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**ARTICLE**

# Financial Development and Agricultural Gross Production Value in Bangladesh: Evidence from a Markov Regime Switching Model

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## ABSTRACT

Agriculture continues to serve as a fundamental pillar of Bangladesh's economy, underpinning food security, employment, and rural welfare. Despite its importance, the sector remains highly exposed to climatic shocks and structural inefficiencies that constrain productivity. Over the past decades, financial development has expanded substantially; however, its capacity to stabilize or accelerate agricultural growth under varying economic and environmental conditions remains ambiguous. This study seeks to address this gap by examining the influence of financial development—measured by domestic credit to the private sector—on agricultural performance in Bangladesh from 1980 to 2023. To account for potential non-linearities, the analysis employs the Markov Regime Switching (MRS) model, which distinguishes between two unobserved phases of the agricultural cycle: crop-loss and prosperity regimes. The empirical results reveal that during crop-loss periods, financial development contributes positively to agricultural recovery by easing liquidity constraints and mitigating income shocks among farm households. Conversely, during prosperity phases, the effect of finance turns negative, indicating inefficiencies and debt accumulation risks associated with excessive credit expansion. These findings suggest that the finance-agriculture nexus is regime-dependent rather than uniform, underscoring the need for policy interventions that adapt to cyclical realities. Accordingly, the study advocates a counter-cyclical credit strategy—expanding credit during downturns while enhancing credit quality and efficiency during booms—to sustain agricultural growth and resilience in Bangladesh.

***Keywords:*** Financial Development; Agricultural Growth; Domestic Credit

***JEL Codes:*** Q14; O16; C22; Q18

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# 1. Introduction

Although the world is undergoing rapid industrialization and modernization, agriculture remains a cornerstone of economic development in many countries, particularly across South Asia. In Bangladesh, the agricultural sector not only ensures national food security but also provides livelihoods for a substantial share of the population. According to the Bangladesh Bureau of Statistics[1] agriculture contributed approximately 11.4% to GDP in FY 2022–23, while about 35.27% of the labor force was employed in the sector (modeled ILO estimate for 2023)[2]. Beyond direct employment, the broader agrifood system—including input suppliers, processing industries, and distribution networks—continues to serve as the backbone of rural income and welfare. However, agricultural production in Bangladesh is inherently seasonal, cyclical, and highly vulnerable to shocks such as floods, cyclones, and price fluctuations. These structural risks require substantial upfront investment, yet farm households often experience delayed income flows. Liquidity constraints are widespread, as poor farmers face limited access to formal credit, whereas wealthier households capture a disproportionate share of available financial resources[3]. Consequently, financial development—particularly through the provision of agricultural credit—emerges as a vital instrument to help farmers overcome liquidity barriers, adopt modern technologies, and cope with both seasonal and climate-related risks[4,5].

The importance of credit becomes particularly evident across different phases of the agricultural cycle. During periods of prosperity, credit functions not merely as financial support but as a catalyst for technological innovation, crop diversification, and productivity enhancement[6]. For instance, government initiatives such as the Agricultural Input Assistance Card and low-interest seasonal loan programs offered by the Bangladesh Krishi Bank have enabled smallholder farmers to invest in high-yield crop varieties and modern irrigation systems, contributing significantly to Bangladesh's achievement of rice self-sufficiency. Conversely, during periods of distress, credit assumes a stabilizing role. Following Cyclone Sidr in 2007, concessional loans provided through microfinance institutions and state-owned banks allowed affected households to resume farming operations and mitigate income losses[7]. These experiences illustrate that, regardless of economic conditions, access to finance remains indispensable for sustaining agricultural growth and safeguarding rural livelihoods.

**Figure 1** illustrates the evolution of agricultural gross production value growth and domestic credit to the private sector in Bangladesh between 1980 and 2023. The contrasting patterns in the figure indicate that financial development, although expanding considerably over time, does not automatically translate into stable or sustained agricultural growth. Rather, the effectiveness of credit in driving agricultural performance appears to depend on broader macroeconomic and structural conditions. For instance, during years of favorable weather and stable input-output prices, credit can serve as a catalyst for productivity gains. Conversely, in periods of flooding, cyclones, or inflationary pressure, credit alone has often proven insufficient to prevent sharp downturns in agricultural output. This reality underscores the need to analyze the relationship between financial development and agricultural performance through a nonlinear and regime-dependent perspective. Conventional linear models risk obscuring the fact that credit may play fundamentally different roles under prosperity and crop-loss conditions. The pronounced volatility evident in **Figure 1** thus provides strong motivation for adopting a Markov Regime Switching (MRS) framework, which enables explicit identification of shifts between high-growth and low-growth regimes in agriculture and a clearer assessment of how financial development operates across these contrasting states.

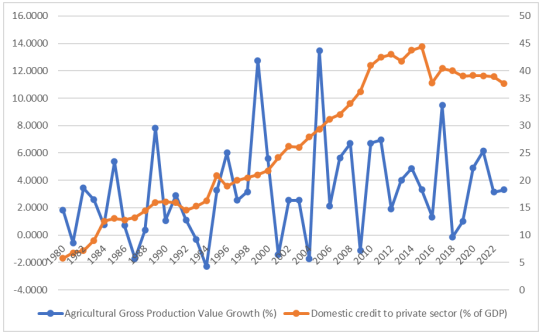


**Figure 1.** Trends in Agricultural Growth and Domestic Credit to the Private Sector in Bangladesh (1980–2023).

Source: World Bank[8].

Existing research has consistently documented the positive contributions of financial development to agricultural productivity and rural welfare [9–12]. However, most studies examine the credit-productivity nexus in isolation, without considering how agricultural performance fluctuates between periods of prosperity and crop loss. This limitation is particularly relevant in the case of Bangladesh, where agriculture remains highly vulnerable to floods, cyclones, and market shocks, resulting in volatile output growth despite ongoing financial deepening.

To address this gap, the present study investigates a central research question: How does financial development affect agricultural gross production value under prosperity and crop-loss regimes in Bangladesh? To capture the nonlinear dynamics inherent in the finance-agriculture nexus, the study employs a Markov Regime Switching (MRS) model using annual data for Bangladesh spanning 1996–2023. Unlike conventional linear models that assume stable relationships, the MRS framework explicitly distinguishes between prosperity and crop-loss regimes, enabling identification of periods when financial development enhances growth and when it may instead amplify risks.

This study contributes to the literature in two primary ways. First, it advances the understanding of the finance-agriculture relationship by revealing how the effects of financial development differ across prosperity and crop-loss states—providing a regime-based perspective often overlooked in previous research. Second, while focusing on Bangladesh, the findings carry broader implications for agriculture-dependent economies, emphasizing that credit allocation strategies should adapt to cyclical agricultural realities rather than follow a uniform approach.

The remainder of this paper is structured as follows. Section 2 reviews the relevant literature on financial development and agricultural performance. Section 3 describes the data, variables, and methodological framework. Section 4 presents the empirical results derived from the MRS model, illustrating how financial development influences agricultural growth under contrasting regimes. Finally, Section 5 concludes with the main findings and discusses key policy implications.

# 2. Literature Review

## 2.1. Theoretical Literature

The impact of financial development on agricultural growth can be effectively explained through the Credit Constraint Theory, which highlights how limited access to finance hampers investment and productivity, particularly in rural and agriculture-dependent economies [13]. Farming activities require substantial upfront inputs but yield delayed and often uncertain returns, leaving smallholders—who frequently lack collateral and face high transaction costs—especially vulnerable to liquidity shortages [4]. During periods of prosperity, farmers may partially bridge this financing gap through retained earnings and favorable market conditions. However, in crop-loss regimes—triggered by floods, cyclones, or sharp price shocks—farm incomes tend to collapse precisely when the demand for external finance is most urgent. Under such circumstances, financial development becomes indispensable to ensure timely access to resources and sustain agricultural resilience.

## 2.2. The Impact of Financial Development on Agricultural Growth

Financial development functions as a critical transmission mechanism for enhancing agricultural productivity. During periods of prosperity, a deeper and more inclusive financial system mobilizes savings and channels them into productive agricultural investments—such as improved seed varieties, fertilizers, irrigation systems, and mechanization—thereby boosting output, lowering transaction costs, and expanding financial outreach to rural farmers. For example, Jimi et al. [14] find that access to credit increases rice yields by approximately 14% among Bangladeshi farmers, with about 11% of this improvement attributed to technological advancement and the remainder to gains in technical efficiency. In contrast, during crop-loss regimes—often caused by floods, cyclones, or pest outbreaks—agricultural incomes decline sharply while production risks intensify. In such periods, financial development assumes an equally vital stabilizing role. Through more

efficient financial intermediation and diversified financial instruments, farmers gain timely access to liquidity, insurance, and refinancing facilities that help cushion adverse shocks and sustain agricultural operations.

A substantial body of empirical research underscores the pivotal role of credit in promoting agricultural growth (**Table 1**). For example, Khan et al.[15] examined the Indian case using data from the Reserve Bank of India and the Central Statistical Office covering the period 1980–2011. Employing the Johansen cointegration test and a Vector Error Correction Model (VECM) framework, they identified a strong unidirectional causal relationship running from agricultural credit to agricultural GDP. This finding confirms that credit serves as a fundamental input for expanding agricultural output and stimulating broader economic growth. At the regional level, Zakaria et al.[16] explored the relationship between financial development and agricultural productivity across South Asian economies from 1973 to 2015. Their results established a long-run cointegrating relationship and revealed an inverted U-shaped effect of financial development on agricultural productivity—indicating that productivity initially rises with financial deepening but declines beyond a certain threshold. In addition, other determinants such as physical and human capital, trade, and income were found to support productivity growth, whereas unfavorable terms of trade, higher carbon emissions, and rural labor intensity exerted adverse effects. This means that agricultural productivity initially rises with financial development up to a certain threshold, but declines beyond that level due to inefficiencies. Evidence from Uganda further underscores this connection. Nakazi and Sunday[17], using quarterly data from 2008Q3–2018Q4 and an ARDL model, found that commercial bank credit significantly boosted agricultural output in the long run, particularly when directed toward production activities. In the short run, however, no significant effect was detected. Their study emphasized that restructuring credit allocation along the value chain, with priority on production, could maximize agricultural gains.

**Table 1.** Summary of Studies Related to Financial Development and Agricultural Productivity.

| Author(s), Year | Country/Region | Data & Methodology | Key Findings |
|---|---|---|---|
| Rayhan et al.[3] | Bangladesh | 500 Boro rice farmers; PSM & Heckman | Formal and semi-formal credit significantly enhanced productivity via improved seeds and input management. |
| Wang et al.[6] | China | Farm-level data | Formal credit facilitated adoption of water-saving irrigation and capital-intensive technologies; improved efficiency. |
| Fink et al.[10] | Zambia | Seasonal household data | Seasonal credit ("hungry season") increased labor use, cultivated area, yields, and household income. |
| Boansi[12] | Ghana | Cocoa farmers; PSM | Credit access raised cocoa productivity, reduced yield gaps, and increased household income. |
| Jimi et al.[14] | Bangladesh | Farm-level survey; econometric decomposition | Access to credit raised rice yield by ~14%; 11% due to technological improvement and the rest to technical efficiency gains. |
| Khan et al.[15] | India | 1980–2011; RBI & CSO data; Johansen cointegration & VECM | Unidirectional causality from agricultural credit to agricultural GDP; credit is a vital input for agricultural growth and economic expansion. |
| Zakaria et al.[16] | South Asia (incl. Bangladesh) | 1973–2015; cointegration analysis | Financial development had an inverted U-shaped effect on agricultural productivity; physical and human capital, trade, and income promoted growth, while adverse ToT, $CO_2$ emissions, and rural labor reduced it. |
| Nakazi & Sunday[17] | Uganda | 2008Q3–2018Q4; quarterly data; ARDL | Bank credit positively affected agricultural output in the long run, especially when directed to production; no significant short-run effect. |
| Seven & Tumen[18] | Cross-country | Panel data; IV estimates | Doubling agricultural credit raised productivity by 4–5%; impact differed by development stage (GDP share vs. labor productivity). |
| Kassouri & Kacou[19] | West Africa | Panel data; controls for endogeneity | Credit constraints remain a barrier; evidence for both supply-leading and demand-following hypotheses; expanding agri-credit more effective than general private sector credit. |

**Table 1.** *Cont.*

| Author(s), Year | Country/Region | Data & Methodology | Key Findings |
|---|---|---|---|
| Ngong et al. [20] | CEMAC region | 1990–2019; ARDL | Long-run cointegration: bank credit, land, and capital positive; money supply, inflation, and labor negative; policy should expand agri-banking and remove barriers. |
| Haryanto [21] | Indonesia | Food Crops Survey; PSM | Access to formal credit improved maize productivity and technical efficiency; formal credit more effective than informal. |
| Yeasmin et al. [22] | Bangladesh | Household survey; econometric models | Farmer experience & land size ↑ demand; loan targets & natural disasters ↑ supply; high interest rates & bureaucracy key barriers. |
| Allahverdiyev et al. [23] | United States | Risk-liquidity analysis | Farmers under high business risk held more liquidity; credit serves as a risk-management tool. |
| Khan & Kim [24] | Cameroon | 404 maize farmers; endogenous switching regression | Access to credit improved maize productivity substantially; confirmed central role of credit in agricultural development. |

Source: Compiled by authors.

Cross-country evidence from Seven and Tumen [18] further confirms that agricultural credit enhances productivity. Using instrumental variable (IV) estimation, they found that doubling agricultural credit could increase productivity by approximately 4–5%. Interestingly, the magnitude and channels of this effect vary by development stage: in developing economies, credit primarily expands agriculture's share in GDP, whereas in advanced economies, it improves agricultural labor productivity. Timing also plays a crucial role. Fink et al. [10], examining the case of Zambia, demonstrated that providing liquidity during the "hungry season for credit" significantly increased farm labor utilization, expanded cultivated land, and improved both yields and household income. Similarly, Kassouri and Kacou [19], analyzing West African economies through panel estimation techniques that control for endogeneity and cross-sectional dependence, found that persistent credit constraints continue to hinder agricultural performance. Their findings support both the supply-leading and demand-following hypotheses: the former posits that financial development stimulates real sector growth, while the latter suggests that financial expansion responds to improvements in the real economy. Overall, they concluded that expanding credit specifically targeted at agriculture and agribusiness sectors would be more effective than relying solely on general private sector credit.

Research in the CEMAC region by Ngong et al. [20] confirmed a long-run equilibrium relationship between bank credit and agricultural productivity using an ARDL approach with data spanning 1990–2019. Their results indicated that bank credit, land, and physical capital exerted positive effects on agricultural output, whereas money supply, inflation, and labor had negative impacts. Accordingly, the study recommended policies to expand agricultural banking, improve financial intermediation, deepen capital markets, and remove barriers that constrain agricultural lending. Country-specific studies provide further empirical support. In Indonesia, Haryanto [21] employed Propensity Score Matching (PSM) using data from the Food Crops Survey across ten maize-producing provinces and found that access to formal credit significantly improved maize productivity and technical efficiency—outperforming informal credit sources. In Ghana, Boansi [12] also applied PSM and showed that credit access enhanced cocoa productivity, reduced yield gaps, and increased household income. Similarly, in China, Wang et al. [6] demonstrated that formal credit facilitated the adoption of capital-intensive technologies such as water-saving irrigation systems, leading to more efficient and sustainable production practices. In the case of Bangladesh, Yeasmin et al. [22] analyzed both the demand and supply determinants of agricultural credit and found that farmer experience and land size positively influenced credit demand, while loan disbursement targets and natural disasters shaped the supply side. However, high interest rates and bureaucratic procedures remained major obstacles, highlighting the persistent structural challenges that Bangladeshi farmers face in obtaining timely and affordable finance.

Other recent works extend these insights. Al-

lahverdiyev et al.[23] found in the U.S. that farmers under high business risk held greater liquidity, highlighting credit's role in risk management. In South Asia, Rayhan et al.[3], using survey data from 500 Boro rice farmers in Bangladesh, combined PSM and the Heckman endogenous treatment model to show that formal and semi-formal credit significantly raised productivity through improved seed adoption and input management. Likewise, Khan and Kim[24], analyzing 404 smallholder maize farmers in Cameroon with an endogenous switching regression, confirmed that access to credit substantially improved maize productivity, reinforcing credit's central role in agricultural development. In recent years, the MRS framework has gained growing attention in empirical economics for its ability to model regime-dependent relationships and capture transitions between distinct states such as expansion and contraction phases. Rahman et al.[25] employed a two-state Markov Switching Model to examine the relationship between financial development and economic growth in Pakistan during 1980–2017. Their findings align with Schumpeter's hypothesis that finance promotes growth. Specifically, financial development was found to stimulate economic growth in both low- and high-growth regimes, with a stronger effect observed during the high-growth phase. This asymmetric result suggests that the responsiveness of economic growth to financial development differs across regimes, reflecting variations in the efficiency of financial intermediation. Among the control variables, trade openness and government expenditure exerted positive impacts on growth, while the labor force had a negative effect, indicating potential structural rigidities in the labor market. Wen et al.[26] extended the application of the regime-switching approach to the agricultural sector by investigating how risk mitigation measures moderate agricultural vulnerability in China from 2000 to 2021. Using a Markov Regime Switching model combined with panel threshold regression, they analyzed 31 regions and identified distinct regimes linking agricultural vulnerability to crop yields. The study revealed that irrigation systems, reservoir capacity, and soil loss control significantly reduce agricultural vulnerability once specific thresholds are reached, highlighting the non-linear nature of these relationships. The findings provide empirical evidence that adaptive and scale-sensitive mitigation measures can effectively enhance agricultural resilience against climatic shocks. In another agricultural context, Van et al.[27] applied a nonparametric Quantile-on-Quantile Regression approach to investigate the link between green credit and sustainable development in Vietnam from 2012 to 2021. Their study highlights that climate change is not only a domestic issue but a global responsibility. Green credit—encompassing environmentally conscious lending and investment in sectors such as agriculture, forestry, and fisheries—plays a vital role in advancing sustainability objectives. The results show a positive relationship between international renewable energy support and SD at lower quantiles (0.05–0.55), which weakens at higher quantiles. Similarly, agricultural credit was found to promote SD at lower quantiles (0.05–0.30), though its effect diminishes at higher levels. In addition, other studies such as Quoc et al.[28], Dinh et al.[29], Quoc and Quoc[30], and Van et al.[31] also highlight the contribution of the financial sector to agriculture and its pivotal role in promoting sustainable development.

## 2.3. Research Gaps

First, although numerous studies have explored the role of credit and financial development in promoting agricultural growth, the majority of this literature concentrates on global or regional contexts such as South Asia or Sub-Saharan Africa. Country-specific evidence for Bangladesh remains relatively scarce, despite the nation's strong dependence on agriculture and high vulnerability to natural shocks. This scarcity of localized evidence constrains policymakers' ability to formulate financial strategies tailored to Bangladesh's unique structural and environmental conditions.

Second, prior research largely emphasizes the positive effects of financial development and credit on agricultural productivity, yet pays insufficient attention to the dual nature of outcomes under varying conditions. In practice, credit can stimulate investment and technological innovation during prosperity regimes; however, under crop-loss regimes—when farm incomes collapse and risks intensify—credit may become a burden, exacerbating indebtedness among rural households. Few

studies have explicitly disentangled these asymmetric effects, leaving a significant empirical gap in understanding how credit dynamics evolve across economic cycles.

Third, from a methodological standpoint, most existing studies rely on conventional linear models that assume stable relationships throughout the study period. Such approaches overlook the potential for distinct economic phases in the agricultural sector, particularly the alternation between prosperity and crop-loss regimes. To address this limitation, the present study employs the MRS model, which accommodates nonlinear and regime-dependent dynamics. This methodological advancement enables the identification of conditions under which financial development serves as a catalyst for growth versus when it may become a source of vulnerability, thereby offering a more nuanced and context-sensitive understanding of the finance-agriculture nexus in Bangladesh.

# 3. Research Methodology

## 3.1. Data and Sample

This study employs annual data for Bangladesh covering the period 1980–2023, obtained from two authoritative sources: the World Development Indicators (WDI) of the World Bank and the statistical database of the Food and Agriculture Organization of the United Nations (FAO). The integration of these datasets ensures both breadth and reliability in examining the nexus between financial development and agricultural performance. Definitions of variables and details of measurement are presented in **Table 2**.

**Table 2.** Variable description and source.

| Symbol | Indicator | Measurement | Source |
|---|---|---|---|
| Dependent variable | | | |
| AGP | Agricultural Gross Production Value Growth | Annual growth rate of agricultural output at constant 2014–2016 international dollars (thousand SLC), adjusted for inflation to allow cross-year comparability. | FAO |
| Independent variable (Financial Development) | | | |
| DR | Domestic Credit to Private Sector (% of GDP) | Serves as the proxy for financial development. It measures financial resources provided to the private sector by deposit-taking institutions (excluding the central bank), expressed as a share of GDP. | World Bank (WDI) |
| Control variables | | | |
| GDP | Economic Growth | Annual growth rate of GDP per capita (%). | World Bank (WDI) |
| TO | Trade Openness | Ratio of total exports and imports of goods and services to GDP. | World Bank (WDI) |
| GFCF | Gross Fixed Capital Formation | Investment in fixed assets (e.g., machinery, infrastructure, land improvements), as a percentage of GDP. | World Bank (WDI) |
| FC | Fertilizer Consumption | Share of domestically consumed fertilizer relative to national fertilizer production (%). | FAO |
| RP | Rural Population | Share of people living in rural areas relative to total population (%). | World Bank (WDI) |

Source: Compiled by authors.

## 3.2. Model Specification and Variables Justification

Building on the works of Khan and Kim[24] and Haryanto[21], this study extends the literature by examining how financial development—proxied by domestic credit to the private sector—affects agricultural productivity under two distinct regimes: crop-loss and prosperity. To capture this relationship, the following econometric specification is employed:

$$AGP_{i,t} = \beta_o + \beta_1 DR_{i,t} + \ \beta_x X_{i,t} + \ \varepsilon_{i,t} \qquad (1)$$

The dependent variable, Agricultural Gross Production Value Growth (AGP), is employed as a comprehensive indicator of agricultural performance. In contrast to partial measures such as crop yield or farm household income, AGP reflects the overall value of agricultural output in real terms, providing a consistent basis for assessing sectoral dynamics across time. As noted by Mamba

and Ali [32], this indicator has been widely applied to capture the link between agricultural exports and sectoral performance. Following this established approach, the present study adopts AGP as the key outcome variable in order to evaluate how financial development—proxied by domestic credit to the private sector—shapes agricultural growth in Bangladesh.

The key independent variable, Domestic Credit to the Private Sector (DR), is employed as the proxy for financial development. This measure captures the extent to which the financial system mobilizes savings and channels them into productive private-sector activities, including agriculture. A higher share of private credit relative to GDP indicates deeper financial intermediation and greater access to financial resources, which in turn relax liquidity constraints, facilitate investment in modern inputs, and enable farmers to adopt new technologies [24]. Thus, DR reflects not only the volume of credit available but also the overall capacity of the financial sector to support economic activity. Consistent with this interpretation, Ngong et al. [20] adopted domestic credit to the private sector as a central explanatory variable and confirmed its positive influence on agricultural productivity, reinforcing its suitability as a standard proxy for financial development in the context of agricultural growth analysis.

To better isolate the effect of financial development on agricultural growth, the analysis incorporates several control variables. Trade openness (TO) is included to account for market access and international price transmission. Greater openness is expected to stimulate agricultural performance by expanding export opportunities and facilitating the diffusion of modern technologies, thus exerting a positive effect on AGP. Gross fixed capital formation (GFCF) captures economy-wide investment in infrastructure, machinery, and equipment, which can reduce transaction and logistics costs while promoting mechanization in agriculture; therefore, its effect is also expected to be positive. Fertilizer consumption (FC) serves as an indicator of input intensity, directly linked to improvements in soil fertility and higher yields, and is likewise anticipated to positively influence agricultural output. Rural population share (RP) reflects the available agricultural labor force but also signals the degree of structural transformation. While a larger rural population may supply abundant labor, it can also be associated with underemployment and lower productivity, making its impact on AGP potentially ambiguous. Finally, economic growth (GDP) is considered a key determinant of agricultural performance. A growing economy increases demand for food, raw materials, and agricultural inputs used in agro-processing industries. As highlighted by Johnston and Mellor [33], agriculture not only contributes to economic development through food supply and labor provision but also benefits from macroeconomic expansion via improved infrastructure, higher public investment, and greater access to technology.

## 3.3. Research Methodology

This study applies a regime-switching framework to explore how financial development, proxied by domestic credit to the private sector (DR), shapes agricultural performance in Bangladesh over the period 1980–2023. The MRS model is employed to distinguish between two unobserved states of the agricultural cycle—prosperity (crop boom) and distress (crop loss).

Unlike traditional linear approaches that assume stable effects across time—such as the Generalized Method of Moments (GMM) [34] and Bayesian estimation techniques [35–38]—the Markov Regime Switching (MRS) model endogenously identifies regime shifts, thereby capturing the evolving and asymmetric dynamics of agricultural production. For instance, Rahman et al. [25] demonstrated that financial development exerts varying effects on economic growth across high- and low-growth regimes in Pakistan, confirming that macroeconomic responses to finance differ across phases. Similarly, Wen et al. [26] applied a regime-switching model in the agricultural context to evaluate how risk mitigation practices influence vulnerability to climatic shocks in China, revealing that the magnitude and direction of impacts depend on regime-specific thresholds. These applications provide robust methodological support for employing the MRS framework in the present study.

This framework is particularly well-suited to agriculture in Bangladesh, where production is highly exposed to floods, cyclones, pest outbreaks, and global price volatility. By modeling hidden regimes of boom

and loss, the MRS approach captures the non-linear and state-dependent influence of financial development. In crop-loss phases, access to credit may operate as a stabilizing buffer by providing liquidity for essential inputs, preventing severe yield declines, and supporting recovery. Conversely, in crop-boom phases, financial resources may act as a growth catalyst through investment in modern technologies, mechanization, and farm expansion.

A key strength of the model is its ability to let transition probabilities evolve based on past conditions, captured through a first-order Markov process:

$$P(s_t = j, |s_{t-1} = i\ ), \text{j,i} \in \{\text{ Crop Failure, Crop Boom}\}$$

**H1.** *In crop-loss regimes, financial development (DR) has a positive effect on agricultural gross production growth.*

**H2.** *In crop-boom regimes, financial development (DR) has a positive effect on agricultural gross production growth.*

These regime-contingent channels are consistent with the Credit Constraint framework, which emphasizes limited collateral, high risk, and asymmetric information, as well as with the macro-finance perspective, which posits that deeper financial intermediation mobilizes savings and allocates them toward higher-return investments. The inclusion of control variables—inflation, GDP growth, trade openness, gross fixed capital formation, fertilizer use, and rural population—further helps isolate the specific impact of financial development on agricultural performance by accounting for key macroeconomic and structural factors.

# 4. Research Findings

## 4.1. Overview of Descriptive Statistics

The descriptive statistics provide an initial overview of the agricultural and financial conditions in Bangladesh over the study period (1980–2023) (**Table 3**). The mean growth rate of AGP is 3.46%, with a relatively high standard deviation of 3.73. This suggests that while Bangladesh has achieved a moderate average pace of agricultural expansion, the sector has been marked by strong volatility. The minimum value of −2.29% reflects periods of contraction, which can be linked to adverse shocks such as floods, cyclones, and pest outbreaks—events that frequently disrupt agricultural output. Conversely, the maximum growth rate of 13.49% demonstrates the sector's capacity for rapid recovery and productivity gains in favorable years, often associated with good harvests, supportive policies, and technology adoption. This wide range highlights the cyclical and shock-prone nature of Bangladeshi agriculture, underscoring the need for financial mechanisms that can stabilize production.

**Table 3.** Overview of descriptive statistics for Bangladesh over the period 1996–2023.

| Variable | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|
| AGP | 3.4590 | 3.7297 | 13.4896 | −2.2921 |
| DR | 29.1997 | 10.6002 | 44.4070 | 13.2145 |
| GDP | 3.9862 | 1.7099 | 6.9726 | 0.2606 |
| TO | 30.9144 | 8.7311 | 48.1109 | 16.6878 |
| GFCF | 24.6415 | 5.2891 | 32.2137 | 15.4734 |
| FC | 271.8632 | 194.8888 | 673.5129 | 90.4899 |
| RP | 72.0658 | 6.7899 | 81.6050 | 59.5270 |

Source: Calculations by the authors.

Turning to financial development, the ratio of DR averages 29.2% of GDP, with a standard deviation of 10.6. This indicates a gradual deepening of the financial system over time but also reveals substantial fluctuations. The minimum level of 13.21% points to early years when financial markets were underdeveloped and access to credit was severely limited, particularly for rural households. In contrast, the maximum of 44.41% reflects periods of significant financial expansion, consistent with banking reforms and policy-driven credit growth in the 2000s and 2010s. Nevertheless, the relatively modest average compared to emerging economies suggests that Bangladesh still faces challenges in channeling adequate financial resources to the private sector,

especially agriculture.

## 4.2. Markov Switching Regression

The estimation results from the Markov Switching model reveal significant asymmetries in how financial development influences agricultural growth under different regimes (**Table 4**). Constant term (C): In the crop-loss regime (MS(1)), the constant is negative (−3.1644, $p < 0.01$), suggesting that, even without considering credit effects, agricultural growth is expected to be negative in adverse conditions. This reflects the inherent vulnerability of Bangladesh's agriculture to shocks such as floods, cyclones, and pest outbreaks. Conversely, in the prosperity regime (MS(2)), the constant turns strongly positive (6.4666, $p < 0.01$), consistent with the sector's capacity to generate robust output when conditions are favorable.

**Table 4.** Markov-Switching Estimates.

| Variables | MS(1) | Std. Error | *p*-Value | MS(2) | Std. Error | *p*-Value |
|---|---|---|---|---|---|---|
| C | −3.1644 | 0.7364 | 0.0000*** | 6.4666 | 1.6571 | 0.0001*** |
| GDP | 0.6470 | 0.1063 | 0.0000*** | 0.8644 | 0.1150 | 0.0000*** |
| TO | 0.0011 | 0.0265 | 0.9669 | −0.1819 | 0.0354 | 0.0000*** |
| GFCF | −0.6160 | 0.0879 | 0.0000*** | −1.8793 | 0.1208 | 0.0000*** |
| FC | 0.0150 | 0.0023 | 0.0000*** | −0.0084 | 0.0022 | 0.0001*** |
| RP | 0.8638 | 0.1382 | 0.0000*** | 0.2034 | 0.2106 | 0.3341 |
| DR | 0.0317 | 0.0035 | 0.0000*** | −0.3884 | 0.0730 | 0.0000*** |
| Probabilities Matrix | | | $\begin{pmatrix} 0.5258 & 0.3385 \\ 0.4742 & 0.6615 \end{pmatrix}$ | | | |

Note: ***, **, and * indicate 1%, 5% and 10% level of significance respectively.
Source: Calculations by the authors.

The results clearly demonstrate that the effect of domestic credit to the private sector is highly regime-dependent. In the crop-loss regime (MS(1)), the coefficient is positive and statistically significant (0.0317, $p < 0.01$). This implies that financial development plays a stabilizing role under adverse conditions, helping farmers secure liquidity, maintain essential inputs, and prevent deeper output contractions. In such circumstances, access to credit acts as a safety net, cushioning rural households against shocks. However, in the prosperity regime (MS(2)), the coefficient of DR becomes negative (−0.3884, $p < 0.01$). This finding suggests that during boom phases, rapid credit expansion may not translate into higher productivity; instead, it can fuel inefficiencies, overinvestment, or even unsustainable debt accumulation. This duality highlights that the benefits of financial development are not uniform: while it mitigates losses in downturns, it may introduce vulnerabilities when conditions are already favorable.

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When compared to prior studies, these results offer a nuanced departure. For example, Khan and Kim [24] and Haryanto [21] reported a uniformly positive impact of credit on farm productivity, consistent with the Credit Constraint theory, which emphasizes that easing liquidity restrictions should always stimulate output. Similarly, Ngong et al. [20] found that bank credit contributed positively to agricultural productivity in the CEMAC region, regardless of broader conditions. By contrast, the

current findings reveal that in Bangladesh, the effect of financial development is conditional on agricultural regimes: positive in downturns but potentially negative in booms.

Relative to the hypotheses of this study, the evidence partially confirms expectations. Hypothesis 1 (H1), which posited that financial development positively affects agricultural performance in crop-loss regimes, is supported by the results. Hypothesis 2 (H2), however, anticipated a positive effect in crop-boom regimes as well, but the negative and significant coefficient contradicts this expectation. This divergence underscores the value of adopting a regime-switching framework: linear models and earlier studies may overlook the asymmetric effects of credit expansion, while the MRS model reveals the state-contingent risks of financial development in Bangladesh's volatile agricultural environment.

The regime-switching probabilities provide additional insights into the persistence of agricultural states. The probability of remaining in the crop-loss regime is 0.5258, while the probability of staying in prosperity is higher at 0.6615. This indicates that once Bangladesh's agriculture enters a favorable phase, it is relatively more stable than during downturns. At the same time, the probability of recovery from crop loss to prosperity is 0.4742, showing that the sector often rebounds after adverse shocks. In contrast, the probability of moving from prosperity to crop loss is 0.3385, underscoring that while shocks are frequent, favorable conditions are somewhat more resilient.

The upper panel (Regime 1) illustrates the smoothed probabilities of Bangladesh's agriculture being in a crop-loss regime. Periods where the probability approaches one correspond to episodes of adverse shocks such as floods, cyclones, pest outbreaks, or sudden price declines. By contrast, the lower panel (Regime 2) captures the prosperity or crop-boom regime. High probabilities here indicate years when favorable weather, stable markets, and supportive policies allowed agriculture to perform strongly. Together, the two panels demonstrate how agricultural performance alternates between downturns and expansions.

**Figure 2** reveals frequent shifts between Regime 1 and Regime 2, reflecting the volatile nature of Bangladesh's agricultural sector. Neither regime dominates for extended periods; instead, the system oscillates, underscoring the cyclical character of agricultural growth. This switching behavior reinforces the appropriateness of the Markov Regime Switching model, since conventional linear approaches would fail to capture such transitions. Crop-loss phases (Regime 1) are often short-lived, implying that while shocks can depress output, recovery usually follows. Prosperity phases (Regime 2) appear slightly more persistent, consistent with the estimated transition probabilities: the probability of remaining in a boom (0.6615) is higher than staying in a downturn (0.5258). This suggests that once agriculture enters a favorable state, it tends to sustain momentum, although vulnerability to shocks remains.

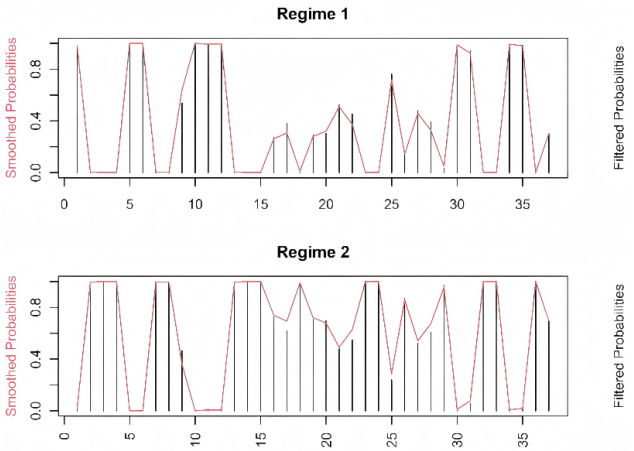


**Figure 2.** Smoothed and Filtered Probabilities of Two Regimes in the Markov Switching Model.
Note: Regime 1: Crop-loss; Regime 2: Prosperity/Crop-boom.
Source: Calculations by the authors.

The residual diagnostics for both regimes confirm that the Markov Switching model is well-specified (**Figure 3**). In Regime 1 (crop-loss) and Regime 2 (prosperity), the autocorrelation (ACF) and partial autocorrelation (PACF) plots of residuals show that nearly all spikes lie within the 95% confidence bands. This indicates the absence of serial correlation, suggesting that the model adequately captures the time-series dynamics of agricultural performance across regimes.

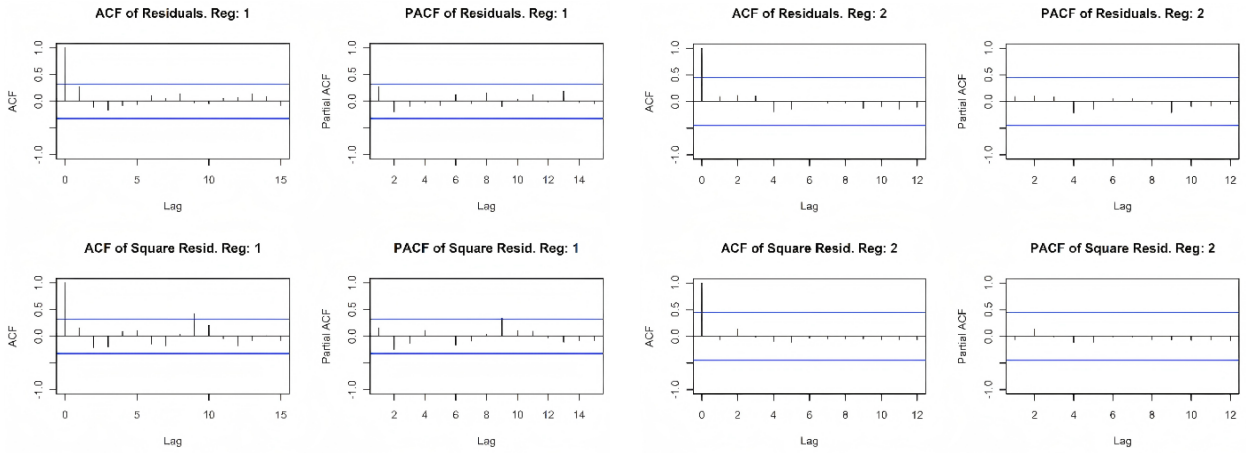


**Figure 3.** Autocorrelation and Partial Autocorrelation of Residuals and Squared Residuals for Regime 1 and Regime 2.
Source: Calculations by the authors.

Likewise, the ACF and PACF of squared residuals in both regimes remain within the confidence bounds, providing no evidence of conditional heteroskedasticity or volatility clustering. The stability of the residual variance implies that the model does not suffer from omitted volatility effects, and the estimated coefficients are therefore statistically reliable.

# 5. Conclusions and Policy Implications

Agriculture remains a cornerstone of Bangladesh's economy, not only as a source of food security but also as a foundation for rural livelihoods. However, the sector is characterized by high volatility due to climate shocks, market fluctuations, and structural constraints. At the same time, financial development has expanded, yet its role in sustaining agricultural growth under varying conditions has not been well understood.

The main research gap addressed in this study is that most prior works either examined the finance-agriculture nexus in a regional or cross-country setting, or relied on linear models that assume stable effects across time. Such approaches fail to capture the asymmetric and regime-dependent impacts of financial development on agricultural performance in Bangladesh.

To fill this gap, the study employed annual data for Bangladesh covering 1980–2023, sourced from the World Bank and FAO. Agricultural gross production value growth (AGP) was used as the dependent variable, while domestic credit to the private sector (DR) served as the proxy for financial development. Control variables included macroeconomic, trade, and input-related factors. Methodologically, a Markov Regime Switching (MRS) model was applied to distinguish between two latent agricultural states: crop-loss and prosperity regimes.

The findings highlight significant asymmetries. In crop-loss regimes, financial development exerts a positive effect, acting as a stabilizer by easing liquidity constraints and enabling farmers to maintain production capacity. In prosperity regimes, however, financial development shows a negative impact, suggesting that excessive credit expansion may generate inefficiencies, overinvestment, and debt risks. These results answer the central research question by demonstrating that the effect of financial development on agricultural growth is not uniform but highly regime-dependent.

The study contributes to the literature by providing new empirical evidence from Bangladesh that challenges the assumption of uniformly positive credit effects. By incorporating regime dynamics, it advances understanding of how financial development can alternately stabilize or destabilize agricultural performance, depending on underlying conditions.

Policy implications are clear and specific. First, credit programs should adopt a counter-cyclical approach: in downturns, expand concessional loans, refinancing schemes, and crop insurance to mitigate losses; in booms, focus on credit quality, efficient al-

location, and links to technology adoption rather than volume expansion. Second, strengthening rural financial intermediation—through reduced transaction costs, simplified procedures, and wider outreach—remains critical to ensure inclusive access. Third, integrating financial policies with broader structural measures such as rural infrastructure, trade facilitation, and climate resilience can maximize the productivity benefits of financial development while reducing risks of instability.

In addition to the general policy recommendations, several international and regional best practices can further illustrate the implementation of counter-cyclical and efficiency-oriented credit policies in agriculture.

For instance, India's Kisan Credit Card (KCC) scheme has successfully provided short-term, low-interest revolving credit to farmers, which automatically expands during adverse agricultural cycles and contracts when conditions improve. This model exemplifies a counter-cyclical approach that could be adapted to Bangladesh's rural credit programs. Similarly, the Agricultural Insurance Program in the Philippines, integrated with the credit system, demonstrates how linking financial access with risk mitigation instruments can reduce farmers' exposure to crop losses and improve loan repayment capacity. On the efficiency side, Vietnam's preferential credit program for high-tech agriculture offers another valuable lesson: by targeting loans toward technology adoption and sustainable practices, financial institutions can enhance productivity while minimizing the risk of over-indebtedness during boom periods.

Drawing from these examples, Bangladesh could strengthen its rural finance system by (1) coupling credit expansion with insurance and technology incentives, (2) introducing adaptive repayment schedules responsive to climatic and market conditions, and (3) enhancing the coordination between banks and agricultural cooperatives to ensure efficient credit utilization.

This study has two main limitations. First, it relies on aggregate annual data, which may mask micro-level heterogeneity across regions, farm types, or household characteristics. Second, financial development is proxied solely by domestic credit to the private sector, which, while widely accepted, does not fully capture other dimensions such as financial inclusion or digital finance. Future research could address these gaps by using micro-level survey data to explore household-level dynamics, and by incorporating broader measures of financial development, including digital financial services and institutional quality, to provide a more comprehensive understanding of the finance-agriculture nexus.

## Author Contributions

Conceptualization, D.L.Q.; Methodology, D.L.Q. and H.N.Q.; Data curation and Formal analysis, D.L.Q.; Validation and Visualization, H.N.Q.; Writing—original draft preparation, D.L.Q.; Writing—review and editing, H.N.V. and H.N.Q.; Supervision, D.L.Q. All authors have read and agreed to the published version of the manuscript.

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Not applicable.

## Informed Consent Statement

Not applicable.

## Data Availability Statement

The data used in this study are publicly available from the World Development Indicators (WDI) of the World Bank and the Food and Agriculture Organization (FAO) databases.

## Conflicts of Interest

The authors declare no conflict of interest.

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