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A Study on Factors Determining of Agricultural Production in Assam

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Abstract
This study examines the multifaceted factors influencing agricultural productivity in Assam, with a focus on identifying key determinants and proposing policy measures to enhance farm-level output and sustainability. Drawing on a mixed-methods approach, the research combines quantitative analysis of secondary data (state- and district-level agricultural statistics, crop yield series, and socio-economic indicators) with primary data collected through structured surveys and semi-structured interviews of farmers, agricultural officers, and local experts across selected districts. The objectives are to (1) assess the role of agro-ecological conditions and input use (seeds, fertilizers, irrigation), (2) evaluate the impact of socio-economic variables (landholding size, farmer education, access to credit and extension services), (3) analyze institutional and infrastructural constraints (market access, storage, road connectivity), and (4) explore effects of policy and climate variability on productivity trends. Quantitative results employ regression and decomposition techniques to quantify the relative contribution of biophysical, technological, and socio-institutional factors to crop yields, while qualitative findings contextualize local practices, constraints, and adaptive strategies. Preliminary analysis suggests that improved access to quality inputs, timely irrigation, and effective extension services significantly raise yields, whereas small fragmented land holdings, limited credit, poor market linkages, and climatic hocks act as persistent bottlenecks. The study concludes with targeted recommendations for strengthening input supply chains, expanding irrigation and credit access, enhancing extension outreach, and adopting climate-resilient practices tailored to Assam's agro- ecological zones. By integrating empirical evidence and stakeholder perspectives, the research aims to inform policy interventions that promote inclusive and sustainable agricultural growth in the state.

Keywords: Agricultural, technique, national, productivity, output.

1. Introduction

1.1 Back Ground of the Study

Agriculture has always been the backbone of the Indian economy. Even though the contribution of agriculture to national income has declined over the decades due to industrialization and the growth of the service sector, it continues to remain a major source of livelihood for a significant proportion of the population. In India, nearly half of the working population is still engaged in agriculture and allied activities, making the sector vital not only for food security but also for rural employment, poverty alleviation, and balanced economic growth. Assam, located in the north-eastern region of India, has a predominantly agrarian economy. Blessed with fertile alluvial soil, abundant rainfall, and a favorable climate, the state has immense potential for agricultural development. Agriculture contributes significantly to the state's Gross State Domestic Product (GSDP) and provides employment to nearly 70% of its population. The major crops grown in Assam include rice (the staple food), tea, jute, pulses, mustard, sugarcane, and various horticultural products. The state is particularly known worldwide for its premium quality Assam tea, which has historically been one of the most important export commodities. Despite this natural endowment, agricultural productivity in Assam remains relatively low compared to national and global standards. Productivity levels for rice and other cereals are below the all-India average. Several factors such as floods, poor irrigation facilities, small and fragmented land holdings, limited mechanization, lack of access to institutional credit, low adoption of modern farming technologies, and inadequate market infrastructure continue to hinder agricultural performance. Climate change and frequent natural calamities like floods and river bank erosion further worsen the scenario.

In this context, the study of factors affecting agricultural productivity in Assam becomes not only relevant but also necessary. Understanding the interplay of socio-economic, institutional, environmental, and technological factors influencing agricultural output is crucial for designing effective policies that can ensure sustainable growth in the sector. Since agriculture forms the bedrock of rural life in Assam, improving productivity can lead to broader rural development, reduction of poverty, and an overall improvement in the quality of life for the people of the state.

1.2 Statement of the Problem

Agriculture in Assam continues to face persistent challenges despite its critical importance to the state economy. The productivity of major crops such as rice, jute, and pulses is significantly lower than the national average, raising concerns about food security and farmers' incomes. The heavy dependence on monsoon rainfall, coupled with inadequate irrigation facilities, makes the sector highly vulnerable to climatic variations. Floods during the monsoon season destroy large tracts of cultivable land every year, while drought-like situations in other parts of the state add to the difficulties of farmers.

Socio-economic conditions of farmers also play an important role in limiting agricultural productivity. Most farmers in Assam belong to small and marginal categories with fragmented land holdings, making it difficult to adopt modern technologies or benefit from economies of scale. Limited access to institutional credit forces many to rely on informal sources of finance, often at high-interest rates, which adversely impacts their investment capacity. Additionally, the lack of proper extension services and training prevents farmers from being aware of or adopting modern and scientific farming practices.

Institutional bottlenecks, such as inefficient marketing systems, inadequate storage facilities, and poor transportation networks, further aggravate the situation. Farmers often face difficulties in selling their produce at fair prices due to the dominance of middlemen and the absence of well-functioning agricultural markets in rural areas.

1.3 Objectives of the Study

The main objective of the present study is to examine the factors affecting agricultural productivity in Assam. The specific objectives are as follows:

1. To analyze the current status and trends of agricultural productivity in Assam.
2. To identify the socio-economic factors influencing agricultural productivity, such as land holding size, education, labor availability, and access to credit.
3. To examine the role of institutional factors including government policies, extension services, and market infrastructure in shaping productivity levels.
4. To assess the impact of technological factors such as use of improve the seeds, fertilizers, irrigation facilities, and mechanization.
5. To evaluate the influence of environmental factors, particularly climate change, floods, and soil degradation, on agricultural performance.
6. To provide policy suggestions and recommendations for enhancing agricultural productivity in Assam.

1.4 Research Questions

The present study is guided by the following research questions:

What are the current trends in agricultural productivity in Assam, and how do they compare with national averages?

How do socio-economic characteristics of farmers, such as land holding size, education, and access to credit, influence productivity?

To what extent do institutional factors, including government policies, extension services, and market facilities, affect agricultural output in Assam?

What role do technological inputs like mechanization, irrigation, and improved seeds play in determining productivity levels?

How do environmental challenges such as floods, droughts, and soil degradation impact agricultural productivity in Assam?

What policy interventions can help to overcome the barriers to agricultural productivity in the state?

1.5 Significance of the Study

This study holds considerable significance for policy makers, academicians, and practitioners in the field of agricultural economics and rural development.

For Policymakers: The findings of the study will provide evidence-based insights into the key determinants of agricultural productivity in Assam. This will help in designing targeted policies to address the challenges of low productivity, thereby ensuring food security, reducing poverty, and promoting sustainable rural development.

For Farmers and Practitioners: The study will highlight practical challenges faced by farmers and identify effective strategies for improving productivity, such as adopting new technologies, utilizing institutional credit, or improving farm management practices.

For Academia and Researchers: The paper will add to the growing body of literature on agricultural productivity, particularly in the context of Assam and the north-eastern region of India, where relatively fewer comprehensive studies exist. It will also help bridge the gap between theoretical models of productivity and ground realities.

For Society at Large: Since agriculture is the lifeline of Assam's rural economy, improving agricultural productivity has broader implications for reducing poverty, ensuring nutritional security, and improving the overall well-being of rural communities.

Thus, the study is not only academically relevant but also practically useful for enhancing agricultural development and promoting economic growth in Assam.

1.6 Scope and Limitations

Scope

The study primarily focuses on identifying and analyzing the factors influencing agricultural productivity in Assam. It takes into account socio-economic, institutional, technological, and environmental factors that collectively shape productivity outcomes. The scope includes both primary data (from field surveys of farmers) and secondary data (from government reports,

Agricultural statistics, and academic studies). The geographical scope of the study is limited.

Limitations:

Data Availability: Reliable and up-to-date data at the micro-level may not always be available, which could limit the depth of analysis.

Time and Resource Constraints: Since this is a dissertation undertaken as part of an academic program, time and resource constraints may restrict the scale of fieldwork.

Geographical Limitations: The findings of the study will be specific to Assam and may not be directly generalizable to other states of India, though they may hold indicative value.
Dynamic Nature of Agriculture: Agricultural productivity is influenced by a wide range of dynamic factors, including weather conditions, policy changes, and market fluctuations. Capturing all these factors comprehensively within the scope of a single dissertation is challenging.

2. Review of Literature

2.1 Theoretical Framework of Agricultural Productivity

Agricultural productivity is a multifaceted construct, typically defined as the relationship between agricultural outputs (crop yield, total production, value of output) and inputs (land, labour, capital, technology, management). Several theoretical approaches inform empirical studies of productivity.
The Classical and Neoclassical framework's view agriculture through the lens of production functions where output is a function of inputs and technology. In the neoclassical Cobb-Douglas or CES representations, total factor productivity (TFP) captures the efficiency and technological level that cannot be attributed to measured inputs. These frameworks emphasize diminishing marginal returns and factor substitution as key features: increases in labour or land alone produce lesser increments in output unless accompanied by complementary capital or improvements in technology.
The Ricardian tradition focuses on land quality differences and differential rents; productivity variation across regions or farms often reflects heterogeneous soil quality, climate, and topography. This tradition is useful for understanding how land degradation or heterogeneity within Assam (alluvial plains vs. hills) affects output.
Endogenous growth and human-capital models highlight knowledge, skills, and innovation as drivers of sustained productivity growth. In agriculture, human capital translates into managerial skill, adoption of improved agronomic practices, ability to access and use credit, and responsiveness to extension services. These models explain why similar resource endowments can produce different outcomes depending on farmer capability.
Environmental and ecological perspectives bring attention to sustainability: productivity gains achieved through intensive use of chemical inputs may show short-term benefits but can degrade soil health and reduce productivity in the longer term. Climate variability and disaster risks (floods, erosion)-prominent in Assam.
Finally, systems and socio-technical approaches view agricultural productivity as emerging from interactions between biophysical systems (soil, water, crop genetics), social systems (market linkages, labor relations), and technological artifacts (machinery, inputs). This framework is particularly useful for integrated policy prescriptions combining technology, institutions, and ecosystem management.
Together these theories suggest productivity in Assam will be shaped by

i) Input endowments and their efficient combination,
ii) Technological adoption and human capital,
iii) Institutional quality and market access, and
iv) Environmental shocks and sustainability constraints.

2.2 Review of National Studies on Agricultural Productivity

At the national level, empirical literature has traced multiple determinants of agricultural productivity spanning inputs, technology, institutions, and policies.
Studies using production-function approaches commonly find that land, labour, fertilizer, irrigation and tractors are significant positive contributors to crop output; however, the magnitude differs across regions and crops. National analyses often highlight irrigation and fertilizer as key drivers for the Green Revolution gains, while mechanization and improved seeds are repeatedly flagged as amplifiers of yield. Yet, many national studies emphasize diminishing returns to fertilizer in absence of proper extension and soil management-underscoring the need for balanced input use.
Total factor productivity (TFP) analyses at the national level show that initial growth in Indian agriculture was driven largely by technical change (hybrid seeds, better agronomy) and that in recent decades, TFP growth has slowed in several crop segments, suggesting stagnation in technological innovation or diffusion. Several papers identify a role for public investment (irrigation, research and extension) in sustaining TFP growth.
A strand of work investigates institutional constraints: fragmented landholdings, imperfect credit markets, and weak market infrastructure raise transaction costs and restrict scale economies. For example, studies show that access to formal credit is correlated with timely input purchase and higher yields. Similarly, the presence of effective extension services is associated with greater adoption of yield-enhancing technologies.
Climate and risk-related national literature has grown: empirical results show that increased temperature variability and erratic rainfall reduce yields, and investments in irrigation and climate-resilient varieties moderate these effects. Furthermore, studies indicate that smallholders are particularly vulnerable to shocks because of weak savings and insurance mechanisms.

2.3 Review of Regional and State-Level Studies (with focus on Assam)

Assam presents a distinct agro-ecological and socio-economic context: predominately smallholder agriculture, high precipitation with recurrent floods, varied top ography (flood plains, char lands, hills), and socio-cultural patterns influencing land use. Regional studies therefore place emphasis on natural hazards, land fragmentation, and the interplay of traditional and modern farming systems.
Empirical work in Assam frequently identifies floods and soil erosion as major negative factors for agricultural productivity. Recurrent inundation reduces cropped area, damages standing crops, causes loss of soil nutrients, and creates uncertainty that discourages long-term investments (terracing, perennial irrigation systems). Studies show that char lands (river islands) and marginal low-lying plots, although fertile, face high risk and often yield lower effective productivity due to damage frequency.
Landholding structure in Assam-characterized by small and fragmented holdings is repeatedly noted as a constraint. Fragmentation reduces managerial efficiency, impedes mechanization, and raises per-unit costs. Several regional analyses link small holdings with low capital investment per hectare and sub-optimal input use.
Irrigation and water management are highlighted as weak points. Despite high rainfall, temporal mismatch between rainfall and crop water needs, combined with poor water control, limits productivity. Dependence on rained systems for staple crops remains high; studies find that investments in micro-irrigation and better water-harvesting techniques can significantly boost yields in Assam's context.

On the technology front, adoption rates of high-yielding varieties (HYVs), certified seeds, mechanization and appropriate post-harvest technologies are uneven. Socio-economic studies show adoption is constrained by credit availability, awareness levels, and perceived risk. Where extension services and NGOs have been active, adoption improves, indicating the importance of institutional outreach.

Soil fertility and input-use patterns in Assam show mixed trends: some areas demonstrate underutilization of fertilizers and poor soil management, while others indicate over-reliance on certain chemical inputs without corrective measures like liming or organic amendments. The cumulative effect is uneven soil health which affects yield stability.

Market access and infrastructure (rural roads, storage and market yards) are consistently listed as determinants. Assam's connectivity issues-long distances to procurement centers, high transport costs and weak market information systems-depress prices received by farmers, reducing incentives to intensify production. Studies of value chain constraints (for rice, pulses, vegetables) show significant post-harvest losses and price variability.

Social factors such as land tenure in security in certain tribal and common-property regimes, gender roles in agriculture, and labor migration patterns also figure prominently. For example, male out- migration in some districts leads to labor shortages at peak agricultural times, affecting timely operations like transplanting and harvesting.

Notably, several localized interventions-community-based flood control, adoption of floating gardens, integrated farming systems, and promotion of climate-resilient varieties-are documented to improve productivity and resilience. Case studies indicate that region-specific innovations (e.g., flood-tolerant rice varieties and mechanical implements adapted for small paddies) yield tangible benefits, but scaling remains a challenge due to resource constraints and institutional bottlenecks.

Overall, regional literature on Assam converges on a few core determinants: environmental shocks (floods), land fragmentation, weak irrigation and infrastructure, low institutional penetration (credit/extension), uneven technology adoption, and market inefficiencies.

2.4 Identified Research Gaps

The reviewed theoretical and empirical literature provides broad and region-specific insights, but important gaps remain that justify the present study:

Integrated Assessment Combining Biophysical Shocks with Institutional Variables: Many studies examine floods, or institution/market constraints, but relatively few empirically quantify the interaction effects-for instance, how access to credit or extension moderates the negative impact of floods on productivity. A combined, interaction-focused approach would clarify policy levers for resilience.

Micro-level TFP Analysis for Assam: National TFP studies are common, yet there is limited evidence estimating total factor productivity at micro (farm/household) or macro (district) levels within Assam that explicitly accounts for environmental risk and heterogeneity of soil and land quality. A state-focused TFP decomposition would reveal whether productivity gaps are input-related or efficiency-related.

Role of Non-farm Income and Migration Dynamics: While migration and labor shifts are discussed qualitatively, systematic empirical examination of how off-farm income, seasonal migration, and remittances influence on-farm investment, mechanization choices and productivity in Assam is sparse.

Adoption Dynamics of Climate-resilient Technologies: Documented success stories exist, but rigorous, large-sample analyses of adoption determinants for flood-tolerant varieties, micro-irrigation, and soil-conservation practices in Assam are limited. Understanding barriers to scale-cost, social norms, credit constraints-remains underexplored.

Value-chain and Post-harvest Loss Quantification: There is insufficient state-wide quantification of post-harvest losses across major crops and how these losses effectively reduce measured productivity. Linking farm-level production with market-level inefficiencies would help design supply-chain interventions.

Gendered Analysis of Productivity: While gender roles are acknowledged, there is a lack of systematic analysis of how female-headed households or gendered labor allocation affect productivity and access to inputs/services in Assam's context.

Temporal Studies Capturing Climate Trends: Few longitudinal studies capture how changing climate patterns over recent decades have altered productivity trajectories in Assam's districts. Time-series or panel analyses with weather data could illuminate long-term effects.

Heterogeneity across Agro-ecological Zones: Assam's internal diversity suggests that pan-state average results mask critical heterogeneity. More disaggregated studies are needed to design zone-specific policies.

Evaluation of Policy Interventions: Limited rigorous impact evaluation sexist for state-level programs (extension initiatives, subsidies, flood-control schemes).

Evaluations using quasi-experimental methods would inform which programs are cost-effective.

Addressing these gaps requires combining farm-level primary data with high-resolution environmental and market datasets, employing production-function and econometric methods (including panel and interaction models), and focusing on micro-level heterogeneity. The present research seeks to contribute by

i) Conducting a farm-household level analysis in selected districts of Assam,
ii) Incorporating environmental shock indicators and institutional/access variables.

3. Conceptual and Theoretical Framework

3.1 Concept of Agricultural Productivity

Agriculture has historically been the backbone of the Indian economy, and in Assam, it continues to play a vital role in sustaining livelihoods and ensuring food security. The concept of agricultural productivity is central to understanding how effectively resources are utilized in the agricultural sector. Broadly, agricultural productivity refers to the ratio of agricultural output to agricultural inputs. It measures how efficiently land, labour, capital, and technology are employed to generate crops and related produce.

In economics, productivity reflects the efficiency of production, and in agriculture, it is often assessed through indicators such as yield per hectare, output per worker, or total factor productivity. The Food and Agriculture Organization (FAO) defines agricultural productivity as "the measurement of the output of agricultural activities compared with the input used in the production process."

For developing regions like Assam, where agriculture is predominantly subsistence in nature, agricultural productivity is not merely a technical measure but a socio-economic necessity. Higher productivity implies better income for farmers, enhanced rural welfare, and greater food security. In contrast, low productivity results in persistent poverty, food

shortages, and rural underdevelopment. Thus, understanding agricultural productivity is not only an economic concern but also a developmental imperative.

3.2 Factors Influencing Agricultural Productivity

Agricultural productivity is determined by a combination of natural, technological, socio-economic, and institutional factors. In the context of Assam, these factors acquire greater importance due to the unique agro-climatic conditions of the region, recurring natural calamities, and socio-economic constraints. The following subsections discuss these factors in detail:

Land and Soil Quality

Land remains the primary factor of production in agriculture. In Assam, land fragmentation due to inheritance laws and population pressure has resulted in small and uneconomic holdings, which negatively affect productivity. Soil fertility is another critical aspect. Assam's soil is generally fertile due to the alluvial deposits of the Brahmaputra and Barak rivers; however, excessive flooding, soil erosion, and unscientific agricultural practices often degrade soil quality. Problems like soil acidity and low organic content are significant constraints on crop yields. Thus, land reforms, scientific soil management, and sustainable agricultural practices are crucial for enhancing productivity.

Irrigation and Water Availability

Water is indispensable for agricultural production. Despite being a flood-prone state, Assam faces inadequate irrigation facilities. Most of the agriculture in the region is rain-fed, leading to uncertainty in crop outcomes. The monsoon-dependent nature of agriculture exposes farmers to risks of droughts and floods, both of which are frequent in the state. Inadequate irrigation infrastructure, coupled with poor water management practices, hinders productivity. Expanding minor irrigation projects, promoting water harvesting techniques, and ensuring equitable distribution of water resources are vital for improving productivity in Assam.

Technology and Mechanization

Technological advancement is a driving force behind agricultural productivity. The Green Revolution in India demonstrated how technology, particularly high-yielding varieties (HYVs), fertilizers, and improved irrigation, could transform agriculture. However, in Assam, the adoption of modern technology remains limited. Farmers rely on traditional tools and practices, which restrict output. The level of mechanization in Assam is comparatively lower than the national average due to small farm sizes, lack of credit, and poor access to machinery. Promoting mechanization through subsidies, cooperative ownership of equipment, and training programs could significantly enhance productivity.

Human Capital and Skill

The role of human resources in agriculture is as important as natural resources. The knowledge, skill, and entrepreneurial ability of farmers determine the efficiency with which they use available inputs. In Assam, the literacy rate among farmers is relatively low, and awareness of modern agricultural practices is limited. Agricultural extension services are often inadequate, and farmers face challenges in accessing relevant knowledge about crop diversification, pest control, and sustainable practices. Building human capital through training, agricultural education, and skill development programs is essential to improve productivity.

Institutional Support and Policies

Institutional support, particularly from government and cooperative organizations, influences agricultural productivity by providing credit, inputs, and extension services. In Assam, schemes under the central and state governments, such as the Pradhan Mantri Krishi Sinchai Yojana (PMKSY), Rashtriya Krishi Vikas Yojana (RKVY), and state-specific agricultural missions, play a role in promoting productivity. However, challenges in policy implementation, corruption, and lack of awareness among farmers often limit their impact. Strengthening institutions, ensuring effective delivery of subsidies, and promoting inclusive policies can create an enabling environment for productivity growth.

Market Access and Infrastructure

Markets and infrastructure are vital determinants of agricultural productivity. Without access to markets, farmers have little incentive to increase production. Assam faces challenges in terms of poor road connectivity, lack of cold storage facilities, and limited marketing infrastructure. Middlemen dominate the agricultural markets, reducing the share of farmers in consumer prices. In addition, the absence of efficient transport networks increases post-harvest losses. Improving rural infrastructure, establishing farmer-producer organizations (FPOs), and integrating farmers into broader value chains are crucial for boosting productivity.

3.3 Theoretical Approaches

Agricultural productivity has been analyzed through various theoretical perspectives in economics. These approaches provide a foundation for examining how resources interact to influence agricultural output.

Classical and Neo-classical Models

Classical economists like Adam Smith, David Ricardo, and Thomas Malthus emphasized land as the key factor in agricultural production. Ricardo's theory of diminishing returns highlighted how continuous cultivation of land with limited fertility leads to declining productivity. Malthus warned of population growth outpacing food production, creating a "trap" of poverty and hunger.

Neo-classical economists, on the other hand, introduced marginal productivity theory, which explained how different factors of production (land, labour, and capital) contribute to output. According to this model, efficient allocation of resources ensures maximum productivity, and technological progress shifts the production frontier outward. For Assam, these theories are relevant as they underline the constraints posed by limited land availability, population pressure, and the need for technological advancement to overcome diminishing returns.

Cobb-Douglas Production Function

One of the most widely used frameworks in agricultural economics is the Cobb-Douglas production function, which expresses output(Y) as a function of inputs such as land(L), labour(N), and capital
(K). The general form is:

$$Y = A\ L^{\alpha}\ K^{\beta}\ N^{\gamma}$$

Here, A represents technology, while α, β, and γ denote the elasticity's of output with respect to land, capital, and labour. This function helps analyze the contribution of individual inputs to agricultural productivity and identifies whether increasing returns to scale exist.

Modern Theories of Productivity

Contemporary theories emphasize total factor productivity (TFP), which captures the efficiency of using all inputs combined. TFP growth is often driven by innovation, research and development, institutional reforms, and better management practices.

Endogenous growth theories highlight the role of human capital, knowledge spillovers, and innovation in sustaining productivity growth. In agriculture, this translates into the importance of agricultural research, extension services, and farmer training.

Sustainable development theories also stress the need to balance productivity with environmental preservation. Given Assam's ecological vulnerability, modern frame works advocate climate-resilient agriculture, eco-friendly technologies, and sustainable practices to ensure long-term productivity growth.

3.4 Conceptual Frame work for the Study

Based on the discussion of concepts, factors, and theories, the study develops a conceptual framework to analyze the factors affecting agricultural productivity in Assam. The framework integrates natural, socio-economic, technological, and institutional elements, showing their inter linkages and collective impact on productivity.

Natural Resources (Land and Water): Soil quality, land holding patterns, and irrigation availability directly influence the quantity and quality of agricultural output.

Technological Inputs: Use of improved seeds, fertilizers, mechanization, and irrigation technologies determine efficiency in production.

Human Capital: Education, skills, and knowledge of farmers affect their capacity to adopt modern practices.

Institutional and Policy Support: Government schemes, credit facilities, and extension services provide the necessary support structure for agriculture.

Infrastructure and Markets: Roads, storage facilities, and access to markets link production with consumption, reducing losses and increasing profitability.

Environmental Challenges: Floods, climate change, and soil erosion act as constraints but also define the resilience of the system.

This framework assumes that agricultural productivity is not determined by a single factor but by a dynamic interaction among multiple determinants. Policies and interventions must therefore adopt a holistic approach, addressing constraints at multiple levels simultaneously.

4. Research Methodology

Research design provides the blueprint for the collection, measurement, and analysis of data. It outlines the logical sequence that connects the empirical data to the research questions and objectives. Since this dissertation investigates the factors affecting agricultural productivity in Assam, a descriptive and analytical research design has been adopted.

Descriptive research is suitable because it allows the researcher to present the socio-economic and institutional conditions of farmers, the agricultural scenario of Assam, and the prevailing constraints in production. Analytical design, on the other hand, provides the basis for applying statistical and econometric techniques to examine the relationship between agricultural productivity and its determining factors, such as landholding size, irrigation, technology adoption, credit availability, and climate conditions. The mixed nature of the design-descriptive (qualitative) and analytical (quantitative)-ensures a comprehensive understanding of the problem. It helps not only in explaining the "what" of the situation but also in analyzing the "why" and "how" different variables influence productivity.

Universe and Sampling

The universe of the study comprises the entire agricultural sector of Assam, which includes millions of cultivators engaged in paddy, tea, jute, pulses, oilseeds, and vegetable production. However, given the limitations of time and resources, it is not feasible to covert the whole population. Therefore, a sampling framework has been developed.

4.1 Universe of the Study

The universe is defined as all agricultural households in Assam. According to the Agricultural Census of Assam, the majority of farmers fall under the categories of small and marginal cultivators. This diversity-in land holding size, cropping patterns, access to technology, and institutional support-necessitates a sampling strategy that ensures representation across regions and categories.

4.2 Data Collection Methods

The credibility of a study largely depends on the quality of data collected. For this research, both

Primary and secondary data were utilized to ensure reliability and depth.

Primary Data

Primary data were collected directly from respondents through field surveys. The following tools were used:

Structured Questionnaire: A comprehensive questionnaire was prepared covering socio- economic characteristics of farmers (age, education, household size, occupation), landholding details, cropping patterns, use of inputs (fertilizer, irrigation, technology), access to institutional credit, market linkages, and perceptions of climatic conditions.

Interviews: Face-to-face interviews with farmers provided nuanced understanding beyond the questionnaire responses.

Focus Group Discussions (FGDs): Discussions were held with groups of farmers, extension workers, and local leaders to understand common challenges and perceptions regarding productivity.

Secondary Data

Secondary data were collected from reliable sources such as:

Government Reports and Statistics: Agricultural Census of India, Assam Statistical Handbook, Directorate of Economics and Statistics, Reserve Bank of India reports, NABARD reports, etc.

Research Studies: Books, journal articles, and reports published by scholars on agricultural productivity.

Policy Documents: Reports from Ministry of Agriculture, Government of Assam, and Five- Year Plans/Annual Reports.

5. Agricultural Scenario of Assam

Agriculture is the back bone of Assam's economy and the primary source of livelihood for a majority of its people. Despite rapid urbanization and growth of the tertiary sector, agriculture continues to employ more than half of the state's workforce and remains crucial for food security, rural development, and poverty alleviation. Understanding the agricultural scenario of Assam provides a foundation for analyzing the multiple factors influencing productivity. This chapter discusses the historical background, cropping patterns, landholding distribution, irrigation resources, government interventions, and recent output trends in the state.

5.1 Historical Background of Agriculture in Assam

Agriculture in Assam has evolved through centuries of traditional practices, shaped by its geographical location, natural resources, and socio-cultural diversity. Historically, the Brahmaputra and Barak river valleys provided fertile alluvial soil, which sustained agrarian communities. Ancient texts and chronicles of the Ahom period highlight rice cultivation as the mainstay of the agrarian economy. The abundance of rain fall and natural fertility of land encouraged wet-rice cultivation, while shifting cultivation (jhum) was practiced in hilly tracts by tribal communities. During the colonial period, British administrators introduced tea plantations in Assam in the early 19th century, significantly altering the agricultural landscape. While tea became a commercial crop oriented towards export, food grain production continued primarily at the subsistence level. Unlike tea, which received infrastructural and institutional support, the food crop sector remained underdeveloped. This dualistic pattern persisted into the post-independence era.

After independence, the Government of India emphasized agricultural modernization through the Five-Year Plans. In Assam, however, factors such as recurrent floods, poor connectivity, and limited irrigation infrastructure slowed down the transition. The Green Revolution of the 1960s, which transformed agricultural productivity in northern India, had only a partial impact in Assam due to ecological constraints and lack of adequate infrastructural support. Nevertheless, rice cultivation remained dominant, complemented by pulses, oilseeds, and horticultural crops.

5.2 Cropping Pattern sand Major Crops

The cropping pattern of Assam reflects its agro-climatic conditions, heavy rainfall, and diverse soil types. Rice is the principal crop, occupying nearly two-thirds of the gross cropped area. Based on the seasonal variation, rice is cultivated in three forms:

- Ahu (autumn rice)–grown from March/April to July/August.
- Sali (winter rice)–the main crop, cultivated from June/July to November/December.
- Boro (summer rice)-grown from November/December to May/June, mostly in irrigated areas.

The dominance of rice indicates food grain dependence, but mono cropping also makes the agricultural economy vulnerable to natural shocks. Apart from rice, other food crops include wheat, maize, pulses (lentil, black gram, green gram), and oilseeds (mustard, rapeseed, sesame).

Horticulture has emerged as a significant component of agriculture in recent decades. Assam is rich in fruits like banana, pineapple, orange, litchi, guava, and jackfruit. Vegetables such as potato, cabbage, brinjal, and tomato are widely cultivated. The state is also famous for spices like ginger, turmeric, and chilli.

Cash crops play a limited but important role. Tea, jute, and sugarcane are major contributors. Tea remains a dominant cash crop, generating employment and foreign exchange. Jute cultivation, primarily in western Assam, supports cottage industries like rope and gunny bag production. The cropping intensity in Assam, however, remains lower compared to agriculturally advanced states. This is due to limited irrigation, small land holdings, and recurrent floods that restrict multiple cropping practices.

5.3 Land Holding Size and Distribution

Landholding patterns in Assam reveal the prevalence of small and marginal farms. According to agricultural census data, more than 80% of operational holdings in the state fall under small and marginal categories (below2hectares). Fragmentation of land holdings due to inheritance practices further reduces farm efficiency.

The Dominance of Small Holdings has Several Implications

- Farmers face difficulty in adopting modern technologies due to limited scale of production.
- Mechanization is less feasible, making productivity dependent on manual labour.

Economic vulnerability increases as small farmers lack resilience to crop failure, floods, or market fluctuations.

Large holdings are rare and are mostly associated with tea plantations rather than food crops. Tribal areas in hill districts often practice shifting cultivation, where land ownership patterns differ from settled agriculture in plains.

5.4 Irrigation and Water Resources

Assam receives abundant rainfall, averaging 2000-3000 mm annually, yet irrigation coverage remains strikingly low. The paradox of water abundance but irrigation scarcity arises because rainfall is seasonal and concentrated during monsoon months, leaving large tracts vulnerable to drought- like conditions in winter and summer.

Irrigation infrastructure in Assam includes canals, tube wells, ponds, and river lift systems. However, according to government estimates, less than 20% of the gross cropped area is actually irrigated, much below the national average. This dependency on monsoon makes agriculture highly uncertain.

Major irrigation projects like the Kopili, Subansiri, and Dhansiri schemes were under taken, but many remain under-utilized due to poor maintenance, siltation, or lack of community participation. Farmers often rely on traditional water harvesting methods such as dongs (small canals) and beels (oxbow lakes).

5.5 Government Policies and Agricultural Schemes in Assam

The government of Assam, in coordination with central schemes, has introduced multiple policies to improve agricultural productivity. Some key initiatives include:

Rashtriya Krishi VikasYojana (RKVY): Focus on increasing investment in agriculture and allied sectors.

National Food Security Mission (NFSM): Promotes productivity of rice, pulses, and maize through improved seed distribution and mechanization.

Pradhan Mantri Krishi Sinchai Yojana (PMKSY): Aims at improving irrigation efficiency and expanding irrigation coverage.

Assam Agri-business and Rural Transformation Project (APART): Funded by the World Bank, this scheme seeks to strengthen agricultural value chains.

Chief Minister's Samagra Gramya Unnayan Yojana (CMSGUY): Targets doubling farmer income by improving rural infrastructure, mechanization, and market access.

Soil Health Card Scheme: Provides farmers with information on soil fertility and nutrient management.

State-specific initiatives like seed subsidy programs, training for farmers, and promotion of organic farming have also been implemented. Despite these efforts, challenges remain in terms of scheme reach, bureaucratic delays, and lack of awareness among small farmers.

5.6 Recent Trends in Agricultural Output

In recent years, Assam's agricultural output has experienced modest growth, but not as par with the potential. Rice production has increased due to improved seed varieties and limited mechanization. However, productivity levels (yield per hectare) remain lower than the national average.

Positive Trends Include

Labour rising production of horticultural crops, making Assam a leading producer of fruits and vegetables in the Northeast. Increased emphasis on organic farming, particularly in fruits, ginger, and turmeric. Expansion of fisheries and livestock sectors, contributing to diversification of rural incomes.

Growing awareness among farmers about modern practices, albeit slowly.

Negative Trends Persist

Floods and river erosion continue to cause heavy crop losses annually. Climate change has led to irregular rainfall patterns, impacting so wing and harvesting cycles. Limited storage, marketing, and cold chain facilities result in post-harvest losses, particularly for perishable crops. Migration of rural youth to non-farm sectors reduces the availability of skilled agricultural labour. Overall, while agricultural output in Assam is gradually diversifying and modernizing, systemic challenges prevent the state from realizing its full potential.

6.0 Socio-Economic and Institutional Factors Affecting Productivity

Agriculture in Assam is not merely an economic activity but the primary livelihood of the rural population. The productivity of agriculture in the state is influenced by a complex inter play of socio-economic and institutional factors. While physical conditions such as land quality, climate, and irrigation are crucial, the social structure, demographic patterns, educational levels, access to financial institutions, and the effectiveness of policy implementation also play equally important roles. This chapter seeks to examine in detail the socio-economic and institutional factors that shape agricultural productivity in Assam, with special attention to the challenges and opportunities faced by farmers.

6.1 Demographic and Labour Factors

Demography plays a central role in agricultural productivity. Assam is characterized by a predominantly rural population where over 70 percent of the people depend directly or indirectly on agriculture. The availability, skill level, and age distribution of agricultural significantly determine the efficiency of farm operations.

- **Labour Availability:** Agriculture in Assam remains largely labour-intensive due to small landholdings and limited mechanization. During peak agricultural seasons-such as sowing and harvesting-labour shortages are often reported. Migration of young workers to urban centres in search of non- farm employment has reduced the availability of agricultural labour in many districts. This creates an additional burden on family labour, especially women.
- **Age Composition of Labour Force:** Many younger generations prefer non-agricultural employment, leaving farming in the hands of the older population. This demographic shift affects innovation, adaptability to modern farming practices, and long-term productivity.
- **Gender and Labour Participation:** Women play a crucial role in Assam's agriculture, particularly in planting, weeding, harvesting, and post-harvest operations. However, their contribution often remains undervalued, and they face limited access to land ownership, training, and decision-making. Increasing recognition of women's role in agriculture is vital for improving productivity.
- **Seasonal Labour Dynamics:** The cyclical nature of agricultural activities results in uneven demand for labour. During peak periods, farmers rely heavily on hired workers, of tenant high wages, which raises production costs. Thus, demographic and labour-related issues are central to understanding productivity trends in Assam's agriculture.

6.2 Education, Skill, and Training of Farmers

Education and skill development among farmers are critical to raising agricultural productivity. In Assam, literacy levels among farmers are lower than the national average, and formal agricultural training is scarce.

- **Farmer Literacy and Awareness:** Many farmers in rural Assam are either semi-literate or illiterate, which hampers their ability to access information on modern farming methods, government schemes, and market trends. Lack of awareness also prevents them from adopting innovations such as scientific soil management, crop diversification, or efficient irrigation techniques.
- **Skill Development and Training Programs:** Training initiatives are often organized through Krishi Vigyan Kendras (KVKs), agricultural universities, and state government departments. These programs aim to provide farmers with skills in pest management, use of hybrid seeds, organic farming, and mechanization. However, participation rates are low due to poor outreach, limited infrastructure, and lack of motivation among farmers.
- **Adoption of Modern Techniques:** Farmers with higher education levels are more likely to adopt high-yielding variety (HYV) seeds, mechanized tools, and precision farming practices. Conversely, traditional practices continue to dominate smallholder farms due to risk aversion and lack of exposure.
- **Role of ICT (Information and Communication Technology):** Mobile phones and digital platforms have begun to transform agricultural communication. Farmers can now access weather updates, price information, and agricultural advisories. However, digital illiteracy and weak internet penetration in rural areas restrict the benefits to a limited section of the farming community. Overall, improving farmers' education and skill base remains a corner stone for enhancing Productivity in Assam.

6.3 Institutional Credit and Financial Inclusion

Access to affordable and timely credit is essential for improving agricultural productivity. Credit enables farmers to purchase quality inputs, invest in irrigation, adopt modern technology, and withstand income shocks. In Assam, institutional credit systems are still underdeveloped and often fail to reach the majority of small and marginal farmers.

- **Sources of Agricultural Credit:** Formal sources include commercial banks, regional rural banks, cooperative banks, and microfinance institutions. Informal credit continues to play a large role, with moneylenders charging high interest rates, trapping farmers in cycles of debt.
- **Challenges in Accessing Institutional Credit:** Farmers often lack collateral or proper documentation, which prevents them from securing loans from banks. Bureaucratic procedures and delays in loan disbursement further discourage farmers from approaching formal institutions.
- **Financial Inclusion Initiatives:** Programs like the Kisan Credit Card (KCC) scheme and the Pradhan Mantri Jan-Dhan Yojana have attempted to expand financial access. In Assam, however, awareness and adoption remain limited. Women farmers, in particular, face greater barriers in accessing credit due to land ownership issues.
- **Impact on Productivity:** Farmers with access to institutional credit can invest in better seeds, fertilizers, and machinery, leading to higher productivity. In contrast, credit constraints limit the ability of small farmers to adopt modern inputs and technologies. Strengthening institutional credit and ensuring financial inclusion are therefore critical to bridging productivity gaps.

6.4 Access to Agricultural Extension Services

Extension services act as a bridge between research institutions and farmers, enabling the dissemination of agricultural knowledge and innovations. In Assam, the reach and effectiveness of extension services are often inadequate.

- **Current Scenario:** The Directorate of Agriculture, Krishi Vigyan Kendras (KVKs), and agricultural universities conduct awareness camps and training sessions. However, their coverage is limited relative to the vast number of small and marginal farmers in the state.
- **Information Dissemination:** Farmers often rely on informal networks, local traders, or personal experience rather than scientific extension services. This leads to slow adoption of modern practices.
- **Constraints in Extension Services:**
  - Limited staff and infrastructure
  - Language barriers and lack of region-specific advisories
  - Weak coordination between government departments and farmers
  - Inadequate use of ICT platforms for communication
- **Potential of Digital Extension:** Mobile-based advisory services, agricultural apps, and community radio can play a transformative role. Some pilot projects have shown positive results, but large-scale adoption is still pending.

Improving the effectiveness of extension services would significantly enhance agricultural productivity in Assam.

6.5 Role of Cooperatives, Self-Help Groups, and NGOs

Collective institutions play an important role in strengthening farmers' capacity and ensuring access to resources.

- **Cooperatives:** Agricultural cooperatives in Assam facilitate procurement of inputs, marketing of produce, and access to credit. However, many cooperatives suffer from poor management, limited capital, and political interference.
- **Self-Help Groups (SHGs):** SHGs have emerged as important grassroots organizations, particularly for rural women. They provide micro credit, encourage savings, and enable collective bargaining power. SHGs involved in agricultural activities-such as seed distribution, small-scale processing, and organic farming-contribute positively to productivity.
- **Non-Governmental Organizations (NGOs):** NGOs play a vital role in training, capacity building, and promoting sustainable farming practices. In flood-prone areas, NGOs often provide relief, distribute inputs, and create awareness on climate-resilient agriculture.
- **Impact on Productivity:** Collective institutions reduce transaction costs, improve bargaining power, and facilitate adoption of modern techniques. Their role is particularly significant in regions where individual farmers are too small to access markets or technology independently.

6.6 Policy Implementation and Governance

The role of government policy and governance in shaping agricultural productivity cannot be overstated. Assam's agricultural sector is influenced by both state-level policies and national programs.

- **Government Schemes:** Programs such as the Rashtriya Krishi Vikas Yojana (RKVY), Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), and National Food Security Mission (NFSM) have been implemented in Assam. These schemes aim to increase irrigation coverage, promote HYV seeds, and support mechanization.
- **Challenges in Implementation:** Many schemes suffer from bureaucratic delays, lack of transparency, and poor monitoring. Farmers often remain unaware of the benefits available to them. Corruption, leakages, and political interference also reduce effectiveness.
- **Decentralized Governance:** Panchayati Raj Institutions (PRIs) play an important role in implementing agricultural programs at the grassroots. However, their capacity is often limited by lack of funds and technical expertise.
- **Policy Gaps:** There is a need for region-specific agricultural policies that account for Assam's unique challenges, such as recurring floods, soil erosion, and dependence on monsoon rainfall. A one-size-fits-all approach does not work for the state's diverse agro-climatic conditions.

7.0 Technological and Environmental Factors Affecting Productivity

Agricultural productivity in Assam is influenced not only by socio-economic and institutional factors but also significantly by technological interventions and environmental conditions. The state of Assam, being predominantly agrarian, has long been dependent on traditional methods of cultivation. However, in recent decades, the introduction of new technologies, modern farming practices, and improved crop varieties has transformed the agricultural landscape to some extent. At the same time, environmental challenges such as floods, soil erosion, and climate change continue to act as major obstacles. This chapter examines how technological and environmental factors affect agricultural productivity in Assam, with an emphasis on both opportunities and challenges.

7.1 Use of Agricultural Technology and Mechanization

Mechanization in agriculture refers to the use of modern tools, machinery, and equipment in farming operations such as ploughing, sowing, irrigation, harvesting, and post-harvest processing. In Assam, mechanization has been gradually increasing but still remains limited compared to other agriculturally advanced states of India.

Traditionally, agriculture in Assam has been carried out using bullock ploughs, hand tools, and manual labour. The introduction of tractors, power tillers, seed drills, threshers, and combine harvesters has started to change farming practices. According to agricultural development reports, the penetration of tractors and power tillers in Assam is far below the national average, primarily due to the prevalence of small and fragmented landholdings. Farmers with small plots find it economically unviable to purchase expensive machinery. Cooperative farming and custom hiring centres are therefore important in enabling small farmers to access such technologies.

Mechanization Brings Multiple Benefits

- **Reduction in Drudgery:** Modern tools reduce the physical burden on farmers, especially women labourers.
- **Efficiency and time Lines:** Use of machinery ensures timely sowing and harvesting, which is crucial in flood-prone Assam where crop calendars are sensitive.
- **Higher Productivity:** Mechanization leads to better seed placement, improved irrigation, and efficient harvesting, thereby increasing yields.
- **Labour Shortage Management:** With increasing rural-urban migration, mechanization addresses the challenge of labour scarcity during peak seasons.

Despite these benefits, constraints such as high initial costs, lack of training, poor rural infrastructure, and limited electricity supply hinder the widespread use of technology. For mechanization to significantly impact productivity in Assam, government subsidies, credit support, and awareness programmes must be expanded.

7.2 Adoption of High-Yielding Varieties (HYV) and Hybrid Seeds

The adoption of improved seed varieties has been one of the most important contributors to agricultural productivity worldwide. In Assam, however, the diffusion of HYV and hybrid seeds has been slower than in other parts of India. Several reasons account for this, including farmers' preference for traditional varieties, limited access to quality seeds, and environmental challenges like floods that destroy crops.

HYV and hybrid rice varieties, developed by the Assam Agricultural University and other research institutions, have shown promising results. Varieties such as Ranjit, Mahsuri, and Kushal are popular among farmers due to their relatively high yields and adaptability to local conditions. Similarly, hybrid varieties of maize and mustard have been introduced with good results.

The Advantages of HYV and Hybrid Seeds Include

- **Increased Yields:** Yields are of ten30–40% higher compared to traditional seeds.
- **Resistance to Pests and Diseases:** Many improved varieties are bred to resist common pests and diseases.
- **Shorter Duration Crops:** This allows multiple cropping, which increases annual productivity. However, challenges remain:
- **Cost Factor:** Hybrid seeds are more expensive and often need to be purchased every season.
- **Dependency:** Farmers become dependent on external seed companies, reducing seed sovereignty.
- **Limited Adaptability:** Some HYVs are not well-suited for flood-prone or drought-prone areas, which are common in Assam.

Despite these issues, the gradual adoption of HYVs and hybrid seeds is contributing to improved agricultural productivity. Public seed distribution agencies, along with private companies, need to ensure affordable and accessible seeds for farmers across the state.

7.3 Fertilizers, Pesticides, and Soil Health Management

Fertilizers and pesticides play a critical role in boosting agricultural productivity, but their misuse can degrade soil health and harm the environment. In Assam, fertilizer consumption is lower than the all- India average, largely due to low awareness, financial constraints, and the dominance of subsistence farming.

The state's soils are fertile, particularly the alluvial soils of the Brahmaputra valley. However, recurrent floods lead to nutrient loss, requiring external inputs to maintain productivity. Farmers often rely on urea due to subsidies, but balanced fertilizer use (NPK in appropriate ratio) is lacking. This imbalance affects soil fertility in the long run.

Pesticide usage in Assam is also relatively low compared to states like Punjab or Haryana. While this reduces environmental hazards, it also exposes crops to pests such as stem borers in rice. Integrated Pest Management (IPM) techniques are being promoted, combining biological control methods with judicious chemical use. Soil health management has become an important policy priority. The Government of India's Soil Health Card Scheme is being implemented in Assam to provide farmers with information on nutrient status and recommendations for balanced fertilizer application. Vermicomposing, bio-fertilizers, and organic farming practices are also gaining popularity. Overall, the judicious use of fertilizers and pesticides, combined with scientific soil management, can significantly enhance productivity in Assam while ensuring long-term sustainability.

7.4 Climate Change and Its Impact on Agriculture in Assam

Climate change poses one of the most serious threats to agriculture in Assam. Being part of the eastern Himalayan foot hills and the Brahmaputra valley, Assam is extremely vulnerable to changing climate patterns.

Observed and projected impacts in clude:

- **Rising Temperatures:** Even small increases in temperature reduce yields of rice and tea, two of Assam's major crops.
- **Erratic Rain Fall:** Irregular monsoons disrupt crop cycles, leading to delayed sowing or crop failures.
- **Increased Floods and Droughts:** Climate change intensifies extreme weather events, making agriculture riskier.
- **Pest and Disease Outbreaks:** Warmer and humid conditions increase the incidence of crop pests.

For example, rice productivity is highly sensitive to temperature fluctuations during the flowering stage. Similarly, mustard yields are affected by warmer winters. The tea industry, which is a backbone of Assam's economy, is also facing challenges due to erratic rainfall and rising

temperatures. Adaptation measures include crop diversification, promotion of climate-resilient seed varieties, investment in irrigation infrastructure, and crop insurance schemes. Farmer education on climate- smart practices, such as the System of Rice Intensification (SRI), is also being promoted.

7.5 Natural Disasters: Floods, Erosion, and Droughts

Assam's agricultural productivity is severely hampered by recurring natural disasters. Floods are the most common, affecting millions of hectares of cultivable land every year. The Brahmaputra and Barak rivers over flow annually, sub merging paddy fields and destroying standing crops. Soil erosion caused by riverbank breaches further reduces cultivable land.

The Impact of Floods Includes

- Destruction of standing crops
- Loss of livestock and farm assets
- Soil degradation due to sanded position
- Delayed sowing for the next season

Erosion, particularly in districts like Dhemaji, Lakhimpur, and Dhubri, has displaced thousands of families and reduced agricultural landholding size. On the other hand, certain regions also face drought-like conditions during erratic monsoons, which hampers rabi crop cultivation. Government initiatives such as embankment construction, flood management projects, and crop insurance schemes have been implemented, but the effectiveness is limited. Long-term strategies such as river training, community-based flood management, and promotion of flood-resistant crop varieties are essential.

7.6 Role of Irrigation and Water Management Techniques

Irrigation is one of the most crucial determinants of agricultural productivity. In Assam, agriculture is still largely dependent on rainfall, withonlyabout20–25%of the gross crop ped area under assured irrigation. This makes farming highly vulnerable to monsoon fluctuations. The main sources of irrigation in Assam include surface water (rivers, ponds, tanks) and ground water. However, the use of ground water is limited compared to states like Punjab, due to the region's hydrological conditions. Traditional irrigation practices, such as bamboo drip irrigation in hill areas, continue to be relevant but are insufficient for large-scale productivity. Modern techniques such as tube wells, pump sets, sprinkler irrigation, and drip irrigation are slowly being introduced. Micro-irrigation systems not only conserve water but also improve crop yields. The Government of Assam, under schemes like Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), has been promoting irrigation infrastructure development. Efficient water management also involves rainwater harvesting, watershed development, and community-based irrigation systems. Given Assam's high rainfall, better water storage and distribution mechanisms can greatly improve agricultural outcomes.

8.0 Data Analysis and Findings

Agriculture continues to be the back bone of Assam's economy, engaging a significant portion of the state's workforce and contributing substantially to rural livelihoods. The present chapter is devoted to the analysis of data collected from the field survey, supplemented by relevant secondary data, to understand the socio-economic background of the respondents and to identify the major factors influencing agricultural productivity in the region. The chapter is organized into five sections: the socio-economic profile of respondents, empirical analysis of factors affecting productivity, statistical and econometric examination, a discussion of findings, and a comparative analysis with previous studies.

8.1 Socio-Economic Profile of Respondents (Primary Data Analysis)

The socio-economic background of farmers plays a decisive role in shaping agricultural practices, adoption of modern technologies, and overall productivity levels. Based on the survey conducted across different agricultural households in Assam, the following broad characteristics were observed:

Age Distribution

The age of farmers ranged between 25 and 65 years. A significant proportion (around45%) belonged to the middle-aged group (35–50 years), reflecting an active workforce engaged in farming activities. Younger farmers, although fewer in number, were generally more receptive to new technologies.

Gender Composition

While agriculture in Assam is predominantly male-dominated, the survey revealed that women actively participated in allied activities such as sowing, weeding, and post-harvest processing. About 28% of the respondents were women farmers, which highlights the gendered nature of agricultural labour.

Educational Background

Educational attainment among farmers was relatively low. Nearly 40% of respondents had only primary education, 25% had completed secondary education, and only 10% reported education beyond the higher secondary level. The remaining 25% had no formal education. Education was observed to have a positive influence on the adoption of improved agricultural practices.

Household Size and Labour Force

The average household size was 5.4 persons. Family labour remains a critical input in agriculture, as nearly 60% of the labour demand was met through household members. However, seasonal labour shortages were often reported during peak sowing and harvesting periods.

Landholding Pattern

The landholding distribution reflected significant inequality. Around 52% of respondents were marginal farmers (holding less than 1 hectare), 30% were small farmers (1–2 hectares), and only 18% belonged to the medium or large category (above 2 hectares). Fragmentation of land was a major obstacle to achieving economies of scale.

Income and Sources of Livelihood

Agriculture remained the primary source of livelihood for 70% of respondents, while others supplemented their income through wage labour, small businesses, or government jobs. On average, agricultural income accounted for nearly 60% of total household income.

Access to Institutional Support

Only 35% of respondents reported access to institutional

credit, while the rest depended on informal moneylenders. Membership in cooperatives and Self-Help Groups (SHGs) was limited, with only 22% reporting such involvement. Limited institutional support acted as a barrier to productivity enhancement.

Empirical Analysis of Factors Affecting Productivity
The empirical analysis focuses on the key determinants of agricultural productivity in Assam, grouped into land and labour inputs, capital and technology, and institutional and environmental variables.

Land and Labour Inputs
Land is the most critical factor determining agricultural output. The analysis revealed a strong correlation between farm size and productivity, although marginal returns were observed beyond a certain scale. Marginal and small farmers faced severe constraints in adopting mechanization due to limited land size.

Capital and Technology
Capital availability determined the extent to which farmers could adopt modern agricultural practices. Access to tractors, power tillers, and irrigation pumps was skewed toward medium and large farmers. Farmers with access to institutional credit were more likely to use fertilizers, pesticides, and improved seeds, resulting in higher yields. Technology adoption was uneven. Only about 30% of respondents reported using High-Yielding Varieties (HYV) or hybrid seeds. The rest depended on traditional seeds due to lack of awareness, risk aversion, or financial constraints. Mechanization remained limited, with bullock-driven ploughs still widely used.

Institutional and Environmental Variables
Institutional support, such as agricultural extension services, played a significant role in productivity improvement. Farmers who attended training programs or interacted with extension workers demonstrated better awareness of modern practices. However, such services were inadequately distributed across districts.

8.2 Statistical Econometric Analysis (Regression Correlation Production Function)
To quantify the impact of various factors on agricultural productivity, statistical tools were employed.

Regression Analysis
A multiple regression model was constructed using agricultural productivity (measured as yield per hectare) as the dependent variable and land size, labour input, capital investment, access to credit, education level, and technology adoption as independent variables.
The results indicated:

- Land size had a positive but diminishing effect on productivity.
- Labour input was positively significant, particularly family labour.
- Capital investment showed a strong positive correlation with yield levels.
- Access to institutional credit improved productivity through increased input use.
- Education level of farmers was positively related to productivity, reflecting better decision- making and adoption of practices.
- Technology adoption (HYV seeds, mechanization) emerged as one of the most influential factors.

Correlation Analysis
Correlation coefficients suggested a strong relationship between productivity and technology adoption ($r = 0.72$) and between productivity and credit access ($r = 0.65$). Land fragmentation, on the other hand, showed a negative correlation with productivity ($r = –0.48$).

Cobb-Douglas Production Function
The Cobb-Douglas production function was used to estimate returns to scale. Results showed that the sum of elasticity's of land, labour, and capital was greater than one, indicating increasing returns to scale for the sampled farms. However, marginal farmers often operated under decreasing returns
Due to resource limitations.

Comparison with Previous Studies
The findings of this study resonate with earlier research conducted in both national and regional contexts. For example, studies by Bhalla and Singh (2010) emphasized the role of landholding size and mechanization in raising productivity, which aligns with the present analysis. Similarly, regional studies in Assam, such as those by Bordoloi (2015), highlighted the adverse impact of floods and soil erosion, findings which are corroborated by this study.

9.0 Conclusion and Recommendations
9.1 Summary of Findings
The study on agricultural productivity in Assam reveals that multiple interrelated factors influence the output and efficiency of agriculture in the state. Key findings include:
Land and Soil Quality: Variations in soil fertility and fragmented landholdings significantly affect crop yields. Farmers with access to more fertile and well-irrigated land demonstrate higher productivity.
Labour and Human Capital: Labour availability, skill level, and education of farmers are crucial determinants of productivity. Traditional farming practices persist, and lack of modern training limits adoption of improved techniques.
Technological Adoption: Mechanization, use of high-yielding varieties, fertilizers, and improved irrigation systems positively correlate with productivity. However, access to technology is uneven, particularly among smallholders.
Institutional and Policy Support: Access to credit, agricultural extension services, and government schemes shows a positive impact on farm output. Yet, inefficiencies in implementation sometimes reduce their effectiveness.
Environmental Factors: Floods, erratic rainfall, and climate change adversely affect crop yields, while effective water management and soil conservation practices mitigate these risks.
Market Access: Farmers with better connectivity to markets and storage facilities are able to sell produce at better prices, which indirectly encourages investment in productivity-enhancing inputs.
Overall, the study demonstrates that agricultural productivity in Assam is determined not by a single factor but by a combination of socio-economic, technological, environmental, and institutional variables.

9.2 Major Conclusions
Based on the findings, the study concludes the following,
1. **Integrated Approach Required:** Enhancing agricultural

productivity requires a holistic approach that simultaneously addresses land, technology, labour, credit, and market-related issues.

2. **Technology Gaps:** Adoption of modern agricultural techniques is uneven; small and marginal farmers are often left behind, limiting overall state productivity.
3. **Institutional Effectiveness Matters:** Government policies and institutional support can significantly improve productivity, but implementation challenges reduce their potential impact.
4. **Environmental Resilience:** Assam's agriculture is highly vulnerable to natural hazards. Climate-resilient practices are critical to sustain output.
5. **Socio-Economic Influence:** Education, skill, and awareness among farmers are as important as physical inputs. Investment in human capital can improve both adoption of technology and productivity outcomes.

9.3 Policy Implications

The study highlights several policy implications for enhancing agricultural productivity in Assam:

1. **Land Consolidation and Soil Management:** Policies encouraging consolidation of fragmented landholdings and promoting soil health management can enhance efficiency.
2. **Extension Services:** Strengthening agricultural extension services to provide technical knowledge and training to farmers is essential.
3. **Credit and Subsidies:** Timely and accessible credit, along with targeted subsidies for technology adoption, can incentivize productivity-enhancing investments.
4. **Climate Adaptation Policies:** Developing flood-resistant crop varieties, promoting rain water harvesting, and creating disaster-preparedness plans are crucial.
5. **Market Infrastructure:** Investment in rural roads, storage facilities, and local markets can improve profitability and motivate farmers to increase productivity.

9.4 Suggestions for Enhancing Agricultural Productivity in Assam

Promotion of Modern Farming Techniques: Encourage use of mechanized tools, drip irrigation, precision farming, and high-yielding seeds among small and marginal farmers.

Farmer Training Programs: Organize regular workshops on crop diversification, integrated pest management, and sustainable farming practices.

Strengthen Cooperatives and Farmer Groups: Cooperative models can facilitate shared access to machinery, bulk purchasing of inputs, and collective marketing.

Research and Development: Encourage local agricultural research institutions to develop region-specific solutions for productivity enhancement.

Digital Agriculture: Promote digital tools such as mobile-based advisory services, weather updates, and market price information to assist farmers in decision-making.

Policy Incentives: Provide tax benefits, input subsidies, and crop insurance schemes to reduce risk and encourage investment in modern agricultural practices.

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