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Assessing Climate Change Vulnerability and Challenges in Agri-Food Production in Gwalior

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Abstract

The impact of climate change on rural life and agricultural stability in Gwalior district, Madhya Pradesh, India. Farmers in this region are heavily reliant on climate-sensitive resources, making them vulnerable to even minor environmental changes. The reliance on traditional farming methods and climate-sensitive crops exacerbates the challenges posed by climate change, affecting agricultural production and farmers' livelihoods. The contemporary agricultural practices, which depend on fossil fuels for machinery and inputs, further complicate the situation. The Climate Smart Cities Assessment Framework (CSCAF), part of India's Smart Cities Mission, aims to address these issues. Understanding the effects of climate change on crop yields, soil fertility, and water availability is essential for promoting sustainable agriculture in Gwalior. The analysis of climate change impacts will help assess the sensitivity of crops, soil health, and water systems, providing valuable insights for local farmers and policymakers.

Keywords: Climate, production, Gwalior, agricultural and Farmers

Introduction

It is anticipated that the influence of climate change on agriculture will be one of the most significant determining variables that will have an effect on the future food security of humanity on earth. The agricultural sector is not only vulnerable to the effects of climate change, but it is also one of the primary contributors to climate impact. The expansion of the agricultural sector as a whole faces obstacle in the form of not only gaining an understanding of the changes in weather that occur over a period of time but also modifying management techniques in order to achieve greater harvests. Due to the fact that there is regional diversity in rainfall, temperature, crops and cropping systems, soils, and management approaches, the climate sensitivity of agriculture is unknown. The fluctuations in temperature and precipitation that occurred between years were much more than the changes that were projected to occur with regard to temperature and precipitation. The expected climate change may result in an increase in the variability of the climate, which might lead to an increase in crop losses.

As a result of the multifaceted effect that global warming will have, many fruits and vegetables will react differently. The tropics are more reliant on agriculture due to the fact that seventy-five percent of the world's population resides in the tropics, and agriculture is the primary profession of two thirds of these people. Because of the low levels of technology, the broad variety of pests, illnesses, and weeds, the degradation of land, the uneven distribution of land, and the fast rise of the population, any influence on tropical agriculture will have an effect on their means of subsistence. The six most important crops in the world are rice, wheat, maize, sorghum, soybeans, and barley. These crops are cultivated in forty percent of the world's cropped land and are responsible for fifty-five percent of the calories that are not derived from meat and more than seventy percent of the animal feed (FAO, 2006) [5]. Consequently, any impact on these crops would have a negative impact on the nation's

ability to get food.

The impact of climate change on agricultural production in Gwalior presents a critical area of concern, particularly due to the region's dependence on climate-sensitive crops and traditional farming methods. Gwalior, located in the central part of India within the state of Madhya Pradesh, experiences a semi-arid to sub-humid climate, making it highly vulnerable to shifts in temperature and precipitation patterns. Over the years, rising temperatures, erratic rainfall, delayed monsoons, and increasing frequency of extreme weather events such as droughts and heatwaves have significantly affected the agricultural landscape of the region. These climatic irregularities have led to decreased soil moisture, reduced groundwater availability, and altered crop cycles, thereby lowering crop yields, especially of staple crops like wheat, soybean, and pulses.

The dependency on rain-fed agriculture further exacerbates the situation, leaving small and marginal farmers economically insecure. Geographic studies indicate spatial variations in the extent of climate impact within different blocks of Gwalior, highlighting the importance of localized adaptation strategies. Furthermore, the shifting agro-climatic conditions are prompting changes in cropping patterns and land use, with farmers often being forced to switch to less water-intensive but less profitable crops. The study of Gwalior from a geographical perspective emphasizes the urgent need for integrated climate-resilient agricultural practices, improved irrigation infrastructure, and government-supported extension services to mitigate the adverse effects and ensure food security and sustainable livelihoods for the farming community.

Literature Review

In the Madhya Pradesh, India, watershed basin of the Chambal River, this research looks at how farmers there see and understand the hazards that climate change poses to their crops. Farmers who reported a rise in temperature had a level of education higher than eighth grade, while those who reported a decline in annual precipitation were more likely to be of the joint family type, according to the study. An individual's opinion of the need to increase the frequency of irrigation is substantially influenced by their income level and amount of agricultural experience. According to these findings, it is critical to put money into farmers' education, promote joint family life, work continuously to raise farmers' income, and learn from the wisdom of older farmers. Challinor AJ, *et al*. (2017) [1].

Both the current level of climate variability and the projected changes in climate due to anthropogenic global warming pose threats to agriculture. Global warming, according to agricultural production models and climate models, will make main crops more vulnerable to heat stress, which would ultimately result in reduced yields. There are still significant uncertainties on the magnitude of these decreases in yields, which vary significantly around the world. The potential for climate variability to reduce yields is comparable to or perhaps larger than the expected decrease in yields caused by rising average temperatures, according to several studies. This research examines the impact of climate variability and projected changes in the mean values of temperature and precipitation at the regional level for India, following a survey of similar results at the global level. Predicting changes in rainfall patterns for India is fraught with significant uncertainties, mainly due to the challenges in understanding and predicting monsoon behavior. There are more robust findings about anticipated increases in temperature in the Indian subcontinent. Easterling DR, 2000 [4].

Vulnerable tribal communities that rely on agriculture based on rainfall and forest products are among the disadvantaged people residing in the area. Hence, it is important to record any change in rainfall patterns as a result of climate change so that future plans may be more accurate. Both the Arabian Sea and Bay of Bengal branches of the Indian Summer Monsoon provide heavy rainfall to the two meteorological subdivisions of Madhya Pradesh, which are the subject of this research. Data on precipitation totals from India's Indian Institute of Tropical Meteorology in Pune formed the basis of the research. In order to find out how much rainfall changed, this research employed Sen's Slope and the Mann-Kendall test to look for trends. During the long-term study in East Madhya Pradesh alone, statistically significant downward trends were seen in both the total annual rainfall (-1.125 mm y^{-1}) and the monsoon rainfall (-1.242 mm y^{-1}). But in East Madhya Pradesh, no patterns have emerged in the last three decades. Over both the long and medium term, West Madhya Pradesh rainfall has shown no discernible pattern. Goswami BN, 2006 [9].

After the Green Revolution, India's agricultural industry went from producing insufficient food to producing an abundance of it. Nevertheless, climate change has impeded the ongoing advancements in Indian agriculture. By calculating the composite vulnerability index using the agricultural vulnerability index (AVI) and the socio-economic vulnerability index (SEVI), this study investigates the climate change vulnerability of Madhya Pradesh districts in India. Variations in susceptibility between districts and the effect of agricultural and socio-economic variables on targeted adaptation and mitigation methods are the foci of this research. From 1951 to 2021, the trend analysis findings show that Madhya Pradesh will experience decreasing rainfall and increasing temperatures, which will have a direct impact on the agricultural sector and people's livelihoods. Results from the composite vulnerability index (CVI) showed that districts like Burhanpur and Balanghai, which had low values (< 0.394), are less vulnerable because of factors including reduced population density, restricted farming, low dependence on rainfall, and lesser sensitivity to drought. Gupta R, 2013 [10].

An important multifunctional river in west India, the Narmada River is located in the Osmanabad region of Madhya Pradesh. The goal of this research is to assess the possible public health risk of temperature and precipitation as they relate to the quality of drinking water along the river in this area. To conduct this study, researchers gathered historical data on air temperature and precipitation, and then used a multiple linear regression model to analyze the total coliform effect of these variables. The research discovered that the public health risk of water-borne infections might vary depending on weather conditions, with the monsoon season posing a particularly high risk. Hauser PM, 1965 [11].

Problems, And Difficulties Facing Agri-Food Production in The Future

Difficulties Faced by Indian Farmers in Agriculture

A number of problems affect farmers globally. A farmer's life is both directly and indirectly impacted by these issues. In addition, there are a lot of time and energy commitments associated with farming and other parts of agriculture. The problems faced by farmers are typically unnoticed in the food industry. The main issues that farmers encounter is intended to be brought to light in this essay. What makes them:

Inadequate transport

The absence of infrastructure, including roads, cars, and capital, makes it difficult for farmers in developing nations to get their goods to market. They often face the difficult and time-consuming task of transporting their harvest from the farm to nearby marketplaces on foot or bicycle. Since they are unable to move their goods to areas with higher food demand, they sometimes have to sell it at very cheap rates.

Lack of capital

Capital is essential for farmers to launch and expand their companies. But since lenders don't comprehend their specific requirements, they often have limited access to loans and funding. Poor financial resources have an impact on agricultural output in terms of both quantity and quality. Poor agricultural quality is a consequence of farmers in some developing nations lacking the capital to invest in modern technology, machinery, and equipment.

Agricultural marketing

Moving goods from the farm to the table is what's known as agricultural marketing. Finding customers, negotiating pricing, shipping items, and gathering quality feedback are all part of this process. This procedure may be fairly complex due to the large number of persons involved. Finding customers willing to pay a reasonable price for their commodities is a constant challenge for farmers.

Soil erosion

Erosion of soil occurs naturally when water or wind carries soil particles to new locations. When this occurs often, it poses significant challenges for farmers. Overturning soil, which reduces water retention and degrades soil quality, is one of several causes of soil erosion. The upper soil layers are swiftly washed away whenever it floods. To avoid soil erosion, one should limit irrigation water usage, shield soil from wind and water using mulch and cover crops, and keep cattle from overgrazing.

Irrigation problems

While advancements in irrigation technology have allowed farmers to see a rise in their revenue, several obstacles unique to irrigation make it difficult, if not impossible, for farmers to get a return on investment (ROI) that is proportional to their inputs. When it comes to irrigation, the most common issues that farmers face are:

- Lack of mechanization
- Climate change
- Surface water overexploitation
- Increased demand for water
- Old irrigation infrastructure
- Inadequate drainage
- Inadequate lighting

It may be challenging to manage irrigation systems when there is little rainfall, flooding, or both.

Droughts have often caused surface water supplies to dry up, forcing farmers to rely on groundwater resources. When sufficient surface water is accessible, they have been forced to depend on groundwater in other instances. When groundwater levels fall, farmers may not have enough water to irrigate their crops adequately during the dry season, which may lead to issues.

Lack of high-quality seeds

If farmers want to increase their agricultural production, they must utilize high-quality seed. Achieving long-term increases in agricultural output also depends on it. Producing and distributing high-quality seed is equally crucial. The exorbitant costs of high-quality seeds put them out of reach for the majority of farmers, particularly those on the margins and with smaller farms.

Difficulties Facing Agri-Food Production in the Future

An agri-food production of the future is most likely to be influenced by a blend of environmental, technological, economic, and socio-political pressures. With increased population and changing climatic changes around the world, agri-food sector is confronted with increased problems in the provision of stable, nutritious and affordable food supplies. The next significant challenges can be considered the most generally perceived threats to the future food production systems.

Extreme weather conditions and Climate Change.

The growing effects of climate change will severely interfere with future agri-food production. Increase in temperature, changing rainfall pattern and the rise in extreme weather conditions, including droughts, floods, heat waves and cyclones, may directly lower crop yields and interfere with harvesting patterns. Much of the staple crops (wheat, rice, maize) is also extremely sensitive to heat stress, which may inhibit photosynthesis, pollination, and grain development. In dry places, there will be a scarcity of irrigation due to prolonged droughts, whereas in wet places there will be soil erosion, waterlogging, and outbreak of crop diseases due to heavy rains.

Moreover, the occurrence rate of the so-called compound events, e.g. concomitant heat and drought, will render the agricultural production more unpredictable. Such climatic stressors can potentially reduce productivity and destabilize the entire world food supply chains unless timely adaptive action is taken.

Water Crisis and Freshwater resources

At present, agriculture is the main activity consuming almost 70 percent of the total freshwater withdrawals, and the scarcity of water in the future may become one of the most serious obstacles to the production of agri-foods. The agricultural systems will be strained by the depletion of groundwater, reducing river flows, polluted water bodies,

and the growing demand on water systems by the domestic, industrial, and environmental demands. In most areas, groundwater is being depleted at a rate that is faster than the natural rate of replenishing, resulting in the scarcity in the long term.

The effect of climate change will be that irrigation systems will be stressed further as the reliability of rainfall becomes low, making the farmers unable to continue with the traditional crop cycles. Scarcity of water can also promote changes to less water-intensive crops, which will change regional food culture and economies. Food systems will not be able to satisfy the demand in the future unless there is major advancement in water-use efficiency and sustainable irrigation technologies.

Soil Erosion and Falling Agricultural Productivity

The degradation of soil, such as soil erosion, loss of nutrients and salinization together with soil contamination are proving to be a significant limitation to the future in food production. The high agricultural activities, excessive use of chemical fertilizer, mono-cropping, and poor land management have drastically decreased the soils fertility in most agricultural areas. Stresses associated with climate make this even worse: high temperatures increase the rate of decomposition of the topsoil, and heavy rains can erode it.

The urbanization and change of land-use also decrease the space that can be used in growing food and limit the possibility of increasing food production. The long run productivity of agricultural systems is at stake as arable land is shrinking, and soils are getting poor. Healing the soil will hence be the key to ensuring the global food security.

Pests, Diseases and Biological Threats

Due to increasing temperatures and changing ecosystems, the number of agricultural pests, plant diseases, and invasive species is expected to increase in the future. Lots of pests and pathogens survive better in warmer conditions and can proliferate to new areas that were not favorable to their existence. Consequently, farmers will experience more losses of their crops and they might need more dependence on pesticides and organic control systems.

Besides this, the process of globalization makes the spread of pests and diseases more likely because it is delivered via trade networks. Animal and poultry systems are also exposed to emergent zoonotic diseases that have the capacity to interfere with meat, dairy, and egg production. Such biological threats need close follow up, enhanced biosecurity and investment in resistant crop and livestock strains.

Reliance on Fossil Fuels and Increasing Cost of inputs

The contemporary style of farming relies on fossil fuels to run the machinery, transport, fertilizers and pesticides. With the increasing cost of fossil fuels or its unavailability in the fields of climate policy, or political unrest, the price of agricultural inputs should soar. Especially fertilizers are exposed to the changes in the global market which is a big challenge to small and marginal farmers.

Food processing, storage, and distribution can also be impacted as a result of increasing energy costs, increasing the disparity between production and consumption. Unless alternative sources of energy are established to support agricultural activities, food prices will go up and access to basic products will be more unbalanced.

Gwalior and Its Vulnerability to Climate Change

As one of eleven places designated as counter-magnets by the National center Region Planning Board Act of 1985, Gwalior serves as the tourism center of Madhya Pradesh. The city's fort is a major draw. The majority of Gwalior's land is used for agriculture (54%), with a small percentage going to residential (15%), hills and hillocks (15%), recreational (nearly 2.5%), and water bodies (less than 1%). Lashkar, Hazira, and Morar are the three main centers of the city. A large portion of Gwalior's ABD area for their smart city project is located in Lashkar, which is mostly the Maharaj Bada. In addition to the Swarna Rekha River on the north and west, the Jai Vilas palace on the north-east, Chatri's on the east, and dense urban populations on the south form the boundaries of Lashkar, which spans 803 acres.

Congestion and a lack of natural space are problems the neighborhood faces, but it is vital that a strong public transit system links it to all the city's significant economic hubs. At now, there is an absence of green open spaces from the local level all the way up to the ABD region as a whole. Concreting the Swarna Rekha riverbed slows the percolation of precipitation and encroaches on the drainage system, both of which may cause floods. Because of this, a controlled wastewater management system is required. As per EPCO's Vulnerability Assessment Report, the mid-century and end-century scenarios based on the Representative Concentration Pathways (RCP) 4.5 pose a significant threat to water availability, crop water stresses, and the frequency of extreme events such as floods and droughts. According to end-of-century predictions, the city's forest vulnerability decreases to very high, although it remains very high in the RCP 4.5 mid-century scenario. The city is very susceptible to climate change, according to the RCP 4.5 mid-century risk estimates, which indicate a significant likelihood of lower average yearly rainfall, more intense precipitation, and higher heat index.

The Climate Smart Cities Assessment Framework (CSCAF) is an initiative of the Ministry of Housing and Urban Affairs that is part of the Smart Cities Mission. Its stated goal is to serve as a guide for the creation of policies and programs at the municipal level in order to mitigate the effects of climate change and adapt to its challenges. Twenty-eight indicators make up CSF-AF's five main areas: energy and green buildings; urban planning, biodiversity, and green cover; mobility and air quality; water resource management; and waste management. EPCO, in collaboration with the Environment and Urban Development and Housing ministries of the MP government, is receiving technical assistance from WRI India as it works on a municipal climate action plan (CAP), adaptation and mitigation methods, and other related projects. The CAP is based on vulnerability assessments and profiles of greenhouse gas emissions from the cities. Following an examination of city-submitted data, the CAP pinpoints current gaps in mitigating future climate risks and proposes critical next steps across the five CSC-AF theme areas. In order to put the suggestions into action, it also suggests an institutional structure.

Agricultural Practices in Gwalior

Gwalior, in the Indian state of Madhya Pradesh, is famous for its varied agricultural terrain, which is influenced by the city's climate, soil, and resources. Despite considerable improvements to irrigation infrastructure in recent years, rain-fed agriculture continues to predominate in the area. Gwalior farmers use a mix of contemporary and ancient methods to boost yields and keep the land habitable.

- **Crop Cultivation:** Wheat, rice, jowar (sorghum), and bajra (pearl millet) are the main crops farmed in Gwalior. Due to the region's ideal cold environment throughout the winter, wheat is the most often planted rabi crop. Conversely, paddy fields are concentrated in water-abundant regions, and rice farming is common during the kharif (monsoon) season. A large portion of the district's agricultural production comes from pulse crops like chickpeas (gramme) and oilseed crops like mustard and soybeans, in addition to basic staples. In addition to bolstering regional food security, these crops are good for the local economy.
- **Irrigation Practices:** Both surface and underground water sources are vital to the Gwalior irrigation system. Essential irrigation for agricultural areas is provided by canals that draw water from surrounding bodies of water. This is especially true in Bhitarwar block, which has the greatest canal irrigation coverage. Nonetheless, many farmers rely on groundwater from dug wells and tube wells to augment their water requirements during droughts. More and more people are worried about the long-term viability of our groundwater supply; therefore, many are trying to get the word out about water-saving practices like drip irrigation and rainwater collection.
- **Modern Agricultural Techniques:** Gwalior has been a trailblazer in the use of cutting-edge farming technology that has improved output while decreasing input costs in recent years. Greenhouse and polyhouse farming, which include protected agricultural approaches, have become more popular among farmers. By minimizing exposure to pests and bad weather, these controlled settings make it possible to grow high-value crops like flowers, cucumbers, and tomatoes all year round. Another new technique that is gaining traction in the area is hydroponic gardening. Hydroponics is a great alternative for urban and semi-urban areas with limited arable land since it allows plants to grow without soil and uses nutrient-rich water solutions. This method also conserves water and makes the most efficient use of available space.
- **Role of Educational and Research Institutions:** The contribution of Gwalior's educational and research institutes in improving farming techniques is crucial. Agricultural education, research, and extension activities are the main focusses of the Rajmata Vijaya Raje Scindia Krishi Vishwa Vidyalaya, which was founded in 2008. Sustainable agricultural methods are the focus of the university's research on soil health, water management, and crop enhancement. The School of Agriculture at ITM University also provides cutting-edge training and courses to help farmers and students stay abreast of technological developments in the field. For the purpose of educating the public and helping local farmers overcome obstacles in the agricultural sector, these establishments play an essential role.
- **Effects of Climate Change in Gwalior region:** Gwalior, like many regions in India, heavily relies on agriculture as a primary livelihood. Understanding how climate change affects crop yields, soil fertility, and water availability is crucial for ensuring the sustainability of local agriculture. Agriculture in Gwalior contributes significantly to regional food security. Changes in climate patterns can disrupt crop cycles, leading to potential food shortages and economic instability. By studying these impacts, policymakers can better prepare strategies to safeguard food production and availability. Agriculture is a major economic sector in Gwalior, supporting livelihoods of a large population. Climate change-induced challenges such as water scarcity, unpredictable weather patterns, and pest outbreaks can severely impact farmers; incomes and overall economic stability.

Understanding these impacts can guide investments in resilient agricultural practices and infrastructure. Agriculture often interacts with natural ecosystems and resources such as water bodies and forests. Climate change can exacerbate environmental degradation through factors like deforestation for agriculture or increased pressure on water resources. Studying these impacts helps in devising sustainable agricultural practices that minimize environmental harm. In conclusion, studying the impact of climate change on agricultural production in Gwalior is not only about understanding environmental changes but also about ensuring food security, economic stability, environmental conservation, and community resilience. It provides a foundation for informed decision-making and proactive measures to mitigate the adverse effects of climate change on agriculture and livelihoods in the region.

The effects of climate change are already well visible by increasing air temperatures, melting glaciers and decreasing polar ice caps, rising sea levels, increasing desertification, as well as by more frequent extreme weather events such as heat waves, droughts, floods and storms. Climate change is not globally uniform and affects some regions more than others. On the following diagrams, you can see how climate change has already affected the region of Gwalior during the past 40 years. The data source used is ERA5, the fifth generation ECMWF atmospheric reanalysis of the global climate, covering the time range from 1979 to 2021, with a spatial resolution of 30 km. The data will not show conditions at an exact location. Micro-climates and local differences will not appear. Therefore, temperatures will be often higher than those displayed especially in cities and precipitation may vary locally, depending on topography.

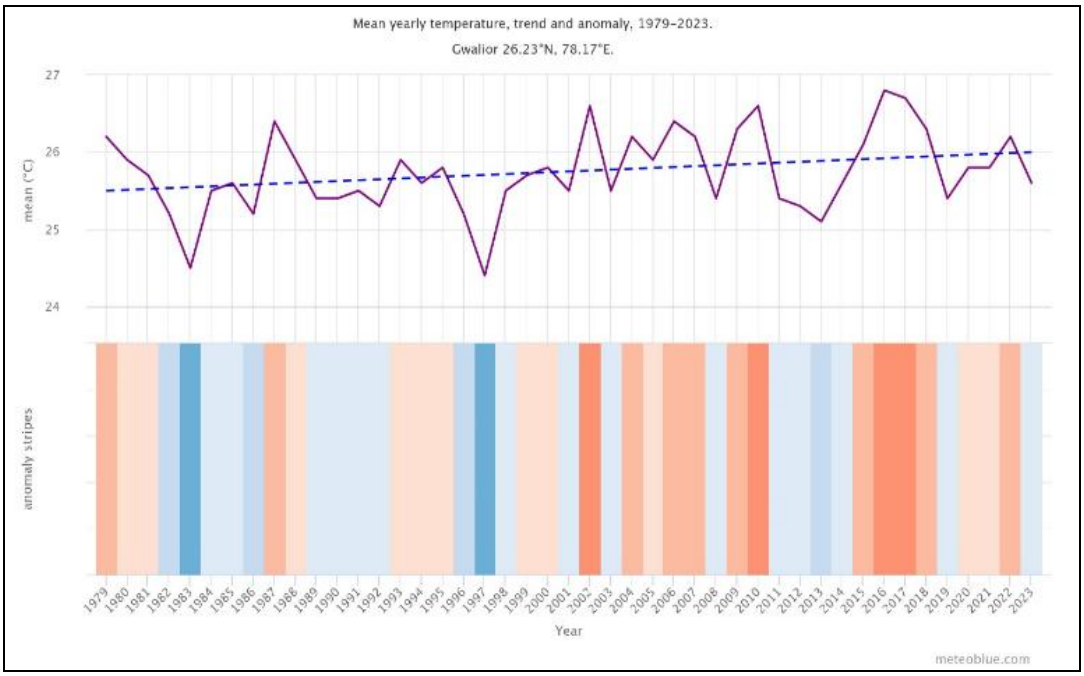

Fig 1: Trends of temperature in Gwalior

Data for Wheat

The break-even analysis of wheat production is presented in Table 1. The table reveals that an average total fixed cost of wheat production was found to be ₹10885.89/ha which was increase with the increase in farm size after marginal and small farm hence it is highest on a small farm (₹14124.50 /ha) followed by marginal (₹12909.57/ha) small (₹14124.50), large (₹9382.18), medium (₹9251.22/ha) and semi medium (₹8762/ha) per hectare. The variable cost per quintal indicated that how much cash expenses are incurred on variable inputs for producing one quintal of wheat output. On an average total variable cost (TVC) per quintal was observed ₹759.31 which is highest on large farm size (₹769/qtl) followed by medium (₹764.51/qtl), semi medium (₹761/qtl) small (₹739.5/qtl) and marginal (₹666.00/qtl). At overall level BEP (break-even Point) was observed 10.24 quintals/ ha which indicated that a farmer should produce a minimum of 10.24 quintal of wheat /ha so as to not incurred any losses.

Table 1: Break-even analysis of wheat production

Particulars	Marginal	Small	Semi medium	Medium	Large	Overall
TFC₹/ha	12909.57	14124.50	8762.00	9251.22	9382.18	10885.89
TVC₹/unit	666.00	739.55	761.22	764.51	769.07	759.31
Price/unit	1750.12	1798.98	1810.00	1850.41	1900.00	1821.90
BEP qtl/ha	11.91	13.33	8.35	8.52	8.30	10.24
Contribution Margin ₹/ha	1084.12	1059.43	1048.78	1085.90	1130.93	1062.59
Margin of safety qtl/ha	21.07	20.90	26.65	26.73	27.70	24.45

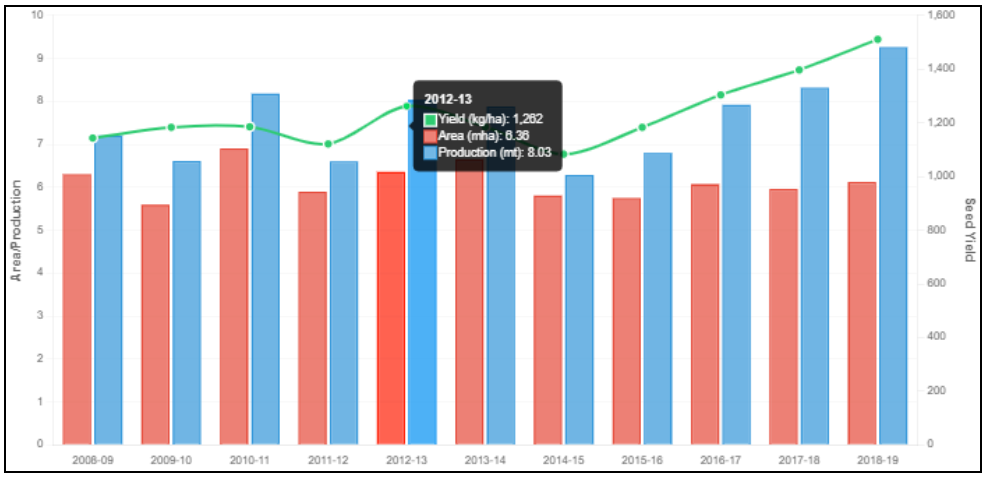

Fig 2: Data for Mustard

Major Schemes and Policies used in Gwalior District

1. **Pradhan Mantri Kisan Samman Nidhi (PMKISAN):** The Pradhan Mantri Kisan Samman Nidhi is a massive government initiative in India. An initial focus was on small and marginal farmers whose parcels of land were less than 2 hectares; however, the program was later broadened to include all farmers. The programmed ensures that all farmers get a minimum yearly income support of Rs. 6,000. Since its implementation on December 1, 2018, this program has been very beneficial to farmers. The program's debut was in the 2018 Rabi season. Thanks to this initiative, subsistence farmers have been able to stay in business. Even if farmers are facing a cash difficulty just before planting, they still have access to inputs like seeds and fertilizer because of this.
2. **Mukhya Mantri Kisan Kalyan Yojna:** Financial aid is available to farmers in Madhya Pradesh under the Mukha Mantri Kisan Samman Nidhi program. Under this initiative, eligible farmers in Madhya Pradesh may get up to four thousand rupees (Rs.) per year and five acres of land. Seeds, fertilizer, and other agricultural inputs are intended to be assisted by the two-part payment plan. Part, one costs two thousand rupees.
3. **Pradhan Mantri Fasal Bima Yojana:** Due to the program's official backing, MP has had significant success with it. The PMFBY program provides low-cost insurance against crop failure and helps stabilize farmers' incomes. It would be carried out in eleven clusters in MP with a budget of Rs 17,75.95 crore for 2020-21. The fiscal year 2021-22 saw over 90 lakhs farmers insuring their crops. More farmers should sign up for crop insurance, thus Crop Insurance Week was an effort to get the word out.
4. **Paramparagat Krishi Vikas Yojana (PKVY):** In an effort to promote organic farming, the government launched the Parampara at Krishi Vikas Yojana (PKVY) in 2015–16. It addresses every aspect of farming, from planting seeds to certifying and selling finished products. Inputs like as organic manure, bio-fertilizers, and pesticides given directly by DBT account for 62% of the total Rs. 50,000/ha/ 3 years that farmers have access to via the program.
5. **National Agriculture Development Plan:** This federally funded program has been a success for the state from the start. Raising farmers' earnings via boosting agricultural output is the aim of NADP/RKVY. It is implemented nationwide with equal funding from the federal and provincial governments. Assistance might be provided for the cultivation of organic vegetables and horticultural crops. For the fiscal year 2022–23, an allocation of Rs 27,576.7 lakh was received, with the first payment amounting to Rs 4512.00 lakh.

Significance of Studying Climate Change in Gwalior District

Climate change study in Gwalior District is highly relevant because of its geo-climatic location, high urbanization rate and because socio-economic development there is highly dependent on climate sensitive industries like agriculture and water resources. Located in the semi-arid region of northern Madhya Pradesh, Gwalior is characterized by steep temperatures, unpredictable monsoons, and the rising levels of environmental stress, which predisposes the given district to the effects of climate in particular. The study of such trends has essential information about the current changes in the local climate and its interaction with ecological, infrastructural, and human systems. This information is fundamental in detecting risks that may interfere with living standards, health of the citizens, and the development of the region on the long-term basis.

Moreover, Gwalior District relies on groundwater, seasonal agriculture and the traditional livelihood systems, which increases the significance of climate variability knowledge. As the number of rainfall days decreases, the intensity of heat increases, and the amount of water becomes scarcer, the local communities become more and more challenged in regards to agricultural production, access to drinking water, and the maintenance of diseases. Climate change in this region can be analyzed to enable the researcher to analyze the sensitivity of crops and soil health, as well as, water systems to climatic changes. This knowledge can be used to develop some form of adaptation protocol like sustainable irrigation, selecting drought-resistant crops, and farming methods that are resource-conserving as some measures to increase the resiliency of rural and peri-urban settlements.

Conclusion

In conclusion, the research indicates that agricultural production in Gwalior District is increasingly vulnerable to climate change, particularly due to rising temperatures and extreme weather events. It emphasizes the importance of understanding how local communities perceive and respond to these challenges, highlighting the necessity for targeted awareness, improved planning, and robust policy support to build resilience. While farmers employ various adaptive strategies to mitigate climate impacts, they face significant barriers, including human, institutional, and technical constraints. The Climate Smart Cities Assessment Framework (CSCAF) under India's Smart Cities Mission seeks to address these challenges. Ultimately, comprehending the effects of climate change on crop yields, soil health, and water resources is crucial for fostering sustainable agricultural practices in the region.

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