, E, et al, 2013). Studies published in the *Indian Journal of Medical Research* and *Nature climate change* have confirmed that climate change has increased the rates of malnutrition, cholera, diarrheal and vector-borne diseases like dengue and malaria (V. Ramana Dhara, Paul J.Schramm,and George Luber, 2013, Camilo Mora, Tristan McKenzie, Isabella M. Gaw,Jacqueline M. Dean, Hannah von Hammerstein, Tabatha A. Knudson, Renee O. Setter, Charlotte Z. Smith, Kira M. Webster, Jonathan A. Patz & Erik C. Franklin, 2022) According to a Save the Children report (2019), more than 50% of those affected by natural disasters worldwide are children, including urban children.

Bihar is a state with high hopes and aspirations. Often called as 'resurgent Bihar,' it is still infamous for recurrent disasters, (natural and human induced), endemic poverty, and caste-ridden society. In-spite of impressive development during the last few decades, the list of challenges is still very long- high rate of child mortality, prevalence of mass female illiteracy, health indices far below the national average, unemployment, mass migration, low per capita income, crumbling roads and other infrastructure, persistent and seemingly irreversible brain drain. Development-oriented problems in Bihar are further exacerbated by the impact of climate change and climate-induced disasters. Consecutive years of drought and erratic nature of rainfall causes waterlogging and flood situations, long dry spells during monsoon, increasing incidences of lightning & windstorms, and higher number of days in a year where the temperature rises above 40° Celsius further add to the vulnerabilities of the unprivileged communities, specifically the women and children of the household. It is estimated that such climatic changes will only increase the vulnerability of the state's 50 million children (Census, 2011). Like many other states, Bihar too does not seem to be in a strong position to combat, withstand or equip itself against the adverse impacts of climatic shifts, be it an increase or decrease in rainfall, a decrease or change in the seasonal and geographic distribution of rain, or changing temperature and humidity regimes.This section of the study seeks to explore the key challenges of different sectors related to child development, identify the underlying causes contributing to the vulnerabilities of children, the need for advocacy on key action points, and related sensitization of government departments and other stakeholders.

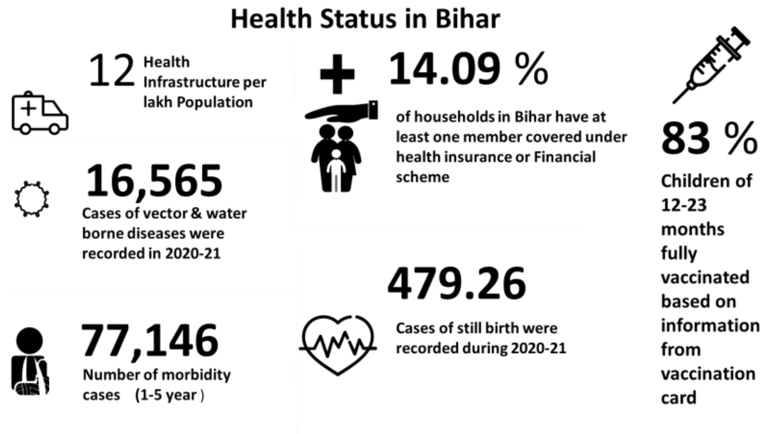
Sectoral performance vis a vis climate change impact

Child Health

Changes in rainfall patterns, frequency of floods, droughts, and other hydro-meteorological events during the last couple of decades in the state have rendered a direct influence on the health and disease patterns of children and taken a significant toll on their well-being. Studies on climate change impact on child health clearly reveal that children are the most vulnerable to the effects of climate change. This is because they have unique metabolism behavior, physiology, and development characteristics (Bunyavanich S., Landrigan C.P., McMichael A.J., Epstein P.R, 2003) and are more dependent on others to satisfy their basic needs.

As per the NFHS-V (National Family Health Survey) report (2019-20), Bihar lies low on the ladder of health indicators, in comparison to other states in the country. The economic survey report of Bihar (2020-21), reveals that both communicable and non-communicable diseases persist and the dimension/severity of these diseases is becoming more extensive with climate change impact. Though the national and state government are trying to control these diseases through different health programs, the situation needs to be improved. A disaggregated understanding of these disease burdens is essential to run an effective health system.

The survey report further reflects on the facts of the poor health system of the state. The cases recorded for different diseases in the state such as Acute Respiratory Infections (0.9 million), followed by Fever of Unknown Origin (0.83 million), Acute Diarrhea (0.32 million), Dysentery (0.15 million) and Enteric Fever (0.13 million), are quite high. Other facts, like the availability of health infrastructures per lakh population, poor health insurance coverage, cases of stillbirth and a large number of child morbidity cases, all indicate a grim scenario. The report also brings out the fact that not only have the cases of periodic water and vector borne diseases increased, but also the time span of these diseases that occurred during the year has expanded in the state. Low levels of education, poor health infrastructure, low female illiteracy, poor living standards of families, poor access to basic services and lack of sanitation and hygiene practices, are the key contributing factors which assist the occurrence of these diseases.



Health related Vulnerability and climate change

The intensity of climate change impact on the performance of the health sector is closely linked to the physical, social, and economic situation at local level. For example, low priority for drainage improvement or construction of embankments without adequate drainage provisions increases the risk potential of water logging with greater intensity of extreme rainfall events. Further, this enhances the breeding ground for vector-borne diseases that further aggravate child morbidity and mortality. In order to understand the key inherent causes that affect the performance of the health sector, a statistical correlation between the indicators of climate hazards, socio-economic development and child health-related issues has been established. The matrix of the multivariate correlation is given in Fig 15. The analysis indicates a high correlation between the Composite vulnerability index of Health (CVI-H) and flood-prone areas (0.64). That means recurrent flooding is one of the key drivers in determining the performance of the health sector. Floods directly cause damage to the health infrastructure and support system and affect the well-being of the affected people. It is also observed from the analysis that the availability of health infrastructure per lakh population, health condition of children, pregnant women, people with chronic illnesses, people who rely on home care, elderly people, people with physical, sensory, and cognitive impairments, homeless people, people from minority populations and socially isolated people are very poor in this area. Due to water stagnation and poor drinking water facilities, the cases of vector and waterborne diseases are also comparatively higher.

Key Drivers of Health Sector vulnerability
Based on multivariate correlation

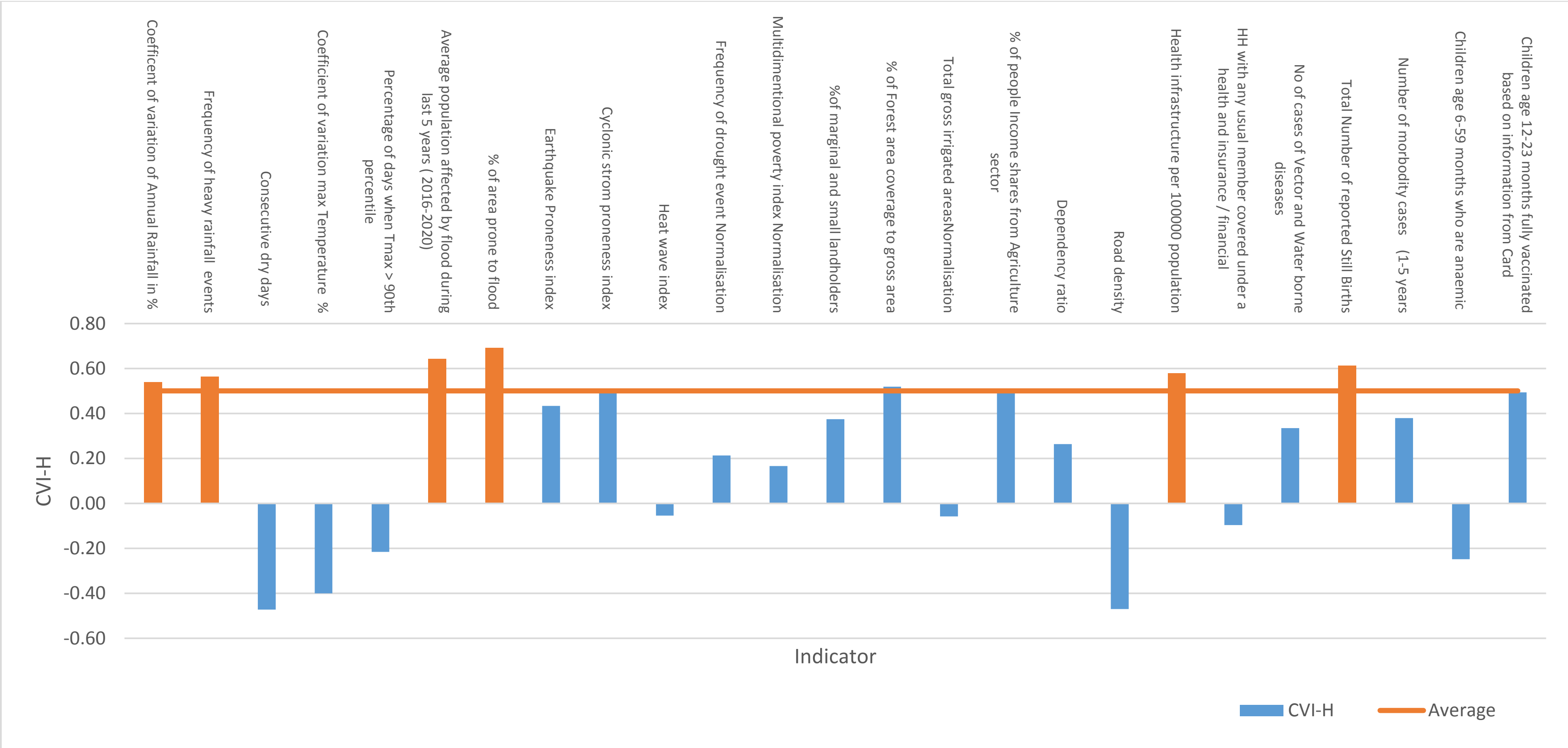


Fig.15

District Level Vulnerability of Health Sector

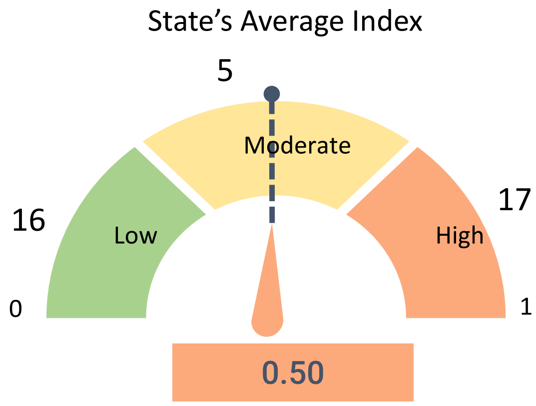


Fig.16

The indicators used for the integrated district-level vulnerability analysis in Health sector assessment are listed in Table 10 along with their functional relationships, induced by climatic and socio-economic vulnerability. Equal weights were assigned to all indicators. The composite vulnerability analysis of the health sector at the state level clearly shows that out of 38 districts, 17 are placed in the very high to high category. Most of them are located north of the river Ganga including Patna, Bhojpur and Nalanda. 5 districts are moderately vulnerable while 16 districts have a low vulnerability index. The state's average Vulnerability Index in the Health sector is 0.50 (Fig 16).

Table 10 : Health related indicator used vulnerability assessment

Theme	Indicator	Baseline	Source	Relation with climate Vulnerability impact
Health	Health infrastructure per 100000 population	2020	HMIS, 2020	Adaptation (Negative)
	HH with any usual member covered under a health and insurance / financial scheme	2019-20	NFHS, 2019-20	Adaptation (Negative)
	No of cases of Vector and Water borne diseases	2020	HMIS, 2020	Sensitivity (Positive)
	Total Number of reported Still Births	2020	HMIS, 2020	Sensitivity (Positive)
	Number of morbidity cases (1-5 years)	2020	HMIS, 2020	Sensitivity (Positive)
	Children age 6-59 months who are anemic (%)	2019-20	NFHS, 2019-20	Sensitivity (Positive)
	Children age 12-23 months fully vaccinated based on information from vaccination card (%)	2019-20	NFHS, 2019-20	Adaptation (Negative)

The Composite Vulnerability indexes (CVIs) of the Health sector of the districts are found to be in the range between 0.59 (in Purniaj) to 0.40 (in Kaimur Bhabhua). The spatial pattern of CVIs of Health sector of the districts (Fig 17) and their corresponding rankings with and without hazards are presented in Fig. 18. This is derived by dividing the range of VIs into equal intervals, wherein three categories are obtained: relatively very high to high vulnerable districts (~0.52-0.59), moderately vulnerable districts (~0.46- 0.52), and districts with relatively low vulnerability (~0.40 – 0.46). Darbhanga, Sitamarhi, Patna, East

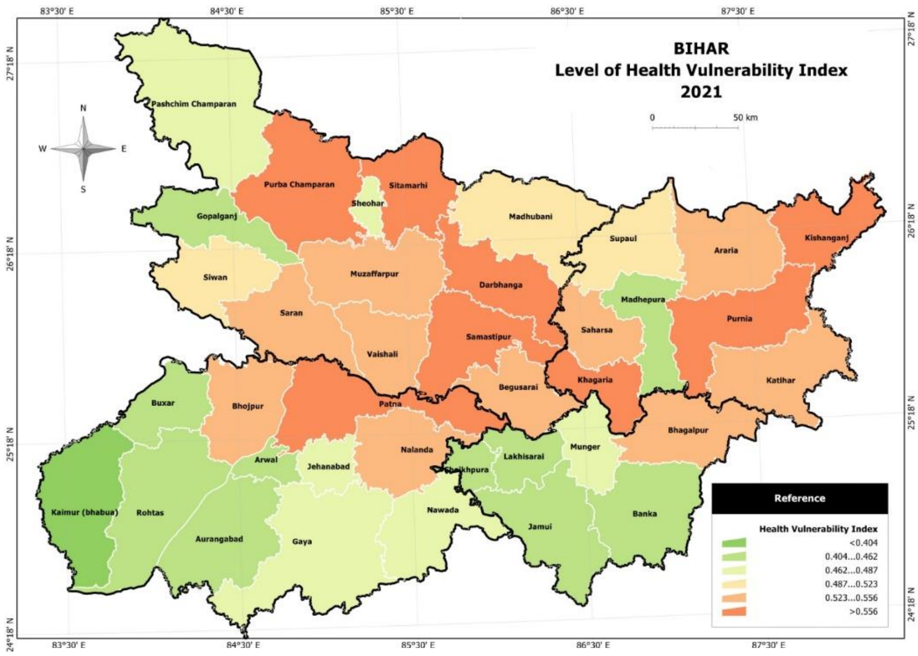


Fig.17

Champaran, Kisanganj, Samastipur, Purnia ,Khagaria and Saharsa are the districts falling under the very vulnerable district, all situated in North Bihar.

Ranking & Level of health vulnerability with and without

District	Sectoral Vulnerability	District	Composite Health Vulnerability Index
Purnia (09)	0.65	Darbhanga (13)	0.59
Patna (28)	0.64	Sitamarhi (04)	0.58
Kishanganj (08)	0.61	Patna (28)	0.58
Samastipur (19)	0.60	Purba Champaran (02)	0.57
Vaishali (18)	0.57	Samastipur (19)	0.57
Begusarai (20)	0.55	Kishanganj (08)	0.56
Araria (07)	0.53	Purnia (09)	0.56
Nawada (35)	0.51	Khagaria (21)	0.56
Madhubani (05)	0.50	Saharsa (12)	0.55
Nalanda (27)	0.50	Nalanda (27)	0.54
Gaya (34)	0.50	Begusarai (20)	0.54
Purba Champaran (02)	0.50	Katihar (10)	0.54
Muzaffarpur (14)	0.49	Bhojpur (29)	0.54
Katihar (10)	0.49	Saran (17)	0.54
Khagaria (21)	0.48	Araria (07)	0.53
Saharsa (12)	0.48	Muzaffarpur (14)	0.53
Jamui (36)	0.47	Vaishali (18)	0.53
Supaul (06)	0.47	Bhagalpur (22)	0.52
Bhagalpur (22)	0.47	Supaul (06)	0.52
Munger (24)	0.47	Madhubani (05)	0.51
Siwan (16)	0.46	Siwan (16)	0.50
Darbhanga (13)	0.46	Jehanabad (37)	0.49
Sitamarhi (04)	0.45	Pashchim Champaran (01)	0.48
Bhojpur (29)	0.44	Nawada (35)	0.48
Lakhisarai (25)	0.40	Munger (24)	0.48
Saran (17)	0.40	Sheohar (03)	0.48
Buxar (30)	0.39	Gaya (34)	0.46
Rohtas (32)	0.37	Gopalganj (15)	0.46
Banka (23)	0.37	Lakhisarai (25)	0.46
Sheikhpura (26)	0.36	Buxar (30)	0.46
Madhepura (11)	0.36	Sheikhpura (26)	0.45
Jehanabad (37)	0.36	Madhepura (11)	0.44
Pashchim Champaran (01)	0.36	Rohtas (32)	0.44
Sheohar (03)	0.36	Aurangabad (33)	0.44
Aurangabad (33)	0.31	Arwal (38)	0.43
Kaimur Bhabua (31)	0.31	Banka (23)	0.43
Gopalganj (15)	0.30	Jamui (36)	0.40
Arwal (38)	0.26	Kaimur Bhabua (31)	0.40

Fig.18

Key Observations

- Health-related indicators like availability of health infrastructure, number of cases of vector and water-borne diseases, cases of stillbirth and proportion of fully vaccinated children between 12-23 months have a higher correlation with areas prone to flood, the average population affected by the flood, area with a high coefficient of variation of annual rainfall and higher frequency of heavy rainfall events.
- This combination is clearly seen in Darbhanga, Sitamarhi, Patna, East Champaran, Kisanganj, Samastipur, Purnia Khagaria and Saharsa districts.
- Vector and waterborne diseases have a positive and comparatively higher correlation with areas having a higher coefficient of variation in annual rainfall like Kisanganj, Araria, Purnia, Supaul, Madhubani, Saharsa and West Champaran. Thus, these areas are more prone to vector-borne diseases because of rampant water logging (providing germination ground) and contamination of surface and groundwater.
- The areas with high stillbirth cases are more prominent in poor small and marginal families who are affected severely due to floods during the last 5 years.
- The number of morbidity cases is comparatively higher in areas which are prone to floods.

- In 2021, the children in age group 6-59 months are comparatively more anemic and prone to experiencing heat waves comparatively in the last 30 years, in most of the districts belonging to the south-western alluvial plain in Bihar.
- The proportion of fully vaccinated children aged 12-23 months is comparatively lower in areas prone to floods or areas which are experiencing heavy rainfall events. Thus, the inference is drawn these floods and extreme climatic events are major setbacks in achieving the goal of a full vaccination process.

Indicator wise performance of districts

The study also tried to find out the indicator-wise performance of districts in the Health sector, as shown in Fig 19. The state's average vulnerability index of the Health sector is 0.50. Out of the 38 districts, 22 are above the state average. That means about 58 percent of the districts are poorly performing in the Health sector. The highlighted boxes in Fig. 19 showcase the districts that are not performing well in the respective indicator. The Health sector has to assemble a well-defined strategy in these districts to improve their health condition.

Districts	HH with any usual member covered under a health and insurance / financial	Children age 12-23 months fully vaccinated based on information from Vacination card	Children age 6-59 months who are anaemic (<110 g/dl)22	Health infrastructure per 100000 population	Total Number of reported Still Births	No of cases of Vector and Water borne diseases	Number of morbodity cases (1-5 yesr)	Health Vulnerability Index
Pashchim Champaran	0.31	0.57	0.21	0.25	0.65	0.32	0.19	**0.48**
Purba Champaran	0.34	0.90	0.19	0.67	0.51	0.71	0.16	**0.57**
Sheohar	0.42	0.91	0.66	0.08	0.10	0.26	0.06	**0.48**
Sitamarhi	0.27	0.81	0.54	0.83	0.50	0.00	0.19	**0.58**
Madhubani	0.35	0.46	0.58	0.58	0.60	0.86	0.10	**0.51**
Supaul	0.65	0.65	0.29	0.67	0.47	0.51	0.08	**0.52**
Araria	0.34	100	0.76	0.67	0.64	0.16	0.12	**0.53**
Kishanganj	100	0.63	0.44	0.67	0.43	100	0.12	**0.56**
Purnia	0.88	0.60	0.46	0.58	100	0.86	0.15	**0.56**
Katihar	0.98	0.57	0.37	0.42	0.78	0.32	0.02	**0.54**
Madhepura	0.92	0.38	0.45	0.17	0.54	0.06	0.02	**0.44**
Saharsa	0.73	0.35	0.51	0.58	0.41	0.23	0.53	**0.55**
Darbhanga	0.00	0.64	0.50	0.83	0.82	0.41	0.01	**0.59**
Muzaffarpur	0.70	0.53	0.33	0.42	0.73	0.70	0.05	**0.53**
Gopalganj	0.73	0.00	0.00	0.75	0.30	0.22	0.10	**0.46**
Siwan	0.99	0.55	0.30	0.42	0.34	0.44	0.21	**0.50**
Saran	0.92	0.46	0.34	0.50	0.43	0.08	0.04	**0.54**
Vaishali	0.69	0.51	0.81	0.58	0.47	0.89	0.06	**0.53**
Samastipur	0.37	0.46	0.43	0.67	0.83	0.97	0.46	**0.57**
Begusarai	0.70	0.64	0.71	0.58	0.47	0.67	0.09	**0.54**
Khagaria	0.56	0.51	0.43	0.42	0.38	0.09	100	**0.56**
Bhagalpur	0.52	0.63	0.88	0.33	0.79	0.05	0.12	**0.52**
Banka	0.68	0.31	0.88	0.33	0.35	0.00	0.02	**0.43**
Munger	0.59	0.49	0.71	0.33	0.28	0.54	0.35	**0.48**
Lakhisarai	0.59	0.79	0.82	0.50	0.12	0.00	0.00	**0.46**
Sheikhpura	0.91	0.42	0.93	0.08	0.08	0.03	0.10	**0.45**
Nalanda	0.73	0.53	0.94	0.25	0.36	0.55	0.15	**0.54**
Patna	0.88	0.95	0.36	100	0.72	0.30	0.24	**0.58**
Bhojpur	0.91	0.65	0.45	0.42	0.36	0.21	0.07	**0.54**
Buxar	0.81	0.60	0.47	0.50	0.13	0.22	0.00	**0.46**
Kaimur Bhabua	0.42	0.28	0.59	0.42	0.19	0.28	0.02	**0.40**
Rohtas	0.47	0.16	0.55	0.67	0.25	0.51	0.00	**0.44**
Aurangabad	0.58	0.27	0.48	0.42	0.28	0.13	0.06	**0.44**
Gaya	0.91	0.51	0.80	0.42	0.70	0.00	0.16	**0.46**
Nawada	100	0.47	0.67	0.67	0.35	0.42	0.03	**0.48**
Jamui	0.64	0.66	100	0.00	0.32	0.66	0.04	**0.40**
Jehanabad	0.70	0.70	0.22	0.42	0.08	0.29	0.12	**0.49**
Arwal	0.56	0.33	0.38	0.33	0.00	0.19	0.03	**0.43**
State Average	**0.65**	**0.55**	**0.54**	**0.48**	**0.44**	**0.37**	**0.14**	**0.50**
Districts Above Average	**20**	**18**	**17**	**19**	**17**	**16**	**12**	**22**

Fig.19

Recommendations for vulnerable areas

<table>
<tr><th>Recommendations</th><th>Timeframe for action to be accomplished</th><th>Framework for implementation</th></tr>
<tr><td>Multi-sectoral approach and inter-departmental coordination needed to be established in public health surveillance</td><td>Medium to long term</td><td rowspan="10">Existing heath policy related to health surveillance needs to be enhanced

Inter departmental collaboration required

Need to generate awareness on preventable diseases at HH level

Database of relief camps to be strengthen</td></tr>
<tr><td>As the minimum temperature is increasing all over the state, concentrated health-related initiatives to be strengthened in the winter season also</td><td>Short term and continuous</td></tr>
<tr><td>Contingency Health Care Plan to be developed for the very high to high vulnerable districts which have large populations and poor access to health facilities</td><td>Short to medium term</td></tr>
<tr><td>Massive drainage improvement initiative to be undertaken in flood affected and water-logged areas</td><td>Medium to long term</td></tr>
<tr><td>Humidity and temperature linkages are a deadly combination; hence, during the formulation of the state heat action plan, special care to be taken to address this linkage and design an action plan accordingly.</td><td>Medium term</td></tr>
<tr><td>Most deaths of children under five in the state occur due to preventable diseases like diarrhea, malaria, AES, etc. Measures like immunization to be expanded at door step level to prevent such deaths</td><td>Short term and continuous</td></tr>
<tr><td>During flood and drought season, particularly with migrating families, record of children to be maintained in relief camps</td><td>Short term and continuous</td></tr>
<tr><td>Children of poor families, as well as those from the socially underprivileged (and largely discriminated) sections of society, are seen to have a proportionately higher mortality rate. Access to potable water, improved sanitation, and hygiene promotion to be ensured.</td><td>Medium term</td></tr>
<tr><td>Age of a mother at childbirth, her awareness (or education), spacing between two children, or gender discriminatory child-rearing practices, and maternal & child nutrition are important considerations for health care during disaster response.</td><td>Short term and continuous</td></tr>
<tr><td>Capacity building and sensitization of health care staff, adequate promotion of healthcare services, appropriate coordination and convergence amongst WASH, adoption of universal health care that would shield the vulnerable populations during a disaster</td><td>Medium to long term</td></tr>
</table>

Child Education

Climate change variability is expected to have severe impact on a child's education. This includes school closures, damage to school infrastructure and resources, and financial difficulties that constrain parental as well as governmental ability to support the continuation of education. The recent District Information System for Education data (2019-20) shows the dismal state of Bihar. Only four out of ten students in the state, who get enrolled in the primary standard, complete their secondary education. These numbers are further reduced at the higher secondary level. Although, the government of Bihar is making a conscious effort to improve the quality of education for its children through different schemes and programs like *Mukhyamantari Samagra Vidyalaya Vikas Yojna, Mukhyamantari Balika Poshak Yojna, Mukhyamantari Balika Cycle Yojna* and *Mukhyamantari Samagra Shiksha Yojna*; but still more concerted efforts are needed. Emphasis is required to identify the causes which adversely impact children education in the state, so that the programs and schemes related to child education are modified and achieve the desired success.

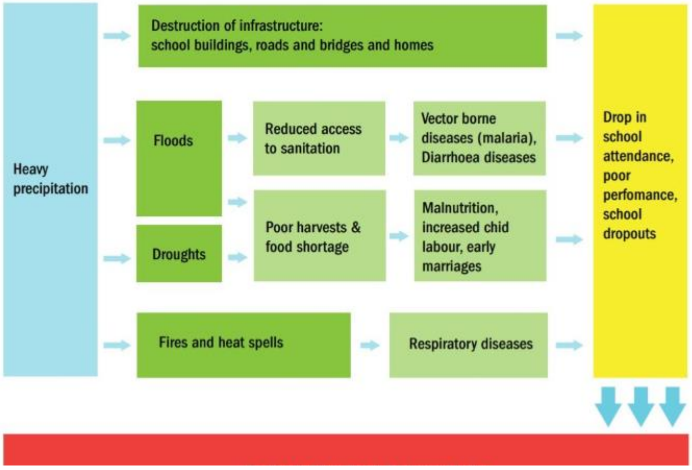


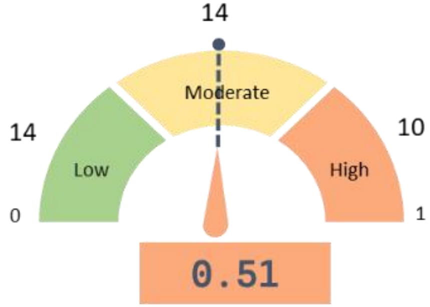
Fig.20

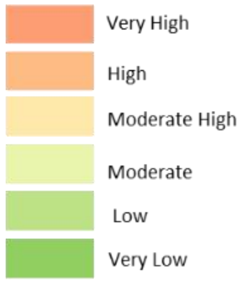
Education related Vulnerability and Climate Change

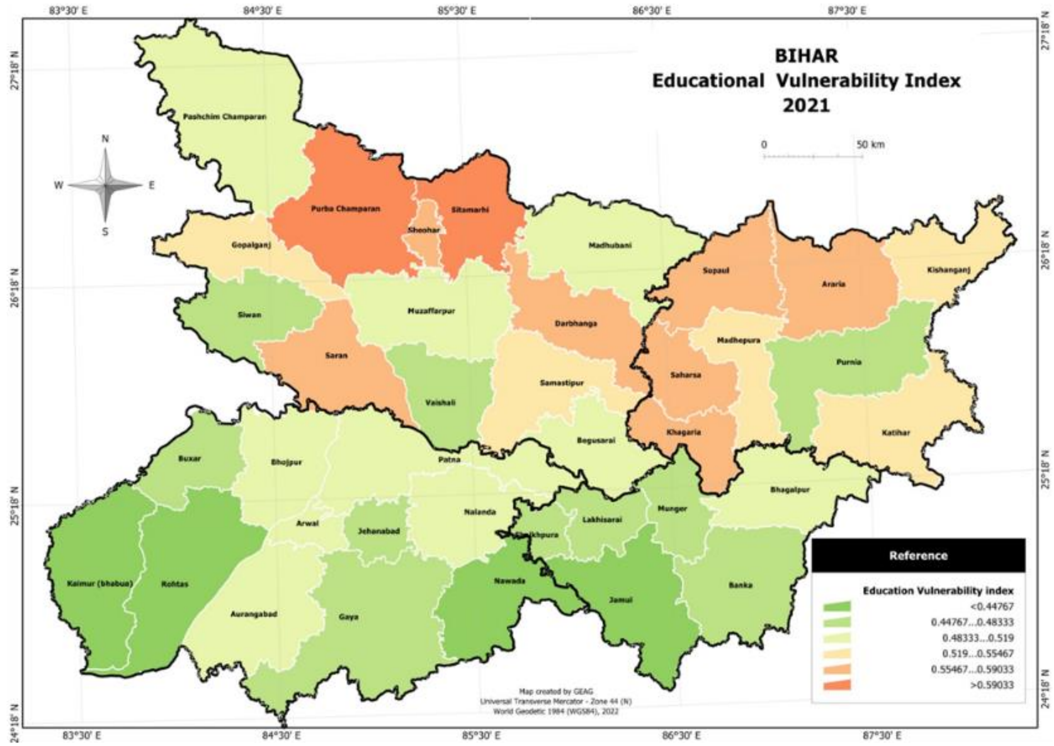
Climate change which causes irregular rainfall, heatwaves and extreme weather events like cyclones has been found to impose a serious impact on the education system. Traditionally, the state of Bihar has already had several reasons behind absenteeism and dropout of school-going children which include poverty, gender discrimination, apathy of parents to educate their children- especially the girl child, and poor health and nutritional status of the family. Climate change has added a new challenge to the existing problems. The state is experiencing more extreme weather events and that causes disruption of physical infrastructure (like school buildings, and roads), access to sanitation, poor harvest & food shortage, nutritional losses, increased workload on females and aggravating vector-borne diseases. Altogether, it imposes a reduction in school attendance, poor school performance and school dropout which ultimately leads to a decline in the education attainment index of the state. (Fig 20)

In the present section, emphasis is given to assess how the above-mentioned effects of climate change disturb the performance of the Education sector of the state. To assess the current spatial scenario, the district-wise composite vulnerability index of education sectors has been determined. For calculating the CVIs of the education sector, indicators like female literacy rate, instructional days in school, availability of teachers in school (Student-teacher ratio), dropout rate from primary to secondary section, and functional facilities in boys' and girls' schools of Bihar has been taken along with their functional relationships with climatic and socio-economic vulnerability. The composite vulnerability analysis of the education sector at the state level clearly shows that out of 38 districts, 10 are identified in very high to a high vulnerable category, 14 in moderately vulnerable while 14 districts have a low vulnerability index. The state's average Vulnerability Index in the Education sector is 0.51.

Level of Educational Vulnerability Index & Spatial Pattern (Based on Hazards, Socio economic and Education indicators)







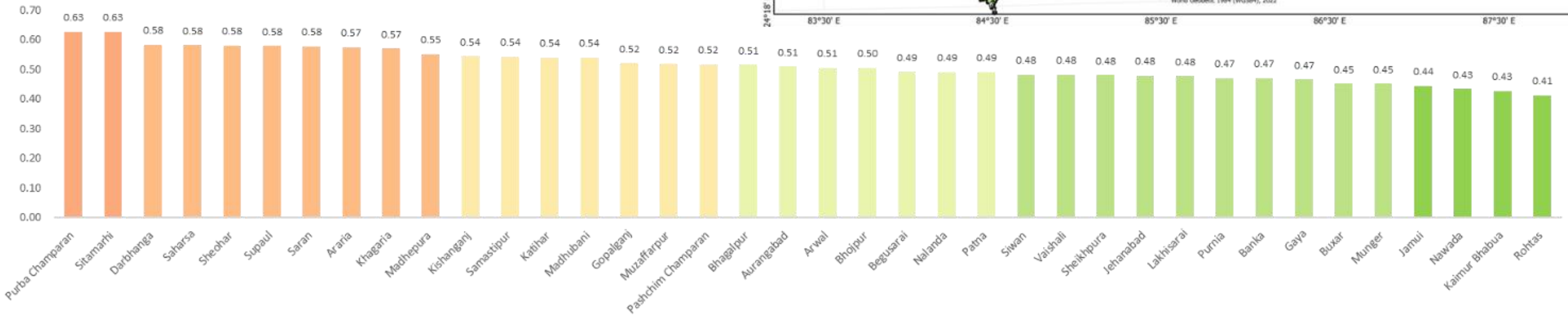


Fig.21

District Level Vulnerability of Education Sector

The Vulnerability indexes (VIs) of the Education sector of the districts were found to be in the range from 0.63 (West Champaran) to 0.41 (Rohtas). The spatial pattern of CVIs of child education of the districts (Fig 21) and their corresponding rankings with and without Hazard are presented in Fig. 22. All the 38 districts are categorized into different levels of vulnerability in education i.e., relatively very high to high vulnerable districts (VIs varies between~0.55-0.63), moderately vulnerable districts (~0.48- 0.55), and districts with relatively low vulnerability (~0.41 – 0.48). West Champaran Sitamarhi, Darbhanga, Saharsa, Sheohar, Supaul Saran, Araria, Khagaria and Madhepura districts have been recognized with very high to high vulnerability. All these 10 vulnerable districts are in northern Bihar and are highly prone to flood and cyclonic hazards.

Ranking & Level of educational vulnerability with and without Hazard

District	Sectoral vulnerability	District	Education Vulnerability index
Madhepura (11)	0.73	Purba Champaran (02)	0.63
Supaul (06)	0.72	Sitamarhi (04)	0.63
Sheohar (03)	0.71	Darbhanga (13)	0.58
Purba Champaran (02)	0.66	Saharsa (12)	0.58
Araria (07)	0.66	Sheohar (03)	0.58
Saharsa (12)	0.63	Supaul (06)	0.58
Sitamarhi (04)	0.60	Saran (17)	0.58
Aurangabad (33)	0.60	Araria (07)	0.57
Khagaria (21)	0.55	Khagaria (21)	0.57
Jamui (36)	0.54	Madhepura (11)	0.55
Kishanganj (08)	0.53	Kishanganj (08)	0.54
Saran (17)	0.52	Samastipur (19)	0.54
Katihar (10)	0.52	Katihar (10)	0.54
Samastipur (19)	0.52	Gopalganj (15)	0.52
Banka (23)	0.51	Muzaffarpur (14)	0.52
Arwal (38)	0.50	Pashchim Champaran (01	0.52
Pashchim Champaran (01)	0.49	Bhagalpur (22)	0.51
Madhubani (05)	0.48	Madhubani (05)	0.51
Gopalganj (15)	0.47	Aurangabad (33)	0.51
Lakhisarai (25)	0.47	Arwal (38)	0.51
Sheikhpura (26)	0.47	Bhojpur (29)	0.50
Gaya (34)	0.45	Begusarai (20)	0.49
Kaimur Bhabua (31)	0.44	Nalanda (27)	0.49
Darbhanga (13)	0.44	Patna (28)	0.49
Muzaffarpur (14)	0.42	Siwan (16)	0.48
Buxar (30)	0.41	Vaishali (18)	0.48
Bhagalpur (22)	0.41	Sheikhpura (26)	0.48
Begusarai (20)	0.38	Jehanabad (37)	0.48
Purnia (09)	0.38	Lakhisarai (25)	0.48
Siwan (16)	0.37	Purnia (09)	0.47
Munger (24)	0.36	Banka (23)	0.47
Nalanda (27)	0.36	Gaya (34)	0.47
Bhojpur (29)	0.35	Buxar (30)	0.45
Nawada (35)	0.34	Munger (24)	0.45
Vaishali (18)	0.33	Jamui (36)	0.44
Jehanabad (37)	0.33	Nawada (35)	0.43
Rohtas (32)	0.32	Kaimur Bhabua (31)	0.43
Patna (28)	0.28	Rohtas (32)	0.41

Fig.21

The multivariate correlation amongst the indicators of climate hazards, socio-economic development and child education-related issues were established to understand the key contributing factors for the poor performance of the Education sector. The value of CVI of child education in areas prone to flood, variation in heavy annual rainfall, and population dependent on agriculture, is comparatively higher. It is also deduced that the poor status of female literacy also makes an impact on child education. The highlighted bars of Fig 22 show that these indicators play an important role in the performance of the sector and in determining its vulnerability.

Key Drivers of Education Sector vulnerability
Based on multivariate correlation

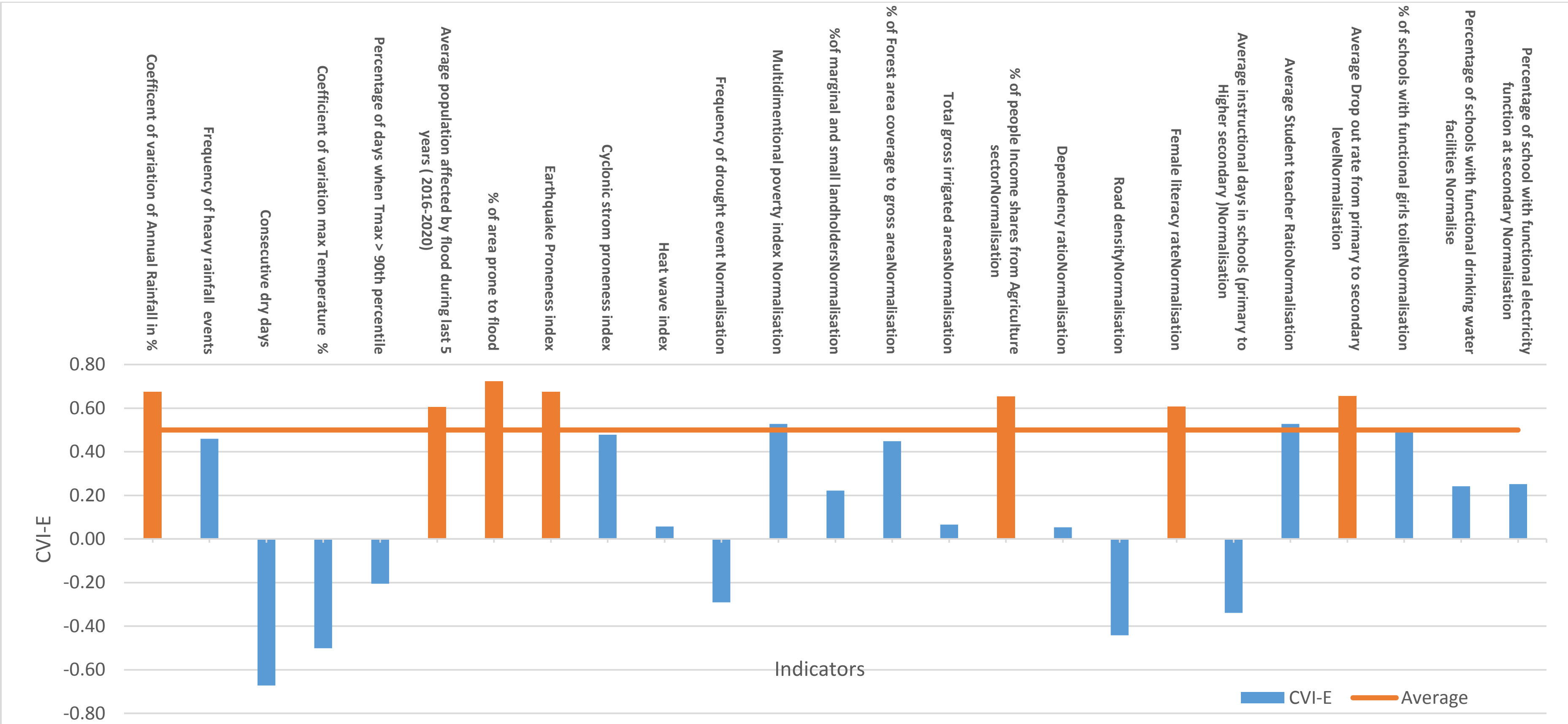


Fig.22

Key observations

- Indicators like areas prone to floods, coefficient of variation in heavy annual rainfall, population dependent on agriculture, and status of female literacy have shown high correlation with the composite educational vulnerability index. This means that all of these play a key role in weakening the education system in the state.

- Areas that have comparatively higher multi-dimensional poverty index (i.e East Champaran, Sheohar, Sitamarhi, Supaul, Araria, Kishanganj, Purnia, Katihar, Madhepura, and Saharsa) and a high coefficient of variation in annual rainfall (Supaul, Saharsa, Kishanganj and Purnia) show a higher correlation; and this affects the education scenario, especially the female literacy rate. This further adds to parental apathy towards child education, more so for the girl child.

- Areas with a higher index of consecutive dry days, and a high coefficient of variation in maximum temperature have shown a higher correlation with the number of instructional days in school. This essentially means that both these factors have an inverse relation to the instructional days. Higher dry and temperature conditions affect electricity status, and thus further affect instructional day of schools. This is more prominent in districts like Siwan, Kaimur, Aurangabad and Munger where the functioning of schools has been affected.

- Dropout rate is high in areas which have a high coefficient of variation in annual rainfall, coupled with a high multi-dimensional poverty index. This is in districts like West Champaran, East Champaran, Supaul , Sitamarhi, Araria, Kishanganj, Madhepura and Saharsa.

Indicator wise performance of districts

Indicator-wise performance of districts in the Education sector is given in Fig 23. The highlighted part shows a higher vulnerability index than the state average. The composite

District	Female literacy rateNormalisation	Average instructional days in schools (primary to Higher secondary	Average Student teacher Ratio	Average Drop out rate from primary to secondary level	%of schools with functional girls toilet	Percentage of schools with functional drinking water facilities	Percentage of school with functional electricity function at secondary	Education Vulnerability index
Pashchim Champaran	0.86	0.43	0.55	0.75	0.00	0.00	0.82	**0.52**
Purba Champaran	0.84	0.21	0.61	0.67	0.59	0.73	0.98	**0.63**
Sheohar	0.83	0.53	100	0.51	0.55	0.73	0.84	**0.58**
Sitamarhi	0.97	0.28	0.78	0.65	0.48	0.19	0.89	**0.63**
Madhubani	0.79	0.30	0.46	0.56	0.06	0.33	0.83	**0.51**
Supaul	0.85	0.36	0.53	100	0.93	0.36	0.97	**0.58**
Araria	0.89	0.23	0.57	0.72	0.68	0.73	0.78	**0.57**
Kishanganj	0.76	0.00	0.31	0.81	0.27	0.63	0.94	**0.54**
Purnia	0.97	0.17	0.52	0.51	0.46	0.00	0.00	**0.47**
Katihar	0.87	0.19	0.51	0.80	0.43	0.03	0.79	**0.54**
Madhepura	100	0.28	0.42	0.90	100	0.65	0.87	**0.55**
Saharsa	100	0.19	0.39	0.79	0.74	0.53	0.74	**0.58**
Darbhanga	0.83	0.36	0.28	0.71	0.00	0.17	0.71	**0.58**
Muzaffarpur	0.39	0.57	0.38	0.49	0.31	0.28	0.55	**0.52**
Gopalganj	0.38	0.49	0.58	0.40	0.31	0.52	0.64	**0.52**
Siwan	0.20	0.96	0.35	0.23	0.00	0.00	0.83	**0.48**
Saran	0.40	0.40	0.53	0.52	0.59	0.51	0.69	**0.58**
Vaishali	0.29	0.34	0.27	0.46	0.23	0.11	0.63	**0.48**
Samastipur	0.54	0.26	0.46	0.36	0.70	0.66	0.66	**0.54**
Begusarai	0.36	0.55	0.56	0.26	0.08	0.09	0.74	**0.49**
Khagaria	0.63	0.81	0.67	0.38	0.28	0.25	0.85	**0.57**
Bhagalpur	0.38	0.53	0.28	0.38	0.43	0.41	0.48	**0.51**
Banka	0.72	0.43	0.41	0.27	0.27	0.46	100	**0.47**
Munger	0.04	0.79	0.31	0.36	0.02	0.13	0.87	**0.45**
Lakhisarai	0.49	0.19	0.36	0.28	0.22	100	0.74	**0.48**
Sheikhpura	0.45	0.72	0.28	0.10	0.39	0.69	0.63	**0.48**
Nalanda	0.46	0.32	0.26	0.38	0.02	0.41	0.65	**0.49**
Patna	0.05	100	0.00	0.10	0.11	0.27	0.46	**0.49**
Bhojpur	0.23	0.53	0.34	0.24	0.14	0.03	0.94	**0.50**
Buxar	0.20	0.68	0.29	0.51	0.13	0.32	0.77	**0.45**
Kaimur Bhabua	0.21	0.81	0.43	0.22	0.43	0.26	0.73	**0.43**
Rohtas	0.00	0.64	0.24	0.37	0.21	0.17	0.61	**0.41**
Aurangabad	0.15	0.79	0.46	0.49	0.72	0.65	0.93	**0.51**
Gaya	0.45	0.49	0.25	0.30	0.47	0.36	0.86	**0.47**
Nawada	0.66	0.06	0.50	0.00	0.18	0.15	0.80	**0.43**
Jamui	0.74	0.36	0.47	0.37	0.12	0.84	0.87	**0.44**
Jehanabad	0.37	0.55	0.24	0.12	0.23	0.05	0.73	**0.48**
Arwal	0.38	0.55	0.51	0.16	0.47	0.57	0.89	**0.51**
State Average	**0.54**	**0.46**	**0.43**	**0.45**	**0.35**	**0.38**	**0.76**	**0.51**
Districts Above Average	**17**	**18**	**18**	**18**	**17**	**17**	**21**	**17**

Fig.23

vulnerability index of the state on education is 0.51. Out of the 38 districts, 17 districts are poorly performing on different indicators. The provision of electricity facility in schools needs a lot more to be desired. 21 districts lag in provisioning electricity facilities in schools and stand below the state average. The districts located in flood-prone areas are also not performing well.

Recommendations for Education sector for vulnerable areas

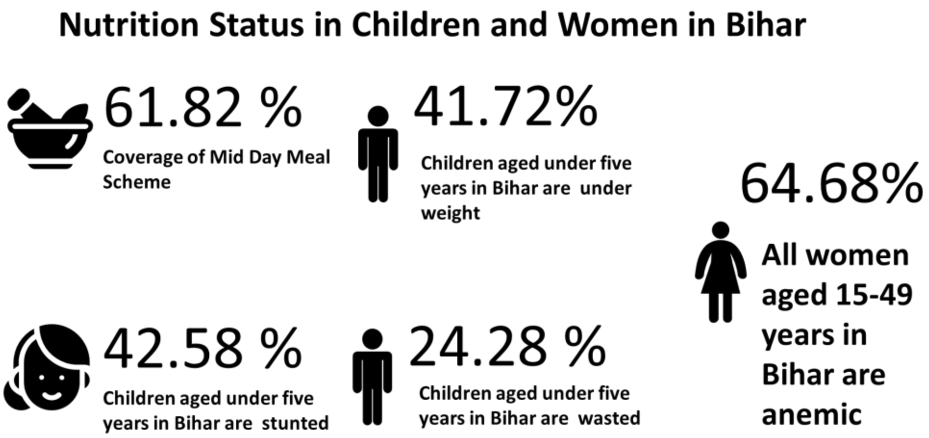
Recommendations	Timeframe for action to be accomplished	Framework for implementation
In flood-affected districts, there must be a provision for "flood vacation" in all the government schools in place of summer vacation so that the full academic session can be achieved	Medium term	Updating the existing school safety policy and program Integration of climate change adaption in school safety program, model school program and school curriculum activities
Need urgent mapping of schools and localities prone to floods and disasters; prepare mitigation plan as per the National and State School Safety Policies.	Short Term	
Ensure school infrastructure in low-lying areas in flood-affected districts adheres to safety norms of state building code and follows the highest flood level in its construction	Medium to long term	
Stringent participation (including older school children and youth) and monitoring of toilet construction/ usage should be undertaken in acute flood and drought-prone areas to ensure standards and achievement of Swachh Bharat Mission Goals	Medium to long term	
In drought-affected districts implement water safety planning in schools to enable school children to understand climate change risks and water sustainability	Short to medium term	Climate resilient practices of water conservation in schools to be included in JJHM
Orient teachers and school management committee members on climate change, disaster risk reduction and preparedness	Short term	
Conduct special coaching and learning activities for children availing MDM (mid-day meals) to add value to their presence at the school campus, and prevent them from migrating along with their parents through awareness, training and dialogue with parents and communities	Medium term	
Review school course curriculum (textbooks) through a climate change and disaster risk reduction lens and suggest supportive and innovative materials for awareness building among children	Medium to long term	
Initiate climate resilient activities through some pilot projects in schools, such as rainwater harvesting, solid waste management, etc. Also develop Climate Resilience Plan for Schools.	Short Term	

Child Nutrition

Climate change impact is increasingly being felt in all regions of the state with growing challenges for water availability, food production and livelihoods of millions of people. This indirectly affects the availability of food, and consequently child health. In Bihar, the burden of under-nutrition among children under five years of age is high, with severe and lifelong consequences, involving irreversible adverse changes to children's physical, cognitive and productive capacity. Despite a fast-growing economy, the state is the second poorest after Odisha in India and has a pivotal role to play in improving the nutritional vulnerability of children.

Bihar also has one of the highest rates of malnutrition in the country. Four out of ten children under 5 years of age are severely malnourished and livelihood is largely dependent on agriculture and allied activities. Though the causal chain of factors that determine childhood malnutrition in the state is mainly attributed to several socio-economic factors, climate change impacts like increasing extreme rainfall events, floods, dry spells during monsoon in northern districts, and frequent drought events in southern districts, seem to have added a new dimension to the deteriorating food production and nutritional status of children. Experts have already warned that climate change will further exacerbate the problem of food production, and thrust an extra burden of hunger and malnutrition in children and mothers.

Nutritional status at State & District Level



In the last few years (2005-2020), the situation of nutrition status in children has improved through several initiatives. The proportion of stunted children has declined from 56 percent in 2005-06 to 43 percent in 2019-20 but the rate of decline is slow. And, the percentage of stunted (43%), wasted (24%) and undernutrition (42%) children in the state is still much higher than the cut-off limit prescribed by the World Health Organization (WHO and UNICEF, (Nd)).

The disaggregated data on nutritional status of children at the district level on stunting, wasting and under-nutrition in children of Bihar indicates that at the spatial level, the situation is serious in flood/drought-affected districts. Acute and moderate drought-prone districts in the southwest and acute flood-affected north east districts of Bihar are severely affected by all the above-mentioned indicators. The analysis further clarifies that cases of stunted children are very high across all districts, ranging from 34 percent in Gopalganj to 54 percent in Sitamarhi. Only seven of the 38 districts, i.e., Gaya, Madhubani, Muzaffarpur, Patna, East Champaran, Samastipur and Sitamarhi account for 31 percent of the 6.1 million stunted children in the state. Each of these seven districts has over 2,50,000 stunted children, with the highest number in East Champaran (3,18,471). The percentage of wasted and underweight children is higher in the south-west and north-eastern districts in comparison to the northwest and southeast districts of Bihar. The reasons behind the widespread malnutrition are the intense flooding and drought events, poor agriculture scenarios, non-availability of food, and non-availability of quality health services. In this context, effective strategies are needed to be developed for the prevention of malnutrition in children in disaster-prone areas.

Nutritional Vulnerability vis- a- vis climate change

More than 80 percent of the agriculture in the state is rainfed (Economic Survey, Bihar, 2021), so any variation in rainfall pattern directly affects food production. The impact of climate change is visible in the changing rainfall pattern. The long-term Assessment Report, 2021 of observed rainfall by IMD clearly shows that variability in the rainfall pattern has been well observed, while the Bihar Economic Survey Report, 2021 reports that the production of pulses which are a rich source of protein has declined drastically in the past few years (2019-20 and 2020-21). Further, a declining trend is also witnessed in other nutritional crops due to the erratic nature of rainfall patterns, leading to intense frustration in farming. However, the situation in the northern districts is more pathetic.

The report also highlights that lower and untimely rainfall has increased the possibilities of crop damage and reduction in agricultural production. The case study of Madhepura district, in one of the UNICEF Bihar supported study in 2018, has raised the community's concern. It explains that in north Bihar districts, the rainfall around harvesting time of rabi crop seriously impacts the grain quality. Subsequently, these food grains do not get a good sale price in the market, have a lesser storage span and are not good for household consumption. Incidences of heavy rainfall in shorter time periods are yet another problem for the farmers where such happenings increase the tendency of water accumulation. This along with reducing drainage possibilities (owing to embankments, earthwork, developmental activities without adequate drainage considerations etc.) consequently increase in size the areas affected by water logging, and its duration which further delays the sowing of rabi crops, which further affects the production of winter crops also.

Another example of crop damage due to climate-induced disaster happened in 2014 due to the HUDHUD cyclone in West and East Champaran. The heavy rainfall in 24 hours in October 2014 caused a serious damage to the standing crops. The topography of both these districts is nearly flat and agriculture fields became waterlogged within 24 hours. It took several days to drain out the water completely, delaying harvesting in the region and sowing of the next crop. Thus, variations in rainfall have significantly influenced crop patterns, food availability and nutritional status of people in general, and children and women in particular. Alternately, southern districts in the state like Arwal, Jehanabad, Nawada, Aurangabad and Rohtas are often confronted with high temperatures and recurring droughts.

The correlation analysis of CVI of child nutrition with different indicators of climatic hazards, socio-economic features and variables related to the nutrition of children in Bihar has shown that areas with high incidences of recurrent flooding, heavy rainfall variability, cyclone-affected areas, high dependency on agriculture, have a higher correlation value of composite nutritional vulnerability index (Fig 24).

The correlation between the percentage of stunted children and multi-dimension poverty with areas with high incidences of heat waves is high. It can be inferred that heat waves have a negative impact on early childhood health. The district-wise data shows a higher prevalence of stunting, wasting and under-nutrition in children in areas with exposure to heat waves. Poor nutritional status of mothers, exposure to heat and increased workload in agriculture; all these factors contribute to increasing the incidences of premature births.

It is also noticed that in flood and drought-affected areas of the state, women play an important role in agriculture. They perform various activities like transplanting paddy, weeding, harvesting, etc. in the field. Studies revealed that working for long durations, exposure to the hot humid climate, repetitive bending and standing in the agriculture field, and non-availability of proper diet, sometimes causes miscarriage and exacerbates the risk of premature births.

Key Drivers of Nutrition Sector vulnerability
Based on multivariate correlation

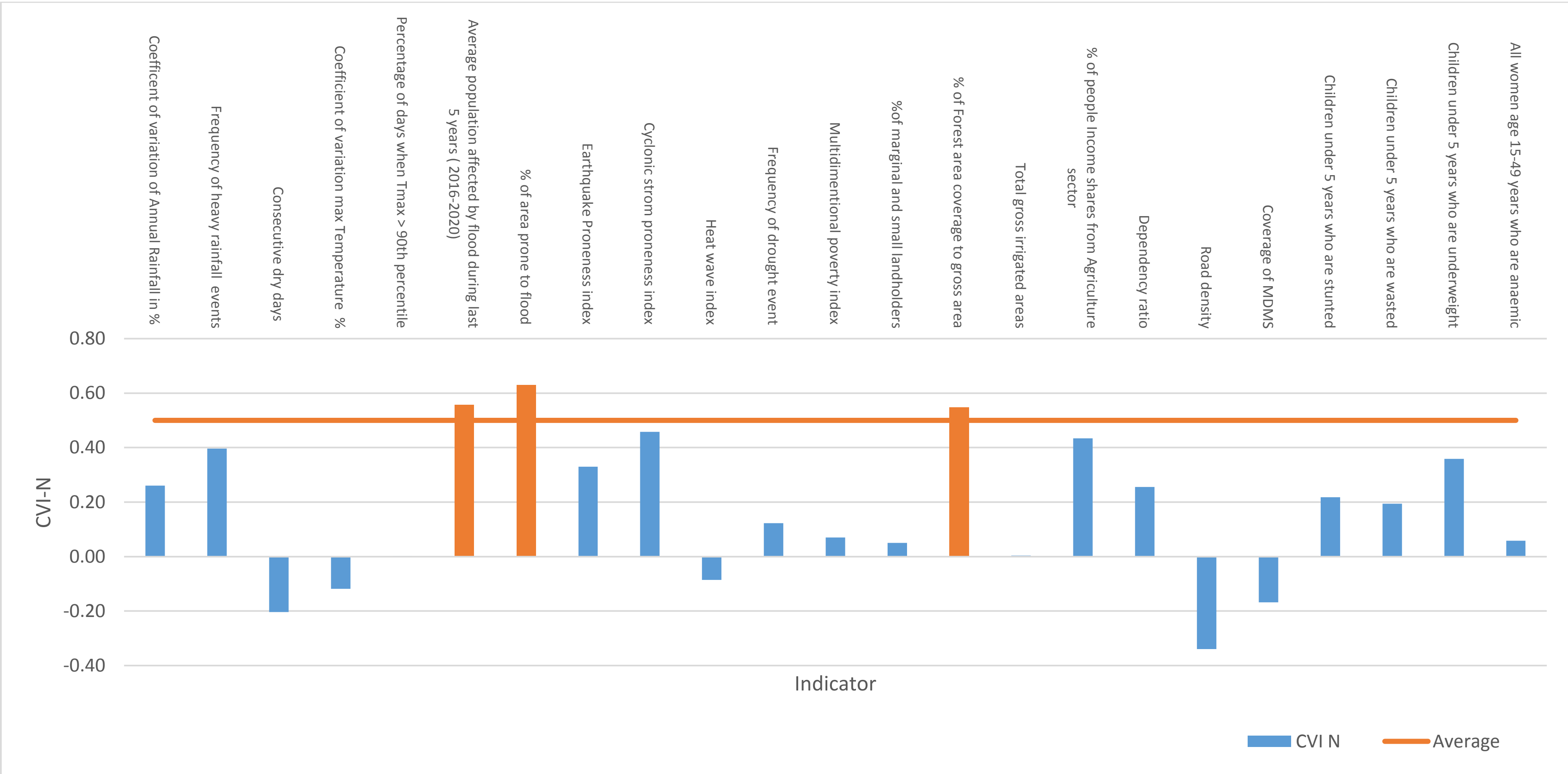


Fig.24

District Level vulnerability of nutrition sector

The indicators used for district-level vulnerability in nutrition sector assessment are the coverage of the Midday Meal Scheme (MDMS), children under 5 years who are stunted, children under 5 years who are wasted, children under 5 years who are underweight and all women age 15-49 years who are anemic along with their functional relationships with climatic hazards and socio-economic vulnerability. The composite vulnerability analysis of the Nutrition sector at the state level clearly shows that out of 38 districts, 13 have been identified as a poor performer in Child Nutrition sector and they are categorized under very high to high vulnerable category. The state's average value of nutrition vulnerability index is 0.52. (Fig 25)

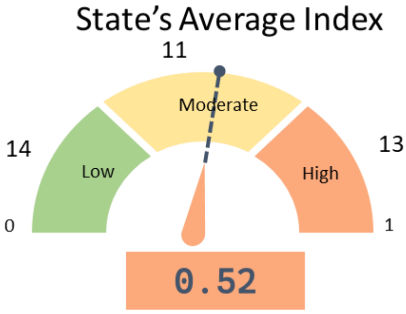


Fig.25

The spatial pattern of composite Vulnerability index (CVIs) of the nutrition sector ranges between 0.60 (Sitamarih) to 0.43 (Jamui)(Fig 26). The corresponding rankings are presented in Fig. 27.

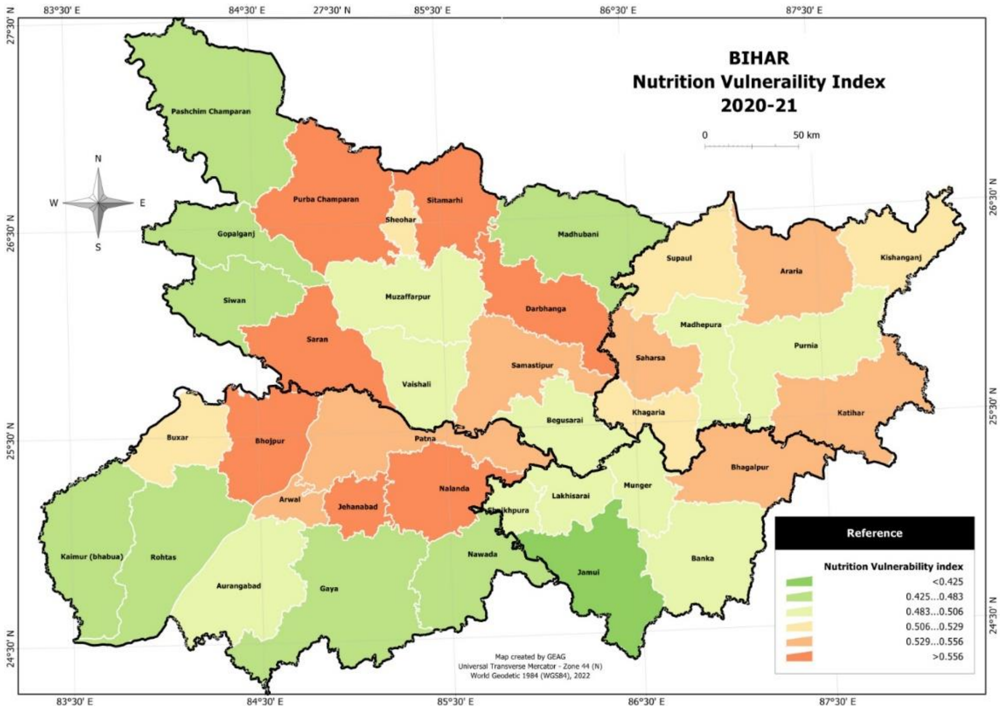


Fig.26

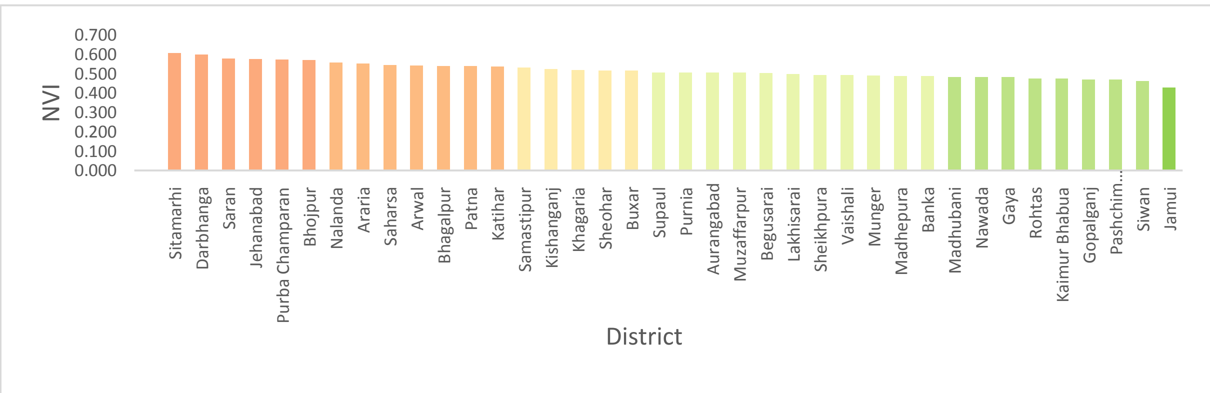


Fig.27

The state has been categorized into relatively very high to high vulnerable districts (~0.52-0.60), moderately vulnerable districts (~0.48- 0.52), and districts with relatively low vulnerability (~0.42 – 0.48). The districts that fall under the very high to the high category are Sitamarhi, Darbhanga, Saran, Jehanabad, East Champaran, Bhojpur, Nalanda, Araria, Saharsa, Arwal, Bhagalpur, Patna and Katihar. 11 districts are recognized as moderately vulnerable while 14 districts are in comparatively low 44ulnerability category.

Key observations

- The nutritional vulnerability index is above 0.5 in areas which are highly prone to floods and have a higher proportion of the population dependent on agriculture, such as Sitamarhi, Darbhanga, East Champaran, Araria etc. Further, due to climate change, the incidence of heavy rainfall in shorter periods in these areas is also prominent, affecting the food production system of small and marginal farmers and food security issues.
- More stunting cases of children below 5 years are noticed in areas which are prone to recurrent floods and drought. In these areas, the proportion of stunting cases is above the state average (42%).
- The cases of underweight in children under 5 years are more prominent in drought-prone areas or those experiencing and suffering from heat waves.

Indicator wise performance of district

The indicator wise performance of different districts in the Nutrition sector is given in Fig. 28. The pink highlighted boxes show a higher vulnerability index than the state average, and are highly vulnerable in the respective indicators. The composite vulnerability index of the state on nutrition is 0.52. Out of the 38 districts, 13 are poorly performing on different indicators. The situation related to anemia in women aged 15-49, underweight and stunting cases in most of the districts is not good. The state's average vulnerability index of anemia in women is 0.57, while of underweight, wasted, and stunted children below 5 years, the average index is 0.53, 0.47 and 0.42 respectively. The percentage of districts that lie above the state average vulnerability index in anemia, underweight and stunted are 55%, 52% and 55% respectively.

District	All women age 15-49 years who are anaemic	Children under 5 years who are underweight	Children under 5 years who are wasted	Children under 5 years who are stunted	Coverage of MDMS	Composite vulnerability Nutrition
Pashchim Champaran	0.00	0.05	0.00	0.47	0.74	**0.47**
Purba Champaran	0.27	0.37	0.15	0.75	0.60	**0.57**
Sheohar	0.45	0.55	0.94	0.01	0.40	**0.52**
Sitamarhi	0.45	0.49	0.13	100	0.39	**0.60**
Madhubani	0.44	0.29	0.17	0.46	0.34	**0.48**
Supaul	0.41	0.67	0.53	0.41	0.17	**0.51**
Araria	0.70	0.78	0.45	0.79	0.16	**0.55**
Kishanganj	0.59	0.50	0.45	0.23	0.38	**0.52**
Purnia	0.63	0.76	0.53	0.47	0.11	**0.51**
Katihar	0.72	0.80	0.44	0.49	0.00	**0.54**
Madhepura	0.61	0.60	0.31	0.61	0.39	**0.49**
Saharsa	0.60	0.57	0.31	0.68	0.17	**0.54**
Darbhanga	0.41	0.42	0.26	0.56	0.53	**0.60**
Muzaffarpur	0.34	0.23	0.28	0.42	0.33	**0.50**
Gopalganj	0.13	0.00	0.35	0.00	0.60	**0.47**
Siwan	0.10	0.07	0.21	0.13	0.60	**0.46**
Saran	0.50	0.67	0.66	0.28	0.37	**0.58**
Vaishali	0.51	0.39	0.27	0.21	0.21	**0.49**
Samastipur	0.40	0.57	0.34	0.49	0.46	**0.53**
Begusarai	0.50	0.27	0.33	0.18	0.60	**0.50**
Khagaria	0.36	0.30	0.51	0.03	0.34	**0.52**
Bhagalpur	0.91	0.47	0.34	0.29	0.40	**0.54**
Banka	0.62	0.70	0.58	0.63	0.46	**0.49**
Munger	0.85	0.43	0.57	0.06	0.56	**0.49**
Lakhisarai	0.89	0.67	0.53	0.43	0.26	**0.50**
Sheikhpura	0.77	0.35	0.13	0.97	0.35	**0.49**
Nalanda	0.83	0.74	0.62	0.42	0.43	**0.56**
Patna	0.67	0.44	0.61	0.01	0.38	**0.54**
Bhojpur	0.93	0.62	0.77	0.33	0.29	**0.57**
Buxar	0.63	0.68	0.85	0.27	100	**0.51**
Kaimur Bhabua	0.80	0.76	0.60	0.50	0.62	**0.47**
Rohtas	0.58	0.80	0.79	0.29	0.36	**0.47**
Aurangabad	0.40	0.82	0.83	0.35	0.66	**0.50**
Gaya	0.56	0.60	0.47	0.66	0.32	**0.48**
Nawada	0.80	0.34	0.21	0.76	0.48	**0.48**
Jamui	100	0.35	0.26	0.44	0.41	**0.43**
Jehanabad	0.71	0.95	0.99	0.36	0.53	**0.57**
Arwal	0.66	100	100	0.57	0.13	**0.54**
State Average	**0.57**	**0.53**	**0.47**	**0.42**	**0.41**	**0.51**
Districts Above Average	**21**	**20**	**18**	**21**	**16**	**17**

Fig.28

Recommendations for Nutritional sector in vulnerable Districts

<table>
<tr><th>Recommendations</th><th>Timeframe for action to be accomplished</th><th>Framework for implementation</th></tr>
<tr><td>Improve linkages between meteorological information, district-level agriculture department and farmers through technologically advanced information dissemination tools</td><td>Medium to long term</td><td rowspan="11">Inter departmental coordination

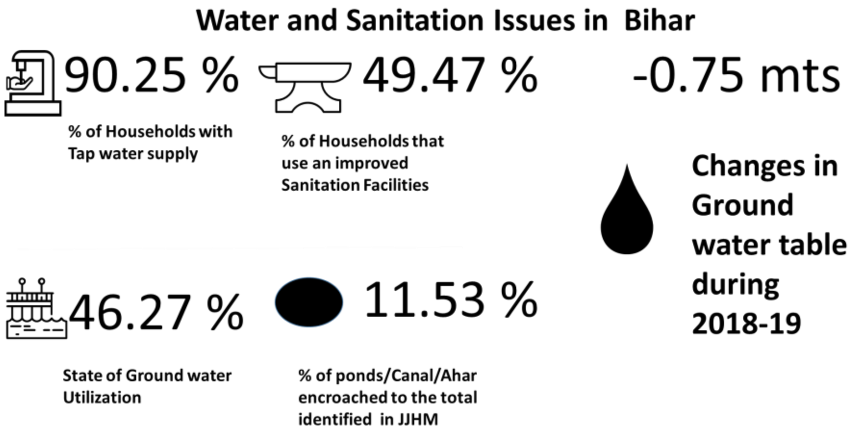
Updating existing policy of child nutrition

Awareness and demonstration of nutritional kitchen garden

Training of Front line workers and PRIs, children on climate change adaptation</td></tr>
<tr><td>Encourage the establishment of kitchen gardens at the household level, AWCs and school gardens with drought and water-tolerant crop varieties and vegetables and promote the consumption of same by children in mid-day meals.</td><td>Short term and continuation</td></tr>
<tr><td>Ensure provision of special food baskets during flood and drought situations which are inclusive of local food</td><td>Short term</td></tr>
<tr><td>Improve capacity building of Anganwadi workers on climate change and its impact on child health, and strengthen MIS on health issues vis a vis fluctuation of temperature</td><td>Medium and long term</td></tr>
<tr><td>Promote decentralized production and supply of flood and drought-tolerant seeds suitable to local climatic conditions</td><td>Short term</td></tr>
<tr><td>Promote organic farming in flood and drought-prone districts for healthy soil and lower crop vulnerability</td><td>Medium term</td></tr>
<tr><td>Ensure coverage of the PDS system with multi-grains in severe drought and flood-affected areas</td><td>Short term</td></tr>
<tr><td>Enhance the capacity building of PRIs and SHGs on climate change and its impacts on child health, nutrition, and maternal care</td><td>Medium term</td></tr>
<tr><td>Strengthen public health preparedness on extreme climate events and response system, and reinforce it through DDMAs and local government bodies</td><td>Medium and long term</td></tr>
<tr><td>Promote multi-cropping with perennial varieties of grain rather than mono cropping</td><td></td></tr>
<tr><td>Involve older children in health monitoring and awareness programs</td><td></td></tr>
</table>

Water & Sanitation

The availability and accessibility of safe drinking water, better sanitation and knowledge about hygiene behavior are referred to as the WASH variables by the United Nations Children's Emergency Fund and are the basic foundation for survival and development of human beings. However, for children, it is most important and essential for their physical, mental, and social-psychological development. But with changing climate and weather variabilities the occurrence of floods, droughts, storms, and other hydro-met extreme events in the state have now become the critical bottleneck in ensuring the provision of safe drinking water (State Water Policy of Bihar,2010). Consequently, availability of safe water and better sanitation systems is a serious issue in the state. It is estimated that the water and sanitation crisis in the state is putting 50 million children at risk of diseases such as diarrhea, cholera, typhoid, and other waterborne diseases and causing a high rate of infant and child mortality. (MCCD Report 2020).



Though the statistics on the availability of water and sanitation facilities have improved, the proper accessibility of these facilities to the people is still an issue. The major chunk of rural households in Bihar do not get a regular supply of water throughout the year from the piped water supply at home or public taps/standpipes (both for drinking and other household use) and 50.53 percent have no access to safe and improved sanitation facilities at home (NFHS 2020). The inter-district disparity in Bihar with respect to sanitation too is significant.

The recent NFHS 2020 data show that amongst all districts in the state, Rohtas has the highest proportion of households (61 %) using improved sanitation facilities among all districts, while only 32 % of the households use the same in district Araria. Often poor sanitation and unsafe drinking water cause water borne disease like intestinal worm infections, which lead to malnutrition, anemia, and retardation among children. The IDSP Report, 2020, reveals that due to poor sanitation and intake of contaminated water Bacillary dysentery cases in Bihar have been on the rise over the years. Acute diarrhea cases constitute 12 % of the total reported cases caused by enteric, food and water-borne diseases.

WASH vulnerability and Climate change impacts

Climate variability has a direct impact on the water, sanitation, and hygiene conditions of people in Bihar. Access to safe drinking water and proper sanitation is closely linked and affected by both abundance and scarcity of water in respective regions, which is one of the direct impacts of climate change. In flood-stricken villages of the northern districts of the state, excessive rains and flooding create the biggest challenges in accessing safe drinking water and sanitation, which are a cause of death of children because of consumption of dirty and contaminated water, and lack of basic toilets and washing habits. Studies in flood-stricken areas often highlight that children die from diarrhea, vomiting and fever in flood camps.

In spite of having tap water connections in more than 90.25 % HHs, due to irregular supply of water 90 percent of HH in rural Bihar are dependent on shallow handpumps for drinking water. However, during the floods, most of these handpumps are drowned, silted up or sometimes even damaged by the sheer force of the water, which ultimately affects the accessibility of safe drinking water during the stress period. Apart from this, widespread water logging after the flood or extreme events creates stagnant pools which are used by local people for drinking, washing and defecating as there are no alternate options. Thus, in these situations of changing climate and variations in rainfall, status of safe water accessibility, hygiene and sanitation are expected to further deteriorate and may increase cases of water and vector-borne diseases. This also plays a significant role in increasing the cases of malaria, AES, cholera, viral hepatitis, enteric fever, and acute diarrheal disorder in children under 5 years of age, a major cause of under-five mortality.

Another impact of climate change is being noticed in the quality of WASH services. The quality of drinking water is a serious challenge for the state; and with frequent floods and droughts, this has further deteriorated. A recent report by the Department of Health and Family Welfare (GoI) on water-borne diseases indicates that out of all the cases of viral hepatitis in India, about 20% have been reported from Bihar alone. Similarly, Bihar accounts for about 15% of all reported cases of typhoid in India (Bihar State Plan of Action for Children, 2017). Flood-affected areas are even more prone to these challenges.

The impact of climate change is also being noticed in the level of groundwater. Though it is more explicit in drought-prone areas due to reduced rainfall all over the state, a new phenomenon is being noticed even in the flood-stricken districts. The groundwater tables are gradually declining during the pre-monsoon period. The fall of water level in the segment of 0-2 m has been observed in the major parts of East Champaran, Bhojpur, Kaimur, Aurangabad, Buxar, Nalanda, Lakhisarai, Purnia, Katihar, Araria, and Darbhanga districts. The fall of water level in the range of 2-4 m has been observed in almost 5% area of the state mostly in Gaya, Nawada, Jamui, Patna, Munger, Lakhisarai, Nalanda, Kaimurand Banka districts. Only small patches in Gaya, Nawada, Jamui and Banka districts have shown a fall of water level more than 4 m.

The correlation analysis of CVI of water and sanitation with indicators of climate hazards, socio-economic features and variables related to WASH in Bihar has been established to understand the key challenges of the WASH sector. The correlation value of CVI of water and sanitation in areas with high annual variability of rainfall, frequency of heavy rainfall, flood events during the last five years, cyclone-affected areas, and connection of tap water supply is high. Thus, an inference can be drawn that they play an important role in determining the composite water and sanitation vulnerability index (Fig 29).

Key Drivers of Water and sanitation Sector vulnerability
Based on multivariate correlation

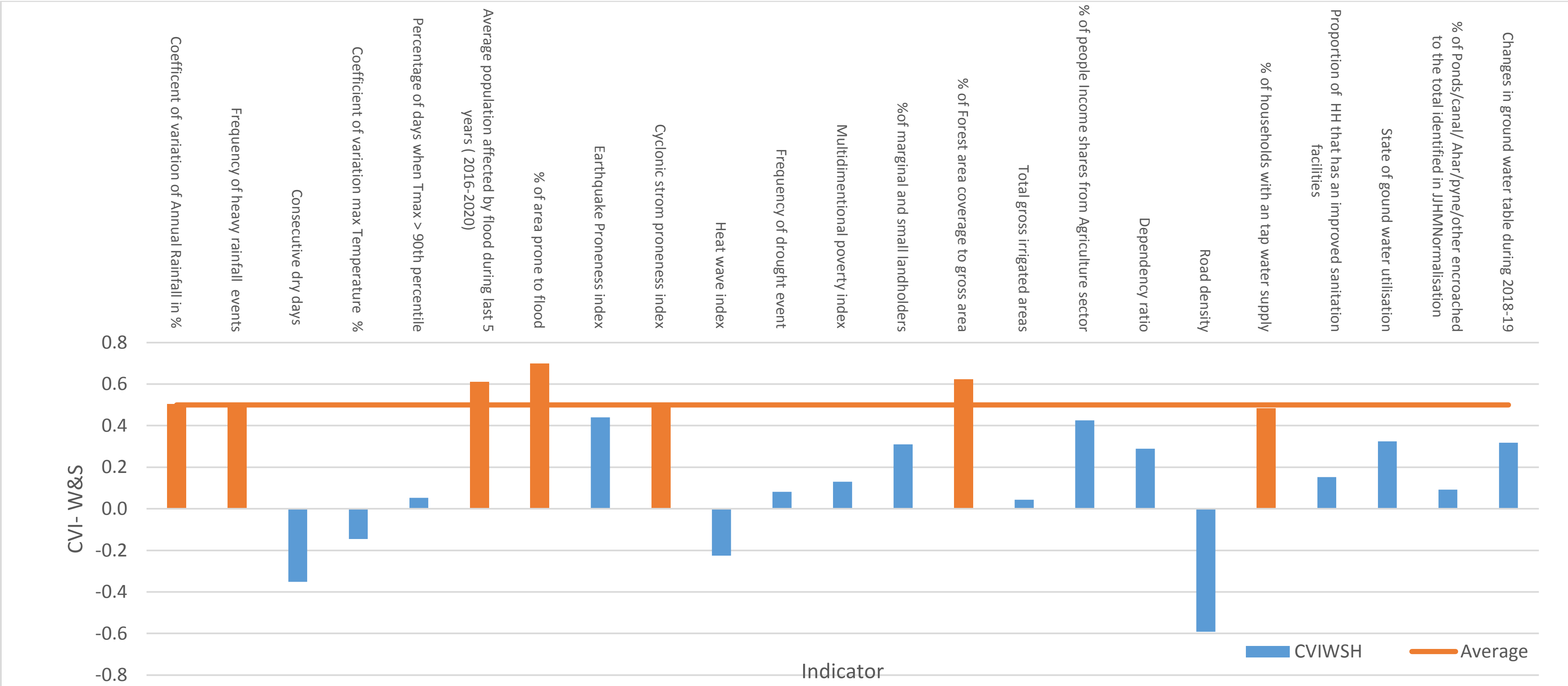


Fig.29

The close relationship between sanitation and child mortality can be well understood in Bihar through the NFHS data. The comparative analysis of NFHS 3 (2005-06), NFHS 4 (2015-16) and NFHS 5 (2019-20) data on sanitation facilities and child mortality in Bihar shows that the state's child mortality rate under the age of five per 1000 live birth has declined from 84 in 2005-06 to 56.4 in 2019-20 (Fig 15). Over the same period, households with improved sanitation increased from 18% to 25 %.

The annual communicable disease surveillance report 2015 of Bihar highlights diarrheal disease as one of the leading causes of under-five mortality; the prime responsible factors being lack of sanitation and unsafe drinking water. It is therefore important that adequate sanitation cover is provided and facilitated in specifically those flood-affected areas on a priority where sanitation facilities are quite low. Such areas will be more vulnerable to changing climate trends. The climate change impacts are differential as per the socio-economic status, gender, age group etc. The impacts are more on those living in *kaccha* houses, in flood plains, and sheltering on embankments during floods, differentially impacting women and children. The case studies of UNICEF Bihar in Gaya and Sheikpura districts reveals that during summer, most of the handpumps become dry due to excessive extraction of water for irrigation. This causes an extra burden on women living in this area who walk long distances to fetch water. They reported an increase of an average of two hours in fetching water. Due to recurring droughts during the last few years, wells are dry and the quality of the remaining water is muddy. The groundwater table also falls low, which makes the handpumps dysfunctional.

On the other hand, in drought-prone districts of Bihar, the NFHS –4(2015-16) data reveals that merely 15-22 percent of households have improved sanitation facilities. Women and adolescent girls in Gaya and Sheikhpura districts informed that due to lack of sufficient water they do not take bath and wash their hair regularly. They do laundry once a week near the village pond or well. They are also not financially sound to invest in the construction of toilets. The case studies also highlighted that people in drought-prone areas "do not have enough water even for cooking; from where they will bring water to flush and clean the toilet." It also provides a further understanding of the reasons for the limited or no use of toilets. In Gaya district, women explained two main reasons for the lack of toilet use: a) lack of adequate water; so they use it only during emergencies or nighttime b) the fear that the pits of the toilet will fill up if all family members use it throughout the year.

It is noteworthy that merely having a toilet is not likely to guarantee its usage because water scarcity is a major limitation, and it is one of the major causes for mass open defecation practices in drought-prone areas in the state. The lack of awareness is also an important factor. Such issues will have to be considered in programs like *Swachha Bharat Mission-Gramin* (SBM-G). The trend of intense rainfall has also negatively affected groundwater re-charging. Ignoring traditional mechanisms like *Ahar-Pyne* and farm bunding in drought-prone areas has resulted in a further depletion of the ground water table.

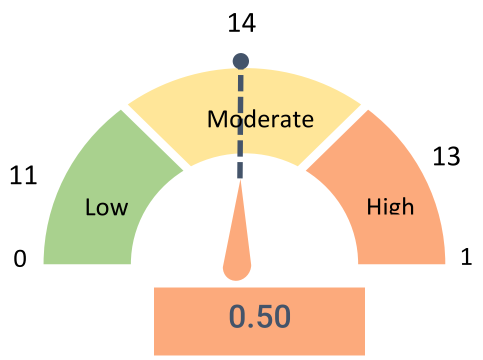


Fig.30

District Level vulnerability of water and sanitation sector

For the district-level vulnerability assessment in the water and sanitation sector with reference to climate change,
a total of 23 indicators are taken, out of which 5 are from the water and sanitation sector, 11 are related to climate hazards and 7 are associated with socio-economic developments. As mentioned in the methodology section, each indicator has been given equal weightage while calculating the composite vulnerability index; and their functional relationships with climatic and socio-economic vulnerability have also been considered. The composite vulnerability analysis of the water and sanitation sector at the state level shows that out of 38 districts, 13 have been identified as belonging to the very high to high category. The state's average water and sanitation Vulnerability Index is 0.5 (Fig 30)

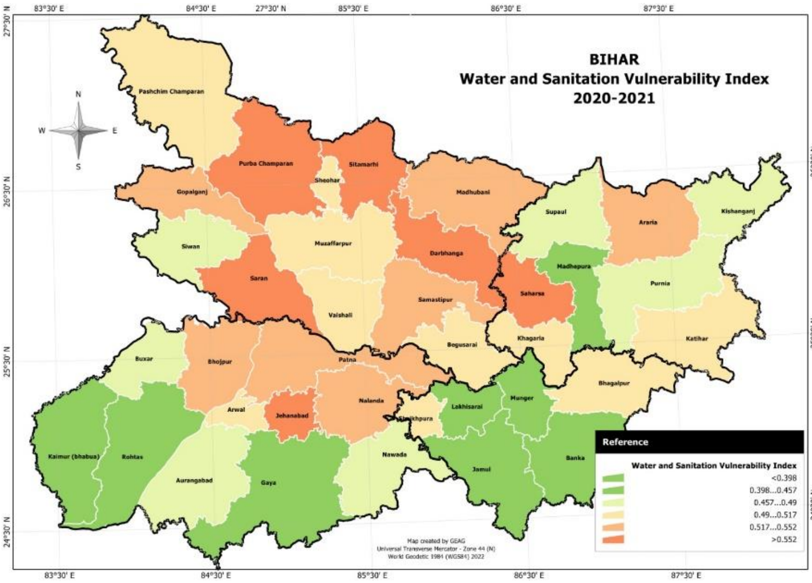


Fig.31

District	Sectoral vulnerability	District	Composite vulnerability of Water and sanitation
Jehanabad (37)	0.61	Sitamarhi (04)	0.62
Sitamarhi (04)	0.56	Darbhanga (13)	0.60
Saharsa (12)	0.55	Saran (17)	0.57
Sheikhpura (26)	0.55	Purba Champaran (02)	0.56
Gopalganj (15)	0.50	Saharsa (12)	0.56
Madhubani (05)	0.50	Jehanabad (37)	0.55
Buxar (30)	0.49	Bhojpur (29)	0.54
Darbhanga (13)	0.47	Patna (28)	0.53
Samastipur (19)	0.46	Samastipur (19)	0.53
Bhojpur (29)	0.45	Gopalganj (15)	0.53
Saran (17)	0.45	Nalanda (27)	0.52
Nalanda (27)	0.44	Araria (07)	0.52
Nawada (35)	0.44	Madhubani (05)	0.52
Araria (07)	0.44	Katihar (10)	0.51
Arwal (38)	0.44	Vaishali (18)	0.51
Patna (28)	0.40	Muzaffarpur (14)	0.50
Vaishali (18)	0.40	Begusarai (20)	0.50
Purnia (09)	0.40	Sheikhpura (26)	0.50
Pashchim Champaran (01)	0.40	Pashchim Champaran (01)	0.50
Sheohar (03)	0.40	Sheohar (03)	0.50
Aurangabad (33)	0.39	Bhagalpur (22)	0.50
Purba Champaran (02)	0.39	Khagaria (21)	0.49
Begusarai (20)	0.38	Arwal (38)	0.49
Banka (23)	0.37	Supaul (06)	0.49
Jamui (36)	0.37	Siwan (16)	0.49
Katihar (10)	0.37	Purnia (09)	0.48
Supaul (06)	0.36	Kishanganj (08)	0.48
Madhepura (11)	0.36	Buxar (30)	0.47
Siwan (16)	0.36	Nawada (35)	0.47
Gaya (34)	0.35	Aurangabad (33)	0.46
Muzaffarpur (14)	0.31	Madhepura (11)	0.46
Bhagalpur (22)	0.30	Gaya (34)	0.44
Lakhisarai (25)	0.26	Banka (23)	0.44
Munger (24)	0.24	Lakhisarai (25)	0.43
Kishanganj (08)	0.22	Munger (24)	0.43
Rohtas (32)	0.21	Jamui (36)	0.40
Khagaria (21)	0.20	Rohtas (32)	0.40
Kaimur Bhabua (31)	0.19	Kaimur Bhabua (31)	0.37

Fig.32

The district-wise composite Vulnerability Indexes of the water and sanitation sector vary between the maximum of 0.62 (Sitamari) to 0.37 (Kaimur Bhabhua). The spatial variation of CVIs is shown in the map (Fig 31), while the rankings with and without Hazards are presented in Fig. 32.

The spatial variation in CVI at the district level indicates that very high to high vulnerable districts (VIs varies between~0.52-0.62) in the water and sanitation sector are Sitamarhi, East Champaran, Darbhanga, Saran, Saharsa, Madhubani, Araria, Gopalganj, Jahanabad, Bhojpur, Patna, Samastipur and Nalanda. Moderately vulnerable districts whose CVI varies between 0.45-0.52, are Katihar, Vaishali, Muzaffarpur, Begusarai, Sheikhpura, Khagaria, West Champaran, Arwal, Siwan, Buxar, Purnia, Kisanganj, Bhagalpur, and Aurangabad. The rest of the

11 districts are categorized as having relatively low vulnerability with CVI varying between 0.37–0.45.

Key observations

- The coefficient of variation of annual rainfall, frequency of heavy rainfall and flood incidence are key components in aggravating the vulnerability of Water and Sanitation sector. It affects the availability, accessibility and quality of domestic water and sanitation situation.
- The tap water supply facilities are relatively poor in areas with a high coefficient of variation in annual rainfall and flood-prone areas like the Sitamarhi, Madhubani, Araria, and Saharsa districts. In these areas accessibility is also a concern.
- The areas suffering from heat wave and having a high multi-dimension poverty index are also important key challenges in ensuring improved sanitation facilities as in districts such as Jamui, Banka, Saran, Madhepura, Purnia etc.
- Encroachment of water bodies is more prominent in areas which are affected by consecutive dry days and increasing maximum temperature such as Nalanda, Arwal, Jahanabad, Sheikhpur and Buxar districts.

Indicator wise performance of district

The performance of different districts in the Water and Sanitation sector as per the selected indicators is given in Fig. 33. The highlighted pink boxes show a relatively higher vulnerability index than the state average. The figure gives an indication that more

District	Proportion of HH that has an improved sanitation facilities	Changes in ground water table during 2018-19	%of Ponds/canal/ Ahar/pyne/other encroached to the total identified in JJHM	State of gound water utilisation	%of households with an tap water supply	Composite vulnerability of Water and sanitation
Pashchim Champaran	0.70	0.48	0.43	0.04	0.34	**0.50**
Purba Champaran	0.56	0.35	0.18	0.29	0.57	**0.56**
Sheohar	0.30	0.69	0.14	0.50	0.34	**0.50**
Sitamarhi	0.50	0.70	0.41	0.35	0.86	**0.62**
Madhubani	0.84	0.49	0.19	0.22	0.74	**0.52**
Supaul	0.50	0.81	0.09	0.21	0.22	**0.49**
Araria	100	0.19	0.02	0.00	100	**0.52**
Kishanganj	0.45	0.12	0.00	0.03	0.51	**0.48**
Purnia	0.91	0.18	0.14	0.47	0.28	**0.48**
Katihar	0.66	0.00	0.19	0.58	0.39	**0.51**
Madhepura	0.93	0.27	0.06	0.51	0.03	**0.46**
Saharsa	0.77	0.67	0.17	0.28	0.88	**0.56**
Darbhanga	0.55	0.47	0.33	0.19	0.81	**0.60**
Muzaffarpur	0.38	0.20	0.13	0.63	0.22	**0.50**
Gopalganj	0.24	100	0.52	0.71	0.02	**0.53**
Siwan	0.58	0.06	0.44	0.49	0.21	**0.49**
Saran	0.86	0.41	0.21	0.58	0.18	**0.57**
Vaishali	0.45	0.47	0.47	0.56	0.04	**0.51**
Samastipur	0.55	0.68	0.41	0.36	0.27	**0.53**
Begusarai	0.18	0.37	0.38	0.43	0.51	**0.50**
Khagaria	0.11	0.28	0.13	0.17	0.34	**0.49**
Bhagalpur	0.22	0.45	0.41	0.10	0.32	**0.50**
Banka	0.84	0.40	0.17	0.20	0.26	**0.44**
Munger	0.17	0.70	0.13	0.18	0.02	**0.43**
Lakhisarai	0.47	0.06	0.38	0.14	0.27	**0.43**
Sheikhpura	0.40	0.60	100	0.25	0.51	**0.50**
Nalanda	0.45	0.35	0.71	0.65	0.07	**0.52**
Patna	0.22	0.27	0.60	0.53	0.38	**0.53**
Bhojpur	0.63	0.17	0.61	0.48	0.38	**0.54**
Buxar	0.45	0.53	0.79	0.42	0.24	**0.47**
Kaimur Bhabua	0.27	0.27	0.24	0.18	0.01	**0.37**
Rohtas	0.00	0.40	0.58	0.06	0.02	**0.40**
Aurangabad	0.60	0.02	0.41	0.09	0.85	**0.46**
Gaya	0.67	0.10	0.38	0.61	0.01	**0.44**
Nawada	0.57	0.33	0.35	0.44	0.52	**0.47**
Jamui	0.85	0.27	0.27	0.16	0.29	**0.40**
Jehanabad	0.64	0.55	0.67	100	0.17	**0.55**
Arwal	0.70	0.55	0.69	0.25	0.00	**0.49**
State Average	**0.53**	**0.39**	**0.35**	**0.35**	**0.35**	**0.50**
Districts Above Average	**20**	**19**	**19**	**18**	**14**	**20**

Fig.33

emphasis is required on the Water and Sanitation sector in these districts. As mentioned earlier, the average composite vulnerability index of the state in the Water and Sanitation sector is 0.50. Out of the 38 districts, the performance of 20 districts is not up to the mark and their vulnerability index is above the state's average. The situation of providing improved sanitation facilities here is still a major concern. Besides improved sanitation facilities, the status of groundwater table is also an important concern. More than 19 districts in the state have a higher vulnerability index. This means that these 19 districts have experienced more changes in the water table in the last two years (2018-2020). The third most important concern in the sector is encroachment of ponds and water bodies. Regarding this concern, the sector must lay emphasis in districts like West Champaran Gopalganj, Siwan, Vaishali, Samastipur, Begusarai, Bhagalpur, Rohatas, Buxar, Nalanda and Arwal to halt the process of public encroachment on water bodies under the *Jal Jeewan Hariyali* Mission.

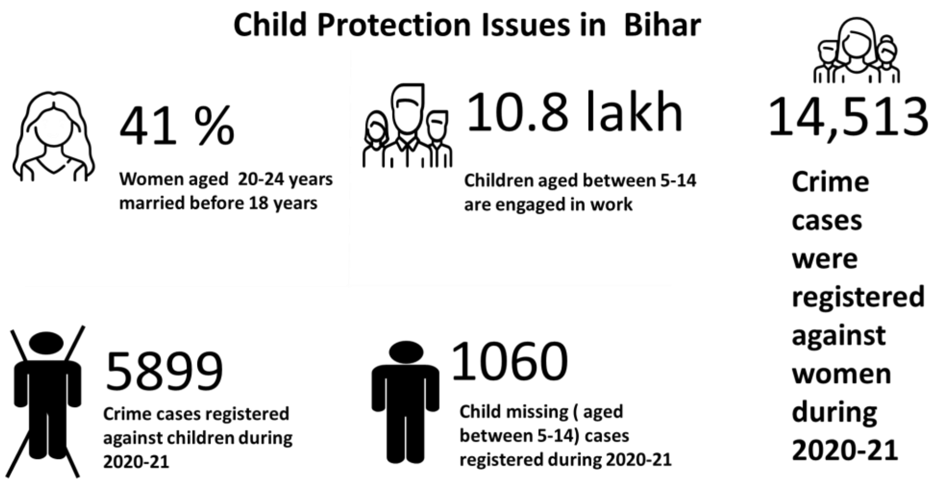
Recommendations for water, sanitation, and hygiene sector in vulnerable districts

Recommendations	Timeframe for action to be accomplished	Framework for implementation
Effective water quality monitoring systems need to be established in flood and drought-affected regions. Special drives during monsoon, post-monsoon (in flood-affected areas) and summers (in drought-prone areas) are needed to be adopted. Special care is required for habitations in flood plains and temporary shelters.	Medium to long term	Policy framework is required Align with existing program Need technological infrastructure intervention Need to generate awareness on water and sanitation
Local water quality testing labs/facilities at PHCs, schools/colleges need to be established in these flood and drought-prone areas	Medium to long term	
Indigenous practices of water treatment/filtration need to be popularized among the community. Awareness and training programs are urgently needed on the disinfection of handpumps and stored water, especially in flood prone regions.	Short term and continuation	
Distribution of hygiene kits consisting of sanitary napkins, medicines, etc. for women and adolescent girls, especially as preparedness activity in disaster-prone areas	Short term	
Decentralized Water Security Planning at the village level, especially in drought-affected villages need to be done. This will ensure water security for the villagers during stressful periods	Medium to long term	
Construction of raised latrines and re-construction of existing ones must be undertaken. Raising of handpumps in flood-affected areas, revival of ponds and dug wells and digging new wells for recharging groundwater, especially in drought-prone districts should be done under the MGNREGA program	Medium to long term	
Develop an emergency plan to recover disrupted services of water and sanitation with the least response time and simultaneously provide alternative access to water and sanitation during system downtime	Medium to long term	
Engagement with district administration to develop linkages with government schemes such as *Swachh Bharat Abhiyan* (Clean India Mission) for specific needs of floods and droughts affected areas.	Short term	

Child Protection

The state of Bihar is notorious for child and youth migration. The climate-induced disasters have had a serious ramification on child protection issues. More than 50 million children and their families confront floods and droughts every year. This forces them to displace for more than three months as they relocate for their survival and protection (Sinha, A, 20016). During any calamity, women and children are more vulnerable to food & health-related issues and risks of separation from their families or caregivers. Thus, across the state, poor households are negatively impacted by disasters. This phenomenon is worsening with increasing variabilities in climatic conditions, with women and children particularly becoming more vulnerable.

The state has unique geo-climatic conditions and climate-related vulnerabilities have altered the intensity of rainfall, minimum and maximum temperature, humidity regimes, etc. In this section of the study, it is essential to understand how climate change-induced disasters are affecting the rights and well-being of children, especially in the local context. This understanding will help concerned sectors and departments to plan and enforce effective safeguard mechanisms for helping destitute children. Lack of data, and accurate and reliable information regarding these issues are the key challenges. This chapter highlights the key problems and causes affecting child protection issues, its spatial vulnerability and actions required to control the problem.



Climate change and Child protection issues

Livelihood Losses of families and its impact on childhood

Studies all over the world on climate change and its impact on child protection show a close connection with the loss of livelihood of the people. Bihar state is a good example of this. The geographical and climatic condition of Bihar is such that agriculture losses happen both in flood and drought-prone regions due to climate variability, thus adding to people's vulnerability. In such a situation, food (and basic nutrition) and a small amount of money become the dire need of the people. Affected by disasters and climate variability, directly or indirectly, and with no alternative source of income, these families are forced into a debt trap and a vicious cycle of reduced resources, leading to greater exploitation. The impact of climate change and disasters, in the backdrop of poverty and socio-cultural norms, adds to the vulnerability of these families, and children end up as one of the worst sufferers in such situations.

The situation of flood or prolonged waterlogging in northern districts has imposed even greater pressure on the children, to take on labor work and contribute earnings for the family. The national Census of 2011 and NCRB report of 2020 reveal that a larger number of children are a part of the workforce in acute flood-affected districts (East and West Champaran, Khagaria, Katihar, Madhubani), compared to those districts that face moderate flooding. A UNICEF study on drought areas during 2015-16 raises concerns about the high rate of school dropouts in drought-prone areas, as the children are engaged in work. The report highlights that poverty induced by crop failures, and livelihood loss for earning members of rural households due to frequent droughts, is one of the major reasons that creates pressure on children to support their family by sharing household responsibilities and earning; thus, increasing the dissociation of children from school (UNICEF, 2015). Another glaring problem that the report highlights is that when the crops get damaged due to climate-induced disasters, the small and marginal farmers are forced to work as laborers in other farmers' fields who are well-off and hold the capacity to cope with such disasters. In this situation, the responsibility of miscellaneous household work increases on women, which is shared by the children in the family. This work includes collecting fodder and fuelwood, taking care of younger siblings and so on. All this makes the children disinclined towards school and education.

Massive displacement of families and children

Every year floods in northern Bihar and drought in the southern part affects millions of people, half of which are children. The massive loss of lives, and displacement of tens of thousands of people, pose a greater threat to these children. They often get disconnected from their families, especially when floods cut off villages and areas, and they are left alone. They, especially girl children, are exposed to several types of abuse and exploitation. It is often seen that there is no social security in the flood temporary camps/shelter homes. Children in such situations are mentally affected and this sometimes leads to all kinds of trauma and disorders in their adult lives. Moreover, during disasters, children also either relocate, move out from the safe environment to which they are habituated, or are exposed to physical and mental distress that makes them even more vulnerable. Family pressure, greater workloads, financial strain, and the immediate need for food in the post-disaster period, pushes them into unsafe environments, where their basic right to a safe childhood simply disappears. Traffickers and other middlemen often lure the displaced children with false dreams of lucrative jobs and money, and these innocent children fall in their traps. All of this leads to a situation where children are forced to endure suffering, in the form of bonded labor, migration, and exploitation.

Distressed Migration

Sometimes technological improvements also have side effects. In Bihar, with increasing mechanization in agriculture, the labor demand in rural areas has reduced and in situations like crop losses due to weather uncertainties, this demand becomes even less. In absence of alternate employment opportunities (Bihar being a state where 88.7 percent of the population is dependent on agriculture and primary production activities: Economic Survey of Bihar, 2020-21) such farmers'/ agriculture laborers have no option but to migrate seasonally or for longer durations. The families left behind face increased responsibilities and workload, while the families that migrate tackle another set of problems in the new migrated destinations. In the face of such distressing migration, children are the worst sufferers as they too indulge in labor activities. School admissions too become a problem for such children in new lands because of identity issues.

Debt trap

The accessibility to formal lending is less in the state and poor farmers are compelled to take loans from private moneylenders. If they are unable to pay back in time, they are forced to work as bonded labor by the moneylenders. The rate of interest charged by such money lenders is quite high (60 percent). This initiates a vicious cycle of crop losses, hunger, indebtedness, drudgery, and exploitation, directly and indirectly impacting children.

Child Labor

The situation of child labor is serious in Bihar. The State infamously stands at the second position in terms of contributing (11 percent) to the child labor population in the country. According to NCRB 2020 report, the number of child laborers between 5-14 years is 1.08 million. One of the main reasons for child labor, as explained earlier, is high poverty, prevailing geo-climatic conditions and under-development situations. Major dependence on rain-fed agriculture for income and livelihood, and adverse impacts of disasters and climate change make the state more vulnerable to distortion, especially denial of children's rights. Natural disasters affect farming and the marginal farmers are worst affected as explained above. In such circumstances, the children of the affected families are doubly impacted. On one hand, their education gets disrupted and on the other hand, due to the financial constraints of the family, they are forced to go out and work, often as a laborer for earning wages for the family. Large number of children go to other villages to work on the lands of well-off farmers. Those who are unable to find any local work, migrate to big cities like Chennai, Delhi and Mumbai, Pune etc. Thus, disaster/climate change-induced child labor in Bihar can be classified as:

- Children helping within households
- Children as agriculture laborers in adjoining fields/ villages with/without parents
- Children as laborers in nearby urban settlements
- Child labor in distant cities

In a nutshell, with the changing nature of floods and droughts, cases of child labor in the state are expected to rise, unless and until the causal factors for such vulnerabilities are addressed on a priority basis, and laws of child protection are cognizant of these causes, incorporating required safeguard mechanisms. Apart from this, there is also a need to engage with primary stakeholders (children and parents), institutions of local governance, frontline workers, and administrative and non-governmental organization to understand the causes and sub-causes of the issue in the local context and design an affirmative action and plan framework at the local level for prevention of child labor in Bihar

Child Trafficking/ Missing and exploitation

Distress migration to other parts of the country, due to crop and livelihood losses in disasters or in the hope of employment opportunities is the most common survival/ adaptation strategy adopted by poor and marginalized communities. In a significant number of cases, such survival strategy (migration) becomes unsafe, leading to acts like human trafficking, where children, poor men and women often get trapped. The vulnerabilities are already high in the state due to prevalent poverty. As per the official record (Disaster Management Department, GoB), the years 2005-2011 were notorious for floods and intermittent droughts in different parts of the state. Data on child trafficking during these corresponding years have shown that the cases of child trafficking have also increased during this period and thus, both these factors are positively correlated.

Bihar is bound by West Bengal in the east, Jharkhand in the south and Uttar Pradesh in the west. It also shares an international border with Nepal, a porous border which is used for unsafe migration and human trafficking. Due to its geographical location, Bihar serves as a place for source, transit, and destination for victims of human trafficking. The entry points in the state on the India-Nepal border are Raxaul, Bairgania, Sonbarsa, Narkatraganj, Jaynagar, Jogbani, and Kakarbita. The districts of northern Bihar (flood-affected areas) like East Champaran, West Champaran, Begusarai, Darbhanga, Katihar, Khagaria, Madhubani, Madhepura, Siwan, Sitamarhi, Supaul, Araria, Kishanganj, and Purnia are high source areas. Most of the children of these flood and poverty-stricken districts are trafficked and sent to urbanized states like Delhi, Haryana, Uttar Pradesh, Rajasthan, Gujarat, and Maharashtra. In sex trafficking cases the victims are sent to Delhi, Kolkata, and Uttar Pradesh (Das, M and Mishra, SK, 2011).

The case study of Interactions with Childline officials in Sitamarhi reveals that the frequency of child trafficking and the number of cases has increased. The officials shared that earlier trafficking was limited to individuals, but at present, it happens in groups with the help of brokers/ middlemen/ contractors/ agents. Due to widespread poverty and the impact of recurring losses due to floods and shrinking opportunities of livelihood in rural areas, agents first motivate parents to send their children to work in other cities. They loan advance money to the parents to meet their basic requirements of food or pay the outstanding loans taken by communities for expenses incurred in marriage, funerals, or medical treatment.

It is worth mentioning here that the Government of Bihar, in 2008, formulated the historical State Plan of Action called “ASTITVA- BIHAR” to combat human trafficking in the state. This action plan has an integrated approach to deal with trafficking with the participation of all the important stakeholders such as government line departments (Education, Rural Development, Social Welfare, Labor, Human Resources, Health, ICDS, Police, District administration, Judiciary etc.), CSOs and the media. In the recent past, a lot of anti-trafficking activities and rescue operations have taken place. Hundreds of people have been rescued from bondage owing to the interventions made by several civil society groups. But the impact of disasters and climate change tends to adversely affect such efforts. The need is for enhancing resilience measures, that may help in reducing the vulnerabilities of poor communities and hence save them from suffering and exploitation.

The correlation analysis among indicators of climate hazards, socio-economic features and variables related to child protection in Bihar has been established to understand the key root causes of child protection issues. (Fig 34). The key observations from the correlation study about child protection are as under:

- Child protection issues like child labor, child missing, and displacement are more prominent in areas which are prone to flood, experience heavy extreme events and have a high coefficient of variation in annual rainfall.
- Early child marriage cases are more prominent in areas which are affected by heat waves and have a high multi-dimensional poverty index (see annexure)
- Child labor cases are more prominent with family of small land holdings. This situation clearly manifested in flood and drought prone areas. The areas with high coefficient of variation in annual rainfall have relatively a greater number of child labor cases.
- Child crime cases are high in areas affected by flood or have higher population affected by flood during last 5 years.
- Child missing cases are high in drought prone areas
- Number of crime cases against women is high in flood prone areas with high incidence of extreme rainfall events

Key Drivers of child protection Sector vulnerability Based on multivariate correlation

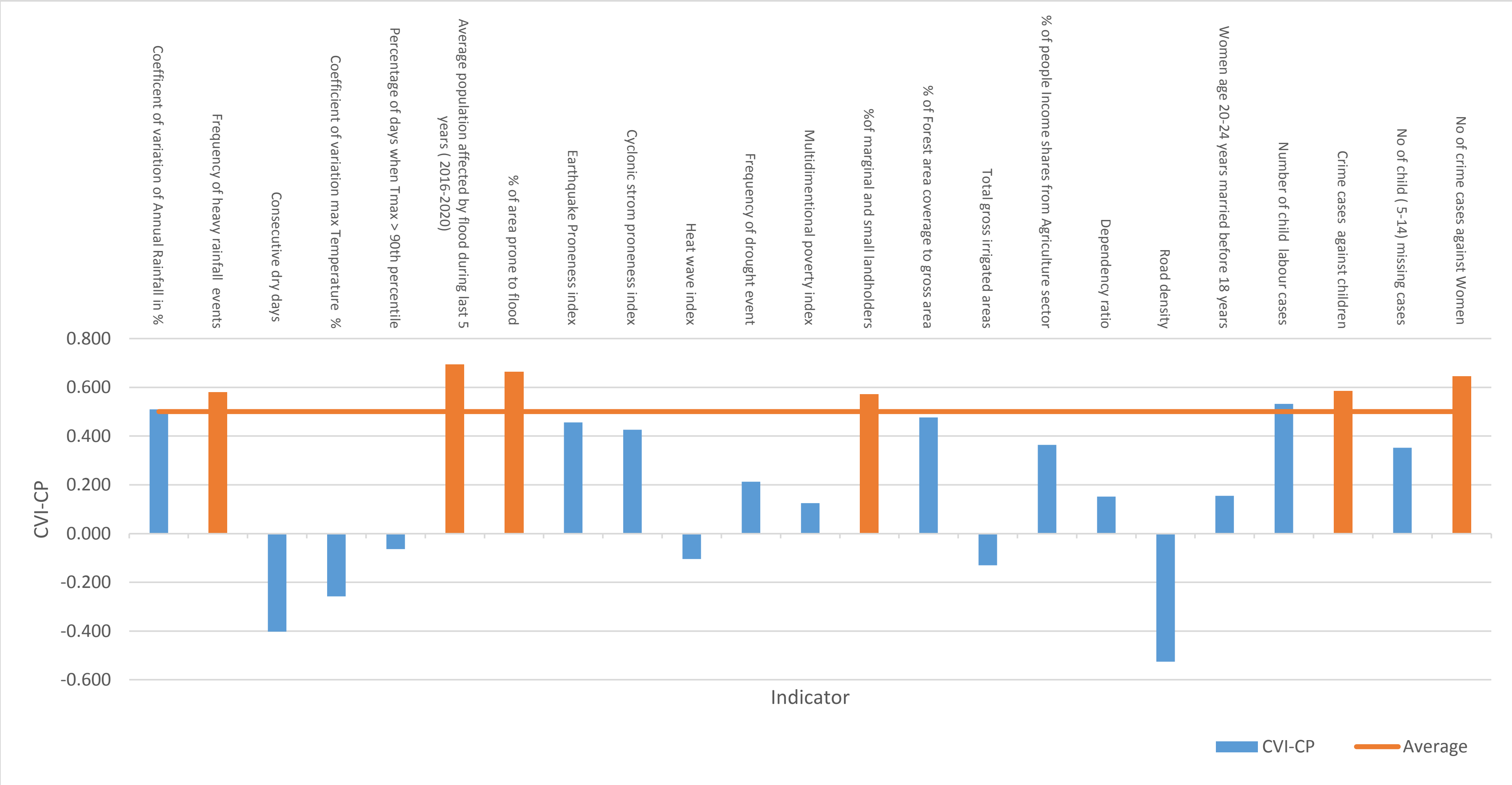


Fig.34

District Level vulnerability of child protection sector

The district-level vulnerability assessment of child protection with reference to climate change impact has been done through a composite vulnerability index using 23 indicators related to climate hazards, socio-economic development and child protection issues. In this analysis, 11 indicators are related to climate hazards, 7 are associated with socio-economic developments and 5 are of child protection issues with direct correlation to climate change impacts. The vulnerability index has been determined by the summation of all the values of the indicators divided by the number of indicators. Each indicator has been given equal weightage while calculating the composite vulnerability index and their functional relationships with climatic and socio-economic vulnerability have also been considered. The average composite vulnerability index of child protection is 0.47. Fig 35 shows that at the state level, out of 38 districts, 13 have been identified as sensitive areas in terms of child protection and they have been categorized into the very high to high category.

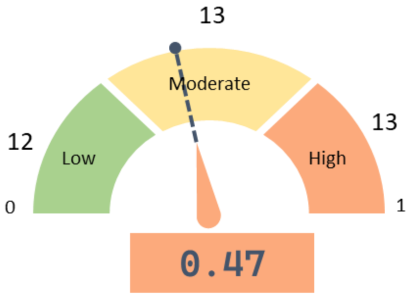


Fig.35

The value of CVI of child protection under the very high to high category varies with a maximum of 0.58 in East Champaran to a minimum of 0.35 in Arwal. The districts most sensitive to child protection issues are East Champaran, Sitamarhi, Muzzafarpur, Saran, Patna, Nalanda, Darbhanga and Araria, Khagaria, Bhojpur, Bhagalpur, Vaishali, Samastipur and Katihar. The CVI values in these districts vary between 0.49 to 0.58. Moderately vulnerable districts to child protection are Purnia, Supaul, Saharsa, Begusarai, Kisanganj, gopalganj, Suapul, Siwan, Madhepura and Gaya whose CVI varies between 0.43- 0.59. The rest of the 12 districts are categorized as relatively low vulnerability areas with CVI varying between 0.35– 0.43. (Fig.36)

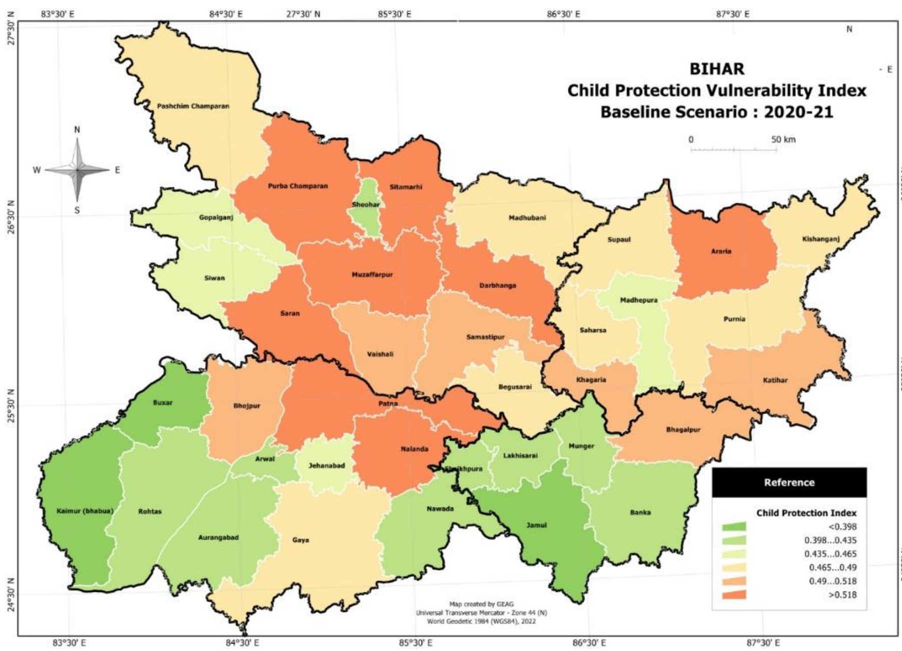


Fig.36

Indicator wise situation of child protection in districts

The situation of different districts on child protection issues as per the selected indicators is shown in Fig 37. The highlighted part represents the area where special attention is required for each indicator. Out of the 38 districts, the CVI value of 21 lies above the state average of 0.47

which indicates that 55 % of the districts are poorly performing on different indicators of child protection.

The situation of early child marriage is worst. There are 22 districts whose vulnerability index lie above the state's average. Fig. 37 shows that early child marriage cases are more prominent in areas which are affected by flood and drought and have a high multi-dimensional poverty index. Crimes against women, another important issue of child protection, is quite prevalent in flood-prone districts. There are 16 districts where this is more prominent, that include Patna, Muzaffarpur, Saran, Bhagalpur, Nalanda and Darbhanga districts. All these districts are amongst the most urbanized in Bihar. This indicates that in urban areas more cases are being registered of crimes against women.

District	Women age 20-24 years married before 18 years	Number of child labour cases	Crime cases against children	No of crime cases against Women	No of child (5-14) missing cases	Child protection vulnerability
Pashchim Champaran	0.51	0.65	0.17	0.07	0.15	**0.48**
Purba Champaran	0.80	0.67	0.46	0.22	0.10	**0.58**
Sheohar	0.38	0.03	0.08	0.01	0.00	**0.43**
Sitamarhi	0.73	0.42	0.14	0.28	0.20	**0.57**
Madhubani	0.51	0.65	0.22	0.28	0.04	**0.48**
Supaul	0.99	0.28	0.03	0.11	0.07	**0.48**
Araria	0.88	0.40	0.60	0.20	0.07	**0.52**
Kishanganj	0.44	0.15	0.06	0.12	0.04	**0.46**
Purnia	0.86	0.47	0.37	0.20	0.14	**0.49**
Katihar	0.81	0.28	0.16	0.25	0.02	**0.49**
Madhepura	0.88	0.26	0.35	0.09	0.10	**0.45**
Saharsa	0.85	0.15	0.00	0.05	0.06	**0.49**
Darbhanga	0.68	0.34	0.21	0.30	0.12	**0.57**
Muzaffarpur	0.33	0.51	0.73	0.46	0.27	**0.53**
Gopalganj	0.19	0.26	0.15	0.15	0.09	**0.46**
Siwan	0.00	0.30	0.23	0.16	0.11	**0.45**
Saran	0.14	0.28	0.46	0.44	0.23	**0.54**
Vaishali	0.68	0.27	0.45	0.35	0.20	**0.51**
Samastipur	0.82	0.27	0.30	0.23	0.00	**0.50**
Begusarai	0.81	0.27	0.19	0.12	0.00	**0.48**
Khagaria	0.68	0.17	0.12	0.08	0.03	**0.50**
Bhagalpur	0.61	0.30	0.30	0.30	0.10	**0.50**
Banka	0.81	0.25	0.06	0.11	0.05	**0.41**
Munger	0.39	0.03	0.20	0.11	0.10	**0.42**
Lakhisarai	1.00	0.05	0.08	0.04	0.02	**0.43**
Sheikhpura	0.71	0.06	0.10	0.02	0.03	**0.42**
Nalanda	0.59	0.42	0.49	0.39	1.00	**0.55**
Patna	0.15	0.82	1.00	1.00	0.00	**0.57**
Bhojpur	0.28	0.34	0.28	0.30	0.12	**0.50**
Buxar	0.27	0.11	0.15	0.14	0.05	**0.40**
Kaimur Bhabua	0.17	0.12	0.16	0.09	0.04	**0.35**
Rohtas	0.26	0.27	0.26	0.18	0.11	**0.40**
Aura[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Gaya	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Naw[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Jamui	0.88	0.26	0.07	0.08	0.07	**0.38**
Jehanabad	0.58	0.04	0.06	0.03	0.04	**0.45**
Arwal	0.47	0.00	0.03	0.00	0.02	**0.42**
State Average	**0.57**	**0.31**	**0.25**	**0.20**	**0.11**	**0.47**
Districts Above Average	**22**	**13**	**14**	**16**	**12**	**21**

Fig.37

Child labor is the third most important component of child protection which needs greater attention. This is most prominent in West Champaran, East Champaran, Sitamarhi, Madhubani, Araria, Purnia, Darbhanga, Muzaffarpur, Nalanda, Patna, Bhojpur, Gaya and Nawada districts. These districts are mostly flood-prone and the livelihood of the people gets severely affected every year. Child trafficking is more prominent in border districts and flood-affected areas like East Champaran, Sitamarhi, Purnia, Muzzafpur and Darbhanga. Crimes against children is also an important issue of child protection. This is noticed mostly in East Champaran, Madhepura, Muzzafarnagar, Saran, Vaishali, Samastipur, Nalanda, Patna and Bhojpur. These districts have comparatively higher CVI values than the state average.

Recommendations for child protection sector for vulnerable areas

<table>
<tr><th>Recommendations</th><th>Timeframe for action to be accomplished</th><th>Framework for implementation</th></tr>
<tr><td>Strengthen and institutionalize village-level mechanisms in flood-affected districts for the reduction in child labor through sensitization on issues related to protection. Older children can play a vital role in this process</td><td>Medium to long term</td><td rowspan="8">Need to create awareness on child protection

Mainstream climate risk of child protection in existing policy

Need departmental collaboration

Training of frontline workers on child protection issues</td></tr>
<tr><td>Link every child with AADHAR with their family to ensure protection against trafficking during distress period</td><td>Medium to long term</td></tr>
<tr><td>Vulnerability mapping of children residing in high-risk flood and drought zones</td><td>Long term</td></tr>
<tr><td>Orient parents, teachers PRI members, SHGs and SMC members and children on various risks faced by children during flood disasters in villages</td><td>Short to medium term</td></tr>
<tr><td>Orient and give training to the families including children on immediate measures that must be taken in case of any disaster</td><td>Short to medium term</td></tr>
<tr><td>Undertake child-centered risk assessment at block and district levels in coordination with District Disaster Management Authorities, District Child Protections Units, PRIs and NGOs</td><td>Medium to long term</td></tr>
<tr><td>Conduct Child Protection Rapid Assessment for pre, during and post-emergency situations in coordination with community members, teachers, ASHA, AWW, PRIs and NGOs</td><td>Medium to long term</td></tr>
<tr><td>Research on emerging areas of concern/threats to children i.e., online safety, rapid urbanization, changing family structures, impact of conflict, violence and crime, and rapid climate change</td><td>Medium to long term</td></tr>
</table>

Section 5

Comparative analysis of Current and Future Composite Vulnerability Index & Spatial Pattern

Based on the above climatic change assessment and its impact on sectoral performance at the district level, an overall composite vulnerability index has been estimated by integrating all 46 indicators related to hazards, socio-economic development and 5 sectoral indicators (see annexure). This total composite vulnerability index (TCVI) will help stakeholders to understand the composite impacts of climate change on the state's economic development and provide information to the sectoral stakeholders to adopt location-specific measures to adapt to climate change.

The comparative analysis of integrated current (1992-2021) and future (2021-2050) composite VIs of the districts indicates that the average CVI of the state in future is going to increase. The current state's average CVI is 0.46 (by integrating climatic hazards and sectoral indicators) but by the mid of the century i.e., by 2050, this is expected to rise to 0.47. Fig.38 gives an indication that with the changing emission scenario, the state will become more vulnerable to climate change impacts and the sectoral development will be affected.

Fig.38

The comparison of districts under different categories also gives the important information that the shades of vulnerability are going to shift. Currently, out of the 38 districts, 12 have been recognized under the very high to a high category, 13 under the moderate to moderate high and the rest 13 under the low to very low segment. (Fig 38). But in the

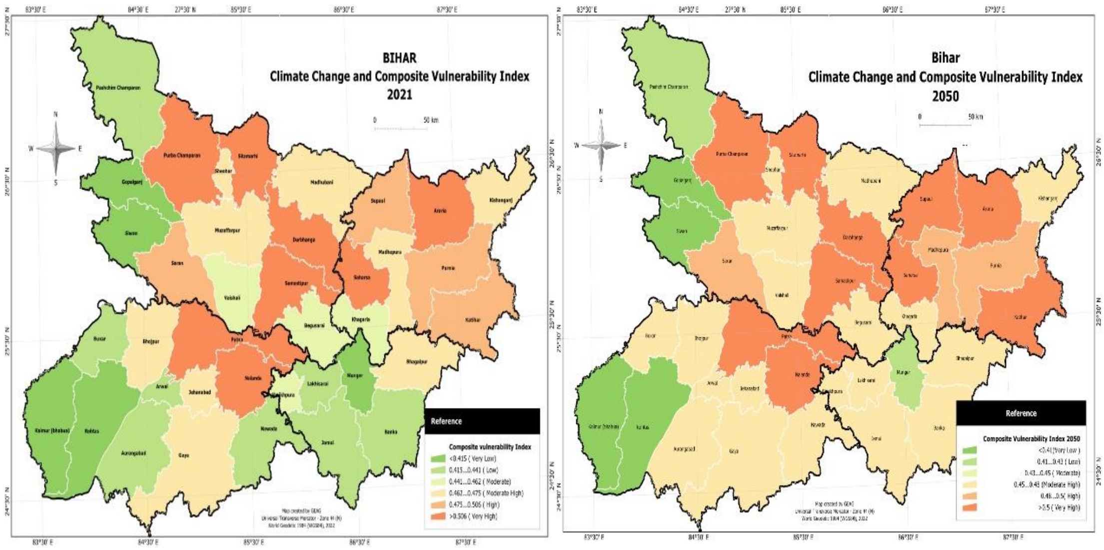


Fig.39

coming thirty years (2021-2050) this allocation of vulnerability shades is expected to change. By 2050, the number of districts under the very high to a high category is expected to increase to 13, but more importantantly by the 2050s, the number of districts under the moderate to moderate high category are expected to increase from 13 to 19. This means, that the number of districts which lie on the upper range of the low to the very low category will move and shift in to the moderate category. The above Fig. 39 shows the spatial comparison of the CVIs of 2021 and 2050s. The analysis of both figures clearly shows that the vulnerability index of districts south of Ganga is expected to change. At present, districts like Aurangabad, Buxar, Arwal, Nawada, Jamui, Banka, lakhisarai are in the low-vulnerable category, but all these districts will be fall under the moderate category by the 2050s. This means, that with decreasing rainfall and increasing average temperature, the agriculture sector will be deeply affected and consequently, this will enhance the vulnerability and challenges of other sectors of child development.

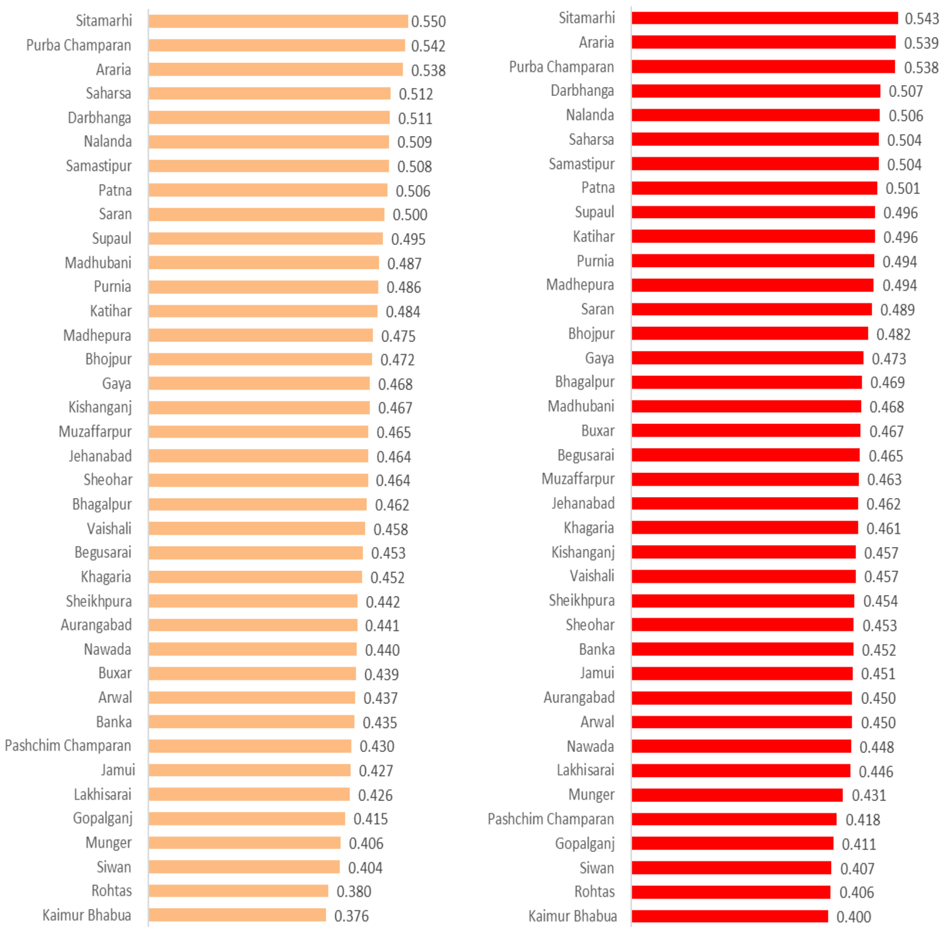


Fig.40

The vulnerability ranking of districts in the future is also expected to change. Fig. 40 shows the ranking of districts in climate change vulnerability. Sitamarhi district will be the most vulnerable, while Kaimur Bhabhua will be the least vulnerable in both years.

Way forward

It is noteworthy that climate vulnerability index is a relative measure, and shows the position of one spatial unit with respect to the other. But that does not imply that a spatial unit with low vulnerability is climate resilient in an absolute sense. The purpose of deriving this index is to measure the comparable degrees of vulnerability for all districts of the states, so as to prioritize climate change adaptation planning and investment. The analysis will also be helpful for the state and district administration to understand the major drivers of vulnerability and target the adaptation actions accordingly. Thus, based on the VIs derived, the report concludes that all districts in Bihar are vulnerable to climate risks. However, the ranking of districts using a VI indicates the relative vulnerability of the district and such an assessment will help policymakers and funding agencies to prioritize districts for adaptation interventions. Also, with differentiation in the relative vulnerability of districts in Bihar, the corresponding response by various stakeholders should ideally be differentiated as well. In more vulnerable districts the adaptation action related to child development should focus on reducing vulnerability, while in districts that are relatively less vulnerable the adaptation actions should be geared towards managing climate-induced hazards and exposure to these hazards. Such a targeted approach will help in enhancing the efficiency and effectiveness of adaptation actions.

This assessment will assist in the following manner:

- A vulnerability assessment can assist in ranking and identification of the most vulnerable districts and help the departments related to child development to prioritize adaptation planning and investments. It will provide a basis to identify the entry point of intervention for adaptation planning and investment at the district level through the identification of priority sectors and major drivers of vulnerability.

- The sectoral vulnerability assessments carried out in the report can be a supporting document to mainstream the climate risk component into the sectoral development plan. Vulnerability assessment is a dynamic and inherently a data-intensive process. Hence it is important for the state, district and line departments to update their data regularly to make their plan coherent and effective. Followed by the state and district-level analysis, the vulnerability assessment should ideally be carried out also at a block/village level. There too the availability of data in a similar resolution is important. Overall, it shows the importance of the generation of data on important indicators in regular and relatively shorter intervals, for an effective risk assessment. Thus there is a need in the future to strategize data generation for climate-change risk and vulnerability assessment and adaptation planning.

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