

IMPACT OF CLIMATE CHANGE ON PRODUCTION OF MAJOR AGRICULTURAL CROPS IN TRIPURA: AN OVERVIEW

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Abstract

Current article presents a meticulous examination of the climate change dynamics affecting agricultural productivity in the state of Tripura, India. Focusing on pivotal crops including rice, pulses, maize, sesamum, and groundnut, the study employs a rigorous synthesis of existing literature, comprehensive data analysis, and insightful case studies. By scrutinizing the intricate interplay between climate shifts and agricultural practices, this review underscores the profound impact of evolving environmental conditions on crop yield. Moreover, it delineates the multifaceted challenges encountered by farmers and elucidates the adaptive strategies devised to mitigate these challenges. Rooted in agricultural economics principles, this analysis not only underscores the urgent need for sustainable agricultural practices but also contributes valuable insights to the scientific discourse on climate change adaptation in agricultural economies.

Keywords: Climate change, Agricultural economics, Sustainable agricultural production.

Introduction

Agriculture stands as a cornerstone of the Indian economy, playing a pivotal role in its sustenance and growth (Kumar and Sharma, 2023). Climate emerges as a principal determinant influencing agricultural production, exerting profound effects on the economy of Tripura, a state heavily reliant on agriculture. With over 72.00 per cent of the state's workforce dependent on agriculture for livelihood, understanding the potential ramifications of climate change on this sector is of paramount importance (Tangiang and Sharma, 2021). Researchers and policymakers alike are increasingly concerned with the anticipated damages and benefits stemming from climate change impacts on agriculture, as these will significantly influence domestic and international policies, trade patterns, and resource allocation for food security (Swain *et al.*, 2022). Climate change, defined as any alteration in climate over time attributed directly and indirectly to human activities modifying the global atmospheric composition (IPCC, 2007), poses a pressing challenge. Statistical data from the Directorate of Economics & Statistics Planning Department, Government of Tripura, reveal a noticeable increase in the state's temperature, rising from 34 °C in 1995 to 39 °C. Climate change impacts increased the chances of hot days, heat waves and drought, leading to decreasing water levels and crop failures. This results in declining agricultural productivity (Kapur *et.al.*, 2009). This upward trend in temperature is accompanied by shifting rainfall patterns, exacerbating the vulnerability of agricultural systems. Major field crops in West Tripura, including rice, groundnut, and

maize, face heightened risks due to climate-induced natural disasters such as droughts, floods, and cyclones, which have become increasingly frequent in recent years across India (Goswami *et al.*, 2006). The confluence of changing temperatures and precipitation patterns poses significant challenges to agricultural cultivation and plantation farming, particularly impacting marginalized farmers in hilly regions. Consequently, understanding and mitigating the adverse effects of climate change on agriculture are imperative for ensuring the resilience and sustainability of Tripura's agricultural sector.

Climate Change Scenario in Tripura

Analysis of historical climate data reveals alarming trends in Tripura, characterized by a consistent increase in temperature and notable shifts in precipitation patterns over recent decades. This climatic transformation manifests in warmer winters, intensified summers, and erratic rainfall patterns, all of which significantly impact agricultural activities. These shifts disrupt the delicate ecological balance, adversely affecting soil fertility, water availability, and the growth cycles of crops. Notably, rice cultivation occupies a significant portion of Tripura's agricultural landscape, covering both irrigated and rainfed areas across approximately 0.25 million ha. Despite its importance, rice productivity in the state remains low, averaging around 3.30 tonne / ha, key challenges in rice production include the prevalence of blast disease, low adoption of high-yielding varieties and the adverse effects of soil erosion exacerbated by traditional jhum cultivation practices. Addressing these constraints is crucial for enhancing agricultural productivity and resilience in the face of ongoing climate change impacts in Tripura.

Climate Change Trends

Historical climate data from Tripura illustrates a concerning trend of climate change impacts on agricultural systems. Over the last 50 years, average temperatures have risen by approximately 0.2 °C per decade, exacerbating the frequency and severity of extreme weather events. In the past decade alone, the region experienced five severe cyclonic storms, resulting in extensive damage to agricultural infrastructure and crops. Additionally, changes in frost days have seen a 20.00 per cent decrease over the past two decades, adversely affecting the cultivation of cold-sensitive crops such as potato and cabbage. Moreover, farmers have reported a significant increase in the duration of dry spells during the monsoon season, leading to water stress for rainfed crops like pulses and oilseeds. Furthermore, erratic rainfall patterns, including a 15.00 per cent increase in the frequency of heavy rainfall events (>100 mm/day) over the last 30 years, have contributed to soil erosion and flooding in agricultural areas. These trends underscore the urgent need for adaptive measures to mitigate the adverse effects of climate change on agricultural productivity in Tripura.

Table 1. Trend analysis of different weather parameter at Tripura (1996-2015)

Particular	Rainfall	Temperature	Evaporation	Relative Humidity
Max	2898.40	32.30	4.1	86
Min	1714.80	30.20	3.4	72
Mean	2399.15	30.77	3.62	78.1
Std	352.03	0.31	0.22	3.82
CV	14.67	1.00	5.95	4.9
Z	0.34	0.51	0.81	-0.11
Sens slope	1.91	1.86	1.73	-1.44

[Source: (Chakraborty *et. al.*, 2017)]

Table 1 reveals that annual increasing trend of total rainfall was at the rate 1.91 mm/year, the trend was somewhat inconsonance with the findings of Das and Goswami (2003) who reported absence of any significant trend in annual rainfall occurrence over North-eastern region of India. Annual trend analysis of temperature reflected significant rising trend at the rate of 1.860C per year which was three times higher than the global increasing rate (@ 0.013 °C/year) since last 50 years (1955-2005). Das (2003) further manifested the regional impact of climate change over whole NE region including Tripura. Annual trend analysis (using Mann-Kendall test) of evaporation reflected significant rising trend at the rate of 1.73 per year. Annual trend analysis (using Mann-Kendall test) of Relative humidity reflected significant decreasing trend at the rate of -1.44 / annum].

Impact on Agricultural Production

The agricultural landscape of Tripura faces multifaceted challenges due to climate change impacts. Farmers have noted a shift in planting and harvesting seasons, with delays in rice cultivation attributed to late onset of monsoon rains, resulting in reduced yields and heightened susceptibility to pest infestations. The incidence of fall armyworm infestations in maize fields has doubled over the past five years, causing substantial yield losses of up to 30.00 per cent in affected areas. Furthermore, extreme weather events like flash floods in 2018 devastated 50.00 per cent of standing rice crops in low-lying areas, inflicting significant economic losses on farmers. Additionally, disruptions in temperature and precipitation patterns have led to a decline in pollinator populations, adversely affecting fruit set and seed production in crops such as sesame and pulses. Moreover, increased heat stress during the reproductive stage of crops like groundnut has led to poor pod development and reduced kernel formation, resulting in diminished yields and quality. These challenges underscore the urgent need for adaptive measures to safeguard agricultural productivity and livelihoods in Tripura.

Table 2. Regression results corresponding to major crops with weather variable

Climate	Rice	Maize	Pulses	Sesamum	Groundnut
Constant	-54.88 (-0.07)	-30.42 -0.29	-66.12 -0.27	5.23 -0.38	51.95 0.01
Rainfall	11.1* 1.58	0.02 0.18	-0.11 -0.36	-0.02 -0.42	0.7 -0.01
Temperature	-132.08 (-0.49)	-9.7* -1.44	1.32 0.02	0.12 0.09	13.57* 1.37
Evaporation	572.28*** 3.37	838.70** 2.16	207.33** 1.74	273.47** 1.91	308.05 0.88
Relative Humidity	13.46* 1.57	1.29 -0.18	4.67** 2.13	4.19* 1.6	-6.89* -1.67

(Source: Chakraborty *et.al*, 2017)

Table 2 reveals the effect of Evaporation and Relative Humidity found significant almost for all the crops. The effect of rainfall has been found positive and significant to rice, maize and groundnut. The effect of rainfall on pulses and sesamum was negative meaning thereby that its effect is non-linear with excess rainfall having a damaging effect on crop yield. The experimental evidence suggests that a rise in day or night temperature beyond its optimum level has a harmful effect on production of pulses crops (Ahmed *et al.*, 1992; Devasirvatham,

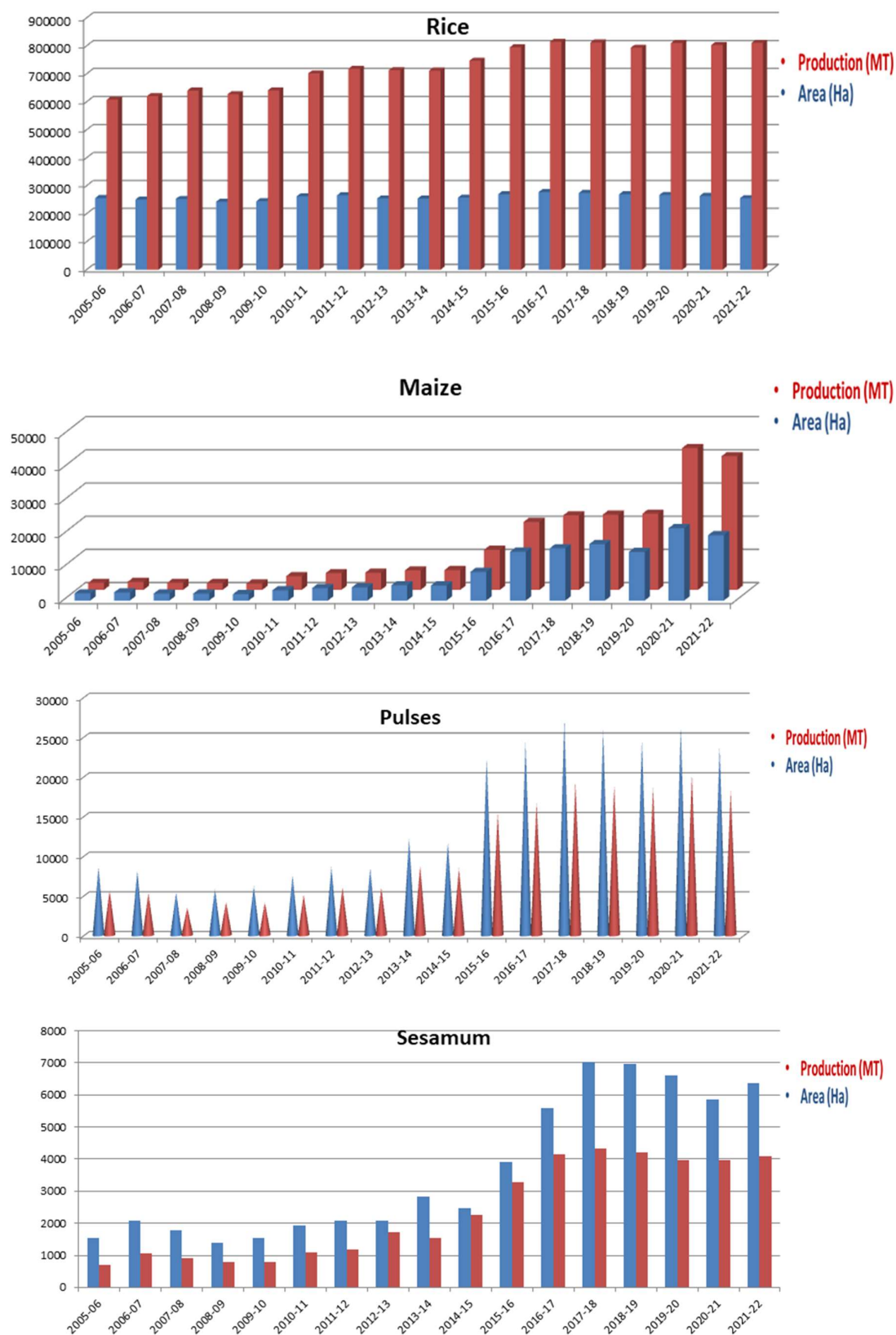
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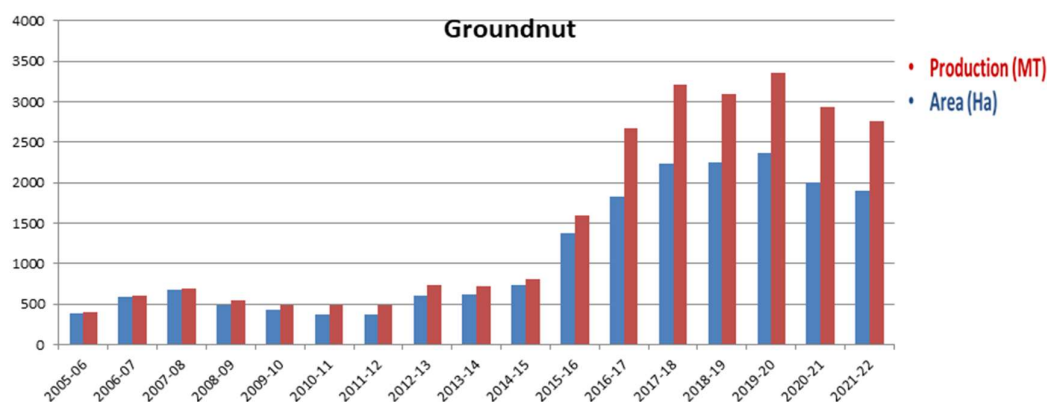
Annexure-I. Area and production of some important crop in Tripura (2005-2022)

Year	Rice		Maize		Pulses		Sesamum		Groundnut	
	Area	Production	Area	Production	Area	Production	Area	Production	Area	Production
2005-06	25607						152			
	8	607780	2150	2113	8544	5608	6	700	379	400
2006-07	25098						207			
	0	620500	2450	2420	8081	5290	7	1048	590	610
2007-08	25289						177			
	7	640422	2123	2125	5361	3496	6	896	679	687
2008-09	24296						139			
	6	627174	2093	2046	5796	4181	2	780	486	539
2009-10	24485						153			
	3	640948	1918	1909	6170	4126	2	801	423	483
2010-11	26232						194			
	0	701562	3100	4101	7500	5085	2	1095	369	480
2011-12	26599						208			
	9	718304	3743	5058	8582	6005	5	1188	369	481
2012-13	25474						208			
	3	713222	3948	5176	8439	5958	5	1706	597	731
2013-14	25425				1215		282			
	4	711831	4589	5863	0	8696	4	1543	613	725
2014-15	25727				1166		246			
	3	746954	4519	5963	4	8426	8	2261	735	801
2015-16	26979				2232		389		137	
	3	794848	8646	12095	7	15463	8	3276	5	1587
2016-17	27710		1469		2432		559		183	
	6	814644	6	20495	7	16717	0	4151	3	2675
2017-18	27429		1573		2723		703		223	
	0	812092	6	22473	4	19358	5	4332	9	3207
2018-19	26936		1698		2585		696		225	
	4	793200	2	22696	4	18918	7	4209	1	3098
2019-20	26733		1463		2457		661		236	
	5	810244	5	22974	0	18663	1	3967	7	3361
2020-21	26379		2178		2614		586		199	
	3	803032	4	42748	5	20263	2	3968	6	2930
2021-22	25574		1970		2371		636		190	
	0	810879	4	40315	4	18263	3	4081	3	2757

(Source : Directorate of Agriculture, Government of Tripura.)

Figure 1. Area and production of some important crop in Tripura (2005-22)





Economic Implications

The economic ramifications of climate change on agriculture in Tripura are profound and far-reaching. The 2019 floods inflicted staggering losses, estimated at INR 500 million, in crop damages across over 50,000 ha of agricultural land, underscoring the vulnerability of farmers to extreme weather events. Moreover, price volatility in agricultural commodities like rice and pulses has exacerbated income instability for farmers, exacerbating poverty and food insecurity in rural communities. Additionally, farmers suffered substantial income losses of INR 100 million in the last fiscal year due to pest outbreaks in crops such as maize and sesame, necessitating government assistance for recovery efforts. Rising temperatures and erratic rainfall patterns have compelled farmers to increase spending on irrigation infrastructure, leading to higher input costs and reduced profitability. Furthermore, climate change-induced shifts in temperature and precipitation regimes have resulted in the loss of traditional crop varieties adapted to local agro-ecological conditions, diminishing genetic diversity and resilience in agricultural systems (Kom et al, 2024). These economic challenges highlight the urgent need for comprehensive policy interventions and adaptation strategies to enhance the resilience of agricultural livelihoods in Tripura.

Adaptation Strategies

In response to the challenges posed by climate change, farmers in Tripura have implemented various adaptation strategies to enhance agricultural resilience. This includes the adoption of drought-tolerant crop varieties such as Swarna Sub1 and Sahbhagi Dhan, which exhibit resilience to water scarcity and heat stress. Additionally, community-led initiatives focused on rainwater harvesting and conservation, including the construction of check dams and farm ponds, have improved water availability for irrigation during dry spells, thereby enhancing crop yields and farmer incomes. Furthermore, farmers have diversified their cropping patterns by integrating cash crops like turmeric and ginger with staple crops such as rice and pulses, reducing dependency on mono-cropping systems and mitigating climate risks. Moreover, the implementation of agroforestry and ecosystem restoration practices, such as planting multipurpose trees like neem and moringa, has provided shade, improved soil fertility, and enhanced biodiversity, contributing to climate resilience and sustainable land management. Lastly, capacity building and extension services provided by government agencies and NGOs through training workshops and educational programs on climate-smart agricultural practices have empowered farmers with the knowledge and skills needed to adapt effectively to changing climatic conditions.

Policy Implications

To support climate adaptation in agriculture, the government of Tripura has implemented various policy interventions. These include subsidies and incentives for the adoption of climate-resilient technologies such as drip irrigation, solar-powered pumps, and weather-resistant seed varieties, aimed at reducing financial barriers for farmers. Additionally, the Pradhan Mantri Fasal Bima Yojana (PMFBY) provides crop insurance coverage against weather-related risks, offering financial protection to farmers and encouraging investments in climate adaptation measures. Moreover, integrated watershed management programs focus on soil and water conservation, afforestation, and sustainable land use planning, promoting resilience to climate change and enhancing ecosystem services. Furthermore, government funding for agricultural research institutions supports research on climate-resilient crop varieties, agronomic practices, and pest management strategies, facilitating evidence-based decision-making and technology transfer. Lastly, there is a recognized need for policy coherence and mainstreaming climate change considerations into broader agricultural policies and development agendas, ensuring coherence across sectors and alignment with international climate commitments such as the Paris Agreement.

Conclusion

The review highlights the significant impacts of climate change on agricultural productivity in Tripura and underscores the urgent need for adaptive measures to safeguard farmer livelihoods and enhance food security. The multifaceted challenges posed by climate change, including shifts in temperature and precipitation patterns, extreme weather events, and pest outbreaks, necessitate comprehensive policy interventions and adaptation strategies. Through the adoption of climate-resilient technologies, sustainable land management practices, and policy coherence, Tripura can build resilience in its agricultural systems and mitigate the adverse effects of climate change. Moreover, investments in research and capacity building are essential to inform evidence-based decision-making and empower farmers with the knowledge and skills needed to adapt effectively to changing climatic conditions. By prioritizing climate adaptation in agricultural policies and development agendas, Tripura can foster a more resilient and sustainable agricultural sector, ensuring the long-term viability of farming communities and enhancing overall rural resilience.

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