

Agriculture in Odisha: Challenges Due to Climate Uncertainty

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by

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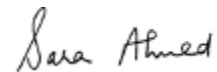
Supervisor: Sara Ahmed

Adarsh Subash Pradhan

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Certificate

This is to certify that this dissertation, entitled “Agriculture in Odisha: Challenges Due to Climate Uncertainty,” towards the partial fulfillment of the BS-MS dual degree program at the Indian Institute of Science Education and Research, Pune, represents a study carried out by Adarsh Subash Pradhan at the Indian Institute of Science Education and Research under the supervision of Sara Ahmed, Adjunct Faculty, Department of Humanities and Social Sciences, during the academic year 2022-2023.



Sara Ahmed

Date: 09/05/23

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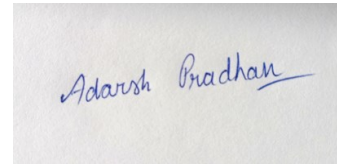
Sara Ahmed

Shalini Sharma

This thesis is dedicated to my parents, who have supported me all my life, and all my teachers, who have guided me in my journey.

Declaration

I hereby declare that the matter embodied in the report entitled "Agriculture in Odisha: Challenges Due to Climate Uncertainty" is the result of the work carried out by me at the Department of Humanities and Social Science, Indian Institute of Science Education and Research, Pune, under the supervision of Sara Ahmed, and that the same has not been submitted elsewhere for any other degree.

A rectangular box containing a handwritten signature in blue ink that reads "Adarsh Pradhan".

Adarsh Subash Pradhan

Date: 30/04/2023

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Abstract

The aim of this thesis is to investigate the impacts of climate change in the rural areas of Angul, Odisha. Due to various political and economic reasons, there is a lack of research on Angul. The study explores the effects of climate uncertainty in Angul using multiple qualitative research methodologies, such as semi-structured interviews, in-depth interviews, qualitative observations, and focus group discussions. The result of this study suggests that climate change has resulted in the loss of agricultural yield, market saturation of crops, water crises, loss of livelihood, migration of young people, health risks, and human-wildlife conflict. Although the four research locations have similar environmental conditions, the impact of climate change is very different. Padmapur is the most affected by climate change, while Naupada and Balipatta can resist climatic shocks due to their natural resources. Further research is needed to expand the sample size and conduct ethnographic studies to better understand climate change's impact on the rural communities in Angul and Odisha.

Chapter 1- Introduction

1.1 Background of the Topic-

Agriculture is the world's oldest profession, sustaining human life. It employs over a third of the world's workers, but there is a decreasing trend in agricultural workers due to industrialization. In most developing countries, agriculture is crucial in achieving economic development, ensuring food security, and improving nutrition. Policies should focus on improving productivity, efficiency, and sustainability and put great emphasis on smallholder farmers, who are often vulnerable to food insecurity and climate change.

Climate change impacts agriculture in multiple ways, including changes in temperature, rainfall, extreme weather conditions, pests and diseases, atmospheric concentrations, the nutritional quality of foods, sea level, and the content of seawater. These impacts are not distributed evenly around the globe. Countries in low-latitude regions may experience a negative impact on their crop production, while those in northern latitudes may be affected positively or negatively (Folnović, n.d.).

“Higher temperatures can reduce crop yields, and changes in precipitation patterns can lead to droughts or floods, harming crops and resulting in less agricultural output. Carbon emissions can improve the process of photosynthesis in C3 crops such as wheat, rice, and soybeans, but C4 crops such as sugarcane and maize, which comprise a significant portion of global crop production in terms of value, do not benefit from increased carbon levels.” (Cline, 2008, p. 24).

Cline (2008) argues that climate change will significantly impact global agriculture, potentially leading to severe food security and economic growth consequences. He suggests that climate change will likely reduce global crop yields and agricultural productivity as a consequence of temperature changes, precipitation fluctuations, and more frequent extreme weather events. This could result in food shortages, higher food prices, and increased malnutrition risk, particularly in developing countries. Additionally, climate change could worsen existing economic disparities between developed and developing countries, with poorer countries being more vulnerable and having fewer resources to adapt.

According to Nelson et al. (2010), there will be a significant impact of climate change on agriculture worldwide, particularly in underdeveloped countries. The authors estimate that agricultural productivity could decrease by up to 16% by 2020 and up to 30% by 2050. Small-scale farmers, who lack the resources and knowledge to adapt, will be the most affected. The authors suggest adaptation measures such as crop breeding and genetic engineering investments, expanding irrigation systems, improving soil management, and promoting

sustainable agriculture practices to help farmers adapt to changing conditions while reducing greenhouse gas emissions.

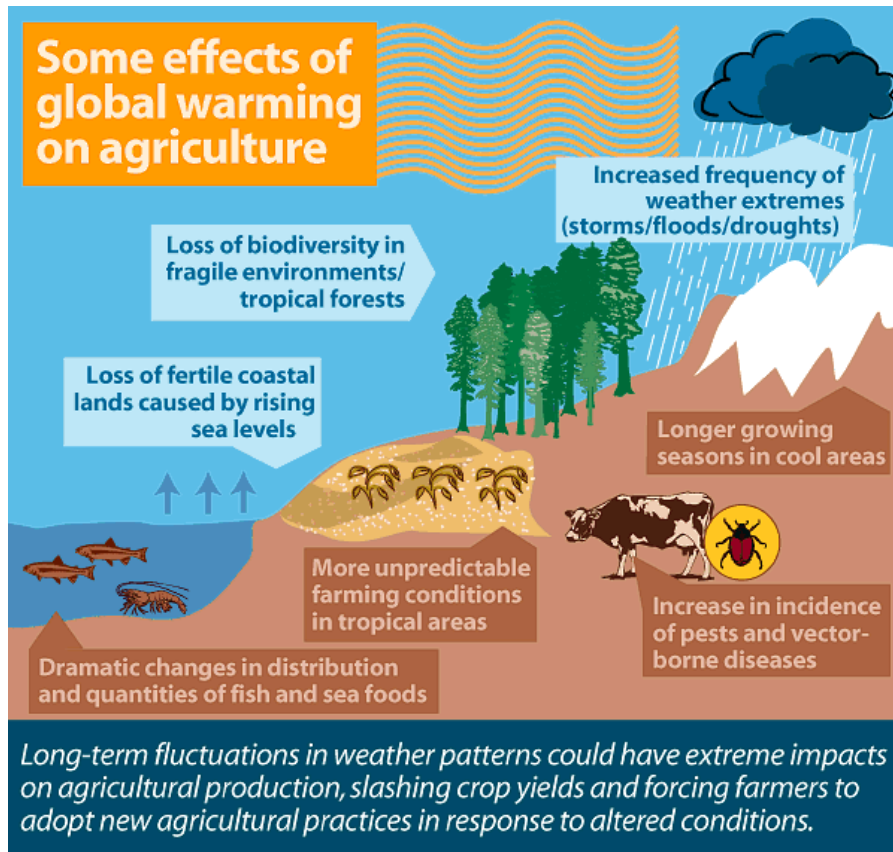


Fig 1- A generalized observation of the effect of global warming on agriculture.

There has been a lot of research on how climate change affects the environment and agriculture, but there haven't been as many studies on how it affects less developed nations and how it affects society. While studies have primarily focused on environmental and economic impacts, it is now increasingly recognized that climate change can also lead to displacement, migration, conflict, and changes in cultural practices and traditions. These consequences can be particularly severe for vulnerable communities in less developed countries.

This project aims to examine how climate uncertainty affects various socio-economic groups in Odisha, a state in eastern India that relies heavily on agriculture. With vast agricultural resources and potential, agriculture is a primary occupation for a significant percentage of Odisha's population. The state's fertile soil, abundant rainfall, and diverse agro-climatic zones make it suitable for various crops, including rice, maize, wheat, pulses, oilseeds, sugarcane, cotton, and jute. Additionally, Odisha has an estimated water resource of 11% of India's total surface-water resources, which supports irrigation from surface-water resources like ponds, lakes, rivers, and groundwater.

Odisha is vulnerable to the consequences of climate change because of its coastal location, high population density, and significant reliance on agriculture and natural resources. These effects consist of more frequent and intense adverse climatic events such as cyclones, floods, and droughts, as well as rising sea levels, coastal erosion, changes in monsoon rainfall timing and intensity, and modified precipitation patterns (Khayat, 2022).

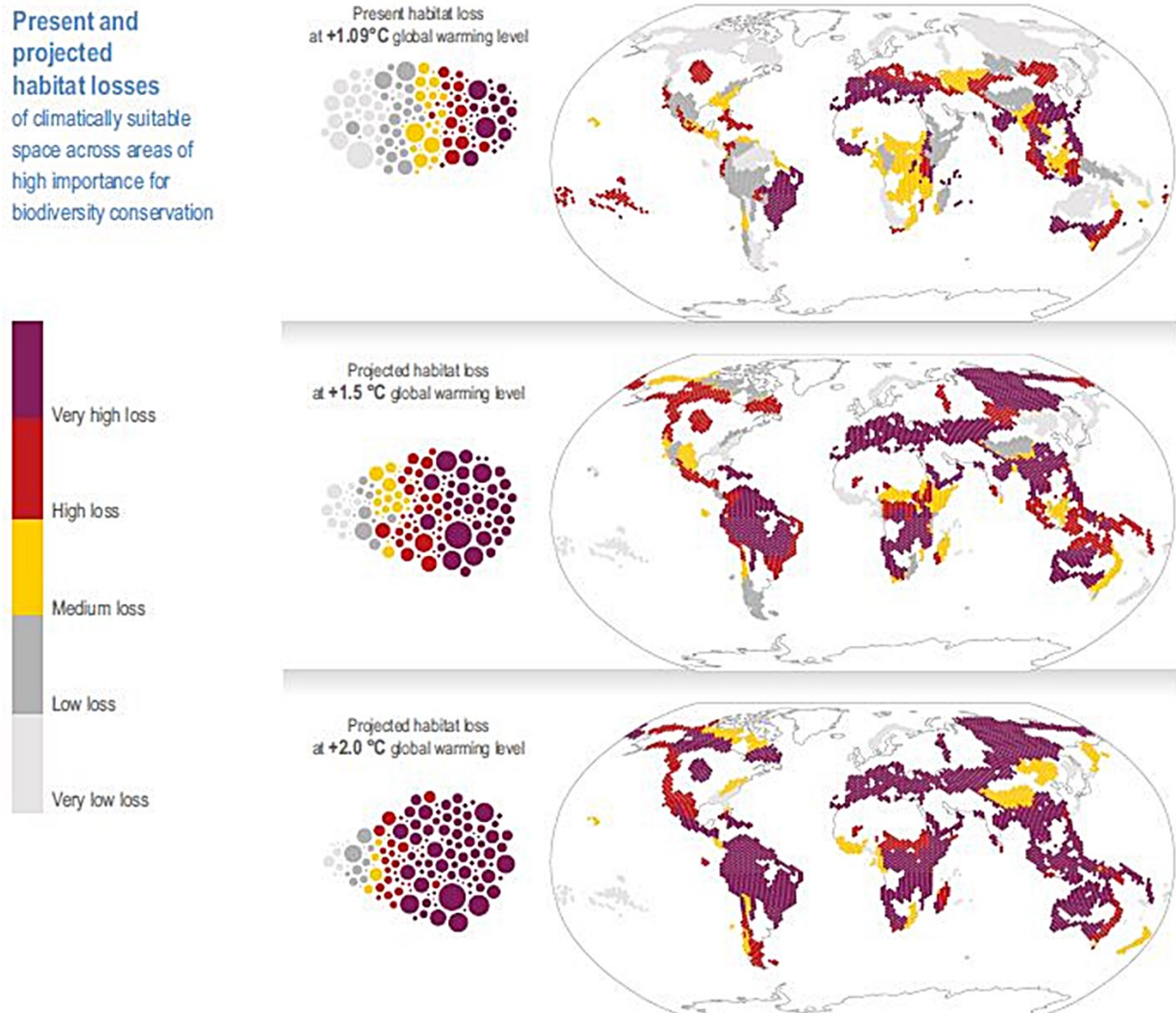


Fig 2- Present and projected habitat losses of climatically suitable areas in terrestrial biodiversity hotspots. Source: IPCC (2022)

The IPCC 2022 report suggests that India's eastern and northeastern regions will face significant habitat loss if the current global warming trend continues. In addition, compared to other regions of India, Odisha has seen less research on the effects of climate change despite its high vulnerability to it.

1.2 Research Scope-

This project aims to explore the consequences of climate change in the rural areas of Angul, Odisha. The project will run for one year, commencing with desk research from June 2022 to September 2022, followed by field visits and data collection between October 2022 and January 2023, and culminating in data analysis and thesis writing from February 2023 to April 2023. The study will be conducted in four villages, namely Naupada, Balipatta, Padmapur, and Ambapal, all located in the Angul district of Odisha.

Farming is the primary industry in these villages, and most of the villagers are engaged in some kind of agricultural activity. The study will employ a combination of semi-structured interviews and qualitative observations to gather data from the villagers. The research participants will comprise farmers, agricultural workers, and female villagers. Due to time constraints and limited experience, the collected data may have limited in-depth knowledge, and some information may be inaccurate. The study will make every effort to guarantee the accuracy and dependability of the collected data.

1.3 Objectives and Research Questions-

The primary aim of this project is to study how climate change affects agriculture and society in Odisha. This study addresses two overarching research questions: first, how climate change impacts agriculture in Odisha and how farmers cope with it, and second, the social repercussion of climate change in Odisha.

To achieve the main objective, this project will look into the following research questions:

- 1- What is the impact of agriculture on the groundwater levels in Odisha, and how does the reduction in groundwater levels influence agricultural productivity and water availability?
- 2- What is the impact of class, caste, and gender on access to water for livelihoods and agricultural production?
- 3- How does groundwater contamination affect agriculture, and how does agriculture impact groundwater quality?
- 4- What measures are available to reduce the effects of climate change on agriculture, and how have male and female farmers responded to water stress resulting from too much, too little, or irregular rainfall?
- 5- What agricultural schemes are available in Odisha, and how do they support farmers during times of crisis?

1.4 Thesis Outline-

This dissertation is structured into seven distinct chapters, each with a specific emphasis. Chapter 1 briefly introduces the subject matter. Chapter 2 provides a comprehensive literature review, which details the various impacts of climate change globally and the current situation in Odisha. Chapter 3 presents the research methodologies that outline the process undertaken during the project. Chapters 4 through 6 focus on presenting the core findings of this thesis. Finally, in Chapter 7, the thesis concludes with a research overview, including a summary of the research questions and limitations faced during this project.

Chapter 2- Literature Review

2.1 Introduction-

Climate change pertains to the alterations in the Earth's climate over an extended period, especially the increase in global temperatures, alterations to precipitation patterns, the rise of sea levels, and extreme weather events resulting from both human activities and natural variability (IPCC, 2018). According to the Intergovernmental Panel on Climate Change, climate change is characterized as "a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer" (IPCC, 2014, p. 118).

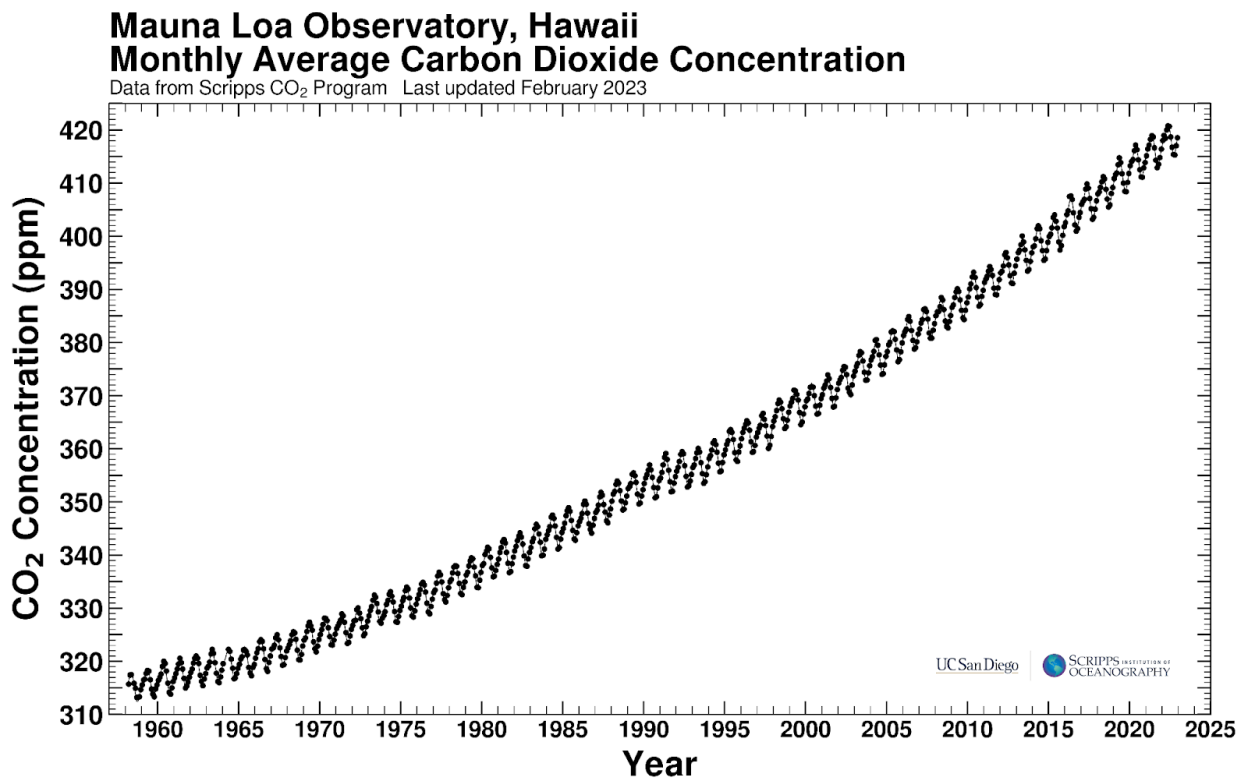


Fig 3- Measurements of atmospheric CO₂ since 1958 from the Mauna Loa Observatory in Hawaii show a steady annual increase in atmospheric CO₂ concentration. Source: Scripps CO₂ Program.

When greenhouse gases, such as carbon dioxide, methane, and nitrous oxide, exist in the atmosphere, they can prevent heat from escaping, contributing to global warming. Human activities, such as burning fossil fuels and deforestation, have caused an increase in the concentration of these greenhouse gases, intensifying the greenhouse effect and leading to climate change.

The levels of greenhouse gases in the atmosphere have risen significantly since the beginning of the Industrial Revolution, and the main factor behind global warming is the rise in global carbon dioxide levels. The “global average surface air temperature has risen by about 1 °C since 1900” (National Academy of Sciences, 2020, p. 9). The Royal Society (2020) states that climate change has various consequences, such as an increase in sea levels, a rise in the occurrence of heat waves and severe weather conditions, and a decline in biodiversity. These consequences have indirect repercussions, such as increased coastal erosion, food and water insecurity, and disease risk.

The National Academy of Sciences (2020) reports that various consequences of global warming have become apparent, such as the reduction in Arctic summer sea ice coverage and the increase in the global average sea level. Changes in temperature and precipitation also affect the distribution and timing of the life cycles of various plant and animal species. Additionally, the surplus carbon dioxide in the atmosphere is causing the acidification of the oceans.

2.2 Climate Change-

Climate change is caused by human actions like burning fossil fuels and clearing forests, which result in the variation of weather patterns and temperatures over an extended period of time. This has resulted in increased heat waves and intense wildfire seasons. As global temperatures continue to rise, different regions will experience further changes.

The water cycle is intensified by climate change, resulting in more severe occurrences of floods, droughts, and rainfall in different regions of the world. High latitudes may experience more precipitation, while the subtropics may see less. The monsoon precipitation will differ in different areas, and coastal regions will encounter a persistent rise in sea level, leading to more intense coastal erosion and flooding. Extreme sea level events may become an annual occurrence by the end of the century. The thawing of permafrost, melting of snow cover, glaciers, and Arctic sea ice will also intensify due to further warming. Ocean warming, acidification, reduced oxygen levels, and more frequent marine heat waves have human links, affecting ocean ecosystems and coastal cities. Climate change can lead to increased heat, flooding, and sea level rise in urban regions (IPCC Press Release, 2021).

Climate change and adverse weather conditions have negatively impacted ecosystems, food security, people's livelihoods, health, and security while exacerbating existing societal issues such as inequality and poverty. According to the IPCC (2019), increased irrigation has decreased groundwater storage, and warmer climates are altering groundwater regimes at higher altitudes.

However, tropical aquifers have demonstrated greater resilience to climate change due to increased recharge from severe precipitation and flooding.

Taylor et al. (2013) highlight that climate change causes shifts in groundwater resources, impacting their quantity, quality, and timing. According to IPCC (2014), climate change threatens the livelihoods of the poor and marginalized by depleting soil nutrients, water reservoirs, and drinking water, causing flooding and erosion that exacerbate food insecurity and negatively affect well-being in several African, Asian, and Latin American countries (Aniah et al. 2016).

2.3 Impact on Agriculture-

The agriculture sector is impacted by climate change, as it disturbs the regional features of ecosystems such as temperature, precipitation, and sunlight. These changes affect vital components of agricultural production like arable land, livestock, and hydrology (Kim, 2012). Nelson et al. (2010) state that higher temperatures may decrease the yields of desirable crops and promote the growth of weeds and pests. Alterations in precipitation patterns raise the likelihood of crop failures in the short term and declines in production in the long term, negatively impacting agriculture globally and posing a threat to food security, despite some gains in specific crops and regions.

The agriculture sector is highly vulnerable to natural disasters, causing increasing economic losses globally. Climate-related disasters accounted for 77% of the direct economic losses of US\$ 2908 billion experienced by disaster-hit countries during 1998–2017. According to an estimate by the Indian government, climate change's adverse effects on agriculture have led to an annual economic loss of around US\$ 9-10 billion (Srinivasa Rao et al., 2019; UNISDR, 2018; Government of India, 2018).

Climate change affects agriculture directly and indirectly through its impacts on crops, livestock, soils, and pests. Although C3 crops can benefit from increased atmospheric carbon dioxide, higher temperatures have adverse effects, including shorter crop growth duration, altered photosynthesis, increased pest populations, accelerated nutrient mineralization, reduced fertilizer effectiveness, and higher levels of evapotranspiration (Gupta and Pathak, 2016).

The IPCC (2019) reports that as the temperature continues to rise, climate change will increasingly harm crop productivity, with the impact varying depending on the concentration of CO₂, the level of soil fertility, and the regional climate. The effects of climate change will impact the production of significant commodity crops like corn, wheat, rice, soybeans, coffee, cocoa, cotton, and palm oil. Additionally, variations in temperature and CO₂ levels will affect the production of fruits and vegetables (IPCC, 2019).

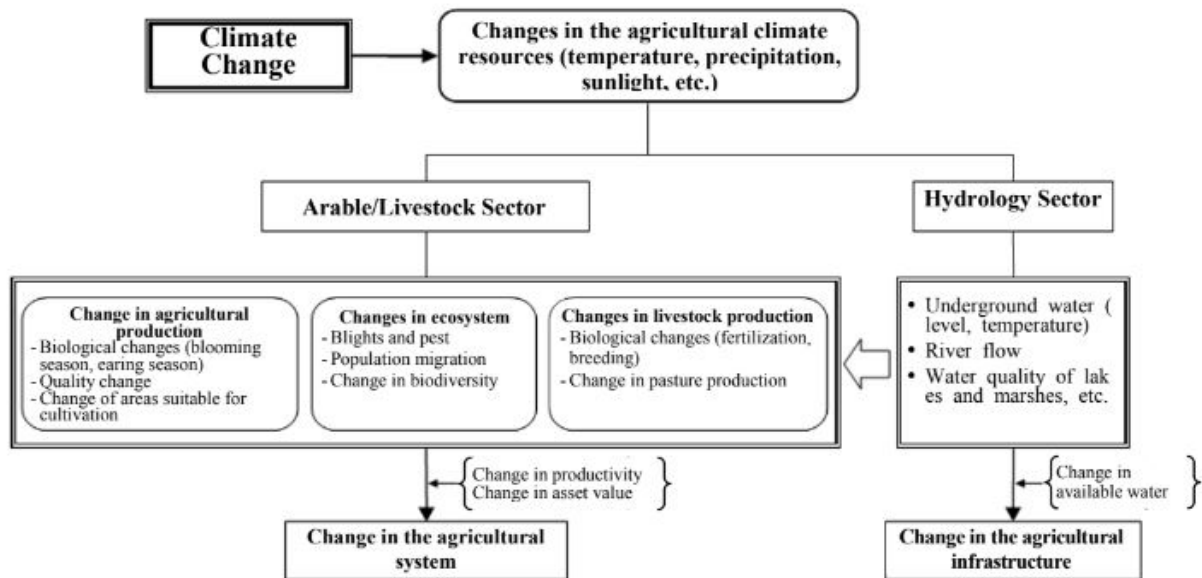


Fig 4- Flow of climate change impact on the agricultural sector. Source: Kim et al., 2009.

According to IPCC (2019), an increase in temperature, variation in precipitation, and atmospheric CO₂ concentration affect livestock systems. Temperature rise impacts animal health, production, reproduction, and water availability, while changes in temperature and precipitation affect disease spread. Livestock productivity is linked to rangelands and pastures, which are affected by increased CO₂ levels in biomass and nutritional quality, potentially resulting in adverse impacts due to variations in factors such as pasture quality, disease spread, and water availability across different regions.

The prevalence of pests, diseases, and vectors that cause diseases in crops and livestock is likely to be affected by climate change. The extent of these changes will depend on local factors, such as local environmental conditions and management practices. Agroecosystems that have been disturbed are more susceptible to outbreaks of pests and diseases. While the exact alterations in pests and diseases may differ, they will most likely occur (IPCC, 2019).

2.4 Social Impact-

Climate change is a pressing global concern with profound implications for social justice that will affect both current and future generations. It creates a division between countries with high greenhouse gas emissions and those with limited resources, who will bear the brunt of the most severe consequences. The anticipated effects of climate change on agriculture, floods, malnutrition, water resources, and health will likely lead to global poverty.

“The impacts of climate change, and the vulnerability of poor communities to climate change, vary greatly, but generally, climate change is superimposed on existing vulnerabilities. Climate change will compound existing poverty. Its adverse impacts will be most striking in developing nations because of their geographical and climatic conditions, high dependence on natural resources, and limited capacity to adapt to a changing climate.” (OECD, 2008, p. ix).

According to Islam et al. (2017), social inequality worsens the negative consequences of climate uncertainties on disadvantaged groups in three significant ways: greater exposure to climate-related risks, heightened vulnerability to damage, and reduced capacity to manage and recover from such damage. This vicious cycle reinforces the link between climate change and inequality.

When climate-related disasters occur, disadvantaged groups tend to experience a lopsided loss of income and assets, such as physical, financial, human, and social assets (Islam et al., 2017). Additionally, climate change adaptation expenditures prioritize wealth over need, further exacerbating social inequality (Georgeson et al., 2016).

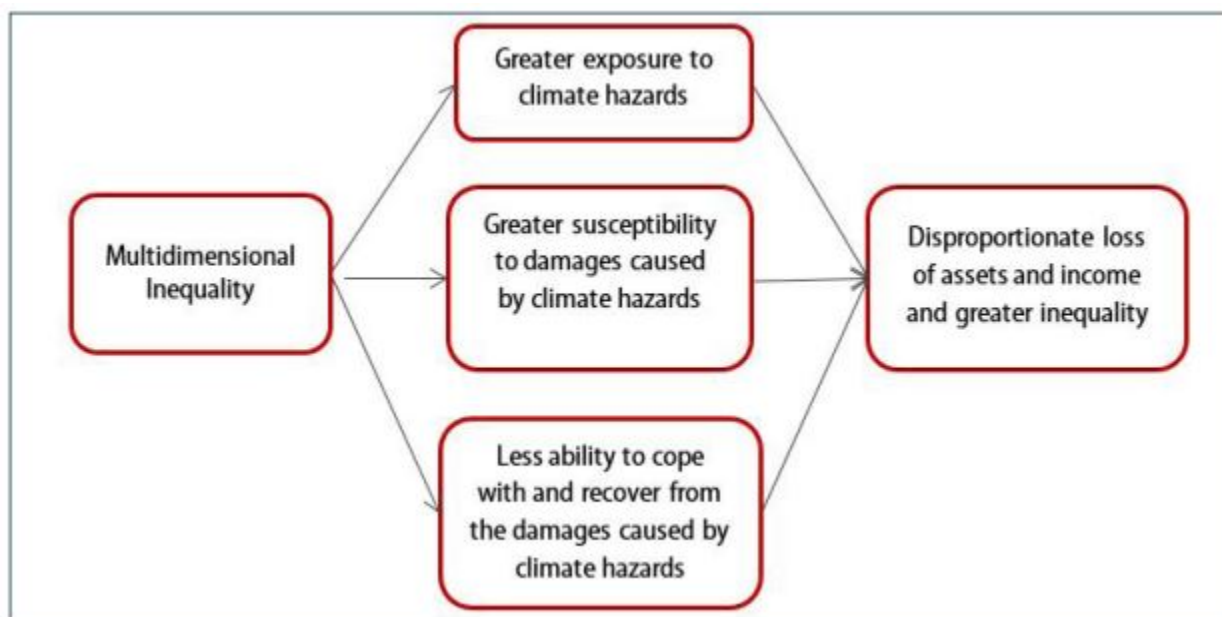


Fig 5:- Three effects of inequality on disadvantaged groups. Source: Islam et al ., 2017.

Climate change has numerous effects on different elements of life. For instance, it affects food availability and prices, reducing energy intake and diet-related mortality, with low-income consumers being the most affected (Nelson et al., 2018). Furthermore, without adaptation measures, the economic losses of crop yields in Russia could reach USD 3.9 billion by 2050.

Central Asian countries face significant risks of plant diseases, pests, and water shortages, putting their livestock at risk (Safonov and Safanova, 2013). The consequences of climate change-induced water insecurity significantly impact vulnerable groups, such as women, children, and indigenous people, adversely affecting their health and overall well-being (IPCC, 2019). Temperature-related morbidity, flooding, windstorms, and dangerous infections also increase due to climate change, leading to significant economic losses and human fatalities globally (IPCC, 2013; Safonov et al., 2019).

2.5 Situation in India-

India faces a significant risk of being impacted by the consequences of climate change due to its vast population, reliance on agriculture, and widespread poverty. Climate change is causing erratic weather, like floods and droughts, which are negatively impacting India's agricultural output. Agriculture is a vital aspect of India's food, nutrition, and livelihood security, being the primary occupation for almost half of India's population. Climate change has various effects on agriculture, that are observable across multiple sectors, such as the economy, water resources, and public health.

Indian agriculture is facing numerous challenges, including “the stagnant growth of the net sown area, plateauing crop yields, soil quality degradation, a reduction in per capita land availability, and various negative impacts of climate change.” (Gupta and Pathak, 2016, p. xi). Climate change poses a significant threat to Indian agriculture, with droughts being a fundamental concern since most agricultural land in India relies on rainfall, and even irrigated land depends on monsoon rains. In addition, flooding is also an important issue, especially in the eastern region of India, where floods are frequent.

Climate change can lead to soil degradation, as increased temperatures can cause soil moisture to evaporate faster, reducing soil fertility. According to Gupta and Pathak (2016, p. 5), “Climate change can also reduce the quantity and quality of organic matter content, which is already quite low in Indian soil, and increased irrigation demands with increased temperature and higher evapotranspiration will lower the groundwater table in many places.” Melting glaciers in the Himalayas may increase water availability in the short run in the Ganges, Brahmaputra, and their tributaries. Still, in the long run, water availability would decrease considerably (Singh et al., 2022).

Agricultural productivity is negatively affected by the increasing frequency and duration of adverse weather conditions such as floods, droughts, cyclones, and heat waves. Rainfed areas experience reduced crop yields due to higher water demand and modifications in monsoon rainfall patterns. Furthermore, crops such as fruits, vegetables, tea, coffee, and medicinal plants are experiencing a decline in quality. “Climate change will lead to changes in the pest and

disease infestation of crops. Higher temperatures can shorten dormant periods, speed up pest and disease growth, and change the dynamics of these populations and their resistance.” (Gupta and Pathak, 2016, p. 10).

The effects of climate change are also evident in feed production and livestock nutrition. Rising temperatures cause plant tissues to become more lignified, which lowers their digestibility. Moreover, a scarcity of water can result in a decline in the production of both food and animal feed. Cooler areas are also affected, as the expansion of the vector population increases the risk of vector-borne diseases among livestock. Heat stress has a negative impact on dairy breeds, leading to reduced feed intake and reproductive potential (Gupta and Pathak, 2016; Sirinivasa Rao et al., 2019).

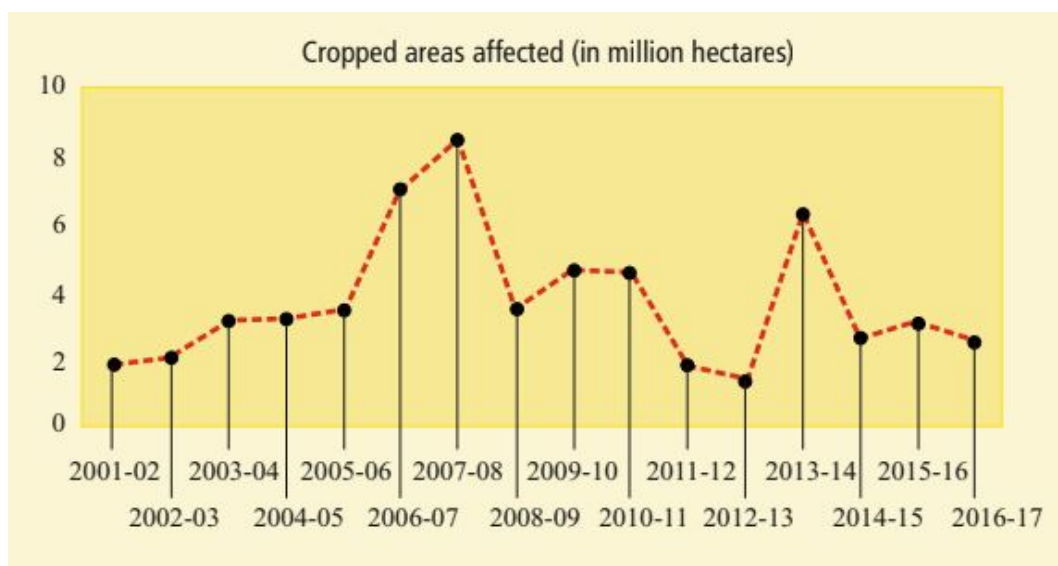


Fig 6- Year-wise damage due to natural extreme events in India. Source: Envistats India 2018.

According to the HSBC Report (2018), India is significant susceptibility towards climate change and ranks at the top for climate-related risks among 67 surveyed nations. The IPCC 2018 report states that if the current trend persists, approximately 600 million people, which is half of India's population, could be impacted either directly or indirectly due to climate change (Climate Scorecard, 2019).

According to the Climate Scorecard (2019), the adverse effects of climate change on the health and overall well-being of the Indian population are often ignored, which damages the country's human resource base. Heatstroke is becoming more common in India, and the rising summer temperatures have made it more prevalent, with temperatures reaching 50 degrees Celsius (122 °F). If global temperatures rise more than 1.5 degrees Celsius, it is predicted that over 350 million Indians may be vulnerable to deadly heat stress by 2050 (Climate Scorecard, 2019).

The quality and amount of water accessible for human consumption and sanitation can be impacted by changes in temperature and rainfall patterns, increasing the risk of waterborne infections. The occurrence of waterborne diseases in India is a significant concern, as the lack of proper surveillance, reporting mechanisms, and data infrastructure makes it difficult to estimate their real impact. According to the Ministry of Health and Family Welfare, a considerable number of people, estimated to be around 40 million every year, are impacted by waterborne diseases. This poses a significant challenge for both the healthcare and economic sectors. Approximately 73% of the rural population in India suffers from inadequate water disinfection, and 74% lack access to proper sanitary toilets (Bush et al., 2011).

According to Bush et al. (2011), the availability of freshwater is expected to decline as a result of both population growth and climate change, with per capita availability estimated to drop from 1,820 m³ to less than 1,000 m³ by 2025. The Indian Ministry of Health estimates that contaminated water and polluted air cause 1.5 million deaths annually in children below the age of five (Bush et al., 2011).

2.6 Situation in Odisha-

Odisha is a coastal state located on the eastern coast of India, at the head of the Bay of Bengal. (Bahinipati & Venkatachalam, 2014). The state's economy heavily relies on agriculture, employing around 70% of the population (Government of Odisha, 2018). It receives an average annual rainfall of 1,500-1,600 millimeters, with some districts, such as Malkangiri, Koraput, Rayagada, and Gajapati, receiving over 2,000 millimeters of rainfall per year (Senapati and Goyari, 2020). However, rainfall distribution during the monsoon season is uneven and unpredictable, resulting in periodic floods and droughts of varying intensities.

In recent times, Odisha has encountered severe weather events, such as intense cyclonic storms and heavy rainfall, causing significant damage to infrastructure and disrupting people's lives. These occurrences have negatively impacted agriculture in the state by causing significant damage to crops. As a coastal state, Odisha faces the onslaught of cyclonic storms almost annually, with farmers bearing the brunt of the damage (Senapati and Goyari, 2020).

The Government of Odisha stated in its Status of Agriculture Report for 2014-2015 that natural disasters occurred in all but 13 years between 1961 and 2014, indicating an 80 percent probability of facing such disasters annually. The years 1974, 1976, 1979, 1987, 1996, 1998, and 2002 witnessed severe fluctuations in rainfall and drought, while flood situations affected the state for around 23 years out of the 54-year period (Government of Odisha, 2014-2015).

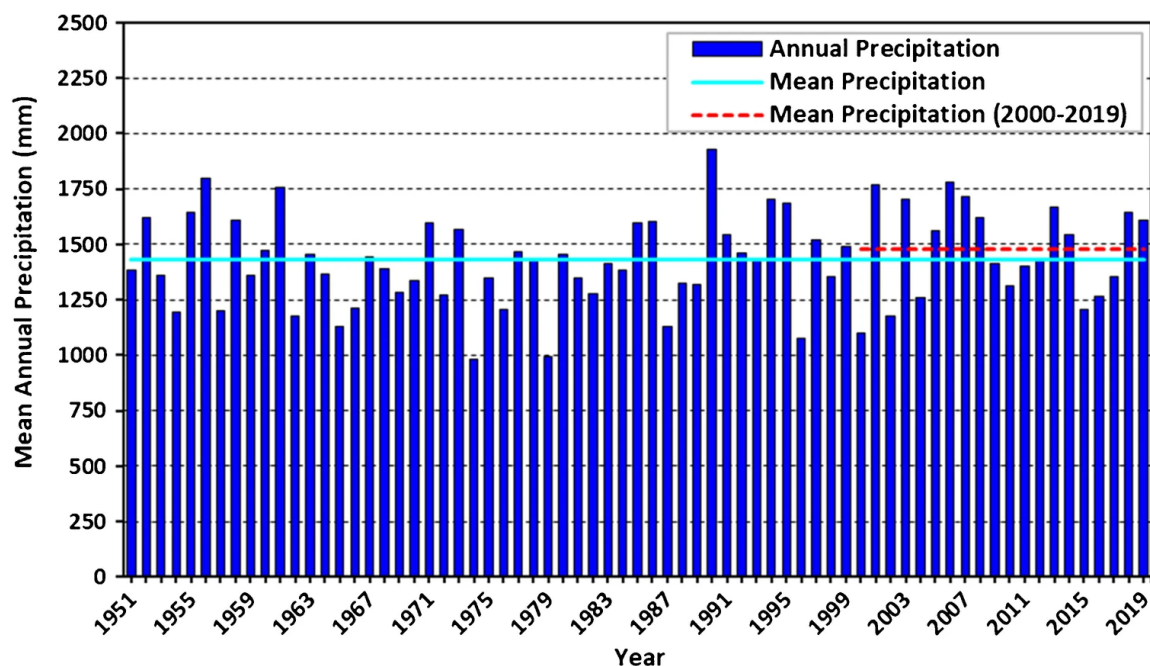


Fig 7- Temporal variation of mean annual rainfall over Odisha from 1951 to 2019. Source: Mahapatra et al., 2021

Year	Nature of calamities	No of District affected	No of Blocks affected	No of Villages affected	Cropped Area affected(Lakh Ha)
1999	Super Cyclone & Flood	12	97		17.86
2000	Drought	29	216	16857	10.59
2001	Flood		219	18790	7.16
2002	Drought	29	290	32603	28.48
2003	Flood	23	128	6846	9.17
2004	Flood	5	20	564	0.37
2005	Flood	14	72	4228	0.14
2006	Flood	27	245	18912	4.85
2007	Flood	15	100	5677	3.18
2008	Flood	21	157	9265	
2009	Flood	14	45	1446	1.25
2010					
2011	Flood	10	71	4060	2.52
2013	Unseasonal Rain & Drought	4	10	314	
2014	Flood	23	176	9675	2.48
2015	Drought	28	235	29176	15.35
2016	Drought	27	233	29040	

Fig 8- Orissa's Vulnerability to Different Disasters. Source: SRC, Odisha.

“Odisha is particularly vulnerable to the effects of climate change due to its geographical location and physical characteristics.” Mishra (2017, p. 95). He points out that frequent droughts in the western hilly region of the state result in severe crop loss and drive small-scale farmers to commit suicide. On the other hand, the coastal districts in the eastern part of the state are prone

to frequent cyclones and floods that result in agricultural distress and leave people without homes or any assistance. Mishra (2017) suggests that the level of susceptibility of agricultural production to climate change can be indicated by the dependence of crop yields on changes in climatic factors.

Climate change has negatively affected Odisha's economy in various ways, including reduced agricultural productivity, health hazards, unpredictable rainfall patterns, and alterations in biodiversity, aquatic life, and vegetation (Mishra and Jena, 2015). Mishra (2017, p. 96) states that “the occurrence of various natural disasters such as storms, floods, heat waves, lightning events, vector-borne diseases, and droughts in consecutive or the same years have significantly affected the economy of the state.”

According to Gupta (2011) and Mishra (2017), in 1999, a tropical super cyclone caused immense socio-economic destruction and resulted in the loss of approximately 10,000 lives in Odisha. The state experienced two severe cyclones during the period from 2011 to 2015, leading to significant harm to infrastructure and crops in the coastal districts. Additionally, Mishra (2017) and Gupta (2011) explain that one of the most severe droughts that the state faced occurred in 2001, affecting more than two-thirds of the districts and 11 million individuals.

The effects of climate change are significantly impacting the health of people in Odisha. Mishra (2017) explains that “the damp, humid, and hot weather, coupled with frequent flooding, has caused the spread of vector-borne diseases such as malaria, dengue, chikungunya, and filariasis. Changes in sea temperature and reduced access to clean drinking water due to droughts and flood-damaged water and sanitation infrastructure have increased the risk of diarrhoeal disease. Increased salinity in soil and drinking water due to sea level rise in coastal belts has caused elevated blood pressure.” (Mishra, 2017, p. 100).

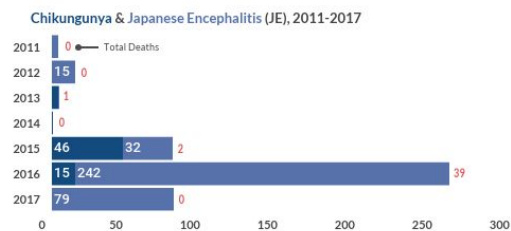
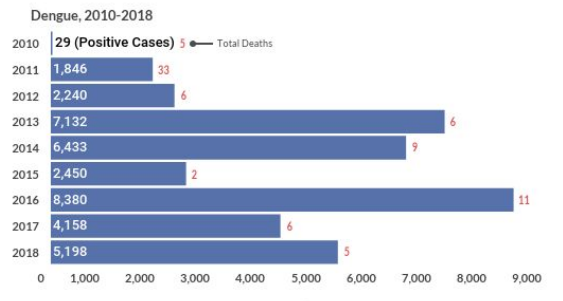
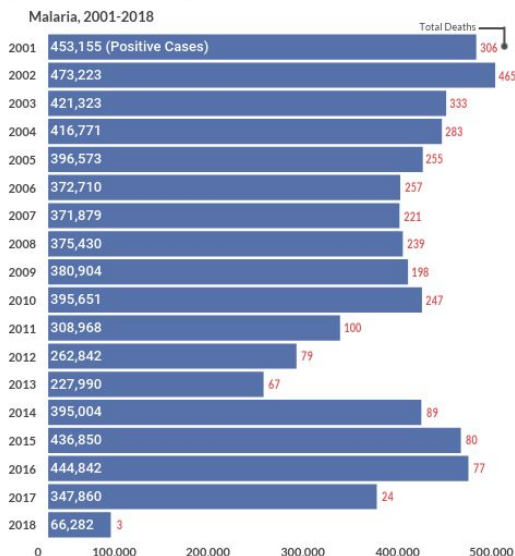


Fig 9- Deaths related to vector-borne diseases in Odisha. Source: Karmakar and Pradhan, Natural Hazards, 2019.

“Extreme weather events like heat waves, cyclones, droughts, and floods have led to health-related issues such as heat strokes, skin diseases, eye diseases, injuries, psychological distress, and human mortality. Air pollution from industrial pollutants and automobile emissions has increased allergies, asthma, bronchitis, heart attacks, and other cardiovascular diseases. Altered food productivity and associated pests and diseases, especially in agriculture, have resulted in malnutrition, hunger, and impaired child growth and development.” (Mishra, 2017, p. 100 and p. 101).

2.7 Conclusion-

Climate change significantly impacts humans, including health problems such as respiratory diseases, heat stroke, and degraded air quality. It can also disrupt agriculture, leading to decreased food production and higher prices, and affect water supplies and sanitation systems. The occurrence of environmental calamities such as floods, droughts, and rising sea levels can lead to the displacement of individuals from their homes, which can lead to migration and a refugee crisis. Climate change can also result in economic losses in infrastructure and decreased productivity due to heat stress.

Chapter 3- Research Methodology

3.1 Introduction-

This chapter aims to explain and defend the research methods that have been used in this thesis in a comprehensive manner. A combination of qualitative research methods was utilized to investigate the effects of climate uncertainties in Odisha. This methodology aims to develop a rapport with the participants and obtain a more profound understanding of the lifestyles of farmers in Odisha, including their approaches to managing the various challenges associated with climate change. The use of qualitative methods in this study enables a better understanding of the social and economic consequences of climate change for farmers in Odisha.

The following is the organization of this chapter: Section 3.2 evaluates the suitability of utilizing qualitative research methods. Section 3.3 outlines the process of recruiting suitable participants for the study, and Section 3.4 discusses the importance of obtaining informed consent and ensuring confidentiality. The semi-structured interview procedure is detailed in Section 3.5, the in-depth interview procedure is described in Section 3.6, the process of qualitative observation is explained in Section 3.7, and the focus group discussion procedure is presented in Section 3.8. Section 3.9 offers a comprehensive account of the data analysis methods used in this study. Finally, in Section 3.10, the researcher presents their positionality statement to acknowledge the potential biases that may have influenced the research.

3.2 Suitability of the Qualitative Approach-

The complexity and uncertainty of climate data limit the ability of quantitative research to capture the social consequences of climate change. Qualitative research methods, such as interviews and focus groups, are better suited to explore climate change's social, cultural, and political dimensions. Qualitative research can provide valuable insights into how individuals and communities experience and understand climate change, identify unique challenges and opportunities, and help design more effective communication and outreach strategies. Overall, qualitative research is essential in informing more effective and equitable climate change policies and interventions.

3.3 Recruitment and Sample-

Sample recruitment is crucial for ensuring the quality and credibility of qualitative research. This type of research aims to understand individuals' experiences, beliefs, and perceptions, making the

selection of participants critical to achieving the research goals. To investigate the effects of climate change in Odisha, I chose Angul as the research location due to my familiarity with the region and language. After a scoping visit, I selected Naupada, Balipatta, Ambapal, and Padmapur as the places to conduct research.

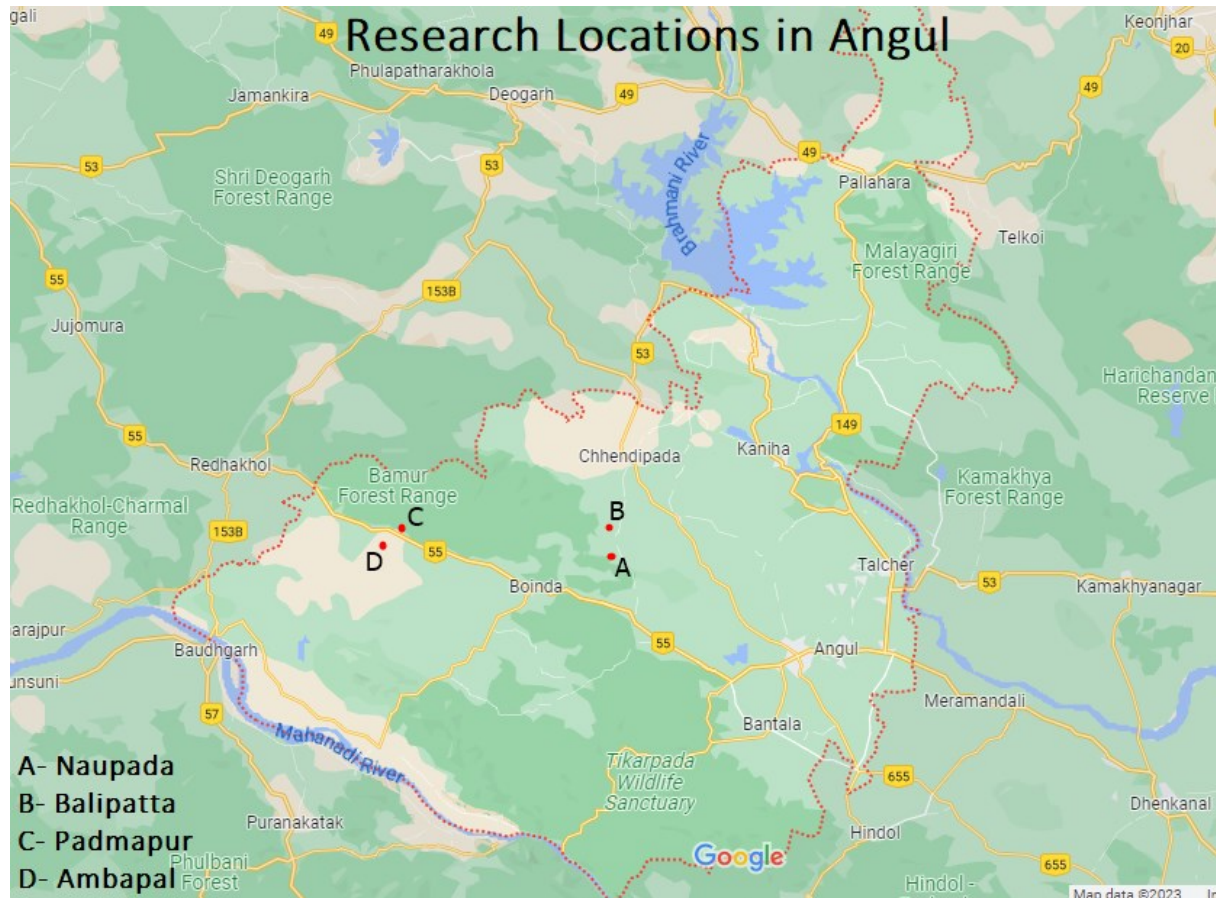


Fig 10- Research Locations for this project. Source: Google Maps.

I conducted three field visits between September 2022 and July 2023, giving the research an ethnographic character and allowing for participant observation. During the second field visit from October 2022 to January 2023, I conducted qualitative research interviews with 125 people from the four villages. To ensure broad participation and representation of views, I included farmers, landlords, workers, village officials, local SHGs, senior citizens, and other actors involved in the agricultural industry.

3.4 Informed Consent and Confidentiality-

Obtaining informed consent is crucial to conduct ethical qualitative research. This involves providing participants with information about the purpose, potential risks, and benefits of the study and obtaining their voluntary agreement to participate. This ensures that participants understand the study's objectives, rights, and potential risks.

Before conducting the interviews, I provided participants with a consent form (Appendix A and Appendix C) to ensure that their participation was voluntary and informed. Since the form was in English, I had a translator present to explain it to the participants in the language they understood best. The consent form allowed participants to include or exclude their personal or business names in the study. Once they understood the requirements, the participants signed the form to indicate their agreement.

3.5 Semi-structured Interviews-

Semi-structured interviews provide a flexible yet structured approach to gathering information. With a prepared list of open-ended questions, interviewers can adjust the phrasing and order based on the interviewee's responses, tailoring the conversation to their experiences and knowledge. They are beneficial for filling gaps in knowledge, investigating complex behaviors and motivations, and collecting diverse perspectives (Hays, 2016).

To better understand the impacts of climate change in the four villages of Angul, I conducted 120 semi-structured interviews with participants in their homes or on their agricultural land, depending on their convenience. The interviews covered background information, agricultural and social impacts, and wildlife invasion, divided into four key parts to facilitate a smoother conversation. Each interview lasted between 30 minutes to an hour, was audio-recorded with permission, and transcribed manually by myself due to budget constraints. Through semi-structured interviews, I gained valuable insights into the various impacts of climate change in these villages.

3.6 In-depth Interviews-

In-depth interviews are a type of qualitative research method that involves one-on-one interviews with participants to gather detailed and flexible information about their experiences, opinions, beliefs, and attitudes related to a particular topic. They help explore complex or sensitive topics and provide valuable insights that other research methods may not capture.

Interview Participants	Village	Topic of Interview
Worker	Ambapal	Market saturation and rising inflation
Farmer	Balipatta	Impact of irregular rainfall on agriculture
Forest Guard	Pamapur	Invasion of wild animals
Village Sabhapati	Naupada	How people view climate change
SHG Member	Naupada	Gender inequalities and women in agriculture

Table 1- Participant sheet of the in-depth interview.

Due to my limited time and lack of interviewing experience, I was only able to conduct five in-depth interviews over a five-month period in the four villages of Angul. I used the interview script (Appendix B) as a reference and provided ample time for participants to express their opinions clearly. The interview participants in all five interviews were different, which increased the quantity of collected data. I analyzed and combined the data from semi-structured and in-depth interviews to improve data quality. Each interview was audio-recorded with permission and later transcribed manually by me.

3.7 Qualitative Observation-

Qualitative observation gathers data about human behavior, interactions, and experiences in their natural settings. It systematically observes and records behaviors and interactions without interference. Qualitative observation captures natural behavior and can be conducted through direct, participant, or non-participant observation.

This project aims to study the consequence of climate change in rural Odisha. I conducted qualitative observations using direct and participant observation techniques and collected data using clear photographs and field notes with proper dates. I obtained verbal consent from the owner of the locations (agricultural fields, ponds, or houses) before taking any photographs. Some qualitative observation data is presented in Appendix D.

3.8 Focus Group Discussion-

After conducting observations of agricultural lands in Padmapur, I discovered that some croplands were destroyed by wild boar attacks. Upon conducting informal interviews with the local villagers, I found that this was a common occurrence. I then consulted with my supervisor

and other experts to determine the best course of action for the project. After receiving some guidance from my expert, I modified the interview script and conducted three focus group discussions to gain rapid and in-depth knowledge about the issue.

I conducted three focus group discussions in Padmapur and Ambapal to assess the impact of wildlife invasion on the villagers living near the Bamur Forest Range and how people adapt to it. During the discussion, I acted as the moderator and guided a conversation with 6-10 participants, encouraging them to share their opinions, attitudes, and experiences. Data was collected through audio recording and note-taking, with verbal consent taken from participants. Each discussion took over 2 hours, and a discussion guide was used to encourage participation. I later manually transcribed the discussion for analysis.

3.9 Data Analysis-

Qualitative research is a method that helps to understand people's beliefs, values, behaviors, and experiences. In qualitative research, data analysis involves analyzing non-numerical data such as text, images, videos, and audio recordings to derive meaning and insights. Several data analysis methods in qualitative research include content analysis, grounded theory, and thematic analysis. The method chosen for a research study is dependent on several factors, including the research question, the data collection method, and the theoretical framework that upholds the study.

In this project, I used content analysis to analyze the data obtained from various interviews and focus group discussions. Content analysis is a research method used to systematically categorize, code, and interpret text-based data to identify patterns and themes. Due to errors in the results provided by free data analysis software, I manually analyzed the data.

I read the transcripts several times and annotated them to identify key recurrent themes. This helped me identify patterns and create codes, thereby reducing the time taken for content analysis. After coding the data, I analyzed the patterns and themes that emerged from the data. Finally, I interpreted the results and drew conclusions based on the data analysis. By using manual content analysis, I gained a more in-depth understanding of the data and ensured accurate analysis and interpretation.

3.10 Researcher's Positionality-

I am a 24-year-old Hindu male from Angul, Odisha, where I spent my childhood and adolescence. Growing up, I had the opportunity to spend all my vacations in the nearby villages of Naupada and Padmapur. Being from the Chasa (Farmer) caste, I often accompanied my grandparents to the mango, mahua, and cashew orchards, where we would collect and later sell

the fruits. During my high school years, I worked in the rice fields during the summer and the onion fields during the winter vacations. All these experiences have given me a deep understanding of local agriculture and people's lives in rural areas.

I grew up in a community of families where the male works and the female primarily take care of the home and the child. Even though I make an effort to be fair and objective in my reasoning, I occasionally let my experience influence me against some feminist views. In addition, I majored in biology in college, which helps me approach problems from a biological standpoint.

I knew that my personal background and experiences could potentially introduce bias in my research, so I tried various methods to minimize the bias. I acknowledged my bias and tried to be self-critical about the research process. I also used various research methods on different populations to minimize the impact of my bias.

I observed and documented behaviors and interactions without interfering during participant observation for my research. I interviewed older people from various backgrounds who shared similar financial conditions but came from different backgrounds. I checked to ensure the interviews had no built-in power dynamics. Additionally, the participants suggested the venues where the interviews were conducted. In order to minimize any impressions of dominance or power, I created a casual and comfortable atmosphere when conducting interviews with participants at my house.

Although I knew most of the interview participants, I did not have any deep relationships with any of them, and I excluded interviews with my relatives. This ensured objectivity throughout the research process and maintained a suitable distance between myself and the interviewees. Ultimately, I took great care to conduct the research as objectively as possible, despite my personal connection to the community.

Chapter 4- Impact on Agriculture

4.1 Introduction-

“Angul is located in the Mid Central Table Land zone at 840.16’ to 850.23’ east longitude and 200.31’ to 210.41’ north latitude, with 300 meters above mean sea level. The district is surrounded by Sundargarh in the North, Sambalpur in the West, Kandhamal and Cuttack in the South, and Keonjhar district in the East.” (District Government of Angul, n.d., p. 1). Angul has a humid climate with hot, dry summers, moist monsoons, and mild winters (Odisha State Disaster Management Authority, n.d.).

According to the Gopabandhu Academy of Administration (n.d., p. 89), “Angul goes through four distinct seasons, with Summer occurring from March to mid-June, followed by a rainy season from mid-June to September, a post-monsoon season in October and November, and finally, Winter from December to February.” The annual average rainfall in the region is 1401.9mm, and it typically rains for 70 days in a year. The predominant soil types are Red, Yellow, Black, Alluvial, and Lateritic, with high organic carbon and low available nitrogen. There is a considerable portion of forest land in the district, and there is hardly any unusable, arid ground (Gopabandhu Academy of Administration, n.d.).

Name of the District	Geographical area (HA)	Forest area (HA)	Cultivable area (HA)	Barren area (HA)
Angul	637500	271682	211291	7000

Table 2- Total area, forest area, cultivable area, and barren area of Angul.

The District Government of Angul (n.d., p. 1) reported that the district has “3 medium irrigation projects, 77 minor irrigation projects, 823 lift irrigation projects, 15,303 dug wells, and 6556 deep borewells, which account for 31.2% of total irrigation.” The primary agricultural produce in Angul district are food grains, including rice, maize, ragi, and wheat, and pulses such as arhar, mung, biri, kulthi, and gram. Additionally, the district produces oilseed crops like groundnut, til, and mustard, and vegetables such as brinjal, tomato, cabbage, cauliflower, potato, and sweet potato. However, rice is considered the most prominent food grain of the district (Gopabandhu Academy of Administration, n.d.).

Drought during the Kharif season in Odisha harms paddy crops, with agriculture becoming more vulnerable due to climate change. The Odisha State Disaster Management Authority claims that insufficient irrigation coverage exacerbates issues by lowering agricultural output and farm earnings. Irregular rainfall causes both drought and flood conditions, damaging crop

productivity. In Angul, rainfall has decreased significantly during the pre-monsoon and monsoon seasons, leading to soil erosion and degradation, nutrient depletion, and reduced crop yield.

4.2 Irregular Monsoon-

Of the 125 interview participants, almost all (97.6%) of them have noticed changes in the local weather patterns within the past ten-year period, mainly as short-term drought (17.1%), irregular rainfall (74%), and reduced rainfall (8.9%). Short-term drought is typically characterized by a shortage of rainfall over a period ranging from a few weeks to several months, which can lead to a temporary depletion of soil moisture, a reduction in water availability, and a decline in crop productivity. All participants were affirmative about whether the changes in the weather pattern affected their farms. However, only 3 participants (2.4%) have not noticed any changes in weather patterns but admitted that their yield has continued to decrease every farming season.

Have you noticed any changes in the weather pattern in the last decade?			
Village	Yes	No	Total
Padmapur	31	0	31
Ambapal	31	0	31
Naupada	30	2	32
Balipatta	30	1	31
Total	122 (97.6%)	3 (2.4%)	125

Table 3- Knowledge of Changes in Weather Patterns over the past 10 years.

The impact of climate change on agriculture was emphasized by a male participant during one of the interviews;

“We used to start farming in late June or early July, but now we cannot tell when the rain will begin. In most cases, we wait for the rain to start before planting, but if there is no rain till August, we use water from borewells or ponds for farming. Sometimes, there will be rain in July, and we would sow the crops, but then the rain will stop for two to three weeks, and everything will die. There were times when we were about to harvest crops, but it would suddenly rain and destroy everything. One year, I decided to cultivate brinjal instead of paddy as brinjal was profitable at that time. I spent all my savings cultivating brinjal, but sudden rainfall during the flowering period destroyed all the crops along with my savings.”

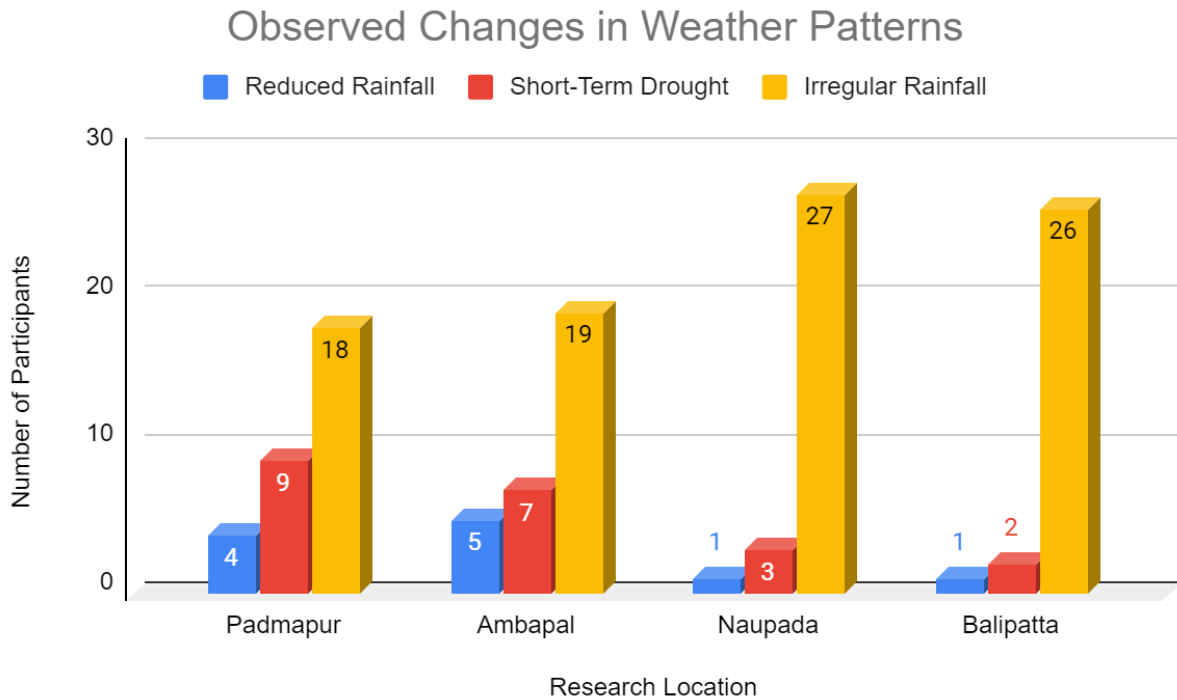


Fig 11- Changes observed over the past 10 years.

Among the four research locations, Padmapur seems to be the most affected due to various reasons such as its elevation, rocky soil, lack of underground aquifer, and fewer water resources. Farmers in Padmapur rely heavily on rainwater for their agriculture, and irregular monsoons have led to water scarcity during the summer season and soil erosion during rainy seasons. Although there is a stream in the village, it is still far away from agricultural fields, and animals frequently visit there, making it unsuitable for irrigation purposes.

Village	Number of Ponds	Number of Dugwells	Number of Borewells
Padmapur	3	9	8
Ambapal	5	16	13
Naupada	14	107	42
Balipatta	13	103	37

Table 4- Methods of irrigation used in the research locations.

Similarly, irregular monsoons in Angul have caused water scarcity, reduced crop yields, affected livestock productivity, and reduced access to drinking water for humans and animals. This has

also led to pest and disease outbreaks in crops and livestock, further reducing agricultural productivity. Farmers in Balipatta, Naupada, Padmapur, and Ambapal have reported increased pests and diseases, damaging crops and livestock, and decreasing agricultural productivity. Farmers are forced to spend more money on fertilizers and pesticides to mitigate these issues, affecting soil quality.

In addition to diseases affecting crops, various new and powerful diseases have emerged among livestock. Almost all cow-raising farmers have reported a significant decrease in the lifespan of cows in recent years, and the cost of raising a cow has increased substantially.

4.3 Market Saturation-

Recently, several news reports have been about farmers discarding or destroying their crops. While many attribute this to the lockdowns and the resulting dampening of business, a closer examination reveals that such situations existed even before the pandemic. One of the factors that can impact the demand and supply of certain crops is climate change. Favorable weather conditions can lead to bumper crops, saturating the market and causing prices to drop drastically. In such cases, farmers may opt to destroy their produce to avoid selling at a loss.

Do you think climate change has impacted the sale of your crops			
Village	Yes	No	Total
Padmapur	28	3	31
Ambapal	26	5	31
Naupada	24	8	32
Balipatta	23	8	31
Total	101 (80.8%)	24 (19.2%)	125

Table 5- Knowledge of extreme weather impacts on the sale of crops.

Of the 125 interview participants, about 80% of them believe that climate change has impacted the sale of their crops. The impact of climate change on market saturation was emphasized by a male participant during one of the interviews;

“After seeing the profit margin in the previous years, I decided to cultivate pointed gourd last year. After harvesting, when me and my wife went to sell our pointed gourd to the merchant, we found that many farmers have also cultivated pointed gourd, so we only got about 5 rupees per kilo. Normally, we could have sold our pointed gourd for at least 10 to 15 rupees per kilo. After

spending about Rs 65,000 and months of hard work, I only earned Rs 35,000. With such losses, how do we run our family, send our children to big colleges, and survive these tough times.”

Among the four research locations, the farmers of Padmapur seem to be the most affected due to their poor environmental conditions. On the other hand, farmers of Naupada and Balipatta are less affected because they plant a variety of crops and have more water resources. Additionally, market saturation has forced many farmers in all four research locations to stop the commercial cultivation of onions and tomatoes.

4.4 Current Solutions-

There are several ways to lessen the effects of climate change on agriculture.:

1- Crop diversification: To lower the chances of crop failure due to extreme weather, farmers are encouraged to produce a variety of crops. This helps to spread the risk across different crops and ensures that farmers have a source of income even if one crop fails.

2- Improved irrigation systems: With changing weather patterns, access to water is becoming increasingly important. Improved irrigation systems can help farmers to conserve water and ensure that their crops receive adequate moisture.

3- Soil conservation practices: Soil erosion and degradation are major challenges in agriculture and can be exacerbated by climate change. To enhance soil health and lessen erosion, farmers are urged to use soil conservation techniques like minimal tillage, cover crops, and crop rotation.

4- Agroforestry: Cultivating trees together with crops and livestock is known to reduce the consequences of climate change by increasing carbon sequestration, promoting soil fertility, and providing shade and shelter for animals and crops.

5- Use of climate-resilient crop varieties: Farmers are encouraged to use crop varieties that are more resilient to extreme weather conditions, such as drought-resistant crops, flood-resistant crops, and heat-tolerant crops.

6- Access to weather information: Farmers need access to reliable weather information to make informed decisions about when to plant and harvest their crops. Governments and NGOs are working to provide farmers with weather information through mobile phone apps, radio broadcasts, and other means.

7- Sustainable land management practices: This entails employing sustainable land management techniques to enhance soil health, boost productivity, and lower greenhouse gas emissions, such as conservation agriculture, agroforestry, and sustainable intensification.

8- Government support: Policy interventions such as crop insurance, disaster relief programs, and market stabilization measures can help support farmers during periods of crop loss or low prices.

4.5 Conclusion-

This chapter discusses Angul's physiographic and agroclimatic conditions and their impact on agriculture, including the challenge of irregular monsoons and the resulting drought-like conditions. Climate change leads to unpredictable weather patterns, increasing the risk of pests and diseases, affecting crop yields and market saturation, leading to falling prices and reduced farmer income.

Chapter 5- Social Impact

5.1 Introduction-

The district of Angul, located in the state of Odisha in India, is already feeling the negative consequences of climate change in several ways. The decrease in crop yields significantly impacts farmers' livelihoods, and the youth of the affected villages are forced to migrate. While rising temperatures are leading to heat-related illnesses, the changes in rainfall patterns are causing water-borne diseases like cholera and diarrhea. The district is classified as a “moderate-risk zone for wind and cyclones, a protected area for floods, a high-risk zone for droughts, a moderate damage zone, and a less damaged zone for earthquakes and major accident-prone areas” in terms of disaster activity. (Planning and Convergence Department, Directorate of Economics and Statistics, 2022, p.49).

5.2 Water Crisis-

Despite the considerable amount of rainfall in Angul, the four research locations are experiencing various types of water crises, mainly due to irregular monsoons. Among the four villages, Padmapur is facing a severe water crisis due to its high elevation, rocky soil, and absence of underground aquifers. Additionally, during the summer season, the ponds in Balipatta, Naupada, and Ambapal dry up, further exacerbating the situation. As a result, farmers in these areas resort to using underground water for agriculture, negatively impacting the area's groundwater level.

Do you think there is an increase in water scarcity in the recent years			
Village	Yes	No	Total
Padmapur	31	0	31
Ambapal	29	2	31
Naupada	19	13	32
Balipatta	21	10	31
Total	100 (80%)	25 (120%)	125

Table 6- Knowledge of water scarcity in recent years.

Of the 125 interview participants, 80% believe there is an increase in water scarcity in recent years. Compared to Naupada and Balipatta, the participants in Ambapal and Padmapur strongly believe that there is an increase in water scarcity. The impact of climate change on water scarcity in Padmapur village was emphasized by a female participant during one of the interviews;

“There is only one proper drinking water source in the whole village. During summer, the water level in all dugwells decrease, and we could only get water from the handpump at the village entrance. I live at the end of the village, and it takes a few trips to get the drinking water necessary for my family, so you can expect how difficult it is for us. During summer, our family takes bath in the open near the handpump. Although many people do this, it is still embarrassing for females like us to bathe in the open. I sometimes resent my father, who made me marry in this village.”

Groundwater level data is not available for the four research locations. To estimate the groundwater level, I interviewed local villagers to gather information on the approximate depth required for borewell digging. Fortunately, the frequent borewell digging in all four villages has enabled the villagers to recall the depth, which has provided us with valuable data for analysis.

Village	Depth (2012)	Depth (2017)	Depth (2022)
Padmapur	200	300	400
Ambapal	120	140	170
Naupada	110	110	110
Balipatta	70	70	70

Table 7- Depth needed to dig a borewell at different times in the four research locations.

No data was available regarding the water quality in the four research locations. However, I gathered information from local residents that affluent individuals in the villages have begun using water purifiers, typically including water quality checks (mostly TDS levels). Our study used TDS levels to compare water quality among the four research locations.

TDS stands for Total Dissolved Solids, which refers to the combined total of all inorganic and organic substances present in water in a dissolved state. Generally, a TDS value of 300 ppm or less is considered acceptable for drinking water. In comparison, a TDS value above 600 ppm is considered high and may indicate the presence of harmful contaminants. The TDS value collected might not represent the correct situation at the four research locations,, but it gives us a general idea of it.

Village	Approximate TDS in Water
Padmapur	120
Ambapal	160
Naupada	650
Balipatta	600

Table 8- Approximate TDS in the water of the four research locations.

Although the approximate groundwater level in Naupada and Balipatta has remained stable over the past decade, the water quality has deteriorated significantly. This decline has led to increased water-borne diseases among residents in both villages. As a result, most individuals are now forced to rely on either clean piped water provided by the Rural Water Supply and Sanitation Project and Jal Jeevan Mission or expensive water purifiers.

Unfortunately, the cost of water purifiers is prohibitive for many villagers, making them inaccessible. Furthermore, clean piped water is unavailable to every household, forcing many residents to stand in long queues to obtain the water required for their daily needs.

5.3 Loss of Livelihood-

The primary occupation in the four research locations is agriculture. However, due to changes in temperature, precipitation, and extreme weather events like floods and droughts, climate change has the potential to have a detrimental influence on crop yields and food production. This, in turn, could result in reduced agricultural productivity and income for farmers, as well as food shortages and higher food prices for consumers.

According to Table-8, the average age of farmers in these regions is around 50 years. While they possess a significant amount of farming expertise, they may lack other skills necessary for employment in the current scenario. Furthermore, many traditional farming techniques have become outdated and may no longer be suitable for modern agriculture, which is significantly affected by climatic uncertainties.

The income of 500 farmers from the four research locations was recorded through a combination of qualitative interviews, observations, and informal interviews. Although this data was obtained through word-of-mouth and may not be entirely accurate, it provides insight into the general situation of farmers in the four research locations.

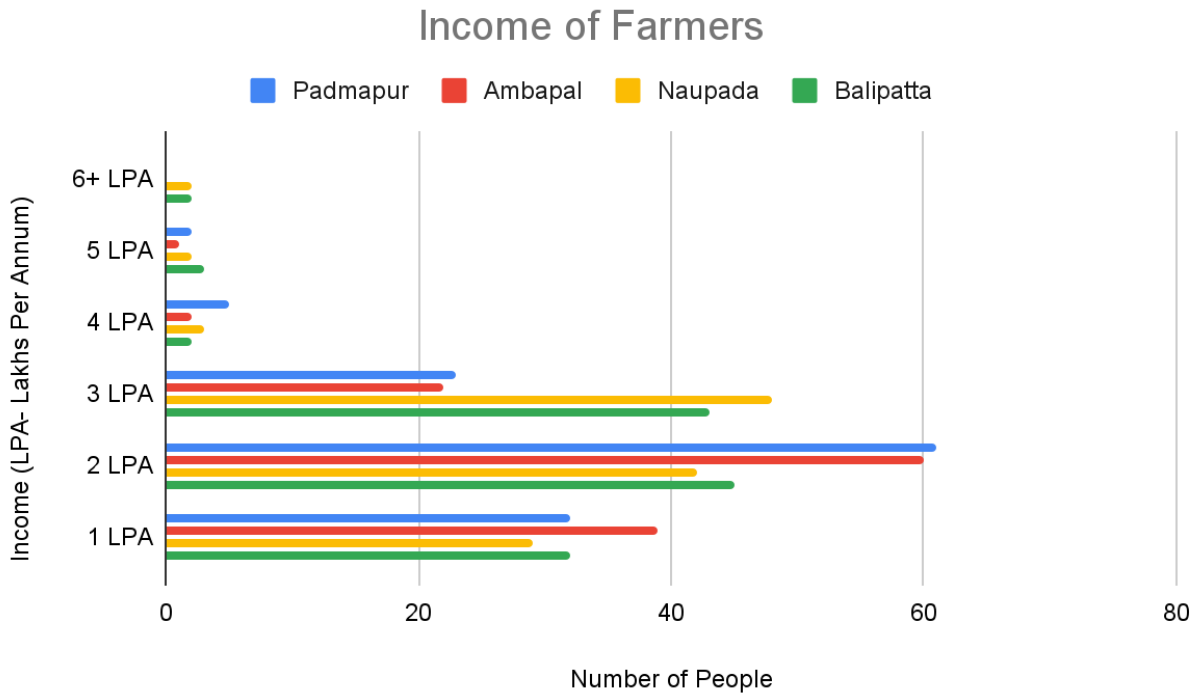


Fig 12- Income of farmers in the four research locations.

Despite potential inaccuracies, the data suggests that farmers in Balipatta and Naupada have access to many irrigation resources and, thus, are relatively prosperous. Meanwhile, although Padmapur has limited water resources, its climate is conducive to the farming of litchi and mango, leading to increased income for some farmers. It is worth noting that there are some underground aquifers in the village's periphery, that are suitable for farming purposes.

5.4 Migration of Youth-

Agriculture, a crucial aspect of our society, faces significant challenges due to climate change. Unfortunately, this sector has become increasingly risky, with very average returns. As a result, many young people from rural areas are migrating to cities in search of better job opportunities, leading to a decline in agricultural productivity. Even though these villages primarily depended on agriculture, the number of young people staying in these areas has significantly decreased.

Village	Estimated Average Age of Farmers (2010s)	Average Age of Farmers (2022)
Padmapur	36	50

Ambapal	35	49
Naupada	37	58
Balipatta	36	54

Table 9- The estimated average age of farmers in the 2010s and 2022 at the four research locations. This data is obtained through word of mouth, making it susceptible to large errors.

The impact of climate change on the migration of young people was emphasized by a female participant during one of the interviews;

“After a year of very hard work by my husband and me, our family earns about 3 lakhs per annum. And this is when there is no unexpected rainfall, random cyclone, problem in the market, or animals destroying our crops. The child of our neighbors is a simple police constable, but he is earning Rs 25,000 per month. And some people in our village earn more money than us by working as factory laborers. [...] We are farming because this is what we have been doing all our lives, and we have an attachment to our field. But now we are growing old, and if anything happens to any one of us, we don’t have enough savings or medical insurance. I don't want my children to suffer like me, I want them to live in a big city, ride a car, and be happy in their lives.”

The migration of young people has created a negative loop, where the decrease in agricultural productivity leads to further migration of young people. This pattern has been consistent over the past decade, and Naupada and Padmapur have been hit the hardest, experiencing the highest number of young people leaving their villages. Consequently, this migration has led to stagnation in the agricultural sector of Angul, and the future prospects of this industry appear bleak.

5.5 Health Risks-

Human health is seriously threatened by climate change, which has varied effects on people. In Angul block, there has been a surge in heat-related illnesses, posing a risk to the health and well-being of the local population. Additionally, air pollution in the Talcher subdivision has increased respiratory conditions such as asthma. Of the 125 interview participants, about 80% of them feel that there is an increase in diseases due to climate change.

Do you feel there is an increase in diseases due to climate change			
Village	Yes	No	Total

Padmapur	21	10	31
Ambapal	23	8	31
Naupada	28	4	32
Balipatta	27	4	31
Total	99 (79.2%)	26 (20.8%)	125

Table 10- Knowledge of increase in diseases due to climate change.

Across the four research locations, there has been a rise in infectious, waterborne, and heat-related diseases, which can have serious effects on public health. In the summer, extreme heat has caused farmers to suffer from heat strokes, hindering their work in the field and leading to reduced yields. Although there is no concrete evidence, it is suspected by many participants that dissolved fertilizers and pesticides in the water may be responsible for the prevalence of major diseases in Naupada and Balipatta.

Village	Major Diseases
Padmapur	Malaria and Typhoid
Ambapal	Cholera, Diarrhea, and Typhoid
Naupada	High Blood Pressure, Diarrhea, and Heatstroke
Balipatta	Arthritis, Neurodegenerative Diseases, and Heatstroke

Table 11- Major diseases in the four research locations.

Despite having low TDS levels, Ambapal has seen an increase in waterborne infections, partly because many low-income households struggle to have appropriate access to safe drinking water. Meanwhile, Padmapur, situated close to the Bamur Forest Range, has a high mosquito population, increasing the number of malaria cases.

5.6 Current Solutions-

There are numerous ways to lessen the negative social effects of climate change. Here are some potential solutions for different issues:

1- Water crisis: One way to tackle the water crisis in Angul is to improve irrigation systems, supply clean water, and implement groundwater recharge projects. Farmers can avoid using borewells for agriculture by using an improved irrigation system, and the pressure on

groundwater will decrease. Furthermore, providing access to clean water can prevent villagers from consuming contaminated water, reducing the incidence of waterborne diseases. Finally, groundwater recharge projects can gradually increase the village's groundwater levels.

2- Livelihood and migrating youth: The issues of livelihood and migration of young people are interlinked. Several strategies are required to improve agricultural production and agri-marketing systems to address this.

(i) Agricultural Marketing: Improving agricultural marketing can help farmers access better markets and reduce their reliance on middlemen, increasing local agricultural products' marketability.

(ii) Private Companies: The government can establish strict regulations for private agro-based companies to help villagers secure employment through contract farming or setting up processing units.

(iii) Strengthening Self-Help Groups (SHGs): Public-private partnerships can work with SHGs to utilize local knowledge, skills, and manpower. SHGs can be trained to establish microenterprises in the agriculture and allied sectors, and private agencies or civil societies can facilitate market linkage and business activities.

3- Health risks: A multifaceted approach is necessary to mitigate the health risks associated with climate change. This may involve improving air quality, developing early warning systems, enhancing public health systems, promoting water and food security, supporting vulnerable populations, and increasing research and development efforts.

5.7 Conclusion-

The social effects of climate change in four Angul villages are discussed in this chapter, including water shortages, loss of livelihood, youth migration, and health problems. Despite the region's high rainfall, irregular monsoons and excessive irrigation have led to water scarcity in the villages. Additionally, climate uncertainties have reduced agricultural output, causing significant harm to farmers' livelihoods and prompting many young people to migrate to urban areas. The increasing prevalence of heat-related illnesses, infectious diseases, and water-borne illnesses is also a significant concern resulting from climate change. Addressing these challenges requires urgent action to build resilience and adapt to the changing climate while ensuring sustainable regional development.

Chapter 6- Human-Wildlife Conflict

6.1 Introduction-

Human-wildlife conflict is increasingly concerning. Wild animals such as elephants, tigers, and bears are forced to venture into human settlements in search of food and shelter due to shrinking natural habitats caused by deforestation, urbanization, and agricultural expansion. This situation threatens human lives and leads to conflict between humans and wildlife. The loss of forest cover and fragmentation of forests into smaller patches also increases the susceptibility of wildlife to diseases, mortality, and inbreeding. Additionally, wildlife is forced to rely on human-made crops for food, leading to conflict with farmers who may kill or injure animals to protect their crops.

The issue of wildlife leaving forests to damage crops and attack humans is not limited to rural areas. Even in urban areas, the encroachment of wildlife into human settlements is becoming more common as urbanization destroys natural habitats. This leads to the migration of animals such as monkeys, raccoons, and coyotes to urban areas, risking human safety, damaging property, and spreading diseases.

Moreover, human-wildlife conflict and climate change are interconnected. Climate change alters the distribution of wildlife and their prey, increasing encounters with humans. Droughts caused by climate change may lead wildlife to seek water sources in human settlements, further increasing the likelihood of conflict. Therefore, addressing both human-wildlife conflict and climate change is necessary to prevent further damage to natural habitats and the safety of both humans and wildlife.

6.2 Destruction of Crops by Wild Animals-

The impact of wildlife invasion or human-wildlife conflict is causing a significant challenge to agriculture in the four research locations. Wild boars, monkeys, and elephants are the primary culprits behind crop destruction. Among them, wild boars pose the greatest threat to farmers in all four locations due to their high reproductive rates and adaptability.

In recent years, elephants have also become a major concern for farmers in Balipatta, as their large size and tendency to move in groups make them difficult to repel. To address this issue, some farmers have resorted to living near their fields in large groups and using loud music to deter the elephants. In Naupada, monkeys near the Singada stream and Sapapal minor irrigation project have also caused significant damage to agricultural yield.

The impact of the human-wildlife conflict was emphasized by a male participant during one of the interviews;

“Yes, I feel that there is an increase in the number of wild animals coming out of the forest. Monkeys have severely damaged all the mango orchards near Singada stream. [...] Wild boars have damaged many of our crops near the Sapapal forest. [...] Nowadays, we have to watch out for these wild animals in addition to the already bad weather system. There is some compensation by the government, I think about Rs 10,000, for damage to an acre of paddy farm. But this is not enough, and it will not solve our problems. [...] According to the current MSP, we get more than Rs 40,000 per acre of paddy farm, but the government compensation is only about Rs 7000 or Rs 8000.”

Village	Major Wild Animals
Padmapur	Wild Boar, Elephant, and Bear
Ambapal	Wild Boar and Elephant
Naupada	Wild Boar, Monkey, Rabbit, and Elephant
Balipatta	Wild Boar, Monkey, Deer, Bear, and Elephant

Table 12- Major wild animals found in the four research locations.

Balipatta and Naupada are located at the intersection of Bamur Forest Range and Tikarpada Wildlife Sanctuary, making them home to a diverse range of wild animals. While elephants have been spotted in Padmapur and Ambapal, they have not caused significant damage to agriculture in those areas. Additionally, bears in Padmapur have deterred wild boars from coming out frequently during harvesting season.

Farmers have been forced to take measures to protect their crops from wildlife invasion, such as using electric fences and chemical repellents. However, some farmers in Balipatta and Naupada have resorted to unethical methods, such as poisoned food or food-containing bombs, to kill wild animals. Such practices worsen the conflict between humans and wildlife and increase the risk of wildlife attacks on humans. It is essential to promote ethical and sustainable practices that balance the needs of both humans and wildlife to mitigate human-wildlife conflict.

6.3 Attack on Humans-

Extreme weather events including heat waves, wildfires, droughts, and heavy rains are becoming more often and more severe as a result of climate change. These events disrupt the natural habitats of wild animals, forcing them to search for food and shelter in human settlements,

thereby increasing the likelihood of conflict between humans and wildlife. Weather reports and interview data confirm that such conflict is more common during extreme weather events than under normal circumstances.

According to a forest guard in Padmapur, there is a sharp rise in the number of attacks of wild animals on humans, and most of these attacks were done by elephants. In 2021, although there was no loss of human lives in the four research locations, more than 20 people lost their lives to the attack by elephants.

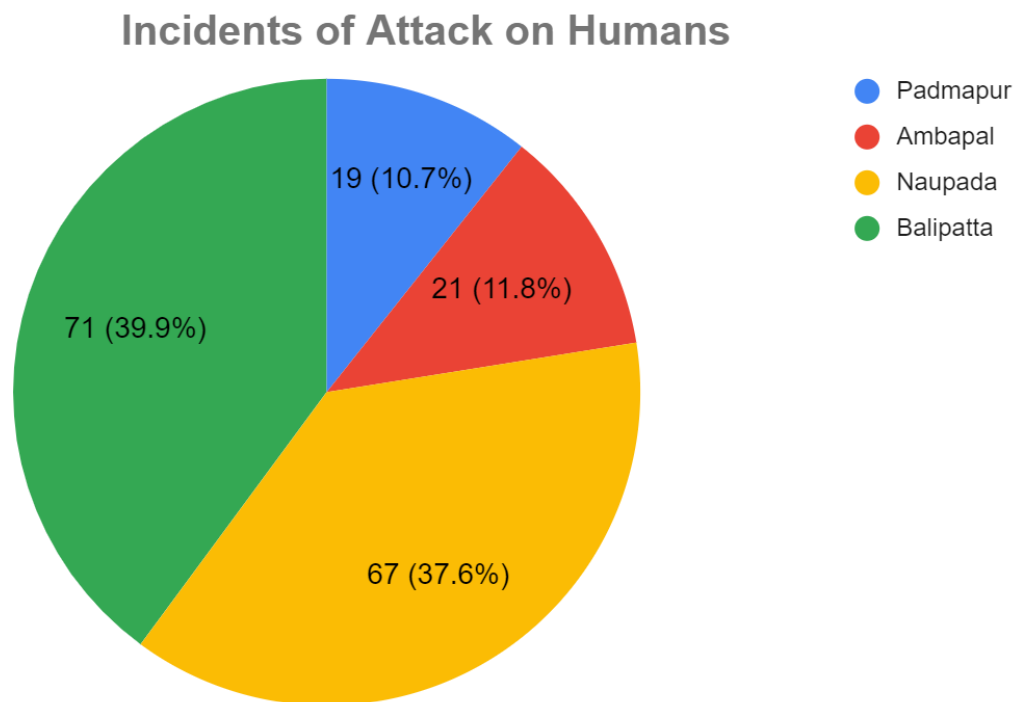


Fig 13- Incidents of wild animal attacks in each research location in the last decade.

Unfortunately, human retaliation against wild animals has significantly increased the number of wild animal attacks on humans. According to Table 11, the incidence of attacks on humans is higher in Naupada and Balipatta than in Padmapur. Although most attacks have resulted in injuries rather than fatalities, any loss of human life in the village can lead to the indiscriminate hunting of wild animals, further exacerbating the human-wildlife conflict and adversely affecting the ecosystem.

6.4 Current Solutions-

A multifaceted strategy is necessary to address the difficult issue of wildlife exiting forests to destroy crops and assault people.

1- Habitat Restoration: Restoring degraded habitats can help to support healthy wildlife populations, reducing the likelihood of conflict. This can involve reforestation, wetland restoration, and corridors connecting fragmented habitats.

2- Human Settlement Planning: Careful planning of human settlements can help to minimize the potential for conflict. For example, building fences or walls around crops or livestock pens can prevent wildlife from accessing them.

3- Education and Awareness: Educating local communities about the importance of wildlife conservation and the role of wildlife in the ecosystem can foster greater tolerance for wildlife and reduce the likelihood of conflict. Awareness programs can also provide information on techniques for reducing the risk of damage from wildlife, such as installing scarecrows or electric fencing.

4- Alternative Livelihoods: Providing alternative livelihoods for communities affected by wildlife damage, such as ecotourism, can help reduce the pressure on wildlife habitats and reduce the likelihood of conflict.

5- Wildlife Management: Managing wildlife populations through controlled hunting or translocation to areas where they are less likely to cause conflict can be an effective way to address conflict in some cases.

6- Research and Monitoring: Researching to understand the behavior of wildlife populations and the drivers of conflict can help inform management decisions and reduce the potential for conflict in the future.

6.5 Conclusion-

Conflict between people and wildlife is a serious problem in the four research locations. It is essential to preserve natural habitats, lessen conflict, and encourage cohabitation between people and wildlife if we are to solve this issue. Initiatives in the areas of education and training can help to foster coexistence, and a comprehensive strategy is required to build a sustainable future for both local wildlife and humans.

Chapter 7- Conclusion

7.1 Research Overview-

The issue of climate change is complex and requires an understanding of its quantitative and social implications. Unfortunately, much of the existing research on the topic has focused on quantitative data and neglected the social consequences. Furthermore, most research has focused on either developed or completely underdeveloped countries, leaving a gap in knowledge about the consequences of climate change in regions like Angul, Odisha.

I carried out a qualitative study in four villages in Angul to look into the effects of climate change on the community in order to fill this gap. I selected these villages based on my familiarity with the region and my ability to communicate with the locals. To ensure broad participation, I interviewed various actors, including farmers, landlords, workers, village officials, local SHGs, senior citizens, and others involved in the agricultural industry.

I used a range of qualitative research techniques, such as semi-structured interviews, in-depth interviews, qualitative observations, and focus group discussions, to obtain data on how climate change has affected the community. Following data analysis, I discovered that erratic monsoons are resulting in a drought-like condition throughout the Kharif season, which reduces water availability and degrades soil quality, reducing agricultural output. Market saturation results from the impact of climate change on crop supply and demand.

Despite high rainfall levels in Angul, the villages suffer from water crises due to irregular monsoons and excessive irrigation. This results in low agricultural output, severely damaging farmers' livelihoods and causing young people to migrate to big cities. Climate change also increases the risk of heat-related, infectious, and water-borne illnesses. Additionally, human-wildlife conflict is a growing issue in the four research locations, with wild animals such as wild boars and elephants destroying crops and attacking humans. The conflict is exacerbated by human behavior, particularly aggression, in Naupada and Balipatta.

In conclusion, the social implications of climate change in Angul include water crises, loss of livelihood, migration of young people, health risks, and human-wildlife conflict. The four research locations have similar environmental conditions, but Padmapur is most affected by climate change. However, Naupada and Balipatta have the ability to resist climatic shocks due to their natural resources. Unexpectedly, I did not discover any significant effects of climate change on caste and gender in the area.

7.2 Insights to the Research Questions-

1- How does agriculture affect the groundwater levels in Odisha? And in turn, how do declining groundwater levels affect agricultural productivity/access to water?

The groundwater levels in the four research locations of this project are subject to variability and depend on numerous factors. The Central Groundwater Board (2021) reports that, compared to the decadal mean, the water level in January 2021 generally increased (2011-2020). However, there are patches where the water level has fallen, primarily in the state's hard rock and hilly terrain. Moreover, due to irregular rainfall in recent years, farmers have started to overuse groundwater for agriculture, causing a steep decline in groundwater levels. In Chapter 4.2 of this thesis, we found that groundwater levels in Padmapur and Ambapal have decreased in the last decade. Based on the example of Padmapur, it is also evident that a decline in groundwater levels could have severe consequences for agricultural productivity and access to water in hilly areas.

2- What is the impact of class, caste, and gender on access to water for livelihoods and agricultural production?

Based on my research on the four villages in Angul, it was found that social class significantly impacts access to water, while gender has a slight impact and caste has no impact on the same. It is possible that the lack of impact of caste on water access is due to various government schemes that were implemented in the early 2000s, such as the creation of ponds belonging to specific castes in Naupada, Balipatta, and Ambapal. In recent years, there have been instances of water crises resulting from climate change. In Chapter 5.2 of this thesis, we found that some women in Padmapur village have faced some difficulty in accessing water for their livelihood. However, several projects like the 'Rural Water Supply and Sanitation Project', 'Jal Jeevan Mission', and other drinking water and irrigation projects have potentially improved water access for people of all social classes, regardless of their gender or caste.

3- What is the effect of groundwater contamination on agriculture? And the effect of agriculture on groundwater quality?

Studies have shown that contaminants in groundwater can negatively impact crop productivity, resulting in lower yields and profits for farmers. However, in my research on the villages in Angul, I did not find a clear correlation between groundwater contamination and agricultural productivity. Nonetheless, according to the Central Groundwater Board (2021) and data from the villages, using chemical fertilizers and pesticides in agriculture can contribute to groundwater contamination, leading to soil erosion and hydrological imbalances.

4- What are the methods to reduce the climatic shock on agriculture? How have farmers (women and men) responded to water stress (too much, too little, irregular)?

Using sustainable agricultural methods can help agriculture be less affected by climate shocks. Crop rotation, conservation agriculture, crop diversification, and water management techniques can all help the agricultural sector become more resilient. Plant breeding and the development of early warning systems can also aid in mitigating the impact of climate change. While researching the four villages, I found that female farmers are slightly more affected (higher workload and increased susceptibility to heat-related illness) by the impacts of climate change than male farmers.

Farmers in the study area adopted various practices to adapt to the changing climate, including using drought-resistant varieties, adjusting planting dates to take advantage of rainfall, capturing rainwater in small ponds near their fields, using mixed cropping, and collaborating with other farmers to manage water resources. Collaboration was found to be the most prominent method, in which multiple households pool resources to dig ponds and collect rainwater for use in the next season.

5- What are the various agricultural schemes in Odisha? And how do they help the farmers in times of crisis?

Scheme	Launched	Description
Kalia Yojana	2018	During the course of five seasons, small and marginal farmers earn Rs. 25,000 per farm family to spend on inputs and other investments.
Mukhyamantri Krishi Udyog Yojana	2018	Simplification of farm loan subsidies.
Mukhyamantri Abhinav Krishi Yantripati Samman Yojana	2018	Rewards innovation in farming tools and implements.
Bhoochetana	2018	Soil health mapping, the Soil Health Card Scheme in Odisha, and assistance for farmers.
Odisha Free Smartphone Yojana for Women Farmers	2018	Provide women farmers access to cell phones so they can access relevant agricultural information.

Mobile for Farmers	2017	Provide smartphones for farmers.
Odisha Fish Pond Yojana	2017	Increase the number of bodies of water and support fisheries.
Mukhyamantri Adibandha Yojana	2017	Improve pond embankment.
Matsyajibi Basa Gruha Yojana	2014	Build housing for fishermen.
Biju Krushak Kalyan Yojana	2013	Agricultural health insurance program in the state of Odisha
Matsyajibi Unnayana Yojana	2003	14-part special welfare program for fishermen that includes financial aid, health and accident insurance, watercraft, cages, and seaweed cultivation

Table 12- Various agricultural schemes for farmers of Odisha. Source: Wikipedia

During my research, I found that farmers of the four research locations mainly use ‘Biju Krushak Kalyan Yojana’, ‘Mukhyamantri Krishi Udyog Yojana’, and ‘Kalia Yojana’. In the recent years, many crop farmers in Ambapal have started doing fish farming, so they avail the benefits of ‘Odisha Fish Pond Yojana’ and ‘Mukhyamantri Adibandha Yojana’.

7.3 Farmers' Perception of Climate Change-

Depending on their region, level of experience, and understanding of climate science, farmers' perspectives on climate change can differ. Others may not be aware of the scientific consensus on climate change and its potential effects. At the same time, some farmers may have noticed changes in weather patterns over time and understand how climate change affects their farming practices. In general, farmers in developing nations who depend on rain-fed agriculture are frequently the most vulnerable to climate change and may be more likely to notice its effects.

After conducting 125 formal interviews and numerous informal ones, I discovered that farmers in the four research locations see climate change as an irregular monsoon and rise in temperature because these factors are causing a decline in agricultural productivity. The four research locations are not affected by additional climate change effects like increasing sea levels, biodiversity loss, or extreme weather events (floods, cyclones, etc.), hence they do not link these effects to climate change.

7.4 Limitations-

There were several limitations to this research study that should be acknowledged:

1- **Limited Data Availability:** There was a scarcity of available and reliable data on groundwater levels, water quality, soil quality, and other essential variables in the Angul district. Therefore, I had to use indirect factors such as the depth of digging borewell and the TDS of water, which may not have been entirely accurate or comprehensive.

2- **Personal and Knowledge Bias:** My personal connection with Naupada, and my background in biology and agricultural sciences could have impacted my data collection and interpretation, leading to personal and knowledge biases. I could have missed some important factors or events due to these biases.

3- **Inexperience in Qualitative Research:** As most of my training and experience were in biological research, I had limited experience and training in qualitative research methods. I had to rely on reading books and watching videos to collect data by trial and error. This lack of expertise could have affected the quality and accuracy of the data collected.

4- **Reliance on Self-Reported Data:** This study relied on interviews, discussions, and observations, which were primarily self-reported by participants. Self-reported data can be susceptible to selective memory, telescoping, attribution, and exaggeration biases, which could have led to inaccuracies in the data.

5- **Time Constraints:** The study was limited by time constraints, as it was conducted as part of an academic honors project. As a result, the sample size could have been larger, and more people associated with agriculture could have been interviewed to provide a more comprehensive and accurate picture of the situation.

6- **Weak Immune System-** Due to the frequent changes in the weather conditions and my weakened immune system, I experienced fevers almost twice a month, significantly impacting my ability to collect data for this project.

7.5 Future Research-

Future studies can further widen the analysis's focus by enlarging the sample to include additional farmers, representatives from various organizations, and government officials. Specialists in qualitative research can improve the efficiency and accuracy of data collection. A year-long ethnographic study can provide a more extensive and in-depth understanding of how the neighborhood has been impacted by climate change. Additionally, obtaining data through

interviews and fieldwork in various villages in the Angul region can provide a comprehensive picture of how climate change affects society.

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Appendices

Appendix- A

Interview Consent Form

Introduction:

This form outlines the details of your participation in an interview that a researcher or an interviewer will conduct. The interview aims to gather information for research purposes, to understand your personal experience, or to explore your opinions and perspectives on a particular topic. Before you agree to participate in the interview, please read the following information carefully and ask any questions you may have.

Participant Information:

Name: _____

Age: _____

Occupation: _____

Gender: _____

Contact Details: _____

Description of the Study:

The interview is being conducted as part of a research study to investigate climate change's impacts on the people of Odisha. The interviewer will ask questions related to the research topic and record your responses. The interview will be audio recorded, and the audio file will be securely saved after being transcribed.

Participation:

You are not required to take part in this study. You are free to decline any questions or leave the interview at any time without suffering any repercussions. If you decide to withdraw, the recording will be stopped immediately, and any data collected up to that point will be deleted.

Risks and Benefits:

There are no obvious hazards related to taking part in this interview. Participating in this interview allows you to share your experiences and perspectives on the topic and contribute to the research study.

Confidentiality:

The interviewee will maintain the confidentiality of all information obtained. The information gathered will be safely saved and used only for study. No identifiable information will be shared with any third party without your permission. However, please note that in rare circumstances, the researcher may be legally required to disclose certain information.

Contact Information:

Please get in touch with the researcher/interviewer if you have any queries or issues about the study or your involvement in the interview at:

1- Email id- adarsh.pradhan@students.iiserpune.ac.in

2- Mobile number- 8018540706

Consent:

I accept to take part in the interview after reading and fully comprehending the data on this form. I am aware that I can leave the interview at any point without suffering any repercussions.

Participant Signature: _____

Date: _____

Appendix- B

Interview Script

Introduction:-

I want to start by saying I appreciate you talking to me today. I'm Adarsh Pradhan, and I'm here to talk about what you think about agriculture and global warming. Let me lay out the general course of events for you. I'll elicit information from you by asking you questions. The fact that this is not a test must be made clear.

Any of the questions have no right or wrong responses. I want you to be as truthful as you can. Feel free to respond anyway you like to the questions; you will not offend anyone with your responses, and I will treat our talk as totally private. I won't divulge information to anyone but the direct team members on this project.

I type a lot slower than I can talk. Can we record this meeting so we can take notes? Please examine and sign the consent form I have created for you. Please inform me at any time if you choose to take a break or end the interview so that I may make accommodations. Have any queries before I start? Let's get going!

Background:-

I would like to learn a bit about you to start this interview.

- 1- How old are you?
- 2- Could you describe your household - family, partner, housemates, or living alone?
- 3- What do you do for a living? How is your living condition?
- 4- What are the major crops or vegetables you produce?
- 5- What kind of livestock do you keep?
- 6- Where do you sell your agricultural products?
- 7- Do you use tractors or traditional farming methods?
- 8- Do you have free time from your work? If yes, then what do you do at that time?
- 9- Do you have a television in your house? If yes, then what do you watch?
- 10- Do you read newspapers or watch the news on television?
- 11- Have you ever heard about global warming or climate change in your day-to-day life?
- 12- Do you know any effects of climate change on your daily life?

Agricultural Impact:-

Global warming is the global rise in temperature of the earth's surface, and climate change is the change of the earth's climate brought about by global warming. Extreme weather conditions are

an example of climate change. I want to ask you some questions about how climate change affects agriculture.

- 1- How is the hotter weather affecting your crops and livestock? Is productivity increasing or decreasing?
- 2- Does extreme heat affect your working conditions in the field?
- 3- Have you observed any trend (increase/decrease/no change) in diseases of crops and livestock?
- 4- Do you use rainfed agriculture or irrigation agriculture?
- 5- What are the different methods you use for irrigation?
- 6- Have you noticed any change in groundwater levels? The water levels are lowering in the wells, or you dig deeper for borewells.
- 7- Have you noticed the irregularity in the rainfall pattern? Some years it rains significantly less, but some years it rains a lot.
- 8- How does irregular rainfall affect your agriculture production? And how do you cope with this?
- 9- Have you ever encountered drought or flood in this area?
- 10- Do you check the soil quality before the plantation period? If yes, have you observed any kind of trend in it?
- 11- Are you aware of the various agricultural schemes the state and the central government provide?
- 12- Are you able to easily access these schemes?
- 13- How do these schemes help you during a crisis?

Social Impact:-

In addition to affecting the environment, climate change affects people's lives in various ways. I want to ask you some questions about how climate change affects your life.

- 1- What else do you purchase for your daily food necessities except for your own agricultural products?
- 2- How do increased food prices affect your economy?
- 3- Do you compromise when buying food? Like you, brought cheaper rice, wheat, dals, vegetables, etc.
- 4- Have you ever faced a situation where you have to worry about food? If yes, how do you cope with that situation?
- 5- Do you notice any effect of too much chemical pesticide in fruits and vegetables? Like they quickly get spoiled or smell unnatural.
- 6- How do you get water for drinking and cooking?
- 7- Do you get enough water for your family?
- 8- Is there a limit to the quantity of water in government taps for your household?

- 9- Have you noticed water quality changes (taste/color/smell)? If yes, then what methods do you use to tackle this situation? Does this extra work put any economic pressure on your family?
- 10- Do you face any challenges (like discrimination) while using the public well, hand pump, river, or pond?
- 11- Have you or anyone in your family suffered from heat waves during summer?
- 12- Does anyone in your family suffer from skin, cardiovascular, respiratory, and kidney diseases?
- 13- Have you or anyone in your family suffered from diseases such as cholera, malaria, typhoid, dengue, chikungunya, filariasis, etc
- 14- Do you know of any effort of the government to increase awareness of the above diseases among citizens?
- 15- How does heavy rainfall affect your infrastructure? Like water leaking from the roof, road potholes, water logging in the drains, etc.

Wildlife Invasion-

From my observation and interviews, I found that there has been an increase in the number of wild animals near the agricultural fields, and many of them have damaged the crops. So, I would like to ask questions about this topic.

- 1- Have you observed any increase in wild animals near croplands? If yes, what wild animals have you seen?
- 2- What is the location of your agricultural land?
- 3- What kind of crop have the wild animals damaged?
- 4- What is the timing of wild animals' invasion? Do they come in the evening, late at night, or very early in the morning?
- 5- What kind of methods do you use to protect your crops?
- 6- How do you feel about news regarding wild animals attacking people in Angul?
- 7- Is there any instance of wild animals attacking the people of your village? If yes, can you describe it?
- 7- Is there any compensation by the government for the attack by wild animals?
- 8- What do you or the people in this village do to prevent animal attacks?
- 9- Have you intentionally or unintentionally harmed any wild animals?
- 10- What is the reaction of the Forest Department towards wildlife invasion?
- 11- Why do you think animals come out of the forest?
- 12- Have wildlife invasions become more frequent, or is it the same? Please explain your opinion.
- 13- How do you think we can solve this problem?

Thank you for sharing your invaluable time and honest opinion with me.

Appendix- C

Focus Group Discussion Consent Form

Title of Study: Agriculture in Odisha: Challenges due to Climate Uncertainties

Researcher: Adarsh Pradhan

Introduction

As a part of a research project, you have been asked to take part in a focus group discussion. Studying the effects of wildlife invasion on village life is the goal of this investigation. It is crucial that you comprehend the processes and hazards associated with this study before deciding whether or not to participate.

Procedures

You will be required to attend a focus group discussion session that lasts about 2-3 hours if you accept to participate. During this session, you will be asked to discuss the wildlife invasion in the village. The discussion will be recorded for later analysis.

Risks

There are very little hazards involved in taking part in this study. The major danger is that the conversation may include delicate or private subjects, which could lead to discomfort or distress. You are, however, free to choose not to respond to any inquiry that causes you any discomfort. The study is completely voluntary, and you are free to leave at any time without incurring any fees.

Confidentiality

The study's findings will all be kept completely confidential. Your responses won't be associated with your name or any other kind of identification when they are recorded anonymously. The data gathered will only be accessible to the academics working on the study.

Benefits

You won't directly gain anything from taking part in this study. Your participation will, nonetheless, aid scientists in their efforts to comprehend the effects of wildlife invasion and how they relate to climate change, which may be to society's advantage.

Consent

It is totally up to you whether or not to take part in this study. By checking the box here, you attest to having read, comprehended, and given your voluntary consent to participate in this study. You may advise the researchers of your decision to withdraw your consent at any time.

I agree to take part in the study having read and comprehended the information above.

Name: _____

Signature: _____

Date: _____

Appendix- D

Guide for the Focus Group Discussions

Introduction:-

Greetings to Everyone. I appreciate you all taking the time to speak with us today. I'm Adarsh Pradhan, and I'm here to talk to you about how you feel about animal invasion. Let me lay out the general course of events for you. I want each of you to offer me your honest opinion and I will ask you questions to better grasp the situation from your point of view. There are no right or wrong responses, so don't be ashamed to express your viewpoint.

If all of you are okay with it, I will take written notes and audio recordings of this discussion. Please examine and sign the consent form I have created for you. Although you all are familiar with each other, I would like to ask each one of you to state your name, occupation, and relevant experience you may have with animals or forests. Now that we are all familiar, let's get started.

Discussion Guide:-

- 1- How have animals affected your village's agriculture and food security?
- 2- Have you or anyone you know been attacked or injured by animals? How did this impact your life?
- 3- What steps have been taken to prevent animal attacks in your village? Have these measures been effective?
- 4- Does your village have any cultural or religious beliefs that affect how animals are treated or managed?
- 5- What are animal attacks' economic, social, and environmental impacts on your village?
- 6- How have government policies and programs addressed animal attacks in your village?
- 7- What can be done to mitigate the impact of animals on your village's crops and people?

So, thank you all for your time and contribution to the discussion. If there are any questions/final comments anyone would like to ask/make, I am happy to answer/hear them. I will use the information gathered in this discussion in my project. If you have any further questions, you can contact me. And I will once again assure you that all information shared will be kept confidential, and your names will not be shared without your consent.

Appendix- E

Qualitative Observations



Fig 1- A rice field in Naupada.



Fig 2- Mixed cropping (banana and groundnut) in Naupada.



Fig 3- A rice field in Balipatta.



Fig 4- Pointed gourd cultivation in Balipatta.



Fig 5- A farmer watering his newly planted banana plants.



Fig 6- A cashew field in Naupada.



Fig 7- A heap of rice straws in Padmapur.



Fig 8- Backyard farming in Ambapal.



Fig 9- Singda stream, which flows from Naupada to Balipatta.



Fig 10- Cashew cultivation in Ambapal.



(A)



(B)

Fig 11- Image of a stream flowing through A- Ambapal and B- Padmapur.



Fig 12- Mixed cropping (banana and sunflower) in Balipatta.



Fig 13- Sapapal minor irrigation project in Naupada.



Fig 14- Tomato cultivation in Naupada.



Fig 15- Mixed cropping (onion and garlic) in Padmapur.



Fig 16- Potato cultivation in Ambapal.



Fig 17- Inside the Bamur Forest Range.



Fig 18- New government irrigation project in Naupada.



Fig 19- Well water used for cultivation of plants in Balipatta.



Fig 20- Mandi in Naupada.