Exploring the link between climate variability, drought, and internal migration in Purulia district, West Bengal, India

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Certificate from Supervisor

This is to certify that the thesis entitled "**Exploring the link between climate variability, drought, and internal migration in Purulia district, West Bengal, India**" submitted by **Tulika Guha** who got registered (**registration no. D-7/ISLM/42/18 dated 16/02/2018**) her name under the Faculty of Interdisciplinary Studies, Law & Management for the award PhD (Science) degree of Jadavpur University is absolutely based upon her own work under the supervision of Prof. Sugata Hazra and that neither her thesis nor any part of the thesis has been submitted for any degree/diploma or any other academic award anywhere before.

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I, **Tulika Guha (Reg. No. D-7/ISLM/42/18 registered on 16/02/2018** do hereby declare that this thesis entitled "**Exploring the link between climate variability, drought, and internal migration in Purulia district, West Bengal, India**" contains literature survey and original research work done by the undersigned candidates as part of Doctoral studies.

All information in this thesis has been obtained and presented in accordance with existing academic rules and ethical conduct. I declare that, as required by thesis rules and conduct, I have fully cited and referred all materials and results that are not original to this work.

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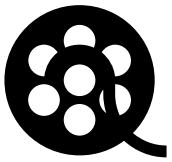

This work is dedicated to my grandmother, Mrs. Sneha Guha, and my parents, Mrs. Shukla Guha and Mr. Tapas Guha.

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- Guha, Tulika, Sugata Hazra "Climate change and drought: understanding people's perceptions and micro-level adaptation decisions in Purulia, West Bengal, India"
- Guha, Tulika, Sugata Hazra. "Trapped Population: Amid Climate Change in Purulia District." Under Preparation.

Abstract:

A variety of environmental and other factors influence the complex link among migration, droughts, and climate change. The exact consequences of climate variability and drought on migration, particularly under various socioeconomic conditions, are still poorly understood in India, despite recent studies illuminating how climate change drives movement due to drought. Rainfed agricultural areas have seen a rise in migration in recent decades to crowded cities, which are becoming more and more susceptible to climate-related hazards. West Bengal, an important agricultural hub, especially its arid western areas, requires detailed research to identify the vulnerability and potential socio-economic risks posed by drought. Purulia, one of West Bengal's districts most susceptible to drought, has yet to be thoroughly studied in terms of climate variability, drought, social vulnerability, and migration. The purpose of this research is to examine the relationships between Purulia's societal vulnerability to migration and climate challenges, focusing on the distinct effects of climate within the wider socio-economic context in a district plagued by drought.

This study aimed to assess this with five objectives: a) To investigate drought and climatic variations in the district b) To evaluate how drought affects agriculture c) To conduct a social vulnerability analysis at the sub-district level. d) To find out the key factors that determine the decision to migrate internally. e) Find out different ways of coping and adapting

This research aimed to fulfill its objectives using both quantitative and qualitative methods. A quantitative strategy was used for the first three goals. To understand the Purulia district's climate variability and the frequency and severity of droughts, methods including linear regression, rainfall anomaly index or RAI, standardized precipitation index or SPI, and precipitation concentration index were used. The study used the crop failure index, multiple regression, and coefficient of variation to evaluate the effects of drought on crops. Social vulnerability was examined through principal component analysis and subsequently visualized using GIS to identify the locations of socially vulnerable populations. The fourth and fifth objectives relied entirely on comprehensive household surveys utilizing semi-structured questionnaires and life histories. The binary regression model, the Kruskal–Walli's test, the Wilcoxon signed-rank test, and the

Likert scale were used to examine the field data. To determine how different environmental and socioeconomic factors affected migration decisions, binary logistic regression was used. During drought years, households spent significantly longer time fetching water from distant springs each trip than in normal years, with a significantly lower overall number of trips/days to distant water sources, according to the Wilcoxon signed-rank test. Additionally, during times of drought, when rice, vegetable, and oilseed output significantly decreased, the amount of water gathered per trip from distant sources was significantly higher. The Kruskal–Wallis test indicated that farmers with smaller landholdings were more likely to sell livestock and household assets. Furthermore, farmers experiencing frequent droughts, with low income and minimal land, were inclined to borrow money to mitigate their vulnerability. The combination of drought, social vulnerability, inadequate landholdings, and scarce income contributed to migration. The Likert scale is used to measure farmers' opinions, attitudes, or behaviors regarding their perception of the damage caused by the drought in their region, and various socio-economic impacts of the drought, etc.

This research adds to the body of knowledge by focusing the micro-level, examining how various environmental stressors such as rising temperatures, reduced rainfall, and droughts trigger internal migration. The research outcomes indicate an increasing frequency and intensity of droughts in recent years, with a notable rise in rainfall concentration; 11 years of very high rainfall concentration were recorded over 30 years, and out of the last 20 years, 10 years experienced high to very high rainfall concentration. However, the amount of rainfall is inadequate to meet the water demand for the cultivation of rice, as the rainfall nowadays falls at the end of the monsoon months (usually at the end of July and August). Additionally, the study area's land cover is extremely thin and made up of reddish and sandy material that is the result of granite and gneiss weathering. The land here is hilly and infertile with a porous layer that cannot store water. 78 percent of fluctuations in rice yields are due to climatic uncertainties, with drought years leading to lower yields and crop failures. Spatial analysis identifies the southern and southwest sections of the district as the primary drought-affected regions. The Social Vulnerability Index from 2001 and 2011 reveals that these areas are more socioeconomically vulnerable as well. Sub-districts such as Baghmundi, Manbazaar 1, Manbazaar 2, Bundwan, and Joypur were struck by drought approximately five times between 2000 and 2011, and they exhibit poor irrigation compared to cultivated areas,

along with limited access to assets and infrastructure, low literacy rates, and high dependence on agriculture. Research shows that the poor and marginalized, who are socially vulnerable, live in areas affected by droughts. These droughts cause repeated crop failures and income losses, forcing them to seek work elsewhere. The data indicates that frequent moderate droughts greatly increase short-term migration in both peak and lean seasons, while severe droughts, like the one in 2010, result in permanent migration. Migration results from the interaction of socioeconomic vulnerability, increasing drought severity and frequency, and climate variability. Reducing social vulnerability through social security programs such as MGNREGA and free food distribution via PDS can help individuals build assets. The water crisis can be addressed through micro-irrigation techniques like constructing ponds, hapas, and dighis, which can mitigate crop failure and alleviate drinking water shortages. Implementing these measures can bolster people's resilience, decrease their vulnerability, and curb migration.

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Chapter 1

(Introduction)

1. Introduction

Migration has been a topic of inquiry in social sciences for decades. The movement of people from one location to another is known as migration. People relocate to pursue greater opportunities and a higher quality of life as economies and populations expand. Migration, therefore, is an integral part of the socio-economic life of countries across the world. Despite being a constant throughout human history, human migration presents opportunities and difficulties as civilizations grow more varied. With growing populations and increased mobility, the world's migrant stock is larger than in the past. At the same time, the world is experiencing environmental degradation, pollution, biodiversity loss, land use changes, and climate change due to these factors (Neil Adger et al., 2015). Yet, the accounts of this global environmental change as a cause behind migration decisions are scarce (Panda, A., 2010). However, the scientific evidence on increasing climate change over the decades and its disastrous impact on migration (IPCC 2014), makes research on migration due to climate change and weather extremes time-sensitive.

1.2 Definition of migration

Migration is a major factor in any geographical analysis of population change (Trewartha, 1969). Among the three primary elements of population change, migration proves challenging to conceptualize. Various scholars have proposed distinct definitions for migration, reflecting their diverse methodologies. Sociologists have focused on the social effects of mobility, while economists have prioritized the economic side of migration, and geographers have highlighted the time and space significance of mobility. Bogue (1959) defined migration as the movement of people as a tool for social integration and cultural dispersion that leads to a more meaningful population distribution. According to Everett Lee, migration is defined as a change of residence that is either permanent or semi-permanent. He also states that migration always involves a place of origin, a destination, and a set of obstacles that intervene in between. Migration, according to Demko, G.J. Ross, and H.M. Schnell (1970), is the

most complicated part of population change. Migration serves as a significant network for the dissemination of ideas and information, and it also reveals the characteristics of social and economic development. Since no one can be in two places at once, Chapman, K. (1979) examined migration as an example of relocation diffusion. According to Zelinsky, W. (1971), migration is a cultural phenomenon that arises from a society's general structure, which includes a range of economic, social, and demographic behaviors. Migration is defined by the United Nations in 1970 as "a taking-up of life in a new or distinct place"—a population movement in space that implies a change in place of origin. According to the International Organization of Migration (IOM), migration is the either temporary or permanent movement of a person from their usual place of residence for a variety of reasons, whether within a nation or across international borders.

Many economic, social, political, demographic, and environmental factors—be it push or pull factors—generally characterize migration. However, to study human migration both theoretically and empirically, social scientists have typically concentrated on social, economic, and cultural factors (Massey et al., 2010). Additionally, theories of migration, whether they be neoclassical or new economics of migration, have not particularly addressed the role of environmental factors in migration dynamics (Jónsson, G., 2010). According to the Foresight report,2011, migration drivers were divided into five: economic, social, political, demographic, and environmental.

1.3 Environmental migration

1.3.1 Evolution through Time

We are currently living in a period when our worries regarding a variety of environmental difficulties and migration are closely linked in policy discussions by several different governments and international organizations, political arguments, and scientific studies. Fifty years ago, there would have been no need or possibility for the environmental migration thesis since there was a lack of solid theoretical or empirical evidence linking population migration, environmental change, and the welfare of people, households, and nations. However, this does not imply that these connections did not exist; rather, it indicates that little research was being conducted at the time. Very few researchers and even smaller policymakers gave this subject any thought until

the middle of 1991. Following that, there was a decades-long surge in interest in migration caused by environmental factors (McLeman, R. and Gemenne, F., 2018).

1.3.2 The timeliness of the research on environmental migration

This chapter looks for answers to why environmental migration continues to be a topic of interest and why more research is needed on it.

First, there has been growing global concern that the scale and scope of human environmental degradation have worrisome implications for human well-being, particularly the danger created by anthropogenic climate change calls for research. The United Nations General Assembly directed the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) to form the Intergovernmental Panel on Climate Change (IPCC) in 1988 to conduct a regular evaluation of scientific understanding regarding the changing climate, its effects, and potential hazards (www.ipcc.ch). The UN Framework Convention on Climate Change (UNFCCC) was not drafted up until 1994, and the Kyoto Protocol (https://unfccc.int) was not signed by the international community until 1997, marking the first significant steps toward tackling the challenges of the changing climate. Through the UNFCCC procedures, governments and institutions were requested to evaluate how susceptible their nations were to the effects of the changing climate. The threat presented by climate change to millions of individuals and their governments beyond the scope of science. As a result, trustworthy research became increasingly important. In its numerous publications, the (IPCC) started to illustrate the kinds of physical changes that would occur in the ensuing decades if greenhouse gas emissions persisted without a halt (Climate Change: The IPCC 1990 and 1992 assessments; IPCC AR4, AR5, AR6; Global Warming of 1.5°C).

Second, there is a growing recognition that the effects of climate change, global warming, and a rising number of natural disasters have profound consequences for human well-being and, in consequently, for human migration. However, many scholars did not feel compelled to investigate the relationship between migration and the environment until the 1970s and 1980s, following a series of catastrophic famines and natural disasters in Africa and Asia (McLeman, R. and Gemenne, F. 2018). Due to multiple research (Lonergan, S., 1998; MYERS, N., 2005; Stern, N. and Stern, N.H., 2007; Brown, O., 2007), the problem of migration caused by climate change has started

to get attention. Then-UN Secretary-General Ban Ki-moon referred to the civil war in Darfur, Sudan, between pastoralist tribes and agrarian communities during a lengthy drought in 2007 as a "climate curse," emphasizing that the bloodshed in Darfur was a result of changing the climate. The study of environmental migration is also growing, and it is clear that the Paris Agreement began in 2016. Signatory nations were asked by this agreement to develop strategies for handling migration problems brought on by the negative consequences of changing the climate. People were being moved for environmental reasons, prompting the development of numerous additional global organizations (UNHCR, IOM).

1.4 Concept of Environmental Migration

Environmental change and migration are both growing and polarizing issues shaping the 21st century (IPCC 2014). The movement of people due to challenging environmental conditions has occurred in all times and places, both voluntarily and involuntarily (De Haas, H., 2010; McLeman, R.A., 2014). How changes in the environment have caused migration over the last ten years deserves more attention in the context of the world's changing environment today (TGOFS 2011; IPCC 2014). Around the world, both abrupt and slow changes in the environment have historically led to various forms of migration; nevertheless, a significant portion of contemporary research focuses on increased concern about the growing effect of change in the environment on migration (Ou-Salah, L., et al. 2022).In recent years, policymakers, researchers, and international communities have paid increasing attention to the grave consequences of changing climate and the degradation of our environment as a tool of livelihood vulnerability that causes migration (Zetter, R., 2017). In its IOM Migration Study Series No. 31, (IPCC) argues that human migration will be the area most affected by changes in the climate. In its AR6 report, the IPCC notes that since the AR5 assessment, there have been rising indications that the majority of migration related to changes in the climate will be internal and that hazards linked to extreme weather and variations in the climate act as a direct stimulus for people's movement (IPCC, 2022: Climate Change 2022). The upcoming decades are predicted to see a surge in catastrophic incidents and catastrophes of nature like floods, droughts, and cyclones, which will raise the likelihood of displacement in susceptible areas in the future, according to the AR6 assessment.

1.5 Drivers of Migration

Drivers of migration are forcing that lead to the triggering of migration and the continuation of movement (Van Hear et al. 2018). A complicated group of interlinked variables that impact a human being, family members, or community decisions concerning migration, particularly displacement, is how the International Organization for Migration (IOM) describes drivers of migration. In addition to local, national, regional, and international incentives and pressures, the idea of "drivers of migration" is constantly changing and represents the interplay of individual, social, structural, environmental, and context-specific elements. The decision to migrate is influenced by a variety of circumstances, including voluntary to forced movement, whether the migration is internal or external, irregular or regular, either short-term or long-term, etc. (2019, IOM Glossary).

1.5.1 Environment as a driver of migration

According to Ou-Salah et al. (2022), change in the environment has an impact on society by exacerbating pre-existing issues and disparities according to Black et al. (2017) and McLeman & Gemenne (2018), environmental factors act as a "threat generator" by putting stress on additional variables that affect choices regarding migration. Migration is often the final resort and is one of the many viable responses to environmental or changes in the climate, although it is not necessarily a deliberate or planned decision (DeWaard, J 2022). Human migration, according to Hunter, L.M. et al. (2015), is a complicated choice impacted by a person's socioeconomic, demographic, and environmental circumstances. Studies conducted by Adger, W. N et al. 2021, Stoler, J. et al. 2022; Moore, M. and Wesselbaum, D., 2023, etc. showed that migration decision or intentions is significantly influenced by various drivers including environmental ones. Globally, abrupt and gradual events are becoming more intense and frequent due to climate change (IFRC, 2021). There is strong evidence that the negative effects of climate-related events on livelihoods that are susceptible to climate change both directly and indirectly contribute to involuntary migration (IPCC, 2022). According to the IPCC's sixth assessment report, involuntary migration from areas with limited adaptive ability and high exposure to climatic threats will happen as warming intensifies.

Climate change shows its effects in many different forms. The consequences of the changing climate can be classified as either slow-onset or rapid-onset events according to the temporal scale (Schafer, L.2021). While some changes manifest gradually over time, others occur rapidly. Environmental migration is caused by either slow-onset or fast-onset natural disasters (Jayawardhan, S., 2017). A gradual disaster like drought takes a long time to develop, whereas a fast-onset disaster happens all at once. While slow-onset catastrophes create difficulties through their effects on the economy of an area and society at large, fast-onset disasters cause havoc that is felt instantly. Geological threats like tsunamis, quakes, and volcanic explosions; hydrological hazards like flooding of the coast and landslides; and atmospheric hazards like typhoons, hurricanes, tornadoes, and snowstorms are all considered fast-onset disasters, according to UNISDR (www.unhcr.org). The dangers and effects of increasing temperatures, rising seas, acidifying the oceans, increasing desertification, glacier melt, and related effects, as well as salinity, land and forest destruction, loss of biodiversity, and (Unfccc. in) drought, are all referred to as slow-onset events (WMO, 2016; NIDM). Both fast- and slow-onset events have interacting effects on internal migration patterns, but the characteristics of movements associated with slow-onset events are diverse and difficult to fully decipher and categorize. According to Li, Y. et al. (2014) and Zickgraf, C. et al. (2016), there is a tenuous connection between migrating desires and disasters that strike suddenly, whereas slow-onset changes are hard to identify since they develop gradually, thus their effects take time to manifest. IOM 2020 warned that in the future, slow-onset events and processes will likely increase environmental risk for a growing number of people in less prosperous countries. Although they will affect all dimensions of human life, measuring the total number of population movements will be difficult. First, at the national, regional, or local level, rapid-onset events are unique, one-off occurrences that have clear beginnings and finish in a matter of days or hours. Slow-onset events, on the other hand, do not have an identifiable beginning and end, but develop gradually, step by step (IOM 2020). Their severity manifests only over time and increases over years, decades, or even centuries (UNHRC 2018)-resulting in loss and damage to livelihoods and assets in affected regions and affecting poor and vulnerable people in society (Kehinde, B., 2014). Second, because there are many social, environmental, and other variables at play, movement related to events that occur slowly frequently requires important choices. The magnitude and nature of impacts on people and society are also influenced by their ability to mitigate risk, their access to alternative livelihood options,

and their welfare and support systems. Third, within the same affected context, people's responses will vary according to their different vulnerabilities. Their socioeconomic profile may also determine whether they will be directly affected by the process or suffer indirect consequences. Fourth, decisions to migrate based on slow-onset events are also influenced by family and individual capacity and inclination. Migration may be a survival strategy for some people to mitigate negative economic impacts, but some people or households may be able to stay put and adapt or cope locally. Others may not have the means to relocate and are stuck in the affected region. Each of these elements contributes to the complexity. The 2020 report of the IOM on displacement within countries in the context of the gradual onset of negative climate change impacts assumes that the majority of these movements will be internal (small distance, possibly following an existing pattern or circular), regardless of the circumstances.

Since 2008, a standard of 25.3 million people has been forced out annually by sudden-onset disasters alone, according to the Internal Displacement Monitoring Center. However, this number does not include people who have moved as a result of slow-onset climate-related events like drought, rising sea levels, salinization, etc. Rapid onset events continue to be a key focus; in 2019 alone, 25 million people had to evacuate due to storms, floods, and other rapid-onset disasters (IDMC, 2019). Even if these numbers are quite convincing, they don't take into consideration slower, gradual events which have a more prolonged effect on people's movements but get less emphasis (Rigaud, K.K et al 2018). Information about migration about slow-onset occurrences undergo a variety of limitations, like data collection efforts, prevailing structures, the complexity of environmental processes, and other socio-economic and demographic issues (IOM,2020). These events along with individual and social vulnerabilities under specific demographic, economic, and political contexts have an impact on people's or communities' capacity to handle stress" The impact of slow-onset events is just one of many factors that influence households' or individuals' decisions to relocate, making it challenging to collect data on movement related to slow-onset incidents (Stapelton et al. 2017). We must acknowledge that slow-onset processes will have a greater direct effect on the everyday lives and means of sustenance of people who work in climate-sensitive industries, such as agriculture. Groundswell has released a research titled "Preparing for Internal Climate Migration." Washington, DC: According to

them internal climatic/environmental migration is increasingly being driven by slow-onset climate change events.

1.5.2 Drought as a Driver

According to Dai (2011), drought is a slow-onset extreme climate phenomenon that is typified by prolonged below-normal rainfall. A protracted dry spell in the natural climatic cycle that can happen anywhere in the world is referred to as a drought by the World Meteorological Organization. The phenomenon has a gradual beginning and is brought on by little rainfall. A period of unusually dry conditions that results in significant hydrological imbalances is referred to as a drought by the (IPCC). The report goes on to define drought by dividing it into four categories: hydrological (low levels of water in lakes, rivers, and groundwater), meteorological (when rainfall is beneath average), agricultural (lack of soil water), and socioeconomic (a mixture of the above). Drought is a naturally extreme climate event that varies throughout time due to its connection with hydrologic, geologic, geomorphic, ecological, and sociocultural factors (Yet al., 2019). According to the United Nations' special report on drought 2021, the Global Assessment Report on Disaster Risk Reduction, drought is a serious and complicated climate-related hazard that has extensive and cumulative impacts on economies and societies. Because of its slow onset, drought is difficult to define and manage. According to NIDM, drought is a significant slow-onset disaster that occurs when a region's water supply is inadequate for months or years due to a lack of or insufficient rainfall. This kind of situation arises when a specific area repeatedly receives rainfall that is below average. The following are some ways that drought is different from other natural disasters.

First: Typically, droughts endure anywhere from a few months to several years and are aggravated by the dryness of soils and the low level of water reservoirs and aquifers. The effects of drought do not occur suddenly as they do with hurricanes or floods, but drought makes itself felt slowly over an extensive period. Compared to harm caused by other types of natural hazards, the consequences of drought are less evident and cover far greater regions (Wilhite et al., 2014). Impacts build up gradually over time. Because of this, it is challenging to identify the beginning and end of drought, and scientists and decision-makers frequently differ over the standards (i.e., criteria) for doing so.

Second, compared to the harm caused by other natural hazards, the effects of droughts are more disorganized and dispersed over a wider geographic area. Compared to other natural hazards, the effects of drought are much harder to measure and offer disaster assistance for since they can have an impact on the environment and the economy across months, years, and sometimes decades. The creation of precise, trustworthy, and timely assessments of the extent and impact (i.e., drought early warning and knowledge systems) as well as, eventually, plans for drought response and preparedness have been impeded by these drought-related features. In contrast to floods, tropical storms, earthquakes, and other natural disasters, droughts frequently have a wider geographic extent, making it difficult for emergency personnel entrusted with responding to these events to deal with the effects. Additionally, the type and magnitude of impacts within the drought-affected area vary due to various economic, social, and environmental vulnerabilities.

Third: The state of drought must be viewed as relative rather than absolute. In almost every climatic regime, it can be found in regions with both high and low rainfall. Drought can have a devastating effect at times, leading to individual hardship as well as environmental and economic damage. To better manage droughts, some nations are now finding it helpful to create or take into consideration national strategies and policies. Both industrialized and developing nations seem to be experiencing an increase in the effects of drought. This trend has a lot of contributing components. Concerns about growing susceptibility are compounded by worries that climate change may make these extreme climate events more frequently occurring, chronic, and, in the case of droughts, longer in the future. In both water-scarce and water-surplus regions, where disputes within and between nations over access to safe and dependable water supplies are growing, more frequently occurring and extreme droughts are a concern as strains on restricted water supplies and other limited natural resources continue to increase. As part of a national development strategy and a climate change adaptation plan, it is essential to reduce the effects of future drought episodes (Wilhite et al., 2014).

In many regions of the world, both the severity and frequency of droughts have recently increased (Milly et al., 2016), for which many factors are responsible, but the concern about increasing social vulnerability is that future extreme climate events, such as droughts, may become more regular, severer, and last longer due to the danger of climate change. Drought has a natural and a social component, just like any other

natural hazard. The social component is typically what turns a hazard into a catastrophe. Both the territory's exposure to the event (i.e., the likelihood of occurrence at different severity levels) and the society's susceptibility to the event influence the risk that a region faces from a drought (Blaikie et al., 1994). Geographical differences in drought exposure notwithstanding, factors such as demographic changes, economic activity, governmental regulations, environmental deterioration, and population shifts all affect vulnerability (Wilhite et al., 2014). As these elements change over time, vulnerability is going to increase or decrease. According to Bokarjova et al. (2004), the worst effects of a drought in the same region include damage to ecosystems, decreased agricultural productivity, a shortage of clean water, income loss, restricted access to resources, welfare, and social safety nets, intergroup disputes, migration, etc.

1.6 Impact of drought

According to Vogt et al. (2018), there are two types of effects of drought: direct and indirect. When certain water limitations intersect with environmental, social, or economic variables, direct effects occur. A complex effect pathway leads to indirect or secondary repercussions, which are not immediately brought on by water shortages. Examples of direct repercussions include drying wetlands, reduced forest productivity, crop loss, diminishing energy production, and restricted public water sources. However, the effects of droughts are frequently indirect because water is essential to lives and economic sectors. These secondary effects have the potential to quickly spread across the economy, impacting regions that are distant from the source of the drought and continuing long after it has ended. In addition, problems with business, income loss, a rise in school dropouts, short- or long-term unemployment, and the spreading of disease from tainted air and water can all result from drought. By resulting in hunger, famine, malnutrition, and shortages of food, it may be a factor in both internal and international migration. According to Adaawen et al. (2019), the latter may increase the possibility of conflicts between communities in the host nation or region.

According to the United Nations Office for Disaster Risk Reduction's (UNDRR) GAR special report on drought 2021, drought is one of the most expensive and damaging climate-related disasters in the world. It has a major detrimental effect on the socioeconomic sectors of local economies, especially in areas where agriculture is the

main source of income (Edwards et al. 2009). However, due to their difficulty in quantifying, drought impacts often get left out of damage evaluations much like other natural hazards like floods or storms. Drought is characterized by three distinct features: first, it is spatially and temporally variable, meaning that it can occur over a range of periods, from a few months to decades, and from a small area to an entire country; second, it has multifaceted impacts that are multi-sectoral and cascading; and third, it is indirect, meaning that its immediate visibility is often limited.

1.7 Drought and Migration

Drought is listed as one of the typical climatic causes of migration in the IPCC AR6 report. Prolonged droughts reduce rural income and force people to explore alternatives, which serves as an indirect driver of migration. One of the main causes of land degradation is drought, which negatively affects rural people who depend on resources and may result in loss of livelihood and eventual migration from impacted areas. In drylands, where environmental changes including rising precipitation variability, more frequent droughts, ongoing water shortages, and soil degradation can have a significant impact on migration, the environment plays a part in the processes of migration. Drought can have a direct impact on migration by reducing environmental services (for example, making water scarcer) or by influencing the other factors that influence migration (for example, lowering crop yields, intensifying social conflict, and eroding local social capital).

However, some communities are deemed trapped, and migration is not a viable choice for everyone (IOM and UNCCD, 2019). Not everyone has the financial and human resources needed for migration. Furthermore, migration may be impeded by certain political and socioeconomic obstacles. The lack of resources needed for relocation binds many pastoralists and families of smallholders to a life of immobility. Some impacted households migrate in circles to make up for losses after prolonged droughts, usually within their nation or to a neighboring country. Individual family members move for a short time to work in commercial agriculture or the unorganized urban economy. One of the earliest studies on migration and drought in Mali, for instance, revealed that short-distance and circular movements typically rise during droughts (Findley, 1994).

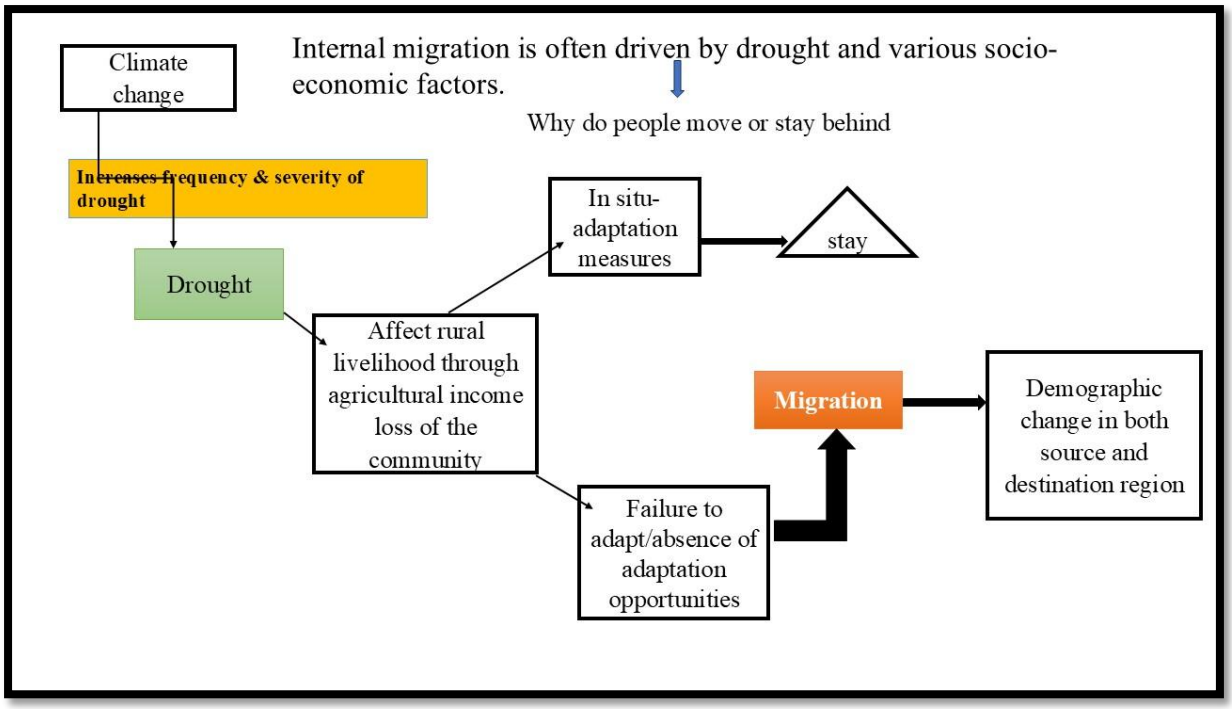


Fig 1 Conceptual framework of drought and migration

1.8 Relevance of the selection of the topic of climate migration/Study context

There are several reasons why climate migration is an important topic. It includes the geopolitical ramifications, the necessity for proactive and compassionate management techniques for such migratory flows, and an awareness of migration patterns as a required type of adaptation in response to changing climates.

The Indian economy is challenged by changes in the climate, especially in agriculture, which is highly dependent on rainfall. In India, weather has a direct impact on crop output (Krishna Kumar et al., 2004). There has been a reduction in monsoon rainfall as a result of climate change (Auffhammer et al., 2012; Dash et al., 2007; Ramanathan et al., 2005), a transition to more extreme rainfall patterns (Goswami et al., 2006), and regular rainfall anomalies during monsoon months. Additionally, surface temperature rises have accelerated noticeably (Padma Kumari et al., 2007). According to research by Hari, Khare, and Subramanian (2018), temperature and rainfall fluctuation have an irregular adverse influence on crop production in India, with the worst effects being at extreme levels. Furthermore, unfavorable weather patterns have been shown to decrease agricultural revenue, which exacerbates poverty (Hari et al., 2018) and increases inequality in rural regions (Sedova, Kalkuhl, & Mendelsohn, 2019). As India's

most impoverished populations are forced to flee their homes, land, and means of subsistence due to an increase in extreme weather occurrences, such as extreme temperatures, hailstorms, flooding, and periods of drought, climate migration is being exacerbated. India is one of the top ten countries most affected by climate change, according to Germanwatch's annual Global Climate Risk Index 2021. The country's inaugural climate change evaluation, released in 2020, forecasts a temperature increase of 4.4 degrees Celsius by the century's end under a "business-as-usual" scenario. The report also indicates that heatwaves could quadruple in frequency, hurricanes could intensify, and sea levels could rise by 30 cm without mitigative efforts.

Interviews were done in Rajasthan, Madhya Pradesh, and Uttar Pradesh—states that are well-known for their seasonal migration—by researchers from the International Institute for Environment and Development (IIED). The lack of agricultural or fishing jobs in these regions leads many people to relocate to Maharashtra, Gujarat, and New Delhi in search of work in the cotton fields or construction industries According to the survey, during the previous ten years, the frequency of droughts increased significantly for more than 70% of households, which increased distress migration as a survival tactic. According to the IIED, India's social security schemes do not promote climate change tolerance and do not account for severe weather. As a result, managing the effects of extreme weather is difficult for many of India's most vulnerable groups, particularly smallholder farmers. Studies in Sunderbans, Kalahandi and Orissa have also shown climate-related migration, however, all these surveys have been conducted at micro level in the absence of any national or state-level initiatives.

1.9 Study Gap

Despite these alarming statistics, there is no unified approach to addressing climate-induced displacements in our country at the micro level. At the national level, there are no comprehensive policies that holistically address climate migration or acknowledge the complex experiences of various migration pathways within this However, several current initiatives and policies about infrastructure development, disaster relief, climate change adaptation, and rural livelihoods indirectly address issues of climate migration. Mitigation and adaptation to climate change are the goals of the 2008 National Action Plan on Climate Change (NAPCC). Despite focusing on regional vulnerabilities, states

have created their own State Action Plans on Climate Change (SAPCC), which do not specifically address climate migration.

In India, internal migration is predominantly viewed as related to livelihoods, with insufficient data to reflect its complexities. There are insufficient statistics on the overall number of internal migrants, displaced people, and climate refugees, and there is a noticeable absence of data that breaks down the numbers by gender. The lack of comprehensive data hampers the ability to fully understand the impact of migration across various locations and its connections, potentially leading to biased policy decisions.

Against this background, a holistic, comprehensive, and context-related approach is required. The purposes of this research are to: a) examine the connection between drought, climate change, and human migration, and b) investigate the processes and channels of climate-induced migration. Although there is a lot of study on migration caused by climate change, little is known about how different climate hazards affect migration in India as a whole. This dissertation addresses this gap through a micro-level analysis that highlights the dynamics of climate-induced migration in a drought-affected, underdeveloped, and impoverished district in West Bengal, an eastern state of India. The research aims to answer key questions such as who the climate migrants are, their destinations, and the reasons for their migration. It extends the current state of research by examining the impact of climate on migration in India at a detailed level. This is a crucial aspect as short-term migration is not captured by the census or other agencies, and, to our knowledge, there is little research on climate-induced migration in West Bengal.

1.9.1 Hypothesis in the study

The hypothesis for the current study, based on the understanding above, was established as follows:

Internal migration is often driven by drought and various socio-economic factors.

1.9.2 Research questions

The current study was primarily conceived and executed to explore answers to the subsequent questions:

- How do climate variations and meteorological drought affect agriculture in Purulia?
- How does social vulnerability to drought affect communities at the sub-district level?
- What strategies did households use to cope with the drought?

1.9.3 Objectives of the study

1. To investigate drought and climatic variations in the district
2. To assess the impact of drought on agriculture
3. To conduct a social vulnerability analysis at the sub-district level.
4. To determine the governing factors that affect the internal migration choice.
5. Find out different ways of coping and adapting

1.9.4 Importance of the study

The socio-economic, political, and institutional aspects have a significant impact on how migration is affected by climate change. Climate change susceptibility and its impact on migration decisions are shaped by these factors. Particularly vulnerable are agricultural workers who face short-term climate disruptions, and studies indicate that people in developing nations often migrate internally in reaction to climatic change. Traditionally, Migration has been used as a common response to climate variability and may remain a viable method for coping with climate risks in the future if certain prerequisites are fulfilled. Providing information on climate change and incremental threats such as droughts in poor, underdeveloped regions can help global policymakers alleviate negative impacts in both the areas of origin and destination.

Chapter 2

(Overview of The Study Area)

2. Introduction

Drought has a serious impact on West Bengal's western region, with Purulia district being one of the hardest hits (Bhunia et al., 2020; Roy & Hazra, 2020). The district's agriculture, primarily dependent on rain, suffers significantly during monsoon deficits, impacting the state's GDP. As a major agricultural hub, West Bengal's drier western region requires detailed analysis to assess the vulnerability and potential socio-economic losses from drought. Purulia has suffered from repeated droughts, which pose a serious threat to its predominantly agricultural population. Marked by high poverty rates, frequent crop failures, loss of livelihoods, and widespread seasonal migration, the district endures persistent water scarcity. It encompasses 20 of the 36 blocks under the state's Drought Prone Area Programme (DPAP). Despite an annual rainfall of 1100–1500 mm, Purulia continues to experience recurring droughts, the most severe occurring in 2010. The district is the third poorest in West Bengal and lags behind in areas such as communication, housing, urbanization, sanitation, safe drinking water, healthcare, and literacy. Small, dispersed agricultural holdings owned by small and marginal farmers make up around 73% of the total cultivated area, with the upland region accounting for about 60% of the total cultivated land. Scheduled Tribes and Scheduled Castes comprise 38% of the population (Census Report, 2011). For the past 76 years, Purulia's conditions have remained largely unchanged, continuing to be a significant administrative concern due to the severity of the droughts.

Although the seriousness of the drought and its negative effects on agricultural output make this district an administrative issue, no research has been done to evaluate the social vulnerability to drought and migration. The nexus between drought and migration varies across regions, depending on their levels of resource access and socio-economic backgrounds. Purulia is, as far as I'm aware, one of the most drought-prone districts in West Bengal; nevertheless, no study has examined the relationship between internal migration, social vulnerability, and drought. In light of this, the current study intends to investigate the relationship between migration and drought by analysing the district's climate variability and social vulnerability.

2.1 Location

The research area was chosen to be the Purulia district in the westernmost part of the Indian state of West Bengal. The district has a total area of 6259 km2, is home to 2,930,115 people, and has an average population density of 468 people per km2 (Census of India, 2011). It is located between latitudes 22.702950 N and 23.713350 N and longitudes 85.820070 E and 86.875080 E. The state of Jharkhand encircles Purulia, which is located in the western portion of the West Bengal district, on three sides. Hazaribagh, Dhanbad, Singbhum, and Ranchi are located on Purulia's northern, southern, and western flanks, respectively. The West Bengali districts of Burdwan, Bankura, and Medinipur enclose the eastern side. Regarding literacy, health care, safe drinking water, sanitation, housing, urbanization, and communication, Purulia district lags behind other West Bengali districts (Bagli, S. and Tewari, G., 2019). In addition, the district is the third poorest in all of West Bengal. According to the 2011 Census Report, 38% of the people in this district are members of scheduled castes and tribes.

Purulia town, which is divided into three administrative divisions—Sadar East, Sadar West, and Raghunathpur—is home to the district's headquarters. There are 20 police stations, 3 districts, 170-gram panchayats, 2683 mouzas, 2468 inhabited villages, and 20 municipal development sub-districts.

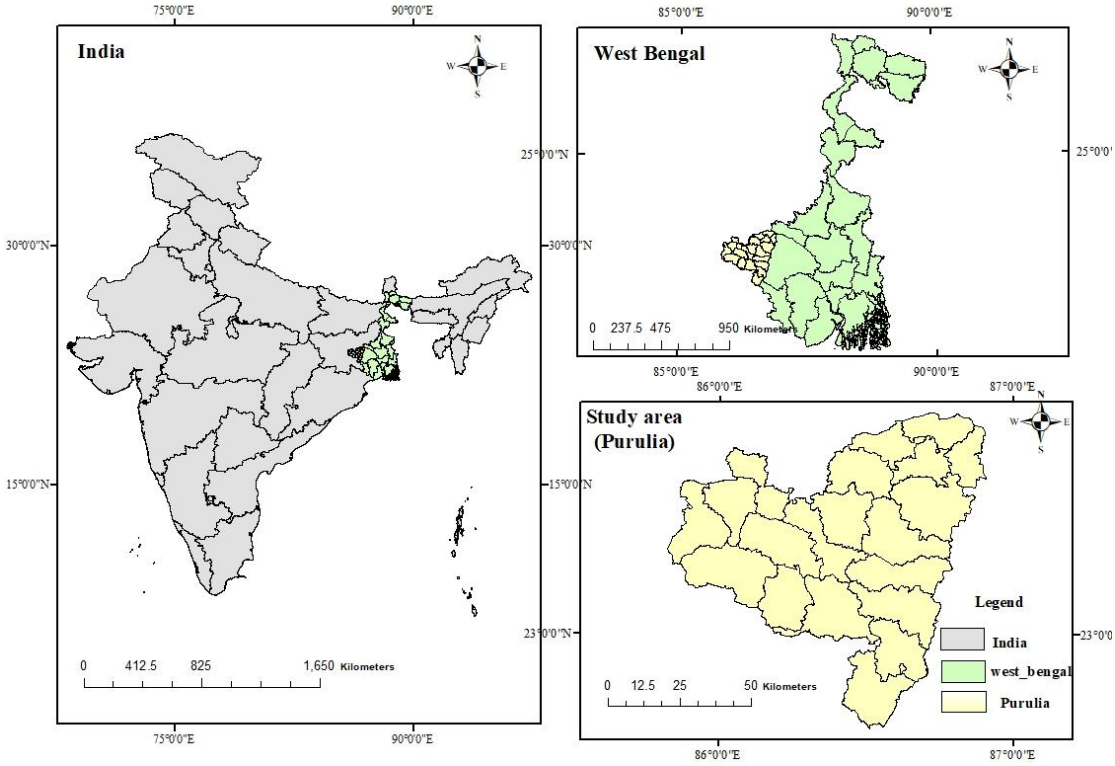


Fig 2 Location of study area

2.2 Physiography

The physical surroundings of the district are distinct. Metamorphic rocks make up the majority of its foundation. The district is clearly influenced by the Ranchi Plateau and the Chhota Nagpur Plateau. This stony terrain has relatively poor permeability and porosity. The primary barrier to the creation of an appropriate aquifer system is impermeable crystalline rock. Groundwater remains in an unconfined or semi-confined form and is found in weathered rock mantles and shallow cracks (Government of West Bengal, 1985; Roy, 2014). But it also happens in hard, crystalline rock cracks that are 50–60 meters below the surface. For quite some time, the area has been suffering severe water scarcity, which is a significant issue for Purulia's socioeconomic growth (Das et al., 2019).

The elevation of the area ranges from 63 to 712 meters above the level of the sea. The elevation of the land surface ranges from 150 to 300 meters. The principal slope of the land is oriented to the east and southeast. A physiographic division of the district into two units is possible. One is the hilly landscape that extends from the Chota Nagpur plateau in the western and southern regions. The remainder of the district, which makes up around 80% of the total area, is made up of an undulating plain with sporadic hills and knolls (NAQUIM Report on Purulia District West Bengal, 2022).

2.3 Climate

West Bengal's Purulia district is among those that are prone to drought. Low rainfall and significant evaporation are characteristics of its subtropical climate. The summers are quite hot, and the winters are cold. Typically, this region experiences winter from November to February and summer from March to June. June to September is often when the monsoon season occurs.

2.3.1 Rainfall

The district typically receives 1321.9 mm of rainfall annually. The district receives 1100 to 1500 mm of rain on average each year. The region experiences irregular and sporadic rainfall, which hinders the kharif crop and contributes to dryness. Eighty percent of the district's total rainfall comes from the Southwest monsoon, which is the primary source of precipitation in this area.

2.3.2 Temperature

The Purulia district has a dry tropical climate with lows of about 10°C at night and a chilly winter. Summers are very oppressive. Summers are very oppressive and often scorching, with daytime temperatures of over 40°C. Winter lasts from November to February. Summer begins at the end of March, lasts until June, and is very oppressive

2.3.3 Humidity and wind

During the monsoon season, the relative humidity is high, ranging from 75 to 85%. However, it falls to 25–35% in the summer. A hot, dry wind sweeps through the district at 5–6 km/h in the summer.

2.4 Drainage

The Purulia district is crossed by multiple rivers. The most significant of these are the Kangsabati, Kumari, Dwarakeswar, Subarnarekha, and Damodar. Over three-fifths of the district's water is drained by the Kasai River, which also controls the district's primary drainage.

The primary perennial rivers draining the district are the Kasai, Damodar, and Subarnarekha, which pass through the district's center. The most significant river in Purulia is the Kasai, which empties into the Kumari, its principal tributary, in the district's southern region. Small sections in the district's northeast and east are drained by the Darakeswar and Silai rivers, respectively. The district's rivers typically run in one of two directions: southeast or east. Additionally, the district has either a radial or dendritic drainage system. Sahara, Jorh, Bandhu, Nangsai, Vanumata, and other ephemeral rivers are the district's principal ones (NAQUIM Report of Purulia District West Bengal, 2022).

2.5 Soil

The most important natural and non-renewable resource is soil, whose appropriate utilization greatly influences a region's socioeconomic growth and life support system's capacity.

In this district, three types of soil have been identified: (1) lateritic soils in the uplands, (2) loam to clay in the valleys, and (3) residual types that are the result of the erosion of granite, gneiss, and schists. Despite the district's average annual rainfall of 1427 mm, nearly all of the soils are inherently acidic, and their shallow water-storing capability results in poor plant growth (District Disaster Management Plan, Purulia, 2020-2021). Lateritic soils predominate at higher altitudes, while reddish loamy loam or white to reddish clay are common in the valleys. There are many textural classes such as sandy loam, reddish loam, white or reddish stiff clay, etc (NAQUIM Report of Purulia District West Bengal,2022). The district's prominent occurrence is soil erosion, which causes a significant amount of fertile soil to be deposited in the valley area. As the soils have long been exposed to severe erosion, the topsoil layers have been lost, consequently, the soil's physical condition and fertility are extremely low. The undulation of the

topography and excessive runoff lead to soil erosion and moisture stress. Large tracts of land remained uncultivated wasteland

2.6 Geology

Hard granite gneisses of the Proterozoic, containing soft phyllites and mica schist rocks of the Singhbhum Group as a portion of the Chotanagpur plateau, dominate the geological makeup of West Bengal's Purulia district. The region is located north of the Singhbhum Craton and is a component of the Chotanagpur Gneiss Complex of the East Indian Shied Peninsula. Granitic rocks and metasediments of the Chhota Nagpur gneiss complex of the Precambrian era are always found in the Purulia district's China clay deposits. Massive Precambrian granites and quartzites, Quaternary semi-consolidated sediments, Permo-Carboniferous sandstone shales, and recent alluvial sediments make up a smaller portion of Purulia's dense stratigraphic sequence, which is primarily composed of Archaean granitic gneiss. In the southern Purulia district, the most common rocks are granite, granite gneiss, phyllite, and mica schist. These rocks are mostly composed of minerals such as quartz, feldspar, muscovite, biotite, albite, and clay (Dolui, G. et al., 2016).

2.6.1 Groundwater condition

Water is an important part of our daily lives. Water is essential to human civilization. Even though water occupies more than 70% of the earth's surface, humans are only able to use 1% of it. Three percent of all water is fresh, whereas the other ninety-seven percent is naturally salty. Glaciers and polar ice sheets hold the majority of freshwater as ice. Less than 1% of all freshwater is found in lakes and rivers, and almost 30% is kept in aquifers as groundwater. Freshwater supplies are under tremendous strain worldwide, particularly in developing countries. In our nation's rural areas, 80–90% of the residential water supply comes from groundwater (Das, B et al., 2019).

Purulia is semi-arid region consisting of hard rock (Chowdhury, P. et al., 2022). This stony terrain has relatively low porosity and permeability. Groundwater is found in semi-confined or unconfined conditions in weathered rock mantles and shallow fissures (Roy, 2014). But it also happens in crystalline, hard rock cracks that are 50–60 meters below the surface. West Bengal's most drought-affected and groundwater-scarce district

is Purulia, which is situated on a hard rock aquifer of the Chotanagpur plateau (CGWB 2021). The economy, society, and ecology are all significantly impacted by droughts. They also have an impact on groundwater, and vice versa. Additionally, the area is more susceptible to climate extremes, according to Guhathakurta et al. (2020). Communities depend on groundwater for domestic use, irrigation, and other purposes because surface waters dry up every summer. However, excessive groundwater consumption has made the problem worse.

2.7 Land & land-use pattern

Table 1 Categorization of Purulia District Land Use Statistics (areas in hectares)

Year	Reporting Area	Forest Area	Area under Non-agricultural use	Barren & unculturable land	Permanent pastures & other grazing land	Land under misc. tree groves not included in Net area sown	Culturable waste land	Fallow land other than current fallow	Current fallow	Net area sown
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
2009-10	625.65	75.05	104.48	5.31	2.56	3.19	8.23	4.72	102.70	319.41
2010-11	625.65	75.05	105.72	3.20	1.81	2.52	7.60	4.22	199.40	226.13
2011-12	625.65	75.05	109.06	2.01	0.80	2.36	7.73	4.70	128.54	295.40
2012-13	625.65	75.05	109.97	1.56	0.67	2.67	6.66	4.11	126.36	298.60
2013-14	625.65	75.05	113.44	1.25	0.43	3.51	3.47	2.82	116.53	309.14

Source : Directorate of Agriculture(Evaluation), Govt. of W.B.

2.7.1 Forest resources

According to satellite imagery data, the district's total forest coverage, including social forestry and degraded forest, is 185726 hectares, or 29.69% of the total land area. According to the forest department's report, 115321 hectares (18.43%) comprise the entire area under its jurisdiction. Purulia Forest Division's forest is classified as a northern tropical dry deciduous forest. It is primarily a coppice sal forest with various species, including kend, kusum, mahua, neem, and palash. the primary suppliers of firewood, small wood, pole wood, timber, and medicinal plants to the local populace. The Purulia Forest Division's primary species include 27 types of bamboo, 59 shrubs, 23 climbers, and 74 trees (purulia.gov.in/district-profiles).

Photo 1 Natural vegetation of Purulia

The district's natural forests are primarily of mixed types and are only found in the northwest, which includes the northeastern Panchet Hills and the Ajodhya Hills. According to studies by Das et al. (2022), afforestation and agricultural development have resulted in the loss of roughly 113 km2 of thick forest, or 21% of the total forest area, and 452 km2 of fallow land, or 35% of the total fallow land. The primary causes of deforestation and afforestation were the conversion of thick forest to fallow land with vegetation and fallow land to fallow land with vegetation. Several government afforestation initiatives have been linked to the loss of dense forests and the growth of fallow land covered with vegetation in recent years. The two most significant LULC transition processes were the change from thick forest to vegetation fallow land and from fallow land to agriculture. Water bodies (95%), vegetated fallow land (96%), and cultivated areas (98%) were all likely to remain in the same LULC. The fallow area was found to be the most affected land cover, followed by deep woodland and agricultural land. Future efforts should be made to safeguard the forest's health in this naturally degraded environment, where the soil is arid, the land is messy, and there is

not enough water.

Photo 2 Undulating topography of Purulia

Ecological Significance: Subarnarekha and Kangsabati are the two main river systems into which the entire region empties. When it comes to collecting the monsoon rainwater, Ajodhya Hill is crucial. Additionally, the forest provides small timber, fuel, fodder, and other material and intangible benefits to the thousands of people who live in and around it. Agriculture is irrigated by small dams like Murguma, Pardi, and Burda.

2.7.2 Cropping pattern

The kinds of crops cultivated within the district is directly influenced by the relief, soil, slope, climate, irrigation possibilities, and traditional social conditions. About 40-50 percent of the cultivated areas are cultivated with monocultures, as the fertility of the soil is low and there are no good irrigation possibilities. The proportion of double and triple-cropped areas is very low. In addition to potatoes, wheat, dal, mustard, maize, maskalai, and other crops, paddy is the primary crop produced in the district. In 2013-2014 alone, 3,39,463 hectares of land was cultivated with Aman paddy. This aman cultivation essentially dominates the kharif season. The crops grown in the district are generally rain-fed and consume very little fertilizer. The overall agricultural production is low to medium. The main causes are its undulating topography, rocky and wasteland, scarcity of water, and medium to low soil fertility (NAQUIM Report of Purulia District

West Bengal,2022). Compared to other West Bengal districts, productivity is significantly lower. The principal crop in each of the district's 20 subdistricts is paddy, primarily Kharif. Among oilseeds, rapeseed & mustard, groundnut, sesame and linseed are mainly grown in Purulia

Table 2 shows the agricultural land use of Purulia

Use of agricultural land	Area in thousand hectares	Intensity of cropping in %
Area of net sowing	317.00	118
The area that has been sown multiple times	57	
Area gross cropped	374.00	

Source: District's Agriculture Contingency Plan: PURULIA

District. Major vegetable crops in Purulia district are brinjal, cucurbits, tomato, and onion; while other vegetables include cabbage, cauliflower, peas, ladies' finger, radish, etc.

Photo 3 Rice field in Man Bazaar 1 during the field visit

Photo 4: vegetable cultivation (during a field visit in Baghmundi)

Vegetables are generally grown on small plots near dug wells, ponds, etc., i.e. with secure irrigation facilities, as can be seen from the picture taken during the field visit to the district.

Photo 5 Sources of irrigation (well) in Man Bazaar 1

2.7.3 Irrigation

There is a growing body of empirical research on the connections between climatic variability and migration as a result of worries that changes in the climate may force significant populations of the climate migrants to migrate both within and between nations. Numerous studies have shown that there is a statistically significant causative link between extreme weather conditions and international as well as domestic migration using both household and aggregate data from various regions of the world. Given that crop production is known to be affected by climatic variations, it is clear that agricultural income losses are the primary cause of the migration triggered by climate variability (Lobell et al., 2011, Lobell et al., 2010). This notion is supported by the theory that people travel in pursuit of other economic prospects when they experience income reduction. If losses in agricultural income are the driving force behind migration in response to changes in the climate, then both agricultural and non-agricultural adaptations might be significant. Access to irrigation during droughts is one example of an agricultural adaptation that has been shown to protect crops from the adverse effects of extreme weather events and lessen their detrimental effects on agricultural productivity (Taraz, 2013, Fishman, 2018).

Canals, tanks, open wells, and various other minor irrigation systems are the district's primary sources of surface water for agriculture. According to purulia.gov.in/district-profiles, the district's total irrigated area is 87816 hectares or 21.57% of the gross cropped area. The entire district lacks the presence of large or medium-sized irrigation systems. Large-scale irrigation depends on surface water as there is insufficient groundwater due to discrete hydrogeological conditions (NAQUIM Report of Purulia District West Bengal,2022).

Table 3 The district's irrigation status, divided up by source, is as follows:

Sources of irrigation	Number	Areas in (thousand Hectares)
Tank	10876	99.31
RLI	110	1.18
ODW	4299	3.42
Canal	Nil	35.73

Other	948	20.71
Total	16233	160.35

Source: Purulia 2013-2014 District Statistical Handbook

In this district, the World Bank-backed WADMI project has been in operation since 2012–2013. An irrigation potential of 273867 hectares was established by the creation of the following irrigation structures by December 31, 2019: RLI (13 pieces), SFMIS (34 pieces), Check Dam (36 pieces), and other MI (176 pieces). There are now 70 minor irrigation systems at different stages of execution. Jal Dharo Jal Bharo, a special initiative called "Jalatirtha," Pradhan Mantri Krishi Sinchai Yojana (PMKSY), and the World Bank-backed West Bengal Accelerated Development of Minor Irrigation (WBADMIP) are some of the continuing government programs that are now being executed. About 16461 hectares of land have been or will be under guaranteed irrigation thanks to loans of Rs. 3839.89 crores that NABARD has approved under the RIDF for the irrigation sector to establish two medium and sixty-one small irrigation projects in the district (Purulia – PLP 2021-22, NABARD).

2.7.4 Animal husbandry

Maintaining agricultural production and farmers' livelihoods in drought-prone areas is a major challenge. The large region, which makes up over 68% of India's arable land, is susceptible to drought, and farmers' lives are made extremely difficult by periodic droughts and unpredictable rains. Vast tracts of land remain uncultivated, water is supplied by tankers, social and economic problems for farmers, migration of people and animals, distress sale of livestock and mortality have been common in most drought-affected areas of the world, including India. Most farmers in arid regions use grazing land for their livestock (Technical Bulletin, 30: Impacts and Management of Abiotic Stresses on Livestock in the Drought Prone Areas of Maharashtra.). Livestock farming serves as a buffer against the vagaries of nature and augments farmers' income, especially in drought-prone areas (Kanwal, V et al.,2020). Purulia is a drought-prone region that is backward and poor. Most of the farmers belong to the marginalized group. The development of livestock can help rural communities to fight during drought years.

The Purulia's terrain and agroclimatic make it an ideal place to raise animals. About 980832 sheep and goats, 62354 piglets,985267 cattle and buffalo, and 1882558 ducks and poultry make up the district's animal population.

Table 4: Purulia district's livestock and poultry

Categories of Livestock	The year 1994	The year 1997	The year 2003	The year 2007	The year 2012
Buffaloes:					
Cows	18571	18806	18557	12907	10781
Bulls and Bullocks	117018	118496	94250	87669	53286
Young Stock	24970	25293	18676	..	11028
Total Buffaloes	160559	162595	131483	100576	75095
Cattle:					
Cows	219017	225504	229593	271775	213187
Bulls and Bullocks	373618	384724	388359	395446	410679
Young Stock	240090	247214	232587	276952	212243
Total Cattle	832725	857442	850539	944173	836109
Poultry:					
Fowls	1454457	1603280	1591956	2102841	1670714
Ducks	439778	498778	477282	491684	324094
Others	1891	974	4818	6778	2592
Total Poultry	1896126	2103032	2074056	2601303	1997400
Horses and ponies	5	5	12	20	7
Pigs	80361	86660	62793	58591	57709
Goats	647800	718075	579990	813191	679536
Other Live-stock	..	..	50808	48713	224
Total Live-stock	2021953	2155441	1949082	2250647	1868655

Source: District Statistical Handbook of Purulia, 2014

2.8 Demography

Demography is a term that comes from the Greek terms "Demos" and "Graphy," which signify "population" and "science," respectively. Therefore, the scientific study of the human population is known as demography. The three fundamental elements of population change are migration, death, and birth. These three factors form the basis of the field of population studies. To give a complete picture of population changes, demographics incorporate relevant social factors like marital status, age, gender, jobs, literacy, and so on (censusindia.gov.in).

2.8.1 Growth Rate of Population

The district has a total population of twenty-nine lakh twenty-seven thousand nine hundred sixty-five, of which 373381 (12.76%) are in urban areas 2554584, and (87.24%) are in rural areas according to the 2011 census. There are roughly 51.15% men, and the rest are women. Of the entire population, 18.29% (463956) and 18.27% (463452) belong to scheduled castes and tribes, respectively. The Purulia has the second-highest proportion of tribal people (18.3%) in comparison to other districts in West Bengal, following Jalpaiguri (18.9%). People from a variety of religious communities consider Purulia home. About 83.42% of the population considers themselves to be Hindus. Some people follow Islam, Christianity, Jainism, and so forth.

The total population of the district grew steadily between 1951 and 2011. However, from ninety-three in the 1951 Census to eighty-seven percent in the 2011 Census, fewer individuals resided in rural areas. Conversely, the proportion of the population living in urban areas increased from 6.7 percent in the 1951 Census to 12.7 percent in the 2011 Census. The decadal growth rate is one of the most important indicators of the population dynamics of a district and a country.

Table 5 Purulia district's population growth rate by decade (1951–2011)

Urban/rural/total	1951-1961	1961-1971	1971-1981	1981-1991	1991-2001	2001-2011
Urban	17.9	43.1	26.0	25.9	21.6	46.2
Rural	16.2	16.0	14.7	19.4	13.2	12.1
Total	16.3	17.9	15.7	20.0	14.0	15.5

Source: 2011 Purulia District Census Handbook

The aforementioned table indicates that, with the exception of 1981–1991, the rural areas' decadal rate of growth has decreased, while the district's overall decadal growth rate has climbed and reduced in each of the ten years from 1951–1961 to 2001–2011. Nevertheless, there is no discernible pattern in the rate of urbanization. However, between 1961, and 1971, and again between 2001 and 2011, the rate of urban expansion rose sharply. The years 1981–1991 and 2001–2011 had the district's fastest rates of urban and rural expansion, respectively.

2.8.2 Population density

The number of people / square kilometer is known as population density. According to the following graph, the district's overall population density grew from 218 people / square kilometer in 1961 to 468 people / square kilometer in 2011. Additionally, from 205 people in every kilometer of land in 1961 to 418 people in every square kilometer in 2011, the rural population density has risen as well. Up until the census for 2001, the urban population density was increasing, as the preceding table also demonstrates. However, it decreased from 3,218 people / km² in 2001 to 2,530 people / km² in the census of 2011.

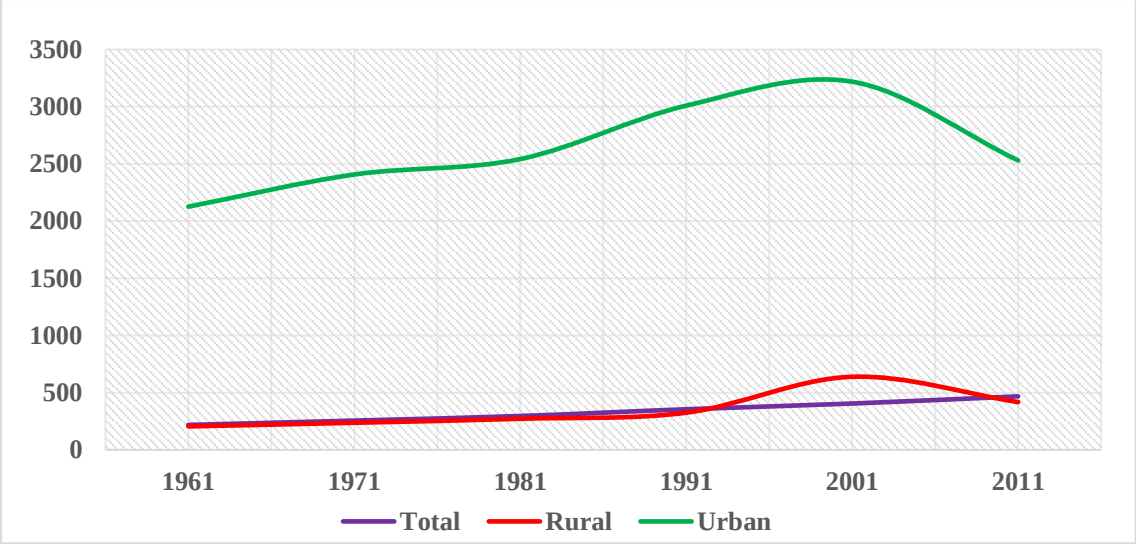


Fig 3 shows the density of the population

2.8.3 Age-sex structure

For demographers, age and sex are the most significant and pertinent features of human populations. They are known as "the demographic variables" because of how crucial they are to demographic analysis (Bogue, 1969). Migration, mortality, and fertility are demographic processes that shape the population's ages and sex structure, and the age and sex structure influence the demographic processes (Horiuchi, S. and Preston, S.H., 1988).

An examination of the age distribution of the population helps determine the proportion of laborers overall. In the 2011 census, the population of working age was defined as those between the ages of 15 and 60, while the child population is classified as those between the ages of 0 and 14. This represents the percentage of ineffective customers. Since 1971, there has been a minor shift in the working-age group's favour.

Table 6 Age-group-specific population distribution percentage

Years	**Specific Age Group**		
	0-15	**15-60**	**Above 60**

1971	41	54	5
1981	39	55	6
1991	38	56	6
2001	35	57	7
2011	38	56	6

Source: District Statistical Hand Book (compiled 1971 – 2011)

The sex ratio, which is calculated for every census year, is another crucial demographic measure for figuring out the male-to-female ratio in the population.

Table 7: Purulia district's sex ratio from 1951 to 2011

Year	**Rural sex ratio**	**Urban sex ratio**	**Total sex ratio**
1951	988	921	983
1961	979	889	973
1971	970	890	963
1981	962	905	957
1991	952	899	947
2001	958	920	954
2011	960	936	957

Source: Census 2011

According to the above chart, the district's sex ratio in the year 2011 was 957, with 960 in rural areas and 936 in urban areas being lower than the overall and rural ratios. After falling from 983 in 1951 to 947 in 1991, the district's overall sex ratio changed course and rose to 957 in the census conducted in 2011The trend of the rural sex ratio has been comparable to that of the population as a whole. The urban sex ratio rose from 889 in 1961 to 936 in 2011, with the exception of 1961 and 1991. Between 1961 and 1991, the urban sex ratio decreased from 921 in the 1951 to 889 and from 905 in the 1981 to 899, respectively.

2.8.4 Migration

Migration, a demographic phenomenon that involves people moving from one place to another, affects fertility, mortality, and population change. Moving people—individuals, families, and groups—between homes or residential areas is known as migration. For a long time, the traits of prospective migrants have been crucial in determining who moves and who does not. It is crucial to remember that those who move for work may be very different from those who travel seeking refugee or asylum status or to reconnect with family. Furthermore, every migration has distinct demographic traits, such as gender, age, status in marriage, level of education, etc. Overall, almost all studies on migration find that demographic characteristics play a significant role in elucidating the populations of migrants. The most significant set of traits changes significantly over time and among different migratory movements.

Migration is closely linked to the livelihood of people in Purulia. According to the District Human Development Report, Purulia, the main reason for this is that there are very limited opportunities in the district to engage in gainful employment to sustain their lives. According to district-level migration statistics, the Purulia district's out-migration rate was 42 per 1000 people in 2001 and 39 per 1000 people in the 2011 census (Hossain, M. et al.,2023).

The above estimate refers only to permanent migrants at the district level. However, it is well known that one of the main livelihood strategies employed by the poorest segments of society in many developing nations, including India, is short-term labor migration (Deshingkar & Grimm, 2005; Deshingkar, 2006; Brauw, 2007; Lam et al, 2007; Pham & Hill, 2008; Ha et al, 2009; Asfaw et al, 2010; Rajan, 2011; Keshri & Bhagat, 2013;). Despite India's high rate of short-term migration, the issue has not gotten adequate macro-level attention. An important source of migration data is a governmental agency such as the Census does not make an effort to record short-term migration and is primarily concerned with permanent migration at the district level. The 64^{th} round of the NSSO provides data on short-term migration, although the unit of analysis was state-level. The data from the NSSO is likewise erratic (last conducted in 2008). As a result, there is an extreme absence of knowledge about short-term migrants at the micro level, who make up a significant portion of the labour force. Due to data

unavailability, researchers are forced to employ household survey data for micro-level studies on migration.

2.8.5 Rate of literacy

The percent of literate individuals aged seven and up is known as the population's literacy rate. The literacy rate for various age groups is determined by the proportion of literate individuals in that age group.

Table 8 Purulia's literacy rate by sex and place of residence (1961-2011)

Year	**Total/ Rural/ Urban**	**Purulia**		
		Persons	**Males**	**Females**
1961	T	20.5	34.4	5.9
	R	18.2	32.0	3.8
	U	52.9	67.3	36.3
1971	T	25.1	39.8	9.7
	R	22.5	37.3	7.0
	U	53.8	65.9	40.0
1981	T	33.7	51.3	15.1
	R	30.9	49.0	11.9
	U	61.7	73.8	48.2
1991	T	43.3	62.2	23.2
	R	40.3	60.0	19.6
	U	70.6	81.7	58.1
2001	T	55.6	73.7	36.5
	R	53.2	72.4	33.2
	U	75.4	85.0	64.9
2011	T	64.5	77.9	50.5
	R	62.7	76.8	48.1
	U	76.2	84.6	67.1

Source: Purulia's 2011 District Census Handbook

The rate of literacy is one of the most important factors that determines not only the development of a region but also many related factors that depend on it, such as migration. Higher educated individuals are believed to be more competent and to travel

in search of better employment opportunities, eventually turning into permanent migrants. The district's literacy rate rose from 20.5% in the year 1961 to 64.5% in 2011, however, it is still below the state's 76.3% literacy rating for that year. Purulia had a literacy rating of 17th in the 2011 census and 15th in 2001 compared to the other districts.

2.9 Livelihood

2.9.1 Agriculture

Although labour participation in agriculture is very high in the Purulia district, the average income of a typical farmer is very low due to low productivity. The lack of factors like alluvial land, irrigation facilities, low education, well-developed markets, and better agricultural extension services is primarily responsible for the slow pace of agriculture in the district. The climate in the district is extreme, and droughts are recurrent, leading to crop failure. 60–70% of the land is upland, 20–25% is medium land, and 10-15% is low land, known locally as Tar-Baid, Kanali, and Bahal, respectively. Tar-baid land is less fertile and is generally cultivated as a monoculture.

The district's main crops include potatoes, mustard, and vegetables during the Rabi season, and paddy, arhar, maize, groundnuts, and vegetables during the Kharif season.

Most farmers are marginal and own less than 1 hectare of land (NABARD, 2016) The land ownership structure in this district shows that most farmers belong to the marginal category.

Table 9 shows the land-holding distribution

Holding Classification	**Land Holding**		**Area (in hectares)**	
	Numbers	Percentage to Total	Hectares	Percentage to Total
More than 2 hectares	17301	5	50877	20

More than 1 to <=2 hectare	49653	16	74490	29
<= 1 hectare	252969	79	130440	51

Source: NABARD (PURULIA – PLP 2021-22)

Of the total number of farms, 79% belong to marginal farmers with scattered and fragmented farms, while only 16% belong to small farmers.

The number of workers is displayed in the following table, especially the main workers, has fallen over the last two decades, while the number of marginal workers has risen. At the same time, the non-working population has increased considerably. This indicates that the district has faced an unemployment problem that has resulted in low economic development. The percentage of main workers in the total labour force was 57% in 2001 and dropped to 49% by 2011. The percentage of marginally employed workers was 43% in 2001 and rose to 51% by 2011.

Table 10 displays the Purulia district's worker category.

Category	**% Distribution in the Census of 2001**	**% Distribution in 2011 Census**
Workers	44	43
a) Main Workers	57	49
b) Marginal Workers	43	51
2. non-Workers	56	57

Source: Census of India 2001-2011

Agricultural workers are also classified as cultivators and agricultural labourers. Data from the 2011 census shows that 60% of the district's workforce is actively involved in agriculture, while the 1991 census data showed a 67% share. Of these, 35% are arable farmers and 65% are agricultural workers. The corresponding figures for the 2001 census are 46% and 53%. It can therefore be said that the proportion of people working in agriculture is decreasing and that there is a significant shift in employment from farmers to agricultural workers. This trend is by no means encouraging for the agricultural sector. During the Rabi season, a majority of agricultural workers usually went to another agriculturally developed district to seek employment.

Table 11 shows Agricultural Workers in Purulia

Years	Cultivators			The Agricultural Labourer		
	Total (in absolute numbers)	Male (in absolute numbers)	Female (in absolute numbers)	Total (in absolute numbers)	Male (in absolute numbers)	Female (in absolute numbers)
2011	268800	203535	65265	492205	239738	252467
2001	352712	231336	121376	406223	173011	233212

Source: Census of India 2001-2011

2.9.2 Industry

Sericulture and the lac industry are two more significant revenue-generating small businesses in this district. Ninety percent of West Bengal's lacquer is produced in Purulia. Around 70,000 people work in the lac industry, which is grown in all of Purulia's subdistricts. In the past, the Purulia district was the leader in lac production. The district had a large number of lac-based industries because of its raw material base, lac producers' traditional expertise, processing capability, etc. It is now the other way around. There are fewer lac industries operating, and lac cultivation has decreased. The vast amount of caterpillar larvae being utilized as raw material supports the sericulture business (District Census Handbook, Purulia 2011).

Since 2001, the district has drawn investments in steel, cement, and energy due to the West Bengal government's new policy on industry. Major enterprises in the district include the Cement facility by ACC Damodar in the Santaldih Thermal Power Plant in Santaldih, Madhukunda, and the Pumped Storage Plant in Baghmundi.

2.9.3 Conclusion

In the present chapter, an effort has been made to present a comprehensive knowledge of the Purulia.

Purulia was selected as the study location due to its harsh climate and drought threat. The granite-gneiss formation has a limited capacity to retain water (Goswami and Ghosal, 2022b). Because of its plateau location, the district's geography is marked by rugged and uneven terrain, which limits monsoon water recharge and increases runoff potential. In terms of human development and the economy, it is among West Bengal's

most underdeveloped districts with a high percentage of rural population (87.26%). The district, which is the second most tribally populated district in the state after Jalpaiguri, also contains a significant concentration of tribal residents. The literacy rate (64.48%) is also poor (below the national and state levels). The main source of income is rainfed agriculture, with most farmers belonging to the marginalized group owning less than 1 hectare of land. According to Purulia, DCHB (2011), the percentage of skilled, semi-skilled, and unskilled labour is 16.32%, 37.33%, and 47.35%, respectively. This figure highlights the lack of education and skill development among the populace. This explains the persistently high percentage of the labor force employed in agriculture—406223 and 128475 in the 2001 and 2011 censuses, respectively. Due to a lack of industrial facilities, low skill levels, inadequate educational attainment, and a scarcity of well-paying employment, the district's economy is badly impacted by the extremely low per capita income. Purulia's per capita income grew by just 23812.98 over ten years, from 7857.06 in 2001 to 31670.04 in 2011. Thus, the district offers a unique opportunity to be selected as a study area for the research work.

Chapter 3

(Research Methodology)

3. Introduction

One important and powerful instrument that propels human advancement is research. There wouldn't have been much advancement without a methodical investigation. According to John W. Best, research is the key to our cultural growth since it reduces the domains of ignorance by revealing new facts that result in better practices and goods. Scientific research promotes progress in many facets of life. Research in the biological, physical, social, and psychological areas is ongoing and leads to the discovery of innovative goods, knowledge, theories, and approaches. These days, scientific labs are not the only places where research takes place.

3.1 Various Definitions of research:

The goal of research is to find, create, and validate knowledge. Over the course of hundreds of years, this cognitive process has changed in form and purpose while continuously seeking the truth.

Rummel, J. Francis

Research is the sincere, thorough, and perceptive pursuit of facts and their significance or ramifications for a specific issue. A specific research project's output or findings should represent a genuine, verifiable addition to the body of knowledge in the topic being studied.

Cook, P.M.

3.1.1 The Purpose of Research:

The goal of research is to use scientific methods to find answers to questions. Its primary objective is to discover truths that remain hidden and unexplored. While each research study has a distinct purpose, there are some common objectives: (i) to gain knowledge of, or fresh perspectives on, a phenomenon (also known as exploratory or formative research projects). (ii) To accurately describe the traits of a particular person, circumstance, or group (referred to as descriptive research studies). (iii) To determine the frequency of occurrence or the connection with another factor (These are diagnostic

research investigations) (iv) To test a hypothesis about a causal relationship between variables (known as research projects that test hypotheses).

3.1.2 The research strategy

The research plan serves as a systematic guide that directs the researcher in gathering, analyzing, and interpreting data. It aids in collecting relevant data and properly analyzing it to address the primary research questions. A variety of quantitative and qualitative techniques, as well as observations, focus groups, interviews, participatory rural assessments, and secondary data gathering, have been used in this study. The following flow chart briefly outlines the research methodology adopted

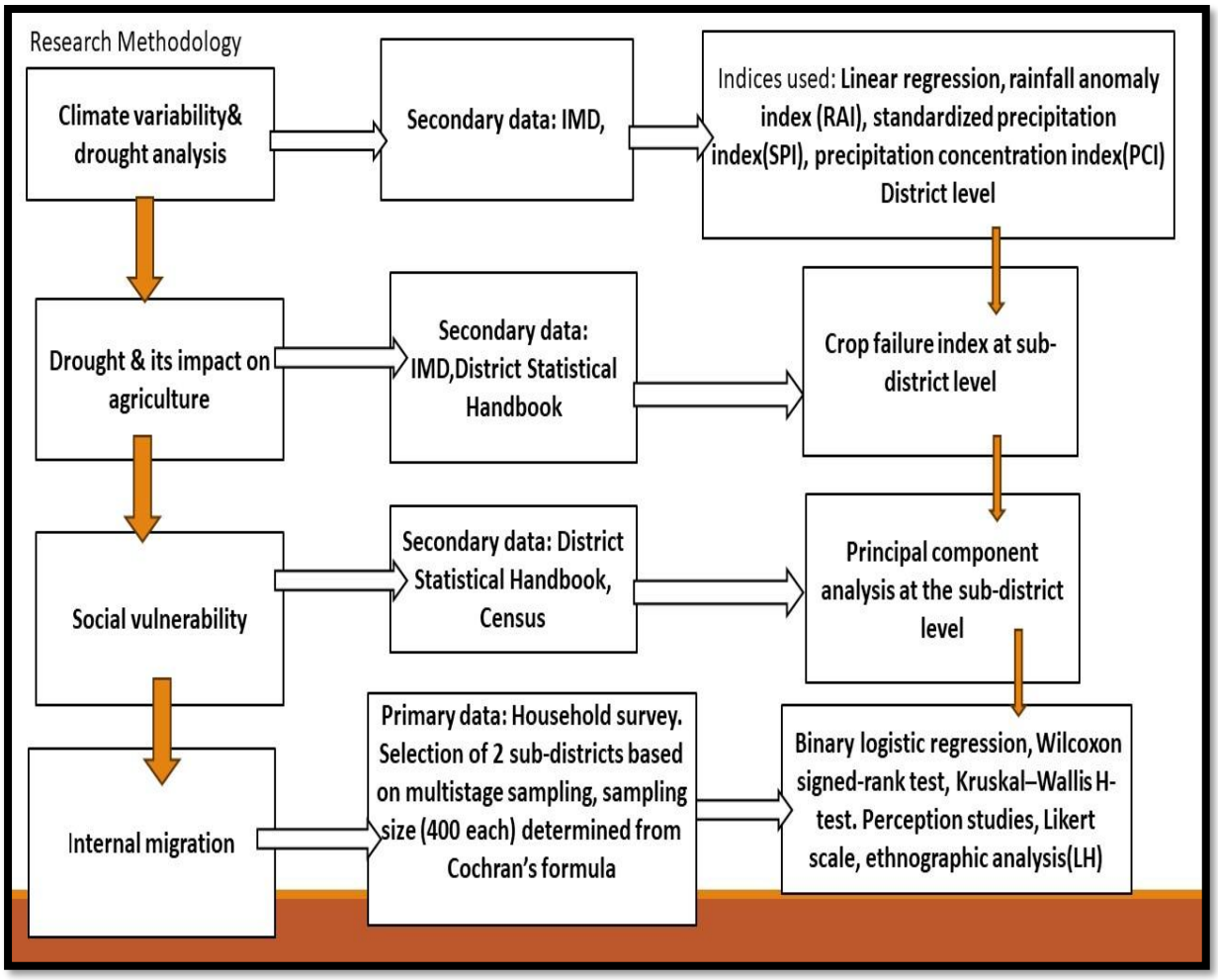


Fig 4 shows the conceptual foundation of the research methodology

3.2 Research techniques for the investigation of drought and climatic variability

This study analyzed significant changes in precipitation and maximum and minimum temperatures, two climate variables, employing linear regression, utilizing the precipitation concentration index (PCI), the rainfall anomaly index (RAI), and the standardized precipitation index (SPI) over 50 years (1970-2020).

3.2.1 Data analysis techniques

This study calculated the temperature and precipitation variability using (PCI), RAI, and the standardized precipitation index. The trend assessment for temperatures was computed using linear regression, indicating whether temperatures and precipitation rise or fall over time. The regression's slope also determines the pace of change. While the SPI was used to look into the meteorological drought, the RAI was utilized to assess the wet and dry years in the research area's precipitation pattern.

According to C. T. Agnew & Chappell (1999) and Viste et al. (2013), the rainfall anomaly index or RAI is computed to analyze the patterns and occurrence of wet and dry years and to evaluate the intensity and frequency of droughts.

$Z = (Xi-\bar{X}i)/Z$

The annual rainfall for a certain year is denoted by Xi, the normalized rainfall anomaly by Z, and the long-term mean annual rainfall during observation by $\bar{X}i$. According to C. T. Agnew and Chappell (1999), there are four different drought severity classes: no drought ($Z > -0.84$), moderate drought ($-0.84 > Z > -1.28$), severe drought ($-1.28 > Z > -1.65$), and extreme drought ($Z < -1.65$). Rainfall variability at various scales (annual or seasonal) is analyzed using the Precipitation Concentration Index (PCI). According to de Luis et al. (2011) and Oliver (1980), the PCI values are calculated as follows:

$$PCI_{annual} = \frac{\sum_{i=1}^{12} p_i^2}{(\sum_{i=1}^{12} p_i)^2} \cdot 100$$

where Pi is equal to the amount of rainfall in the ith month. Oliver (1980) states that a PCI value of less than 10 suggests a low amount of precipitation, a number between 11 and 15 indicates a moderate monthly rainfall distribution (low concentration), a value between 16 and 20 implies an elevated concentration and a value beyond 21 suggests an excessive concentration.

Linear regression is used to calculate the trend of monthly rainfall and temperatures, with the slope being the change in y for every unit increase in x. The severity of drought is evaluated and the precipitation deficit is quantified over different timelines using the standardized precipitation index (SPI) (WMO, 2012). According to McKee et al. (1993), there are several levels of drought severity: near normal (-.99 to.99), moderately dry (-1.0 to -1.49), severely dry (-1.5 to -1.99), extremely dry (2.0+), very wet (1.5 to 1.99), moderately wet (1.0 to 1.49), and extremely dry (-2 and less). According to Roy and Hazra (2020b), SPI is computed using the following formula:

$$SPI = \{(Xij - Xim)/\delta\}$$

where δ is the standard deviation of the monthly precipitation for the full 50 years in the research region, Xij is the district's yearly precipitation, and Xim is the long-term mean precipitation (in this study, the average of the data collected over 50 years). The annual SPI for the research region with a predetermined time frame has been calculated using R Studio.

Smallholder farmers' perceptions of rainfall and temperature change over time and drought occurrence are also supplemented following an ethnographic approach (as case studies).

3.3 Research methodology for studying the impact of drought on agriculture

3.3.1 Data analysis technique

Given that rice is the state's major food crop, this chapter examines temperature, rainfall, and crop yield data to address the goals for rice in Purulia district from 1970 to 2015. The effect of drought on crop yields was evaluated using the crop failure index. Maximum and minimum temperatures, along with monthly rainfall data, were obtained from the Indian Meteorological Department (IMD) between 1970 and 2015. At the

same time, (ICRISAT) the International Crops Research Institute for Semi-Arid Tropics provided annual crop yield data for the same period.

3.3.2 Method for yield variability

A coefficient of variation (CV), meaning the standard deviation from the mean, was used to examine the variability of crop yields (Tabari & Hosseinzadeh Talaee, 2011). The degree of dispersion around the mean increases with the coefficient of variation. It is generally expressed as a percentage. The inter-annual variability of crop yields was calculated using the coefficient of variation and the results were presented in a graph to show the extent of variability.

$CV=\sigma/\mu$

σ means the population standard deviation

μ means the population mean

3.3.3 Method for Trend Analysis

The research analysed trends in rice crop yields from 1970 to 2015. These trends were determined through linear regression analysis, which reflects the change in yield values over time. In the linear regression analysis, the trend is essentially the slope obtained by graphing yield on the vertical axis against the year on the horizontal axis. Graphs representing the results of these investigations showed an increasing trend with a positive slope and a decreasing trend with a negative slope.

3.3.4 Method to estimate climate contribution on crop yields

Crop yields were regressed using multiple regression on climate parameters, including precipitation and temperatures. Crop yields' responses to monsoon-induced variability and average annual variability were computed. In this way, the relationships between precipitation temperatures and crop yields in our study area could be determined. The coefficients resulting from these analyses represent the mean change in yield (kg/hectare) for one unit of change in the predictor variable. The regression's coefficient of determination (R2) also indicates which variation in magnitudes—that is, the highest and lowest temperatures and precipitation—can be attributed to climatic variability.

Furthermore, the effects of each climate variable on rice yields were assessed for statistical significance using a 95% confidence range. The output was represented in table format. The calculations are based on the following formula:

$$\gamma = C + aT + bT + \in$$

Where γ is yield (kg), 'a' temperature related co-efficient, 'T' temperature data (° C), 'b' precipitation co-efficient, P the precipitation data (in mm) 'ε ' error term or other variables which influence the yields and C, is the constant

Index of crop failure

The Crop Failure Index of Simelton et al. (2009), which is represented by the formula Crop Failure Index= Ā / A, where Ā represents the average production over 24 years (1992-2015), was also employed in this study. Crop data for the study area is available only for these periods.

The observed production of a specific year is denoted by the letter A. A crop failure or below-normal production in a given year is indicated by a score greater than one on the aforementioned measure.

3.4 Research methodology for assessing drought and social vulnerability at the sub-district level

Data for these studies was gathered from the West Bengal government's District Statistical Handbook and the Indian Census.

At the national and subnational levels, censuses are crucial for planning and policymaking because they yield vital data. Understanding a nation's economic, social and demographic makeup requires knowledge of its census. The most complete source of statistical data on the Indian population is the census. It serves as a valuable source of data for scholars and researchers in various fields such as demography, economics, anthropology, sociology, and statistics. The decadal census highlights the great diversity of India's population and provides a basis for understanding and analysing the country. The social vulnerability index used in this study was developed using a variety of demographic and amenity data taken from the Indian Census.

A comprehensive summary of the socioeconomic, demographic, and infrastructure conditions of every state district may be found in the District Statistical Handbook. Numerous economic and social facts can be gleaned from these handbooks because they are local in scope. Additionally, the study uses a variety of sub-district data sources.

3.4.1 Data analysis technique

Principal component analysis was used to create the social vulnerability index. For social vulnerability analysis, a smaller as well as more cohesive set of independent components was obtained from a large number of variables using principal component analysis (PCA). The sub-district (block level) is the spatial scale used in this study to analyze social vulnerability.

At various dimensions, social vulnerability has been evaluated using a variety of techniques and methodologies (Adger & Kelly, 1999c; Vincent, 2004; Viet Nguyen, 2015). Principal component analysis (PCA) has been used to create a social vulnerability index (SVI) at the sub-district level for this study. PCA was performed in this study using SPSS software (version 22). PCA is a multivariate statistical technique that is employed as a data reductive approach, according to Solangaarachchi et al. (2012). By identifying patterns in high-dimensional data and highlighting the underlying factors (principal factors) that best explain data variations, this technique condenses an initial set of variables into a smaller number of linear collections (varieties) by identifying and grouping variables that estimate the same point (Kaźmierczak & Cavan, 2011). Household structure, education, socioeconomic status, housing, access to basic amenities, and the proportion of rural to urban areas are socioeconomic factors that are used to determine social vulnerability. These particular characteristics are essential for determining whether subdistricts are socioeconomically vulnerable to climatic variability and drought. In our study area, which includes 20 community development blocks or sub-districts with 11 different variables, the PCA performed admirably. The presence of outliers in SPSS has been detected using box plots and histograms. The Kolmogorov-Smirnov statistic was examined as part of the normalcy test, and the result (sig. = 0.00) indicates that the assumption of normalcy has not been broken. The Kaiser-Meyer-Olkin (KMO) and Bartletts Test of Sphericity are two statistical tests used to assess the model's robustness (Mavhura et al., 2017). Using Bartlett's (1954) Test of Sphericity, which also indicates whether a correlation matrix

differs significantly from an identity matrix, the KMO test is used to assess adequate sampling, identify multiple collinearity in the data, and gauge the strength of the relationship between variables (Mavhura et al., 2017).Varimax rotation is used to make components easier to understand and to streamline the structure of the underlying dimensions. Kaiser's criteria (eigenvalues > 1) were applied in the component selection process. Most of the variance in the set of original variables can be explained through the principal components, with the first component accounting for the majority of the variation, followed by the second component, and continuing so forth (Antony & Visweswara Rao, 2007).Following that, component scores were multiplied by the proportion of variance (or weights) to create the social vulnerability index (SVI) for each of the 20 sub-districts (Antony & Visweswara Rao, 2007).The following method can be used to calculate the index:

$SVI = \sum (Fi /TV) *FSi$

where TV is the total variance explained by all the components that were kept, FSi is the component scores on each component, and Fi is the percentage of variance explained by each component.

High social vulnerability is shown by a greater SVI score, whereas low social vulnerability is represented by a lower SVI value. Ultimately, the whole range has been separated into three equal groups, each of which has been given a qualitative social vulnerability indicator (ranging from low to high).

Table 12 explains the socioeconomic factors taken into account in the current study's social vulnerability analysis.

Variables used	**Description**	**Rationale (justification)**
Mean household size	Average number of persons in each home	Large families are less resilient to and recover from dangers because they have fewer resources and more work obligations.

Illiteracy rate	percentage of the population that is illiterate	People who lack literacy are unable to escape their misery and miserable circumstances, are unaware of their rights, and are ensnared in a variety of social ills. It denies them the chance to participate in the community on an equal footing. Thus, it makes them a socially vulnerable population.
Agricultural dependency	percentage of all working people who are farmers and agricultural laborers	Compared to other workers, agricultural dependents are more affected by hazard events and climate variability.
HH's percentage without electricity	The proportion of homes without access to electricity	It lowers a household's resistance to risks and climate shocks and lowers their level of living.
Non-worker	percentage of the entire population that does not work (does not work at all in any economically productive activity, such as students, people doing household chores, or dependents)	Non-workers used to recover from the disasters slowly due to lack of funds
Access to drinking water	It is expressed as the proportion of people who have access to sources of drinking water.	Drought-prone regions' water supplies are susceptible to the negative effects of climate change, and their shortage makes people more vulnerable.

percentage of HH that do not own a home	The proportion of households without a dwelling of their own	During a crisis, these individuals have fewer access to information regarding financial relief.
Population growth	It provides an outline of the proportion of population growth in a given decade.	Rapid population increase puts low-income families at risk and makes it harder for them to pay for everyday expenses, particularly in times of crisis. Growing populations make it more difficult to guarantee that future development is inclusive of the local government and sustainable.
Percentage of irrigated area	The proportion of total arable land area that is irrigated	Irrigation can lessen farmers' vulnerability during drought or unreliable or unfavorable monsoons, which in turn lessens overall vulnerability.
The proportion of cultivable land to total area	The area that matches the total sown area is referred to as the area under cultivation.	Where agriculture is main source of income, bringing more area under cultivation helps to achieve self-sufficiency, more earnings for the farmer, and boost the economy
% of HH with no assets	Households who have access to assets	Households having assets help to recover from any kind of shocks or vulnerability

3.5 The research methodology used for the analysis of drought and internal migration in two sub-districts of Purulia

This study defines a migrant as an individual from a rural household who moves out due to climatic reasons, specifically drought. Here, drought is identified as the cause, with migration as its direct consequence. Climate change and internal migration are connected at Purulia's sub-district (block) level. While there are no national reports of population movements at this scale, rural inhabitants frequently migrate for short-term economic opportunities. Although primarily driven by economic factors, climate variations also indirectly influence the decision to relocate. This issue has not been

addressed in Purulia, a economically disadvantaged district and frequently affected by drought. To explore how drought impacts migration patterns, this work seeks to bridge this gap through a comprehensive household survey in two sub-districts, Baghmundi and Man Bazar 1.

3.5.1 Selection of Subdistricts

The choice of Man Bazar 1 and Baghmundi for the study was influenced by their social vulnerability and the prevalence of droughts. Both sub-districts are socio-economically vulnerable and have been regularly impacted by droughts.

The selection of the sub-districts (Manbazar1 and Baghmundi) is based on three factors: a) drought; b) migration; and c) social vulnerability

Table 13 shows sub-districts affected by drought in various years

Drought	References
Extreme drought occurs in the northwest and southwest of the study area, where Baghmundi is located. Mild and moderate droughts occur in the central part of the study area (Purulia I, Purulia II, Man bazar I, Raghunathpur II, and Para are the sub-districts that fall in the central part of the study area)	Pal Chaudhuri, M. and Biswas, S., 2014. Analysis of meteorological drought using standardized precipitation index–a case study of Purulia district, West Bengal, India. International Journal of Environmental and Ecological Engineering, 7(3), pp.167-174.
Jaipur, Baghmundi, Balarampur, Purulia I & II, Raghunathpur I & II, Neturia, Hura, Bandwan, Bara bazar, Man bazar I & II, Para, Arsha, and Kashipur are the major sub-districts that have suffered from the drought.	Bera, B., Shit, P.K., Sengupta, N., Saha, S. and Bhattacharjee, S., 2021. Trends and variability of drought in the extended part of Chhota Nagpur plateau (Singbhum Protocontinent), India applying SPI and SPEI indices. Environmental Challenges, 5, p.100310.
The south-western and north-eastern sub-districts of Purulia were affected by extreme drought, which led to a high level of out-migration from these areas.	Raha, S. and Gayen, S.K., 2021. Drought-induced human mobility in Purulia district of West Bengal. Habitat, Ecology and Ekistics: Case Studies of Human-Environment Interactions in India, pp.263-277.
Extreme agricultural drought in the western highlands (Jaipur, Baghmundi, Balarampur, Arsa, and Jaldha) I, II, Para, and Purulia I, II sub-districts) of the district and severe drought in the residual soils of the eastern part (Kashipur, Puncha, Hura, Man bazar, and Raghunathpur) in 2005, 2009, 2010, 2012, and 2014	Roy, S., Hazra, S. and Chanda, A., 2023. Assessment of wet season agricultural droughts using monthly MODIS and SAR data in the red and lateritic zone of West Bengal, India. Spatial Information Research, 31(2), pp.195-210.

The two sub-districts of Manbazar1 and Baghmundi (the study area for conducting a household survey to find out the relationship between drought and migration) are described as drought-prone in the work of the authors mentioned above.

Man Bazaar 1 had the highest outmigration rate, while Baghmundi had the lowest, according to a rural household study carried out by the West Bengal government in the district. The following diagram shows the percentage of outmigration in 2012 in each sub-district.

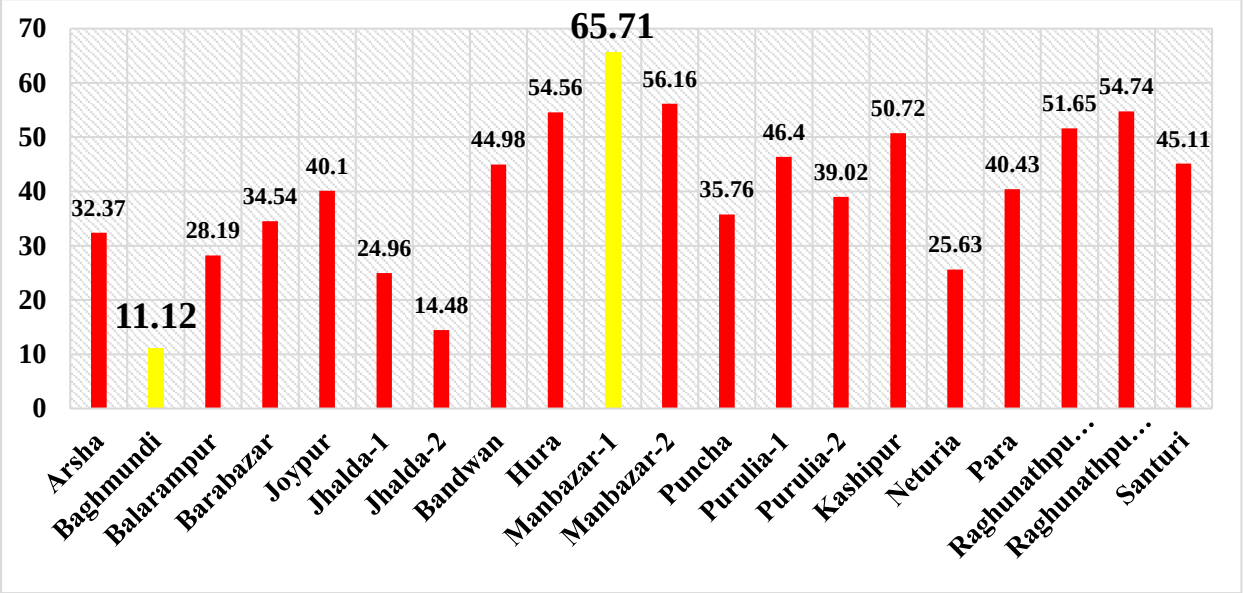


Fig 5 Percentage of outmigration in 2012 in each sub-district (source: District Human Development Report,2012)

An examination of social vulnerability across Purulia's 20 subdistricts served as the basis for the third criterion in the subdistrict selection process. Numerous socioeconomic characteristics, including household composition, level of education, occupation, socioeconomic status, housing circumstances, access to essential services, the ratio of urban to rural areas, the presence of irrigated land, and reliance on agriculture, form the basis of the social vulnerability analysis. These selected variables are crucial in determining the socio-economically vulnerable sub-districts affected by drought. The analysis for the years 2001 and 2011 revealed that Man bazar 1 and Baghmundi fall in the category of high social vulnerability.

3.5.2 Overview of Man Bazar 1 and Baghmundi

The total size of the Man Bazar 1 subdistrict is 381.32 square kilometres. The Sub-district is where the Kasai River empties into the Kangsabati Reservoir. The Puncha Subdistrict surrounds the Man Bazar I Subdistrict to the north, the Bankura district's Hirbandh Subdistrict borders it to its east, the Man Bazar II Subdistrict borders it to the south, and the Bara Bazar Subdistrict borders it to the west.

Man Bazar 1 has a total population of 154,071 according to the 2011 census, of which 78,039 are male and 76,032 are female. The census for 2011 found that 93.8% of people reside in rural areas and 6.2% of people live in urban areas. At 20.74 per cent, Man Bazaar-I Sub-district has the greatest decadal growth rate. The overall literacy rate of Man bazaar-I is 63.78%. Urban areas have an average literacy rate of 81.6%, whereas rural areas have an average of 62.6%. Man Bazaar-I's average sex ratio is 974. In Man Bazaar I, the sex ratio is 956 in urban areas and 975 in rural areas. The Schedule Caste (SC) is 22.44%, and the Schedule Tribe (ST) is 22.03% of the total population of Manbazar-1 in West Bengal. In Man bazar 1, 47.95% are total workers. 17.48% of them are main workers (employment or earning for more than 6 months), whereas 52.05% are unemployed and 30.47% work in marginal jobs that sustain them for fewer than six months. Male main workers constitute 26.89% and the respective percentage for females is 7.82. Marginal workers (male) are 27.95% and female is 33.05%. Manbazar1 has the lowest percentage of male main workers it has the greatest percentage of male marginal workers (27.95). There are 219 villages in this sub-district.

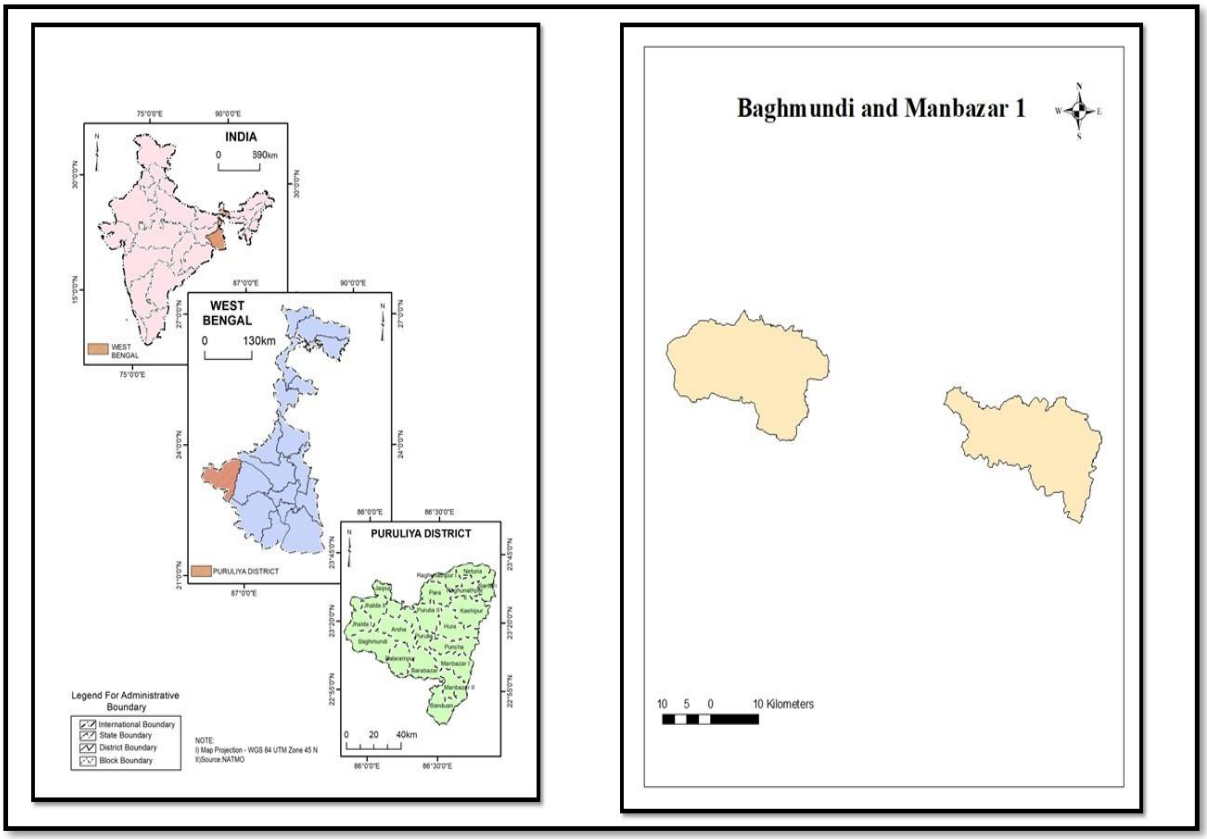


Fig 6 shows the location of Baghmundi and Man Bazaar 1

Baghmundi is situated in the Ajodhya Hill foothills. The Baghmundi is 427.95 km² in size. It is situated in the district's southern region. The eastern portion of the Baghmundi highlands, which is covered in thick sal forest, is traversed by the Kumari River. Jhalda I, Jhalda II, and Arsha Sub-districts border the Baghmundi sub-district on the north; Balarampur Sub-district borders it on the east; Kukru Sub-district on the southern side, and Jhalda I Sub-district borders it on the west.

According to the 2011 census, there are 135,579 people residing in the Baghmundi sub-district of Purulia, all of them reside in rural areas. There are 66,059 females and 69,520 males among them. At 20.57 percent, the Baghmundi sub-district has the greatest decadal growth rate. Baghmundi's total literacy rate is 57.17%. There are 138 villages in this subdistrict. According to the 2011 census, Baghmundi's overall sex ratio is 950. The population of this subdistrict is made up of 25.11% Scheduled Tribes and 10.36% Scheduled Castes. The percentage of workers in this subdistrict is 46.64 out of the entire population.Of these, 53.36% are non-workers, 20.02% are main workers, and 26.63% are marginal workers. Male major workers make up 31.87% of the workforce, while

female main workers make up 7.54%. Men make up 23.43% of the marginally employed workforce, while women make up 29.99%.

3.6 Strategies for determining sample size:

A sample must be designed to accurately reflect the population from which it is drawn and should be selected using an appropriate sampling frame. In random sampling, a subset of individuals or social phenomena is chosen from a larger group for study. Probability sampling, or representative sampling, is governed by the principles of probability theory, which can be distilled into a table to determine the necessary sample size. The central question is, "How large must the sample be to ensure confidence in our results?" The size of probability samples is determined by available resources, planned methods of analysis, population variability, and statistical guidelines. Beyond these factors, when determining sample size, The population size or degree of variability, the desired confidence level, and the accuracy level must also be taken into account.

•Degree of Precision - Every survey inherently contains some level of error. The degree of precision, which is quantified as a percentage, reflects the amount of error deemed acceptable by the researcher. In essence, it measures how close the estimated data is to the actual population characteristics. Typically, a margin of error of 5% is utilized, signifying that the survey findings are expected to be accurate to within plus or minus 5%.

•The desired confidence level, indicated as a percentage, informs the researcher of the certainty associated with the results. Commonly, researchers opt for 90%, 95%, or 99% confidence levels. A 95% confidence level is frequently used, signifying that if a researcher were to take 100 independent samples from the same population, 95 of those samples would yield an estimate that falls within the specified precision.

•The total number of components or traits in a population from which researchers would conclude is referred to as the population size or level of variability. To achieve the required precision, a bigger sample size is required for a more broadened population. A sample size of 50% offers more variability than one of 20% or 80%, as the latter percentages suggest that a large majority either disagrees or agrees strongly, respectively.

The most useful formula for calculating sample size is: size = pqZ2 ÷ E2 (Payne, G., & Payne, J. (2004)

The (estimated) percentage of the population that possesses the property in question q is 1 – p, and e is the acceptable level of precision (also known as the margin of error).

The above formula indicates that 400 households are needed as the sample size for each of the two sub-districts. A multi-stage sampling method was selected for conducting the survey. This approach, also known as multistage cluster sampling, involves drawing a sample from a population by progressively forming smaller groups at each stage.

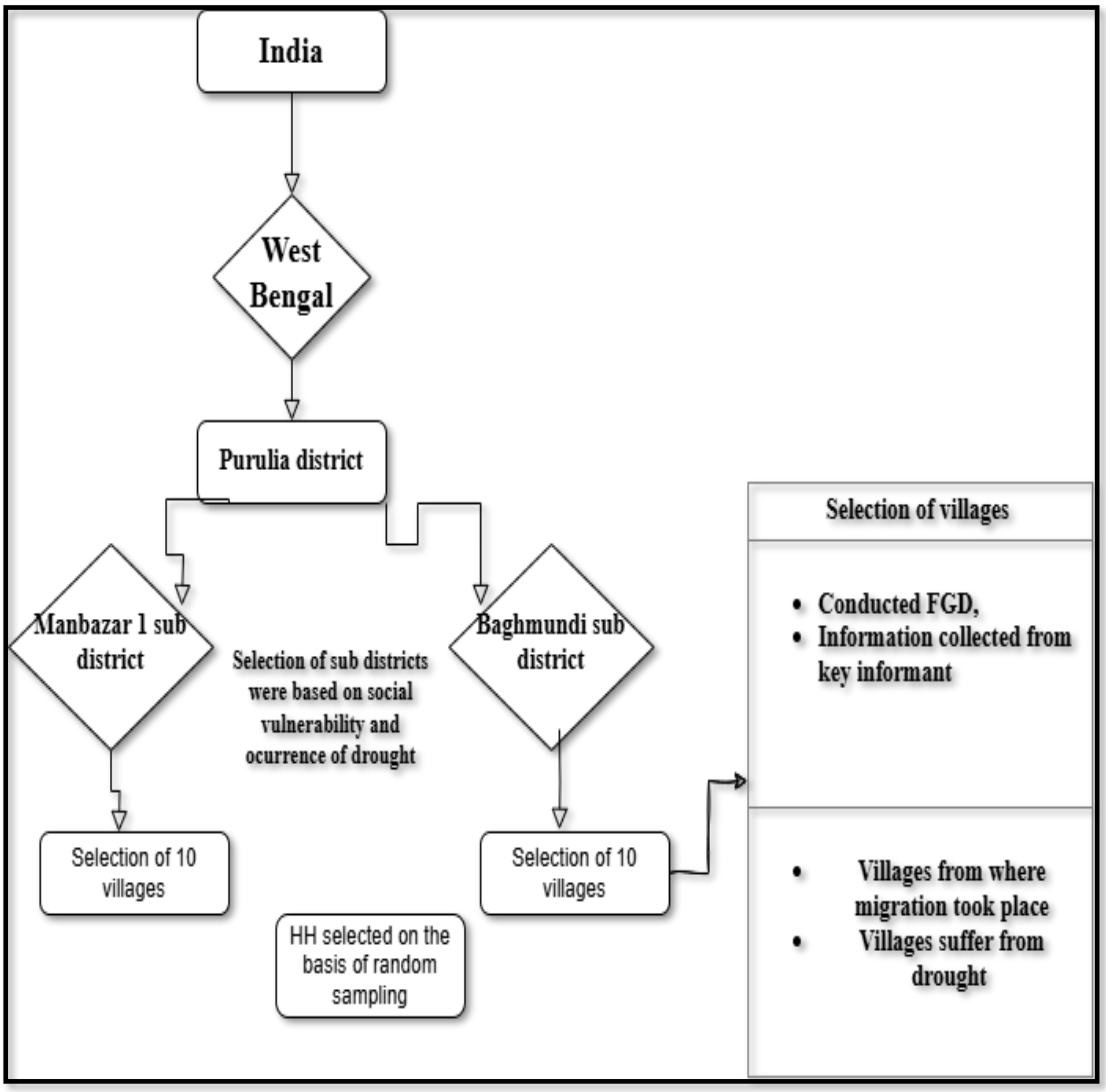


Fig 7 shows the conceptual framework of multistage sampling

3.7 Methods for Interpreting Field Survey Data

Methods refer to the specific techniques employed in social research, whereas 'methodology' generally pertains to the conceptual and philosophical underpinnings that validate the use of these methods, despite its strict definition as methodological studies. Social research methods encompass the technical procedures for formulating research questions, gathering and analysing data, and presenting outcomes. Both quantitative and qualitative methodologies were applied in this study. Social research methods are commonly categorized into two types: 'quantitative' and 'qualitative,' to delineate the distinctions among the diverse research methodologies.

Quantitative methods, typically employing deductive logic, seek patterns in human behaviour by deconstructing the social world into measurable elements, or variables. These variables can be quantified as frequencies or rates and their interrelations can be examined through statistical techniques. They are made accessible via stimuli introduced by the researcher and through systematic observation and measurement.

"Quantitative methods" is a broad term that covers various research types (Bryman 1988). At its most basic, it involves tallying event frequencies (e.g., educational achievements of school leavers, usage of doctor's offices, divorce rates); The proportion of people who are below the poverty level (Kumar 1999: 226–40; Iganski and Payne 1999); and displaying these frequencies in summarized tables and diagrams (Frankfort-Nachmias and Leon-Guerrero 2000). It can be expanded to explore the relationships between two or more variables, that is, their associations (Rose and Sullivan 1993: 3–31), or to complex multivariate statistical methods and mathematical models that describe social patterns.

Almost all forms of quantitative research share certain features.:

- The primary focus is on describing and explaining patterns in social behaviour, rather than identifying and interpreting the meanings individuals ascribe to their actions.
- Behavioural patterns can be deconstructed into variables and quantified numerically, rather than viewing actions as elements of a comprehensive social process and context.

- Frequently, explanations are expressed as statistical correlations between variables, usually in a way that makes it possible to forecast results based on known patterns.
- In addition to studying social phenomena as they naturally occur, researchers also introduce stimuli such as survey questions and collect data methodically through controlled measures.
- The assumption is that social processes operate beyond the comprehension of individual actors, restrict their actions, and are accessible to researchers through their pre-existing theoretical and empirical knowledge.

Researchers often test theoretical hypotheses using deductive logic rather than inductive reasoning, seeking regularities or "laws" of social behaviour. However, this method is not as prevalent as some critics suggest. The intricacies of social interaction and the meanings individuals attribute to these interactions are considered secondary and less critical levels of explanation. This perspective prioritizes the existing social order or external social structures that influence outcomes over individual actions.
Quantitative research typically delves less into detail compared to qualitative methods but covers a broader scope and offers a more general explanation. It employs representative samples to account for individual differences.

The data gathered was analyzed in this part using a variety of quantitative techniques, including the use of binary logistic regression, the Kruskal–Wallis H test, and the Wilcoxon signed-rank test.

3.7.1 Binary logistic regression technique

The link between a dichotomous dependent variable and one or more independent variables—which could be binary, interval, or ratio-level—is predicted using regression analysis. Events are frequently used to describe discrete or qualitative variables. The usual coding scheme for dichotomous or dummy variables is 1 for "yes," and 0 for "no." A dichotomous variable with codes of 1 and 0 has an average that is equal to the percentage of cases with codes of 1, which is also known as the chance that an event will occur.

To examine the link between several independent variables and a binary response variable, researchers utilize binary logistic regression. Parameter estimation is a crucial step in logistic regression modelling. This statistical data analysis technique determines the effects of multiple variables when the response variable is categorical, accepting both ordinal and nominal variables, with predictor variables that may be categorical or continuous. Logistic regression encompasses multinomial, ordinal, and binary types. Multinomial logistic regression is suitable for analysing multicategorical outcomes, while ordinal logistic regression is appropriate for ordinal variables. With a value of 1 signifying the presence of a characteristic and a value of 0 signifying its absence, binary logistic regression specifically examines the relationship between several independent variables and a binary response variable. In this case, the response variable is dichotomous qualitative data (Rohmah, D. A. M., Astuti, A. B., & Efendi, A. (2023).

3.7.2 Wilcoxon signed-rank test

The non-parametric equivalent of the paired t-test is the Wilcoxon signed-rank test. In contrast to the latter, it merely assumes that the distribution of differences is symmetric, not necessarily normal, and makes no assumptions about the initial population's distribution. This test was first presented by Frank Wilcoxon in 1945. Two paired data samples are used to illustrate its use. The following steps are included in the Wilcoxon signed-rank test procedure:

creating a null hypothesis, according to which the median difference between the paired data is zero, and another hypothesis, at a selected level of confidence.

Finding the distinctions between the pairs of samples, ranking them only according to their size, adding up the rankings of the positive and negative differences, and selecting the smaller sum as the test statistic are the steps involved in calculating the test statistic.

To determine whether to reject the null hypothesis, the test statistic is evaluated with a critical value; if the test statistic is less than the critical value, the null hypothesis is rejected (King, A. P., & Eckersley, R. (2019).

3.7.3 Kruskal–Wallis H test

The "one-way ANOVA on ranks," or Kruskal-Wallis H test, is a nonparametric technique for determining if samples come from the same distribution. It is employed to compare two or more independent groups on a continuous or ordinal outcome when the presumptions of a one-way ANOVA are not fulfilled. The Mann-Whitney U test, which only compares two groups, is extended to several groups by this test.

In 1952, Kruskal and Wallis developed the Kruskal-Walli's test, a non-parametric technique for figuring out whether samples come from the same distribution. For more than two groups, it is an expansion of the Mann-Whitney U test. The null hypothesis of the Kruskal-Wallis test asserts that the mean ranks of the groups are the same. It is the non-parametric equivalent of the one-way ANOVA and is frequently called a one-way ANOVA on ranks.The Kruskal-Walli's test doesn't need that the data have a normal distribution, in contrast to the one-way ANOVA. Because of this, it is especially well-suited for analyzing microbiome data, which is often not regularly distributed after sequencing and may contain notable outliers. By using ranks instead of actual numbers, the test's results are less affected by outliers or an irregular data distribution. Y. Xia (2020).

Qualitative methods offer in-depth, non-quantitative insights into small groups, aiming to interpret the significance individuals attribute to their lives within natural settings. This approach is grounded in the belief that social interactions constitute a cohesive network of relationships best comprehended through inductive processes. Qualitative methods concentrate on "how ordinary individuals perceive and articulate their life experiences," as noted by Silverman (1993: 170). The term encompasses a range of research methodologies. Qualitative sociology concentrates on individual interactions, highlighting the interpretation of meanings each person contributes to the interaction and the negotiation of mutual understandings. In this approach, outcomes are not predetermined by any social order or structure beyond the actors' lived experiences. Searching for general "laws" of how "society" functions is less meaningful, as society is merely the aggregate of numerous complex social situations occurring at once (Bryman 1988).

The primary focus is to discern and understand the meanings individuals ascribe to their actions, rather than outlining patterns or statistical correlations between "variables."

- Actions are viewed as elements of an integrated social process and context, not as isolated units for analysis.

- They aim to experience social phenomena in their organic state (they watch events unfold rather than causing them to occur).

- Their explanations are more concrete and specific rather than abstract and general.

- They opt for non-representative, small groups of individuals instead of large, representative samples to uncover widespread national trends.

- They concentrate on the intricacies of human existence.

- Rather than testing a preconceived hypothesis, they investigate the data they encounter, allowing theories to develop from their observations (that is, they employ inductive reasoning over deductive reasoning).

In this research, life histories were utilized as qualitative techniques

3.7.4 Life history

Life history (LH) interviews are a qualitative data collection method where written or oral narratives are gathered through questions and answers to describe or comment on an individual's life (Bertaux, 1981; Olive, 2014). In this approach, participants provide a subjective life narrative within a specific timeframe, using their own words and chronology. LHs are thus employed to examine temporality and are typically conducted across multiple sessions, focusing on continual changes. This method aids researchers and subjects alike in understanding how events and behaviours shape personal choices and actions. The subjective aspect of LHs offers a deeper contextual comprehension of the reasons behind certain decisions. Narrating LHs enables the identification and chronological mapping of significant events or "turning points" in respondents' lives (Ingelaere et al., 2018).

Life histories are utilized across various contexts to comprehend the transitions people undergo during times of vulnerability and resilience. For instance, they have been employed to examine poverty dynamics, observing how families may fall into or escape poverty over time (Kothari and Hulme, 2004; Bird and Shinyekwa, 2003). Additionally,

this method has analyzed the effects of policies on individuals' livelihoods (Chimwohu and Hulme, 2006) and their susceptibility to climate change, influenced by deep-seated structural issues like social and economic disparities (Singh, 2018). In the realm of development research, life histories have enabled scholars to uncover subtle distinctions in community members' views and opinions, such as during protest movements, challenging preconceived notions about specific groups or sociocultural settings (Kothari and Hulme, 2004). Life histories, irrespective of the application context or discipline, offer profound insights into the events that have moulded an individual's life, delving into the subjective interpretations and significance people assign to their experiences, beyond merely considering the overarching social, cultural, and economic factors that precipitate certain occurrences.

Chapter 4

(Assessment of Climate variability and drought in the Purulia district)

4. Introduction

Climate variability's influence on droughts has garnered significant global attention in the past few decades. One of the main causes of changes in hydrometeorological variables throughout time and space is climate variability (Nobre et al., 2017). Moreover, it is directly associated with various natural disasters, including floods, droughts, and hurricanes (Heltberg, 2011).

Research by Park et al. (2018) indicates that droughts may become increasingly frequent and intense due to rising temperatures. Historical climate data from recent decades reveal that atmospheric warming has led to longer and more severe droughts worldwide (Chiang et al., 2021). Studies by (Touma et al., 2015) found that droughts' duration and frequency are expected to rise in various global regions, particularly in subtropical and tropical zones, during the periods 2010–2054 and 2055–2099, based on a multi-model ensemble of 15 General Circulation Models (GCMs).

4.1 Concept of climate variability

Climate variability is a complex event at the intersection of climate change and weather variability. On all spatial and temporal scales that extend beyond the purview of specific weather incidents, it refers to changes in the average state of the climate as well as other statistics (e.g., the frequency of extremes, standard deviations etc.) (IPCC_AR6, 2022). The temporal and spatial changes in hydrometeorological variables have been reported to be significantly influenced by climate variability (Guimares Nobre et al., 2017). Extreme weather is an inevitable outcome of weather and climate variability. These occurrences are more atypical and severe than typical weather and include droughts (low rainfall events), heat waves (high temperature episodes), cold waves (low temperature occurrences), and rains (heavy rainfall events) (van der Wiel & Bintanja, 2021). Extreme weather events are becoming increasingly dangerous to natural ecosystems and societies. Human-caused greenhouse gas (GHG) emissions, land use change, and other activities impacting the global energy balance are causing changes in the frequency and severity of extreme weather and climate events. Droughts, floods, and heat waves are becoming more frequent in some areas (IPCC 2019).

Conflicts are linked to climate variability and extremes because of increased food costs, water and food shortages, income loss, and loss of livelihoods. Through such fluctuations and extremes, climate change poses serious threats to world peace, especially in regions with weak governance, low economic growth, and a heavy reliance on climate-sensitive enterprises. The most severe impacts are anticipated to occur in weather-dependent societies with several underlying risk factors and inadequate resistance to climatic extremes. Food insecurity, which can result in malnutrition, including undernutrition, overweight and obesity, and disease vulnerability in low- and middle-income countries, is exacerbated by climate variability and change. There is a greater chance of migration in response to climatic variability and change since rural livelihoods and incomes dependent on agriculture, livestock, and the collection of natural resources are intrinsically vulnerable to these changes (Bohra-Mishra et al., 2017; Viswanathan & Kumar, 2015).

Interannual climate variability has the potential to either increase or decrease regional hazard activity and risk on a seasonal or annual basis. In addition to other statistics, the average climate condition varies annually on all regional and temporal scales (Rädler, 2022). Both present and future climate change, including changes in climate variability and the frequency and intensity of extreme events, have an impact on hazards (here, "hazard" refers to the possibility of a natural or man-made event that could result in death, serious injury, or other adverse health effects, and also loss or damage to assets including infrastructures their livelihoods, property, and environmental resources) (IPCC_AR6, 2022). By changing their frequency, severity, spatial extent, duration, and timing, climate change has the potential to bring about previously unheard-of extreme weather and climatic phenomena. Even minor incidents have the potential to worsen and result in severe weather catastrophes like droughts (Field, 2012).

Despite being a natural occurrence, droughts have become more frequent and extreme due to climate change, which has had several negative effects. (Sarma, 2010). Both rich and developing nations are affected significantly by droughts, which are becoming more frequent, severe, and lasting longer. There is growing evidence that droughts can have significant, long-term impacts on farms, businesses, and families. They can jeopardize agricultural systems, accelerate the destruction of forests, reduce business productivity, and significantly affect the health of women and children. The disproportionate impact on poorer countries is a result of often harsher climatic

conditions and limited resources to cope with the consequences of dry shocks and droughts(Zaveri et al, 2023)Drought threatens the food safety and lives of millions of people worldwide, with the effects being most severe and acute for those in Asia. It also causes crop losses, which lowers food supply and raises food costs.

The IPCC AR6 report, 2022 warned that the impacts of weather and climate extremes, particularly droughts, will increase vulnerability and lead to violent intrastate conflict if global warming increases, and pointed out that in Asia, food and water security will be at risk from increased temperatures, droughts, and rainfall variability.

4.2 Understanding drought

Many people have defined and explained the phenomenon of drought. Droughts are seen in almost every climate, in regions with high and low rainfall, and are typically linked to a decrease in precipitation over a long-time span, like a season or a year (Wilhite & Glantz, 1985). Although they cannot be avoided, droughts can be predicted and closely monitored to reduce their negative impacts (C. Agnew, 1990; Palmer, 1965; Smakhtin & Hughes, 2007). Droughts are a natural occurrence brought on by a lack of rainfall. Of all the natural hazards, it is the most complicated and little-understood phenomenon, and it is also unpredictable (Amrit et al., 2018). Environmentalists, ecologists, hydrologists, meteorologists, geologists, and agricultural experts have all taken notice of drought as an environmental crisis (Mishra & Singh, 2010). They contend that there are many explanations for droughts since they are influenced by both the atmosphere and the hydrological processes that contribute moisture to it. This makes their causes complicated. When dry hydrological conditions are reached, a positive feedback loop known as droughts occurs. This mechanism involves the loss of moisture from the top layers of soil, which decreases the rate of evaporation and ultimately the relative humidity in the atmosphere. It becomes more difficult for a normal low-pressure system to reach saturation conditions over the area, so the probability of precipitation decreases as the relative humidity decreases. Drought is a severe weather condition characterized by a lack of moisture (Rawat et al., 2022). Droughts can be broadly categorized as ecological, hydrological, agricultural, and meteorological. When a considerable drop in precipitation relative to seasonal and typical precipitation is anticipated, a meteorological drought may result. The primary causes of hydrological

drought are thought to be the decline in the groundwater table, a decline in groundwater outflow, the loss of water stored in lakes and reservoirs, and the drop in river water levels. An agricultural drought happens when there is not enough rainfall or soil moisture throughout the crop season to support good crop development.

Hydraulic extremes, such as droughts, cause extended periods of water scarcity, which affect global food security and agricultural productivity(Herrera & Ault, 2017). During the 19th and 20th centuries, major famines occurred in monsoon-reliant areas like India due to frequent droughts (Aadhar & Mishra, 2020; Mallya et al., 2015). The main source of groundwater recharge in India is the southwest monsoon rainfall, which makes up 80% of the country's yearly rainfall(Asoka et al., 2017) and agricultural water supply(Singh et al., 2019). India is very susceptible to drought, with around two-thirds of its area affected by drought(Udmale et al., 2016). In recent decades, India has experienced multiple catastrophic droughts(Amrit et al., 2018).In India, a nation sustained by agriculture and home to 1.4 billion people, droughts significantly affect agricultural productivity, water resource management, and socio-economic health. Over recent decades, the occurrence, intensity, and duration of droughts have escalated, a trend likely to worsen with the advancing impacts of climate change(Aadhar & Mishra, 2021). Considering the rising demand for food driven by population growth and urbanization(Pandey & Seto, 2015), and it is anticipated that the consequences of droughts will get worse in the future. Reducing the Indian population's vulnerability for future drought episodes requires an understanding of the observed droughts and their trends.

In India, the frequency of droughts has been a recurring problem that has increased since 1965. In the eastern areas, droughts happen once every five years, while in the Gangetic zone of West Bengal, they happen more frequently and with greater intensity. The monsoon's waning intensity, an anticipated increase in average temperatures, and a prolongation of the summer season are all contributing causes (Alley et al., 2007; WBSAPCC, 2017).

The Purulia district is situated in the eastern region of the Indian peninsula, is known for its susceptibility to drought, vulnerability, and frequent exposure to drought conditions. The frequency and severity of drought in the Gangetic plains and the region that borders them in eastern India have significantly increased during the last 50 years,

according to Nath et al. (2017). According to (Bhunia et al., 2020), Purulia is among the districts in western West Bengal most badly impacted by drought (Roy & Hazra, 2020a). Since Agriculture in eastern India predominantly depends on rainfall, thus any abnormal monsoon activity, exacerbated by other environmental factors that reduce soil moisture, directly affects the state's GDP. Given that West Bengal is a key agricultural hub in India, its drier western region necessitates detailed analysis to assess vulnerability and the potential socioeconomic losses from drought.

4.3 Results

For the research area, linear regression is used to display the maximum and minimum temperatures as well as the annual and monsoon rainfall rate of change, which is determined by the slope of the regression line. The rate at which annual and monsoon rainfall changed between 1970 and 2020 is depicted in Fig. 8, where it was around 0.23 mm/year for annual rainfall and -0.68 mm/year for monsoon rainfall.

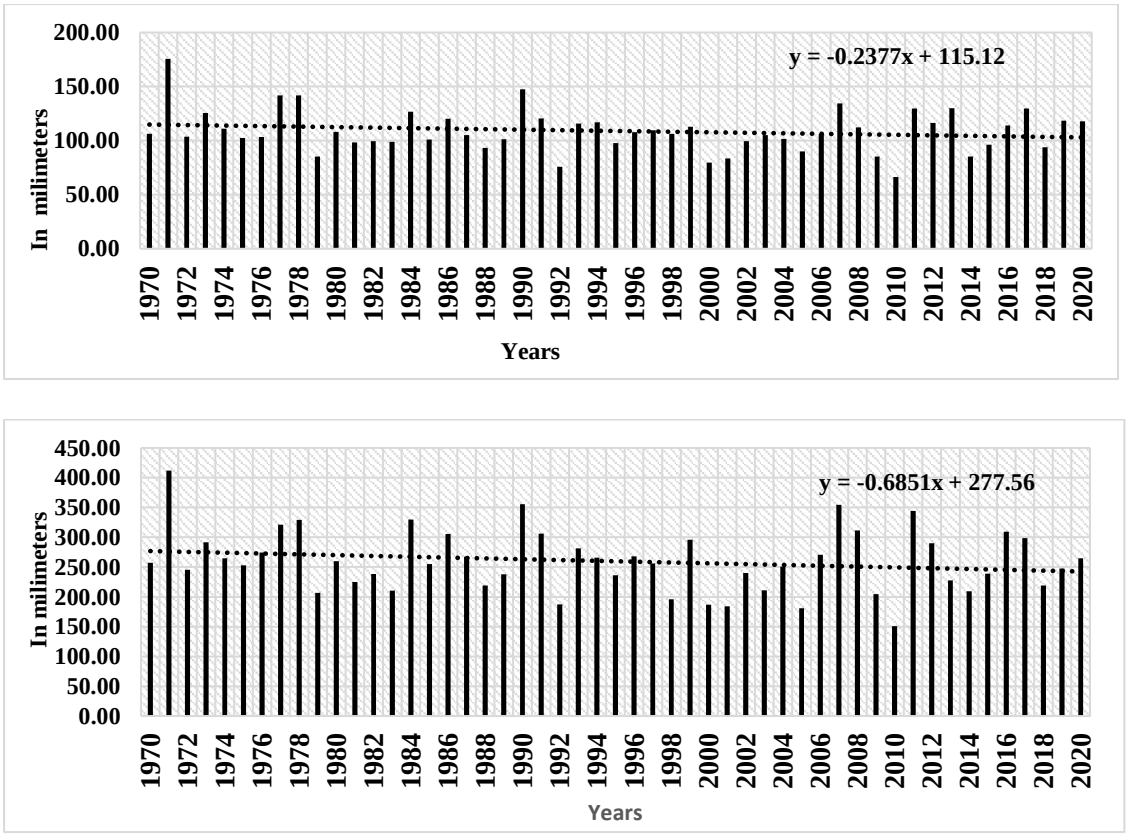


Fig. 8. Depicted The yearly and monsoon rainfall trends from 1970 to 2020

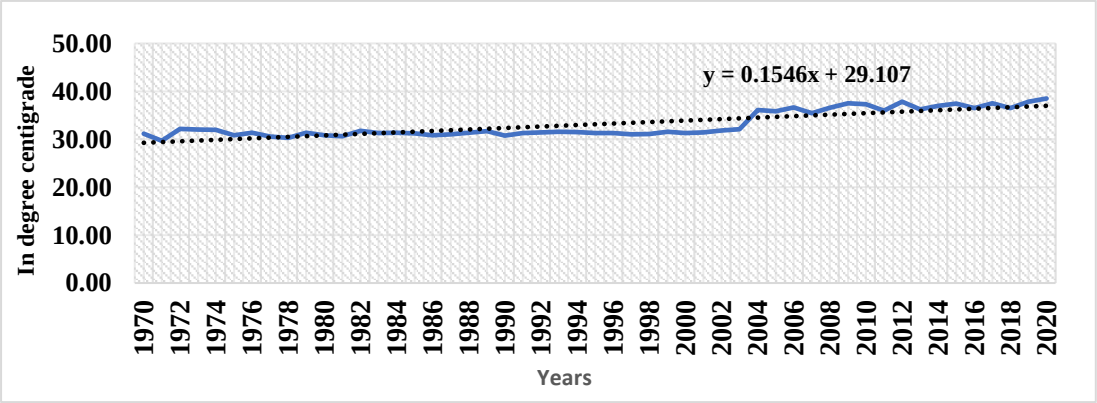
The declining trend in annual and monsoon rainfall is statistically significant (Table 14). Purulia is an agricultural district with rainfed agriculture and low irrigation

facilities, making the agriculture sector vulnerable to the changing effects of climatic parameters, especially rainfall. The persistent decline in annual and monsoon rainfall over the years poses a substantial risk to the district's agricultural and people' food security.

Table 14 Linear regression model result (Annual and monsoon rainfall,1970-2020)

Season	Change in the rainfall (mm per year)	p-value	Percentage of total rainfall
Annual	-0.23mm /year	0.04	100
Monsoon	-0.68mm /year	0.03	79.5

Regarding temperature, it is evident (Fig. 9) that both the maximum and minimum temperatures are increasing, with the maximum temperature changing at a pace of +0.15°C/year and the minimum temperature changing at a rate of +0.03°C/year. Since 2000, there has been a considerable increase in both the maximum and minimum temperatures, with the maximum temperature rising faster than the minimum. The results align with the 2017 West Bengal State Action Plan on Climate Change (WBSAPCC, 2017) analysis.



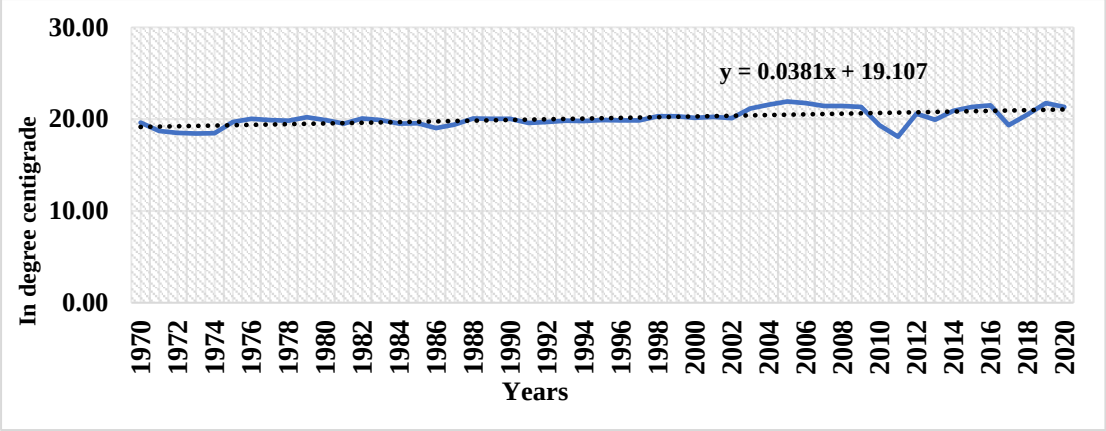


Fig 9 shows trend of mean annual maximum and minimum temperatures (1970-2020)

Wet and dry years are identified using the Rainfall Anomaly Index (RAI) analysis, and the number of dry years in our research area was rising. The rainfall anomaly index's interannual variability is depicted in Fig. 10, and it is clear that the trend is below the long-term average, particularly after 1992. Highest negative RAI of -2.09 was observed in 2010. An interesting observation is that in the period 2000-2020, negative RAI values of more than one intensity were observed in five years, namely 2000, 2001, 2009, 2010, and 2015, while the frequency of negative anomalies of high intensity (more than 1) in the period 1970-1999 was only two years (1979 and 1992). Very low RAI values correspond to severe droughts, and the increasing number and intensity of RAI over the years is worrying as the district is already drought-affected.

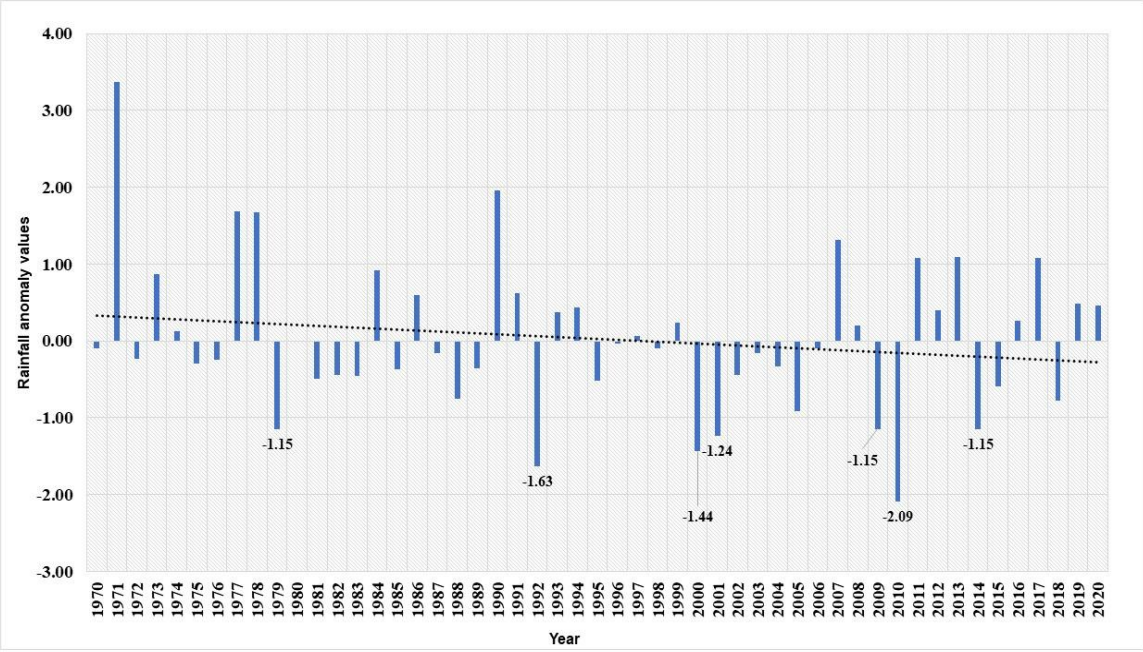


Fig 10 shows the Purulia district's rainfall anomaly index (RAI) trend from 1970 to 2020.

According to the annual standardized precipitation index (SPI), which is frequently used as a drought indicator, the frequency and severity of droughts have increased, particularly since 1992 (Fig. 11). During the 30 years (1970-1999), drought occurred 15 times. Severe (1992) and moderate (1979) droughts occurred in only one year. However, in the last 20 years (2000-2020) there have been 12 droughts. In the period between 2000 and 2020, there was one extreme drought year (2010), one severe drought year (2000) and three moderate drought years (2001, 2009 and 2014).

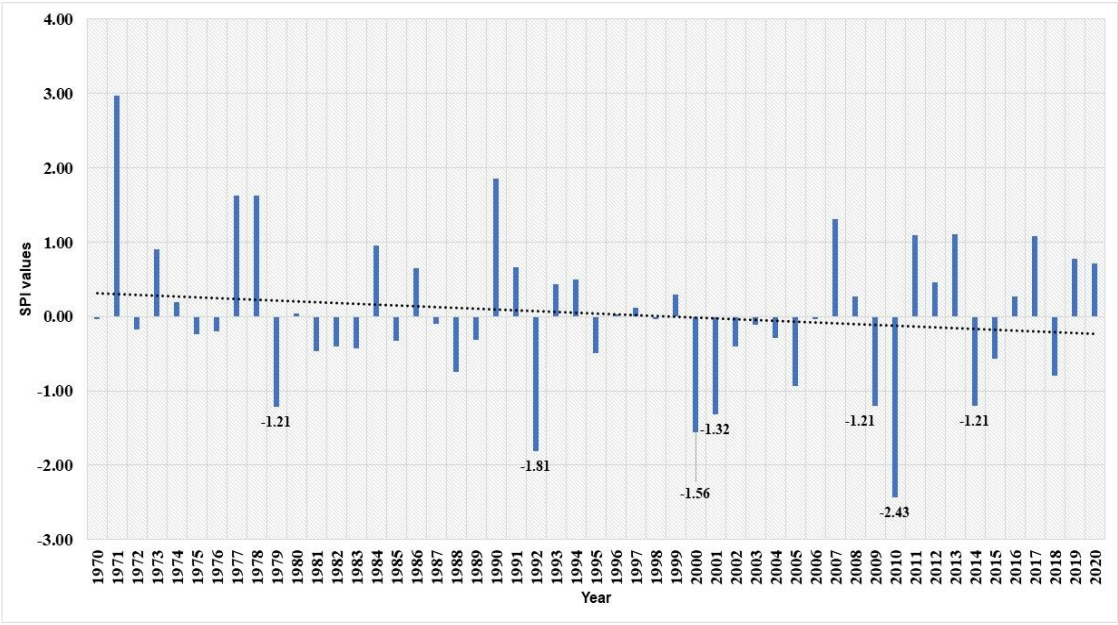


Fig 11 shows the trend of standardized precipitation index (SPI 12) of Purulia district (1970-2020)

The precipitation concentration index (PCI) (Table 15) indicates the occurrence of heavy and very heavy precipitation concentrations, despite the fact that precipitation has declined over time and dry years are rising. Our study's findings are in line with the IMD report for West Bengal, which discovered that this district had a comparable concentration of heavy rainfall (Guhathakurta et al., 2020).

Table 15 Precipitation Concentration Index (PCI) of Purulia (1970-2020).

PCI Index	**Explanation**	**Number of years (1970-2020)**
Less than 10	Low concentration of precipitation (almost constant)	0

11 to 15	Medium concentration	1
16 to 20	High concentration	26
≥21	Very high concentration	23
Mean Precipitation concentration (1970–2020) =19.44(high rainfall concentration)		

Our statistical test is consistent with the information obtained from the survey of small and marginal farmers in the field, where farmers reported a decrease in rainfall, the occurrence of heavy precipitation, and the increasing number and intensity of droughts over the years.

Case no 1:" Farming under uncertainties ″

An informant from the Manbazar1 sub-district, a 51-year-old marginal farmer with less than 1 hectare of land and a father of five children, described the importance and recent fluctuations in monsoon rainfall as follows:

The monsoon rains are crucial for agriculture in the district as it is rainfed agriculture. The availability of irrigation facilities is low. It is the monsoon rains that sustain our agriculture and livelihood. The monsoon provides most of our rainfall and determines the yield of our staple food, rice. We pray for good rains every year. Good rains mean a good harvest. This means that we do not have to look for other means of livelihood and do not have to leave our `families`*. A good monsoon year means economic prosperity for small farmers like us. However, climate change in recent years has put agriculture under pressure. We are* ***suffering from crop failures****, which are our only source of food and income. In recent years, our growing season has been shortened because the* ***monsoon has been delayed****. The dates for the onset of the rains have shifted considerably. It has become* ***very unpredictable****.* ***Recurring droughts during the monsoon season*** *are now a major challenge. Their frequency and intensity have increased. I can recall the conditions during the drought years of 2000, 2001, 2005, and 2010. Another problem is that we are now using hybrid varieties of seeds that require more water.* ***The number of strong rainy days has increased, rainfall has decreased, and there have been longer dry intervals during the rainy season. The growth and maturity of paddy crops are negatively***

impacted by recurrent dry spells. Another issue we have is unexpected rainfall. *Even during the rainy season, the temperature has risen.. We had expected the rains to start in June, but now they have started only by the end of June****. The delayed rain has led to a reduction in the area under rice cultivation and low production***. *Our irrigation systems (tube wells, river lift, hapa) have also been affected. I and some of my colleagues* ***do not want the next generation to stay in agriculture***. *We want them to go to the cities and work as construction workers or in hotels. He added that these jobs are not dependent on the vagaries of the climate*

Case no 2:" Good monsoon days are gone ″

Monoj Sutradhar from Baghmundi, a cultivator (having land between 1-1.5 hectares) and craft maker (aged 44 and father of 3 children) depicted his story as:

"I live with my parents and my children. We have 7 members in our family. We have our ancestors land and till my father's time we were solely dependent on agriculture only. My grandfather, father used to cultivate not only rice, but also vegetables. But, now in our time (in the last 10 to 15 years) I cannot dependent solely on agriculture to run my 7-member family. So, I make mukhos, idols and sell those to tourist. I also come to Kolkata to sell my mukhos, idols. I attend handicraft fairs in Kolkata. These additional works supplement my income. My family is not a traditional crafts maker one as most of the houses of chorida village. When I am not around my wife takes care of the field. We now only produce rice, though I want to lease out the land but my father doesn't. My father says we always eat rice from our land, it is an addiction to grow rice. When I am not around, my wife cultivates rice.

Agriculture is now stagnant, and unprofitable. *Rainfall is erratic now, the* ***increasing intensity of drought*** *damages crops, and groundwater has become insufficient due to decreasing rainfall availability. The temperature has significantly increased, the heat has gotten more intense, the lands are becoming dry, and the extreme heat makes it impossible for us to labor in the field for extended periods. The timing, severity, and length of rainfall all fluctuate. The availability of rainfall throughout the primary crop-growing season is our biggest concern. For the past 20*

years, the rainy season has been decreasing unreasonably and unpredictably, and the heat is getting unbearable. These days, crop failure is a common occurrence. The agricultural period shortens as a result of the monsoon's delayed arrival. Crop growth was impacted by sporadic dry spells throughout the wet season. The parched earth made it impossible to labor on the field.

Huge loss is regular phenomenon in the agriculture sector nowadays. We do not have good irrigation *to cover up the water deficiency during drought years just like farmers in Punjab, Haryana. I have seen the hardship of my fellow cultivators during drought years (2005,2010,2015) whose families were solely dependent on agriculture."*

4.4 Conclusion

The district is facing a decline in monsoon and annual rainfall, which is crucial since the district's agriculture is rainfed. Since 2000, there has been an increase in both the frequency and severity of droughts. Additionally, rainfall is becoming increasingly concentrated, resulting in heavier downpours.

Chapter 5

(Impact of drought on agriculture)

5. Introduction

Global change in the climate is expected to have serious effects, many of which are already being felt. Extreme weather phenomena, such as heat waves, torrential rains, hurricanes, droughts, and destructive storms, are predicted to become more frequent due to global warming (IPCC, 2018). A World Bank report states that low- and middle-income nations are home to 85% of those impacted by drought (Zaveri et al., 2023). Based on data collected from 101 countries Parties to the UNCCD, 1.84 billion people are affected by drought, of which 4.7% of the population is at risk of severe or extreme drought (UNCCD, 2023). The effects of drought are magnified by its widespread impact across various sectors, including rivers, agriculture, power generation, and industry, as well as its substantial influence on GDP and overall prosperity (IPCC, 2022)It is anticipated that climate change would put increasing strain on food availability and production, especially in vulnerable areas, jeopardizing food security. If little or no adaptation is done, the increased frequency, severity, and intensity of droughts will likely increase the risks to food supply in these areas from medium to severe with 1.5°C to 2°C of global warming (IPCC AR6,2022). Due to its direct exposure to the climate, the agricultural sector faces 84% of the economic effects of droughts, including decreased outdoor worker productivity from heat stress, crop failure, and low crop yields, according to the United Nations Annual Report on Climate Change. When taking into account two factors—physical vulnerability and socioeconomic vulnerability—drought can have long-term, indirect consequences in addition to a gradual or cumulative influence on agricultural production. Reduced soil fertility and agricultural productivity as a result of water stress are examples of physical vulnerability. The decline of livelihoods and income-generating activities, especially in rural areas, is a component of socioeconomic vulnerability (TP, 2023).

A significant portion of the rural populace in developing nations depends on agriculture for their livelihood. When agriculture relies on rainwater, weather anomalies like droughts can drastically impact both production and productivity(Hanna & Oliva, 2016). India is highly vulnerable to drought, with approximately two-thirds of its land area being drought-prone(Dar et al., 2020). The frequency, severity, and duration of droughts have increased in India in recent decades; this trend is expected to worsen as a result of climate change (Aadhar & Mishra, 2020). Approximately 80% of India's

yearly precipitation falls during the monsoon season. But this rainfall's pattern has become more unpredictable. The severity and frequency of monsoon-related droughts have significantly increased nationwide within the last ten years (Panda, 2016). Higher temperatures brought on by climate change have caused extreme short-term droughts in recent years, which have an impact on small farmers, crop yields, and arable land (Sam et al., 2020). Previous research has indicated that crop failures due to drought are becoming more frequent, which weakens farmers' resistance and puts food security at risk (Ghosh & Jana, 2018).With 1.4 billion residents and a largely agrarian economy, droughts have a major effect on socioeconomic conditions, agricultural output, and water resource management.

Even though West Bengal's sub-humid red and lateritic zones (RLZ) receive 1300 mm of monsoon rainfall on average each year, precipitation only happens for around 30 to 40 days of the year, usually in the form of severe storms that last 48 to 72 hours (Roy et al., 2023). The laterite soils atop the Precambrian granite gneiss and the hilly terrain result in significant surface runoff and soil erosion. This renders the Red and Lateritic Zone (RLZ) vulnerable to climatic extremes, causing frequent droughts that hinder monoculture farming in the area and contribute to food scarcity(Mukherjee & Palit, 2013).

The Purulia district located in West Bengal's RLZ, experiences drought conditions approximately every three years, a pattern that has persisted over recent decades(Mandal & Chakrabarty, 2013). In the sub-humid Purulia district, drought is frequently experienced (Goswami, 2019). About 80 % of the rural population in Purulia, which consists mainly of small and micro workers, lives in agriculture. About 75% of the total cultivated area in Purulia is rainfed (mainly depending on the rainfall of the southwest monsoon) therefore, slight changes in rainfall pose a significant threat to agriculture. The southwest monsoon, which lasts from June to September, is the main source of precipitation in the area. Rainfall in the district averages around 1300 mm per year. However, about half of this precipitation ends up as runoff because to the RLZ's rugged terrain and poor soil permeability. Only 17% of the arable land is cultivated with various crops, primarily due to insufficient irrigation. During the monsoon season, 77% of the net agricultural land is used for the district's primary crop, aman rice. Due in major part to insufficient irrigation, very little wheat, legumes, and oilseeds are grown during the Rabi season. The agricultural land has not increased significantly during the last 25 years (Pal Chaudhuri & Biswas, 2020). The Purulia district is crossed by a number of

rivers, such as the Kumari, Damodar, Kansabati, and Darakeswar, all of which dry up in the summer and cause water scarcity (Roy et al., 2022). Apart from crop losses, the drought also leads to price increases, unemployment, and more difficult access to food for small and micro farmers(Dasgupta & Chattopadhyay, 2008). Against this backdrop, assessing the impact of the drought in Purulia district is crucial for any plan to improve the population's living standards.

5.1 Aim and Objectives

The impact of drought on agriculture is examined in this chapter. Researching the impacts of drought on agricultural land and crop production is crucial since Purulia's assessment of the drought has revealed that the region's agriculture is significantly impacted by the regular short-term monsoon droughts.

To what extent does the region's crop yield variability vary from year to year for each crop?

What role do climatic factors like temperature and rainfall play in explaining crop output variability, and which climate factor—the maximum or minimum temperature, rainfall, or both—has the most impact on crop yield?

How does the recurrent phenomenon of drought explain crop yield variability?

5.2 Results

5.2.1 Crop Yield Variability and Trends

The first question—how agricultural yields have fluctuated from year to year between 1970 and 2015—is addressed in this section. The coefficient of variation (CV), or the yield variability standardized to the average yields, was employed as a metric to show these changes for every crop.

The following image shows the inter-annual variability (CV) of crop yields for the district

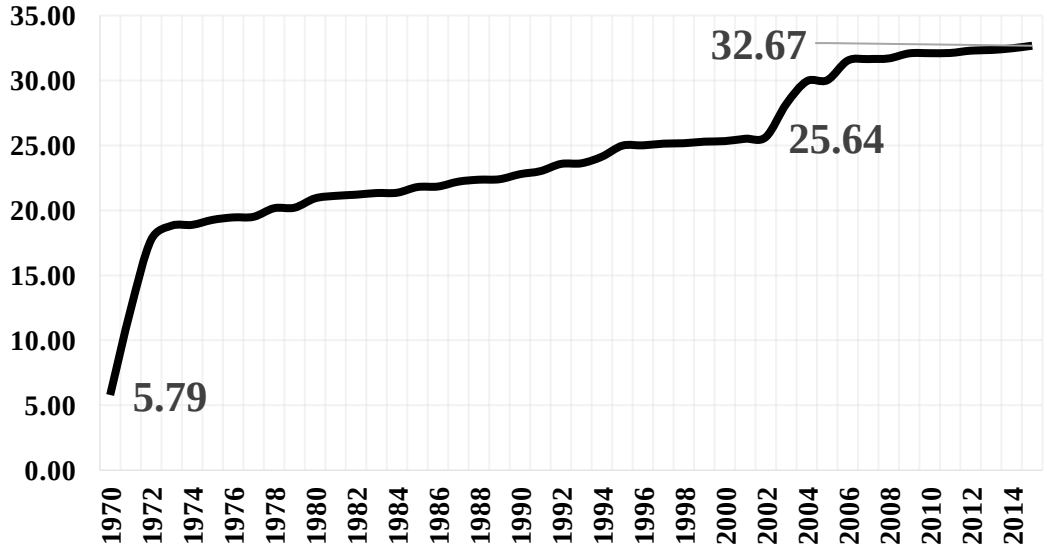


Fig 12 shows Rice yield variability between 1970-2015

The variation in rice yields increased from 6% to 33% between 1970 and 2015. Factors influencing agricultural yield and its variability globally encompass climate, soil, irrigation, and field management practices, along with decisions related to fertilizer use, tillage, and more(Kukal & Irmak, 2018). Among these, climate stands out as the most significant factor affecting agricultural production systems, even with technological advancements and other variables. Climate elements like temperature and precipitation directly affect cultivation (Panda et al., 2019), with changes in these elements influencing crop yields and total production. Rice production is significantly influenced by the weather patterns of the monsoon, e.g. the total amount of precipitation(Davis et al., 2019) and the distribution of rainy days(Fishman, 2016). Because rice is essential to the lives and food security of hundreds of millions of people in India, variations in monsoon weather dynamics can have a significant impact on rice productivity. According to research, the Indian monsoon has changed in the second half of the 20th century to produce fewer rainfall events and less overall precipitation, which has increased the likelihood of droughts and floods (Jin & Wang, 2017; Singh et al., 2019). Reduced rainfall and rising temperatures are two signs of the Purulia district's growing climate unpredictability (WBSAPCC, 2017). With 55 to 61 dry days during the monsoon season, the district's yearly rainfall is trending downward. At the same time, the district has experienced a notable rise in the number of dry days during the monsoon season (Guhathakurta et al., 2020). Monsoon-dependent agricultural systems are particularly vulnerable to the effects of climate change. The district depends on these

rains for agriculture, which is essential for the food security of its people, because it is underdeveloped and underprivileged, with little irrigation infrastructure.

To measure the difference between present and potential crop yields and production restrictions, it is essential to look at crop yield trends in addition to interannual variability. The rice crop yield patterns are shown in (Fig. 3).

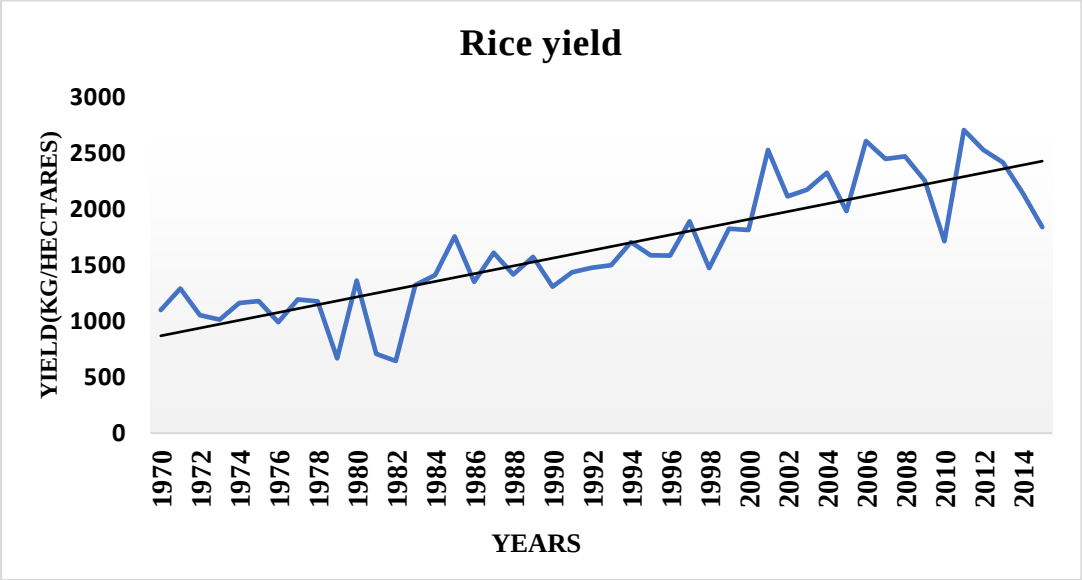


Fig 13 shows the trend of rice yield from 1970-2015

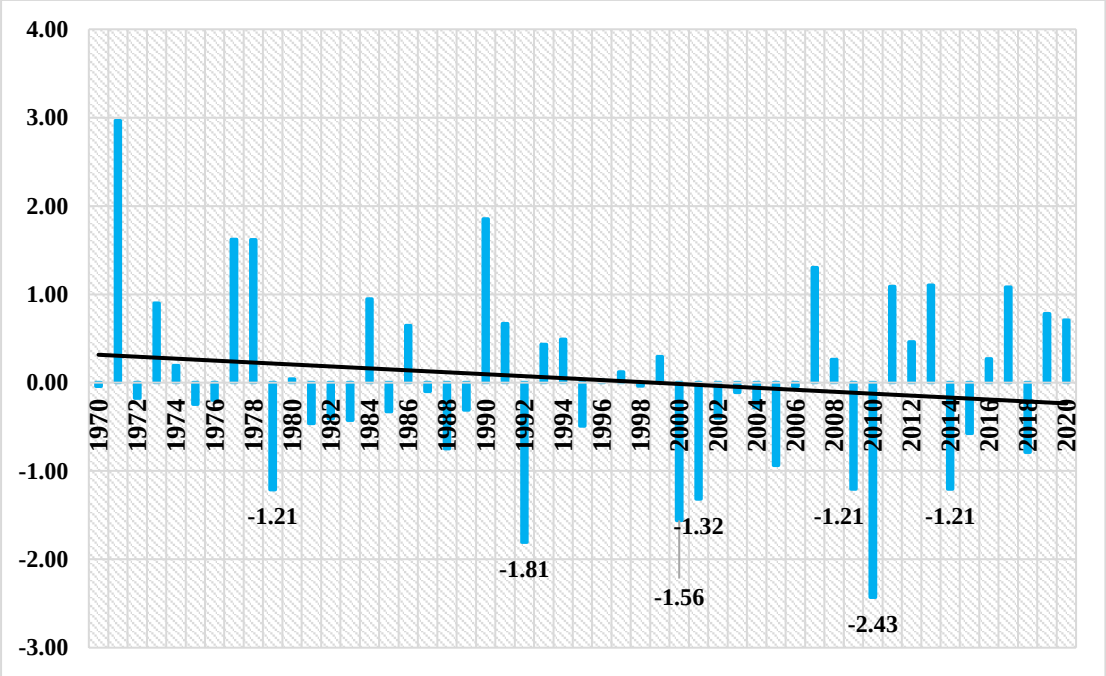


Fig 14 shows the trend of rainfall anomaly index (RAI) of Purulia district (1970-2020)

The trend in rice yields has consistently shown a positive increase over the years, except for the years 1980, 1992, 1998, 2005, 2009, 2010, 2014, and 2015, which experienced droughts, as indicated by the precipitation anomaly index.

5.2.2 Climate Explained Yield Variability

This section addresses the second question: how are crop yields influenced by climate variables? It utilizes multiple regression analysis to evaluate this relationship.

Table 16: Multiple regression analysis between rainfall, minimum and maximum temperature, and crop yields for the period 1970-2015

Rice	**Coefficient**	**t**	**P(sig)**	**R^2**
Annual rainfall	6.860	1.573	.003	.785
Minimum temperature	153.774	2.057	.046	
Maximum temperature	228.101	5.468	.000	

This multiple linear regression model aims to assess how crop yields respond to various climate factors. The slope coefficients derived from this analysis indicate the increase in yield for each unit change in temperature and precipitation. The percentage of crop output fluctuation attributable to these climatic conditions is shown by the regression's coefficient of determination (R^2). Moreover, a 95% confidence interval was used to assess the statistical significance of the influence of each climate variable on yields. The data indicates that 78% of the variation in rice yields is due to climate variables. The statistical significance of the P-values for precipitation and maximum temperature confirms their substantial effect on rice yields.

Stable crop yields are vital as the demand for food, fodder, and fibre escalates in a rapidly growing country like India. Variability in crop yields can adversely affect national and state food reserves, escalating food prices, and impact livelihoods,

particularly in the agricultural sector. Hence, it is imperative for regions such as Purulia, which are socio-economically disadvantaged and susceptible to drought, and where agriculture is the primary livelihood for many, including small and marginal farmers, to enhance their resilience to yield fluctuations to mitigate these effects, as even minor variations can significantly influence productivity.

5.3 Assessment of drought on agriculture

5.3.1 Temporal Patterns of Drought-Induced Crop Yields at the District Level

Agriculture as a source of livelihood in Purulia district lags behind other districts of West Benga. Despite high labour participation in agriculture, the average income of farmers remains low due to poor productivity. This situation mirrors the district's sluggish agricultural advancement. The lack of adequate irrigation, flat lands, fertile alluvial soils, educational opportunities, developed markets, and effective agricultural extension activities, which are vital for agricultural growth in other areas, are mainly to blame for Purulia's slow agricultural progress. The district predominantly practices monoculture farming, heavily reliant on rainfall. With 60% of the cultivated land located in highland areas and approximately 73% consisting of small, fragmented plots owned by small and marginal farmers, the challenges are compounded (Baral et al., 2023). Frequent droughts and scarce irrigation resources pose a significant threat to these farmers' livelihoods, underscoring the need to assess the impact of droughts on rice yields in Purulia.Figure 15 illustrates the annual pattern of drought events and their impact on rice yields. A drought year is characterized by low SPI values.

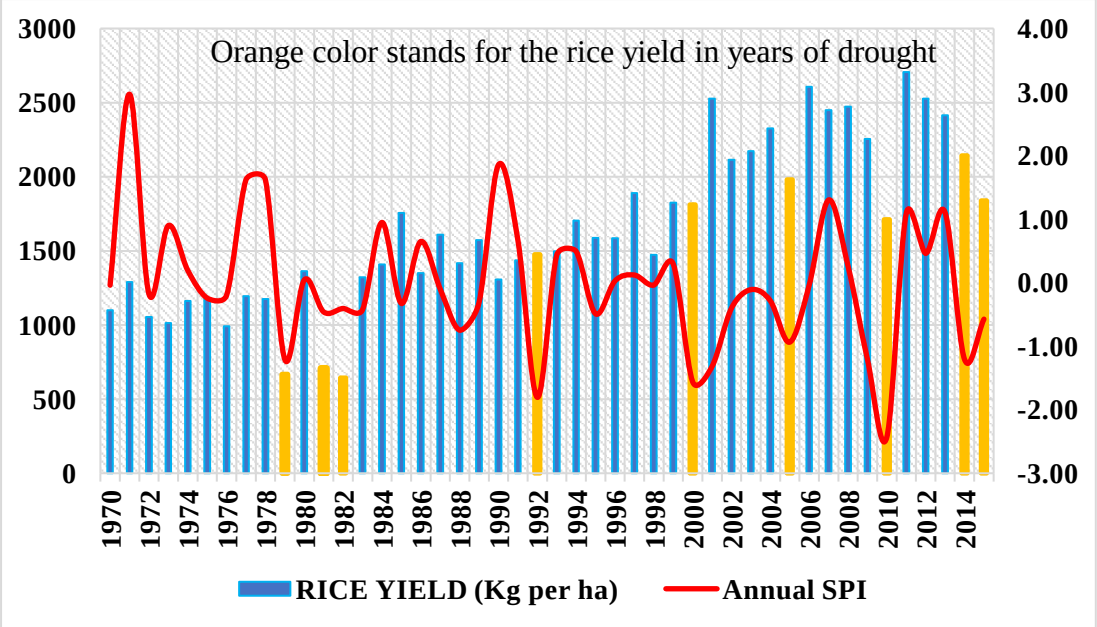


Fig 15 shows the temporal pattern of drought and rice yields (1970-2015)

The above graph shows that low spi values in drought years go hand in hand with a decline in rice yields. Prolonged and severe droughts can have a major effect on agriculture and food security by reducing demand for non-agricultural items, increasing rural poverty, causing forced migration, depleting productive assets, and overusing natural resources (Kumar et al., 2014). The prevalent practice of traditional subsistence farming heightens the risk of crop failure amidst frequent droughts. Unusual or extreme weather events, such as droughts, which are predicted to occur more frequently in the future, increase this risk even more. Areas like Purulia, which are underdeveloped and impoverished, are especially susceptible to these disturbances because they are heavily dependent on agriculture and lack the financial and technical means to deal with these issues. In Purulia, even though agriculture's contribution to GDP is minor and decreasing, it still employs over half of the state's workforce (67.3%) and is primarily made up of small and marginalized landholders.

Concerns regarding food and livelihood have been raised by the regular occurrence of droughts. The body of research on how climate change affects agriculture and food security has grown significantly in recent years (Kurukulasuriya et al., 2011; De Salvo et al., 2013; Birthal et al., 2014;). However, to the best of my knowledge, there hasn't been a thorough examination of how extreme weather events, such as droughts, affect the socioeconomic well-being of people in a microregion like Purulia. To illustrate the

effect of drought on agricultural yields in sub-districts across time, this study offers a crop failure index.

5.3.2 Sub-district level assessment of the impact of drought on agriculture

Fig 16 illustrates sub-district-wise drought-induced yield losses or crop failure (used as a proxy indicator of drought) from 1992-93 to 2014-15. Studies by (Roy et al., 2022) have identified that crop failure occurred between 2005,2010, and 2015, however, the year 2010 significantly decreased crop production (60%) and led to crop failure/ drought-induced yield losses for all 20 community development blocks due to extreme drought. Fig 14 shows that drought intensity was at a maximum in 2010. We chose the year 2010 to show the spatial distribution of drought based on the crop failure index as all sub-districts were affected by it.

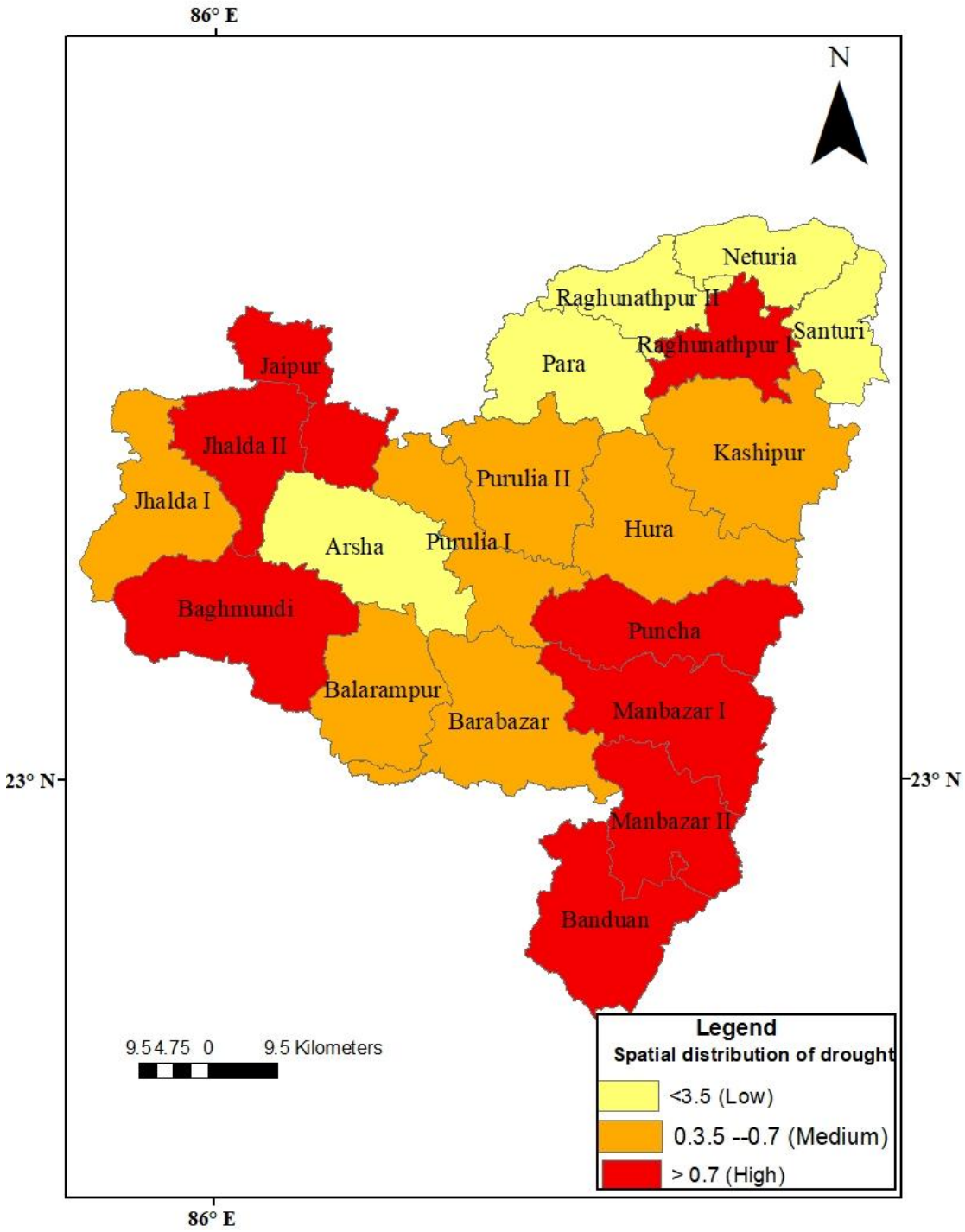
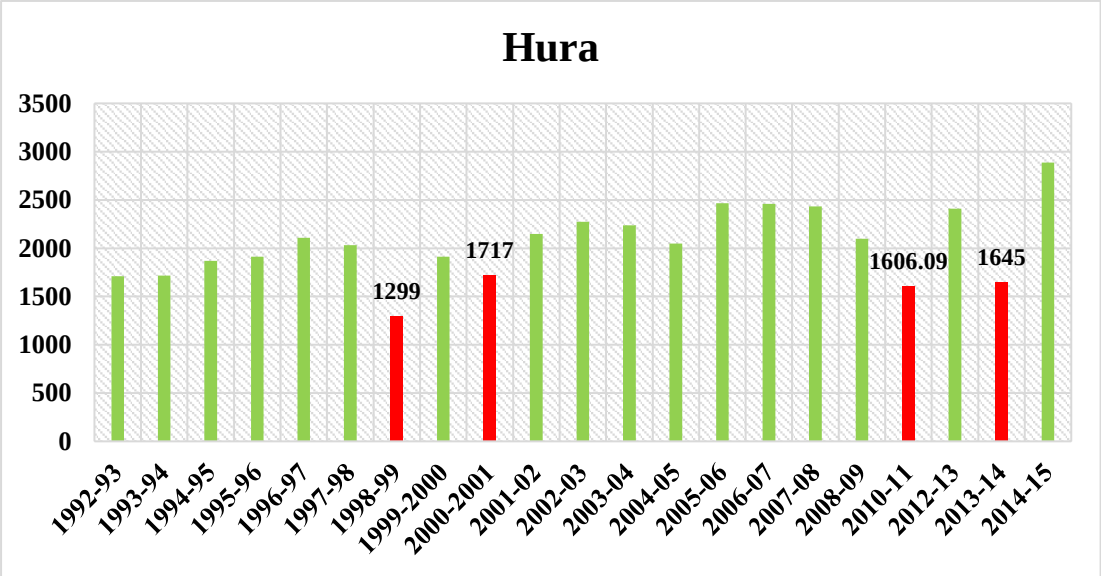
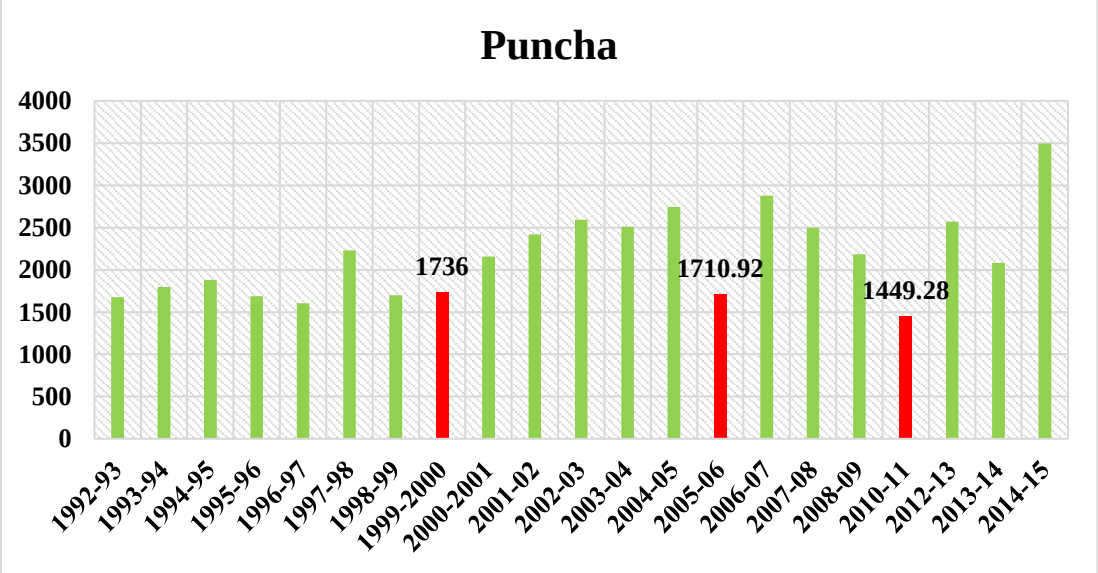


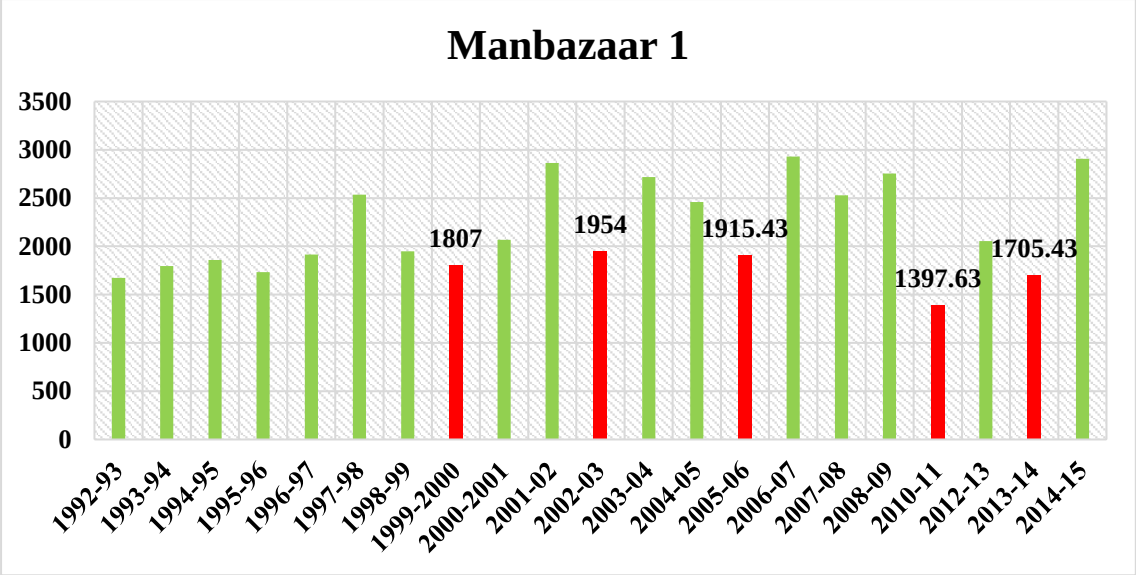
Fig 16 Crop failure index by subdistrict during the severe drought of 2010

Crop failure index showed that the community development blocks of Baghmundi, Bandowan, Jhalda2, Joypur, Raghunathpur1, Puncha, Manbazar1, and Manbazar2 in the district experienced the highest drought-induced yield losses/crop failure. The CD blocks of Jhalda1, Hura, Bara bazar, Kashipur, Purulia1, Purulia2, and Balarampur experienced medium levels of crop failure/drought and the CD blocks of Santuri, Para, Raghunathpur2, Neturia, and Arsha experienced low crop failure/drought. In the

extreme drought year 2010, the analysis of the crop failure index at the sub-district level of Purulia indicates that the southern and western blocks experienced extreme drought. The work of (Roy et al., 2022) also argued that the sub-districts of Bandowan, Joypur, Balarampur, Jhalda, Puncha, Kashipur, Purulia, and Bara bazar of Purulia district were frequently affected by extreme to moderate drought between 2005 and 2020. Subsistence farming practiced with rain-fed agriculture with poor irrigation led to crop failures of different intensities in various blocks.






Manbazaar 1
3500
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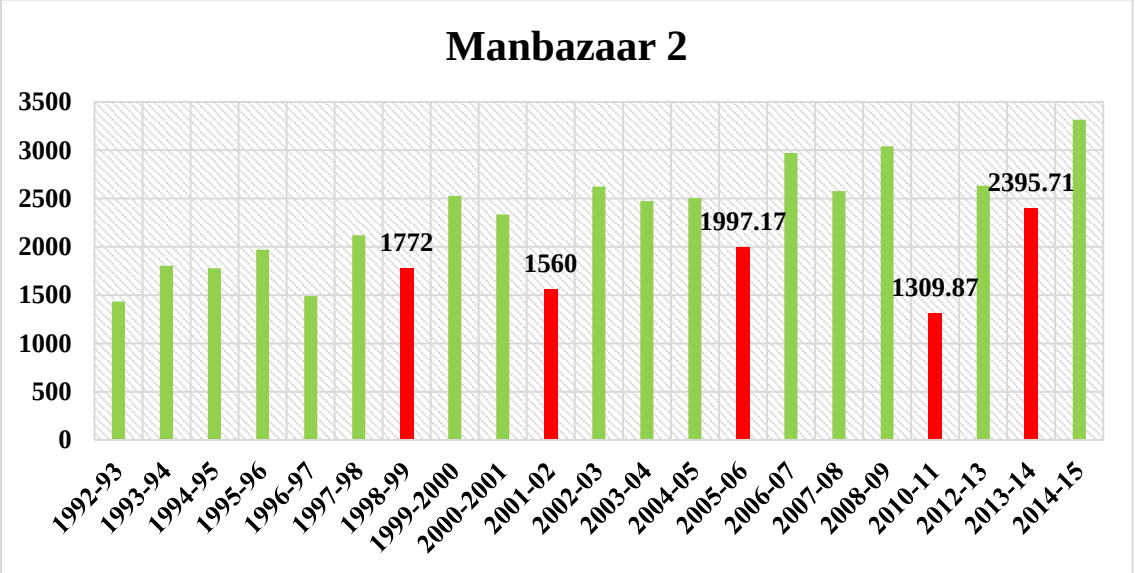
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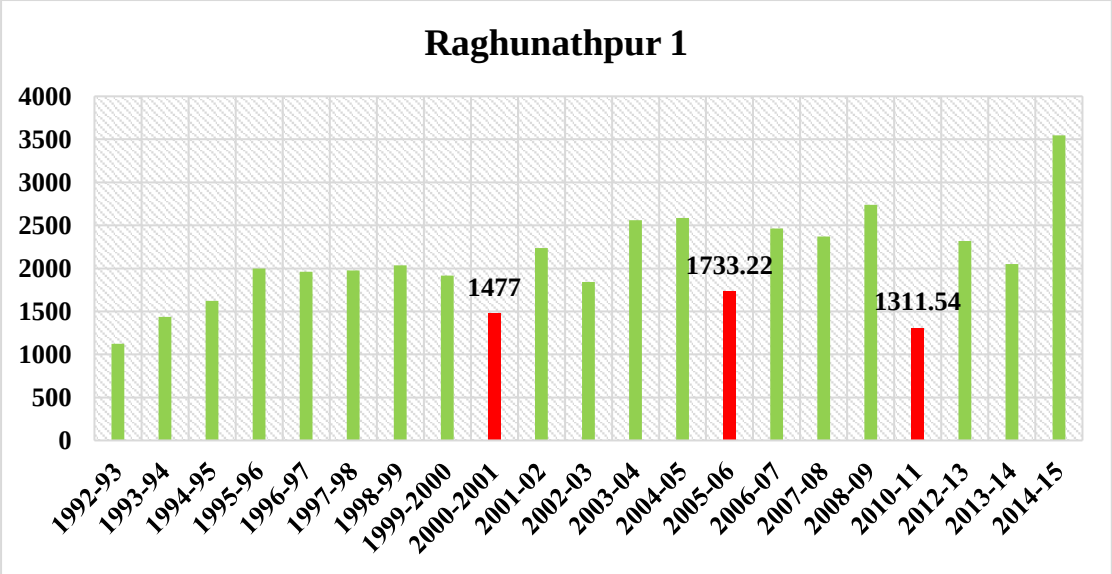
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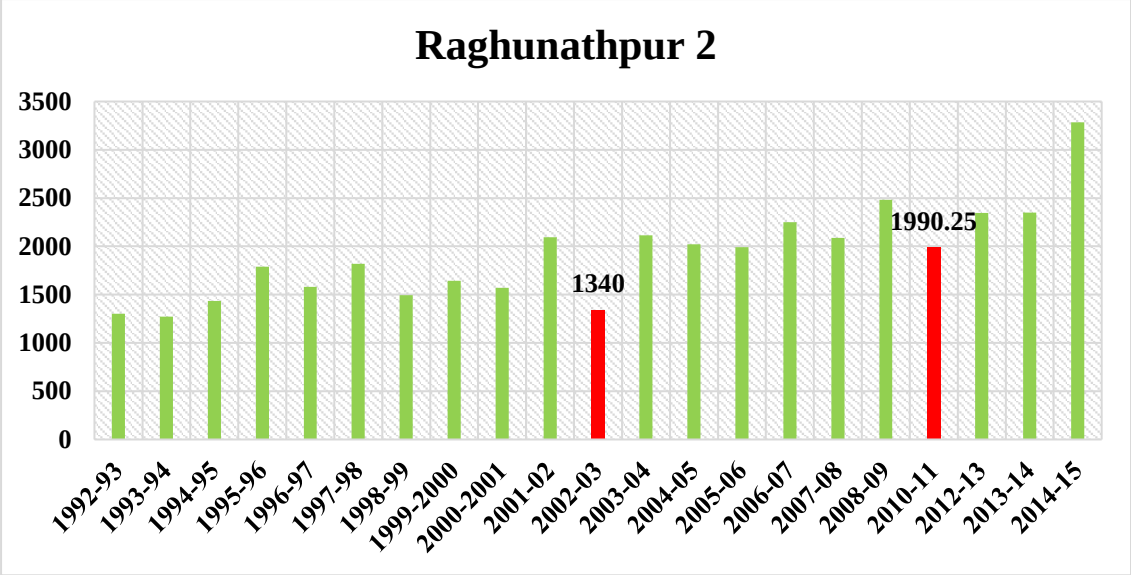
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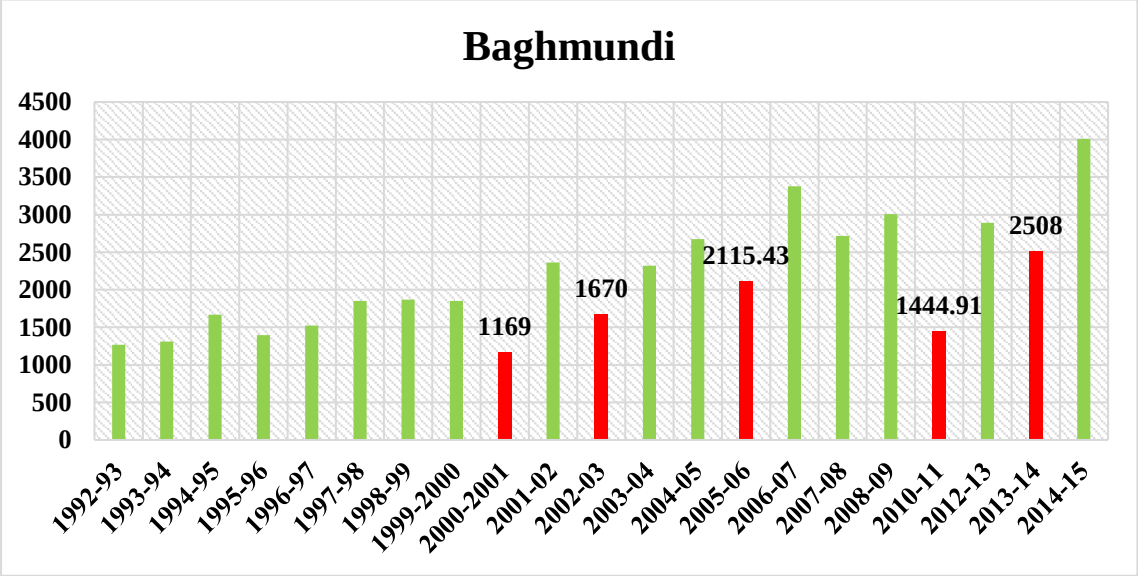
Baghmundi
4500
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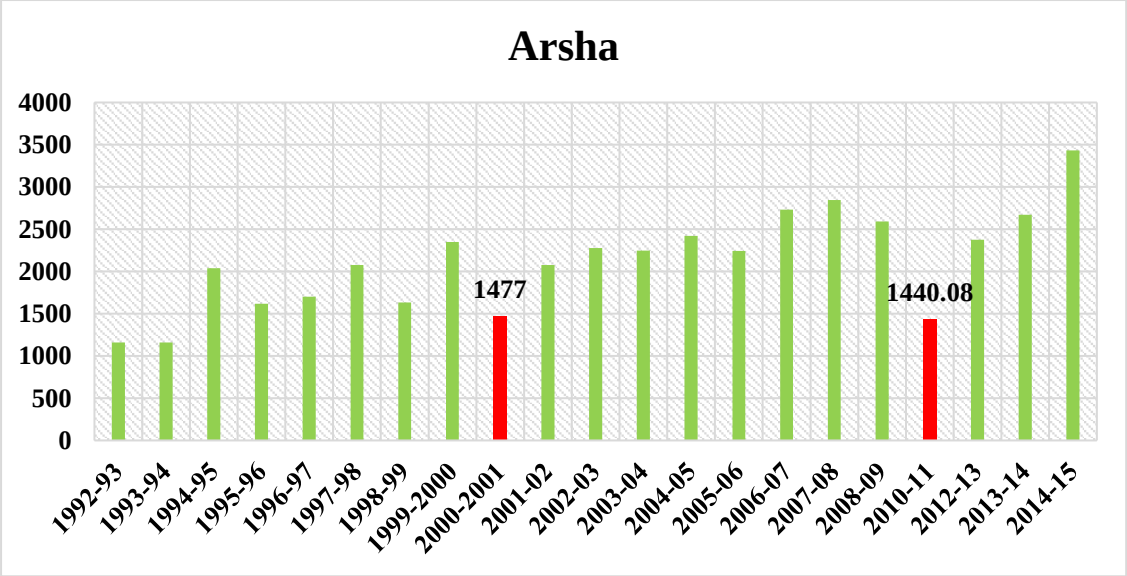
Arsha
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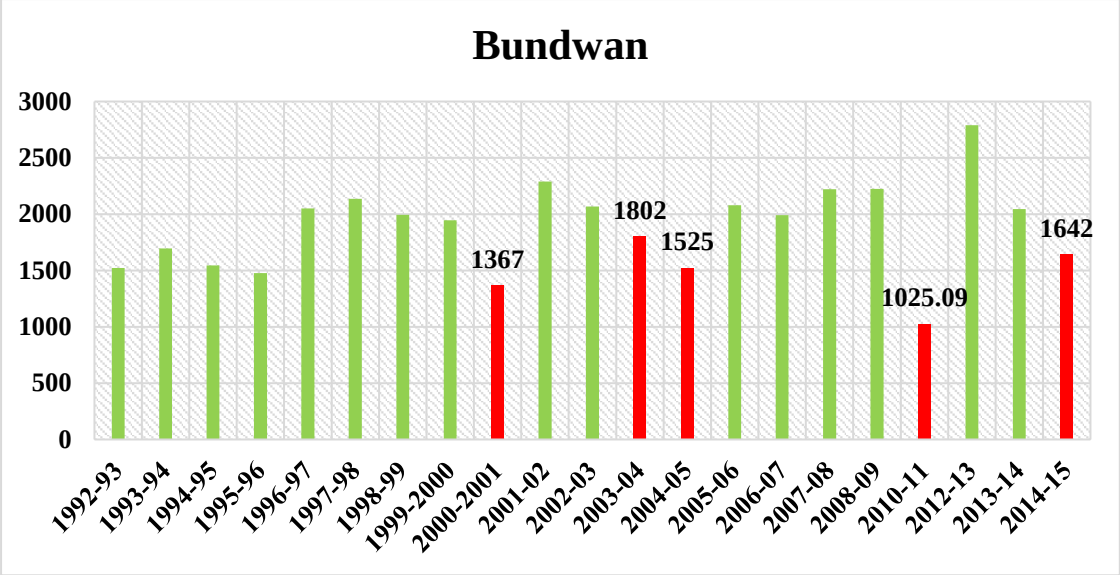
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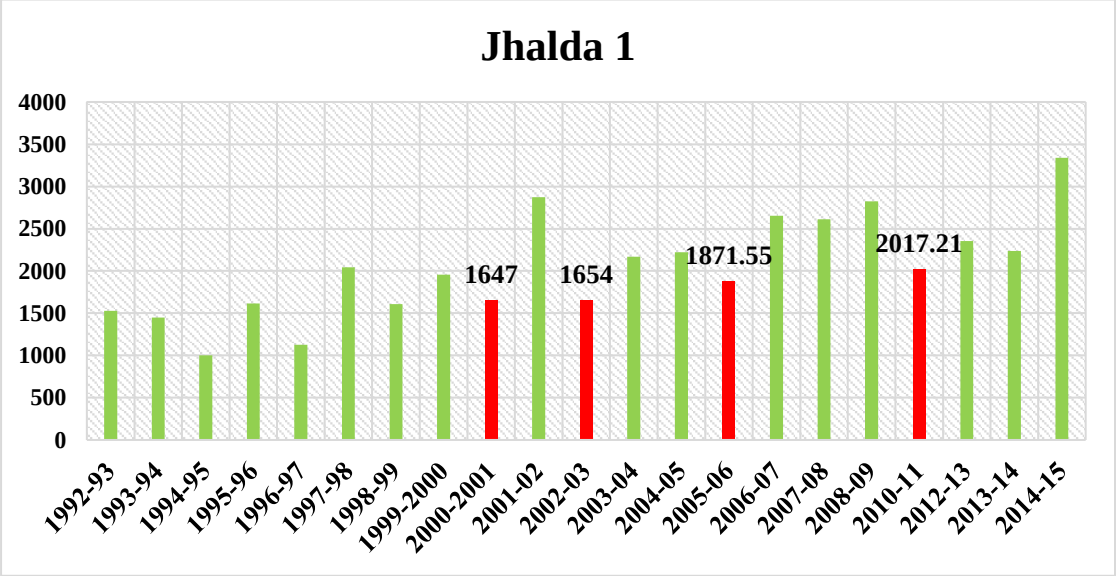
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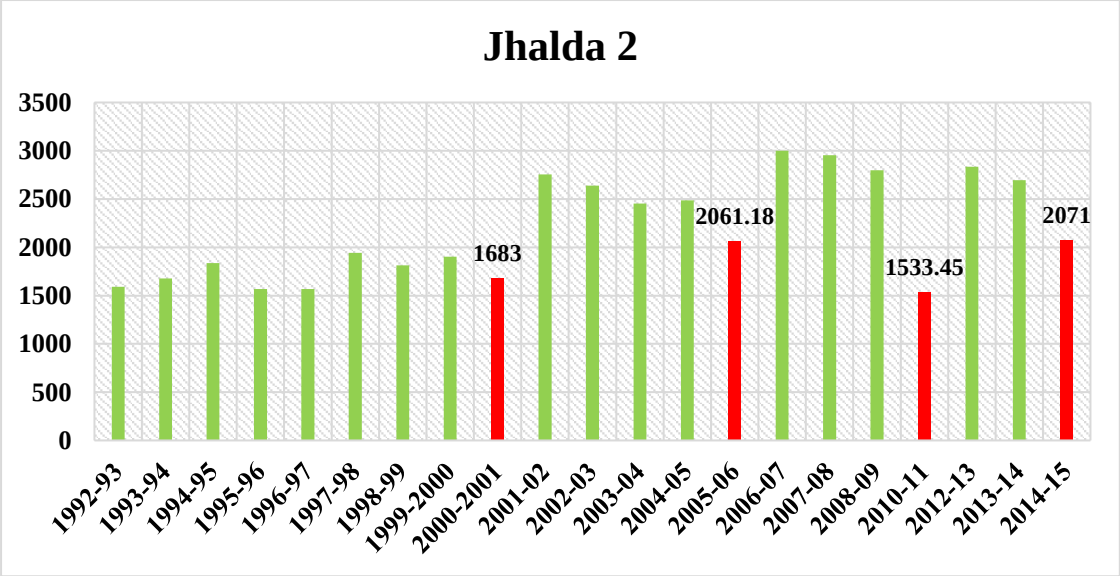
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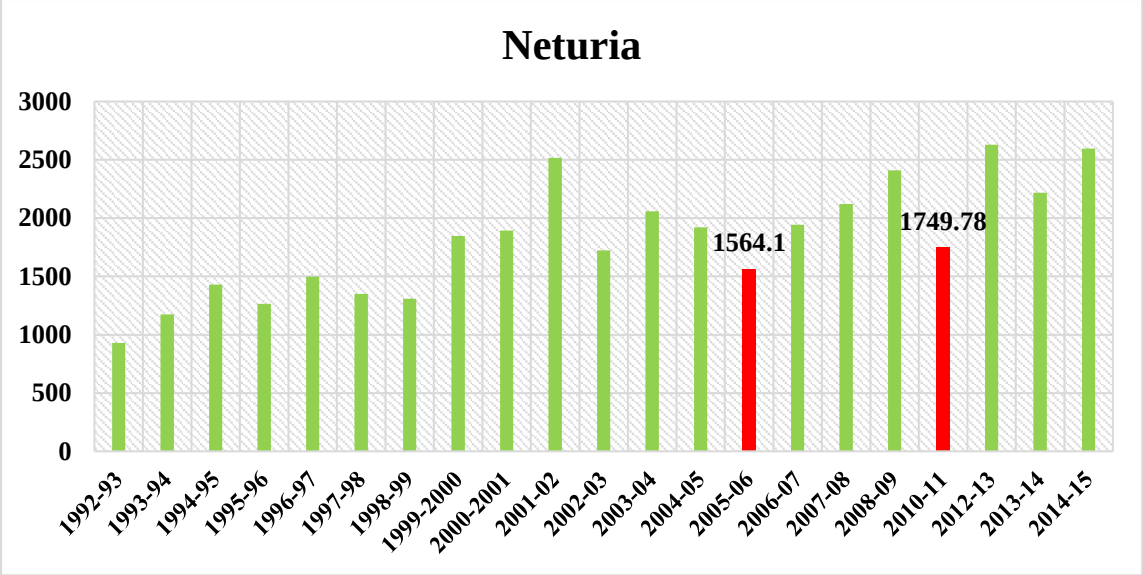
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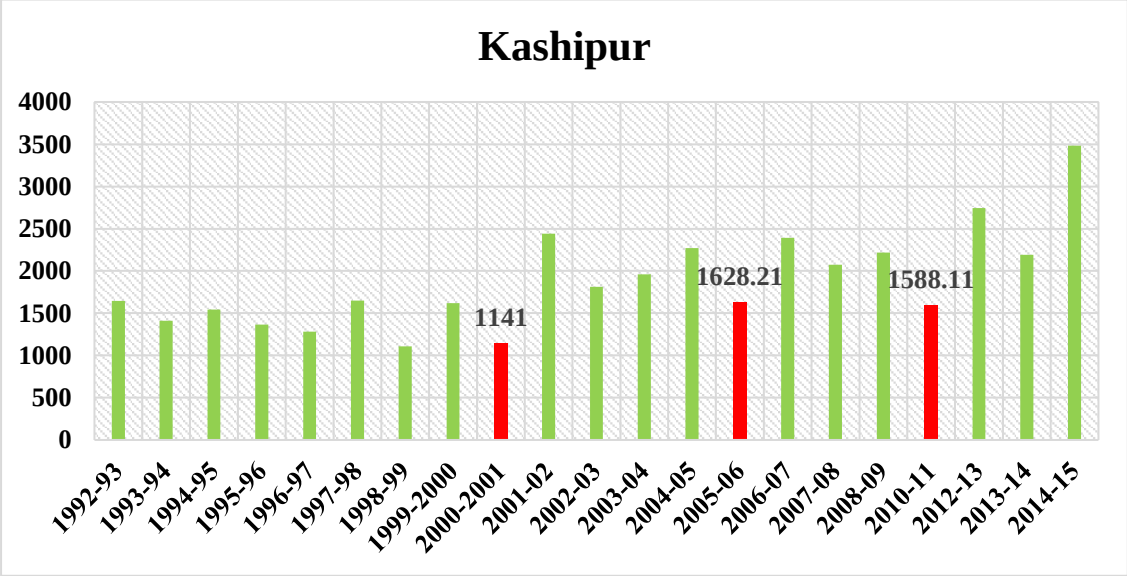
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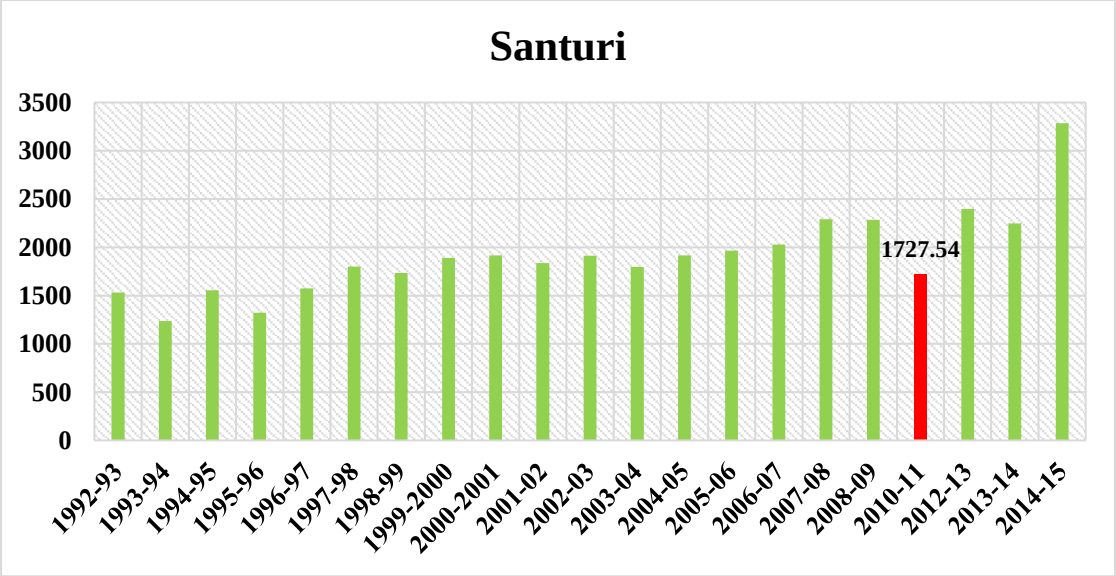
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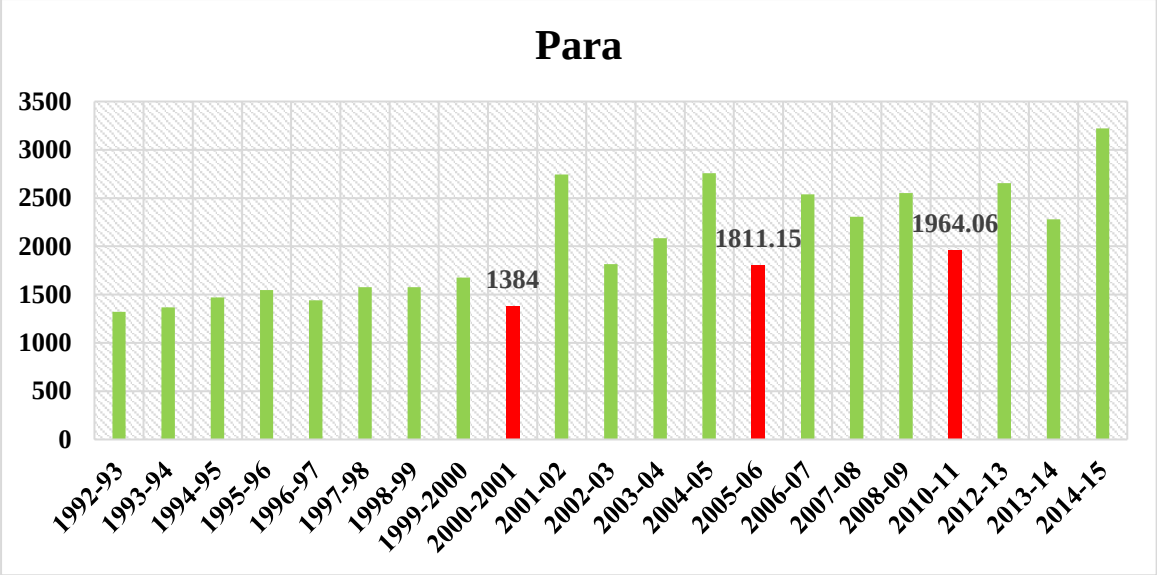
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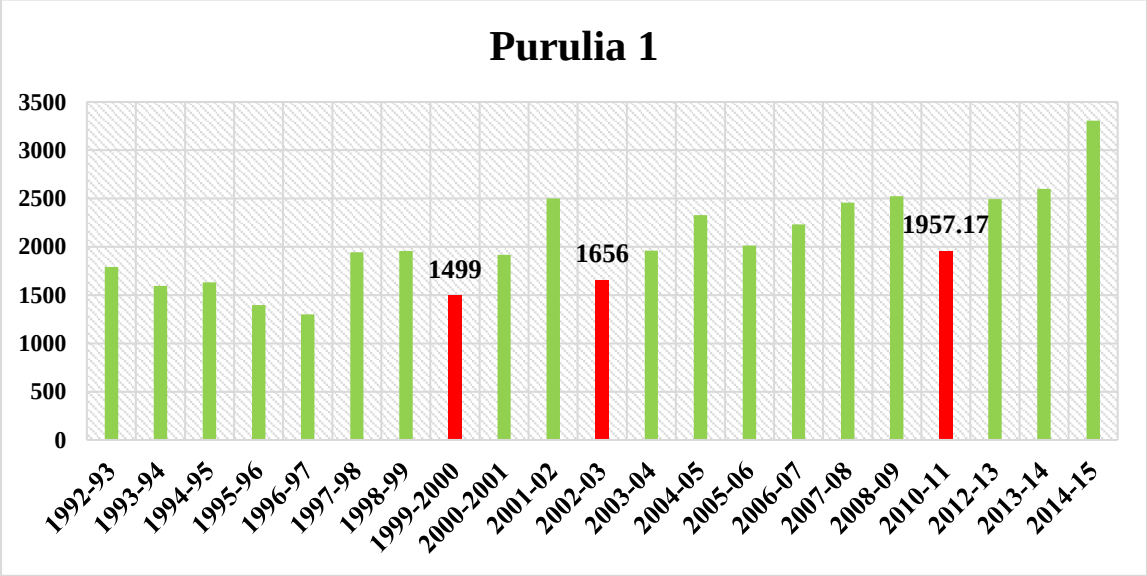
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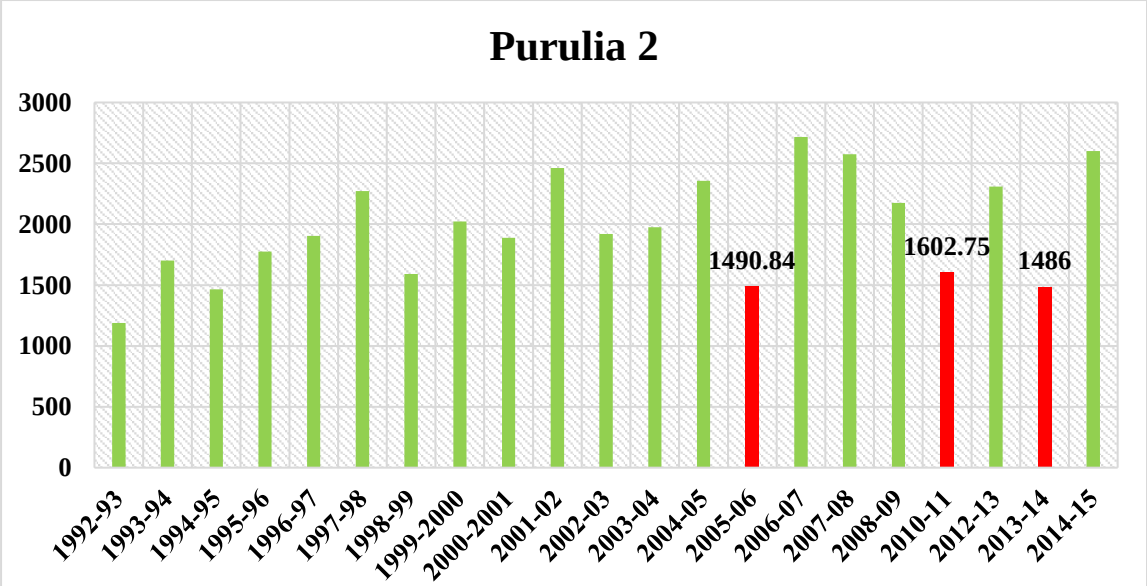
Purulia 2
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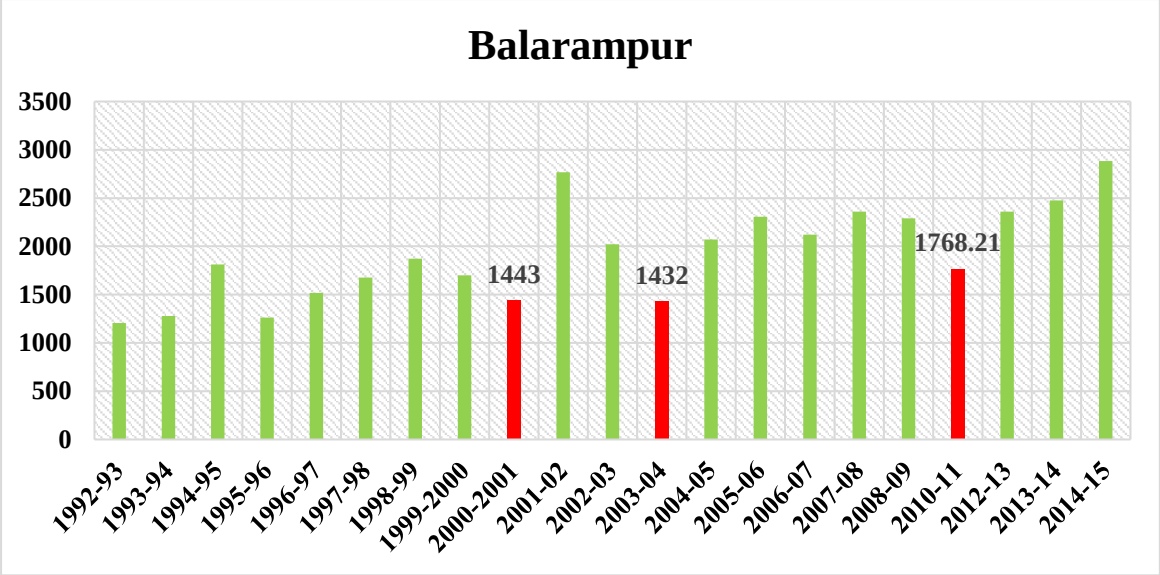
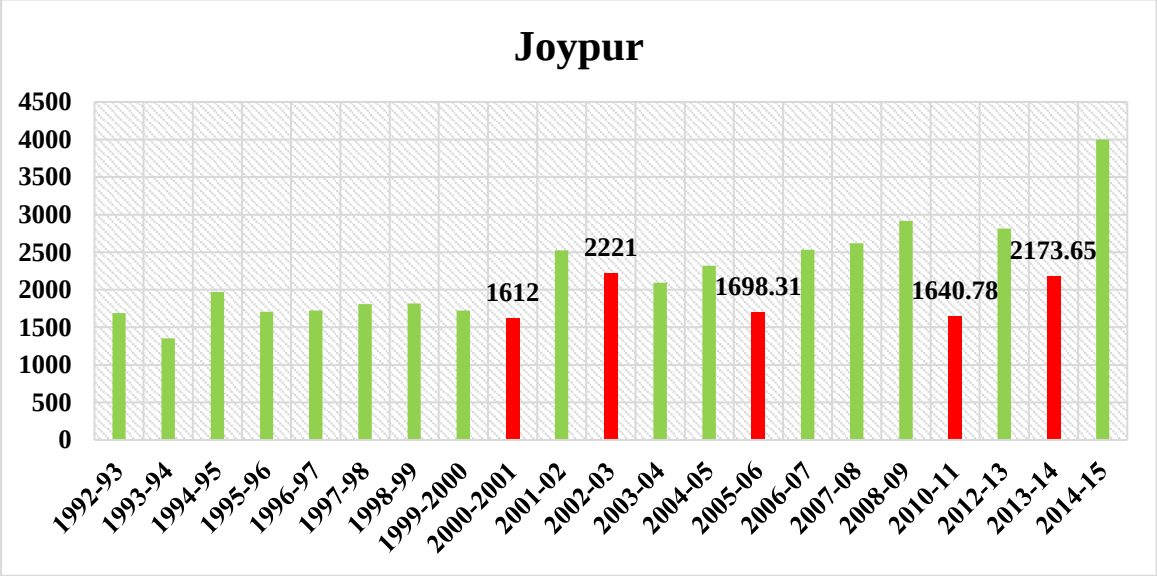




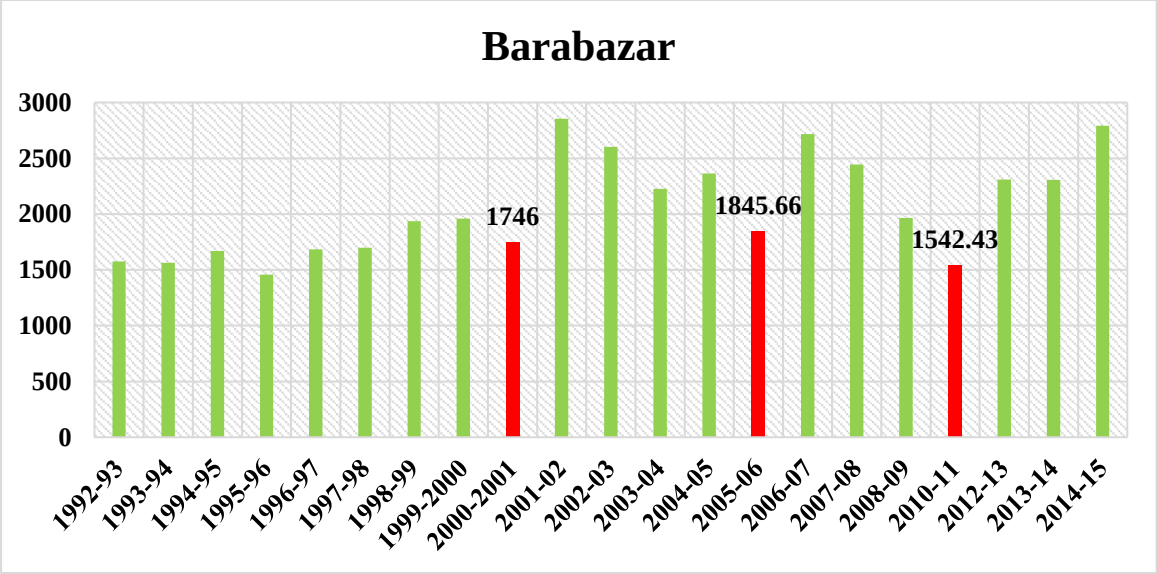


Fig 17 shows sub-district wise (20) occurrence of drought during 1992-2015

The diagram below categorizes the sub-districts based on their recurrence of droughts from 1992 to 2015, reflecting the impact of droughts within the same timeframe.

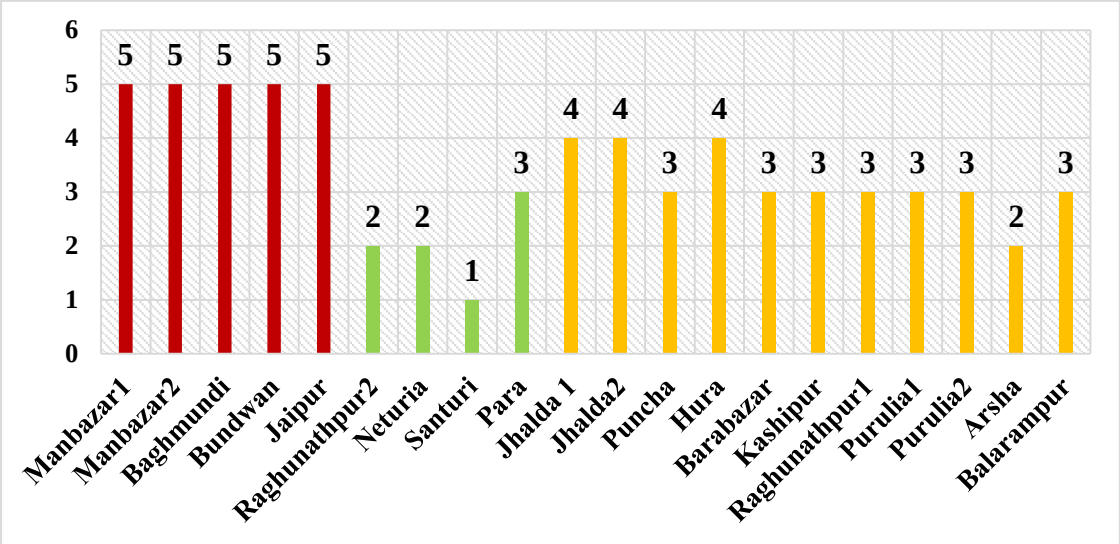


Fig 18 Frequency of drought-affected sub-districts (1992-2015)

Red- Frequency of drought is highest (5 sub-districts)

Green-Frequency of drought is low (4 sub-districts)

Orange-drought frequency is medium (9 sub-districts)

The district's south and southwest are key drought-affected areas, according to spatial analysis (fig. 18)**.** The work of (Raha & Gayen, 2021)also showed that. Sub-district-wide fluctuations of rice yields correspond to rainfall anomaly and SPI years. Extreme drought (spi value of -2.43) in 2010 has reduced rice yield in all sub-districts. During the 2005 drought, rice yield has reduced in 17 sub-districts, namely, Puncha, Manbazar1, Man bazar 2, Raghunathpur 1 & 2, Baghmundi, Arsha, Jhalda1 & Jhalda 2, Neturia, Kashipur, Santuri, Para, Purulia 1 & Purulia 2, Joypur and Bara bazar respectively. Severe drought in 2000 and 2001 have reduced rice yield in 18 sub-districts namely, Hura, Manbazar1 & Manbazar2, Raghunathpur 1 & 2, Baghmundi, Arsha, Bundowan, Jhalda1 & Jhalda 2, Kashipur, Santuri, Para, Purulia 1 & Purulia 2, Balarampur, Joypur and Bara bazar respectively. The difference in rice yields between drought-affected years and non-drought years is evident from careful observation. Over the past ten years, the district's average agricultural production has decreased by 15–25% compared to its typical output (Bhunia et al., 2020). Baghmundi,Jaipur, Balarampur, Purulia I & II, Neturia, Raghunathpur I & II, Bara bazaar, Hura,

Bandwan, Man Bazaar I & II, Para, Arsha, and Kashipur are the main sub-districts affected by the drought, according to the Department of Land Resources.

5.4 Discussion

The year 2010, marked by extreme drought, significantly impacted Purulia at the sub-district level. According to the analysis, the southern (Bandwan, Man bazar I and II, Puncha) and western sub-districts (Baghmundi, Joypur, Jhalda II) suffered from extreme to severe drought from 2000 to 2015. Rain-fed subsistence farming was particularly hard-hit. Drought conditions prevailed in most sub-districts in 2005 and 2015, coinciding with a decrease in the primary working population and a rise in marginally employed and non-working individuals from 2001 to 2011. Crop production suffered during the drought years of 2000, 2005, and 2010, causing increased marginalization and unemployment. Frequent droughts, inadequate irrigation, and crop failures have led to persistent unemployment, entrenched poverty, increased social vulnerability, and a high rate of out-migration among agricultural workers in the southern, western, and eastern block(Ghosh & Mal 2017).

Chapter 6

(Assessment of drought and social vulnerability at sub-district level)

6. Introduction

Drought and climate variability, negatively impact farmers engaged in rain-fed agriculture, potentially leading to food insecurity. Drought results in various socio-economic consequences, including crop failure, unemployment, income loss, asset depletion, and out-migration from affected areas, thereby heightening community vulnerability. Conducting a spatial assessment of social vulnerability can pinpoint the locations and communities most at risk of drought and climate variability. This study analyzes social vulnerability at the sub-county level in Purulia County, pinpointing which sub-counties are and will continue to be susceptible to drought.

Around the world, the frequency, intensity, and geographical extent of extreme weather conditions like heat waves, droughts, and heavy rainfall are all rising (Min et al., 2011). Future increase in this trend is projected (Kodra & Ganguly, 2014). Extreme weather occurrences can have a detrimental impact on the people,their surrounding environment and to the community it is recognized as a hazard. Environmental hazards, whether they develop slowly or quickly, pose an immediate threat to human life and livelihoods. These hazards include crop losses, food insecurity, unemployment, asset erosion, limited risk absorption capacity, and increased social vulnerability. The significance of climate extreme events, such droughts, and their effects are widely recognized. Drought is the natural hazard that impacts the greatest number of people globally (Singh et al., 2014). Drought has recently become more severe and frequent worldwide due to climate change and global warming (IPCC, 2022) causing a marked reduction in crop yield, associated crop failure(Zhang et al., 2017) and considerable socio-economic losses in developing world. India has witnessed an increasing frequency of severe droughts in recent years(Sharma & Mujumdar, 2017a). In India frequent monsoon droughts had a detrimental impact on agricultural production causing huge economic losses (Sharma & Mujumdar, 2017b) because of dominant nature of rainfed agriculture(Vikramarjun et al., 2019) and also because over 50% of the population in our nation still makes their living from agriculture (Rao et al., 2020). The lack of monsoon rainfall in India is associated with meteorological drought. Due to the unpredictable and unequal distribution of monsoon rainfall, drought conditions are seen even in India's sub-humid regions. According to several studies on drought analysis in our nation (Nath et al., 2017; Saleem et al., 2022), the agriculturally significant sub-

humid eastern part of the country has seen an increase in drought frequency and severity in recent decades. The southwest region of West Bengal is part of the red lateritic zone in eastern India; rain-fed cultivation is significantly impacted by even a small deviation from the average monthly rainfall (Brahmachari et al., 2019).

Droughts have a multidimensional effect on poor rural communities especially farmers who derive their livelihoods from rainfed agriculture(Lottering et al., 2021a). These vulnerable people's livelihoods are predicted to be impacted by drought and climatic variability, which will worsen their poverty in the years to come. The severity of impacts caused by natural events is not only aggravated by the magnitude and severity of extreme events but also by the impacted society's degree of susceptibility (Birkmann, 2007). The pain brought on by droughts and other extreme weather events emphasizes how crucial it is to have coping mechanisms. Without well-thought-out plans, they can have serious effects on livelihoods and societies, particularly in communities that depend on natural resources. Building strength against extreme events and managing vulnerability are the two most important challenges, particularly for developing nations worldwide. Though nobody can escape the adverse impacts of extreme climate events or hazards, some populations suffer greater loss of resources, greater impact on their livelihood(Thomas et al., 2019) and have less adaptive capacity to cope with these changes than others. This differential vulnerability is not only the function of physical factors but also social factors. The social dimension of climate change goes beyond biophysical factors and is associated with the social and structural factors underlying vulnerability(Adger & Kelly, 1999a). Climate change will cause drought and other extreme climate events to occur more frequently and with greater intensity in the near future (Lottering et al., 2021b).In this situation, it is imperative to assess, who is most affected by weather and climate related shocks, what are the underlying socio-economic characteristics that bolster vulnerability, and where are these vulnerable groups situated. Before drought risk assessment and management practices can be put in action, it is necessary to have a thorough understanding of vulnerability, its extent over the regions, mapping and formulation of vulnerability functions (O'Brien et al., 2004). In order to increase the adaptive capacities of the regions and communities, these approaches will help with resource identification, prioritization, planning, and direction. Though all the people living in drought prone regions are susceptible to the hazard and its ill effects, however, socially vulnerable groups have lower adaptive capacities to respond and are

affected to a larger extent (De Silva & Kawasaki, 2018). We must realize that the degree to which a community or human society will be impacted by extreme weather events or hazards depends on both the underlying vulnerability of the communities living in those hazard-prone areas and the severity and frequency of such events (Das et al., 2021).

6.1 Concept of Social Vulnerability

The focus on the social dimension of the phenomenon is the essential component of societal vulnerability to climate change (Adger & Kelly, 1999b).The ability of individuals, groups, and societies to withstand the negative effects of numerous stressors to which they are exposed is a measure of social vulnerability. According to(Ekanem & Umoh, 2021a) differential capacity of individuals or communities to respond to natural hazards is called social vulnerability. The rise in the frequency and severity of extreme events worldwide in recent years has made it a prominent topic of concern (Ekanem & Umoh, 2021b).Socioeconomic characteristics, including income, wealth, poverty, education, housing quality, size of household, age, gender, marginalization, and so on, influence social vulnerability (Adger, 2003; Cutter et al., 2008; Cutter & Finch, 2008; Antwi et al., 2015;).It contributes significantly to sensitivity in the IPCC vulnerability framework and is one of the primary factors of vulnerability (Adger et al., 2004).

West Bengal's Purulia district is among the region's most severely impacted by drought (Government of West Bengal, 2023). The district has recently seen severe to extreme droughts during 2000,2001,2005,2010, and 2015. The Department of Land Reforms, Ministry of Rural Development (GOI), has listed each subdistrict under the Drought Prone Areas Programme (DPAP) (Bhunia et al., 2020).According to studies by Bera et al. (2021), the district also experienced severe drought in 2016, mild drought in 2004, and extreme drought in 2003 and 2016.The main sub-districts impacted by the drought include Baghmundi, Man bazaar I & II, Jaipur, Balarampur, Purulia I & II, Raghunathpur I & II, Neturia, Hura, Bandwan, Bara bazaar, , Para, Arsha, and Kashipur, according to their study. District disaster management report of 2020-21 stated that the whole district is drought prone. Work of (Raha & Gayen, 2021) showed that southwestern and north-eastern sub-districts of Purulia face extreme drought which led to high level

of out-migration from these areas. Studies by (Roy & Hazra, 2020) shows occurrence of droughts during monsoon period leading to crop failures in the district. Accompanying with increasing incidence of drought after 2000, climate variability is also observed in the district.(WBSAPCC, 2017)stated that, both minimum and maximum temperatures are rising and there has been a decline in rainfall availability in Purulia district. While annual rainfall of the district is showing a decreasing trend, and monsoon months have experienced 55 to 61 dry days, an increasing trend of heavy rainfall days (for both annual and monsoon period) have been also observed in the district (Guhathakurta et al., 2020).Additionally, they have observed that the district has seen a marked increase in the frequency of dry days throughout the monsoon months. Agriculture is the district's main source of income which is rainfed (Pal Chaudhuri & Biswas, 2020),with poor irrigation availability. Around 60% cultivable land is in upland and 73% farmers belongs to marginal and small category. In comparison to other West Bengal districts, the crop production per hectare is also poor (purulia.nic.in.).The district's agricultural output is limited beyond subsistence level by factors such the growing frequency of drought, the lack of rainfall, the rise in dry days during the monsoon season, the harsh environment, poor soil, and the absence of irrigation facilities (Mishra & Chatterjee, 2018a).In many regions of our nation, development has historically been linked to the corresponding expansion of agriculture. However, vast rural areas (such as our study area) where economy is driven by agriculture which is already non-profitable, further environmental limitations put the people in jeopardized situation(Mishra & Chatterjee, 2018b).According to Hazra et al. (2017), the district also falls behind other districts in terms of human and economic development. Furthermore, there has been an additional issue with the existence of extreme poverty in several areas of the district (Dasgupta & Chattopadhyay, 2008). The district of Purulia is being investigated as a research area because of the complex concerns that are entangled with its residents.

6.2 Aims and objective

The purpose of this chapter is to assess and identify social vulnerability in 20 sub-districts of Purulia, West Bengal.

The goal is to observe the temporal changes in social vulnerability between 2001 and 2011. Assessing social vulnerability at the micro level is crucial for pinpointing

potential hotspots that require targeted efforts and adaptation strategies from authorities. Such measures are vital to lessen the vulnerability of impoverished and marginalized populations. It is essential to acknowledge that traditional livelihoods, including agriculture, are unsustainable amidst the ongoing depletion of natural resources and the effects of drought.

6.3 Results

6.3.1 Analysis of Social Vulnerability

Tables 17 and 18 display the findings of principal component analysis using varimax rotation as the method. Three factors explain 74.591% of the variation in 2011 and 77.958% of the variation in 2001 data. The percentages of non-workers, illiterate people, households without any assets or home ownership, and households without electricity connections had significantly greater positive loadings for the first component in 2001 (which accounts for 43.676% of variances). The correlations between the components and the variables are referred to as loadings. On a scale of -1 to +1, they indicate the relative contributions of each variable to a specific main component. Whether a variable and a principal component have a positive or negative correlation can be identified by the loading's sign. It means poor economic conditions are associated with high dependence on agriculture, large household size, moderate number of populations served by drinking water facilities. The second components explain 18.808% of variation. Variables such as average household size, population served by drinking water facilities, percentage of cultivated area have shown high positive loading while percentage of irrigated area shows markedly high negative loading. The third component accounts for 15.475% variation. Decadal variation of population, agricultural dependency, have shown high positive loading. First component in 2011 that explains 29.942% of variations, include decadal variation of population, illiteracy and households without any assets. They all have shown higher positive loading. Second component of 2011 explains 21.469% variations. Average household size shows high positive loading while households without home ownership shows high negative loading. Third component which explains 13.514% variations, shows that percentage of irrigated area, agricultural dependency and percentage of cultivated area have higher positive loading and households without electricity

connection has negative loading. Fourth component of 2011 explains 9.665% variations. Population served by drinking water shows high positive loading.

Table 17 shows statistical test computed to perform principal component analysis or PCA

Statistical Tests		2001	2011	Remarks
Kolmogorov-Smirnov test (Normality)	Sig.	0.00	0.00	Significant
Correlation Matrix	Determinant	0.000001	0.00001	>0.00001, No multicollinearity or Singularity issue
Kaiser-Meyer-Olkin Measure of Sampling Adequacy	KMO	.725	.688	Good
Bartlett's Test of Sphericity	Approx. Chi Square Df Sig.	168.642 55 .000	102.972 55 .000	Significant, not an identity matrix
Total Variance Explained	Percentage of variance	77.958	74.591	More than 70%, Good

Table 18 PCA Results: Varimax Rotation Factor Matrix.

Variables	**Component 2001**			**Component 2011**			
	1	2	3	1	2	3	4
Percentage of irrigated area		-.805			.	.643	
Population growth			.606	.544			
Percent of the population served by		.720					.965

Drinking water							
Illiteracy rate	.693			.909			
Average household size		.403			.562		
Agricultural dependency			.705			.695	
% of HH with no assets	.735			.747			
% of non-workers	.898				.667		
% of HH with no home ownership	.501				-.400		
Percentage of the cultivable area to the total area		.794				.714	
% of HH with No Electricity	.647					-.518	
Percent of Variance	43.676	18.808	15.475	29.942	21.469	13.514	9.665

Principal Component Analysis is the extraction method; Varimax with Kaiser Normalization is the rotation method. Reduce minor coefficients (absolute value less than 0.30).

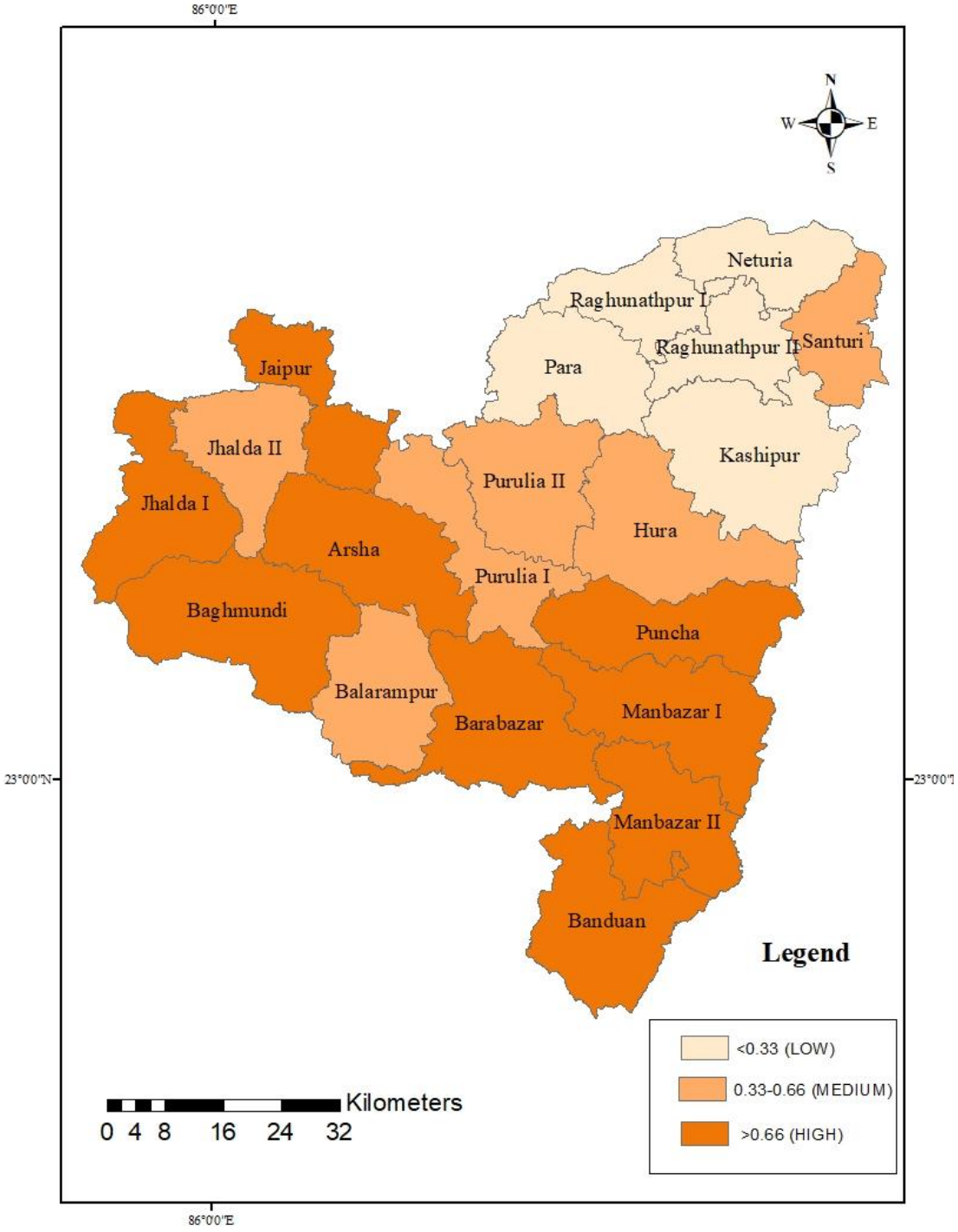
The PCA results reveal that our study area has a high agricultural dependency, the presence of a vast number of non-workers, and a high percentage of people who have limited access to material well-being, irrigated areas, and limited drinking water facilities. These conditions make them impoverished and socially vulnerable because of their poor ability to adapt to the extremes and variations of the climate

6.3.2 Drivers of Social Vulnerability

It is crucial to recognize that although agriculture's contribution to India's economy has diminished to under 15%, and the average annual growth rate of agriculture has been stagnant for the past six years, leading to income losses for farmers, its role in the nation's economic and social structure remains significant. 70% of rural households still rely on agriculture as their main source of income, while 82% of farmers are small and marginal farmers. Agriculture is the main economic activity in our research area, and 73% of small-scale farmers possess less than one hectare of land, with insufficient irrigation, and produce just mere food for their own consumption only. The reliance on agriculture, especially rain-fed farming in drought-prone regions with increasing temperatures and reduced monsoon, presents a challenge to food security. Additionally, the high illiteracy rate is a critical factor; education equips individuals with the knowledge and information necessary to understand risks from hazards and climate extremes, enabling them to take appropriate actions. Especially in areas prone to hazards, possessing thorough knowledge of community risks is essential for informed decision-making and coordinated action. Moreover, a higher proportion of asset-less individuals diminishes material well-being and socio-economic resilience, making it harder to cope with and recover from shocks when they occur. The impact of hazards or extreme climate conditions does not discriminate in whom it affects.

6.3.3 Spatial distribution of social vulnerability

The social vulnerability index was computed using the PCA results and depicted for all 20 community development blocks or sub-districts to determine areas where people are more susceptible to drought and extreme climate events. Finding socially vulnerable subdistricts and the cause of their vulnerability is essential, as different individuals face varying levels of hazards and crises, with their responses shaped by their social and economic status. To help the district's most vulnerable residents, site-specific hazard planning, a social vulnerability map, and development initiatives are therefore crucial. The sub-district level social vulnerability map for our study area between 2001 and 2011 is shown in Figure 19.


86°0'0"E
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Raghunathpur II
Santuri
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Jaipur
Jhalda II
Kashipur
Purulia II
Jhalda I
Hura
Arsha
Purulia I
Baghmundi
Puncha
Balarampur
Barabazar
Manbazar I
Manbazar II
Banduan
23°0'0"N
23°0'0"
86°0'0"E
Legend
<0.33 (LOW)
0.33-0.66 (MEDIUM)
>0.66 (HIGH)
Kilometers
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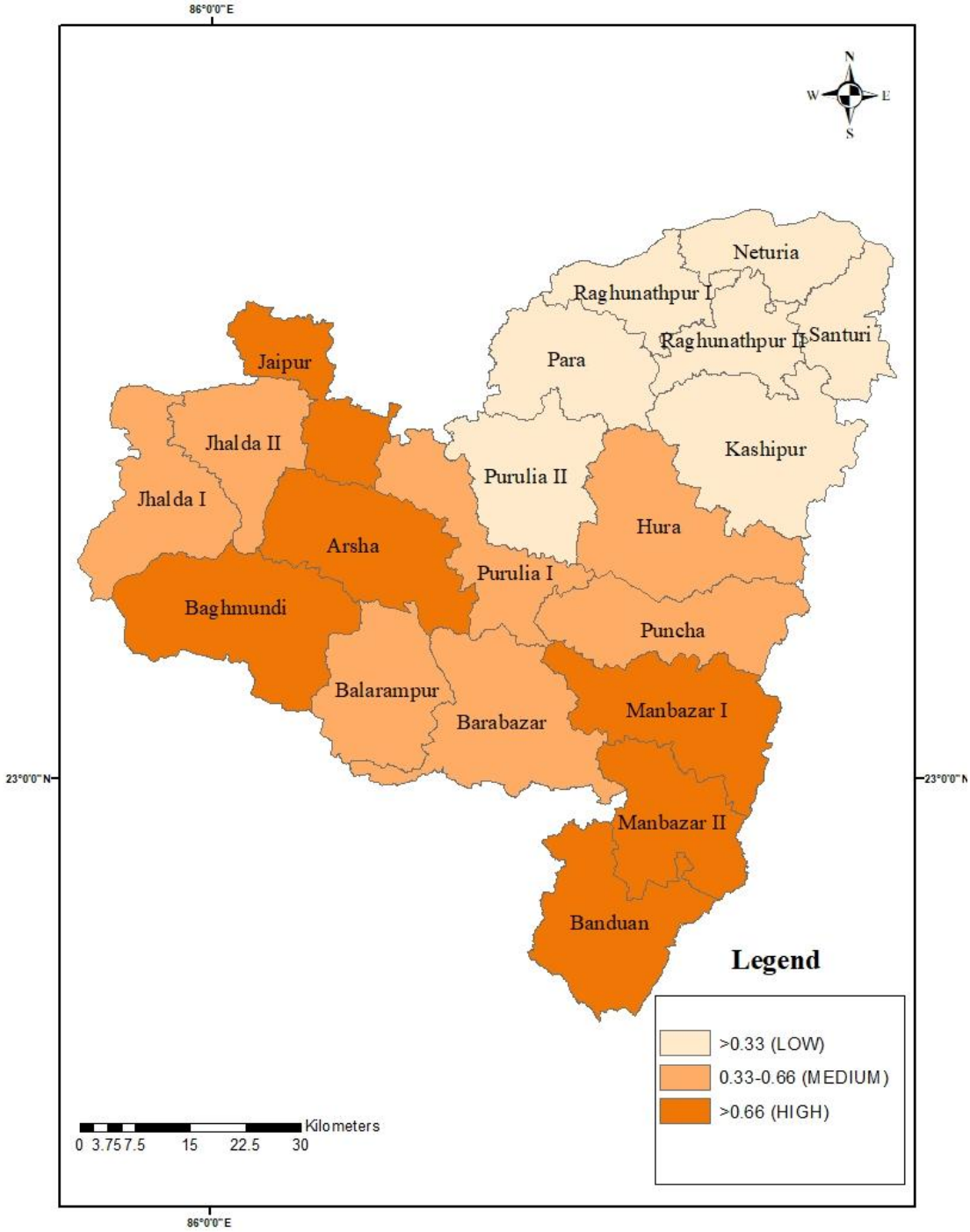


Fig 19 Purulia district's sub-district level social vulnerability map for 2001 and 2011

Analysing socio-economically vulnerable blocks or sub-districts is crucial for pinpointing areas prone to hazards and socio-economic issues. Six sub-districts—Arsha, Baghmundi, Bundwan, Man bazar 1, Man bazar 2, and Joypur—were notably vulnerable socio-economically in both assessed years. Despite a reduction in social vulnerability from 2001 to 2011, these sub-districts remained more vulnerable compared to others according to the 2011 Social Vulnerability Index. A succession of

droughts in 2000, 2001, 2005, and 2010 precipitated events like crop failures, diminished agricultural output, and limited drinking water access. Pal Chaudhuri & Biswas (2013) reported extreme droughts in the district's north-western and south-western parts, affecting Baghmundi, Joypur, and Bundwan, leading to income loss, a high non-working population, and inadequate drinking water access. These areas also saw minimal advances in material well-being, heavy reliance on agriculture, significant population growth over ten years, and a high illiteracy rate. Improvements in irrigation were negligible in these six sub-districts.

Conversely, five sub-districts—Neturia, Kashipur, Raghunathpur 1, Raghunathpur 2, and Para—exhibited low social vulnerability in both years. These areas avoided recurrent droughts over several years. Improvements were noted in electricity, drinking and irrigation water access, and asset availability. Reliance on agriculture declined as the number of other workers—including teachers, government staff, workers in factories and plantations, and workers in trade, commerce, transportation, mining, financial services, construction, governance, social work, religious services, and entertainment—increased, suggesting a move toward the service sector.

While other workers (those who fall under this category of "OW" include all teachers, government employees, municipal employees, factory workers, plantation laborers, and people working in commerce, trade, industry, transportation, financial services, mining, building, political or social work, priests, entertainers, etc.) have increased, agricultural dependency has also decreased. Increasing engagement in the service sector in these sub-districts has increased their standard of living and reduced their social vulnerability. Cultivated land also decreased in these sub-districts except Kashipur, Neturia, and Para where cultivated land increased only by 1 percent during 2001-2011

Environmental hazards have a likelihood to impact the subdistricts with the highest social vulnerability, requiring government intervention in the form of targeted adjustments. The sub-districts with low vulnerability are more urbanized and have better assets, higher living standards and educational attainment, which will enable them to more effectively address environmental issues.

6.3.4 Temporal analysis of social vulnerability

Social vulnerability may change over time, depending on changes in socio-economic and demographic parameters and the development and adaptation measures taken by the government. Social vulnerability has declined in all sub-districts during the reference period 2001-2011, although percentages vary between sub-districts. Figure 20 shows the changes in social vulnerability overtime during the period 2001-2011

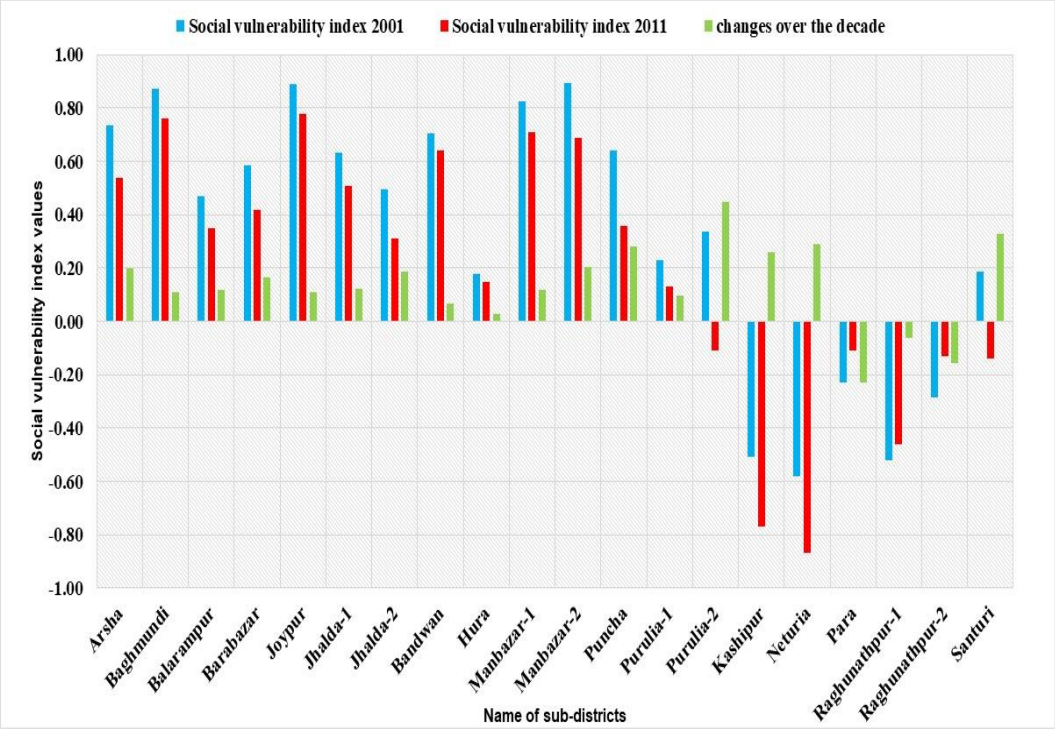


Fig 20 Temporal changes in social vulnerability during 2001-2011

In 2001, nine sub-districts (Arsha, Baghmundi, Man bazar 1, Man bazar 2, Joypur, Bandwan, Bara bazar, Puncha, and Jhalda 1) were categorized as highly vulnerable sub-districts. By 2011, this number decreased to six (Arsha, Baghmundi, Man bazar 1, Man bazar 2, Joypur, Bandwan), with three sub-districts (Bara bazar, Puncha, and Jhalda 1) moving to the medium-risk category. During the decade, these sub-districts experienced drought only twice. The increase in irrigated land has lessened their vulnerability to drought, allowing farmers to water crops as needed. Additionally, improvements in access to drinking water, electricity, assets, and literacy rates have been noted.

The gap between the sub-districts in the low and medium vulnerability categories is minimal, with negligible differences in percentage points across the 11 indicators used

for social vulnerability analysis. The lack of frequent droughts, more irrigated land, enhanced access to drinking water, and socio-economic advancements from 2001 to 2011 helped maintain their low to medium vulnerability status. Furthermore, a significant rise in employment in sectors other than agriculture was observed in these sub-districts during the same period, reducing reliance on farming and boosting living standards.

6.3.5 Drought and Social Vulnerability

The relationship between drought and the SVI is depicted in Figure 21. In the Purulia district, 14 of the 20 subdistricts are associated with drought and social vulnerability.

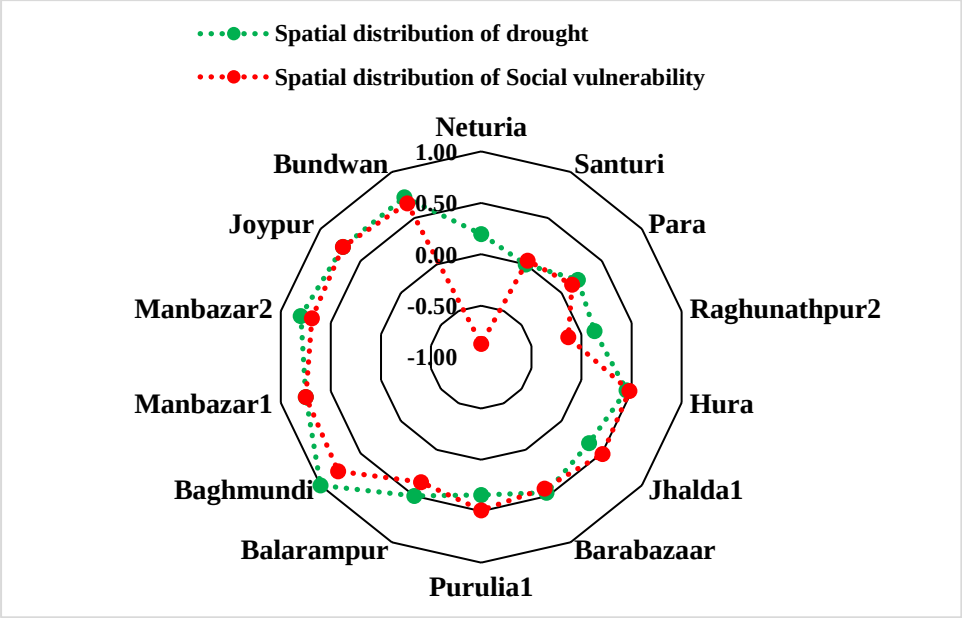


Fig 21 Concordant sub-districts

Among the fourteen sub-districts categorized under drought and social vulnerability, Baghmundi, Manbazar1, Manbazar2, Joypur, and Bundwan are classified as highly vulnerable to both drought and social challenges. From 2001 to 2011, these sub-districts experienced droughts more frequently compared to others, yet saw no improvement in irrigated areas. With irrigated land making up less than half of the total cultivated area, their capacity to mitigate the growing severity of droughts is limited. Socio-economically, these sub-districts are also struggling, with a larger rural population reliant on natural resources to sustain themselves, thus being more susceptible to climatic extremes like increased drought occurrences. High population growth,

restricted asset access, and a greater proportion of non-labourers contribute to their vulnerability to droughts.

Four sub-districts, Santuri, Para, Raghunathpur2, and Neturia, were in the low drought and social vulnerability category in 2011. These areas have a lower frequency of droughts and more irrigated land than the district's average (25.66%). Enhanced irrigation has lessened their susceptibility to droughts and crop failures. Socio-economically, these four sub-districts have improved resource access and a higher employment rate in the service sector, which lessens the reliance on agriculture and elevates living standards. Infrastructure advancements are evident; literacy rates have significantly dropped, population growth has decelerated, average household size has reduced, homeownership rates have risen, and access to potable water has greatly increased, all contributing to reduced social vulnerability.

Five sub-districts, Jhalda1, Hura, Bara bazar, Purulia1, and Balarampur, exhibit medium drought and social vulnerability

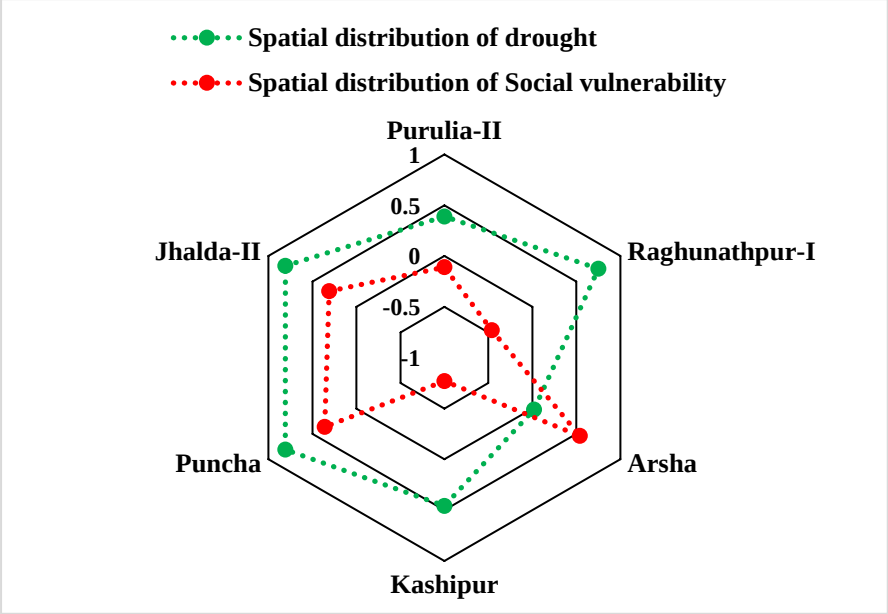


Fig 22 Incongruous sub-districts

6.4 Discussion

This is the first sub-district-level spatial analysis of social vulnerability in Purulia district. The study reveals that the most socially marginalized individuals reside in sub-counties severely impacted by drought, relying on climate-dependent rainfed

agriculture for sustenance. Additionally, the district's southwestern region is more socio-economically vulnerable compared to its north-eastern counterpart. Analysis of climate variability shows that yearly and monsoon rainfall patterns are dropping while maximum and minimum temperatures are trending upward. Despite a recent increase in rainfall concentration, the rainfall anomaly index and the yearly Standardized Precipitation Index (SPI) indicate that the frequency and intensity of droughts are increasing over time.

Social vulnerability to hazards and climate variability is influenced by the socio-economic and demographic profiles of people or particular regions, and it differs across affected areas. Addressing this vulnerability necessitates comprehending the contextual vulnerability of people, which possesses a spatial aspect. This understanding aids in alleviating community stress and enhancing the capacity to manage hazards and growing climate variability effectively. Vulnerability factors in Purulia's twenty sub-counties include high illiteracy rates, large household sizes, a significant rural population, insufficient sanitation facilities, limited electricity access, asset inaccessibility, and a significant reliance on rain-fed farming on smallholdings with inadequate irrigation. To minimize the adverse consequences of drought and increased climate variability, a comprehensive strategy is essential, encompassing the improvement of material conditions, the provision of micro-level irrigation systems, the launch of livelihood development programs, hazard preparedness, and capacity building. An integrated, location-specific hazard plan is imperative.

Chapter 7

(Climate Change and Migration: Understanding the Conceptual Challenges and Connections)

7. Introduction (A growing crisis)

Geophysical hazards like volcanic eruptions, earthquakes, and tsunamis, as well as climatic hazards like droughts, floods, and storms, can cause population migration K. Smith (2013). The interaction of political, economic, and social elements with natural occurrences frequently exacerbates the effects of these risks, resulting in social and political upheaval, heightened susceptibility, and extensive human misery. People are forced to leave their homes as a result of these detrimental effects, which leads to tension, insecurity, and significant loss of life and property.

Millions of people may have been moved as a result of floods, agricultural disruption, and coastal erosion, according to the Intergovernmental Panel on Climate Change (IPCC), which recognized human migration as the primary effect of climate change as early as 1990. Future studies have repeatedly emphasized that environmental deterioration, particularly climate change, may emerge as a major factor in human displacement—an imminent problem. About a quarter of a million people lost their homes and lands in the mid-1990s as a result of extreme environmental stresses such droughts, pollution, degradation of land, and natural catastrophes, according to Myers (2005). These individuals outnumbered those affected by both war and political intimidation put together. According to the Red Cross and Red Crescent Societies' 2001 World Disaster Report, there are currently an estimated 25 million "environmental refugees." The Institute for Environment and Human Security at the United Nations University issued a warning in October 2005 that by 2010, the world community could expect to see 50 million environmental refugees. Numerous experts, such as the renowned Norman Myers of Oxford University, have tried to estimate how many people will be forced to move as a result of the long-term consequences of climate change. According to Professor Myers, disturbances in monsoon and other patterns of precipitation, droughts with high severity and duration, increasing sea levels, and coastal floods might impact up to 200 million people if global warming takes effect.

The IPCC and the Stern Review on the economic implications of climate change have both cited Professor Myers' estimate of 200 million climate migrants by 2050, which has acquired momentum (Stern, N. 2007). This alarming number signifies a tenfold increase Dupont, A., & Pearman, G. (2006) from the current figures of refugees and

internally displaced persons. For example, one in 45 people worldwide may experience climate-related displacement by 2050, which would exceed the current global migrant population. Approximately 192 million people, or 3% of the world's population, currently live outside of their country of origin, according to the International Organization for Migration (IOM).

30.7 million people were displaced by natural catastrophes in 149 countries and territories in 2020. Thirty million people were displaced within their nations as a result of climate-related disasters alone, with a peak of 38.3 million displaced in 2010 (IOM 2021; IDMC 2021a). Since a variety of contextual factors influence migration decisions, it is difficult to pinpoint the precise number of displacements brought on by climate change (de Haas 2021) (Mcleman 2019) . Nonetheless, according to the Internal Displacement Monitoring Centre (IDMC), between 2008 and 2020, climate disasters caused the internal displacement of around 283.4 million persons (Table 1), accounting for nearly 89% of all displacements caused by disasters during this period (IDMC 2021a).

In recent years, researchers, policymakers, and the mass media have increasingly focused on how climate change may impact migration—a trend expected to grow in the coming decades. While the discourse often emphasizes environmental factors, the role of contextual or intervening factors is acknowledged. A complex interplay of political, economic, cultural, demographic, and environmental variables shapes migration trends. People's mobility within and between nations is influenced by economic reasons. However, Hugo, G., & Bardsley, D. K. (2013) believe that environmental factors, particularly changes in the climate, also play a key influence in this dynamic. The Sixth Assessment Report (AR6) highlights that climate change acts as a direct driver of human mobility and displacement through climatic hazards and as an indirect driver by degrading climate-sensitive livelihoods (IPCC, 2022). Numerous researchers have demonstrated how climatic events instigate migration. Climate-induced hydrological shifts, whether due to gradual occurrences like droughts or sudden ones like floods, can influence human movement and migration by affecting economies and livelihoods. In their paper, De Campos, R. S., Adger, W. N., and Mortreux, C. (2018) investigate these impacts. It is well-established that agriculture is mostly negatively impacted by droughts and floods (Bergmann et al., 2021); Mastrorillo et al., 2016; Nawrotzki, R. J., & Bakhtsiyarava, M. (2017). According to estimates from the Internal Displacement

Monitoring Centre (IDMC), floods and droughts result in an average of 12 million new displacements each year. Seven million people had been displaced by natural catastrophes, such as floods and droughts, by the end of 2020 (IDMC, 2020). Additionally, because of its social, economic, psychological, and physical impacts, water scarcity in households has been recognized as a factor in migration. Stoler et al., (2021).

According to the IPCC AR6 report, there is a medium degree of confidence that migration will rise as temperatures continue to rise. According to McLeman et al. (2016), future migration and displacement may increase as a result of population growth in susceptible areas, particularly in low-income nations. For example, a study on flood vulnerability by (Kakinuma et al., 2020) revealed that low-income nations, especially those in Africa, are more likely to experience displacement due to flooding. Furthermore, according to a model that looks at slow-onset climate effects like crop failure, sea level rise, and water scarcity, between 31 and 72 million people (RCP2.6, SSP4) and 90 to 143 million people (RCP8.5, SSP4) may be forced out in South Asia, sub-Saharan Africa, and Latin America by 2050 (Rigaud et al., 2018). Asia and the Pacific are among the regions most affected by climate hazards, including floods, droughts, land degradation, typhoons, and cyclones, which have led to the displacement of large numbers of people (Asian Development Bank, 2012; Pörtner et al., 2022). In India, the consequences of climate change impacted almost 20 million people in 2020 alone (Bharadwaj et al., 2022).

There are several words used to describe people who have been uprooted from their homes because of climate-related risks, including, environmental migrants, climate migrants, climate refugees, and environmental refugees (Perkiss & Moerman, 2018). Similar to this, there are other names for the migratory process linked to climate-related dangers, such as environmental displacement, climate-induced migration, environmental migration, and climate migration (Bronen, 2008). The focus of this study is climate-induced migration, particularly that which is brought on by drought, a slow-onset climate disaster.

7.1 Conceptualizing climate migration

Although the problem of human migration brought on by environmental effects has gained attention recently, there is still a great deal of ambiguity over how populations will react to long-term changes in the environment. Many people believe that the relationship between migration and climate change is deterministic, meaning that people in impacted areas will eventually move. However, empirical evidence indicates that this relationship is highly complex and shaped by many social, economic, and political factors (Foresight 2011).

The scientific evidence supporting climate change is becoming more and more solid. The effects of climate change on the weather, including drought, increased sea levels, changed patterns of rainfall, and more intense and frequent storms, have been determined with a great deal of time and effort. However, empirical research on the effects of the changing climate on human populations has received far less attention, time, and funding. This is due in part to the relationship's unpredictable nature: the science behind climate change is complicated enough, let alone how it will affect societies with varying resources and levels of resilience to shocks from the outside world. Determining the causal relationship between economic "pull" and environmental "push" is frequently quite subjective, in part because individual migrants' reasons for leaving their countries vary so greatly. Lastly, it takes a bold analytical leap into the dark to separate the role of climate change from other environmental, economic, and social aspects (IOM, 2008).

Global societies are seriously threatened by climate change with mass climate migration becoming an increasing concern. Human migration may be one of the most severe consequences of climate change, according to the Intergovernmental Panel on Climate Change (IPCC), which has been warning since 1992 driven by coastal erosion, flooding, and severe droughts. Tens of millions of people have been displaced each year by natural catastrophes in recent years, which frequently causes more internal displacement than hostilities, according to the Internal Displacement Monitoring Centre. Unpredictable rainfall and droughts are challenging the livelihoods of smallholder farmers worldwide. Governments have started the planned relocation of communities at risk from increasing sea levels and natural disasters. The consequences

of climate change will worsen as it gets harsher. The number of people who would be displaced by climate change is estimated to be between several hundred million and over a billion, which has led to the creation of phrases like climate refugees, environmental migrants, and, more recently, climate migrants.

These phrases, however, are ambiguous and devoid of a legal definition. No government now offers a legitimate migration route based only on a person's susceptibility to climate change. It has been made clear by the United Nations High Commissioner for Refugees (UNHCR) that avoiding the effects of climate change does not make one eligible for refugee status, which is reserved for people fleeing persecution. The use of such words, particularly "climate refugee," has provoked controversial debates among activists, scientists, and others.

7.2 Defining Climate Migration

However, these terms are vague and lack legal definition. As of right now, no country offers a legitimate migration route that is determined exclusively by a person's susceptibility to climate change. Since refugee status is only granted to individuals fleeing persecution, the United Nations High Commissioner for Refugees (UNHCR) has made it clear that escaping the effects of climate change does not qualify one for it. The employment of these terms, especially "climate refugee," has sparked contentious discussions among scientists, activists, and others.

Labeling is crucial. The argument over whether they should be classified as climate migrants or refugees goes beyond terminology. The phrase that was selected has significant ramifications for the international community's duties under international law.

There is currently no internationally accepted term or legal definition for individuals who are moving as a result of environmental reasons. The IOM is one of several players working on these topics, though, and they have created conceptual structures to deal with. A wide working definition of environmental migration was proposed by the IOM in 2007 in an effort to convey the complexity of the problems at hand. Environmental migrants are individuals or groups of individuals who are compelled to leave their familiar homes, either permanently or temporarily, primarily because of abrupt or

gradual changes in their surroundings that negatively impact their quality of life or living conditions. They might move domestically or overseas (IOM, 2007:33).

Environmental migration is defined in a way that is deliberately flexible and wide encompassing a vast array of population movements driven by various environmental factors. It demonstrates how environmental migration can take many different forms, including being forced or voluntary, transient or permanent, internal or external, individual or group, and taking place over short or long distances. Whether environmental migration is a reaction to abrupt events like floods, hurricanes, and storms, or to gradual events and processes like increasing temperature, sea level rise, and land degradation—all of which are exacerbated by the negative effects of the changing climate and environmental degradation—affects its characteristics, duration, and extent. The degree to which other social, economic, cultural, and political elements interact also affects whether a shift is necessary or not. Because of the complexity and variety of causes, environmentally driven migration should not be viewed as purely positive or bad; although it may exacerbate underlying vulnerabilities, it can also present chances for individuals to become resilient.

Without a legally binding or globally accepted definition, various proposals have emerged to categorize environmentally induced migration. These proposals often suggest a more specific definition by concentrating on a single mobility, like displacement, or on a single environmental element, such as the impacts of climate change.

The movement of an individual or group who is forced or chooses to leave their usual place of home, either temporarily or permanently, inside the country or across a global border, primarily because of sudden or slow environmental changes brought on by changes in the climate, is known as climate migration (IOM, 2019). It is a subset of environmental migration, specifically denoting migration where environmental shifts are attributed to climate change. The term is recognized in the enforceable Cancun Agreements on Adaptation to Climate Change, which were ratified by participants in the 2010 conference of the UN Framework Convention on Climate Change (UNFCCC), despite the fact that the IOM's working definition is only used for advocacy and analytical purposes and has no legal standing. Three categories of "climate change-induced" movements are distinguished by the Cancun Agreements: planned relocation,

migration, and displacement. The phrase has also been used by the World Bank to forecast possible future movements brought on by the negative effects of climate change.

Unlike other migrant classifications, climate migrants are not legally recognized, hence there is no universally accepted description for them. Climate change often coincides with other migration drivers, such as economic conditions, political turmoil, and conflict, leading to the assumption that many migrate partly due to environmental decline or climate-related events. The multitude of terms related to this issue has led to confusion. For instance, "climate refugees" is a misnomer since climate change alone does not qualify one for refugee status. Although some regional or national policies address those displaced by disasters, they typically do not cover individuals moving because of climate change's indirect consequences. 'Climate mobility' is a broad term that captures the full spectrum of movement, including internal and international, forced or voluntary, and temporary or permanent migration.

The other aspect of this issue is that numerous individuals are impacted by climate threats yet remain stationary, whether by choice or due to constraints. These so-called trapped populations, who desire to escape areas affected by climate change but are hindered by financial or other limitations, are disproportionately marginalized and face higher risks by staying in perilous conditions compared to those who migrate.

7.3 Who are climate migrants?

When is environmental change-- or more precisely climate change-- the main reason for moving?

When addressing this question, it's crucial to differentiate between rapid-onset climate events that happen within days or hours, like hurricanes, wildfires, or floods, and gradual changes that unfold over years, such as inconsistent rainfall, shifting and more severe temperatures, alterations in soil salinity, or rising sea levels. With sudden events, the connection between extreme weather and displacement is more immediate. Yet, even then, the decision to move, and the ability to do so, hinge on a family's resources and social networks, along with government readiness and humanitarian aid.

The connection between migration and environmental issues is intricate and indirect in the context of slow climate impacts. Research in areas affected by climate stress

indicates that many individuals resist migrating even when their livelihoods are under severe threat, and those who do migrate seldom attribute their move to environmental reasons. The World Food Programme, the Migration Policy Institute, and MIT's Civic Data Design Lab, for example, conducted a study in 2021 that found that only 6% of participants in northern Central America, a region experiencing severe drought and food scarcity, indicated that they would like to move because of climate and environmental factors. Most of them cited economic reasons. As climate change progressively asserts itself, environmental stressors become entangled with other drivers of migration and non-migration, complicating the identification of who exactly is a climate migrant and who migrates for different reasons.

What might appear as a minor semantic issue carries significant real-world implications. Policymakers won't be able to create laws or policies that encourage climate migrants if they can't agree on what constitutes a climate migrant. The fact that climate impacts almost always overlap with other causes of migration and immobility presents a fundamental challenge to the definition of climate migration. As a result, there are numerous ways that migration may be caused by climate change, including labour migration, immigration for academic purposes, family reunification, and even human trafficking. Different policy solutions are needed for these various climate-related movements.

7.4 The necessity of studying climate migration

The lack of a precise definition for the phrase "climate migrant" contributes to the complexity and uncertainty of estimating the number of people who may move as a result of climate change. Although it is simple to link extreme weather events with the displacement of populations, it is much more difficult to determine whether migration is climate-related, both within and across national borders. Climate migration impacts livelihoods and requires concerted efforts in the areas of migration, climate adaptation and development policy to protect communities whose well-being is increasingly threatened by environmental change. Contrary to popular belief, which often predicts massive migration movements, the reality is much more subtle. The majority of migrant movements brought on by disasters and changing climates are transient rather than permanent and internal rather than international. The inclination to migrate is also

influenced by how vulnerable a community is to the effects of changing climates. Adaptation measures like constructing coastal embankments and enhancing access to the resources required for migration, like social networks, legal pathways, and transportation, can lessen this vulnerability.

A bigger problem over time could be migration triggered by the slow, gradual effects of climate change. Hotter temperatures can threaten agricultural livelihoods, rising sea levels can exacerbate flooding and desertification can encourage conflict over access to water - all of which can lead to migration. While rapid-onset disasters usually lead to short-term displacement, repeated events or massive damage can cause people to decide to move permanently or move further away. The most vulnerable people may have the fewest options to relocate or adapt when persistent climatic threats affect their ability to respond. The key challenge, then, is increasingly unpredictable mobility as climate change exacerbates existing inequalities and insecurities around the world. As climate change makes livelihoods more difficult and disasters more severe, displacement is likely to increase and become more unpredictable, although government action can help people stay in place or move to safety(www.migrationpolicy.org).

This emphasizes how crucial it is to comprehend how migration is impacted by climate change. Even if they are not always obvious, environmental factors surely have an impact. The significance of the changing climate can be unclear in situations when calamities result in displacement (for example, earthquakes are unrelated to climate change, and not all disasters are caused by climate change). Additionally, government policy is vital.

7.5 Climate change and migration in India

With its vast expanse across various climatic and ecological zones, India has a population that is acutely susceptible to the harsh effects of climate change. About 67% of the country's 1.3 billion people live in rural areas and depend on industries like forests, fishery, and agriculture for their livelihood, making them particularly susceptible to the impacts of climate change. Climate change will therefore unavoidably impact these populations' food production and agricultural productivity, occasionally resulting in migration trends. The agriculture industry has suffered greatly over the last 20 years due to ongoing droughts and extreme weather events such as flooding, heat

waves, cyclones, and sea level rise. As a result, many people have moved from rural areas impacted by climate change to urban areas (CANSA, 2021). Migration brought on by climate change not only affects governmental and social infrastructure but also lowers the region's development index. When families relocate, their connection to the land is cut, affecting the efficiency and profitability of associated activities like livestock, poultry, and dairy farming. Given that over 60 per cent of India's agriculture depends on rainfall and more than 80 per cent of farmers are smallholders, adopting a climate-resilient approach to agriculture is vital to curbing out-migration.

Some estimates suggest that India might experience a substantial out-migration of up to 45 million people by 2050 due to climate change (Krishnan, M., 2023, April 19). Being a country of vast and varied geographical features, India could encounter diverse impacts from climate change, including land degradation, coastal flooding, and desertification (Balaji, M., 2023, July 4). The Climate Action Network South Asia (CANSA) has reported that 2050 climate disasters could force approximately 45 million people in India to migrate, tripling the current numbers. Despite these alarming statistics, a consensus on addressing climate-induced displacement remains elusive.

Numerous factors, including cultural, social, economic, environmental, and regional dynamics, have an impact on migration in India. While some individuals threatened by climate change opt to migrate if they can, others are compelled to remain. The Foresight Group emphasizes that the population unable to migrate is just as crucial in the adaptation and planning for those impacted by climate change (Foresight 2011). Nonetheless, predicting migration driven by climate change is challenging due to its dependence on numerous socio-economic factors. However, changes in rainfall, temperature, and extreme weather events such as cyclones, droughts, floods, and cloudbursts impact a large number of people. Reduced crop yields and desertification are gradual processes that affect livelihoods and cause migration. This could result in increased mortality and disease rates in the absence of mitigation and adaptation measures, undermining attempts to meet the Millennium Development Goals. Though research conducted in India suggests that migration socioeconomically selective process (Bhagat 2010; Oberai and Singh 1983; Skeldon 1986), not all individuals impacted by climate change are able to move. Nevertheless, migration may be a useful adaptation technique. Additionally, this condition may exacerbate poverty and starvation, increase sickness and death among the most vulnerable groups, and intensify

seasonal and temporary migration. Seasonal and short-term migration may increase as a result, poverty and starvation may intensify, and rates of sickness and mortality among at-risk groups may rise. One of the many possible outcomes that can be impacted by many economic, social and political circumstances is migration. A number of factors, such as the intensity of climate change, adaptation strategies, and the availability of migration possibilities to other locations, influence the unpredictability of climate change susceptibility and migration likelihood.

Annually, one hundred million individuals migrate within India to earn a livelihood. According to Deshingkar, P., & Akter, S. (2009), these internal migrants remit vast sums of money back home, amounting to eight times the combined budgets of the Indian government's health and education sectors. Migration has long been a part of life, particularly for households in semi-arid regions. However, the scale and pattern have shifted over the past two to three decades. In rural India, moving is becoming a more popular way to manage risks, fulfill goals, and make money (Singh, C., & Basu, R., 2020). India has one of the highest rates of movement from disasters worldwide and the highest rate in South Asia. According to the IDMC 2020 report, an average of almost 3.6 million people left their homes annually between 2008 and 2019, primarily during the monsoon season.

Approximately 80% of all immediate impacts of drought are felt in agriculture, according to the Food and Agriculture Organization of the United Nations (FAO). This has a big impact on rural communities' livelihoods, food production, and food security. Droughts have a significant impact on economic performance, can result in starvation and migration, diminish natural resources, and create wide-ranging difficulties for rural communities—a condition that is especially noticeable in India. The Indian Human Development Survey has pinpointed various socio-economic factors that affect migration decisions, such as household income, access to information, and community networks in both the place of origin and the place of destination. Additionally, administrative barriers to interstate migration may arise from residency requirements for employment and education, as well as the non-transferability of social benefits and legal entitlements, as noted by the FAO in 2018. Small-scale farmers and those lacking irrigation facilities are particularly vulnerable. According to World Bank estimates, 26 million people fall into poverty each year as a result of natural disasters, which cost the world's economy an astounding $520 billion (World Bank 2017). The World Bank

predicts that within the next 13 years, forty percent of Indians will relocate to cities, bringing the country's current population of about 150 million people spread across 53 cities to 300 million. Nearly 65% of Indians will reside in urban agglomerations by 2047. (OrfOnline.org)

7.6 Nexus between climate change and migration

Over the past few decades, scientists and policymakers have become more concerned about the possible causal link between migration and climate change. This relationship has gained more attention in the media and public discourse and has become a major topic on the international political agenda. A 2°C increase in the global average temperature over pre-industrial levels is widely expected to lead to significantly higher migration flows in the coming decades (Myers, 2002; Biermann & Boas, 2010). This view is also supported by the most recent Groundswell reports from the World Bank (Rigaud et al., 2018; Clement et al., 2021). Due to significant data gaps, this perspective, however, lacks solid research and conclusive empirical proof (Boas et al., 2019).

While there isn't enough solid proof currently, the possibility of a significant increase in migration due to large-scale climate events has sparked an empirical research field focused on The effects of climate risks on human mobility. Consequently, there is a burgeoning amount of research exploring the causal relationship between these two factors to meet the demand for dependable forecasts and robust empirical data. The findings vary based on environmental factors, data scope, analytical methods, and geographic areas studied. Nonetheless, the consensus among researchers is that data scarcity remains a major challenge. Despite more accessible micro-level panel data sets, enhanced conceptual frameworks, and improved econometric methods, numerous critical issues and technical obstacles still need resolution, such as differentiating various migration types and information requirements Letta, M., Montalbano, P., & Paolantonio, A. (2024).

Here is how this chapter is structured. The most recent empirical work on the causal connection between migration and climate change is presented in the first section. The

second section outlines the methodological and empirical difficulties as well as the relevant data gaps.

7.6.1 A synthesis of recent empirical findings

Heterogeneity appears to be a key component of the relationship between climate and migration, impacted by a number of context-specific elements such the type and frequency of climate events, people's resources, and their adaption tactics. Predictions that climate change will force tens of millions of people to relocate domestically or overseas should be made with care due to its intricacy (Boas et al., 2019; Clement et al., 2021). It also emphasizes the need for more attention to the potential for climate change to trap the poorest and more vulnerable categories of people in a condition of immobility, which would have a substantial impact on the welfare of the entire world.

Through the analysis of this burgeoning body of literature, this chapter aims to illuminate several thematic concerns deemed essential for the ensuing examination of empirical inquiries and data deficiencies. Specifically, We concentrate on the most recent research on the five main aspects of the relationship between migration and climate change that have been established in academic works: direct and indirect links (Bardsley & Hugo, 2010); comparisons between internal and international migrants; financial constraints; events with a gradual or rapid onset (United Nations Framework Convention on Climate Change, 2012; Bohra-Mishra et al., 2014); and migration as a means of adaptation.

7.6.2 Rapid-onset events compared to gradual-onset changes

Rapid-onset severe weather conditions that are linked to climate change, like hurricanes, landslides, and floods and high rainfall, frequently have direct and immediate implications on migration. Usually, these lead to short-term, transient moves (McLeman & Gemenne, 2018). One particular area of research examines the impact of flooding on migration, with varying results: while Gray and Mueller (2012a) and Bohra-Mishra et al. (2014) found no significant effect of flooding on migration in Ethiopia and the Philippines, Mueller et al. (2014) found that flooding reduces the

likelihood of migration in Pakistan respectively. Koubi et al. (2016) found that while long-term environmental changes, including salinization, tend to reduce the risk of migration, abrupt shocks are more likely to start migration in Vietnam. Except Mueller et al. (2014), who additionally take into account all forms of migration, these studies, which find a general lack of large-scale movement as a result of weather shocks, mainly use direct migration measures from household survey microdata for internal migration analysis.

On the other hand, Robalino et al. (2015) conducted a meso-level analysis utilizing census data as an indirect proxy for migration and discovered that while more severe disasters decrease migration in Costa Rica, flooding and other water-related catastrophes promote migration. According to Kaczan and Orgill-Meyer (2020), catastrophic floods and other sudden shocks might deplete household resources and assets so rapidly that they prevent migration.

Castells-Quintana and colleagues (2021) explore the macro-level link between shifts in population distribution, economic activity, and weather patterns, discovering that deteriorating climate conditions correlate with increased urbanization. Their findings indicate that gradual climate changes might lead to more enduring and extensive migration, whereas abrupt climate events tend to result in temporary relocations and temporary moves to nearby urban centers. Koubi and colleagues (2022) examine data from cross-country surveys conducted in Vietnam, Cambodia, Nicaragua, Peru, and Uganda, revealing a diverse range of migration responses: individuals with lower education and income levels are less inclined to migrate following abrupt shocks in contrast to people who are better educated and have more money. Furthermore, even when faced with an imminent resource shortage, impacted groups in economically challenged nations frequently lack the financial resources for long-distance relocation (Zickgraf & Perrin, 2016).

According to Cattaneo et al. (2019), the main finding drawn from this body of research is the limited potential of rapid-onset events to trigger long-term, long-distance migration, particularly when it involves expensive international moves. Significantly, this conclusion remains consistent across various studies, despite a broad range in the analytical approach—from micro-level to meso-level to macro-level—and the variety of data sources used to generate migration outcomes, from indirect proxies based on census and urbanization data to direct measures employing conventional and non-traditional data.

However, research on the migratory effects of gradual changes has been less extensive than that on abrupt disasters, even though slow-onset changes tend to trigger migration more than rapid-onset changes (Kaczan & Orgill-Meyer, 2020). This is partly because Since gradual changes have less direct repercussions on people, they are not thought to be severe enough to cause migration (Koubi et al., 2022). It is more difficult to precisely connect migration to slow changes like floods, landslides, cyclones, and the like since the effects of events like desertification, drought, and warming are gradual. Furthermore, migrant flows may be sporadic, more difficult to record, and more prone to measurement errors.

Many studies suggest that increased migration is associated with slow environmental change and rising temperatures (Feng et al., 2010; Dillon et al., 2011; Mueller et al., 2014; Cai et al., 2016; Mastrorillo et al., 2016; Bohra-Mishra et al., 2017; Dallmann & Millock, 2017; Hunter et al., 2013; Jessoe et al., 2018). These findings are further corroborated by more comprehensive macro and meso-level assessments of international migration, which frequently use household surveys to evaluate internal movement (Hunter et al., 2013 Cai et al., 2016). Contrarily, few research highlights that slow-onset climatic changes may conversely reduce migration. Notably, Cattaneo and Peri (2016) found that increased temperatures decrease migration from impoverished nations, aligning with significant financial constraints. This is supported by data on bilateral migration and urbanization rates. Similarly, Cottier and Salehyan (2021), Martinez Flores et al. (2021), utilizing IMO cell-level migrant statistics and data on unlawful migration, corroborate these findings. Focusing on internal migration, in rural Tanzania, Hirvonen (2016) showed that temperature fluctuations reduce male migration because of increased financial constraints. Additionally, a district-level study in India by Liu et al. (2022) concluded that ongoing warming and temperature rises hinder structural change and limit rural-to-urban migration for families living in remote regions.

Others point out that migration is largely influenced by political and economic factors, with slow-onset environmental changes playing a minor role. For instance, Selby et al. (2017) argue that environmental factors had a negligible impact on the migration to Syria before the civil war. In a similar vein, Niva et al. (2021) analysed global net migration data from 1990 to 2000 and discovered that gradual environmental shifts like droughts and water scarcity were significant in explaining migration patterns.

Nonetheless, they also highlight the significant influence of income levels and the capacity to adapt in shaping migration trends.

In summary, while the prevailing view is that slow-onset events generally increase migration, there are instances where affected populations become immobilized due to the adverse effects of such events on their financial resources. This is not unexpected, given the complexity of migration determinants, particularly those related to climate (IPCC, 2014). The nature of the relationship is not predetermined and depends on local conditions, making it fundamentally an empirical question. In terms of data gaps, there is little micro-level evidence on the immobility consequences of slow-onset catastrophes like droughts, erosion of soil, and desertification from research that uses direct measures of movement, such as household surveys and individual panel data. Furthermore, there is a dearth of comprehensive study conducted inside nations to pinpoint the precise causes of the disparate reactions to events with gradual and quick beginnings, particularly with regard to the direction of the relationship beyond its size in less developed countries.

7.6.3 Direct and indirect migration

Climate change can directly and indirectly influence migration patterns. It is essential to comprehend how climate events affect other migration drivers via political, socioeconomic, and demographic channels. The main avenues via which weather and climate-related dangers indirectly impact migration are socio-political and economic variables. Nevertheless, there is still little and incomplete evidence of these connections. The relationship between extreme temperatures, crop yields, farmers' earnings, and migration from Mexico to the United States was empirically demonstrated by Feng et al. (2010), who used census data to conduct a meso-level analysis of international migration. In a major macroeconomic study, Marchiori et al. (2012) used annual panel data from 1960 to 2010 and found that weather shocks in sub-Saharan Africa have a direct and indirect impact on international migration in addition to increasing rural-urban movement by lowering rural wages. Similarly, in India's agricultural states, droughts have a more noticeable impact on interstate migration, according to Dallmann and Millock (2017).

Developing countries are particularly vulnerable to climate-related hazards due to their heavy reliance on agriculture for income, which is highly weather-dependent. These

countries often experience higher temperatures and are near biophysical thresholds, lacking the ability to adjust to climate change's detrimental effects. Using bilateral migration data from 1980 to 2010, for example, Cai et al. (2016) showed that temperature changes only cause international movement from agricultural countries, increasing migration to OECD countries. Beine and Parsons (2015) conducted a macro study using a panel of bilateral migration flows and discovered an indirect effect of climate factors on international migration through wage dynamics. Using cell-level net migration data and a machine learning forecasting model—more precisely, a random forest model—Niva et al. (2021) found that income was a critical component of both positive and negative net migration. They deduced that the critical aspect is the income disparity between origin and destination regions, rather than the absolute income level.

The most significant political and social component that has been studied in the literature, aside from income, is the well-known (and frequently prominent in the media) conflict channel. As to Kelley et al. (2015), the afflicted population's (pre-existing) vulnerability was made worse by a lengthy and severe drought in portions of Syria, which led to their migration. According to them, migration further heightened tensions and aided in the start of the civil war. However, it should be highlighted that there is considerable debate regarding the potential direct role of migration-induced climate change in the Syrian civil war (Fröhlich, 2016; Selby et al., 2017) and that the relationship between climate change, migration, and conflict is generally very complicated and context-specific.

There aren't many microeconomic studies that look at the distinctions and connections between direct and indirect effects, especially when it comes to survey data that provide direct information on the paths of migrants. This is one example of a data gap.

7.6.4 Internal versus international migration

Due to a lack of data on internal migration in underdeveloped nations, previous studies concentrated more on foreign migration caused by climate as well as weather change (Laczko & Aghazarm, 2009). The last ten years have witnessed a change, though, as an increasing amount of research has looked at the relationship between adverse weather and both short- and long-distance migration inside nations, occasionally comparing

results across different destinations. Natural catastrophes in Bangladesh have a greater and more substantial impact on local migrations than on long-distance out-migration, according to Gray and Mueller's (2012b) analysis of longitudinal household survey data. By combining daily meteorological data from ground-based stations with a retrospective individual panel, Jessoe et al. (2018) showed that extreme heat events in Mexico promote migration across the border to the United States as well as internal migration from rural to urban areas. In rural Tanzania, Hirvonen (2016) found that rising temperatures reduce internal migration because they raise financial limitations brought on by negative consumption shocks. This effect is unique to men. Using a global dataset from 1970 to 2000, Peri and Sasahara (2019) examined internal migration between rural and urban areas. They discovered that while increasing warming boosts it in middle-income countries, it decreases it in poorer ones. According to Gray and Bilsborrow (2013), in Ecuador, unfavorable rainfall conditions increase internal long-distance migration (between cantons) while decreasing internal short-distance migration (within the same canton) and international migration. These findings suggest that the effects vary according to the kind of movementUsing individual retrospective migration data from censuses, Nawrotzki et al. (2013) discovered a positive and statistically significant correlation between extreme weather conditions and international migration from Mexico.

Using temporally disaggregated information Cottier and Salehyan (2021) tracked undocumented migrants at the EU's outer borders and discovered that droughts in the countries of origin do not cause an increase but a decrease in international migration to the European Union, particularly for agriculture-dependent countries, while increased rainfall boosts migration. They suggest that the high costs of international migration and the exacerbation of liquidity constraints by adverse weather events are the reasons. According to Schutte et al. (2021), who also looked at the relationship between climate variables and asylum migration, variations in temperatures are not accurate indicators of bilateral asylum migration to the EU. They also believe that policy changes, not climate change, will be the main factor driving future asylum migration. These results are consistent with a meso-level analysis for West and Central Africa by Martinez Flores et al. (2021), who estimated that a one standard deviation rise in moisture in the soil leads to a 25 percent decrease in foreign migration, most likely as a result of financial limitations. Additionally, Bekaert et al. (2021) examined individual-level longitudinal data from Gallup World Polls in 90 countries, showing that environmental

stressors increase the desire to migrate internationally and within countries, with a stronger effect within regions, especially in rural and less developed regions.

To put it briefly, there appears to be significant variation in the kind and final destination of migratory flows brought on by climatic shocks, contingent on a number of variables such as the shock's frequency and intensity, the impacted individuals' gender and financial resources, and the case study's setting. Nevertheless, despite this diversity, meta-analyses of the literature have discovered evidence that the case for weather-related migration is stronger for domestic, within-country movements than for worldwide movements across borders (Hoffmann et al., 2020). This finding defies the "typical understanding" regarding common international migration brought on by climate change. The lack of research reconstructing a possible climate migration cycle that might be generated, directly or indirectly, by climatic changes in the originally impacted areas is the final significant missing element, which is partly caused by data shortages. According to recent studies, prior internal migration in Sub-Saharan Africa is strongly linked to the intention to migrate globally (Cirillo et al., 2022). Regarding climate migration, it is not impossible to envision a situation where future increases in the frequency or severity of extreme weather events in rural areas will dictate internal migration between rural and urban areas. This, in turn, leads to worldwide, international movements of urban workers as a result of fluctuations in local labor markets. As climate change accelerates, it is currently uncertain if and to what extent this type of climatic-related movement will become increasingly significant.

From the standpoint of data, internal migration, and climate factors are more strongly correlated and are better captured by household surveys, while there's a lack of evidence for significant impacts of weather shocks on international migration. These sources often provide direct migration-related measures, tracking the movements of individuals, but they fall short in the study of international migration. With a few notable exceptions, surveys are usually insufficiently comprehensive to analyze the relationship between internal migration and climate trends. Only statistical correlations are revealed by cross-sectional surveys and surveys with only two waves, which are unable to conclusively establish causality because of identification problems. Therefore, improving data collecting should be a primary goal for migration studies in order to increase the availability of household surveys with at least a medium-term scope. Last but not least, the most inventive and promising strategy for investigating

possible migration chains seems to be interoperability across several data sources, both traditional and non-traditional, micro and macro.

7.6.4 Heterogeneous Responses: Trapped Populations and Migration as an Adaptation Strategy

The fact that climate-related risks might result in or exacerbate financial limitations is a significant finding from the most recent research (Cattaneo & Peri, 2016; Cottier & Salehyan, 2021; Hirvonen, 2016). Because of this, the ability to migrate in response to changes in the climate is far more constrained than is generally believed: those who are poor, who are more severely affected by climate change, have more reason to migrate but frequently are unable to do so due to a lack of resources (Cattaneo et al., 2019). This viewpoint claims that poorer households are "compelled to stay" rather than "pushed to move," and that migration is an expensive investment in diversification of risks that only wealthier households can undertake (Kaczan & Orgill-Meyer, 2020). We should anticipate a wide range of outcomes depending on whether financial constraints or migratory responses ultimately prevail, as well as the interaction between the magnitude of the climate-related event and household-specific attributes like money, number of sources of income, and resources.

Regarding migration in reaction to weather shocks, the empirical data is not entirely clear. Some studies suggest that weather volatility increase the likelihood of migration among the most impoverished households (Grey & Mueller, 2012b; Mueller et al., 2014; Mastrorillo et al., 2016), while additional research suggests that the poor are prevented from migrating by a lack of financial resources (Bazzi, 2017; Cattaneo & Peri, 2016; Hirvonen, 2016). These contradictory results, according to Cattaneo et al. (2019), might be resolved by taking into account the various migration strategies: While wealthier households may choose more costly, semi-permanent, long-distance risk management migration, destitute families may choose low-return or "survival" migration across short distances after unfavorable events. Furthermore, according to Koubi et al. (2022), the type of climate stress and the impacted people's ability to adjust, depending on their resources and assets, both increase the chance of (im)mobility. To support this viewpoint, Choquette-Levy et al. (2021) employ simulations using an agent-based model adjusted with household survey data from Nepal. They also

emphasize how risk-sharing and financial assistance might lessen the immobility caused by climate change for farmers.

Essentially, each household and situation have a unique ultimate result. A household or individual may choose to migrate as one of several adaptation techniques, and migration and immobility are only two of the many possible outcomes. Because the results are context- and household-specific, it is essential to carefully determine the causes of the variations in these results. Thus, a microeconomic approach is preferred over a macroeconomic one when examining this particular aspect of climate migration. While macro-level analysis can indicate an inverse relationship between wealthy and poor nations (for instance, Cattaneo and Peri (2016), it fails to illuminate the underlying causes and timing of liquidity shortages about weather shocks. Policies frequently focus on "those who leave" rather than those who are unable to go, therefore it is crucial to comprehend both the causes and implications of the immobility experienced by people stranded by environmental disasters (Findlay, 2012). The advantages of thorough, longitudinal household surveys that cover a variety of objectives and subjects should be the main focus of researchers to close these data gaps.

7.6.5 Migration as an Adaptation

Migration and adaption difficulties have gradually been merged into a single theoretical framework in recent academic literature. Migration is seen as one of the adaption methods for climate change within this paradigm. According to empirical data, migration is a component of a larger set of choices about coping mechanisms and adaptation to environmental stressors (Black et al., 2011; Alam et al., 2016; Kattumuri et al., 2017; McNamara et al., 2018). On the other hand, in contrast to other local adaptation mechanisms, migration can be viewed as an expensive last alternative (Wodon et al., 2014). There is a lack of sequential study to ascertain if migration decisions come before or after other adaptation methods, despite some research suggesting that migration and on-farm adaptation may be interchangeable (Cattaneo et al., 2019). There is currently conflicting evidence, mostly from cross-sectional research like Bangladesh's Alam et al. (2016). To better understand the dynamics between migration and in-situ adaptation, long-term micro-level surveys that are rich in information on agricultural methods, inputs, and technology must be implemented.

The difficulties with immobility and stranded individuals could also be a result of a lack of adaptability, warranting an integrated approach to research from an adaptation standpoint. However, the research that is now available is sparse and uneven. One noteworthy exception is a study by Flores et al. (2021), which employs the IOM's cell-level population of international migrants as an outcome variable. They found that, in contrast to people in wealthy or impoverished areas, only those in middle-income areas are less likely to leave following a drought. Farmers may use a variety of coping mechanisms, such as migration, to mitigate the effects of climate change. The scholarly community has frequently failed to recognize that migration is only one of many reactions to environmental strain and that it should be considered in conjunction with other adaption methods that may be used in place of or in addition to migration (Hoffman et al., 2020). Thus, research should focus on how migration integrates into this broader array of coping mechanisms, as well as the causal mechanisms and temporal aspects of the link between migration and adaption. A microeconomic approach that relies on direct sources of migration data enables the reconstruction and tracking of individuals' and households' migration histories and intentions, providing a means to analyze the migration decision in conjunction with the coping and adaptation strategies available to households before and after experiencing shocks.

Even with the growing body of studies, there are still important gaps in our understanding of the complex interaction between migration and climate change, which calls for more investigation. However, recent findings challenge the oversimplified view that climate change will inevitably cause large-scale permanent migration (Findlay, 2012). Factors such as gradual environmental changes, the tendency towards immobility, internal migration, diverse responses due to specific local factors and financial limitations, and the interplay between local adaptation strategies and migration are increasingly recognized as crucial for predicting climate migration trends. These elements have been somewhat overlooked in research, often overshadowed by the exaggerated depiction of climate change as a trigger for immediate, large-scale cross-border migration, and also because of the lack of comprehensive data. It is now believed that these critical factors can be explored through detailed, long-term household surveys, which could be tailored to address these data shortages.

7.7 Climate migration

Table 19 shows climate-induced migration: Evidence from India

Place	Unit	Types of migration	Causes of migration	
Bihar	Household-level analysis (primary survey)	Internal migration: Farmers impacted by seasonal temperature fluctuations and temporary climate shifts chose to temporarily secure revenue in order to meet their basic needs.	• Climate-related livelihood risk factors significantly contribute to farmers' migration. • Farmers' migration decisions are influenced by socioeconomic considerations and their perceptions of climate change.	Migration is considered an option for adaptation.
West Bengal (Bankura)	Household-level analysis (primary survey)	Internal migration (short-term and long-term)	• seasonal and temporary out-migration is a yearly occurrence, • its intensity notably escalates during droughts. • frequent drought periods heighten the propensity for male migration.	They use migration as a way of sustenance during droughts.

West Bengal (Sagar Island, Sundarbans)	Household-level analysis (primary survey)	Internal migration	• According to this study, a significant portion of houses have very poor climate resilience, and the effects of storm surges and embankment collapses are becoming more severe. • When physical or social systems are disrupted and ecosystem services have deteriorated, people who have been moved frequently find it difficult to establish a sustainable life in their own environment. • High vulnerability index values were assigned to severe erosion, tidal ingression, embankment breaching, and flooding brought on by complex hydrodynamics and sea level rise. Due to their poor sociodemographic profile, poverty, livelihood status, lack of social security, poor health, and increased exposure to environmental risks, the climate refugees in these mouzas are particularly susceptible.	Forced migration
Orissa (village of Khaliakani)	household level	Internal migration (temporary)	• Drought is a creeping disaster. Initially, villagers	forced migration

			may consume less food. As conditions deteriorate, they often resort to borrowing money for animals or equipment. In severe cases, they may sell productive assets like seeds, livestock, or machinery. Ultimately, migration becomes the final option. • during times of drought, it increases significantly and is the most important coping strategy. •	
India	State level (using 64th round NSSO data and data from IMD)	Internal migration (temporary Migration)	• Districts affected by the drought have slightly greater rates of temporary migration.99.46% of all short-term migrants in rural India moved within the country's borders, whereas 67.12% moved from rural to urban areas. According to the study, the likelihood that a household will have at least one temporary migrant member is strongly correlated with the occurrence of drought.	When drought strikes, they use migration as a strategy to livelihood

7.8 What is known about how environmental factors affect migration flows?

The documents examine climate-induced migrations within the framework of climatic hazards, categorized as either slow-onset or rapid-onset. The following points assist in recognizing how environmental factors trigger migration and distinguish such movements as climate-related migration.

- These instances show that climate stressors mainly initiate migration through socio-economic impacts in the case of climate migration it is impossible to isolate climatic factors as the sole reason behind the migration decision., the decision to migrate is shaped by various factors, including environmental risks and economic opportunities. Individuals and families' decisions to relocate or remain are also influenced by the complex interplay of social, environmental, and economic variables.
- Studies suggest that for both incremental environmental changes and abrupt disasters, there are specific thresholds that induce migration rather than remaining. This research is based on models that incorporate environmental considerations into migration choices, highlighting ecosystem services that underline the environment's productive benefits, or models that account for risk factors leading to tolerance thresholds and, thus, the choice to migrate.
- Climate migration is mainly internal: people have limited resources to move outside national borders.
- Migration isn't always a forced decision, particularly in gradual processes; it remains a choice, as numerous individuals opt not to migrate. Additionally, many remain confined in vulnerable regions due to lacking resources.

7.8.1 Need for climate migration policy and legislation

Despite international efforts to decrease greenhouse gas emissions, a December 2020 report by ActionAid and the Climate Action Network South Asia estimates that 37.5 million people will be displaced by 2030, with approximately 62.9 million affected in five South Asian countries: India, Nepal, Bangladesh, and Pakistan, and Sri Lanka. By 2050, catastrophic climate changes are predicted to uproot 45 million people in India, triple the country's present climate-related migration figures.

Over three million people are predicted to be moved out in 2020–2021, making India the fourth most affected nation in the world by climate-induced migration, according to the State of India's Environment-2022" study. Approximately 14 million people have been relocated as a result of climate change, according to India's Internal Displacement Monitoring Centre (IDMC).

Few institutions provide long-term assistance for the needs of migrants, despite the fact that they get emergency aid and rehabilitation in the immediate aftermath of major disasters.

According to a 2021 study titled "Climate Induced Displacement and Migration in India," individuals are fleeing poverty as a result of the collapse of their traditional occupations and the growing failure of infrastructure brought on by climate change.

It is well known that the growing frequency of climate-related extremes has altered the character of the long-standing inter-state and intra-state (rural-urban) movement that occurs in India as a result of floods, droughts, and other severe weather.

People have been migrating within India for a long time, in part due to improved social and economic possibilities, and internal migration is a crucial component of the country's development. The 2011 census estimated that there were 139 million internal migrants, or almost 10% of the population, whereas the Economic Survey of India from 2017 states that the amount of interstate migration between 2011 and 2016 was nearly 9 million individuals annually. Another stressor for internal migratory patterns is climate change.

There is no broad national policy for the planned resettlement of persons impacted by climate change, and governmental efforts to prepare for the relocation of inhabitants owing to climate-related dangers have been negligible. People who have been moved out by environmental problems or climate change are not specifically acknowledged by India's current institutional and legal structure. There is no special category for those displaced by climate change dangers in the present Inter-State Migrant Workers Act of 1979, which regulates interstate movement, and no revisions have been proposed to accommodate climate migrants.

India lacks plans for migration and displacement brought on by slow-onset catastrophes, but each state's disaster management strategy handles abrupt

displacements brought on by cyclones and typhoons. The issue of displacement brought on by climate-related hazards has been largely ignored by India's State Climate Change Action Plans, despite the fact that they have recently emerged as the primary subnational policy document for addressing climate change vulnerabilities and promoting essential infrastructure projects and interventions.

Recently, on July 7, 2022, Bill No. 160 of 2022 concerning CLIMATE MIGRANTS (PROTECTION AND REHABILITATION) was presented in Parliament by MP Shri Pradyut Bordoloi. The purpose of this bill is to create an appropriate policy framework for the rehabilitation and safeguarding of internally displaced climate migrants. The phrase "climate migrants" describes people, groups, households, or whole communities who are either temporarily or permanently: (i) compelled to move because of climate-related factors; (ii) evacuated by the government from unsustainable and dangerous habitats; or (iii) voluntarily leaving their normal place of residence because of deteriorating living conditions and livelihood prospects brought on by climatic events, whether they start slowly or quickly; or (iii) voluntarily leaving their usual place of residence because of disasters or stress brought on by climate-related factors or gradual climatic changes.

The Central Government is mandated to develop a National Policy for managing climate-induced migration within one year of this Act's commencement, after consulting with State Governments. This policy will aim to uniformly protect, relieve, and rehabilitate climate migrants across the nation. Furthermore, the Central Government will establish the National Climate Migration Authority by official notification to fulfil this Act's purposes. This Authority will be an inter-ministerial group with representatives from various Central Government departments, including the Ministries of Forests, Environment and Climate Change, Home Affairs, Labour and Employment, Rural Development, Women and Child Development, Agriculture, Law and Justice, Jal Shakti, and Housing and Urban Affairs. The representatives will be appointed as prescribed by the Central Government. Concurrently, State Governments are required to create inter-departmental agencies to manage A/C migration at the state level throughout India, ensuring uninterrupted protection and rehabilitation for A/C migrants. Additionally, sub-district level Migration Facilitation Centres will be set up by State Governments to identify, document, and monitor all climate migration moving into and out of their areas. Each State authority will be tasked with devising action

plans, offering guidance to subordinate bodies and other government agencies, coordinating the enforcement and execution of these plans, and suggesting fund allocations for activities related to the prevention, mitigation, and rehabilitation of climate migrants, as prescribed.

7.8.2 Background of the bill

Current national legislation and policies mainly address short-term and immediate climate disasters. However, they often overlook slow-onset events like increasing dryness, recurring droughts, desertification, sea level rise, glacier melting, and river erosion, leaving affected communities without adequate protection or rehabilitation. The focus tends to be on emergency relief and the immediate issues of disaster-stricken communities, neglecting their long-term rehabilitation and support. Consequently, the economic and social challenges of these communities multiply significantly. Considering the escalating climatic and ecological pressures on habitats and the expected rise in climate-induced migration, it is imperative to develop a comprehensive, integrated national strategy that tackles the root causes, mitigates the impacts, and safeguards the communities in question. This is the purpose of the proposed bill.

7.9 Conclusion

The number of people impacted by climate migration is expected to rise in the years to come since severe environmental events become more frequent. The way that migration is conceptualized and defined in policies and programs has risks that must be addressed to keep an opportunity from turning into a challenge for adaptation measures, even though migration can help people cope with the effects of climate change.

Chapter 8

(Addressing the link between climate change and migration - evidence from two sub-districts of Purulia district, West Bengal)

8. Introduction

This study defines a migrant as an individual from a rural household who moves out due to climatic reasons, specifically drought. Here, drought is identified as the cause, with migration as its direct consequence. In Purulia, internal migration and climate change interact at the sub-district level. While there are no national reports of population movements at this scale, rural inhabitants frequently migrate for short-term economic opportunities. Although primarily driven by economic factors, climate variations also indirectly influence the decision to migrate. This issue has not been addressed in Purulia, a district that is economically disadvantaged and frequently affected by drought. To explore how drought impacts migration patterns, this work seeks to bridge this gap through a comprehensive household survey in two sub-districts, Baghmundi and Man Bazar 1.

8.1 Demographic and socio-economic characteristics of migrant households

Man bazaar 1

Research on migration has revealed that a multitude of factors at the macro, meso, and micro levels, along with specific contextual elements, intricately facilitate, enable, restrict, and prompt the complex processes of migration. Demographic and socio-economic drivers shape the framework within which individuals decide whether to migrate or remain. These factors influence the importance of migration, the likelihood of specific migration paths, and the allure of various locations. Although environmental and economic variables are frequently taken into account separately, it is becoming more widely accepted that migration is not a single cause but rather the result of complex interactions between several interrelated elements. A comprehensive analysis of these factors is essential for grasping the motivations behind migration and understanding why the majority choose not to migrate.

The type and intensity of out-migration in rural areas are influenced by various demographic, economic, and socio-cultural factors. Additionally, age, gender, caste, education, and socio-economic status shape both the intensity and the decision-making process regarding migration. Therefore, it is vital to investigate the diverse demographic and socio-economic attributes of rural migration in such studies

8.1.1 Household characteristics

Before analyzing the demographic and socioeconomic characteristics, Understanding the unique traits of migrant households is essential. Table 20 provides an overview of the characteristics of surveyed households

Table 20 shows the household characteristics

Total Sample HH	400	
Mean Household size	5.6	
Mean Landholding size (bigha)	2.71	
Mean Age of HH head	43.7	
Sex of HH head	Male	98.5
	Female	1.5
Education of HH head	Illiterate	15.25
	Primary (one to eight)	73.5
	Secondary level (nine to ten)	7.75
	Higher Secondary level (eleven to twelve)	3.5

Source: Household survey

The significance of the household in individual migration decisions is profound. Household characteristics significantly influence the decision to migrate, to the extent that they can propel or deter the movement. Kley (2011) highlights the intricacies of the migration decision-making process.

Table 20 indicates that the average household consists of more than five individuals. However, their average landholding falls below one hectare (equivalent to 3.954 bighas). Consequently, large family's dependent on such limited landholdings may face slower development, exerting strain on both land and food resources

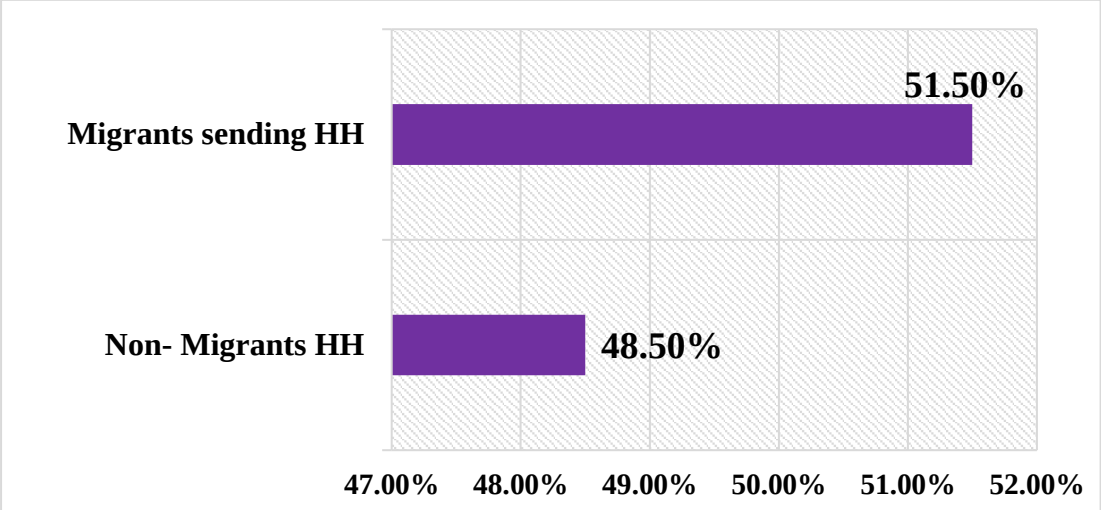
The Indian census identifies the head of a household as the person primarily in charge of managing the household and making decisions for it. This role is not confined to the eldest male or the primary earner; it can be assumed by a woman or a younger family member, regardless of gender. With a mean age of 43.7 years, men make up 98.5% of household heads in the research area. The decision-maker's role in household decisions might be indirectly reflected in the age of the head of the home. The effect of this variable may be positive or negative. A positive indication means that a seasoned household head, skilled in balancing agricultural and family responsibilities, may be more likely to allow active family members to pursue employment opportunities in the city. On the other hand, older household heads may choose to keep their children close to home, suggesting a negative correlation between the decision to migrate and the intensity of migration.

Photo 6 field visit in Man Bazaar 1 and Baghmundi

The family head's level of education is crucial, as it is linked to higher personal income and increased wealth for the household. Educational attainment is often associated with success. A lack of education in the household usually correlates with lower educational levels among the children. Furthermore, higher educational attainment can lead to more job opportunities for the household head, the integration of technology in farming practices, improved agriculture, and the reduction of poverty. Table 20 shows, over 70% of household heads have only primary education, and 15% are illiterate.

8.1.2 Overview of Migrants' Household

Fig 23 displays the number of households in the study region that are migrants and non-migrants.



Haan, (1997) argued that migrants, particularly those who oscillate between rural and urban areas, present a complex subject for analysis. In both migration literature and public opinion, migrants in Third World cities are often depicted as destitute, with their migration viewed as a desperate measure—a compulsory exodus from rural areas devoid of alternatives. Conversely, some scholars regard migrants as rational agents, making decisions to migrate in response to economic incentives. Additionally, there is a perspective in the literature suggesting that the poorest individuals are unable to migrate. It has been deduced by some researchers that villagers with better economic standing are more inclined to be attracted, while those less fortunate are compelled to migrate. Understanding why a significant portion of the surveyed population in Man bazar 1 opts for migration is crucial.

Historically, the choice to migrate has been viewed as a singular decision based on individual cost-benefit analyses, often monetary (Harris & Todaro, 1970; Massey et al., 1993). However, hazards, future educational and economic prospects, and environmental and social variables also influence internal migration (Black et al., 2013). Recent studies indicate that environmental changes impact human migration, introducing complex temporal and spatial factors (Piguet, E., 2011), and the drivers of migration differ with the nature and intensity of disasters. Research by Adger et al. (2021) shows that age, ecosystem, livelihood, and migration networks are significant in influencing migration intentions. Additionally, various studies have identified

multiple factors that prompt migration in response to disasters or environmental challenges.

A range of economic and non-economic factors influence migration decisions. Migrants may be "pushed" from their home countries by worsening economic situations or political turmoil. In contrast, "pull" factors in destination countries, such as higher wages, quality healthcare, robust education systems, or language similarities, attract migrants. Individuals weigh the net benefits against the costs when deciding to migrate. A deeper understanding of the specific forces driving migration flows, such as demographic traits, migrant networks, and economic conditions, is crucial.The following tables show the socioeconomic characteristics of migrant households.

Table 21 shows the gender of the household head

Head of HH	**Percentage**
Male	**91.75**
Female	**8.25**

Table 22 shows the social composition of migrant households

Social group of HH	**Percentage**
General	**4.37**
SC	**41.75**
ST	**44.17**
OBC	**9.71**

Table 23 displays the family head's level of education.

Educational status of HH head	Percentage
Illiterate	**34.47**
Primary level (one to eight)	**41.26**
Secondary level (nine to ten)	**19.90**
Higher Secondary level (eleven to twelve)	**4.37**

Table 24 shows the livelihood of migrant's household

The livelihood of the migrant's HH	Percentage
Agriculture & livestock	**79.61**
Landless laborers	**20.39**

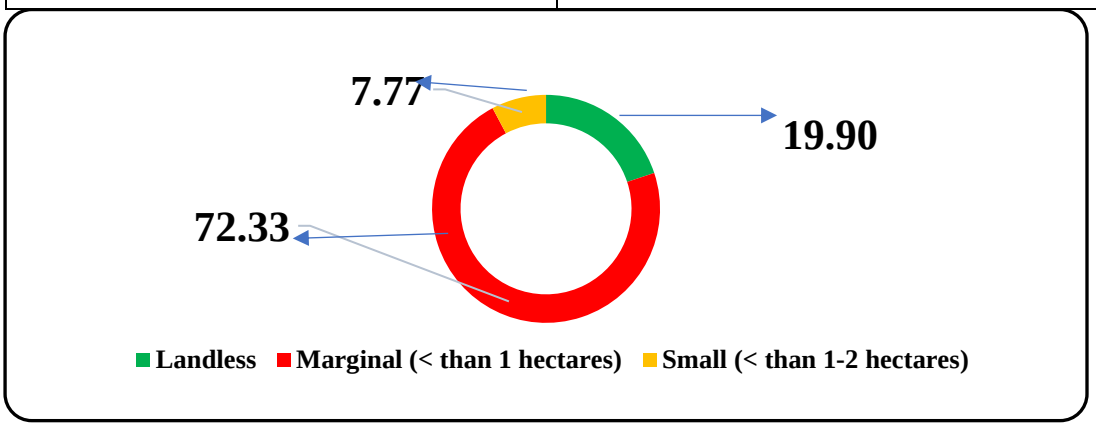


Fig 24 shows different types of landholdings of migrant household

Over 90% of household heads are men with limited education. Approximately 80% of households engage in agriculture, with the rest employed as agricultural labourers. Additionally, as is common in Indian communities, 70% of the farmers are marginal, holding less than one hectare of land.

8.1.3 Pattern of Migration

The migration patterns within a region are becoming a growing reflection of the region's economic stratification. The effects of migration on individuals, households, and region's significantly influence the region's economy and society. These migration trends are intertwined with the patterns of growth and development, offering

individuals the prospect of an improved standard of living abroad. It is within this framework that the pattern of migration is analysed.

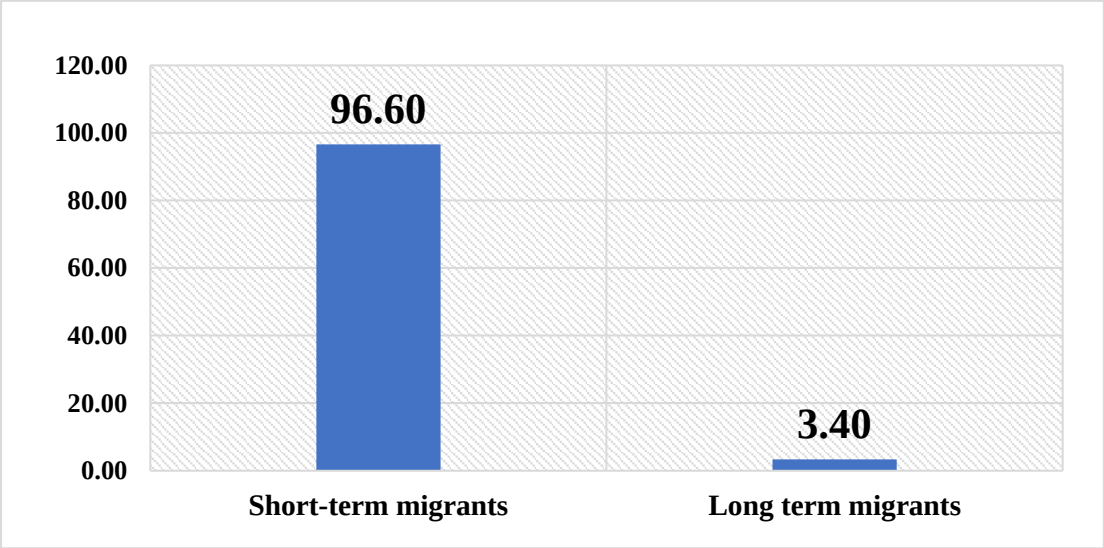


Fig 25 shows the types of migration

The fig indicates that short-term migration accounts for a significant 96.60%, a figure not captured in the census survey. Such migration has historically been a key survival strategy for many farmers in our country.

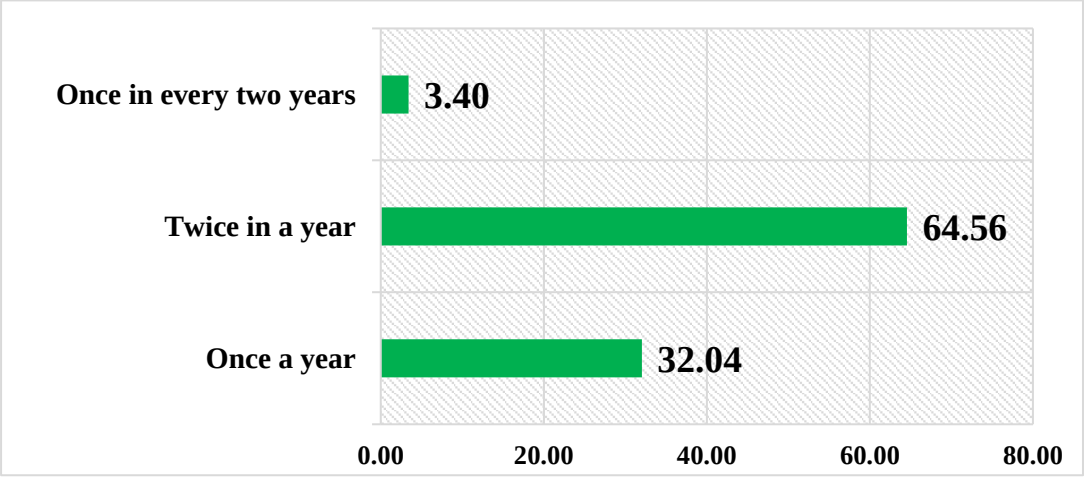


Fig 26 shows the frequency of migration

The fig shows around 65% of migrants migrate twice in a year. Most of the migrants are male and they belong to 25-34 age group. Sixty percent of these migrants have primary education and most of them are married. Sixty-five percent of them move intra-state. The following figures provide graphical representations.

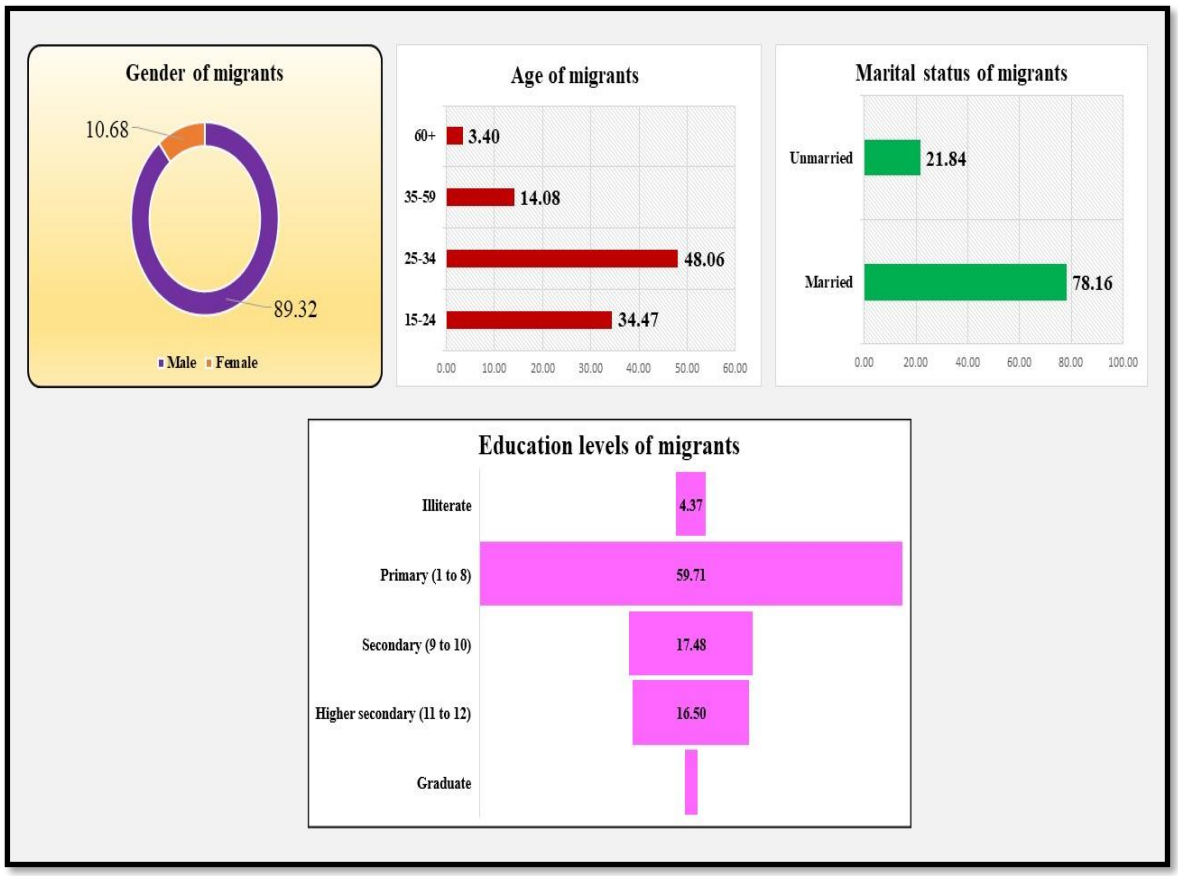


Fig 27 shows the demographic characteristics of migrants

Migration alters the demographic characteristics of regions experiencing both in and outmigration. Along with the rate of population increase, it has an impact on the distribution of the population by age and gender. Our research indicates that the migration pattern is predominantly led by male household members with lower education levels who are in the most productive age bracket; most migrants are married, adding to the household's responsibilities.

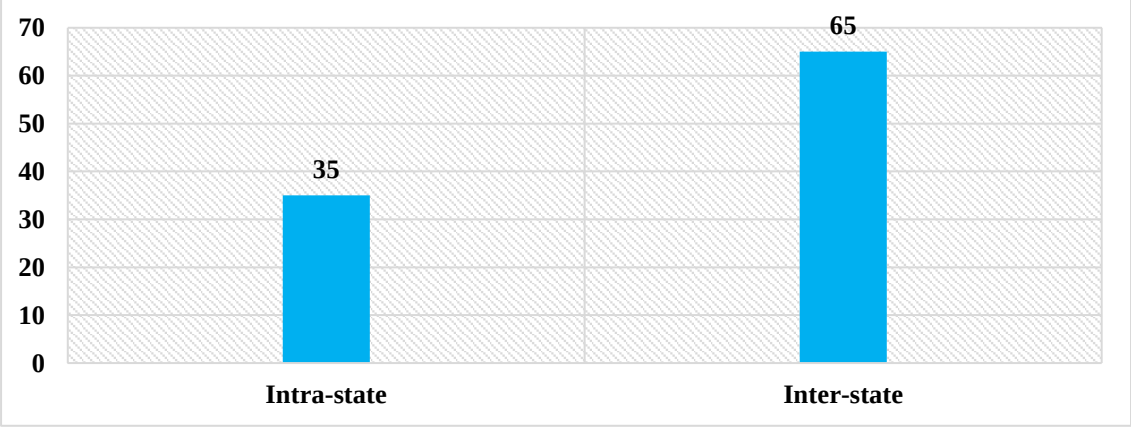


Fig 28 shows destination types.

In intra-state migration, individuals often choose destinations like Burdwan, Kolkata, and South 24 Parganas, whereas inter-state migration is common to Maharashtra, Tamil Nadu, Karnataka, and Jharkhand.

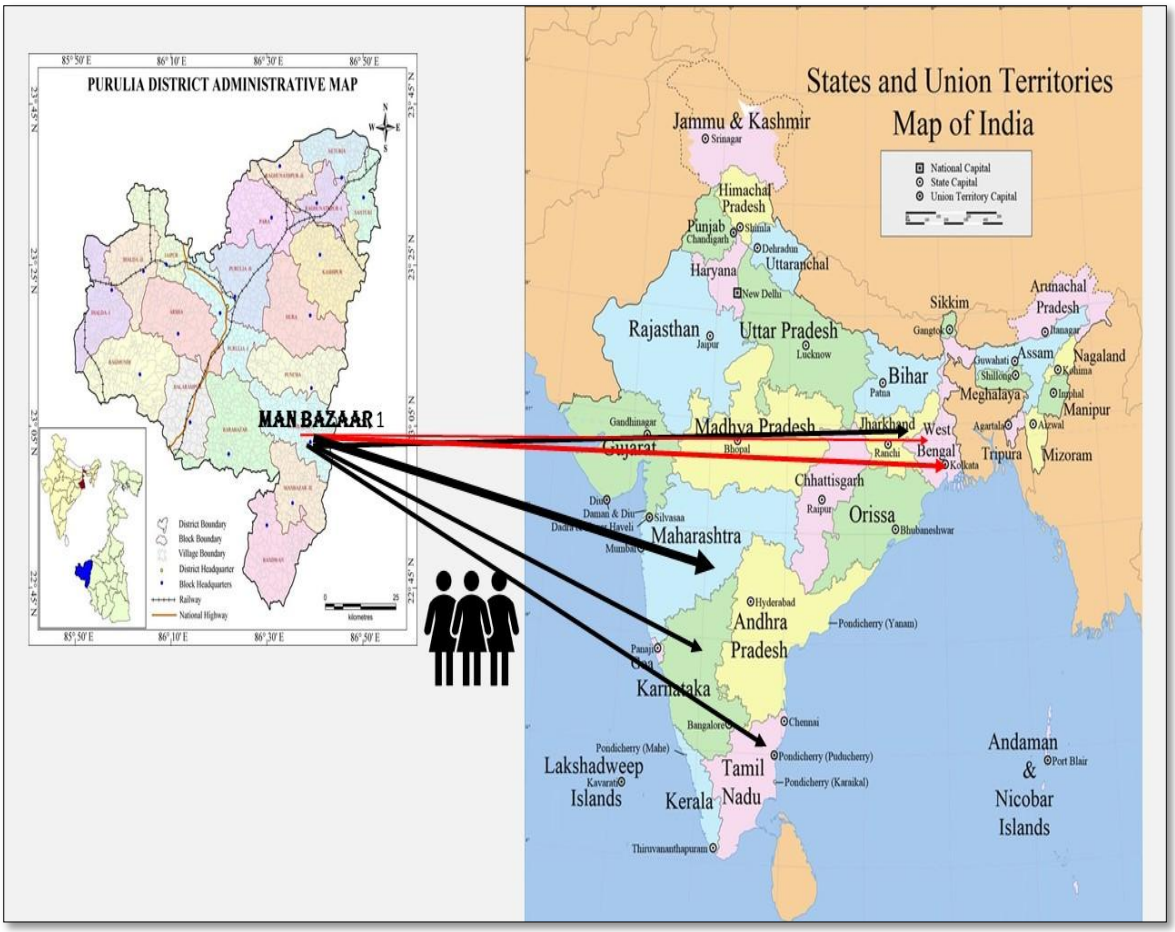


Fig 29 shows the destination regions of migrants

Migrants choose their destinations based on a variety of factors, the most common of which include seeking better economic and social opportunities, fleeing from conflict, famine, and persecution, as well as adapting to environmental changes. Family members, neighbours, and occasionally agents assist in identifying potential regions for relocation. In the study area, individuals select their destination considering the following factors:

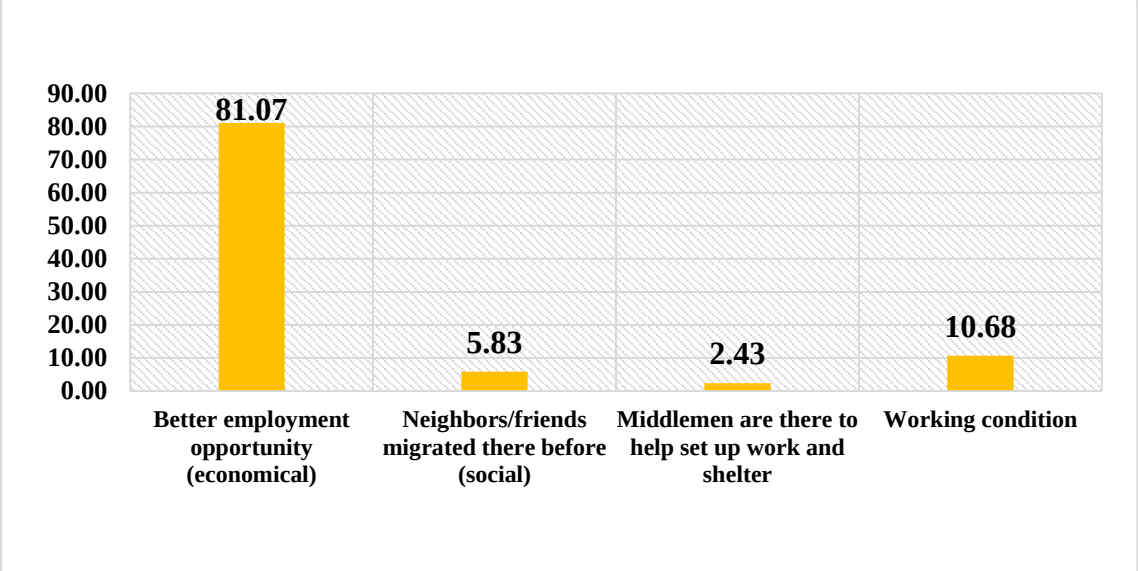


Fig 30 shows reasons for choosing a particular destination

The primary reason for selecting a destination region is the prospect of better employment opportunities, as improved economic conditions enable the sending of increased remittances back home.

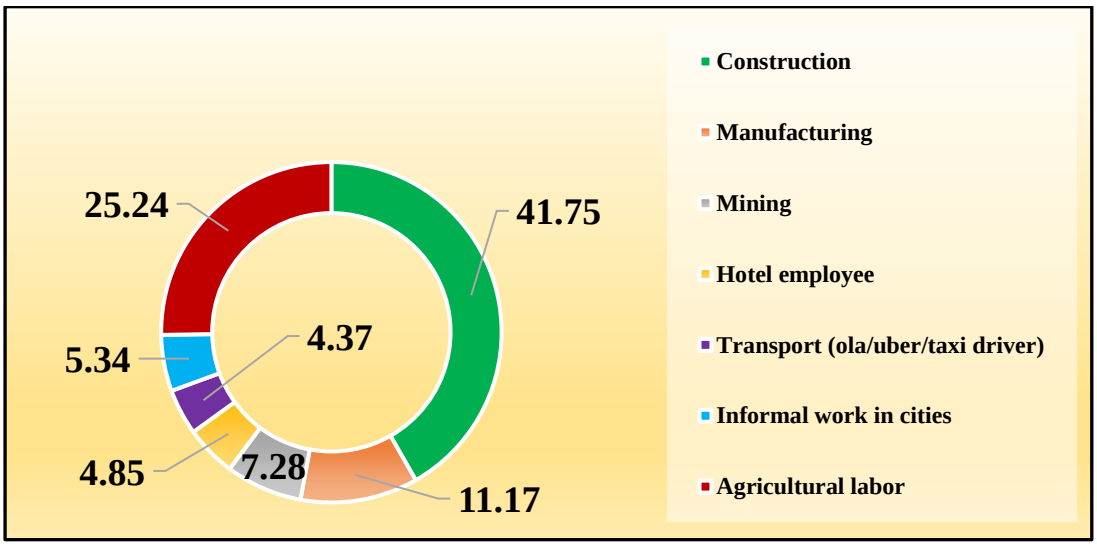


Fig 31 shows various types of works in the destination area

The research indicated that most migrants opted for employment in the construction sector. Seventy-five percent favored non-agricultural work, viewing it as significantly more profitable due to the higher earnings compared to agricultural labor. Moreover, escalating climate uncertainties, such as natural disasters and shifting weather patterns, have resulted in production deficits and crop failures. When inquired if non-agricultural endeavours facilitated better remittances to their home regions, the respondents

answered affirmatively. The following figures show the amount, uses, and frequency of sending remittances.

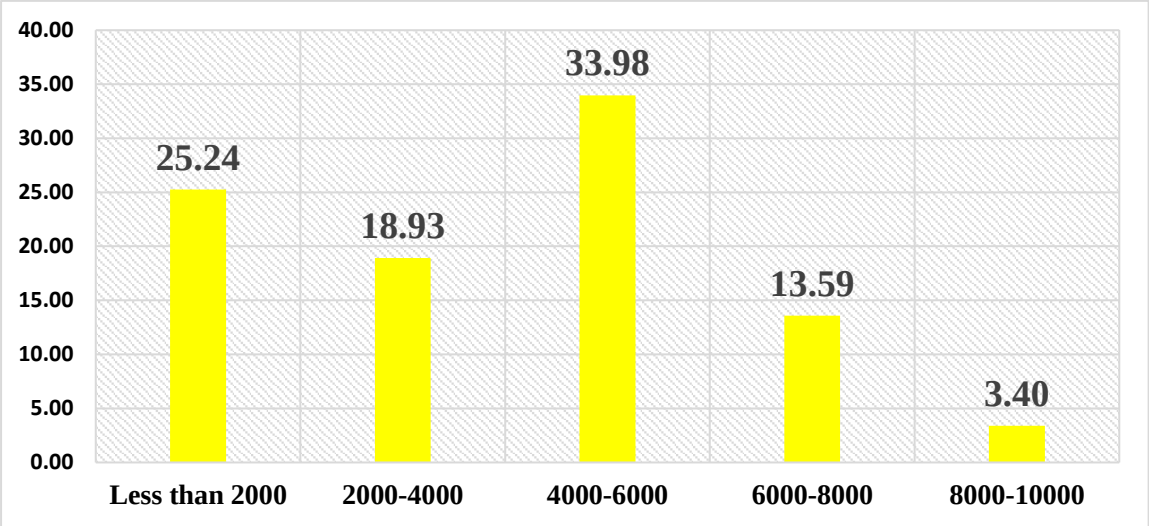


Fig 32 shows amount of remittances

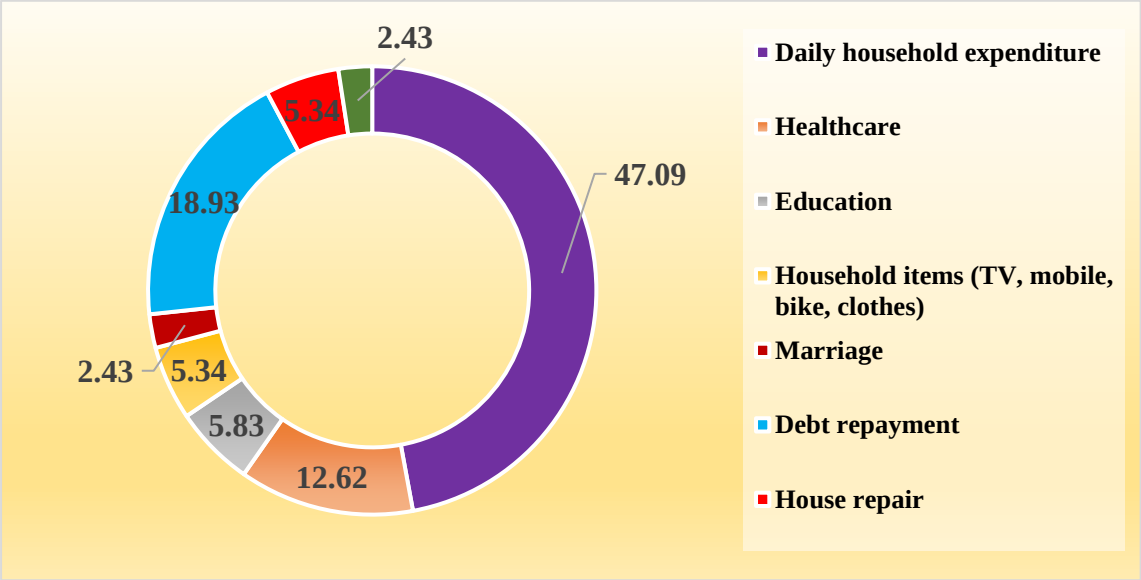


Fig 33 shows various usages of remittances

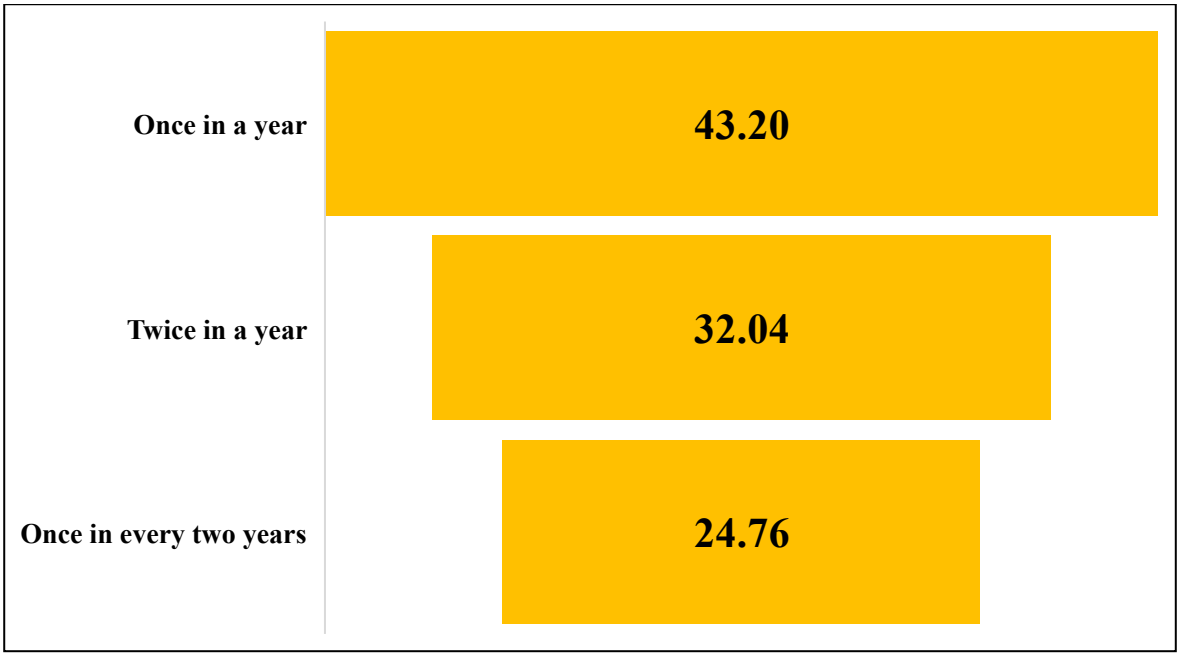


Fig 34 Frequency of sending remittances

Remittances, typically money or goods sent by migrants to their families and friends in their home countries, serve as a vital connection between migration and economic development. Relocating to a better area can rapidly assist reduce poverty when migrants send a percentage of their wages home, helping both the migrants and their family members. These funds are often utilized for purchasing food, securing housing, accessing health services, funding children's education, and investing in businesses.

In the study area, 44% of respondents received remittances annually, while approximately 32% received them biannually and 25% every two years. The remittance amounts varied from under 2000 to 10000, with around 48% of this money being allocated to daily household expenses.

Analyzing the frequency of this migration in drought-affected and non-drought-affected years is essential, emphasizing the importance of climatic extremes or hazards in migration decisions.

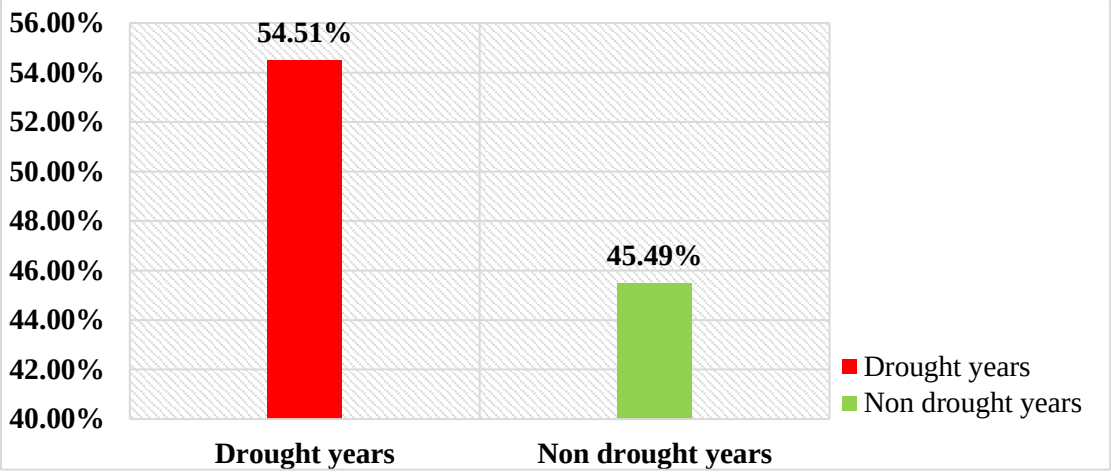


Fig 35 demonstrates migration in both drought-affected and non-drought years.

The study shows a strong relationship between drought occurrences and the probability that a household will have at least one migrant member. Households primarily reliant on agriculture are especially susceptible to droughts and often choose to migrate from affected rural regions to pursue different means of subsistence.

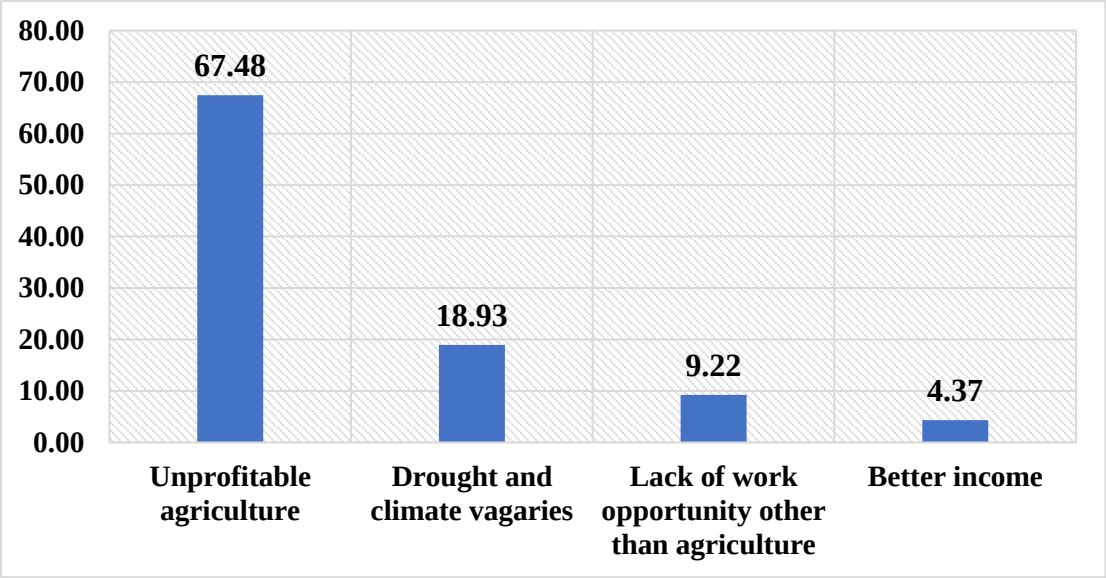


Fig 36 shows reasons for migration

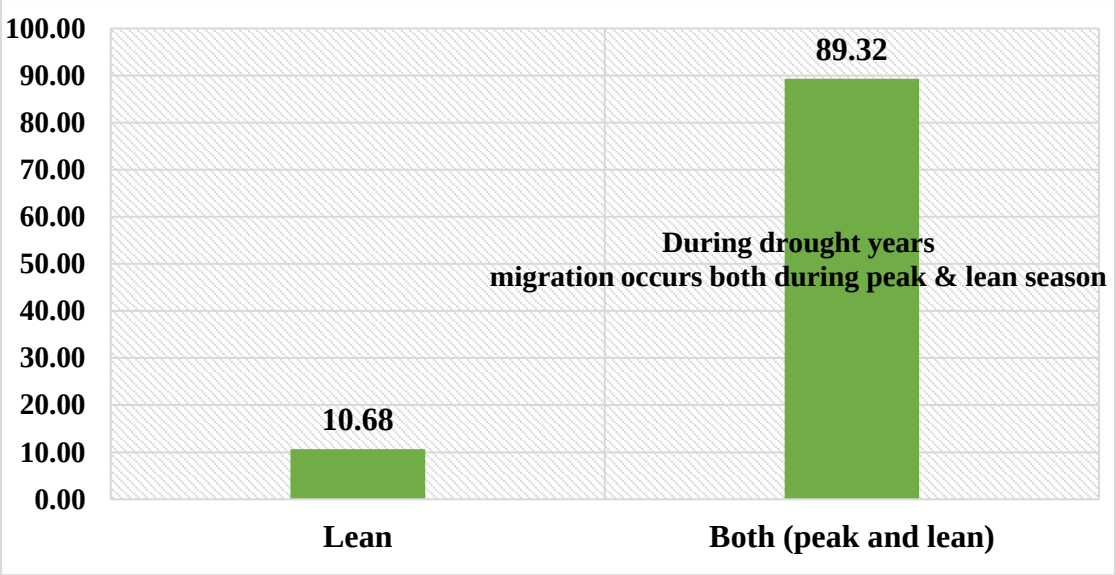


Fig 37 shows the timing of migration

The increasing frequency and intensity of droughts, along with shifting monsoon rainfall patterns, render these populations vulnerable because their livelihoods are heavily dependent on the environment. Agriculture, being highly dependent on climate patterns, is susceptible to climate change. The majority of developing nations probably cannot reduce or adjust to the uncertainties caused by climate change, considering their poverty, reliance on the environment for their subsistence, and lack of agricultural technology developments (IPCC, 2007). One important discovery from the research shows that approximately 90% of farmers migrate during both the peak and off-season of an agricultural year because of delayed monsoons and droughts, which result in crop failures.

8.2 Perceived Likelihood of migration and drought

The field study indicates that migration among farmers has risen over the past decade. A majority of the farmers concurred with this observation. They attributed the increase in migration to a variety of factors.

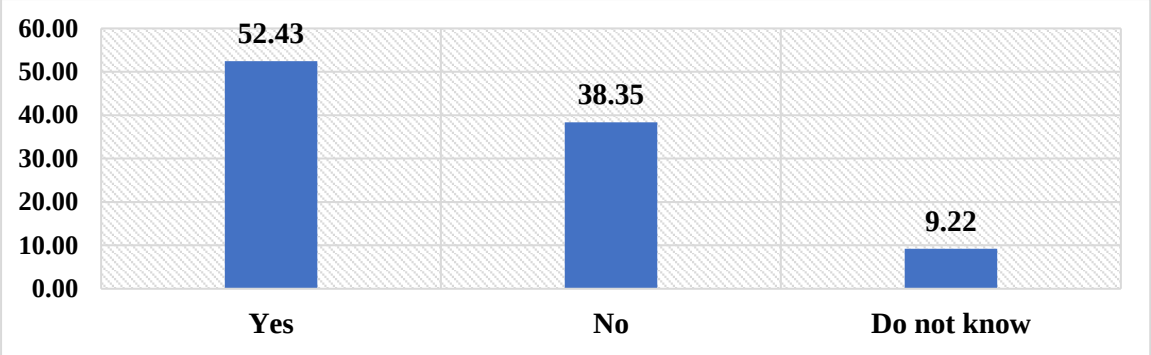


Fig 38 Increased frequency of migration in the last 10 years

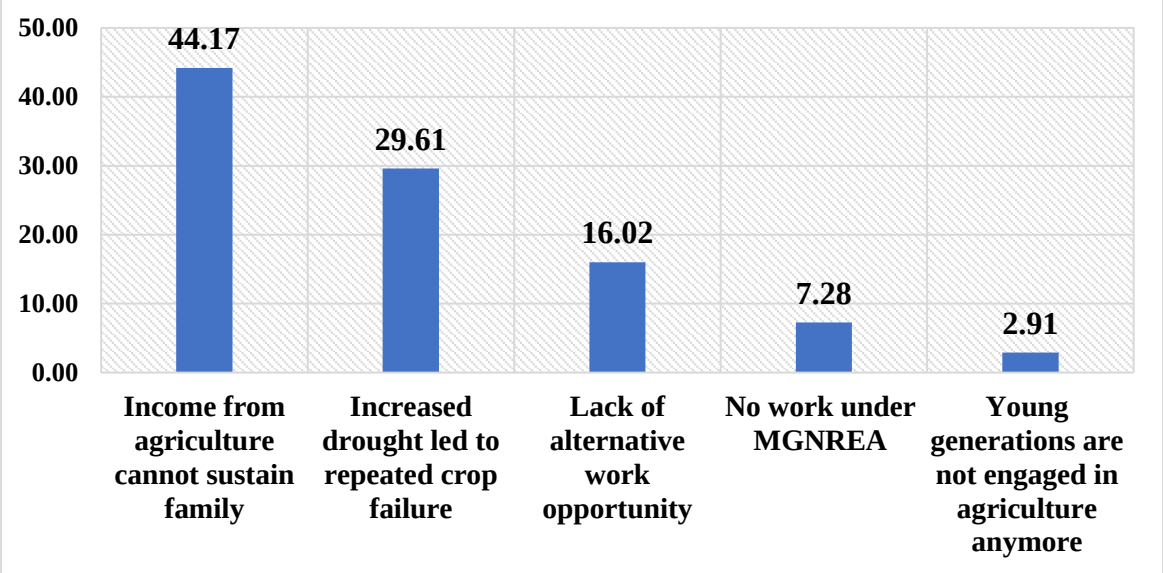


Fig 39 Reasons behind the increasing frequency of migration

Numerous interrelated economic, social, political, and environmental variables influence how vulnerable livelihoods are in Indian drylands. These areas, where 40% of India's population resides (Harriss-White, 2008), are marked by scant and unpredictable rainfall, escalating degradation of natural resources, increasing drought, low agricultural yields, crop failures, insufficient government policies, and lagging development metrics as a result of economic marginalization (Mehta, 2000; Bantlan & Anupama, 2006; Harris-White, 2008; Yadav & Lal, 2017). In India's semi-arid regions, the growing climate unpredictability poses serious problems to agricultural revenues (Bantilan & Anupama, 2006; Banerjee, 2014), and climate change is expected to make livelihoods even more vulnerable (Mall et al., 2006). In response to these multifaceted risks, communities in the drylands have historically adapted their livelihoods, with migration becoming a key strategy.

Across rural India, migration is a key strategy to diversify sources of income, spread risk (Deshingkar & Start, 2003; Deshingkar, 2016; Bhatta & Aggarwal, 2016; Singh et al., 2018), and satisfy more and more non-agricultural aspirations (Singh and Basu, 2019; Sugden et al., 2014). A combination of agency, assets, and goals influence the decision to move (Deshingkar, 2012; Warner & Afifi, 2014; Sugden et al, 2014). Although there are increasing numbers of rural-urban migration cases, particularly under the duress of agricultural hardship in India, the phenomenon is historical: in some parts of India, there has been a "culture of migration" for almost a century, according to Tumbe (2012, p. 87). Migration is a crucial adaptation strategy in the face of rapid environmental changes, greater variation in the climate, fragmentation of land, and fundamental institutional weaknesses.

Approximately 30% of respondents identified drought as a cause for increased migration, while about 45% attributed it to unprofitable agriculture. Changes in climate and agricultural systems are expected to affect food security, with farmers experiencing the most severe impacts first. Crop failures can result in farmer distress, inflation, and economic repercussions. Additionally, it is suggested that climatic stress exacerbates farmers' debt burdens, prompting migration due to the lack of alternative employment opportunities and insufficient work availability under MGNREA.

To get real insights, respondents were also asked about how droughts and climate change affected their lives and how they felt about migration.

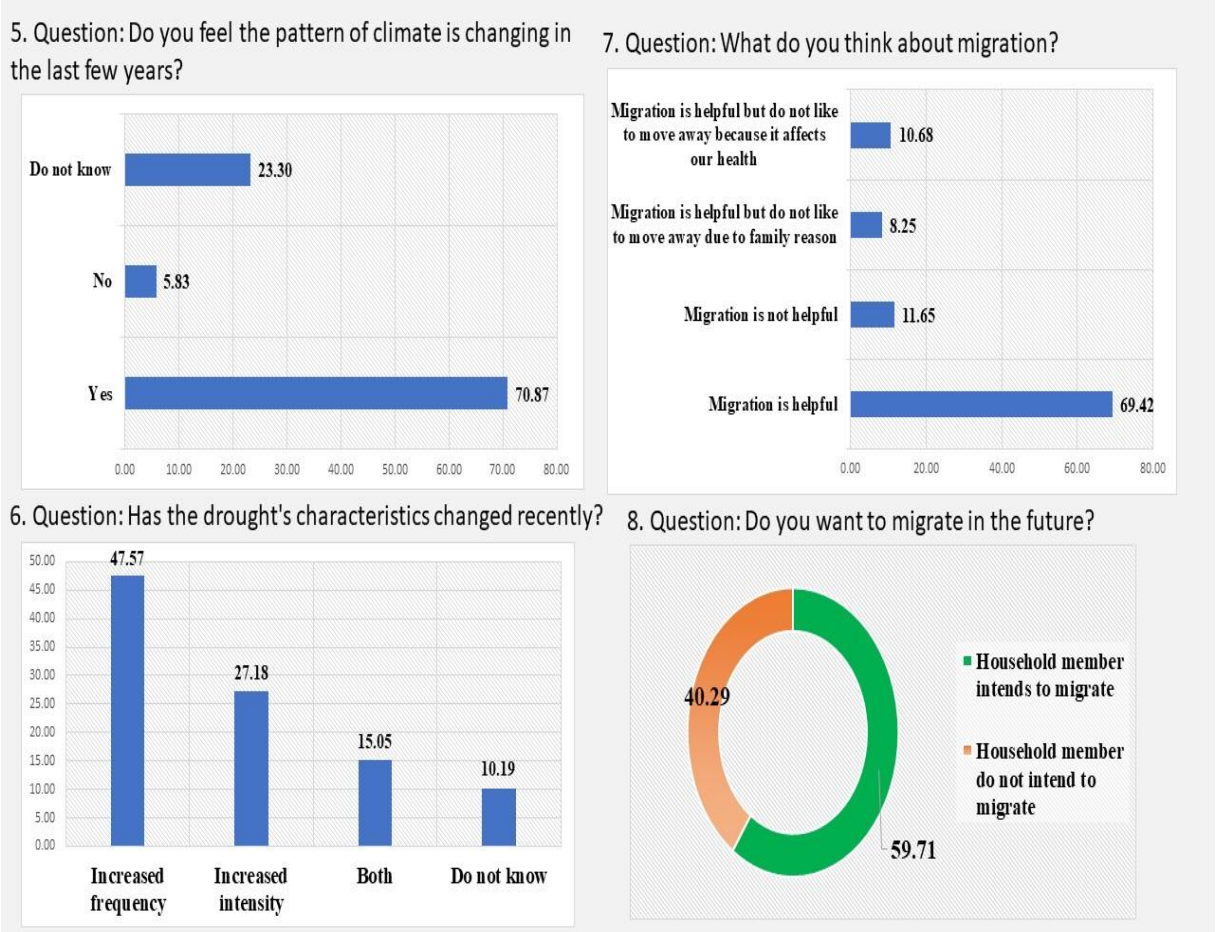


Fig 40 Farmer's insight

Regarding climate change, 70% of respondents have felt its impact, while approximately 50% have observed an increased frequency of droughts, and about 30% have noted that the intensity of droughts has risen. Furthermore, 15% of those surveyed said that throughout the past ten years, droughts had been more frequent and more intense.

Policy approaches to address these difficulties are thought to depend critically on farmers' assessments of and adaptations to the rapidly changing climate. Understanding the human-environment interaction in agriculture is vital, and it heavily relies on farmers' insights. They use their traditional knowledge to recognize shifts in climate behaviour and accordingly adjust their livelihood strategies.

They were also asked about the types of help they usually receive during drought.

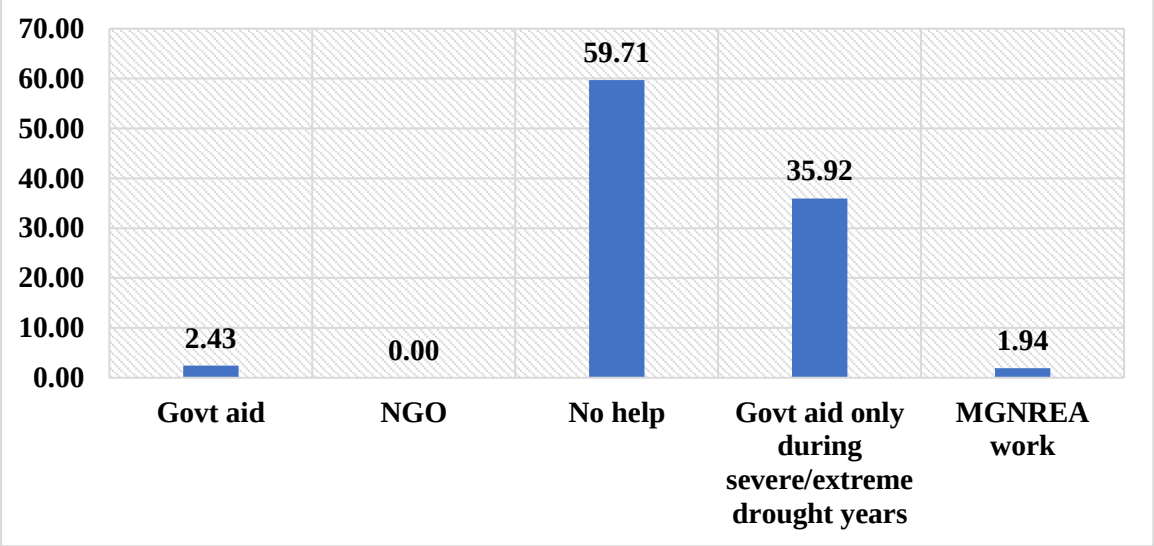


Fig 41 Types of help available during drought

To counteract the negative effects of drought, it is recommended that State Governments initiate mitigation measures such as constructing water harvesting structures under MGNREGA, promoting moisture conservation in agriculture, encouraging the growth of water-efficient crops, and rehabilitating irrigation infrastructure through desilting canals, reactivating tube wells, and repairing broken pumps. Regular assessments for Kharif crop preparation, especially for emergency crops, and investments in water conservation structures under schemes like the Integrated Watershed Management Program (IWMP) are also advised to utilize rainwater effectively. Nonetheless, only 2.43% of respondents have received assistance, while approximately 60% reported no assistance during typical drought conditions. About 35% indicated that help is provided only during extreme or severe droughts. Recognizing that agriculture is increasingly impacted by recurrent droughts, recovery without aid is challenging.

Crop failures result in income losses for households reliant on agriculture and related sectors. Under such circumstances, accruing debt becomes unavoidable. According to reports, the mounting debt load on rural households—particularly farmers—has compelled millions to give up farming, resulting in thousands of distressed migrants and, in the worst cases, suicides (Taylor, 2013; Ghosh, 2013; Vaditya, 2017). The economic, social, and environmental circumstances surrounding debt can make it oppressive for borrowers, causing them to endure great stress (Gerber, 2013; Guerin, 2014; Ramprasad, 2018). However, debt is not intrinsically harmful and is an essential tool for households to manage consumption (Garikipati, 2017) and deal with crises like

crop failures and health emergencies (Collins et al., 2009). Even small loans can become crippling burdens due to a variety of factors, including social and economic marginalization, the deterioration of natural resources like land and water, and poor government policies (Gerber, 2013 and 2014; Kumar and Venkatachalam, 2018). Rural households' financial stability is expected to be increasingly jeopardized by the anticipated impacts of climate change (Dasgupta et al., 2014). Climate change has been associated with lower household incomes (Kar and Das, 2015) and lower crop yields (Arora and Birwal, 2017), both of which are direct contributors to the increase in rural household debt. More than 80% of survey participants still owed money on loans that were necessary to support their everyday lives.

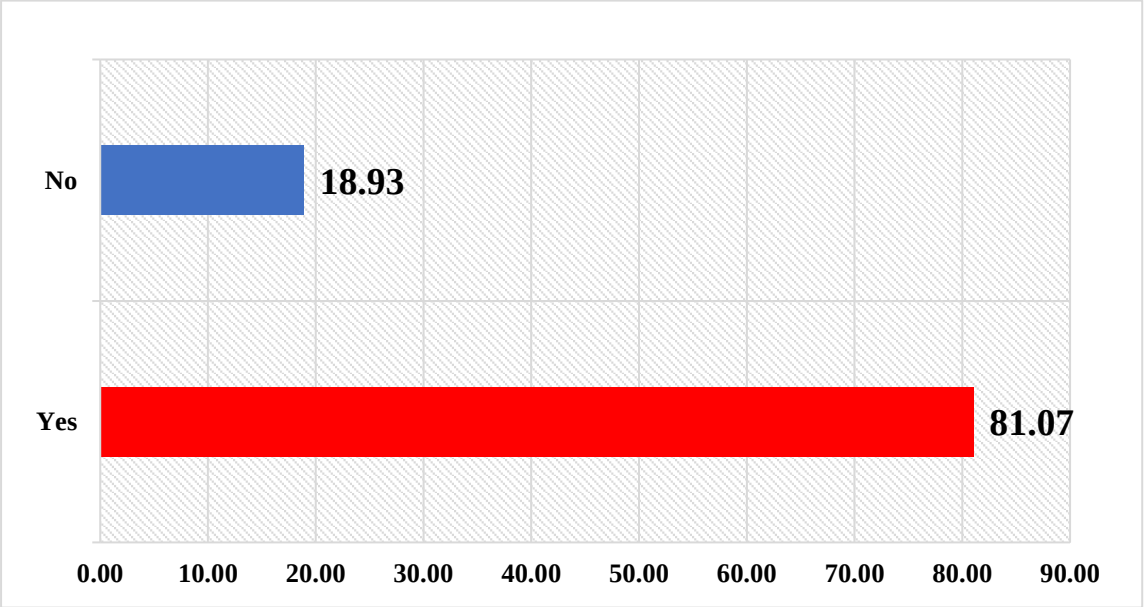


Fig 42 Outstanding loan

8.2.1 Perception of socio-economic impacts of drought

Designing technical and legislative measures that successfully combat droughts and mitigate their aftermath requires an understanding of the economic and social implications of droughts. Droughts exert a profound economic toll, impacting the primary economic pursuits of residents in affected areas, such as rainfed agriculture or farming with minimal irrigation. In rainfed agricultural settings, drought always leads to crop failure and reduced yields of livestock, horticultural produce, pulses, and grains, which lowers agricultural households' incomes. It also precipitates unemployment among unskilled workers and squanders their time in securing water. An ensuing figure

illustrates the influence of drought on socio-economic conditions.

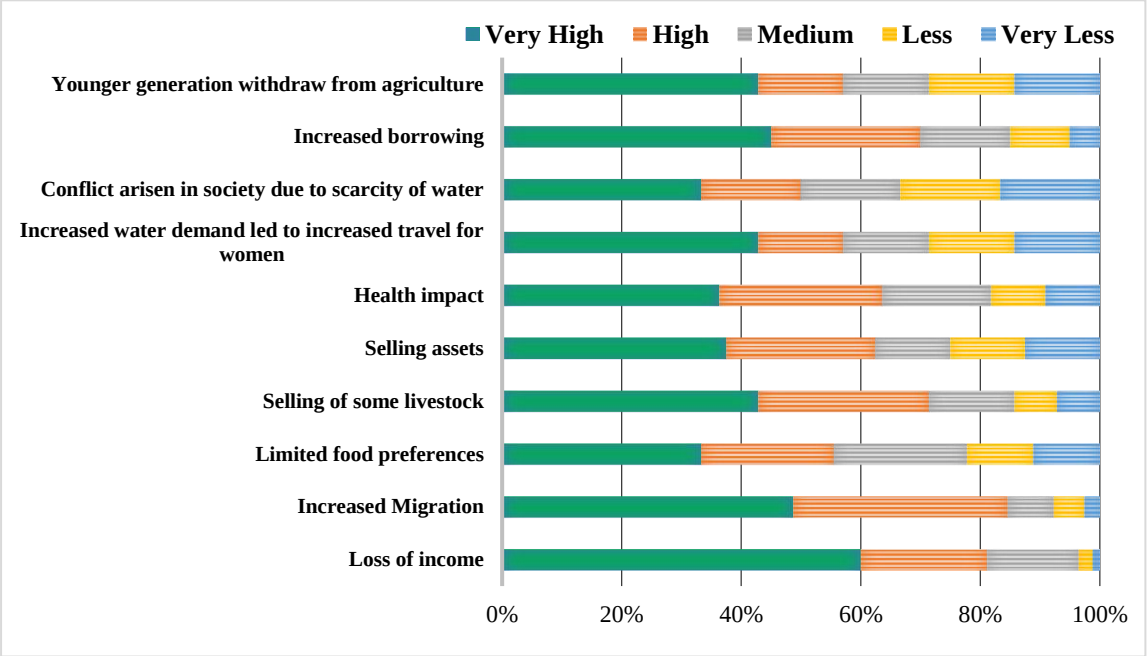


Fig 43 Likert scale illustrating different drought-related impacts on society and economy

Farmers' perceptions of the economic and social effects of drought are reflected in the Likert scale replies. Eighty percent of responders reported that the drought had a negative economic impact on their income, while 82% observed an increase in out-migration. Approximately 70% were compelled to sell their livestock, a vital asset for rural sustenance. The drought consistently affects water availability, and with women in rural India typically tasked with water collection, around 58% reported increased travel distances for water. Additionally, 56% of respondents noted a reduced variety in their food choices for daily consumption. To cope with the recurrent droughts, 62% have resorted to selling assets. The economic repercussions have had social, health, and psychological consequences on the livelihoods of farmers. These consequences encompass issues like the unequal allocation of water, disputes among water users, a decline in school attendance, migration of populations, deteriorating health, and feelings of despair or loss stemming from the drought.

Droughts have extensive effects on regions, resulting in famine, starvation, and crop failures. For effective monitoring and response, the full impact of a drought on a community needs to be comprehensively understood. Following Likert scale depicts the impact of drought in the sub-district

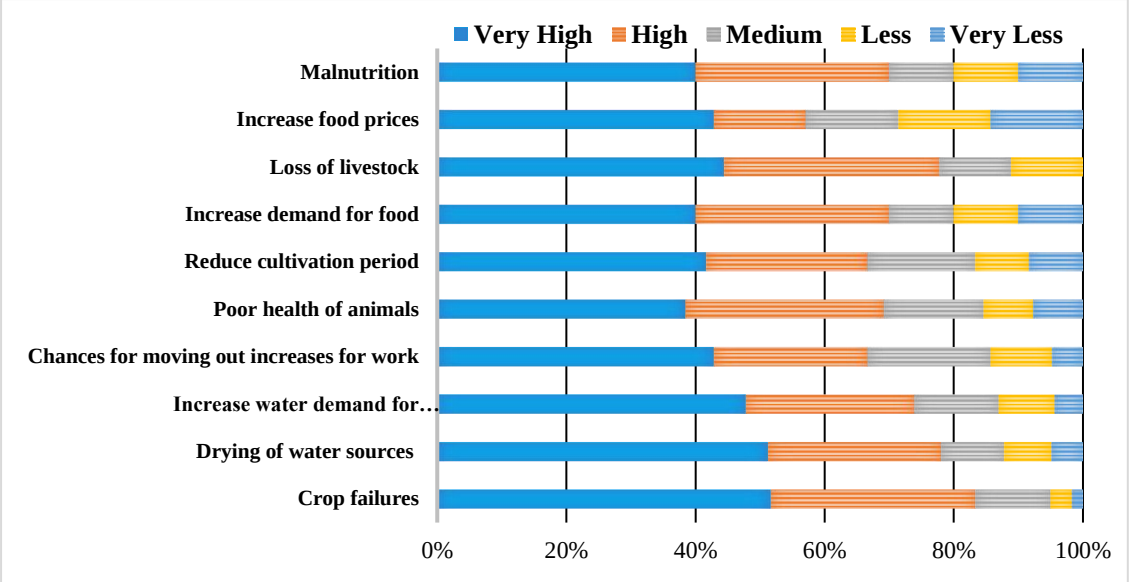


Fig 44 Likert scale showing impacts of drought in the sub-district

Approximately 80% of respondents have reported the drying up of water bodies and crop failures, while 75% indicated an increase in water demand due to scarcity. About 62% attributed a reduction in the cultivation period to the delayed monsoon. Other effects of drought in the sub-district include malnutrition, rising food prices, and the deteriorating health of animals.

8.2.2 Perception of environmental impacts

There are several ways that drought affects the ecosystem. It causes diminished aquifers, lower lake levels, and decreased river flows. The combination of low flow rates and high-water temperatures can severely degrade water quality. Additionally, droughts decrease soil moisture, adversely affecting soil fertility and biodiversity, and increasing the risk of wildfires. The figure illustrates the environmental consequences of drought as observed by farmers.

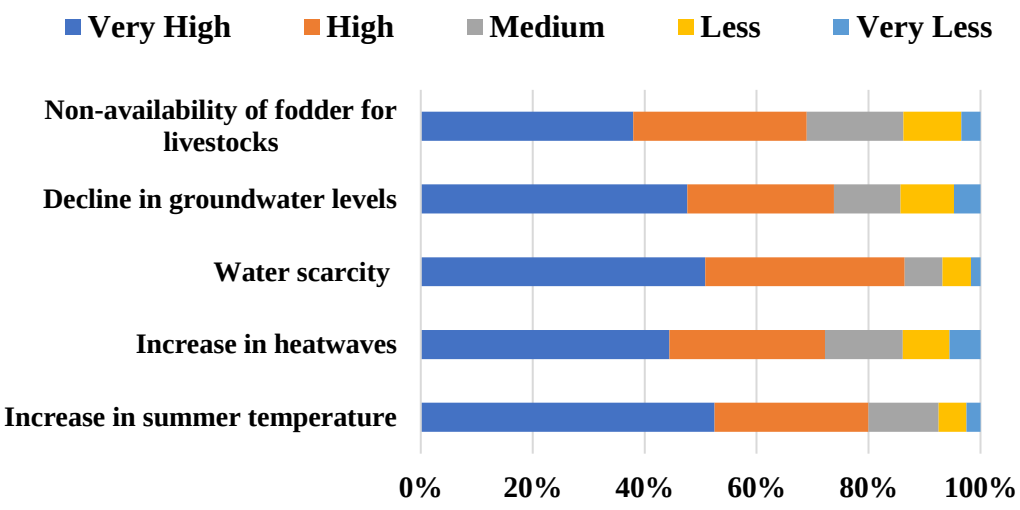


Fig 45 Environmental impacts of drought

In comparison to a typical year, respondents saw that the average summer temperature increased during the drought year. In surface water bodies, farmers faced severe water constraint a decrease in groundwater levels, and more frequent heat waves as additional environmental impacts were observed in the field of study. Forests and grasslands have been significantly impacted by the combined effects of drought, intense heat, and shortages of water. In conclusion, respondents rated the drought's environmental effects as severe.

8.2.3 Impact of drought on drinking water and agriculture

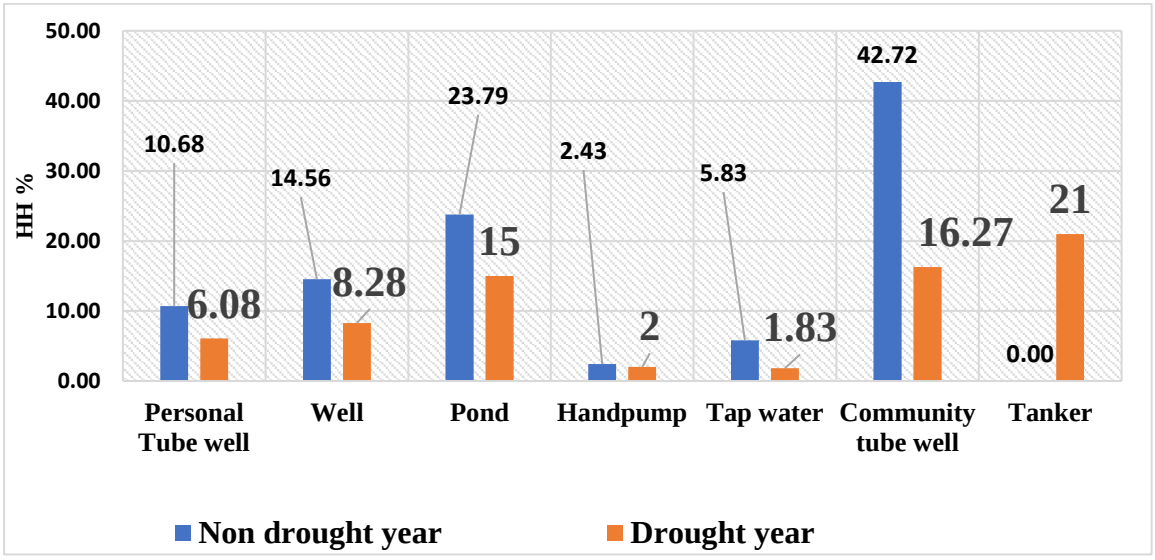


Fig 46 The state of various drinking water sources in drought years and without drought years

Table 25 indicates how far apart the water sources are

Various drinking water sources	**Distances of drinking water sources**	**Drought year**
Personal Tube well	within premises	walk for 2/3 km
Well	within 1 km	walk for 1.5/2 km
Pond	2/3 km	4/4.5 km
Handpump	within premises	no change
Tap water	Wwithin 500 meters	walk for 2/3 km
Community tube well	1.5/2 km	walk for 3.5/4 km

Table 26 shows inferential statistics, the Wilcoxon test

Activity	**N**	**z**	**p**	**r**
Number of trips (per day)	206	-3.24	**0.001***	-0.182
Water fetched (l/trip)	206	-3.17	**0.001***	-0.168
Time spent (min/trip)	206	-8.64	**0.000***	-0.485

The sources of drinking water in the research area include individual and communal tube wells, wells, ponds, hand pumps, and tap water. During drought years, except for hand pumps, the supply from these sources diminishes significantly. This implies that during droughts, the villages' public water supply fails, forcing more households to fetch water from farther away. Additionally, it was observed that individuals who normally accessed water from these sources had to resort to sources that were far away

because of supply fluctuations during drought years. Some areas experience year-round water scarcity, with local authorities providing water via tankers.

According to the Wilcoxon signed-rank test, in drought years (mean = 41.4 min/trip, median = 30 min/trip) households spent considerably more time each trip obtaining water from a remote spring than during normal years (mean = 20.4 min/trip, median = 15 min/trip). Additionally, compared to normal years (mean = 6.6 trips/day, median = 5 trips/day), the average number of daily travels to the spring was much lower during drought years (mean = 5.9 trips/day, median = 5 trips/day). This was probably because it took longer and required more distance to get to the water source. Compared to normal years (mean = 44.7 l/trip, median = 30 l/trip), the quantity of water collected per trip was significantly higher during drought conditions (mean = 55.8 l/trip, median = 40 l/trip), indicating that respondents sought to reduce the frequency of trips while collecting more water each time to reduce the total amount of time spent obtaining water.

The major crops grown in Man Bazaar 1 include rice, vegetables, and oilseeds (mustard). The following table provides inferential statistics.

Table 27 lists the subdistrict's principal crops along with how drought has affected them.

Major crop grown	**Z**	**p**	**r**
Rice	-7.668	**0.000***	-0.792
Vegetables	-4.836	**0.001***	-0.605
Oilseeds (mustard)	-9.475	**0.000***	-0.743

During drought years, the yields of all major crops significantly decreased, according to the Wilcoxon signed-rank test. Farmers report that agricultural households experience crop production losses each drought year, attributable to reduced soil moisture for sowing, insufficient irrigation, and a falling water table.

The scope of irrigation is crucial in reducing drought's effects on crops. The enhancement of agricultural production and productivity largely hinges on water availability. Irrigation boosts agricultural output by not only enlarging the area that can be cultivated compared to rainfed agriculture but also by enhancing crop yields. As a

result, the importance of irrigation depends on having sufficient irrigation infrastructure, which the district does not currently have. The various irrigation systems in the region are depicted in fig. below.

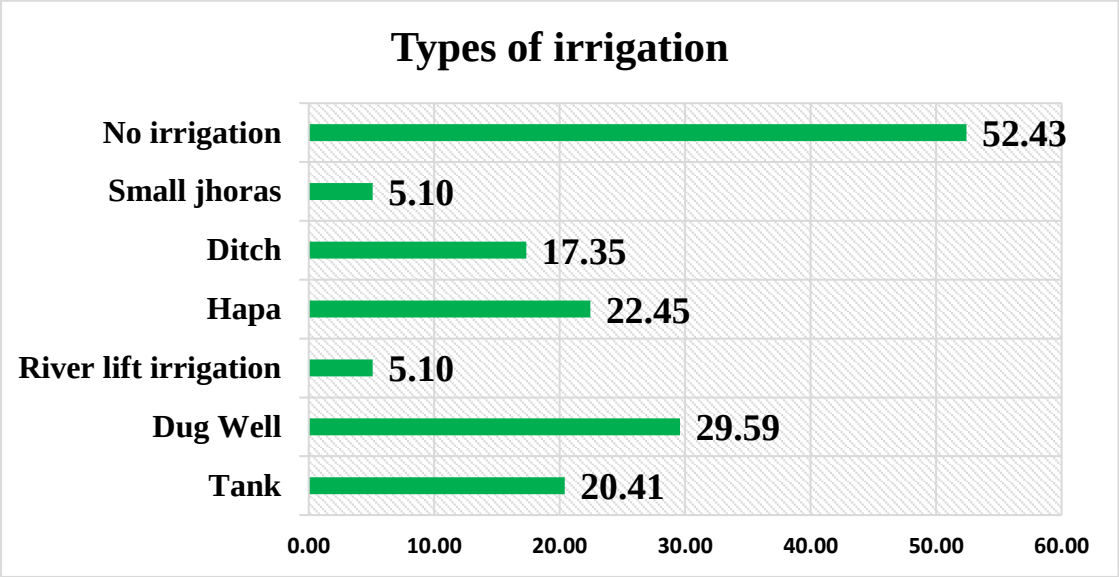


Fig 47 shows the types of irrigation

Over half of the surveyed households lack irrigation facilities. The district of Purulia has long been afflicted by a severe water crisis, which significantly hampers its socio-economic development (Das 2018). As an economically disadvantaged district in West Bengal, the lower-class population, forming a substantial portion of its demographic, does not possess the modern technology or financial means to build tube wells for individual or communal use. Consequently, for their water needs, locals rely on dams or surface water. Groundwater utilization in the Man Bazar 1 and Baghmundi blocks is notably low. Agriculture is the primary livelihood in Purulia, with rivers dependent on rainwater, resulting in seasonal water flow that aligns with the monsoon season, thereby increasing the demand for irrigation water. During drought conditions, 50% of the respondents observed a decrease in water levels in tube wells and wells, while approximately 40% noted that the water in ponds and ditches had entirely dried up.

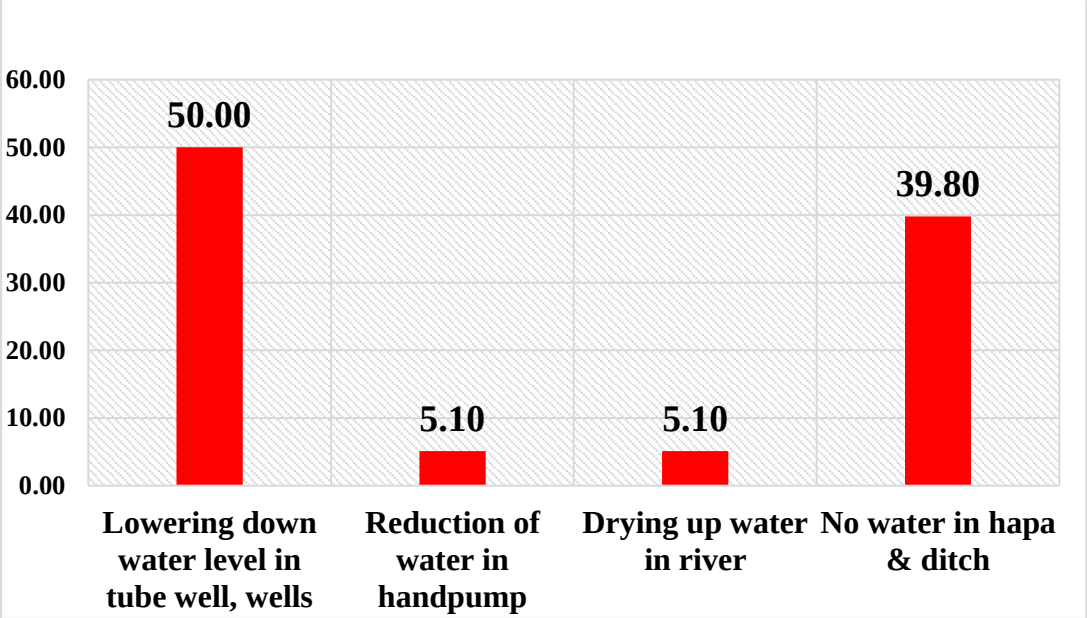


Fig 48 Conditions of water sources during drought years

8.3 Empirical analysis

To determine if environmental stresses have influenced migration decisions, a comprehensive, methodical empirical investigation of the hypotheses need data from both migrants and non-migrants who originated from the same area. Unfortunately, there is a lack of sub-district-level data meeting these requirements. As a result, the original survey data used in this study was gathered especially for the quantitative examination of individual migration decisions. In order to collect data on personal and household characteristics, such as any household member's prior migration, the household survey focused on one individual per home, ages 18 to 64.

Table 28 Binary logistic regression

Variables	**coefficient**	**S. E**	**Odd ratio**
Household size	0.925	0.032	**1.159*** **
Age of HH head	0.547	0.236	0.425
Sex of HH head			

Female (reference cat)			
Male	0.852	0.182	1.056
Educational attainment of HH head			
Illiterate (reference cat)	*		
Primary (1 to 8)	-0.235	0.336	1.31
Secondary (9 to 10)	0.635	0.11	**0.836****
Higher secondary (11 to 12)	0.387	0.21	0.532
Graduate			
Age of Migrants			
15-24 (reference cat)	***		
25-34	0.839	0.506	**5.353*****
35-59	0.524	0.265	**2.231****
60+	-0.563	1.025	**0.569**
Gender of migrants			
Female (reference cat)			
Male		0.126	**2.621*****

Educational attainment of migrants			
Illiterate (reference cat)	***		
Primary (1 to 8)	1.245	0.514	**4.061*** **
Secondary (9 to 10)	1.029	1.306	**3.542**
Higher secondary (11 to 12)	0.625	0.667	**1.867**
Social group			
General (reference cat)			
ST	0.852	0.918	**2.215*** **
SC	0.653	0.557	**1.021***
OBC	-0.932	0.557	**0.471**
Landholding size			
Landless (reference category)	***		
Marginal (< than 1 hectare)	0.248	0.178	**1.36** **
Small (1-2 hectares)	-0.649	0.577	**0.523**
Monthly HH income	-0.491	0.221	**.430*** **

outstanding loan			
No (reference cat)			
Yes	1.111	0.175	**2.273****
Drought			
No (reference cat)			
Yes	0.921	0.242	**2.528*****
Climate variables			
No Environ challenges (ref cat)			
Delayed monsoon	0.456	0.236	**1.748****
Decreasing rainfall during monsoon	0.548	1.231	**1.412**
Increased summer temp			
Increasing heavy precipitation days	0.236	0.246	**1.302***
Increasing heatwaves	0.693	0.216	**0.605**

At the 1%, 5%, and 10% levels of confidence, the following values indicate statistical significance: Constant =1.021*** (0.369), Cox and Snell R Square 0.425, Nagelkerke R Square 0.71, Log-likelihood 117.293, ***, **, and *. The reference category is denoted by reference cat, while robust standard error is reported by robust S.E.

* p<0.1, **p<0.05, and *** p<0.01

A measure of the correlation between an exposure and an outcome is called an odds ratio (OR).

The odds of an outcome are unaffected by OR=1 exposure, higher odds of an outcome are related with OR>1 exposure, and lower odds of an outcome are connected with OR<1.

It is recognized that the reference category serves as a comparative category for other categories.

The current study makes use of the binary logistic regression model. The choice of migration by a household is measured by our dependent variable. If there has been any recorded migration from any household, that takes on the value 1, and if there has been no reported migration from any household, it takes on the value 0. We have also analysed the effects of determinant factors on migration decisions from logistic regression.

Environmental stressors are one of our primary independent variables, such as drought, delayed monsoon, decreasing monsoon rainfall, increasing heavy precipitation days, increasing summer temperatures and heatwaves respectively, based on our survey questions asking families to list the primary climatic hazards and other weather-related events they had encountered during the previous ten years, our study used these seven dummy variables. We have coded positive respond (yes) as 1 and negative (No) as 0. we have included variables of environmental stressors to see how they shaped migrant's decision. Given that we were unable to ask the non-migrants the identical question, we instead asked them if they planned to move in the future and, if so, why.

Furthermore, we included a number of control variables that are commonly employed in studies that examine migration decisions in our logistic regression model. Data for every variable is derived from the survey. People decide to migrate for many reasons, and in our study area it is more of a household's condition that force people to move out and the migration decision usually taken by household head. We do not, however, downplay the significance of the demographic traits of migrants, as every movement Flow is different for demographics such as marital status, age, gender, and level of education. First, we include household size as larger households need to diversify their livelihood for income maximization and risk diversification to use the economic benefits of out-migration through remittances. Next, we include household heads age, gender (female as reference category) and educational attainments (illiterate as a reference category) to understand the decision maker's profile. Following this, we have incorporated migrants' socio-demographic profile like age, gender (female as reference category), education attainments (illiterate as a reference category), social groups (general category as a reference category), marital status (unmarried as a reference category) to understand which particular age group with what educational attainments

are more likely to move. Gender helps us to know who dominate the migration streams and who are left behind in the source region. Because those who belong to these groups are among the poorest in our nation, as evidenced by the government's national sample survey on expenditures in 2011–12, control variables like social group are crucial in determining whether socioeconomically disadvantaged groups choose to migrate or stay in their original area.

Furthermore, we have also included economic variables because the decision of migration is a complex one involving many factors at household levels. We have incorporated the determinants like nature of work (main/marginal/non-worker) to understand whether the households have work throughout the year or seasonal. We used non-workers as reference category. Then, we have included the following 5 types of work in our model, while households involved in agriculture sector acts as a reference category: workers in service sector (works in schools, health centres), workers run local hotel, transport workers, local grocery stores and agriculture labourers. Then we have added households' monthly income and outstanding loan (if any) to understand the economic wellbeing.

We have employed a single hot encoding method for categorical variables with more than two categories, which transforms them into a form that can be used as a dummy variable in a binary logistic regression model.

Given that our dependent variable is binary, we analyze it using a logistic regression model whether migration takes place (Yes=1) or not (No=0). We also wanted to find out which factors (among social, economic, environmental, and demographic) have a major influence on migration decision. The chosen factors accounted for 71% of the variation in outmigration from our research area (pseudo R2), and our model displays a strong standard error for each variable. From table, it is found that household size has a positive relation with outmigration where odd ratio shows migration is about 1.159 times more likely to occur from large households. Households' heads age, gender does not have any significant impact behind migration decision, however education plays an important role. We have used illiterates as reference category and they show a statistically significant relation with the phenomenon of outmigration. Interestingly, education up to secondary level also shows statistically significant relationship with migration decision. We can say that household head with

both illiterate and secondary level education have positive relationship regarding migration decision.

The age of migrants is an important parameter to understand the challenges of dependency ratio at originating regions if the bulk of the outmigrants fall in the working age category. In our study, we have taken age groups between 15-24 as a reference category and it shows a statistically significant relation with migration. According to the odd ratio, migrants in the 25–34 age range have a 5.35-fold greater chance of leaving the country than those in the 15–24 age range. While the odd ratio is negligible for those over 60, the probability of outmigration rises 2.235 times for those between the ages of 35 and 59. The age group above 60 also shows a negative relationship with migration which implies older the age, the less is the migration. To check the gender of migrants we have used females as a reference category which shows an insignificant relationship while male migrants have a statistically significant relation with migration and an odd ratio implies males are 2.621 times more likely to move out than females. There is a significant statistical relationship between the caste and the economically and socially impoverished schedule tribe among the social categories. It turns out that the ST (odd ratio 2.215) and SC (odd ratio 1.012) populations have higher migration rates than the general class. The other backward class shows a negative relation with migration and they are about 53% less probable to migrate than scheduled class and tribe. For this class, the odd ratio is also negligible. One crucial factor in migration is educational attainment. The reference category in this case is illiterate migrants, who exhibit a substantial correlation with migration (at a 1% confidence level). Those who migrate up to the primary level of education (class 8) show a substantial correlation with migration and are 4.061 times inclined to migrate than those who are illiterate. Additionally, the study discovered that the likelihood of migration is the same for both literate and illiterate people. The likelihood of migration is three times higher for married migrants than for single ones. Among the economic variables, we have taken landless labourers as reference category which shows statistically positive significant relationship at 5% level of confidence. In rural areas, the amount of landholdings has a significant role in determining outmigration. Marginal farmers are 1.36 times more inclined to migrate than laborers without land, and their link with migration is statistically significant and favorable. Small farmers are 48% less likely to move than laborers without land, according to the odd ratio of small farmers. Negative coefficient

implied increase in number of small landholders decreases the probability of migration. Thus we can say that landless labourers and marginal farmers have higher likelihood of leaving than small landholders. Nature of work is another important parameter behind migration decision because non-availability of work throughout the year increases households drudgery and force them to move out. Here we have taken main workers as a reference category which shows insignificant relationship with migration, whereas marginal workers show statically significant positive relationship with migration and they are 2.356 times more likely to migrate than main workers. Low income is an important push factors of migration. Large families, low income from agriculture, and landlessness are seen as the main reasons why migrants migrate to developing nations like India in search of better economic possibilities. We have added income as a continuous variable which has a statistically negative significant relationship with migration, implying low income generates more migration. The odd ratio of continuous variables can be explained as follows: if the odd ratio is more than 1, then the event has a greater likelihood of occurring as the continuous variable grows, and vice versa. Here odd ratio of monthly household income is .430 which implies that as the income increases, migration is less likely to occur. Outmigration and the pressure of outstanding loans or incompetence are found to be of statistical significance at the 5% level of confidence. According to the findings, households with outstanding loans are roughly 2.273 times more probable to move than those without any loans. The environmental factors such as drought, decreasing rainfall etc act as stressors that brings about hardship in poor households where their livelihood is primarily rainfed agriculture with lack of irrigation facilities and forced households to think of migration as an answer. To put it another way, households are more inclined to relocate to areas with greater economic opportunities in order to support their family when environmental conditions or shocks jeopardize their well-being, lower their household income, or degrade their limited assets. In environments where people rely more heavily on primary activities for their sustenance and where natural disasters are a frequent occurrence, environmental stress is probably going to be more noticeable. In our study, we have taken 7 variables under environmental factors to understand which variables have profound impact behind migration decision. We have taken increasing summer temperature as a reference category which shows no significant relationship with migration. However, the incidence of drought, delayed monsoon, increasing heavy rainfall days during harvest shows a significant relationship with migration. Odd ratios

revealed that increasing droughts are about 2.528 times more likely to increase migration, while odd ratio of delayed monsoons are about 1.748 times more likely to trigger migration and odd ratio of increasing heavy rainfall days during harvesting period are 1.302 times more likely to trigger the phenomenon of migration.

8.3.1 Adaptation strategies

Agricultural adaptation differs in terms of type, scale (cultivating land or national), and duration (short-term or long-term). Three main types of agricultural-level adaptation were distinguished by Smit and Skinner (2002): developments in technology, adjustments to farm management techniques, and financial measures to protect farms. Studies have pinpointed various adaptation strategies within these categories. Crop diversity is one example of a micro-level farm management modification, modifying the growing season's length, altering planting dates, adjusting cultivated areas, and varying irrigation usage. Using weather forecasts, adopting new crop kinds, and conserving water and soil are examples of technological breakthroughs. Relocating to cities for work, purchasing crop insurance, and switching from farming to non-farming pursuits are examples of monetary strategies (Kurukulasuriya and Mendelsohn, 2006; Nhemachena and Hassan, 2007; Deressa et al., 2009; Gbetibouo and Ringler, 2009; Hisali et al., 2011; Below et al., 2012). Farmers' actual adjustments frequently depend on their capacity to forecast climate change, and local social, cultural, and political considerations have a significant role in their choices. Farmers' large-scale adjustments usually require prompt decision-making, which is mostly influenced by the arrival of seasonal climates.

Table 29 demonstrates the main agricultural adaptations undertaken by farmers in the research region.

Coping	Drought	Landholding size	HH income	Education
switching to crops that require less water (they	0.23	0.04*	0.65	0.44

utilize Desi seeds instead of HYV)				
Less use of fertilizer	0.74	0.20	0.97	0.39
Use of Water harvesting techniques (hapa, ditch)	0.14	0.01*	0.24	0.52
Reducing cultivation area	0.20	0.02*	0.31	0.43
Borrowing money	**0.00***	**0.01***	**0.01***	0.31
Selling livestock & HH assets	**0.02***	**0.03***	0.28	0.87
Withdraw farming	0.54	0.21	0.47	0.98

* The Kruskal-Wallis H-test is significant at the 5% level of significance. * At the 5% significance level, the Mann-Whitney U-test is significant.

Research indicates that farmers are well aware of how farming and their life are being impacted by climate change. Those with smaller plots of land are increasingly choosing to sell livestock and other assets. Meanwhile, farmers who regularly contend with droughts, earn a low income and possess minimal land are more inclined to take loans to mitigate their susceptibility.

8.4 Life histories of migrants

8.4.1 Surviving hardship through permanent migration

Sunil Sutradhar is a 45-year-old marginal farmer of Keshargaria village of Man bazar 1 block, Purulia district. His family consists of 3 children (2 sons and a daughter) and his wife. He owns a land of less than 1 hectares and produce paddy. Cultivation is solely depended on monsoon rainfall. Recurrent drought, delay of onset of monsoon rainfall,

shorter cultivation period, increasing events of heavy rainfall days, lack of irrigation has affected cultivation badly. Crop failure is a regular phenomenon in recent times (in last 10 years). He added, crop production also vary year to year due to erratic nature of monsoon and increasing intensity and frequency of drought. When asked, Sunil mentioned that, government only provides aid in the severe drought years like 2010, but small to medium drought hit them regularly, they suffer tremendously during those years. Crop production is not more than subsistence level. Day to day household level expenditures, cannot be run by income from agriculture. But, he added, this was not the case 30years ago when his parents cultivate and they produce enough to run their basic family needs. Now, agriculture is so unprofitable that it does not bring daily needs and prosperity and force his elder son to migrate in Tamil Nadu permanently.

After passing higher secondary in 2015, he tried to find out work here, but could not find any.2015 was a drought year. Cultivation was bad. There was no other work available here, not even 100 days' work. Sunil shares*, "we had to take loan from local trader like we took in 2010, which was still unpaid in 2015, however we did not have any option, he added. We had enough. How can I raise my other son and daughter if we do not have any regular income. I told my elder son to try to look for job in other states which pays good.2015 drought was like a trigger point for our family. My son managed to get a job in construction at Tamil Nadu. I had to take loan to send my son to Tamil Nadu. We were anxious at first, especially my wife as no one from our family ever moved out but we did not have any choice. We cannot depend on cultivation any more. My son migrated there in 2017 and sends around 7000/8000 every 6 months."* With the money sent by his son, the expenses of the family get covered, our loans are getting paid eventually. Sunil still works in the field and he shares*," now he is able to produce rice only, not like before when my parents used to produce a lot of vegetables"*. He also said that; he does not want next generation to continue cultivation.

However, While Sunil's son is earning a steadier income as a construction worker, it has come at the costs of deteriorating health condition especially lungs due to continuous exposed conditions in dust. Long absence from the family makes him sad. When asked, Sunil said that work burden slightly increased for his daughter in laws as she has to manage the entire home and she also miss her husband. In these 2 years *"my son could not manage to come even for once. I have also told another son to find work*

just like his elder brother somewhere else where money is good. I still have to repay loans, need money for my daughter's marriage"

Sunil shares that, thought of permanently move to a new state or a big city is scary for them but reality is hard. He added *"who wants to move out from their roots, but when moving out saves your life, it is worth it."*

8.4.2 Seasonal migration as a coping

Dulal Mahato is a 32-year-old man with a family of 8, living in Majhihira village in Manbazar1 block, Purulia. Within the household, he migrates to Burdwan and Purulia town along with his brother to work as agricultural labour and wage labourers seasonally. They are marginal farmers and cultivate rice and vegetables at subsistence level. They do not have any livestock. Over the past 10 years increasing frequency of drought and climatic shocks have reduced agricultural production forcing them to opt for seasonal migration to supplement family income.

Dulal and his younger brother (who is 29 years old) are both passed class 8. Dulal and his brother both had to drop out from school due to their parents' illness in 2005 and 2008 respectively. They both started to work in their small land. After few years, Dulal and his brother got married and became parents. Dulal shares*," our family size has increased, so is responsibility."* Dulal's family has gone through several risks like illness in family, crop failures during drought, lack of any assets, daily hardship due to insecure livelihood. In response, the family typically takes loans. Until recently, Dulal's family was unable to repay their multiple loans as frequent drought and repetitive crop failures makes it impossible to recover from earlier loans. Dulal shares, *"being a family of 8, meagre income from agriculture could not support our daily expenses. Moreover, money was also required for repayment of loan, house repairs, medical needs. Since 2009/10, drought, irregular rainfall has become regular phenomenon. It affects agriculture, because we do not have irrigation facility. So, crop failure, loss of income has become also regular since last 10/12 years. So, me and my brother started to go Burdwan where we can work in the field as an agriculture labourer."* He added that, in earlier days their family used to migrate only during severe drought years, however migration is a regular phenomenon now. Regular droughts, shorter cultivation period,

delayed monsoon, long dry spell during monsoon season -are the reason Dulal cited which forced them to migrate twice a year for 2 to 3 months both during lean and peak season. He also added, *"during lean season we travel to Purulia town in search of work. Some years if we are lucky, we get a job in a small hotels or local shop. We both managed to get approximately 1700-2000 rupees. However, he mentioned, if works were available under MGNREA we wouldn't have to move out during lean period. During peak season we usually go to Purba Burdwan to work as agricultural labour. We usually go to Natunbazar, Kumirkola, Sehara bazaar area"* In Bengali, they referred to it as Pube jaua. The term "pube jaua" describes a periodic eastward migration from Purulia and Bankura districts in western West Bengal to Purba Bardhhaman and Hooghly districts.

Dulal also said," we *do not like to migrate twice a year, because commuting between home and burdwan and working in the field as labour becomes difficult now due to increasing temperatures. We fell sick, but we have no option except migration, because we do not have other work opportunities here".* Their wives take care of both cultivation during harvesting and household chores during their absence. He noted that income from seasonal migration is not adequate like those of permanent migration but have helps their family to survive. When asked, he said that permanent migration can increase income of his family, however*, "we have to borrow again to move out for longer distance. Also due to persistent illness of family members both of the brothers cannot be absent from their family for long period".*

Baghmundi Sub-district

8.5 Household characteristics

Droughts have a significant and negative effect on households. So, it is important to know the characteristics of a household. Table 1 gives a summary of the traits of the households that were surveyed.

Table 30 shows household characteristics

Total Sample HH	400
Mean Household size	5.21
Mean Landholding size (bigha)	2.83
Mean Age of HH head	45.6
The HH head's sex	Male 92.75 Female (widow) 7.25
HH head's education	Illiterate 38 Primary level (one to eight) 52.5 Secondary level (nine to ten) 8.5 Higher Secondary level (eleven to twelve) 1

According to the data, the average size of the homes surveyed is more than five people. With an average age of 45.6 years, men make up more than 90% of the heads of these families. While more than half of these household heads have attained primary education, 38% have no formal education. Additionally, the average landholding size is under one hectare, suggesting a prevalence of smallholder farmers.

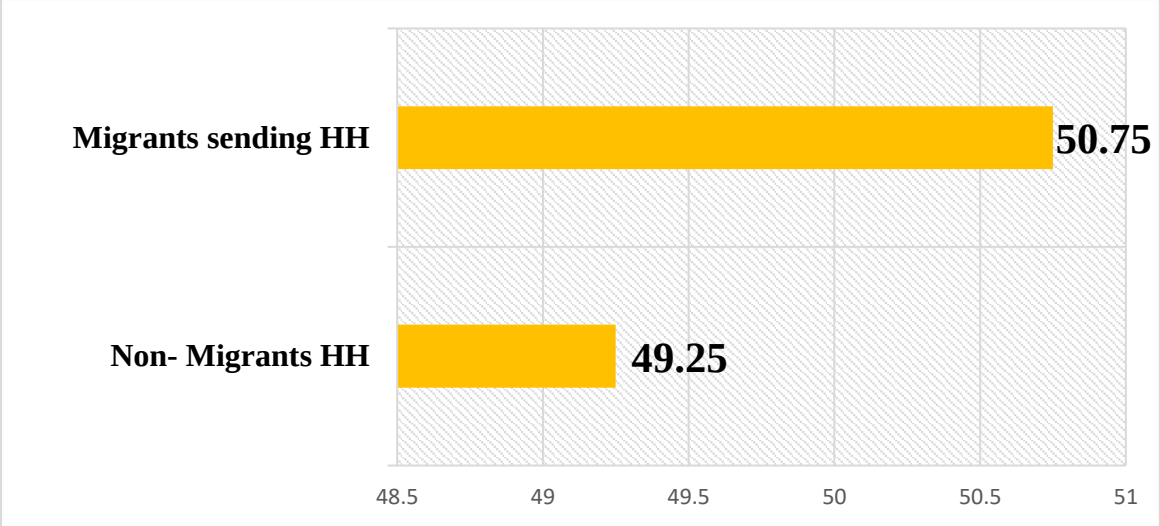


Fig 49 displays the number of households in the research region that are migrants and non-migrants.

figure 49 shows that around 51% of households have migrants, while non-migrant households make up 49%.

8.5.1 Socio-economic and demographic characteristics of migrant households

Understanding migration trends requires an understanding of economic and social variables. The characteristics of the homes from which migrants come play a crucial role in identifying the causes of migration. The demographic and socioeconomic details of the Baghmundi households surveyed are displayed in the following tables.

Table 31 displays the head of the household's gender.

Head of HH	**Percentage**
Male	**84.24**
Female	**7.39**

Table 32 displays the family head's level of education.

The HH head's level of education	**Percentage**
Illiterate	**64.04**

Primary level (one to eight)	**32.02**
Secondary level (nine to ten)	**3.94**
Higher Secondary level (eleven to twelve)	**NA**

Table 33 shows the social composition of migrant households

Social group of HH	**Percentage**
General	**15.27**
SC	**25.12**
ST	**53.20**
OBC	**6.40**

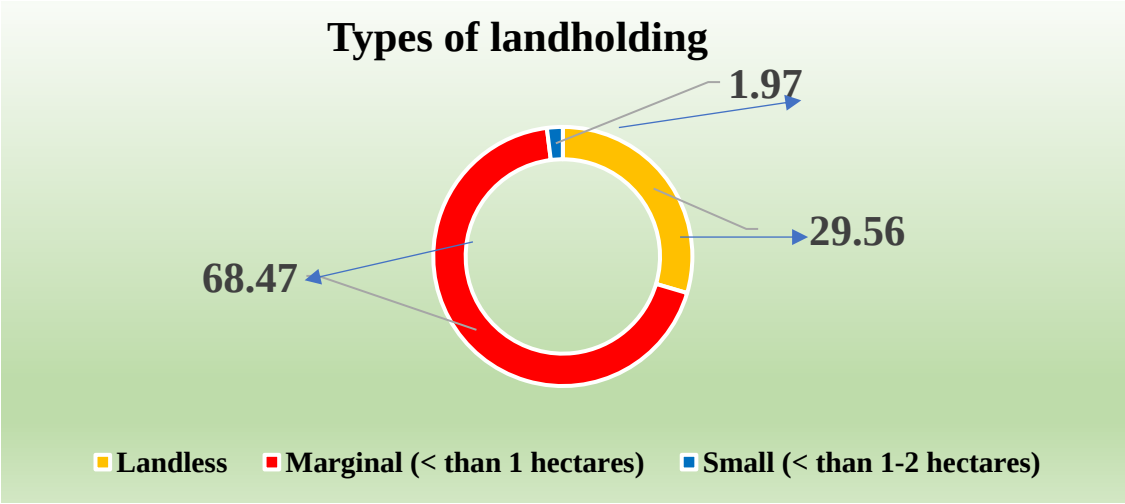


Fig 50 shows different types of landholdings of migrant household

The study shows that the migrant households are predominantly male, 64% of them are illiterate and more than half of them belong to the ST category. 68% of them are marginal farmers and 30% of them are landless labourers.

8.5.2 Pattern of Migration

Migration significantly affects individuals, households, and regions, and has profound implications for national economies and societies. The migration patterns are intertwined with growth and development trajectories, offering individuals a chance at an improved standard of living away from home. Consequently, data is crucial for identifying trends and flows from, to, and within regions to inform policy-making. Countries equipped with adequate resources, expertise, and experience can effectively gather, analyse, and utilize data to guide policy decisions.

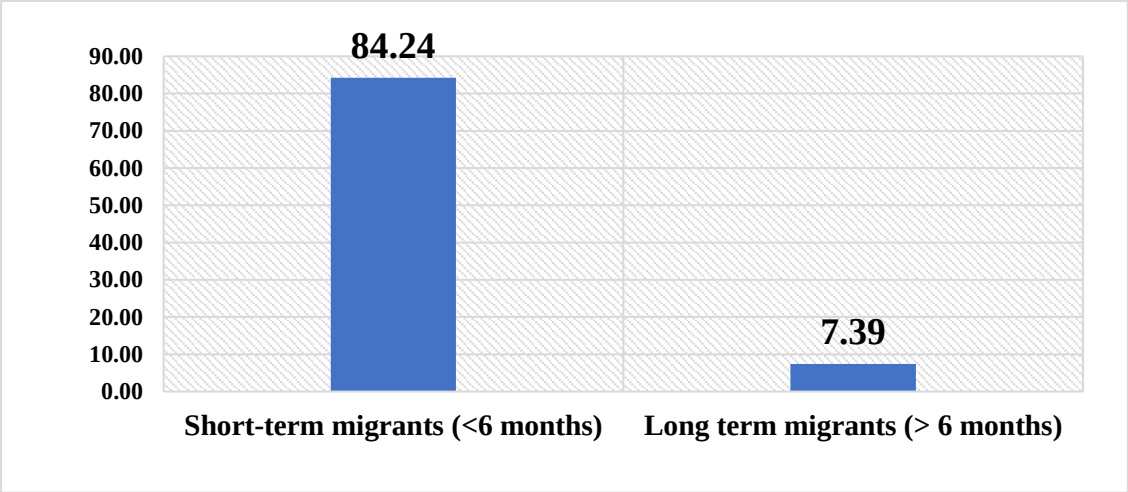


Fig 51 shows the types of migration

The figure suggests that short-term migration predominates the migration patterns, a trend that is reflected in the characteristics of households, indicating their impoverished conditions. Households with limited resources are often unable to afford long-distance relocations.

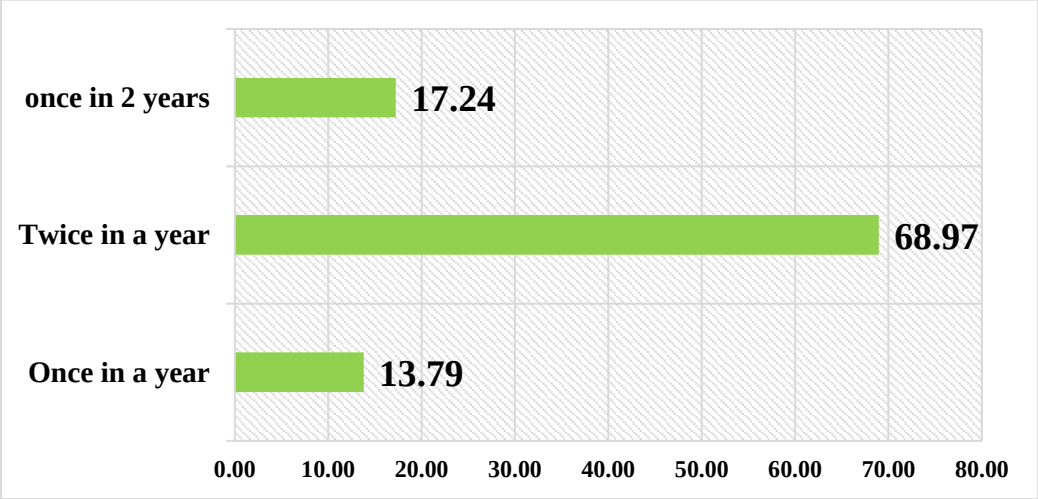


Fig 52 shows the frequency of migration

Frequency of migration is dominated by -approximately 69% of them move out twice in a year

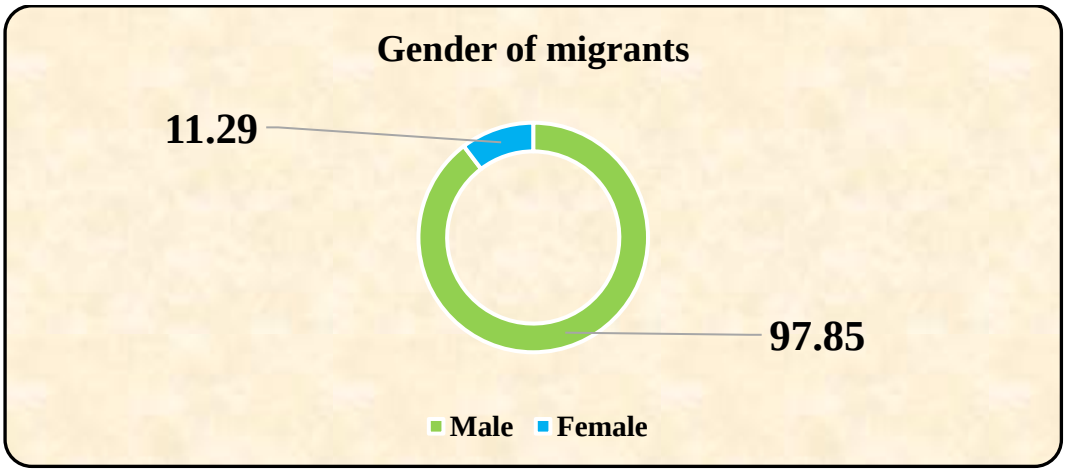


Fig 53 shows gender of migrants

Migration is dominated by the male members of the household, leaving the women behind, which increases their burden of housework.

Fig 54 displays the migrant population's age distribution.

Young adults (15–34 years old) have migrated more than any other age group in the research area, according to the age distribution of migration statistics. More than fifty percent of migrants are in the 25–34 age range, followed by the 15–24 age range. The economic success of migrants depends on their educational background. 44% of the migrants in this study had only completed primary education before deciding to migrate.

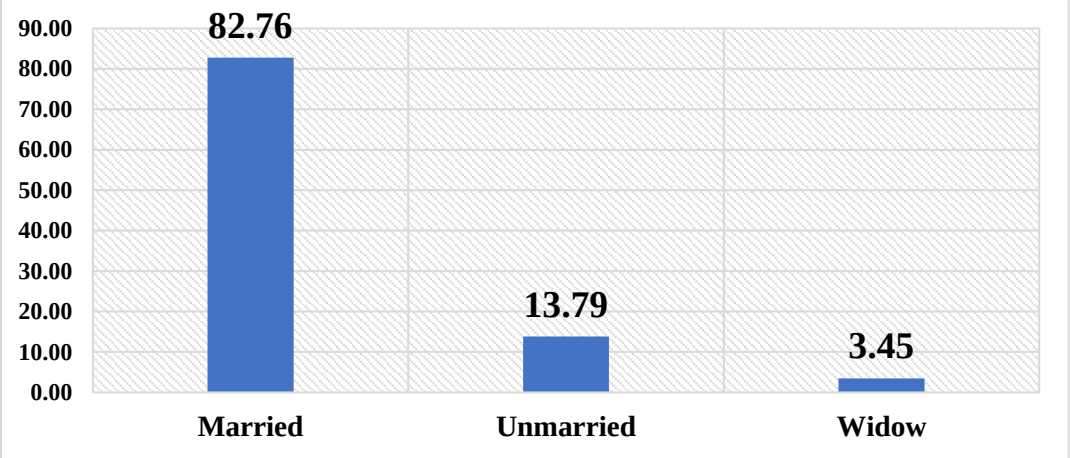


Fig 55 shows marital status of migrants

Approximately 83% of migrants are married, which heightens their financial requirements and susceptibility compared to single individuals.

Environmental change affects population movements across different times and places. However, the decision to migrate is complex, involving various factors such as environmental risks and economic prospects.

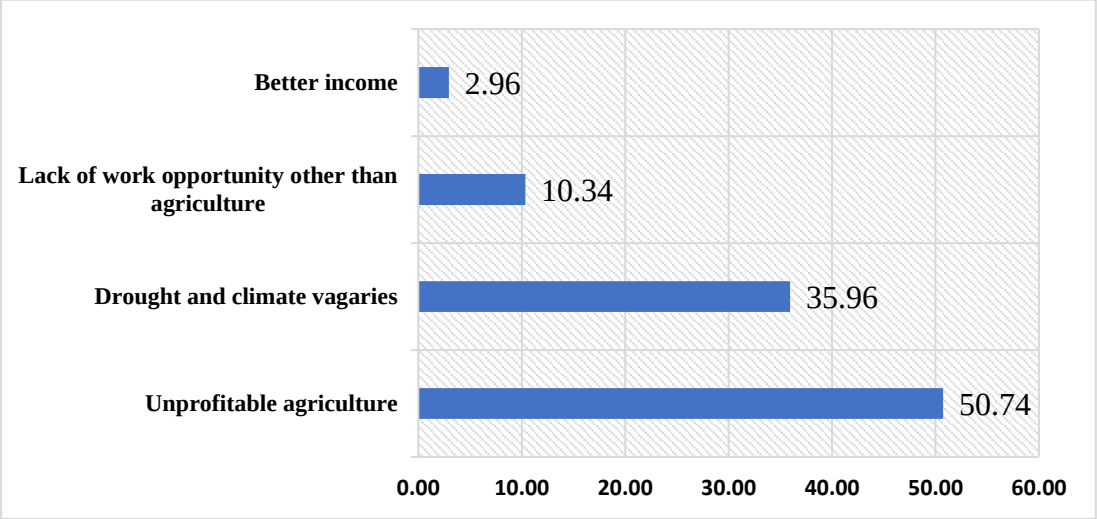


Fig 56 shows the reasons behind migration

In the studied region, over half of the population identified unprofitable farming as the primary cause for migration, with drought and climate uncertainties, and a scarcity of other job opportunities also contributing factors. Climate is a key factor in agricultural yield, particularly in India where two-thirds of the arable land depends on rainfall. Climate change is a critical issue, impacting agriculture both directly and indirectly on a vast scale. Rising global temperatures, more intense rainfall, rising sea levels, melting

glaciers, changing growing seasons, and an increase in the frequency of severe weather conditions like floods and droughts are some of its consequences.

8.5.3 Destination of migrants

In India, moving from rural to urban areas is frequently seen as a necessity rather than a choice, and the possibility of better job possibilities influences the decision.

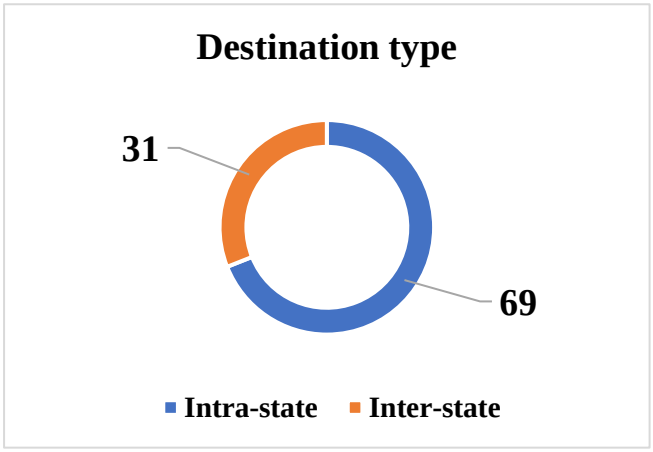


Fig 57 shows the types of destination

Approximately half of the migration occurs within the state, suggesting the migrants' households are in a disadvantaged state, which limits their mobility.

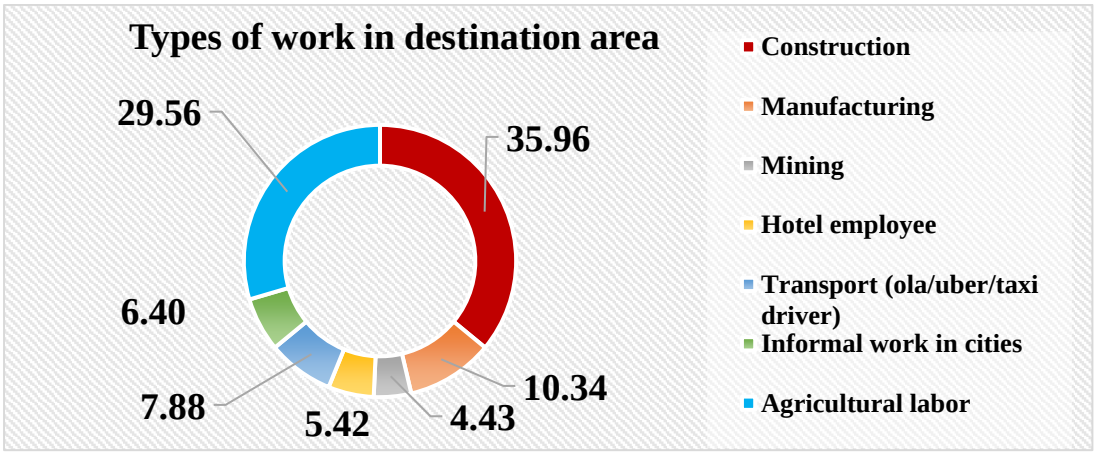


Fig 58 shows types of work in destination area

In the destination region, the predominant types of work are in construction, followed by agricultural labour and manufacturing. Non-agricultural activities generally offer better wages; however, about 30% of migrants engage in agricultural labour in Burdwan, due to the distance and lack of resources.

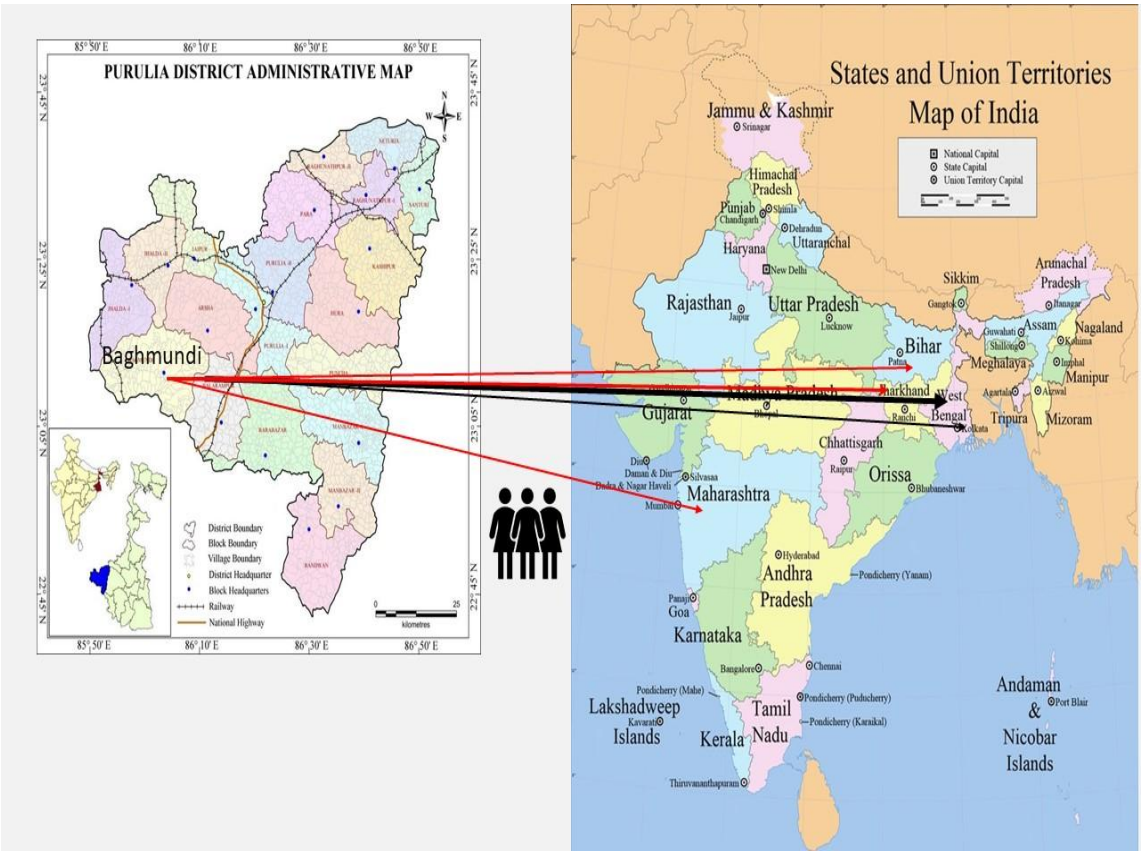


Fig 59 shows the destination regions

The map indicates that within the state, migrants are moving to Kolkata and Burdwan, whereas inter-state migration is directed towards Jharkhand, Bihar, and Maharashtra.

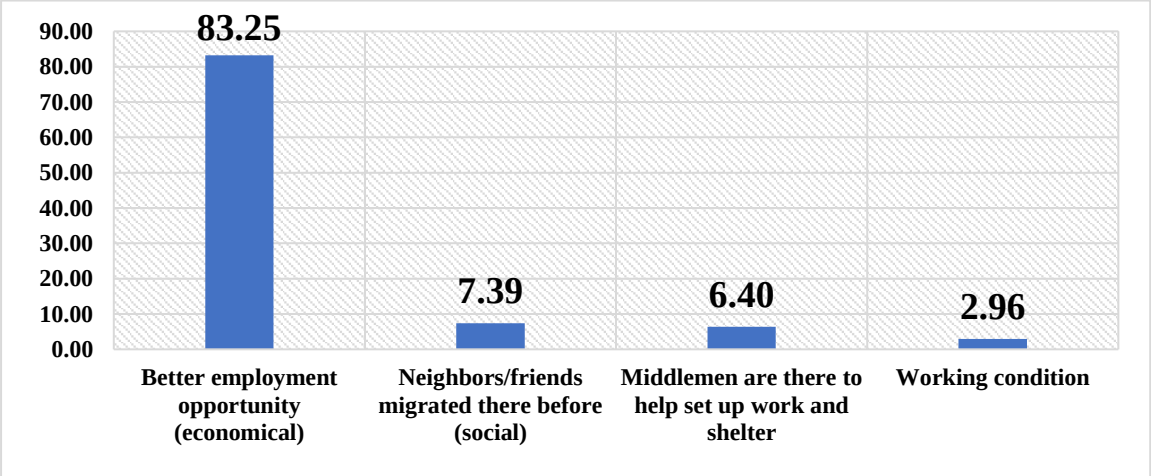


Fig 60 shows reasons for choosing destinations

From The figure above, it is clear that the main reason for choosing a particular region is the better employment opportunities it offers, enabling them to make remittances that meet the needs of their households.

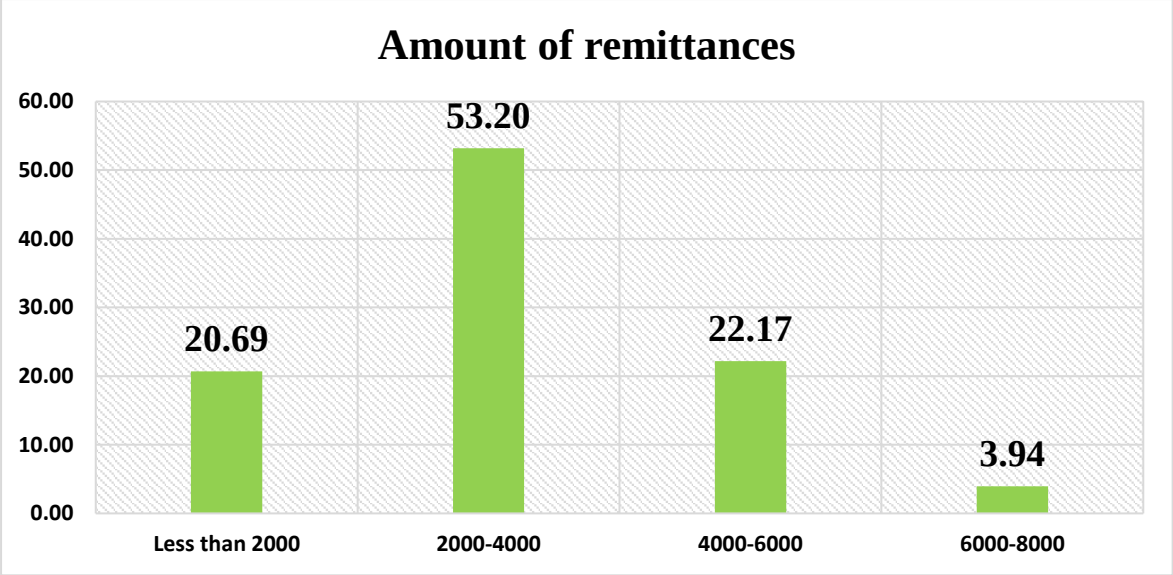


Fig 61 shows amount of remittances

More than half of the households surveyed received remittances in the range of 2000-4000, followed by 4000-6000.

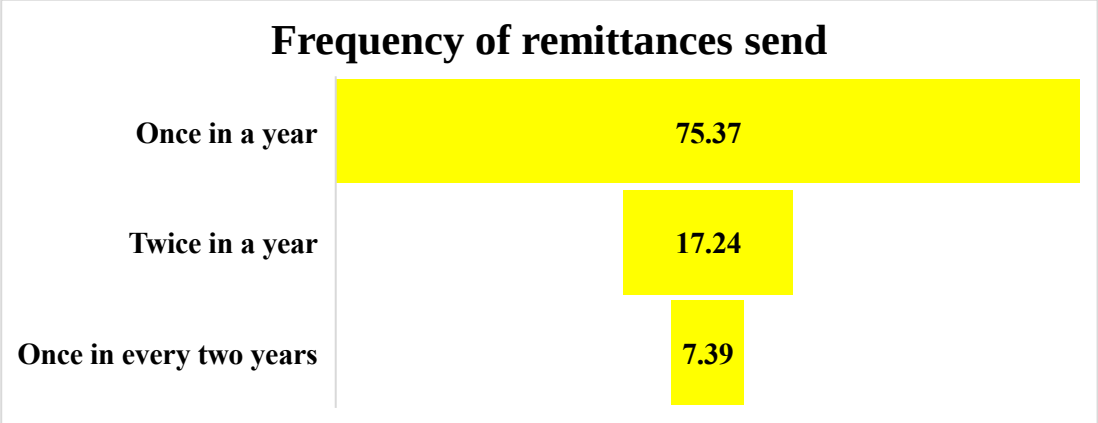


Fig 62 shows the frequency of remittances sent

More than 75% of the respondents send remittances once a year which are used mainly in daily household expenditure (44%), followed by debt repayment, healthcare, house repair, etc.

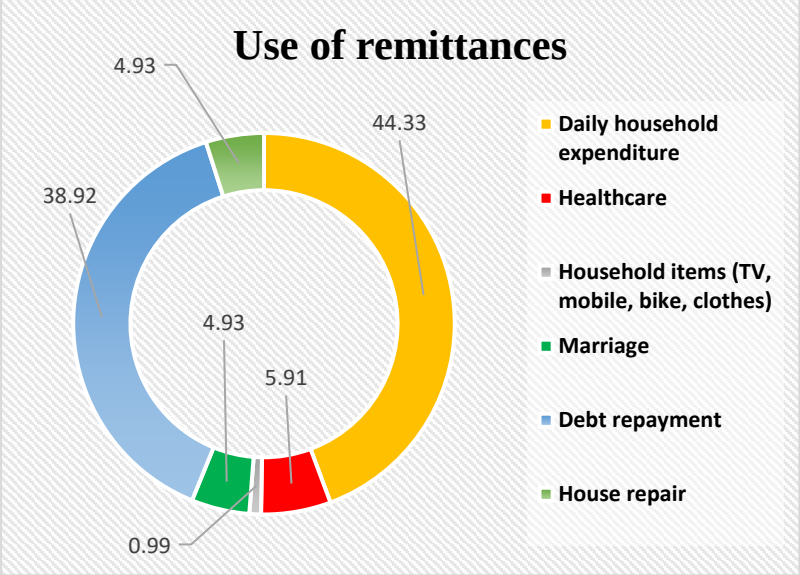


Fig 63 shows various uses of remittances

They contribute in particular to overcoming poverty and hunger, promoting health, good education, clean water, and sanitation. Especially for poor migrant households, remittances can help eradicate poverty by creating employment opportunities.

Analyzing how common this migration is in drought-affected and non-drought-affected years is essential in order to show how climatic hazards or extremes affect migratory choices.

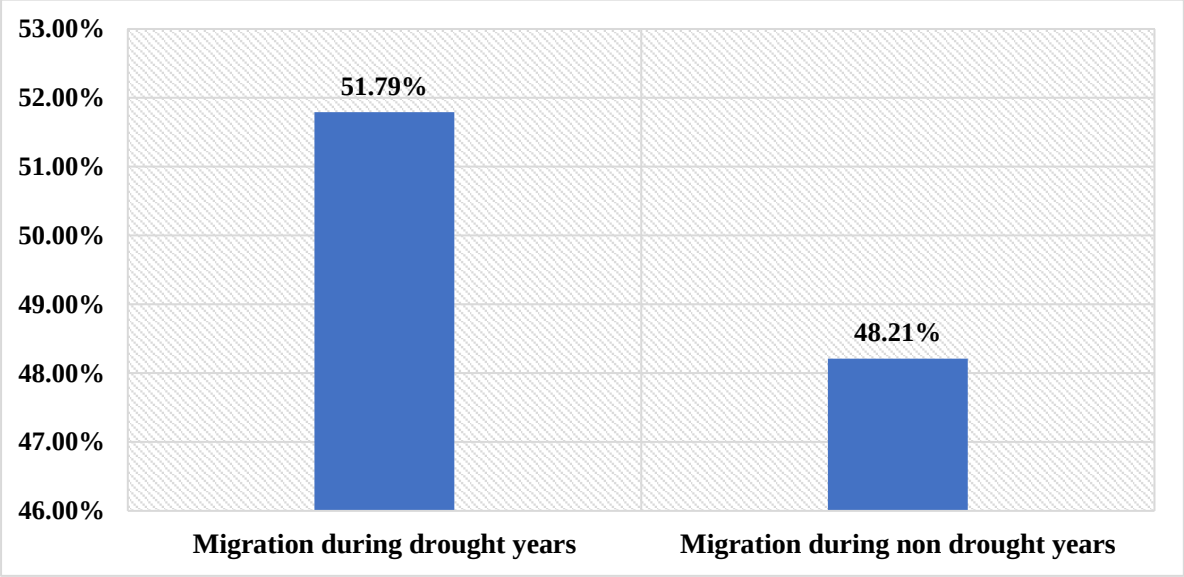


Fig 64 shows the timing of migration

Farmers are more inclined to migrate during drought conditions compared to non-farmers. The presence of irrigation and alternative non-farming businesses diminishes

the likelihood of migration during droughts. 52% of respondents opt to migrate in years of drought, as opposed to 48% in years without drought.

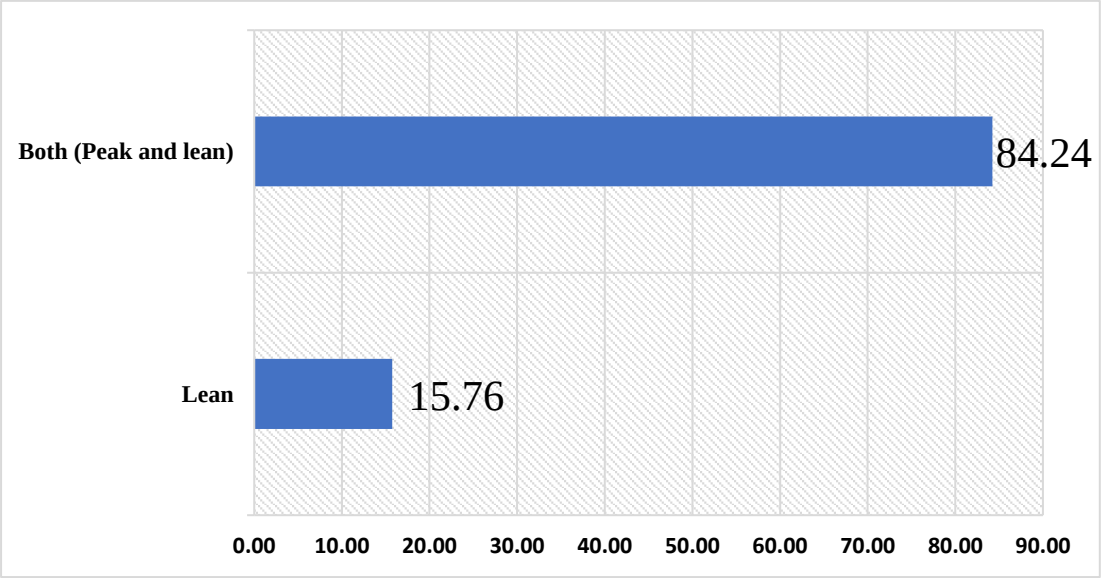


Fig 65 shows the timing of migration during drought years

Approximately 85% of respondents said during drought years they move out both during peak and lean seasons.

8.5.4 Perceived likelihood of drought and migration

The study revealed a positive correlation between farmers' perception of drought and migration, suggesting that an increase in perceived drought conditions is linked to a greater propensity for migration.

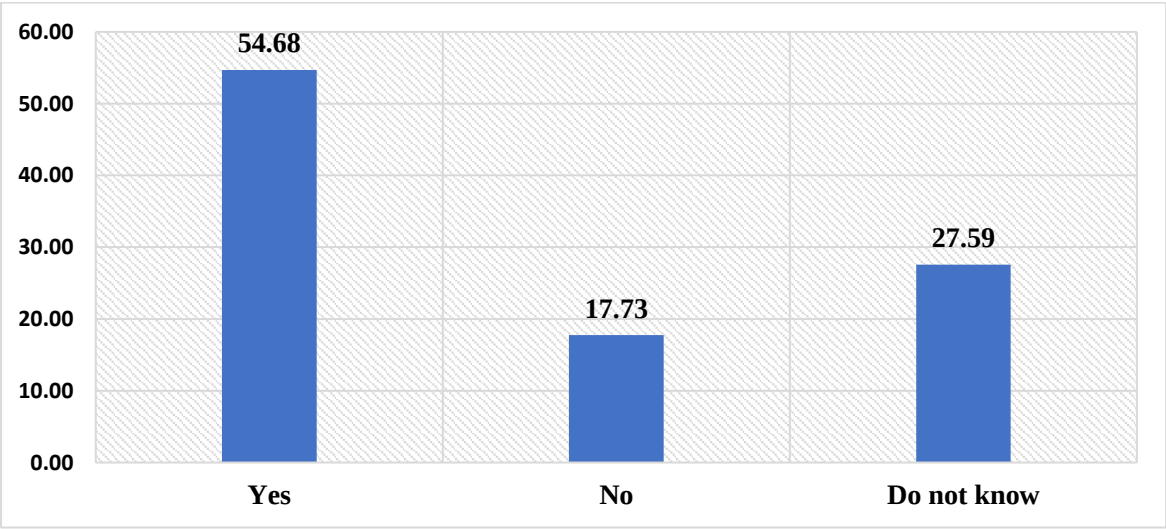


Fig 66 shows the Perceived likelihood of migration

Approximately 55% of people concurred that migration has risen in the past decade. When inquired about the causes, their responses included:

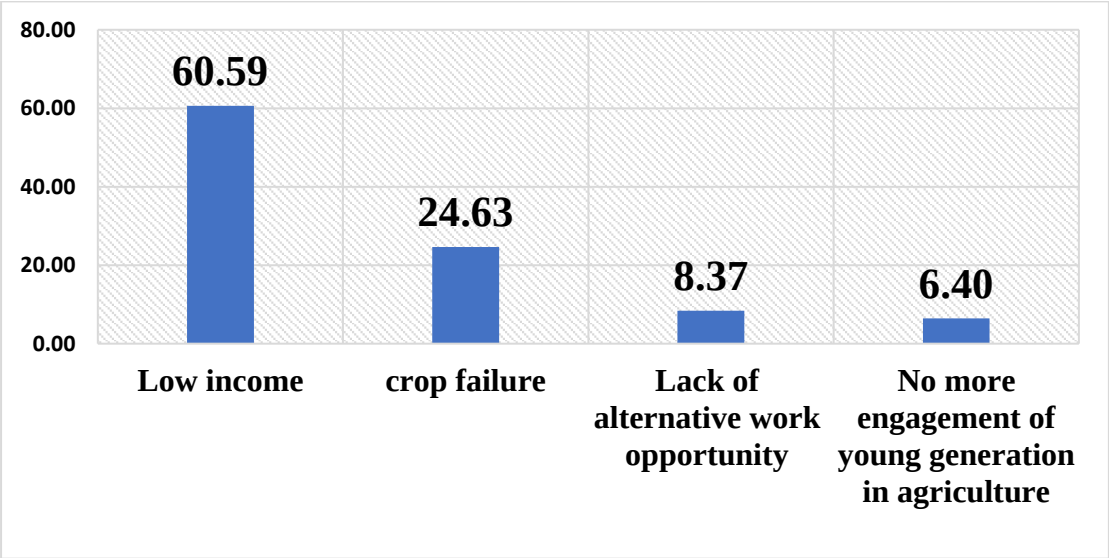


Fig 67 shows reasons for increasing migration in the last 10 years

Approximately 85% of respondents attribute increased migration over the past decade to low income and crop failure. Drought is identified as the primary cause of loss in agricultural production. Crop loss, decreased income, livestock and human starvation, degradation of land, a drop in overall economic activity, the spread of disease, and livestock and human migration are all common outcomes of agricultural drought. Recurrent drought makes it more difficult to recover from past occurrences, resulting in annual income loss and asset deterioration.

8.5.5 Insight of farmers regarding changing climate

Perception is an essential prerequisite for adaptation. The extent to which farmers adjust their agricultural practices to climate change hinges on their awareness. Shifts in weather patterns, like increased droughts and floods, have compelled farmers to modify their cropping patterns and adopt new methods to reduce yield loss. In this region, approximately 68% of farmers acknowledge climate change, while around 50% concur that the intensity and frequency of migration have escalated in recent years.

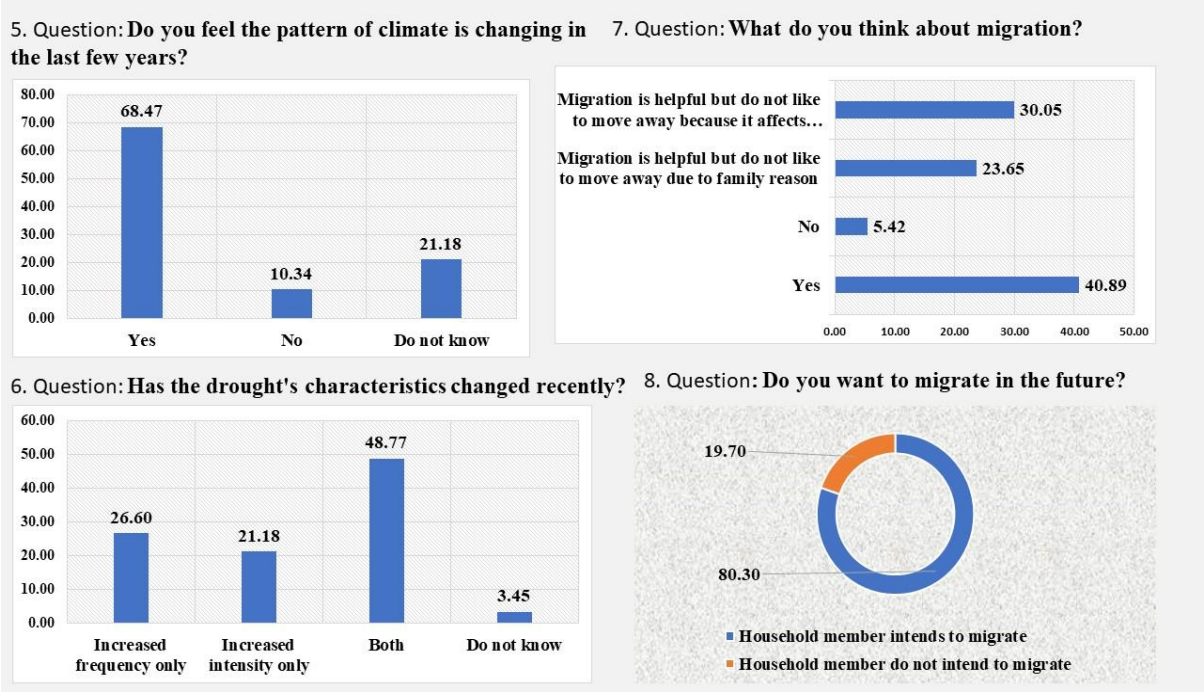


Fig 68 Farmers' insight

Concerning migration, 41% of respondents believe it is beneficial, while 30% feel that although it is advantageous, it impacts their health. Additionally, 24% dislike migrating as it requires them to leave their family. However, 80% of people wish to migrate in the future because it leads to financial gain and household prosperity.

Regarding assistance during drought years, 75% reported that they typically receive no help unless it is a severe drought, which accounts for 18.72% of cases.

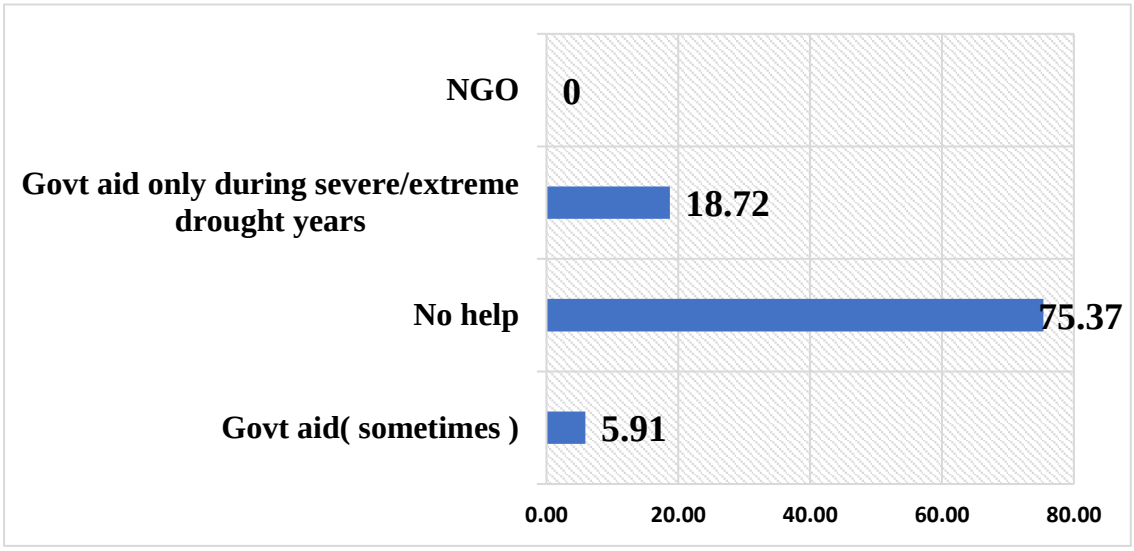


Fig 69 Types of help available during drought

Climate change and indebtedness are frequently cited as significant factors contributing to the distress of rural households in India. In the absence of government assistance during successive droughts, farmers have struggled to recuperate from crop losses, leading to a cycle of debt.

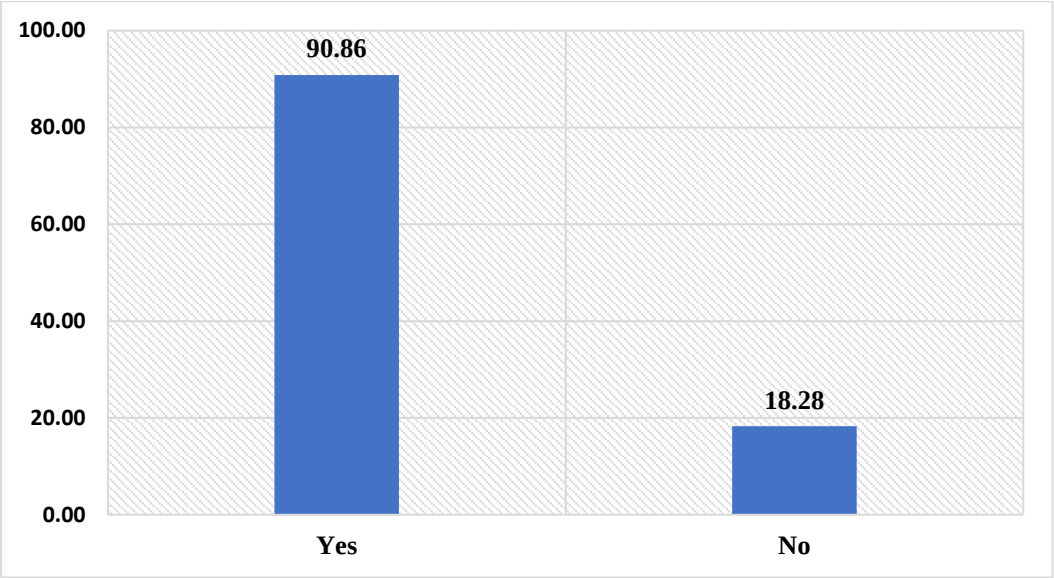


Fig 70 Outstanding loans of migrants

In the study area, repeated periods of droughts have led to increased indebtedness among poor households, with around 90% of families having outstanding loans.

8.5.6 Perception of socio-economic impacts of drought

At all levels—national, regional, zonal, district, village/community—it is crucial to comprehend the economic and social impacts of drought.

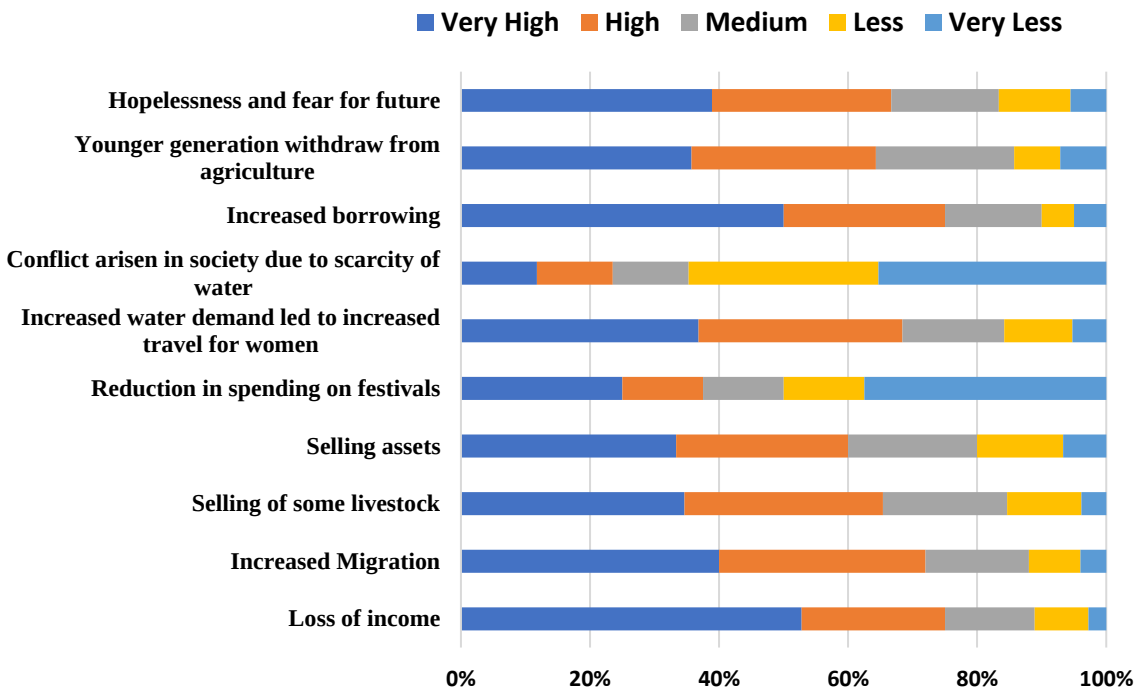


Fig 71 Likert scale shows various socio-economic effects of drought

Farmers have indicated that the major impacts of drought include loss of income, increased migration, selling off livestock and assets, increased borrowing, and a sense of hopelessness and fear about the future, among others.

Drought has caused damage in the area, as indicated by the Likert scale in the study. Effects include the drying up of water bodies, increased demand for food, rising food prices, and heightened water demand for both drinking and irrigation purposes.

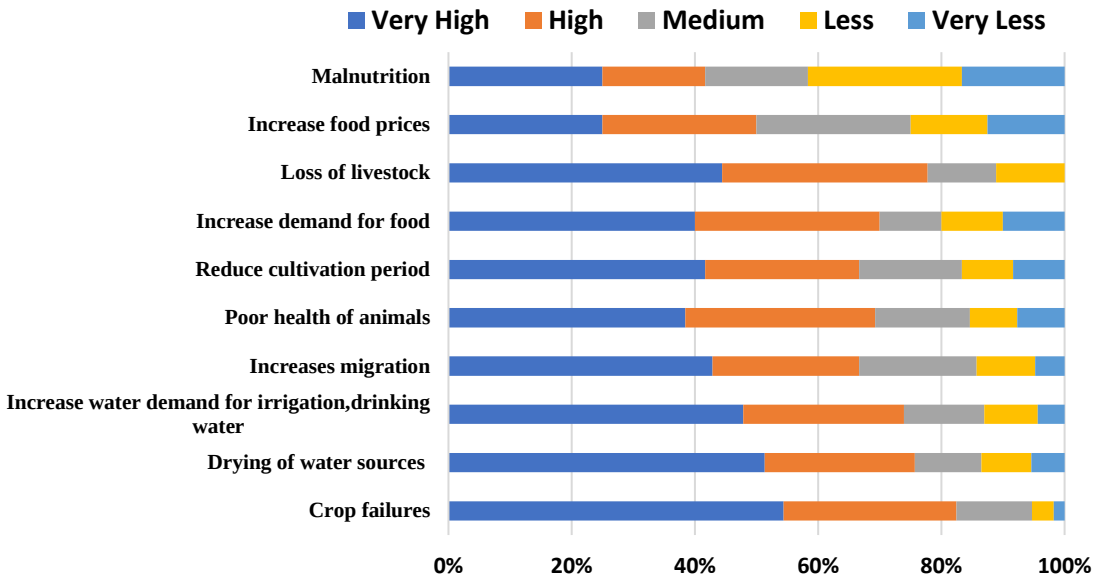


Fig 72 Likert scale shows various damages caused by drought in the block

8.5.7 Perception of environmental impacts

The environment is impacted by drought in several ways. It causes drained aquifers, lower lake levels, and reduced river flows. The mix of reduced flow rates and elevated water temperatures can significantly deteriorate water quality. Moreover, droughts lead to a reduction in soil moisture, negatively impacting soil fertility and biodiversity, and heightening the likelihood of wildfires. The figure depicts the environmental repercussions of drought as noted by farmers.

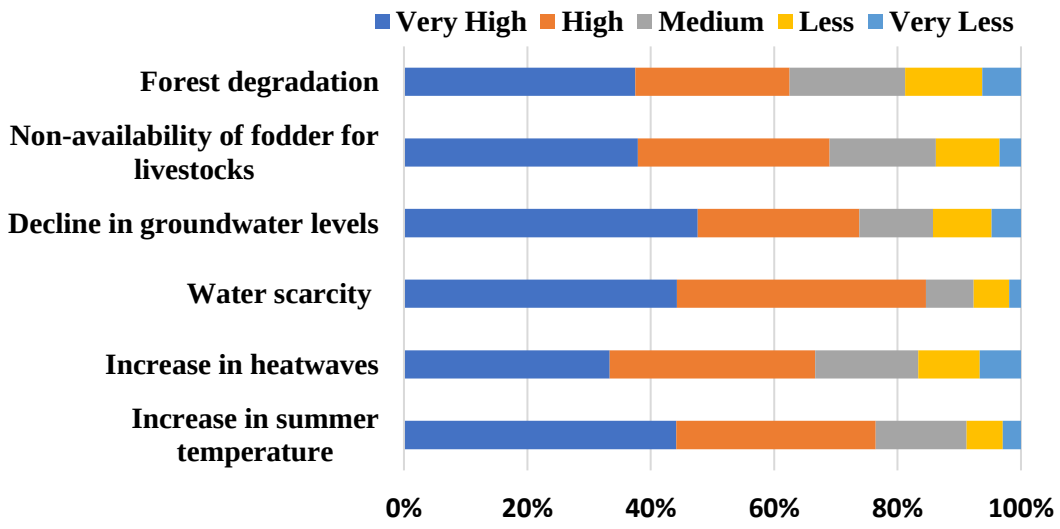


Fig 73 Likert scale shows various environmental impacts of drought in the block

The Likert scale indicates increase in summer temperature, water scarcity, an increase in heatwaves, decline in groundwater levels are the perceptions among farmers.

8.6 Impact of drought on drinking water and agriculture

Drought presents numerous challenges to crop production and significantly affects the environment. In the absence of irrigation, crops experience reduced productivity, and both humans and livestock face a scarcity of drinking water.

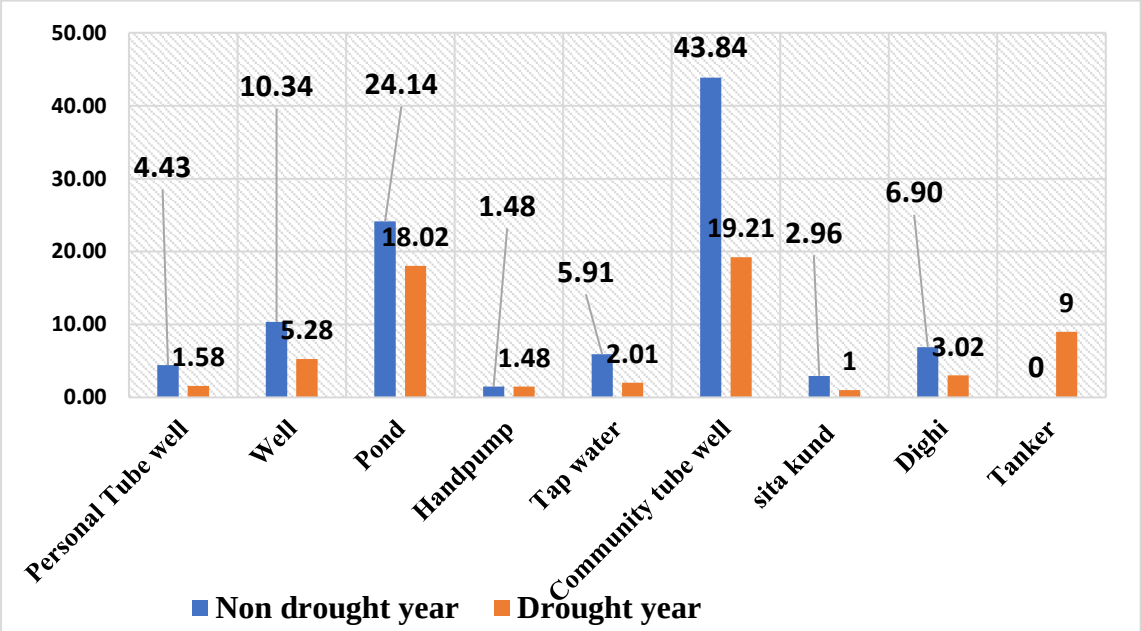


Fig 74 shows conditions of various sources of drinking water sources during drought-affected and non-drought-affected years

The research area's numerous drinking water sources are depicted in the picture, which also shows how these supplies significantly decline during drought years.

Table 34 shows time spent fetching water during drought (using inferential statistics)

Activity	**N**	**z**	**p**	**r**
Number of trips (per day)	203	-2.27	**0.001***	-0.132
Water fetched (l/trip)	203	-4.13	**0.000***	-0.198

Time spent (min/trip)	203	-7.54	**0.002***	-0.425

According to the Wilcoxon signed-rank test, during times of drought (mean = 49.4 min/trip, median = 29 min/trip) households spent considerably more time each trip obtaining water from a distant spring than during normal years (mean = 20.4 min/trip, median = 15 min/trip). Furthermore, compared to normal years (mean = 5.6 trips/day, median = 5 trips/day), the average number of daily travel to the spring was significantly fewer during times of drought (mean = 2.9 trips/day, median = 5 trips/day). This was probably because it took longer and traveled farther to get to the water source. Compared to normal years (mean = 34.7 l/trip, median = 30 l/trip), the amount of water collected per trip was substantially greater during times of drought (mean = 74.8 l/trip, median = 40 l/trip). This suggests that respondents sought to reduce the number of trips while collecting more water each time in order to reduce the total amount of time spent getting water.

Table 35 shows the distances of drinking water sources

Various drinking water sources	**Distances of drinking water sources**	**Drought year**
Personal Tube well	within premises	walk for 1/1.5 km
Well	within 500 meters	walk for half to 1 km
Pond	2/3 km	4/4.5 km
Handpump	within premises	no change
Tap water	Within premises	walk for 1-2 km
Community tube well	1.5/2 km	walk for 3.5/4 km

During drought years, individuals are compelled to walk additional kilometers to collect water. This responsibility frequently rests on women, resulting in children leaving school and women undertaking more domestic tasks.

The primary crops cultivated in Baghmundi include rice, vegetables, oilseeds, and potatoes. Inferences can be drawn from the Wilcoxon signed-rank test.

Table 36 major crops grown and the effect of drought on these crops

Major crop grown	Z	p	r
Rice	-8.668	**0.000***	-0.592
Vegetables	-3.836	**0.001***	-0.605
Oilseeds (mustard)	-7.475	**0.000***	-0.743
Potato	-5.214	**0.118**	-0.538

The Wilcoxon signed-rank-rank test showed that during drought years, rice, vegetable, and oilseed production significantly decreased.

In order to lessen the impact of drought on crops, irrigation level is crucial. The availability of water has a major impact on increasing productivity in agriculture and production. Irrigation not only expands the cultivable area beyond what rainfed agriculture allows but also boosts crop yields. Thus, the significance of irrigation is tied to the presence of sufficient irrigation infrastructure, which is presently lacking in the district. The figure below illustrates the various irrigation methods utilized in the region.

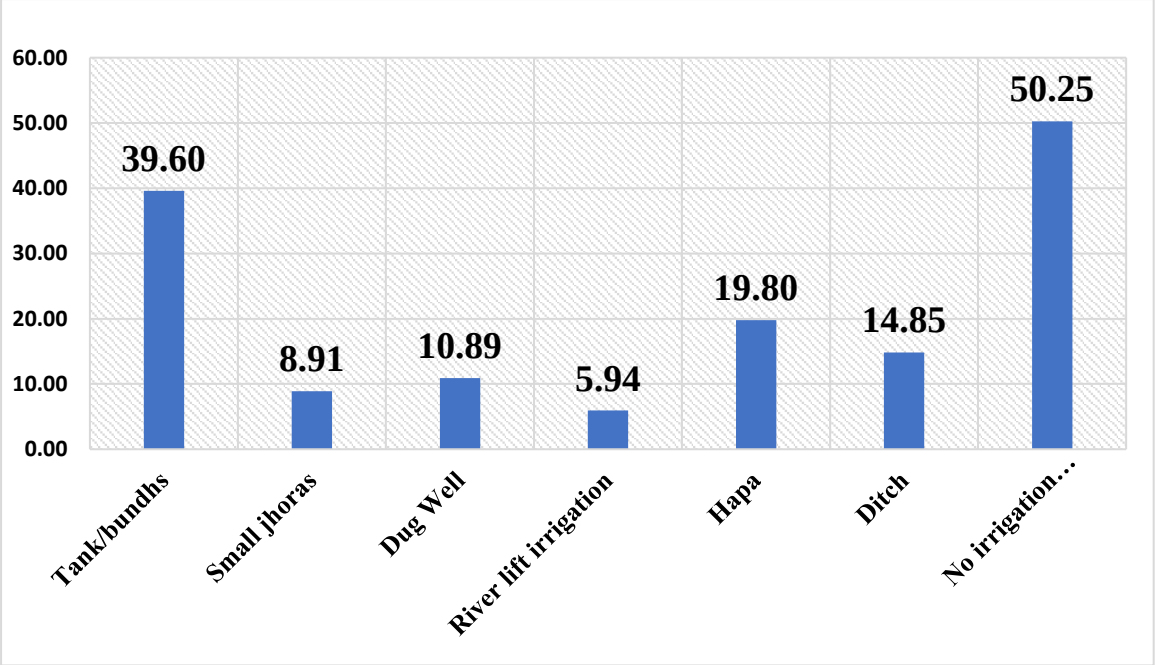


Fig 75 Types of irrigation

Over half of the surveyed households lack irrigation systems. 40% rely on tanks or bundhs for irrigation, along with other methods like hapa, ditches, and dug wells. During drought years, these methods become ineffective, adversely affecting the farmers.

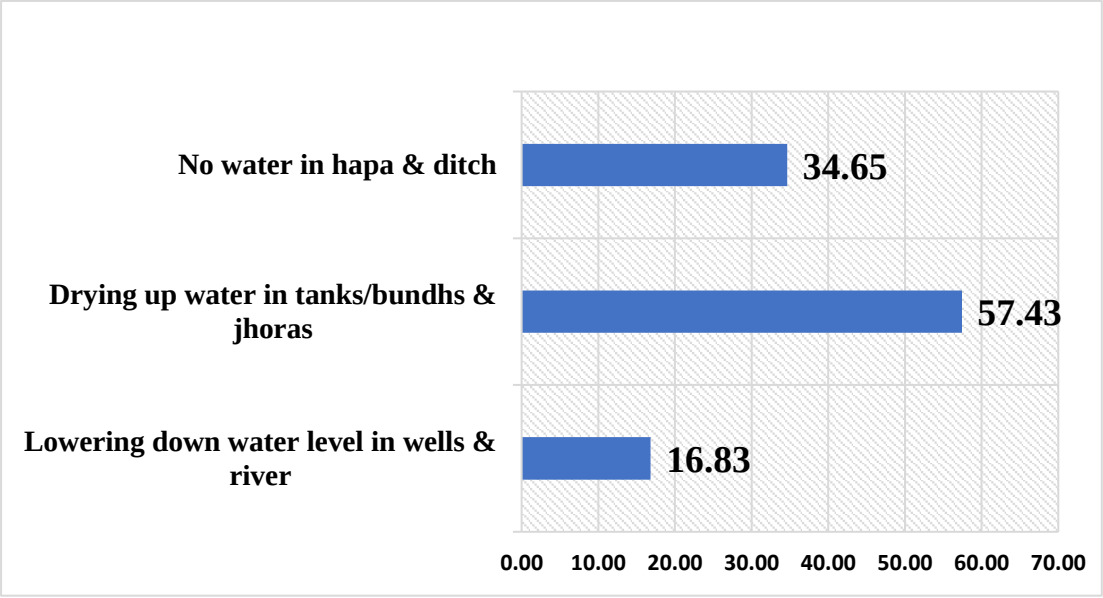


Fig 76 Conditions of different sources of irrigation during drought

According to farmers, every drought year farming households suffer a loss in crop production due to low soil moisture for sowing, absence of irrigation, and lowering of groundwater.

8.7 Empirical analysis between drought and migration

Table 37 Binary logistic regression

Variables	Coefficient	Standard error	Odd ratio
1. **Household size**	0.431	0.177	1.890**
2. Age of HH head	0.488	0.183	0.681
3. Sex of HH head			
Female (ref cat)			
Male	0.621	0.583	1.248*
4. Educational qualification of HH head			
Illiterate (reference cat)	**		
Primary (1 to 8)	1.671	0.214	2.52
Secondary (9 to 10)	-0.921	0.649	0.745
Higher secondary (11 to 12)			
Graduate			
5. **Age of Migrants**			
15-24 (reference cat)	***		
25-34	1.352	0.225	3.412***
35-59	-0.447	0.358	0.829
60+			
6. **Gender of migrants**			
Female (reference cat)	*		
Male	1.528	0.301	3.214**
7. **Marital status**			
Unmarried (reference cat)			
Married	0.791	0.257	4.218***
8. **Educational attainment of migrants**			
Illiterate (reference cat)	***		
Primary (1 to 8)	0.387	0.174	3.289**
Secondary (9 to 10)	. 0.578	0.336	0.612
Higher secondary (11 to 12)	214	0.247	1.875*
Graduate			
9. **Social group**			
General (reference cat)			
ST	0.412	0.247	4.387***
SC	0.214	0.871	1.214*
OBC	0.324	0.547	1.114*
10. **Landholding**			
Landless (reference cat)			
Marginal (< than 1 hectare)	0.678	0.247	2.317***
Small (1-2 hectares)			1.201*

11. **Nature of occupation**			
Main worker (ref cat)			
Marginal worker	0.671	0.118	2.102***
12. **13.Monthly HH income**	-.841	0.534	.591*
13. **Indebtedness/outstanding**			
No (ref cat)			
Yes	0.712	0.657	2.317**
14. HH suffers from drought			
NO (ref cat)			
Yes	1.114	0.714	3.127***
15. **Other Environmental challenges except drought**			
Faces no Environ challenges (ref cat)			
Increased summer temp	0.574	0.247	0.438
Delayed monsoon	0.260	0.814	0.571
Decreasing rainfall during monsoon	0.879	.871	1.817**
Increasing heavy precipitation days	-0.791	0.417	1.124
Increased winter temp	0.671	0.214	0.771
Increasing heatwaves	0.214	0.478	0.314
Cox and Snell R Square Constant *, **, and *** stand for statistical significance at the 1%, 5%, and 10% levels of confidence, respectively, for Nagelkerke R Square Log likelihood 102.204. The reference category is denoted by reference cat, and the robust standard error is reported by robust S.E.			
* p<0.1, **p<0.05, and *** p<0.01			
A measure of the correlation between an exposure and an outcome is called an odds ratio (OR). The odds of an outcome are unaffected by OR=1 exposure, higher odds are related with OR>1 exposure, and lower odds are linked with OR<1 exposure. The reference category serves as a benchmark for other categories.			

The selected independent variables explain 69% variation (pseudo R^2) of outmigration from our study area and our model demonstrates a strong standard error for each variable. According to the table, outmigration and household size are positively correlated, with the odd ratio indicating that migration is around 1.890 times more probable to originate from large households. Migration decisions are also statistically significantly influenced by the gender of the head of the household. Since the head of the home typically makes the decision to migrate, their stage of education is a crucial consideration. Here majority of the household head have no formal education and our model shows statistically significant relationship between illiterate household head and

migration. Various demographic (age, sex) and social (education, social groups) characteristics of individual migrants are considered an essential determinant behind migration decision. This model uses the 15–24 age range as a reference group. At the 1% level of confidence, it is statistically significant. According to the odd ratio, migrants between the ages of 25 and 34 are 3.412 times more inclined to out-migrate than those between the ages of 15 and 24. The following age group (35–59 years) has negligible out-migration probability, indicating that migrants in this age range are less likely to leave than those in younger age groups. In general, younger generations relocated more than older ones. According to the migrants' gender, there is a statistically significant connection between males and females at the 10% and 5% levels of significance; however, males have 3.214 times greater chances than females to migrate (females are in the reference category). Regarding the marital status of migrants, we have taken unmarried migrants as a reference category which is found to be insignificant. The likelihood of migration is 4.218 times higher for married migrants than for single ones. Education level is a significant migratory factor. Generally higher education level increases the probability of migration, however, we have to remember that those type of migrations do not belong to the distress category where people move out due to various socio-economic, environmental, and political hindrances. The reference group in this case includes illiterate migrants, and at the 1% level of confidence, there is a statistically significant correlation. The likelihood of migration is 3.289 times higher for migrants with a primary education than for those without one. Semi-literate migrants (secondary level) are found to be insignificant and they are less likely to move out than illiterates. It's interesting to note that migrants who have completed higher secondary school (12th grade) are 1.875 times more prone to migrate than illiterate people, and their link is statistically significant at the 10% level of confidence. According to our research, the likelihood of migration is the same for both literate and illiterate people. Among social groups, we have considered the general category as a reference category which shows no significant relationships; however, Schedule tribes are 4.387 times, Schedule castes are 1.214 times and other backward classes are 1.114 times more likely to migrate than general populations. Our survey data shows that majority of these socioeconomically disadvantaged groups belongs to landless labourers and marginal farmers. Size of landholding is an important economic force behind migration decision. With landless labourers considered as a reference category, it shows an insignificant relationship. Odd ratio of marginal farmers reveal

that they are 2.317 times more likely to migrate than landless labourers. This is really important because landless labourers are “trapped” in drought affected area due to economic constraints. Marginal workers have statistically significant relationship at 1% confidence level and odd ratio indicates that as the number of marginal workers increases, out-migration also increases. This is justified as lack of work availability throughout the year increases economic burden to the households while people move out looking for work. Household income is the most important parameter determining migration decisions. Here negative coefficient of monthly income implies that lower the income, higher the migration. Indebtedness is central to the lives of migrants in our country. It can motivate the need for migration and conversely, migrants, can take loans to finance their movement outside their state boundary. The remittances that migrants send home are often used to repay household debt. In this case, the model indicates that households under pressure from debt have a 2.317-fold higher likelihood of migrating than those without any loans. Outstanding loans explores how debt and financial insecurity influence migration decisions, so it is critical to understand how many households have outstanding loans and are used in migration. Next, the model has included several variables related to environmental vagaries, and through their contribution, we want to argue that drought and other environmental vagaries a significant factors that propel migration. The study used micro-level data from a household survey to demonstrate that stresses from the environment do not have the same effect on everyone and that households do not react to environmental stresses in the same way because, although migration may be an option for survival for some households, there are other reasons why migration may not be triggered. For example, in our study, we showed that while people move out due to crop failure as a result of increasing drought and climate stress, many households suffering from the same environmental challenges get trapped due to a lack of resources. However, from our model, we can observe that drought and decreasing amount of rainfall during monsoon showed a significant relationship at 1% and 5% confidence levels and the odd ratio showed that drought-affected households are 3.127 times and households specified decreasing rainfall during monsoon are the likelihood of migration is 1.817 times higher than that of households without any environmental challenges.

8.7.1 Adaptation strategies

Table 38 shows major coping & adaptations used by farmers in the study area

	Drought	Landholding size	HH income	Education
Changing to low water consuming crops (Instead of HYV, they use desi seeds)	0.13	0.07	0.75	0.42
Less use of fertilizer	0.51	0.20	0.97	0.59
Use of Water harvesting techniques (hapa, ditch)	0.02	0.08	0.34	0.72
Reducing cultivation area	0.35	0.25	0.28	0.45
Borrowing money	0.00*	0.01*	0.00*	0.02*
Selling livestock & HH assets	0.02*	0.01*	0.28	0.47
Internal migration	0.00*	0.00*	0.02*	0.47

Farmers with small landholdings often resort to selling livestock and household assets. Moreover, those who experience frequent droughts, have low incomes, possess minimal land, and have limited education are inclined to take loans to mitigate their vulnerability.

8.8 Life history

8.8.1 "Semi-permanent migration is good"-improves the quality of life of people.

Dinesh Mahato is a 48-year-old small farmer living in Gopal Nagar village in Baghmundi block, Purulia district. He has two sons and two daughter-in laws along with his wife. He owns 1 to 1.50 hectares of land and grows rice and vegetables. His two sons used to migrate in Kolkata and Tamil Nadu respectively during lean season. They first migrated in 2015.Since then it is a regular phenomenon. His elder one, who migrates to Kolkata has taken up various informal, low paying jobs (such as cleaner, driver, carrier etc), and the other one who migrate to Tamil Nadu works in Brick-kilns. Dinesh's elder son passed class 12 and the young one has passed class 10. Dinesh said, *"both of my son never has the intention to cultivate, I do not blame them. They have both seen the meagre income from cultivation, especially during drought years when we face crop loss and reduced income. And further, the hardship has increased after they got married, expenses got increased. Limited income from cultivation only manages two square meals for the family, nothing else. My sons are young, they need more than just meals. They have aspiration to buy bikes, smartphones. You cannot fulfil these aspirations with these little income from agriculture. They have contacted people who have migrated in Tamil Nadu and Kolkata, managed to get a temporary work. They both migrate during lean season. They assist me in the field during the busiest times of the year, but I'm not sure how long they will be there. They both wants to move out permanently. Once they got that opportunity and accommodation, they will take their wives as well*" When asked that how long his sons stay at their destinations, he informed that *"around 5/6 months they are out"*.

Dinesh recalled, "*during my childhood, my father and my uncle both used to cultivate the land and produce rice, and vegetables. We were able to sell excess after keeping for ourselves. Drought was there, but once in a decade. We had works under MGNREA back in the day, but now we do not have that work as well. Now, income from agriculture alone cannot support my family. We do not have excess now"*. He added that, now a

days agriculture becomes unprofitable and the price of agricultural equipment have increased. Frequency and intensity of drought has increased, cultivation days get shorter, yield gets hampered with heavy precipitation during harvesting period. Both of his sons are not interested in agriculture and asked him to rent out the agricultural land. He does not blame his sons but could not rent out the land as well. He added, *"I got the land from my father, I have cultivated in this land since my childhood, cultivating rice is an obsession".* He mentioned that young generations are withdrawing themselves from land and opt for migration which pays more than land.

When asked about the challenges in destinations, he mentions, *"my elder one who used to migrate in Kolkata, only have the problem of accommodation, it's too costly. But my son who works in Tamil Nadu faces numerous problems there. Language difference, health problems and sometimes even get paid less than the local workers, still, I would say migration is good, at least it helps to repay our debt, cover daily expenses and helps during health emergency".*

8.8.2 Tale of a female migrant

Sandhyarani Mondal is 38 years old mother stays with her 2 daughters, husband and in laws in Kendbediya village of Baghmundi block. Her family own land of less than 1 hectare and produce only rice. Her husband works as a construction worker in Karnataka for the last 8years.Her father-in-law works in the field. Sandhya takes care of her entire family, works in the field along with her in law. She said, *"my husband stays outside, used to come once in 2 years. He sends money every 2/3 months for our family. My mother-in-law is sick. She cannot do any domestic work. I have to do all the domestic work, taking care of my 2 daughters and mother-in-law. Burden increases when we hit by drought, or monsoon is not good. I have to migrate to Purba Burdwan in those years to work as an agricultural labour (like severe droughts during 2002,2009,2010). However, droughts became regular phenomenon since then".* She added, *"increasing frequency of droughts, absence of irrigation, untimely monsoons led to regular loss of income. Also, cost of agriculture has increased, so does, daily expenses of family and increasing burden of illness. We took multiple loans. So, I had no choice but to work regularly as an agricultural labourer during harvesting time*

since 2015. Most of our money used to spend on the treatment of my mother-in-law. Pressure increases when I have to migrate, but we are left with no other option. I have two daughters, I have to think about their education and marriage, moreover we have already taken loan".

She added that "*My husband sends around 5000-6000 every 2/3 months, but regularity does not always maintain*". When asked about migration, she said, *"I do not want to move out every year. It is hectic for me to travel Purba Burdwan and work in the field. I worry about my daughters, my sick mother-in-law. Even my health is deteriorating. I even do not want to stay away from my husband. My husband also doesn't want to stay so far away from family. He also struggles a lot over there. But there is no work here. How can my husband come here? We cannot even go there. My in-laws are ill, we simply cannot abandon them".*

Table 39 Farmers' various coping and adaptation strategies towards drought in Man Bazaar 1 and Baghmundi sub-districts

	Categories	Strategies
Coping	Crop management (growing less water-demanding and heat-tolerant crops)	**Pulse-like Arhar can be grown**
		Sahabhagi and Bhupen are examples of short-duration, drought-resistant paddy types that can be grown.
		If monsoon departs early short-duration seed kits like Toria, linseed, khesari, gram is grown
Coping	Modifications in input usage due to drought	**Reduced fertilizer use**
		Use of desi rice seeds which require less water

Coping	Water management techniques because of drought	**Look for water in other villages**
		Re-excavation of ponds
		Dug hapa/ditches
		Construction of dug well (pat kua)
Coping	Cultivation:	**Reducing cultivation area**
Coping	Cultivation:	**Altering sowing time**
		As a village-level local coping mechanism to address the issue farmers face during seasons with insufficient rainfall, a staggered communal nursery
Adaptation	Income diversification	**joined local jobs (daily wages, construction workers etc.)**
		Migration
Coping	**Assets depletion**	**Livestock (Selling of animal for fulfilling household requirement)**
		Selling households utensils
		Sold or mortgaged land

Coping	**Expenditure adjustment**	**Borrowing money**
		reducing spending on things like clothing, food, medical expenses, education, building a home, and family and social gatherings.

8.9 Findings

1. Since 2000, drought has been more prevalent and more severe in the study area.
2. There have also been more instances of high to very high precipitation, but this precipitation could not to sustain cultivation—it usually began around the end of July in recent times—and because Purulia has hard rock and undulating terrain, runoff is quite high.
3. All the drought year coincides with low yield in rice which is the staple food of the region
4. Variation in the rice yield has increased from 6% to 33% from 1970-2015
5. Reduced rainfall during monsoon and increasing maximum temperature have a statistically significant relationship with crop
6. It is discovered that the majority of those impacted by the drought are socioeconomically vulnerable and mainly live in the Purulia district's south and southwest.
7. The subdistricts that fall into the same category of high socio-economic vulnerability and drought have poor irrigation facilities, high agricultural dependency, illiteracy, poor access to resources, and low landholding sizes with large families.
8. The binary logistic model has identified large households, education and age of migrants, backward social groups, outstanding family loans, poor household

income, drought, and delayed monsoon as the underlying drivers behind migration decision

9. According to the study, the likelihood of short-term migration due to drought is higher among those with socioeconomic disadvantages. In recent times people have migrated during both peak and lean periods as monsoons started late

10. In the research area, when all factors are controlled for, there is a positive correlation between drought and the likelihood that a household will have just one short-term migrant member.

11. Repetitive drought led to temporary migration, while the extreme drought (during 2010) with intensities above 2 is causing permanent migration

12. Inter-state migration is predominant in the migration stream, often involving loans that subsequently increase the debt burden.

13. Recently, there has been a significant decline in intra-state migration in West Bengal, primarily due to the scarcity of work opportunities, particularly under the MGNREGA scheme.

14. Major coping strategy includes crop management, use of desi rice seeds, excavation of ponds, hapa, ditch, livelihood diversification, borrowing money

15. Internal migration, whether temporary or permanent, acts as an adaptation strategy for both emigrants and recipients of remittances. The region is plagued by increasingly severe droughts, insufficient irrigation, crop failures, income loss, drinking water shortages, and a dearth of social support programs.

Chapter 9

(Summary and Conclusion)

9.1 Summary and Conclusions

The current thesis, "Exploring the link between climate variability, drought, and internal migration in Purulia district, West Bengal, India," used a primary household survey dataset on two Purulia sub-districts to investigate how internal migration flows are affected by drought and climate variability.

The study indicates a significant decrease in monsoon rainfall within the district. This decline in both annual and monsoon rainfall is statistically significant. Regarding temperatures, since 2000, both the maximum and minimum temperatures have considerably increased, with the maximum temperature rising more quickly. These results are consistent with the 2017 analysis of the West Bengal State Action Plan on Climate Change. The Rainfall Anomaly Index (RAI) analysis, which identifies dry and wet years, shows an increase in dry years within the study area. The most severe negative RAI, at -2.09, occurred in 2010. From 2000 to 2020, negative RAI values exceeding one were recorded in five years: 2000, 2001, 2009, 2010, and 2015. In contrast, such high-intensity negative anomalies were only noted twice between 1970 and 1999, in 1979 and 1992. The growing frequency and intensity of negative RAI values, indicative of severe droughts, are concerning for the already drought-prone district. The annual standardized precipitation index (SPI) results reveal droughts occurring more frequently and with greater severity post-2000, with significant droughts occurring in 2000, 2001, 2002, 2005, 2009, 2010, and 2015. These years also saw negative SPI values ranging from -1 to -2.09. Before 2000, such high-intensity droughts were rare, occurring only two or three times. The precipitation concentration index, which averages a high PCI of 19.44, shows high to extremely high precipitation concentrations despite a decrease in total precipitation and an increase in dry years. However, because it does not fall during the sowing months, this high concentration of rainfall is unable to sustain rainfed agriculture in the district. The primary survey and secondary data both clearly show this delayed monsoon occurrence.

While rice yields have generally increased over time, they have also experienced fluctuations due to extreme climatic conditions. A significant correlation exists between

rice yield patterns and the occurrence of droughts. Recurrent droughts, compounded by inadequate irrigation, have resulted in crop failures. Drought has affected 20 sub-districts in varying years, with the 2010 drought impacting all of them. In 2010, an extreme drought year, Purulia's southern (Bandwan, Manbazar I and II, Puncha) and western (Baghmundi, Joypur, Jhalda II) sub-districts were profoundly affected, having already suffered severe drought from 2000 to 2015. Drought conditions in 2005, 2010, and 2015 coincided with a decrease in the primary working population and an increase in marginally employed and non-working individuals from 2001 to 2011. Spatial analysis indicates that the district's south and southwestern parts are predominantly affected by drought, as confirmed by Raha and Gayen's 2021 study. Drought years have led to reduced crop production, resulting in increased marginalization and unemployment. Persistent droughts, insufficient irrigation, and regular crop failures have led to continuous unemployment, entrenched poverty, and heightened social vulnerability. The traditional practice of subsistence farming heightens the risk of crop failure amid repeated droughts, a risk exacerbated by unusual or severe weather conditions, which are probably going to happen more often. Areas like Purulia, which are underdeveloped and impoverished, are particularly vulnerable to these disruptions due to their reliance on agriculture as well as a lack of funding and technical assistance to deal with these issues.

This study assesses social vulnerability at the sub-district level to ascertain which sub-districts in Purulia are vulnerable to drought. Six sub-districts—Arsha, Baghmundi, Bundwan, Man bazar 1, Man bazar 2, and Joypur—were significantly vulnerable socio-economically in both assessed years (2001 & 2011). Despite a decrease in social vulnerability from 2001 to 2011, these sub-districts were still more vulnerable compared to others, as per the 2011 Social Vulnerability Index. The study also revealed that 14 out of 20 sub-districts have faced drought and social vulnerability. Among these, Baghmundi, Man Bazar 1, Man Bazar 2, Joypur, and Bundwan are categorized as highly vulnerable to both drought and social adversities. From 2001 to 2011, these sub-districts underwent droughts more frequently than others and did not see an increase in irrigated areas. With irrigated land constituting less than half of the total cultivated area, their ability to counteract the intensifying severity of droughts is constrained. Socio-economically, these sub-districts face challenges, with a larger rural populace reliant on natural resources for their livelihood, making them more prone to climatic extremes

such as increased drought incidences. Factors like high population growth, limited access to assets, and a higher percentage of non-labourers add to their vulnerability to droughts.

Man Bazar 1 and Baghmundi were chosen for the primary survey due to their social vulnerability and frequent droughts. These sub-districts are socio-economically vulnerable and have consistently faced droughts since 2000. A binary logistic model has identified factors such as large family size, education and age of migrants, marginalized social groups, outstanding debts, low household income, drought, and delayed monsoon as significant in influencing migration decisions. Household size is positively related to outmigration; larger families may have a greater need for income, prompting members to migrate for better economic opportunities, particularly when local resources are scarce. Illiterate migrants have a significant relationship with migration at a 1% confidence level at Baghmundi. The chance of migration is 4.061 times higher for migrants who have completed elementary school (class 8) than for those who have not in Manbazaar 1. Compared to those between the ages of 15 and 24, migrants between the ages of 25 and 34 had a 5.35-fold greater chance of leaving Manbazar 1. Migration among social groupings is statistically significant for the socially and economically marginalized Scheduled Tribes and Castes in both blocks. At a 5% confidence level, the relationship between outmigration and outstanding loans or debt pressure is statistically significant. The chances of migration are roughly 2.273 times greater for households with outstanding loans than for those without. One of the main drivers of migration is low income; as income rises, the likelihood of migrating declines. The primary survey identified two patterns of migration: short-term and permanent. Repetitive moderate droughts have led to short-term migration, whereas extreme droughts, like the one in 2010 with intensity over 2, have resulted in permanent migration, as the survey results show. According to the study, economically disadvantaged rural inhabitants are more likely than their wealthier counterparts to experience temporary migration as a result of drought. Even after controlling for all other factors, there is a positive relationship between drought conditions and the chance that a household will have at least one temporary migrant. The increasing occurrence of droughts has prompted temporary migration, while the severe drought of 2010, with intensities exceeding 2, has led to permanent migration. Intra-state migration is predominant, with short-term migrants mainly moving within the state. Males are the

majority in this migration flow, often citing unprofitable agriculture as the primary reason for relocating, followed by the recurring issue of drought. Most have migrated during both peak and lean seasons in the last 10 years due to the escalating droughts in the monsoon months, and 60% of households are considering future migration as it is more lucrative than farming. Major coping strategies include crop management, the use of local rice varieties, digging ponds, creating hapas and ditches, diversifying livelihoods, and borrowing money.

This research is the inaugural study within the Purulia district to examine climate variability, drought, social vulnerability, and internal migration. It reveals a rising trend in climate variability and drought, negatively impacting agriculture by causing reduced production, crop failures, unemployment, and increased social vulnerability. The study also shows that the most disadvantaged individuals live in drought-affected areas with substandard socio-economic conditions. Continuous droughts, diminishing rainfall during monsoon seasons, inadequate irrigation facilities, and recurrent crop failures in the district's rainfed agriculture have resulted in asset erosion, indebtedness, heightened vulnerability, and a scarcity of alternative employment options, prompting internal migration.

Interventions in the areas of irrigation, cultivation methods, and the reduction of social vulnerability are necessary to strengthen the resilience of the population. The introduction of micro-irrigation systems such as hapas, ponds, and dighis can reduce dependence on rainfall for agriculture and serve as an alternative source of drinking water in times of drought, eliminating the need to fetch water from long distances. The provision of these facilities at the sub-district level can lessen the adverse consequences of drought. Additionally, it can increase the effectiveness of the Public Distribution System's (PDS) free food distribution which is already underway. Social security concerns can be addressed through existing programs such as MGNREGA, which require efficient and consistent labor distribution, especially during droughts when agriculture is unproductive and people lose their income. As far as farming practices are concerned, the cultivation of millets, which require less water and are drought resistant, can be promoted. The population's social vulnerability can be decreased by ensuring that there is water available for irrigation and consumption, growing foods that can withstand drought, and offering social security programs. These actions can also lessen out-migration.

9.2 Limitations of the study

The research is based on demographic data from 2011, as more recent statistics are unavailable. The study is confined to the year 2015, the most recent year for which agricultural data for the district exists. Evaluating the effects of drought on crop yields and social vulnerability is critical, necessitating current data to pinpoint socially vulnerable groups in the impacted regions. Moreover, due to limited resources, the survey was restricted to just two sub-districts of Purulia. The study relies on women's accounts of their husbands' migration, potentially leading to recall bias. Importantly, gathering formations from women includes male migrants not present during the data collection, who form a substantial part of the sample.

Although this study has its constraints, it notably advances our comprehension of the climate-migration connection by offering considerable proof that out-migration in the study area is linked to climate extremes, particularly droughts. It further corroborates the idea that the economic, and social, characteristics of the originating communities, along with climate disruptions or risks, significantly shape migration decisions. In the specific situation, characterized by an economy reliant on rainfed farming with insufficient irrigation, restricted access to resources, and a lack of local alternative job opportunities, migration presents itself as an attractive solution for families dealing with the repercussions of climate shocks.

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