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Effects of Climate Change on Land Use and Agriculture: A Study of Patna Planning Area

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Abstract:
Agriculture is the most vulnerable to climate change, due to its huge size and sensitivity to weather parameters, causing huge economic impacts (Malhi et. al, 2021). During the past 140 years, India has experienced remarkable land use and land-cover changes including deforestation, cropland changes, and urban expansion (Roy et al., 2015; Tian et al., 2014). The changes in climatic events such as temperature and rainfall significantly affect the yield of crops. The effect of rising temperatures, precipitation variation, and CO2 fertilisation varies according to the crop, location, and magnitude of change in the parameters. The temperature increase reduces the yield, while the precipitation increase will likely offset or reduce the impact of increasing temperature (Mendelsohn, 2009). The past few decades indicate that significant global climate changes were triggered by countless local changes resulting from enhanced human activities that altered the composition of the worldwide atmosphere (Karimi et. al, 2018). This paper reviews the information collected through the literature regarding the issue of climate change, its possible causes, and its impact on the agriculture sector as an influence on the physiological and metabolic activities of plants, and its potential and reported implications for growth and plant productivity. The study reveals that the nature of land and land use is dynamic and the surroundings of agricultural land are also changing with the invasion of different types of construction. Traditional farming is practised in the study area by the common farmers and they lack an understanding behaviour of climate.

Keywords: Land Use, Agriculture, Climate Change, Temperature, Rainfall

Introduction

The impact of climate change is very comprehensive but its far-reaching effects are now clearly visible on the agricultural sector, which relies on the world's food production and economy. Climate change is one of the most defining concerns of today's world and has greatly reshaped or is in the process of altering the earth's ecosystems. Although climate change has been a constant process on earth, in recent times, approximately the last 100 years or so, the pace of this variation has increased manifolds. Due to anthropogenic activities, the average temperature has risen by 0.9 °C since the nineteenth century, mainly due to greenhouse gas (GHG) emissions in the atmosphere. As per estimates, this rise is expected to be 1.5 °C by 2050 or even more, the way deforestation is occurring, GHG emissions are increasing and soil, water bodies and air are being polluted. Environmental changes of either kind become global change in one of two ways by affecting a globally fluid system (the atmosphere, world climate, sea level) or by occurring in a localized or patchwork fashion in enough places to sum up to a globally significant total (Raj & Prasad, 2024). Land use change is conditioned by the associated physical factors and cultural

factors. Physical factors include geology, relief features, climate, soil and vegetation which limits the uses and capabilities of land. Cultural factors represent the length of occupancy of the area, demographic and socio-economic conditions, institutional framework and the technological levels of the people which determine the extent to which the land can be used (Salvati et.al 2018).

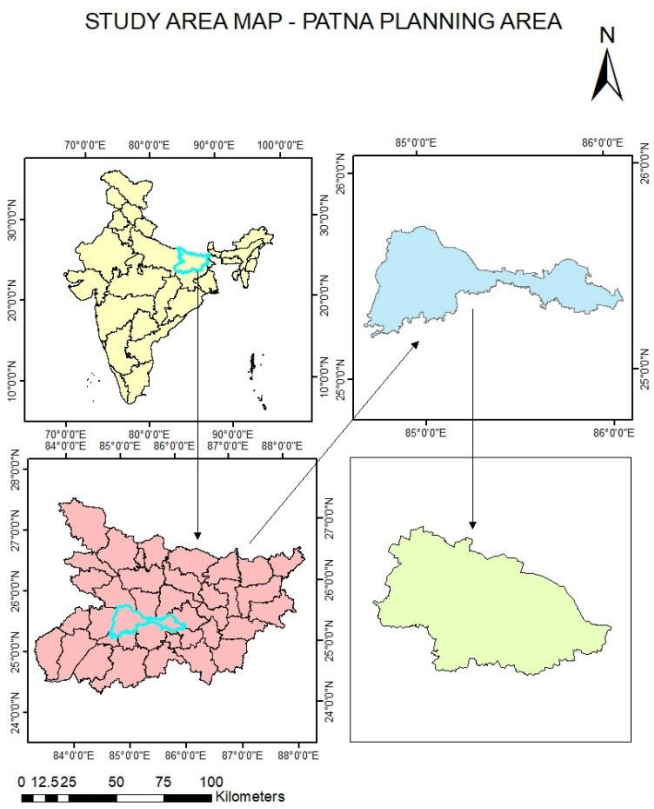
The unprecedented hike in temperature has resulted in increased events of droughts, floods, irregular precipitation patterns, heat waves and other extreme happenings throughout the globe. As per the annual report of weather, Climate and Catastrophe Insight, natural disasters alone have caused economic losses to the tune of USD 225 billion across the world in 2018 and since 2016 the losses due to natural calamities have crossed USD 200 billion per year. About 95% of these losses are attributed to weather-related incidences, of which cyclones, floods and droughts are the key players and are directly related to climate change.

Connecting and sensitizing farmers to sustainable technologies and activities is of utmost importance as they are the ones who can play a major role in the implementation of ecological goals. Climate change and agriculture are strongly correlated (Arora, 2019). The fast pace of climate change will have a far-reaching impact on agro-ecosystems and their productivity. Hence it is high time that we prepare ourselves for the upcoming challenges to combat the effects of climate change and ensure food security for humans and other living beings. Thus, the climate has always influenced the scenario for livings.

What are the ideal land use strategies for the disadvantages against climate change to ensure higher capital formation and improve livelihood of the people? One has to understand the natural resource base of the district and the socioeconomic milieu of the region to decide broad strategies for such areas. In the present paper, an attempt has been made to evaluate the impact of climate change on farmers and their understanding its nature towards transforming land use and agriculture to identify the major issues which need to be addressed for improving the livelihood on a sustainable basis. Emphasis is also placed on steps to tackle the problems which originated in farming. The authors' experience of working in one the basic disadvantage of district Patna (Bihar) is illustrated to demonstrate that the major issues and challenges faced by local farmers and people which makes the situation much critical in terms of behavioural aspect of population and climate change.

Research Coverage: Theme and area

Located in the mid-Ganga plain, Patna shelters a large population. The extension of the Patna Planning Area spans from 25°43´30.82"N to 25°23´42.60"N in latitude and from 85°22´19.51"E to 84°46´58.93"E in longitude. After Kolkata, Patna is the second most important urban centre in the eastern region of India. As the only metropolitan region in the state, Patna exhibits characteristics of a primate city and has experienced rapid population growth and urban expansion, placing immense pressure on its urban ecology. Uncontrolled expansion of the city and its periphery could result in haphazard development, leading to an undesirable cityscape. Therefore, recognizing the need for controlled development, an approach to planning the Patna Planning Area was proposed. The Patna Planning Area consists of mostly fertile land across the 13 blocks of Patna district which has immense scope to be converted in the Patna Metropolitan Region.



Map 1.1: Patna Planning Area

Aims and objectives

1. To understand the impact of climate change on agriculture.
2. To identify the problems in crop cultivation due to climate change and land use.
3. To assess the behaviour of farmers to tackle climate change.

Methods and Materials

This paper is based on primary and secondary data comprising both quantitative and qualitative approaches allowing for a deeper understanding of the phenomenon. The primary data has been acquired through a structured survey of 100 respondents. The secondary data has been acquired through an extensive literature survey and various government and non-governmental concerns.

Climate Change and Agriculture

Agriculture, forestry and other land uses are unique due to their capacity to mitigate climate change through greenhouse gas (GHG) emission reductions, as well as enhance removals (IPCC 2019). The effect of climate change on crop yields varies according to the area and irrigation application. Crop yields can be increased by expanding irrigated areas, which can have a detrimental effect on the environment (Kang et al., 2009). The temperature rise is likely to reduce the yield of many crops by reducing their duration (Mahato, 2014). The aggregate production of wheat, rice, and maize is expected to decrease if both the temperate and tropical regions experience a warming of 2 ◦C (Challinor et al., 2014). Climate change in general has more impact on tropical regions, as tropical crops remain closer to their high-temperature optima, and thereby experience high-temperature stress during elevated levels of temperature. The temperature increase reduces the yield, while the precipitation increase is likely to offset or reduce the

impact of increasing temperature [40]. As influenced by climatic variables when witnessed in Iran, crop productivity depends on adaptation abilities and crop type, climate scenario, and CO2 fertilization effect (Karimi et al., 2018).

According to the Economic Survey 2023–24, agriculture in India employs more than 50 per cent of the total workforce and contributes around 18.2 per cent to the country's GDP. However, the unpredictability of weather negatively impacts Indian agriculture, and the inevitable effects of climate change are expected to worsen these challenges. Bihar, one of India's poorest states, has a population of over 100 million, with 73 per cent of its people employed in the agriculture sector. The state's small-scale, intensive agriculture is focused on the cultivation of rice, wheat, pulses, as well as fruits and vegetables. Bihar's highly fertilized alluvial plains allow for double cropping, contributing over 24 per cent to the state's GDP (Anshul et al., 2019).

Lack of water in the soil can cause plants to lose their biological functions, making them more susceptible to diseases and pests. On the other hand, large areas of the world, such as northern Europe and the eastern parts of the Americas, have become wetter, with extreme rainfall events significantly increasing global precipitation (Skendžić et al., 2021). The Patna Planning Area faced groundwater due to climate change as well as high demand in all sectors of the economy.

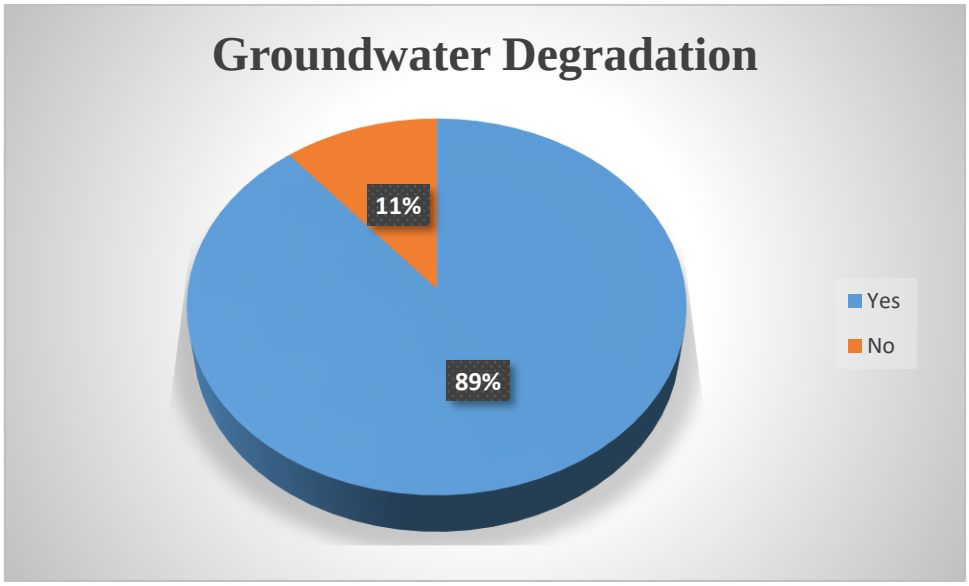
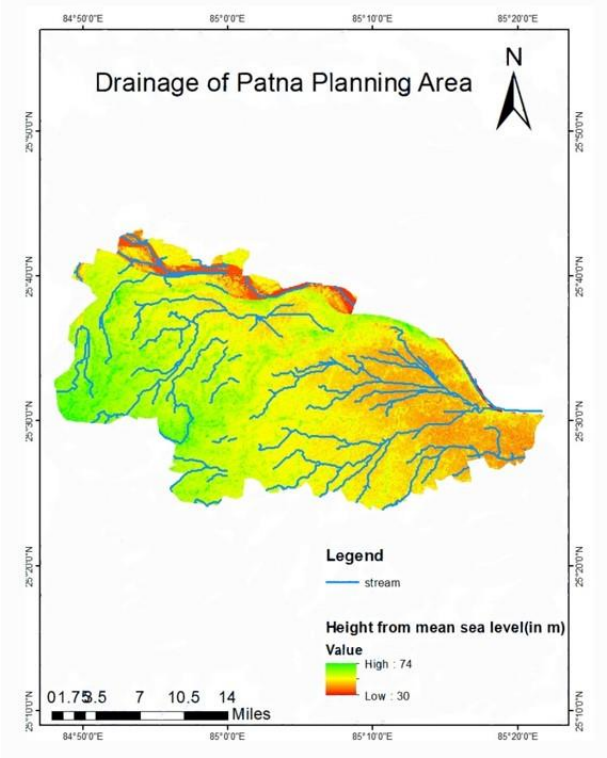


Fig: 1.1

Source: Based on data collected during a field survey in the year 2024.

The continuous population pressure is increasing the demand for groundwater. The dependency on irrigation has shifted from monsoon and seasonal rivers to groundwater as it is the only trusted source at dooming times in agriculture. . In the neo-Malthusian position, global population increases are accorded primary importance in most environmental change because of the resources required to sustain the demands of eight billion people. Population growth is seen as having exceeded the capacity of the biosphere, as managed by society, to sustain it(Raj & Prasad, 2024)



Map 1.2: Drainage of Patna Planning Area

Crop irrigation facilities are needed when crop demands increase, so farmers have the ease and suitability to irrigate their farms according to their will in changing climatic situations. The availability of electricity and electric motors or submersible pumps enhanced irrigation. At the same time, groundwater recharges face many challenges in the study area.

Crop production is heavily influenced by water availability, which is closely linked to changes in climate. Climate change is expected to alter rainfall patterns, soil moisture storage, evaporation, and runoff, with more than 80% of global crop production relying on rainfall. As a result, variations in total seasonal rainfall or its patterns are crucial for agriculture. There is clear evidence of an intensification of the global hydrological cycle, driven by temperature changes. However, predicting its exact impact on crop production remains challenging, as other climate variables, such as the frequency and intensity of extreme weather events influence it. In regions where dry seasons limit crop production, changes in precipitation patterns may have an even greater impact on agriculture than temperature changes (Pathania et al., 2020).

Crop cultivation and land use affected by climate change

Indian Institute of Technology Guwahati, in collaboration with IIT Mandi and the Centre for Study of Science, Technology, and Policy (CSTEP), Bengaluru, released the report “District-Level Climate Risk Assessment for India: Mapping Flood and Drought Risks Using IPCC Framework”. In this report, the key feature highlighted that the study area has a unique feature related to climate change. A study of 600 districts was conducted of which Patna (Bihar) district is included in those 11 districts of India with dual risk areas that are at "Very High" risk for both floods and droughts, necessitating immediate interventions. Patna district is situated at a very interesting location where so many rivers drain this area. But being part of South Bihar Plain it also has effects of drought.

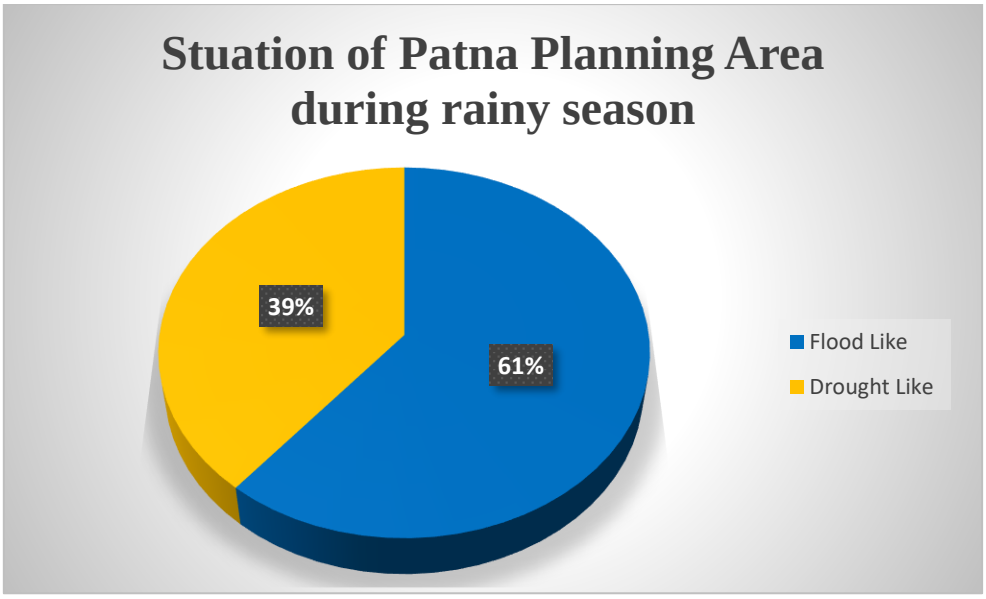


Fig: 1.2

Source: Based on data collected during a field survey in the year 2024.

The everlasting increase in the built-up area and the cementation of the land reduces the agricultural land. The well-defined ahar, pyne and canal is being encroached for construction of roads and other uses leading to the accumulation of water at different patches in the study area. The study area itself has 13 blocks of which each has different types of problems related to flood and drought.

Farmers tackling climate change

Direct human activities, land use, deforestation, clearing of agricultural land, and soil degradation, can release carbon dioxide (CO_2) into the atmosphere. The majority of CO_2 from agriculture is produced by excessive fertiliser use and burning fossil fuels, as stated by (Lawrence et al., 2021). With the changing land use pattern and local situations like encroachment and different developmental activities, farming in small patches is becoming tougher for small and marginal farmers. Crop cultivation has now transformed into plantation agriculture specifically banana cultivation in some low-lying areas. Farmers transposed to crops that are non-traditional in the area and more weather-resistant. Some believe that productivity per hectare is a matter of a better environment and climate so they shifted to other products. The farmers are compelled to use more fertilisers and hybrid seeds. Organic farming is promoted but still not practised as a beneficial aid in the study area.

Agriculture is projected to be responsible for about 80% of anthropogenic (nitrous oxide) N_2O emissions, 70% of anthropogenic (ammonia) NH3 emissions, and 40% of anthropogenic (methane) CH_4 emissions, essentially due to enteric fermentation (Birch, 2014).

Conclusion

Addressing the multifaceted challenges of climate change requires collective efforts and a deep understanding of the complexities inherent in our systems. The diverse geographical and climatic conditions across India, from the Himalayan region to the plains, present unique challenges that must be addressed with tailored, region-specific strategies. Patna Planning Area is being developed with the prospects and potential to become a sustainable capital region of Bihar. A marked change is visible

according to the land use pattern in this area in terms of built-up area and behaviour of agriculture. A comprehensive framework needs to be framed by policymakers, enabling them to devise targeted solutions that consider the distinct needs of each region. Effective planning and execution of climate change policies are essential for driving impactful, long-term outcomes. By highlighting these regional disparities, the paper will be guidance for effective action. This initiative marks a significant step toward enhancing climate resilience across regions and states, ensuring that our efforts are both relevant and impactful in mitigating the effects of climate change.

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