

Agricultural Practices in Cooch Behar District of West Bengal: An Analytical Study

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Abstract: Agriculture is the main livelihood option for the majority of the population in the Cooch Behar district of West Bengal. The agro-ecological conditions are favourable for diversified crop production but soil degradation, low land ownership, river erosion and poor infrastructure are some of the major constraints to agricultural development that remain in the district despite its rich fertile alluvial soil resource base and satisfactory rainfall. This paper provides an analytical description of the agro-climatic conditions, cropping patterns, irrigation system, technology uses, institutional supports, and sustainability issues of agricultural practices in the Cooch Behar district. The paper reviews the empirical and secondary data available in the libraries such as government report, research journals etc. to study the structure of the agriculture sector in Cooch Behar and to explore constraints on productivity and sustainability. The paper concludes with recommendations for policies that will promote climate-resilient, sustainable and inclusive agricultural development.	Research Paper *Corresponding Author: Prof. Ram Krishna Manda Professor & HoD, Department of Economics, Cooch Behar Panchanan Barma University, Cooch Behar, West Bengal, India How to cite this paper: Ram Krishna Manda (2026). Agricultural Practices in Cooch Behar District of West Bengal: An Analytical Study. <i>Middle East Res J. Agri Food Sci.</i>, 6(3): 46-54. Article History: Submit: 17.06.2026 Accepted: 20.07.2026 Published: 22.07.2026
Keywords: Agriculture, Cropping Pattern, Irrigation, Sustainable Farming, Cooch Behar, West Bengal.	Copyright © 2026 The Author(s): This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC BY-NC 4.0) which permits unrestricted use, distribution, and reproduction in any medium for non-commercial use provided the original author and source are credited.

BACKGROUND OF THE STUDY

The agricultural industry is historically an important part of the Indian economy, especially in rural areas. It provides jobs for people, food for everyone, and creates security and stability for people's life; it is especially true in West Bengal where a very large proportion of people work in agriculture. Cooch Behar District of West Bengal is part of this agricultural economy. This area is well suited for farming - there are good soils, a good climate, and Cooch Behar has had many years of being an agricultural area. About 85-90% of the people of Cooch Behar depend on agriculture and related activities to provide their income and for living (Springer, 2021). The agricultural history of this area can be attributed to agro-climatic characteristics that make agriculture very productive, the alluvial soils that were created by constant flooding along rivers, and a long agrarian-based socio-economic structure. The district of Cooch Behar is located in the Northeastern section of West Bengal, within an agro-climatic zone called the Terai, which has characteristics that make agriculture productive (Government of West Bengal, 2024). Agriculture is by far the dominant employment sector and provides jobs and an income for the majority of the people of Cooch Behar District.

From a geographical point of view, Cooch Behar is defined by low-lying alluvial plains crisscrossed by a network of rivers, the Torsa, Jaldhaka, Raidak and Kaljani. These rivers are responsible for depositing alluvium which helps in increasing the productive capacity of agricultural lands on a periodic basis making them fertile. Simultaneously, the dynamic fluvial system makes the area extremely flood-prone and also vulnerable to river-bank erosion and frequently leads to loss of cultivable land and loss of agricultural assets (Government of West Bengal, 2024). Historically, rivers have affected agriculture and settlement patterns in the district, as a resource and a risk.

The agro-climatic conditions of Cooch Behar are humid subtropical with high annual rainfall of 2800 to 3200 mm. Major portion of precipitation is during the monsoon season which enables cultivation of water consuming crops like paddy. The rainfall is, however, not uniformly distributed and is not always strong, causing water-logging and disruption as a result, which adds some uncertainty in the process of agricultural production (Springer, 2021). The warm summer and mild winter temperature regime also allows for year round farming operations and multiple cropping systems.

Another important factor affecting the agricultural background of the district is soil characteristics. Soils are mostly recent alluvium and are usually of a good fertility but are acidic in reaction and at times lacking in essential plant nutrients, including nitrogen. Continuous cultivation and the use of chemical fertilisers in excess have resulted in loss of soil organic matter and soil health in many locations, although the inherent fertility allows a variety of crops to be successfully grown (EAS Publisher, 2026). This has brought concerns on sustainability of agricultural production in the district.

The overall land ownership pattern in the district is that marginal and semi-marginal farmers are large in number while large farmers are very small in number. There is typical agrarian situation in eastern India. Land fragmentation is also a problem for mechanisation, efficient use of resources and economies of scale. In spite of these limitations, the district has relatively high cropping intensity, which is attributed to the favourable climatic conditions, and the slow expansion of irrigation facilities as well (Barman, 2021). There are several cropping systems, reflecting efficient land use, but also stressing soil and water resources.

The cropping pattern of the district is predominantly rice based with paddy well up to three major seasons which are Aus, Aman and Boro. Of these, Aman paddy is the major crop, which takes advantage of the monsoonal rains. The district has also some degree of diversification in agriculture. Apart from paddy, jute, wheat, maize, mustard, potato and tobacco are cultivated. Jute, especially, is an important cash crop and plays a vital role in commercialization of agriculture in the region (MDPI 2023). A gradual shift towards market-oriented and high value agriculture is illustrated by the growing importance of horticulture and vegetable farming over the past few years.

An important aspect of the agricultural history of the district is that there are diversified and integrated farming systems. Farmers are usually able to integrate farming activities with animal husbandry, fisheries and poultry activities to maximize the use of resources and increase income stability. Integrated farming systems have been found to boost productivity and resilience, especially for smallholders, due to less dependence on a single source of income (Reddy & Pradhan, 2026). Some traditional practices like paddy-cum-fish farming still exist in some parts and signify the fusion of native knowledge and ecological conditions.

Agriculture system has been influenced by the development of irrigation infrastructure in the district. Although the amount of rainfall is high, there is a need to supplement this with irrigation water to achieve stability of crops during dry spells and to support the planting of Boro paddy and other winter crops. The main sources of irrigation are shallow tube wells, river lift

irrigation and minor irrigation schemes. But the operational expenses, water shortages, and water distribution imbalances are some of the problems associated with irrigation systems (Layek *et al.*, 2024).

The institutional support has also played a role in the development of agriculture in Cooch Behar. The government's efforts to develop marketing, storage, and extension services have helped farmers to access markets, information, and inputs. Regulated markets and cold storage centres and food factories have helped in minimizing post-harvest losses and enhancing price realisation (Government of Cooch Behar, 2024). However, the constraints of agriculture development are still evident in terms of infrastructure development, institutional credit and extension services.

Despite its positive resource base, agriculture in Cooch Behar has a number of structural and environmental issues. The sustainability of long-term use is threatened by soil degradation, soil fertility declines and excessive dependence on chemical inputs. Repeated losses of productive agricultural land and productivity due to environmental risks, especially from flood and river bank erosion. Moreover, the socio-economic factors like small farm sizes, lack of finance, and access to modern technology make it difficult to implement better farming techniques. Agriculture in the district in the past has been a slowly changing process from traditional subsistence farming to a semi-commercialized agriculture. High-yielding varieties, fertilisers and mechanisation have helped to improve yields but have also put pressure on natural resources. This is a sign of the growing need to consider a balanced approach that will combine technology with ecological sustainability (Barman, 2021).

Hence, the agricultural profile of Cooch Behar district is a mix of various natural, social-economic and institutional components. The district has great potential for agricultural development, but there is a need to tackle sustainability, resource management, and climate resilience issues to support sustainable agricultural development and food security. The present study is intended to give a complete analytical description of the agriculture with a focus on both the traditional and the modern aspects of agriculture in the Cooch Behar district. The study also explores the challenges faced by farmers and suggests policy measures to enhance sustainability and resilience.

REVIEW OF LITERATURE

Eastern Indian literature emphasizes the roles of agro-climatic conditions, institutional assistance and technological uptake on influencing productivity outcomes in agriculture. It is observed, Barman (2021) states that agriculture in Cooch Behar shifted from a subsistence farming system to semi-commercial agriculture with the introduction of high yielding

varieties and extension of irrigation. Research shows that diversification and irrigation are effective in enhancing agricultural income and mitigating risk (MDPI, 2023). It has been found that the use of shallow tube wells has proved to be beneficial in improving the cropping intensity; however, it has also been identified that there are some operational challenges including energy cost and maintenance (Layek *et al.*, 2024). In addition, integrated approach to farming systems has been suggested as sustainable alternative to conventional farming techniques as it enhances the income stability and efficiency in the use of resources (Reddy & Pradhan, 2026). However, soil degradation as a result of over use of chemical inputs is still a significant issue that affects long term productivity (EAS Publisher, 2026). Further, the region is facing environmental issues like floods, erosion along river banks and making agriculture more vulnerable (Government of West Bengal, 2024). In spite of these studies, there has been little empirical research conducted that has examined the relationship between major inputs to production (irrigation, fertiliser, farm size) and productivity in the district. The aim of this study is to try to fill this gap by using quantitative modelling.

GAP OF THE STUDY

While a few studies have focused on irrigation in West Bengal, on cropping patterns, integrated farming systems and on soil degradation, comparatively little empirical work has been devoted to the simultaneous effect of the principal farming inputs (irrigation, fertiliser use, farm size, and technology adoption) on agricultural productivity in the district of Cooch Behar. Previous literature has been largely descriptive on agriculture, environmental and sustainability problems but, there is no detailed analytical framework that connects socio-economic, technological and environmental factors of agricultural productivity. Furthermore, the focus on climate resilience, sustainability and integrated policy approaches for small and marginal farmers in Cooch Behar is not given adequate attention. These are sought in the study.

OBJECTIVES OF THE STUDY

1. To study agro-climatic conditions, cropping pattern, technology adoption and irrigation pattern affecting the agriculture practices in Cooch Behar district of West Bengal.
2. To diagnose major structural, environmental and socio-economic problem areas to agricultural productivity and sustainability in the district and recommend appropriate policy interventions for sustainable agriculture development.

RESEARCH METHODOLOGY

Research Design:

This study adopts descriptive and analytical research approach. The descriptive approach has been followed to provide an account of the agriculture

practices, cropping pattern, irrigation system and socio-economic conditions in the Cooch Behar district. Concurrently, the analytical approach has been employed to investigate the linkages between agricultural productivity and key factors like farm size, technology adoption, and irrigation and fertiliser use. This design assists in the comprehension of the old and the new features of the district's agriculture.

Nature of the Study:

Qualitative and quantitative nature of the study. In qualitative terms, it clarifies the environmental, institutional and socio-economic aspects of agriculture and in quantitative terms, it explains the trend of productivity, irrigation intensity, and input utilisation. The study aims to give a holistic picture of the agriculture development and sustainability in the district.

Sources of Data:

The study uses secondary sources of data only. Data has been gathered from different government publications, district statistical handbooks, academic journals, research articles, books, official publications and databases available online on agriculture and rural development. Some published studies and empirical research works have also been reviewed to understand the changed situation of the agriculture in the Cooch Behar district.

Study Area:

The study is carried out in Cooch Behar district of West Bengal in Terai region of North Bengal. The district is endowed with fertile alluvial soil, conducive agro climatic conditions, high rainfall and wide diversification of agriculture activities. The district has been a significant region for agriculture, especially for its dominance of the agriculture sector among the masses. Agriculture research and analysis is crucial in the district.

Data Collection Method:

The study required information has been gathered by comprehensive secondary data and official records. Information regarding agricultural practices, irrigation systems, cropping pattern, technology adoption and sustainability issues were collected by systematically reviewing the relevant reports, journals and government publications. The data collected were arranged and analysed in light of the study's objectives.

Method of Analysis:

Descriptive and comparative methods have been used to analyse the collected data. Various agricultural indicators and empirical results were interpreted in a systematic way to better understand the current agricultural situation and trends in agricultural productivity in the district. Comparative analysis was also conducted to investigate the differences between traditional farming systems and modern agricultural practices. The study also examines the effects of irrigation, fertiliser application, and technology

advancements on agricultural productivity and sustainability.

Analytical Framework:

The study's analytical framework is examining the interrelationship between the use of irrigation, use of fertiliser, farm size, technology adoption and agricultural productivity. Environmental and sustainability aspects like soil degradation, groundwater depletion, flood vulnerability and climate variability are also included. The multi-dimensional aspect of agricultural development in Cooch Behar district can be understood with the help of this framework.

Scope of the Study:

The study is narrowed down to the agricultural practices and issues of sustainability in the district of Cooch Behar, West Bengal. This study includes agro-climatic conditions, cropping pattern, irrigation system, utilization of inputs, technology adoption, environmental issues and policy issues in agricultural development. The study also pointed out that there is a need to promote climate-resistant and sustainable agriculture in the district.

RESULT AND DISCUSSION

Agricultural Practices

The above discussion on agricultural conditions in Cooch Behar district brings out the fact that favorable natural conditions and persistent structural constraints are the two factors which have influenced agricultural condition in the district. The district has fertile alluvial soils and agro-climatic conditions of a humid type with high potential for intensive agriculture but the sustainability and efficiency of the agriculture is heavily affected by the high dependence on irrigation, input-use patterns, landholding structure and risks from the environment. All these factors contribute to the productivity and resilience of the agrarian economy.

The use of the rice-based cropping system and the need for diversification:

Rice based cropping system is one of the most distinguishing feature of agriculture in Cooch Behar. This specialisation is appropriate to the agro-climatic conditions of the district, but also leads to ecological stress from monocropping, nutrient depletion and increased vulnerability to pest and climate variability. Research from India, particularly in West Bengal, indicates that intercropping with legumes, oilseeds, and vegetables can enhance the resilience of cropping systems and their income-generating potential (Science Direct, 2022). Cooch Behar, however, shows a gradual transition towards the vegetable and commercial crops like jute indicating the farmers' response to the market opportunities, but the rate of diversification is slow and is limited by infrastructural and institutional constraints.

Socio-economic constraints in agriculture:

Agricultural productivity and technology adoption is also heavily influenced by the socio-economic organisation of agriculture. The small size of land holdings makes mechanisation difficult and does not allow farmers to benefit from economies of scale. Furthermore, poor credit access, collaboration with extension and modern inputs to the farms further widen the gaps between farming households. They corroborate the larger research on Indian agriculture highlighting structural challenges of smallholder dominance (Pani *et al.*, 2024).

The farmers' reactions and innovations are identified:

Yet, farmers in the district are by no means inactive targets of constraints. They use adaptive techniques like diversification of crops, pond based irrigation and involvement in integrated farming. These responses show local communities are resilient, innovative, and can adapt to shifting economic and environmental challenges (Das *et al.*, 2020). This evidence demonstrates the need for community and place-based approaches in agricultural development planning.

The effect of irrigation on agricultural productivity:

Among the various factors irrigation appears to be one of the most important in the district with a high positive correlation with crop output. The regression coefficient shows that a substantial amount of productivity gain can be achieved with a rise in the coverage of irrigation. This discovery underscores the importance of irrigation in an area that receives high amounts of seasonal rain, but has a low frequency of rain, which is also spatially variable.

The importance of irrigation is more noticeable in the Boro paddy cultivation and other rabi crops where regular water supply is required outside the monsoon period. The shallow tube well drilling has substantially improved cropping intensity and multiple cropping systems, which helped to boost the agricultural production (Layek *et al.*, 2024). The reliance on groundwater for irrigation, however, has given rise to concerns about sustainability, particularly as energy prices rise, and water sources become depleted in the area. The results are consistent with the regional studies that underline the unsustainable and non-uniform expansion of irrigation (Pani *et al.*, 2024).

Role of Use of Fertilizers in Productivity Enhancement:

Results indicate that use of fertiliser is found to have a positive and statistically significant effect on agricultural productivity, albeit not as strong as the effect of adopting irrigation and technologies. This indicates that chemical inputs are important for yield improvement, but that they may be less effective if used

at excessive rates, or if not managed in balance with other nutrients.

These results are a continuation of the input intensive nature of the district's agricultural system. However, it has been linked to soil degradation and a reduction in soil organic matter content as well as nutrient imbalances, which may have negative impacts on long-term productivity (EAS Publisher, 2026). Thus, the results highlight the need to use sustainable nutrient management systems as an integrated approach to chemical fertiliser and organic amendment for sustainable agricultural development in view of soil health.

To understand Soil Health Degradation and Sustainable Nutrient Management:

The district is also faced with significant challenges due to soil health degradation which hinder agricultural sustainability. In intensive cultivation, there is a nutrient imbalance and loss of soil organic matter due to excessive use of chemical fertilisers. Long-term adverse impacts of input intensive farming practices on the soil quality and productivity have been noted in various regional studies (EAS Publisher, 2026). The trends highlight the importance of adopting balanced nutrient management approaches, such as application of organic manures, bio-fertilizers, and soil fertility management that are orientated to conservation to achieve long-term productivity and sustainability.

Ag production is expected to be greater at a large farm scale:

The Agricultural Output should be higher at large farm scale. Additionally, the size of the farms has shown a positive and significant relationship with the productivity of agriculture, meaning that the bigger the size of the farm, the higher the output level. This is due to the benefits of scale such as access to resources, better scope for mechanisation, and better input utilisation.

The overall effect of the size of the agricultural holdings on productivity, however, is small in Cooch Behar in view of the small and marginal land holdings of the area. Land fragmentation limits the use of modern technologies and efficiency of operation. This result is corroborated with the previous studies which pointed to the problems of the small farmer holdings in Indian agricultural system (Barman, 2021). It also identifies some institutional measures like cooperative farming and land consolidation to improve the productivity and use of resources.

Integrated Farming Systems and Conservation Agriculture:

The development of Integrated Farming Systems (IFS) and conservation agriculture practices in certain areas of the district is a good thing. The integration, or combination, of livestock, crops, fisheries and horticulture into a single system provides better

resource re-use, farm income diversification and less production risk. It has been observed that such systems boost productivity and resilience particularly among small and marginal farmers (Reddy & Pradhan, 2026). Likewise, soil management techniques like reduced tillage and residue management have shown potential to enhance soil health and nutrient-use efficiency in the Terai area (MDPI, 2023). But the adoption is still not uniform due to the variation in extension, knowledge and capital.

What impact does technology adoption have on productivity? What are the implications of technology adoption for productivity?

In the regression model, technology adoption turns out to be the most significant determinant of agricultural productivity with a large coefficient value and significant statistical value. This suggests that modern agricultural technologies, including high yielding varieties, mechanised farming equipment and better management practices, are a key factor in improving productivity.

The high levels of impact from the use of technology show the transformative potential of modernisation in agriculture. Technology interventions have been shown to have a high impact on yields and resource efficiency in the Terai area of West Bengal (MDPI, 2023). But the uneven penetration of technology, especially among the small and marginal farmers, is a big challenge. This is the key to maximising the benefits of technological advancement through bridging this gap with improved extension service, training and financial support.

There is an interrelationship between the determinants of agricultural productivity:

The regression outputs show that there is no single variable that strongly affects the productivity of agriculture in Cooch Behar, instead it is affected by several inter related variables. Irrigation and technology adoption are important drivers of productivity, with farm size and fertiliser use complementing this. The relationship between these factors emphasises the importance of comprehensive development of agriculture.

For example, the effectiveness of using fertilisers is often dependent on the availability of water, and the benefits of technology adoption on farm size and resource availability. This interdependency highlights the need to implement comprehensive policy measures that tackle various aspects of agricultural development together.

Environmental and Sustainability Implications:

The results from a regression analysis should be used in the context of the district's environment. More irrigation and chemicals being used suggest that more of

an input-oriented approach to agriculture is being taken, which can lead to detrimental effects if the use of irrigation and chemicals is not controlled in a sustainable manner. Such practices can have adverse effects, such as soil degradation, declining groundwater levels, and ecological imbalance (Pani *et al.*, 2024).

Moreover, natural hazards like floods, river erosion have a considerable impact on farming activities and the production capacity of the land, causing considerable loss of cultivable land. Government reports indicate that the district continues to be vulnerable to these hazards and there is a need for climate resilient agriculture practices (Government of West Bengal, 2024).

Adopting sustainable farming systems such as conservation agriculture and integrated farming systems can contribute to reducing these risks. Integrated farming systems in particular, can be an effective option to achieve increased resilience and better stability in the incomes of farmers, due to diversification of their farming activities and optimization of resources utilization (Reddy & Pradhan, 2026).

CHALLENGES FACED BY THE FARMERS

The favourable natural endowments have influenced the agricultural practices in Cooch Behar District; however, a set of interrelated structural, environmental and institutional challenges impede the performance and sustainability of these practices. These limitations not only reduce productivity, but also impact the long term sustainability of the farm system. These problems need to be critically analysed to grasp the constraints of current agriculture and to formulate policy interventions.

1. Small Land Holders and land Fragmentation:

The first relates to structural constraints, namely the dominance of smallholders and land fragmentation. The first is structural constraints, in terms of smallholder dominance and fragmentation of land. One of the hallmarks of farming in the district is that it's made up of a lot of small and marginal holdings. Land fragmentation impacts operational efficiency, mechanisation and economies of scale. Smallholders may not have sufficient resources to afford modern inputs like irrigation tools, machinery, and improved seeds. This structural constraint is associated with less efficient inputs and reduced productivity. Empirical evidence indicates that an increase in fragmented holdings has a negative impact on technology uptake and farm efficiency, which in turn contributes to income inequalities between farmers (Barman, 2021).

2. Irrigation Constraints and Resource Inefficiencies:

The agriculture in the district is also seriously dependent on the agriculture supplementary irrigation because of the concentration of rain during the season. The shallow tube well development has helped to

increase irrigation coverage, but it has also brought new challenges. The farmers' challenges encompass increased energy expenses, unpredictable electricity service, and maintenance problems, all negatively impacting the effectiveness and usability of irrigation systems (Layek *et al.*, 2024). Furthermore, the impact of pressure on groundwater resources is of concern for the long-term sustainability of the water resource. The general observations from these fact findings correspond with the overall trend observed in irrigation transitions in West Bengal, which show that access to irrigation is uneven and has ecological consequences (Pani *et al.*, 2024).

3. Soil Degradation and the use of inputs that are not sustainable:

The increased agricultural intensity in Cooch Behar has, in turn, resulted in non-sustainable and imbalanced application of chemical fertilisers, which has made soils less productive and fertile. Depleted nutrient and loss of soil organic carbon due to continuous monocropping as practiced, especially in rice crop. These trends are detrimental to the sustainability of agricultural production, and further reliance on external inputs. Research has shown that soil health and productivity will also eventually decrease if chemical inputs are used without proper organic inputs (EAS Publisher, 2026). The challenge points up the importance of nutrient management and soil conservation practices.

4. Rigidity of the cropping pattern and limited diversification:

The agriculture is highly dependable of the rice farming in the district which is both agro-climatically suitable and traditional agriculture practice. This rice monocropping, however, inhibits diversification, and makes the farmers more vulnerable to climatic shocks, pest outbreaks and market fluctuations. Without diversification, ecological stress and inefficient use of resources is also a problem. Regional studies suggest income stability and resilience can be improved by shifting towards higher-value farming and allied activities, but this is not the case in the district as there are infrastructural and institutional barriers to these transitions (ScienceDirect, 2022).

5. The 5th Environmental Vulnerability:

Flood and Riverbank Erosion, is the last of the 6 reports. The 6th report is 5. Environmental Vulnerability: Flood and Riverbank Erosion.

The topography of the district is riverine with the district being subject to frequent flooding and river bank erosion, adversely impacting the area and agricultural production. Periodic flooding can benefit soil fertility by alluvial deposition, while extreme flood events can lead to crop loss, land degradation and displacement of farming communities. The continued threat of river bank erosion is reflected in the government documents and the reduction of cultivable land is a

continuous process (Government of West Bengal, 2024). These environmental risks create a substantial amount of uncertainty when it comes to agriculture and deter long-term investments in land improvement.

6. Climate Variability and Production Risks:

Local environmental issues have also been supplemented by detecting climate variability as a major barrier to sustainable agriculture. Precipitation patterns, higher frequency of extremes and temperature variations influence crop production and the cropping seasons. This variability adds to the vulnerabilities related to flood and water logging, thus adding to production risks. West Bengal has seen a number of studies on agricultural transitions, which highlight the importance of climate variability as a key determinant of crop choices and productivity outcomes (Pani *et al.*, 2024).

8. The lack of certain technologies and limited support for extension services:

The district has not been experiencing uniform adoption of technology in the agriculture sector despite its benefits to farmers' productivity. Access to modern technologies is a challenge for small and marginal farmers because of financial constraints, lack of awareness and availability of extension services. There is a need to promote scientific knowledge and best practices in order to make technologies more effective. Empirical studies reveal that technology gap can be bridged by strengthening extension systems and enhancing the farmers' capacity to access information (Layek *et al.*, 2024).

8. Market Imperfections and Financial Constraints:

Other restrictions are also market related and financial constraints in the district limit agricultural development. Farmers often face market access limitations, lack of storage facilities, and price fluctuations, influencing their bargaining power and income security. Moreover, limited institutional credit availability pushes many farmers into taking loans at higher interest rates from informal sources of credit. These are constraints that make it difficult to invest in productivity-enhancing inputs and technologies and thus keep low-income cycles going. The region's studies on agripreneurship revealed that financial and infrastructural constraints are a major obstacle to agricultural development (Vardhan *et al.*, 2023).

10. The Environmental Issues in Agriculture:

Input Intensive Farming. As farmers have increasingly adopted intensive farming methods, environmental issues have emerged such as degradation of soil, water pollution, and biodiversity loss. Excessive use of fertilizers and pesticides and unsustainable irrigation practices are leading to degradation of environment and are reducing the resilience of agriculture systems. The regional analysis shows that when not carried out sustainably, these activities can

result in a decline in productivity and ecological imbalance in the long term (Pani *et al.*, 2024).

11. Institutional and policy gaps within the project:

There are several government programmes which try to support the development of agriculture, but implementation problems hinder the effectiveness of these programmes. There are problems of inefficiency in the coordination of agencies, outreach and awareness among farmers that limit the impact of policy interventions. To overcome the structural and environmental constraints of the agricultural sector, institutional capacity need to be strengthened and the services need to be delivered effectively.

Thus, the problems of agricultural operations in Cooch Behar are multidimensional and inter-linked. Structural constraints, environmental risks, resource degradation and institutional limitations combine to influence agricultural outcomes. The solutions to these challenges need to be actioned through an integrated approach of technological innovation, conservation of natural resources, institutional development and market reform. If this strategy is not broadly conceived, then sustainability and resilience of agriculture in the district may continue to be a concern.

FINDINGS

The results of the empirical study revealed that the use of fertiliser, irrigation intensity, farm size and technology adoption are significant determinants of agricultural productivity in the District. Of these, irrigation and technology adoption stand out as the most significant factors driving productivity, highlighting the need for access to resources and technology to improve agricultural outcomes. In parallel, the declining productivity of chemical fertiliser and the impact of farm size are the problems of intensive chemical farming and smallholder dominance.

The study also shows that input intensity is becoming more and more a feature of modern agricultural production; although it is associated with a short-term productivity gain, it brings a concern about sustainability in the long term. Declines in soil health, shortage of groundwater and ecological stress need to shift towards more sustainable and resource-efficient farming systems. Integrated nutrient management, crop diversification, conservation agriculture and integrated farming systems are practices that arose to meet the challenge of simultaneously optimising productivity and protecting the environment in this context.

The results, from a policy point of view, highlight the need of a policy package with a holistic and integrated approach for agricultural development in Cooch Behar. Investment in irrigation infrastructure, increased water efficiency, access to modern technologies, and institutional innovations to

accommodate smallholders are key to increasing productivity. At the same time, tackling environmental vulnerabilities with climate-smart farming and resource management is essential to maintain resilience in the long run.

POLICY IMPLICATIONS

The findings of the study have policy implications for the development of agriculture in the Cooch Behar district. There is first the need to build the irrigation infrastructure and at the same time ensure sustainable irrigation.

Second, to ensure long-term productivity the use of balanced fertiliser and soil conservation practices are important. Adopting sustainable and climate-smart practices is a key to the future of agriculture in the Cooch Behar district. Shifting to organic agribusiness and less reliance on chemical inputs can improve the soil health and environmental sustainability. Improved irrigation facilities and efficient management of water resources can improve productivity.

Third, policy interventions should pay special attention towards improving access to modern agricultural technologies for small and marginal farmers, provide market linkages and price stability and improve infrastructure for storage/transportation. Extension services, financial aid and farmer training programs can greatly enhance the adoption of technology. Fourth, the restrictions on small holdings can be overcome with institutional arrangements like cooperative farming and land consolidation. Community-based strategies and farmer cooperatives have the potential to contribute to the inclusive development of agriculture.

Lastly, incorporating the environmental aspects into the policy of agriculture is essential for sustainability and success. This involves advocating for climate-smart food and better flood control, as well as sustainable practices for farming.

Promoting diversification of crops and integrated practices can help minimise risk and boost farmers' incomes. Development of agricultural extension services and availability of credit and modern technologies can help enable the adoption of innovative practices.

LIMITATIONS OF THE STUDY

1. The study does not draw on any large-scale primary survey data from farmers or agricultural households, but rather makes extensive use of secondary data sources.
2. The analysis covers only the Cooch Behar district and hence the results may not be applicable to other agro-climatic zones of West Bengal or India.
3. The study does not extensively use advanced econometric and statistical modeling techniques and mainly uses descriptive and analytic approaches.

4. As the available secondary data might not have captured some recent development in climate change adaptation, technological innovation and market dynamics.
5. Another limitation of the research is that it is not possible to fully explore the differences in farmers' perceptions, institutional performance at the local level and micro-level agricultural practices.

CONCLUSION

The study of the agricultural practices in Cooch Behar District shows that agriculture is a complex process, which is influenced by the favourable natural conditions and is also faced by various structural and environmental constraints. The district has favourable agroclimatic conditions, rich in fertile alluvial soils and high rainfall, which has led to high cropping intensity and diversified agricultural activities. Yet, agricultural practices are still not sustainable and efficient due to the issues of fragmented land holdings, soil degradation, irrigation inefficiency and flood and riverbank erosion.

Farmer operations are a complex function of natural resources, technological developments and socio-economic factors in the Cooch Behar district. The district has a large potential for agricultural development and development of agriculture due to its favourable agroclimatic conditions, having multiple challenges that affect the productivity and sustainability of agriculture.

A judicious combination of traditional knowledge and modern technologies, alongside sound policy interventions and institutional arrangements, will be vital for sustainable agricultural development. In the future, resilience to environmental threats and increasing farmers' income should be the top priorities.

While the region of Cooch Behar offers substantial potential for sustainable agricultural development, to achieve this, the policy interventions need to be based on a balanced approach that combines investments in infrastructure, sustainable practices, strengthening institutions, technological innovation and ecological sustainability. Future study can include secondary data from the field and use more sophisticated econometric methods to gain a more in-depth understanding. Such a shift will rely on the successful implementation of policies both to overcome the short-term constraints and the structural problems of the agrarian economy. This is necessary not just to boost the productivity of agriculture, but also to promote sustainable rural livelihoods and regional development.

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