Journal of Climate Change, Vol. 10, No. 1 (2024), pp. 35-42.
DOI 10.3233/JCC240005

Disruption in Agricultural Pattern Due to Unpredictable Weather Conditions and its Effect on Farmer's Family of Kishanganj District of Bihar

Saifuddin Soz* and Md. Shahid Raza
Department of Social Work, Maulana Azad National Urdu University, Hyderabad, Telangana, India
✉ saifsoz93@gmail.com

Received January 16, 2024; revised and accepted February 10, 2024

Abstract: The unpredictable weather conditions due to climate change have resulted in significant changes in global weather patterns, affecting various sectors across the world; mostly the agriculture sector which got affected. This study focusses on the changing agricultural patterns caused by climate change and their severe effects on farmers' livelihoods in the Kishanganj District of Bihar. The purpose of this study is to look at the dynamic interaction between changing weather patterns and agricultural practices and the socioeconomic implications for the local farming community. This study intends (1) to explore farmers' perceptions and their experience of climate change towards agricultural practices, (2) to understand the adaptive techniques used by farmers in the Kishanganj district of Bihar in response to altering the agricultural patterns, (3) to assess the socioeconomic consequences of shifting agricultural patterns on farmers' lives. Through a comprehensive literature review and primary data collection, including in-depth interviews with local farmers, to discover variations in agricultural patterns, changing weather patterns, and changes in farming practices adopted by the farmers in response to unpredictable weather conditions. From the findings of this study, it is revealed that the agricultural sector in Kishanganj is extremely vulnerable to unpredictable weather patterns, such as severe droughts, unseasonal rainfall, and temperature variations. The changing weather patterns have resulted in significant crop loss, which resulted in lower agricultural production, less income, and more debt for farmers' families. The negative effects of weather-related disruptions extend beyond economic factors, affecting both farmers' families and food security.

Keywords: Climate change; Agriculture; Farmers; Livelihood; Green social work.

Introduction

Climate change is causing rapid shifts in agricultural patterns, which is very important for the survival of humans. The unpredictable weather patterns in India, where agriculture is the backbone of the country's economy provide a living for millions of people being an agrarian society, the complicated connection between climate change and agriculture is most obvious, because of its specific geographical and climatic characteristics, the Kishanganj District of Bihar appears to be an interesting study focus point within this complex range of climate-induced changes in agriculture. Kishanganj District is located in northeastern "Bihar" an Indian state, near the borders of Nepal and West Bengal. Kishanganj's weather is influenced by several weather patterns, especially the Indian monsoon. Weather variations have a major effect on how people do farming and live in this region (IMD, 2011). According to a 2008 research conducted by the Institute for Human Development, farming is extremely significant for the local economy of Kishanganj's districts. Here the farmers grow a variety of crops throughout the year. During the winter, they concentrate

*Corresponding Author

on crops like wheat, maize, jawar, gram, masoor, pea, mustard, flax seeds, etc. The agricultural landscape changes as the Kharif season approaches to include GarmaDhan (non-seasonal rice), Moong, Til, and Jute. However, some areas of the district are also devoted to horticulture, with 675 hectares of extensive mango orchards, 640 hectares of pineapple plantations, 305 hectares of banana cultivation, 230 hectares of coconut groves, 47 hectares of guava farms, and 33.5 hectares of fertile land for litchi orchards.

The unpredictable weather condition is a matter of concern not only for India, or not just for Kishanganj but for the whole world. According to the Indian Meteorological Department (IMD) and other climate research, the climate in the Kishanganj district of Bihar in India has changed significantly in the last few years. The traditional agricultural practices, which used to follow a predictable rhythm of weather events with the monsoon, are now less predictable due to recent climate change. Those farmers, whose livelihoods were heavily reliant on farming, were suddenly confronted with new and unanticipated challenges. Such changes had an impact on the overall aspects of their life, from how much money they could earn and the food they consumed to how they interacted with others in their community for social well-being.

Climate Change and Food Security

The Intergovernmental Panel on Climate Change (IPCC) issued a warning that variations in rainfall patterns, global warming, and extreme weather conditions can have a major negative impact on food production throughout the world. Also, as per the Food and Agriculture Organisation (FAO), farming is highly sensitive to the negative impacts of climate change. From the World Bank study, it was found that climate-related factors might reduce our food production by 30 percent by the end of 2050. This will certainly worsen hunger and malnutrition in existing vulnerable areas. For this, we all must work together to prevent climate change and promote sustainable farming. In this manner, we can guarantee that there is enough food for everyone on the planet (IPCC, 2022). Also, melting glaciers and altering rainfall patterns disturb agricultural water sources, which is especially difficult in developing countries where small farms lack the means for adaptation. Global collaboration, sustainable farming practices, and new technology are critical for maintaining food security for everyone while tackling climate change (FAO, 2015).

Background

Unpredictable weather patterns produced by global climate change are of great concern impacting many sectors, and such patterns are being seen in the Kishanganj District in Bihar, India, which is undergoing significant changes. This study dives into the complex interaction between climate change and developing agricultural practices in Kishanganj, to understand how these changes affect the way of life of local farmers.

Significance of the Study

This study is essential because it focusses on the complex interaction between unpredicted weather conditions due to climate change and agriculture, particularly in places like Kishanganj, where farming is essential to the community's well-being. The study intends to add to our understanding of the impact of climate change on agriculture and adaptation techniques, with a focus on the vulnerable state of Bihar in India. This study can help to build sustainable and climate-resilient agriculture strategies that benefit both the community and the environment.

Literature Review

Food and Agriculture Organisation of the United Nations (FAO, 2021) emphasises the importance of weather in effective farming, resulting in how farmers live and earn their livelihoods. Even non-weather events, such as pollution or loss of wetlands, contribute to severe weather changes. Climate change is expected to exacerbate food poverty by boosting costs, less production, and causing a decrease in productivity as a result of severe occurrences such as heatwaves and droughts. This has the potential to raise poverty rates, particularly in vulnerable areas, also Soz and Mankar (2021), in their study, found that "People now have the understanding of variation in climate change in terms of changes in the weather, unseasonal rain, and drought." Chandler (2023) adds that as the planet is getting hotter every day due to global emissions, climate change has a huge impact on agriculture, particularly on small farmers in low-income countries. Extreme weather conditions and changing weather patterns exacerbate agriculture and livestock affecting around 80 million people in the Horn of Africa. Without adaptation to this, the global food supply might fall by 30 percent by the year 2050, putting 43 million Africans in poverty by 2030.

In a study done by Paria et al. (2022), they found

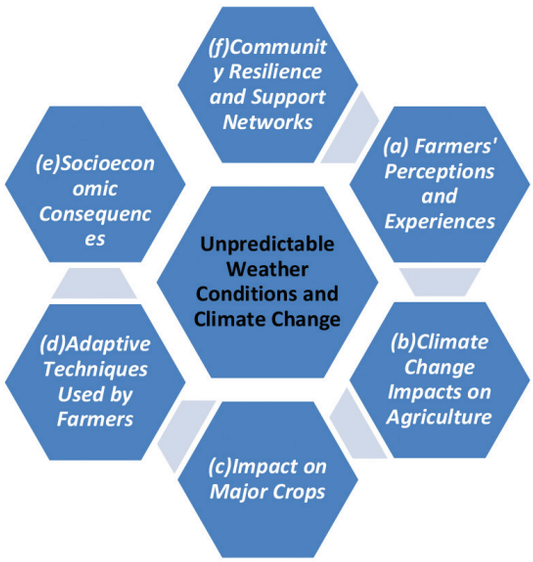
that climate change is causing problems in agriculture in West Bengal state, particularly in places like Alipurduar and Cooch Behar. More extreme weather, such as heavy rainfall and droughts, have harmed more than 60 percent of farmers, which resulted in a 70 percent loss in food production. It was also noted that to overcome this problem only 40 percent were eager to experiment with new ideas. The impact of climate change on agricultural patterns in India has been studied in a 2019 policy paper by Srinivasa Rao, Prasad, and others from ICAR. Farmers' lives had more difficulties due to climate change, which is affecting the way crops are grown.

The influence of climate change on farmers' lives was studied by Krishnakanth and Nagaraja (2020) in Kolar District, Karnataka, India. Their study showed that climate change, particularly a considerable shift in rainfall over the last decade, has been recognised as a serious threat undermining traditional farming techniques. Groundwater levels have been drastically lowered as a result of increased extraction for water-intensive crops, which has been exacerbated by insufficient rainwater gathering systems. The study conducted by Choudhary and Sharma (2022) on Rehua village in Bihar, India, focuses on the consequences of climate change on small farmers. The study emphasised the difficulties farmers face, such as altering weather patterns, decreased rainfall, greater temperatures, and rising farming expenditures.

Rohin Kumar emphasised the significant issues Bihar confronts as a result of climate change in a 2021 paper. According to an Indian Institute of Technology (IIT) report, 14 of Bihar's 50 districts are at high risk, citing factors such as limited forests, unreliable food crops, and insufficient farmer support during crises. Pushyamitra highlighted how farmers in Bihar adapted to harsh weather in 2021. To make their agriculture more sustainable and to cope with floods, they shifted to growing makhana, commonly known as foxnuts. Bihar is a major producer of makhana all over the world. To avoid flooding, they began cultivating it on low-lying land with government assistance. Farmers discovered makhana to be more resilient due to the erratic weather that affected maize and rice.

Conceptual Framework

This study shows how unpredictable weather conditions due to climate change affect the lives of farmers and their families. It starts with (a) Farmers' Perceptions and Experiences, in which farmers offer their perspectives on how climate change and changing weather patterns are affecting their conventional method of farming and their lives. While going through (b) Climate Change Impacts on Agriculture, it shows real problems such as crop failures, decreased agricultural production, and increased pest infestations on the farm. Specific crops like (c) rice, wheat, jute, and maize are being examined for susceptibility, which had an impact on local supply and market pricing. (d) Farmers' new adaptive techniques include crop diversification, improved irrigation techniques, early planting times, and improved insect management. Apart from crop yields, there are (e) socioeconomic consequences such as income instability, distress on food security concerns and financial vulnerability. These challenges affect more than just the residents of the neighbourhood. Examining (f) Community Resilience and Support Networks which highlighted the local communities' collaborative efforts to aid farmers, emphasised collective action in the face of climate-related challenges. This comprehensive approach is a lens through which to examine the complex dynamics of disturbed agricultural practices.



Research Methodology

Food Security Concerns

The methodology shows the technique adopted in this study to explore changes in agricultural patterns due to unpredictable weather conditions.

Objectives

- To Explore Farmers' Perceptions and Their Experience of Climate Change Towards Agricultural Practices.
- To Understand the Adaptive Techniques Used by Farmers in Kishanganj District of Bihar in Response

to Altering the Agricultural Patterns.
- To Assess the Socioeconomic Consequences of Shifting Agricultural Patterns on Farmers' Lives.

Research Design and Methods Used

The researcher has used descriptive, qualitative research design to conduct this study. For this in-depth interviews were conducted in the Kishanganj District with different groups of farmers from various age groups, genders, and agricultural methods used by them as well as the size of land on which they do farming. The purposive sampling technique of non-probability sampling was used to choose participants for in-depth interviews. This study is qualitative in nature and based on data saturation, the appropriate sample size for in-depth interviews was chosen. The required number of interviews were held to achieve data saturation and 15 in-depth interviews were taken.

Data Analysis

Thematic analysis was used to do a qualitative data analysis of the in-depth interviews, which included the following: Transcription, coding, and development of themes based on which the interpretation was done.

Ethical Consideration

During the study, all ethical guidelines were strictly followed by the researcher. People's dignity, the choice to participate, privacy, and the freedom to exit the research at any moment were all protected. The information gathered was kept secure and was only utilised for the study.

Discussions

Farmers' Perceptions and Their Experience of Climate Change Towards Agricultural Practices

The sudden weather change due to unpredictable weather conditions is a matter of concern for the farmers of Kishanganj district of Bihar, which has a direct influence on their method of agricultural practices which is a great source of livelihood for them.

Farmers' perspectives towards climate change: Farmers have observed that local weather is unpredictable due to climate change as compared to earlier days. They have observed variations in the temperature, rainfall pattern, draughts, and unseasonal rain. Such observations and experiences are serious in realising the effects of climate change on their daily lives. An important background for more extensive knowledge is provided by the farmers' experiences is:

*"**IDI-1:** I have never seen such changes in the weather conditions in the last 10-15 years, sometimes it rains when there are no rainy seasons, during the rainy season we get extreme heat during the paddy cultivation when we need water the most, the cost of our agriculture expenditure goes up because we have to be dependent on the borewell pumping set operated through Diesel engines which cost us more but when we try to yield during the early winter we get rain which destroys our paddy cultivation which puts an economic burden on us as the brokers don't give us enough price for these crops."*

Climate Change Impacts: These studies related to climate change provide significant evidence of how changes in weather patterns affect agriculture with an emphasis on the following major areas:

1. ***Crop Failures:*** Farmers agreed on crop failure due to climate change. Unpredictable weather, such as irregular rainfall, and sudden unexpected rain, badly affect their regular cultivation schedule, resulting in reduced harvest and financial loss.
2. ***Less outcomes:*** Farmers are finding it difficult to grow adequate crops they were growing previously due to climate change. They are getting less production, making it difficult to feed their family and sell them in the market, causing food and financial distress among them.
3. ***Increased Pest Infestations:*** Climate change has produced ideal circumstances for pest infestations, causing agricultural loss and lowering farmers' production. Insect pests and other crop diseases thrive in the changed environment, creating extra pest control issues for the farmers.

*"**IDI-2:** Our forefathers were dependent on agriculture like we are also dependent on agriculture but at their time there were no such advanced tools, technology, or techniques they were getting quality of their cultivation and these days with advanced technologies and high yielding variety of seeds, chemical fertilizers, insecticides, and pesticides we get something which is poison for us, this time we use such chemicals which makes us sick they are very powerful but for better production we need them to use or else it is not possible to get better production."*

Impact on Major Crops Due to Climate Change in Kishanganj District

Paddy: Because of unpredictable rainfall patterns

and droughts, paddy agriculture is severely disrupted. The output of paddy may fluctuate as a result of these weather-related issues, which might have an impact on both the local supply and the price of this important crop.

*"**IDI-3:** I have grown paddy for decades and I have always been in the farming sector, we got good quality of seeds and better fertilizers and I was supposed to get better production, what happened in the last three to five years is the unseasonal rain has destroyed the hope for us, because when we need water we don't get, we have to be dependent on groundwater, they small plant get dry if the required amount of water we can't give to the farm, but if we grow with all efforts then at the time when there is no rainy season we get rain that time, and which damages the crop and brings loss to us, but these days I do not have much courage to do farming, the cost is getting high and we also don't get labor these days."*

Wheat: Climate change-related adversities might affect the region's wheat farming, lowering production. These setbacks can affect the local wheat supply and affect wheat market prices.

*"**IDI-4:** I and many other people who were farming Wheat have stopped doing it because of three major reasons, they are, climate change unavailability of labour, and another is the COVID-19 pandemic, since the government has started giving us ration for each family member that is sufficient for us, earlier we were doing Wheat cultivation for our personal use only, but now it is not needed as we get them in the ration shops. The quality of wheat is good, so we wash and dry them, and then take out the flour, but the rice quality is not good, we sell it and buy other necessary ration with that amount, because of this reason we have stopped cultivation of wheat, and we don't have to suffer as we do suffer in other crops."*

Changes in the weather pattern have affected Jute farming, which was an important source of revenue generation in this district. On understanding about how climate change affects important crops like Jute was critical for developing adaptation measures in this region. The farmers' experiences, which revealed the hard reality of climate change adaptation in Kishanganj, showed that these issues stretched beyond farming and affected their lifestyle as well as the entire community.

*"**IDI-5:** Those days are gone when people relied on rainwater. These days, technology and electric supply in agriculture fields, along with pumping sets, make it easy to water our crops. However, these systems are costly, and not everyone can afford to fill a pond through motorized water pumping sets. This is essential to fill low-lying areas or ponds so that jute plants can be submerged to facilitate ripening and the extraction of Jute fibers. The Jute production has significantly decreased in this area, particularly in 'Chhattargachh-in Kishanganj District,' where we used to have a Jute mill for processing the fiber. Unfortunately, it had to be closed down. We also had a 'Mustard oil' extraction mill, which met a similar fate due to the declining production of both Jute and Mustard, leading them towards extinction. Only a few farmers still engage in this cultivation, primarily for personal use as edible oil in their households."*

The Adaptive Techniques Used by Farmers in Kishanganj District of Bihar in Response to Altering the Agricultural Patterns

Farmers in Kishanganj District, Bihar, are being forced to innovate and use adaptive techniques as climate change disrupted the well-established agricultural patterns they have been practicing for years. Adaptive methods are:

Diversification of Crops: Diversification of crops is one adaptation technique used by farmers. Many farmers have increased the variety of crops they grow due to the unpredictable weather conditions and the rising frequency of severe incidents like droughts and unseasonal rainfall. Farmers are incorporating more robust and climate-adaptive crops like drought-resistant millets, pulses, and climate-resistant vegetables instead of only relying on Paddy and Wheat.

*"**IDI-6:** Our father planted a Mango Orchard with more than 50 plants all together when we were young, but our children could not eat, the unpredictable weather conditions and hail storms unseasonal rain destroy the mango flowers, or damages the mangoes, "SurjapuriAam" is most common mango variety in this area but what happens is the mango looks fine from outside but once you cut it there are insects inside, god knows from where it goes inside, it looks fresh from outside but from inside you can't even think of eating, now what we did it we have sold those Trees and in that place cultivated "Tea garden" along with "Nuts plant-Supari" which will give benefits The Tea plantation is dominating these days in this area and profitable you don't have to wait for months to get money once the plant grows in every 45-50 days of cycle you get income which is quite sustainable."*

Improved Irrigation Techniques: Farmers are investing in better irrigation techniques to address such issues by irrigation methods, such as drip and sprinkler irrigation techniques, to save water and confirm that crops are adequately moistened even during dry seasons. To store rainwater for irrigation, some farmers are now following rainwater harvesting techniques to store rainwater.

Improved Planting Schedules: The farmers are adjusting to the timing of crop planting, opting to sow their crops either a little earlier or later than the usual time by closely monitoring weather predictions and by studying local climate trends, these farmers aim to optimise planting schedules. This positive approach not only enhances crop development but also minimises the risk of losses caused by unpredictable weather conditions.

*"**IDI-7:** Me and my brother used to grow wheat, but we have stopped doing it, we save the land to grow Maize, in this belt the production of Maize is getting high, and we get better prices for it, sometimes it becomes very challenging, due to unseasonal rain to get them dry, last year while processing and drying, two days of continuous rain have brought economic burden for us, we have borrowed money to get the production and the rain has destroyed everything we get less price than the market price, the production was good but we could not process it and dry them gave us less value, it is uncertain what kind of weather we will get."*

Improved Pest and Disease Management: Climate change has increased the number of pests and diseases affecting the crops on the farms. Farmers are responding to this by implementing integrated pest control techniques. To reduce pest infestations, they use pest-resistant crop types and cultural methods such as crop rotation and intercropping methods.

*"**IDI-8:** I grow vegetables but earlier the production was less and most of my vegetables got damaged because of the insect bites in the early stage of the growing stage of the vegetable but the insecticides helped us to keep them away and get more production, many people say that this will harm the people who will eat them, but who will feed me? I have no other work to do, I have three boys who work as laborers in different states, what they earn they only know, but the advanced chemicals help in flowering and mass production, I grow "Lauki-Bottle Guard", "Baigan-Brinjal," "Kheera-Cucumber," what I earn from them is sufficient for me and my wife.*

While these adaptive strategies have become essential for farmers in the Kishanganj District, to cope with shifting agricultural patterns, they are also concerned with difficulties.

Socioeconomic Consequences of Shifting Agricultural Patterns on Farmers' Lives

The response of the farmers has uncovered the challenges the farmers have faced, they also gave an understanding of new farming techniques such as adaptive changes in the cropping cycle, the crops they plant regularly and the new crops they grow and how they have adopted and how these techniques have influenced their livelihood in farming. These techniques provide an important context for understanding the complicated social effects of agricultural developments due to unpredictable weather conditions.

Socioeconomic Effects

This study has also highlighted the socioeconomic effects due to altering agricultural patterns faced by farmers. These implications are divided into the following categories:

Income Variability: Farmers described income changes as a result of shifting agricultural trends. Unpredictable weather and crop choices have resulted in financial insecurity, limiting their capacity to satisfy family requirements and invest in their farms.

Food Security: Changes in agricultural patterns have ramifications for regional food security. Farmers expressed difficulties in securing a consistent food supply for their families, with some resorting to market purchases owing to lower crop yields.

Rural Livelihood: Changes in farming methods influence rural livelihoods. Farming has traditionally been a significant source of livelihood in this region. However, as agricultural practices change, farm labourers have fewer opportunities during particular seasons. This move has an impact on rural occupations, threatening agricultural labourers' lives. For example, if weather changes cause some crops to fail, there will be less employment during planting or harvesting, resulting in job insecurity. This can result in unemployment and financial problems for agricultural workers and their families, prompting some to seek employment outside of agriculture and leave the rural job market.

Market Dynamics: Farmers emphasise the impact of agricultural changes on the local market. The main source of concern is the uncertain agricultural

production caused by climate change. When crop yields remain uncertain, it impacts the availability of local agricultural products, affecting market supply and demand and generating price changes. For example, poor output in a given year leads to restricted supply and increased pricing, making it difficult for farmers to forecast market circumstances and influence crop selection and selling decisions.

Financial Vulnerability: Farmers are financially susceptible as a result of the socioeconomic effects of shifting agricultural trends. Economic uncertainties and unpredictability make it difficult for them to plan for the future. Because of the uncertainty of weather and agricultural production, people were hesitant to invest in modern farming procedures or technology.

Impact of Shifting Agricultural Patterns on Major Crops in Kishanganj District

Understanding how evolving agricultural patterns influence different crops is critical for establishing strategies and policies. Here are some examples of how certain crops are affected:

Paddy: This farming is hampered by erratic rainfall patterns and extended droughts. This caused changes in paddy yield, affecting local supplies and potentially the price of this critical crop.

Wheat: Changes in agricultural techniques can have an impact on wheat growing in the region, and lowered production. These setbacks influenced both local wheat supplies and market pricing.

Jute: Jute agriculture, an important source of revenue for the area, was adversely affected by unpredictable weather conditions due to climate change. Variations in the amount and quality of jute produced had an impact on market pricing.

The consequences of climate-related challenges to farming extend beyond agricultural operations, affecting farmers' livelihoods as well as the larger society. Crop failures and decreased agricultural output that have a direct impact on farmers' income, causing financial hardship and insecurity. This economic vulnerability not only limits farmers' capacity to prepare for the future, but also restricts access to necessities like food, education, and healthcare, boosting stress levels. The broader community is feeling the consequences as well, with financial difficulties among farmers reaching through local markets and community organisations. Hence the climate-induced disturbances in farming practices have broad implications for farmers and wider society.

Conclusion

The main focus of this study was to investigate the unpredictable weather conditions effect of climate change on the farmers and their families, affecting their farmings in the Kishanganj District of Bihar. They have faced various obstacles such as sudden rainfall and prolonged droughts, which have affected their regular methods of farming and which have also affected their lifestyle. They were well aware of the disruption due to climate change and accepted it as fate but tried to cope and be resilient with these changes by adopting new techniques or changing cropping patterns.

Recommendations

- The disruption in the agricultural pattern is due to climate change and people are aware of it but they have no help from the Government side or any awareness campaign, what they have learned is from the neighbouring state WB nearby area Siliguri and Uttardinapur, they have adopted the agricultural practices from these places and learned to cultivate tea and pineapple, now heading towards dragon fruits too.
- The Kishanganj District has an Agriculture College i.e. "Dr. Kalam Agricultural College", the college must engage with the local farmers and adopt the nearby villages to train the farmers in adapting new techniques and promoting climate-resilient crops in dealing with recent issues and challenges faced by local farmers.
- The farmers get agriculture loans with lots of hardship but there is no crop insurance for them, the Government must provide crop insurance to all the farmers who take loans for agricultural purposes so that there won't be any distress among the farmers and their families if their production gets affected.
- The government should promote sustainable farming practices by the farmers which can promote soil health by promoting organic fertilisers and minimising chemical fertilisers which will directly lead to better production.

Promotion of inter-state farm products exhibitions in the District for the farmers of the Kishanganj District so that, knowledge, methods, and techniques can be learned by the farmers and they can choose better adaption methods to resilient climate change.

References

Chandler, M., 2023, March 30. How Does Climate Change Affect Agriculture? Heifer International. Retrieved from https://www.heifer.org/blog/how-climate-change-affects-agriculture.html on 24-09-2023

Choudhary, K. and Sharma, G., 2022, April 30. Bihar: Climate Change Aggravates Agrarian Crisis For Small, Marginal Farmers. Newsclick. Retrieved from https://www.newsclick.in/Bihar-Climate-Change-Aggravates-Agrarian-Crisis-Small-Marginal-Farmers on 23-09-2023

Food and Agriculture Organization of the United Nations (FAO), 2015. Climate change and food security: Risks and responses. Retrieved from https://www.fao.org/3/i5188e/I5188E.pdf on 23-09-2023

Food and Agriculture Organization of the United Nations (FAO), 2021. The impact of disasters and crises on agriculture and food security: 2021. Rome. Retrieved from https://doi.org/10.4060/cb3673en on 23-09-2023

Government of India, India Meteorological Department, 2011. Climate of Bihar. Issued by the Office of the Additional Director General of Meteorology (Research), India Meteorological Department.

Institute for Human Development, 2008. A Baseline Survey of Minority Concentration Districts of India: Kishanganj (Bihar). Sponsored by the Ministry of Minority Affairs, Government of India, and the Indian Council of Social Science Research.

IPCC, 2022. Chapter 5: Food Security. In Special Report on Climate Change and Land: An IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. Retrieved from https://www.ipcc.ch/srccl/chapter/chapter-5/ on 23-09-2023.

Krishnakanth, B.N. and Nagaraja, B.C., 2020. Adaptations to climate variability and agrarian crisis in Kolar District, Karnataka, India. *Nature Environment and Pollution Technology: An International Quarterly Scientific Journal*, **19(3):** 1279-1285.

Kumar, R., 2021, May 19. Bihar highly vulnerable to climate change, says study, but lacks action plan. Mongabay India. Retrieved from https://india.mongabay.com/2021/05/bihar-highly-vulnerable-to-climate-change-says-study-but-lacks-action-plan/ on 23-09-2023

Paria, B., Mishra, P. and Behera, B., 2022. Climate change and transition in cropping patterns: District level evidence from West Bengal, India. *Environmental Challenges*, **7:** 100499. Retrieved from https://doi.org/10.1016/j.envc.2022.100499 on 24-09-2023

Pushyamitra, 2021, March 25. Bihar farmers take up makhana farming to cope with weather uncertainties. Mongabay India. Available from: https://india.mongabay.com/2021/03/bihar-farmers-take-up-makhana-farming-to-cope-with-weather-uncertainties

Soz, S. and Mankar, D., 2021. Impact of climate change on rural livelihood: A case study of central Rajasthan. *Journal of Climate Change*, **7(4):** 19-27.

Srinivasa Rao, Ch., Prasad, R.S. and Mohapatra, T., 2019. Climate Change and Indian Agriculture: Impacts, Coping Strategies, Programmes and Policy. Technical Bulletin/Policy Document 2019. Indian Council of Agricultural Research, Ministry of Agriculture and Farmers' Welfare and Ministry of Environment, Forestry and Climate Change, Government of India, New Delhi.