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ARTICLE

# Agricultural Value Addition and Structural Transformation in a Developing Agrarian Economy: Evidence from Bihar, India

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**Abstract**

Agricultural value addition and structural transformation are central to sustainable rural development in developing agrarian economies. Although Bihar remains predominantly dependent on agriculture, existing studies have focused mainly on production growth, technological change, or public investment, with limited attention to the interrelationships among Agricultural Gross Value Added (AGVA), structural transformation, and the production-side sources of agricultural growth. This study addresses this gap by examining the evolution of agricultural value addition and structural transformation in Bihar during 2000–2024. The analysis integrates structural composition analysis, production-decomposition techniques, and Ordinary Least Squares (OLS) regression using time-series data obtained from the Ministry of Statistics and Programme Implementation (MoSPI), Government of India, and the Directorate of Economics and Statistics, Government of Bihar. The findings reveal that agriculture's share in Gross State Value Added declined substantially during the study period, while a large proportion of the workforce continued to depend on agriculture, indicating persistent structural imbalance. Crop production remained the principal contributor to AGVA, although the contributions of livestock, fisheries, and horticulture increased gradually, reflecting emerging diversification. Production-decomposition analysis shows that yield improvement consistently replaced cultivated area expansion as the principal driver of agricultural growth, while econometric results confirm that crop production remains the strongest determinant of AGVA, with fruit production making a significant positive contribution to agricultural value creation. The findings suggest that Bihar's future agricultural transformation will depend on productivity enhancement, diversification towards higher-value enterprises, stronger value-chain integration, and climate-resilient production systems, supported by expanded rural non-farm employment and agro-processing. By integrating structural analysis, production-decomposition, and econometric modelling within a unified analytical framework, the study provides a practical approach for evaluating value-led agricultural development and structural transformation in developing agrarian economies.

**Keywords:** Agricultural Value Added; Gross Value Added (GVA); Structural Transformation; Agricultural Diversification; Growth Decomposition; Econometric Analysis; Agricultural Productivity; Value Chain; Bihar; India.

## 1. INTRODUCTION

### 1.1. Agricultural Value Addition and Economic Development

Agriculture remains a cornerstone of economic development, particularly in low- and middle-income countries where it supports food security, employment, poverty reduction, and industrialization. Beyond its traditional role in food production, agriculture increasingly contributes to economic growth through value addition, technological upgrading, diversification, and stronger linkages with manufacturing and service sectors. As economies develop, the transformation of agriculture from a subsistence-oriented activity into a productive, market-integrated, and value-generating sector becomes a fundamental component of structural change. Consequently, enhancing agricultural value addition has emerged as a central objective of sustainable development strategies worldwide [1-3].

Agricultural value addition refers to the increase in the economic value of agricultural products through improvements in productivity, processing, quality enhancement, storage, transportation, branding, and market integration. Unlike conventional production-based measures, value addition reflects the net contribution of agriculture to the economy after deducting intermediate consumption, thereby providing a more comprehensive indicator of sectoral productivity and economic performance. Higher agricultural value addition not only raises farm incomes but also stimulates agro-industrial development, creates rural employment, strengthens value chains, and enhances export competitiveness [4-6].

Gross Value Added (GVA) has become the internationally accepted indicator for measuring agriculture's contribution to national and regional economies. Consistent with the System of National Accounts (SNA 2008), GVA measures the additional economic value generated by production activities and serves as the principal indicator for evaluating sectoral productivity, efficiency, and structural transformation. Because GVA excludes intermediate inputs, it more accurately reflects the real economic contribution of agriculture than gross output measures alone. Consequently, agricultural GVA has been widely employed to compare sectoral performance across countries and to assess long-term structural change [7-9].

Recent empirical evidence demonstrates that agricultural value addition plays a critical role in achieving multiple Sustainable Development Goals (SDGs), particularly those related to poverty reduction (SDG 1), food security (SDG 2), decent work (SDG 8), responsible production (SDG 12), and climate action (SDG 13). Improvements in agricultural productivity and value addition generate multiplier effects throughout the rural economy by stimulating demand for modern inputs, logistics, processing industries, financial services, and digital technologies. Moreover, investments in climate-smart agriculture, precision farming, biotechnology, and digital extension services increasingly enable agricultural systems to improve productivity while reducing environmental pressures [2, 10-12].

However, the contribution of agriculture to economic growth depends not merely on expanding production but on improving the efficiency with which agricultural resources are transformed into higher-value outputs. Countries that have successfully modernized their agricultural sectors have generally experienced sustained increases in agricultural GVA through technological innovation, commercialization, diversification toward high-value commodities, and stronger integration between primary production and downstream value chains. Understanding the drivers of agricultural value addition has therefore become essential for designing evidence-based policies that promote inclusive rural development and sustainable structural transformation.

### 1.2. Agricultural Transformation in Developing Economies

Agricultural transformation constitutes one of the defining features of economic development. It involves a gradual transition from low-productivity, subsistence-oriented agriculture toward diversified, market-oriented, technology-intensive production systems characterized by higher productivity, increased value addition, and stronger linkages with industry and services. This process is accompanied by structural changes in production patterns, labour allocation, resource utilization, and institutional arrangements, ultimately contributing to sustained economic growth and rising rural incomes [13].

International experience demonstrates that successful agricultural transformation is driven by sustained investments in agricultural research, irrigation, mechanization, rural infrastructure, human capital, and market institutions. China's agricultural modernization illustrates how technological innovation, institutional reforms, and rapid commercialization substantially increased agricultural productivity while facilitating structural shifts toward high-value horticulture, livestock, and agro-processing industries. Similarly, Vietnam's agricultural reforms transformed the country from a food-deficit economy into one of the world's leading exporters of rice, coffee, seafood, and horticultural products through market liberalization, export orientation, and continuous productivity improvements [2,13].

Comparable experiences have been observed elsewhere in Asia and Latin America. Bangladesh has achieved remarkable improvements in agricultural productivity through investments in irrigation, improved seed varieties, mechanization, and expansion of fisheries and livestock production, resulting in significant reductions in rural poverty despite severe resource constraints. Brazil has emerged as a global agricultural powerhouse by combining scientific innovation, tropical agricultural research, commercial farming, and integrated value chains, demonstrating the importance of technological capability and institutional support in raising agricultural value added. Across the European Union, structural transformation has increasingly emphasized productivity growth, environmental sustainability, digital agriculture, and value-chain integration, enabling agriculture to remain competitive despite declining employment shares [4,9,14].

Although the pathways of transformation differ across countries, comparative evidence reveals several common characteristics. Successful agricultural transformation is typically associated with diversification toward high-value crops and allied activities, adoption of modern technologies, strengthening of producer organizations, expansion of agro-processing industries, and improved market connectivity. Conversely, regions characterized by fragmented landholdings, inadequate infrastructure, weak institutional support, and limited value-chain integration often experience slower growth in agricultural value addition despite maintaining relatively high production levels [11,14].

These international experiences suggest that agricultural development should be evaluated not only in terms of output growth but also through changes in value creation, productivity, and structural composition. Consequently, analysing agricultural Gross Value Added alongside sectoral diversification and growth decomposition provides a more comprehensive understanding of agricultural transformation than conventional production indicators alone. Such an analytical perspective is particularly relevant for agrarian regions where agriculture continues to support a large proportion of the labour force while simultaneously undergoing structural adjustments in response to technological progress, changing market conditions, and evolving patterns of rural development.

### 1.3. Bihar's Agricultural Economy

Bihar is one of India's most agriculture-dependent states, where the sector remains the principal source of livelihood, employment, and food security. Although rapid economic growth has diversified the state's economy over the past two decades, agriculture continues to play a pivotal role in sustaining rural livelihoods and supporting overall economic development. More than two-thirds of Bihar's workforce remains engaged in agriculture and allied activities, substantially exceeding the national average. The predominance of small and marginal holdings, which constitute nearly 96% of operational farms, makes agricultural development central to inclusive growth and poverty reduction [15].

Following the bifurcation of Bihar in 2000, agriculture assumed even greater strategic importance in the state's economic recovery. Between 2000 and 2023, Bihar recorded one of the fastest rates of economic growth among Indian states, supported primarily by expansion in manufacturing and services. Nevertheless, agriculture remained the foundation of rural livelihoods and continued to provide employment despite its declining share in Gross State Value Added (GSVA). This divergence between employment dependence and economic contribution reflects the persistence of low labour productivity within the agricultural sector and highlights the need to enhance agricultural value addition rather than merely increasing production [15,16].

Structural changes within Bihar's agriculture reveal a gradual transition from traditional crop-dominated production toward a more diversified agricultural economy. Although crop production continues to account for the largest share of agricultural output, allied activities—including livestock, fisheries, and horticulture—have expanded at considerably faster rates over the past two decades. Livestock production has benefited from rising demand for milk, meat, and poultry products, while fisheries have emerged as one of the fastest-growing agricultural subsectors due to increasing aquaculture development. Similarly, horticultural production has expanded in response to changing consumer preferences, urbanization, and improvements in market connectivity. These developments indicate an ongoing process of agricultural diversification that offers significant opportunities for increasing rural incomes and value addition [15,17].

Despite these positive developments, Bihar's agricultural sector continues to face substantial structural constraints. Average farm size remains among the smallest in India, limiting economies of scale and mechanization. Agricultural production is highly vulnerable to recurrent floods in northern districts and periodic droughts in southern regions, contributing to considerable year-to-year variability in output. Inadequate irrigation coverage, fragmented marketing systems, insufficient storage infrastructure, and limited agro-processing capacity further constrain productivity and reduce farmers' ability to capture greater value from agricultural production. Consequently, much of the state's agricultural output continues to be marketed as primary commodities with relatively limited value addition [15,18].

Recent public investments in rural roads, irrigation, electrification, digital services, and agricultural extension have contributed to measurable improvements in productivity and market access. Nevertheless, the transformation of Bihar's agriculture remains incomplete. Future growth will increasingly depend on improving productivity, strengthening value chains, expanding agro-processing industries, promoting climate-resilient technologies, and integrating crop production with livestock, fisheries, and horticultural enterprises. Understanding the changing composition of agricultural value addition is therefore essential for identifying the principal drivers of agricultural growth and designing policies capable of accelerating structural transformation.

### 1.4. Literature Review

#### 1.4.1. Agricultural Value Addition

Agricultural value addition has increasingly become a central concept in development economics because it captures the net economic contribution of agriculture beyond gross production. Unlike output-based indicators, value-added measures reflect improvements in productivity, processing, marketing, and supply-chain efficiency. Recent studies demonstrate that higher agricultural value addition is closely associated with technological innovation, institutional quality, infrastructure development, and stronger market integration. Gelgo et al. showed that improvements in institutional quality significantly enhance agricultural value added in East African countries by strengthening investment incentives and production efficiency [5]. Similarly, Mergoni et al. identified productivity growth, environmental sustainability, and technological modernization as complementary determinants of agricultural value creation within European agriculture [6].

#### 1.4.2. Agricultural Structural Change

Structural transformation theory suggests that economic development is accompanied by a gradual decline in agriculture's share of output and employment, together with increasing productivity and stronger intersectoral linkages. However, successful transformation does not imply agricultural decline; rather, it reflects the modernization and commercialization of agriculture through technological progress, diversification, and value-chain development. Sen emphasized that structural transformation in Asia has depended largely on improvements in agricultural productivity and rural industrialization [13]. Comparative evidence from China, Vietnam, and other rapidly growing Asian economies demonstrates that agricultural modernization has been achieved through investments in irrigation, research, rural infrastructure, mechanization, and institutional reforms that facilitate commercialization and integration with domestic and global markets [2,3].

#### 1.4.3. Agricultural Diversification

Agricultural diversification has emerged as an important strategy for increasing farm income, reducing production risks, and improving resilience against climatic and market uncertainties. Numerous empirical studies indicate that diversification toward livestock, fisheries, horticulture, and other high-value commodities generates substantially greater returns than dependence on cereal production alone. Feher et al. demonstrated that diversification and technological upgrading significantly enhance long-term agricultural productivity and value addition in Romania [9]. Likewise, Grujić Vučkovski et al. reported that although crop production remains the principal contributor to agricultural Gross Value Added in Serbia, diversification into higher-value agricultural activities offers considerable opportunities for improving sectoral performance [14].

#### 1.4.4. Agricultural Gross Value Added

Gross Value Added has become the internationally recognized indicator for assessing agricultural performance because it measures the economic value generated after deducting intermediate consumption. Andreescu demonstrated that GVA provides a more meaningful indicator of sectoral performance than gross output by capturing productivity improvements and structural changes within the economy [8]. Studies across Europe and Asia similarly conclude that agricultural GVA effectively reflects technological progress, efficiency gains, and changing production structures, making it particularly suitable for evaluating long-term agricultural transformation [9].

### 1.4.5. Empirical Evidence from Bihar

Research on Bihar's agriculture has primarily focused on agricultural investment, technological change, productivity growth, irrigation, and sectoral performance. Earlier studies have demonstrated the importance of public investment in promoting agricultural growth and improving rural incomes [19-24]. Other studies have examined the role of technology adoption, mechanization, capital formation, and institutional support in enhancing agricultural productivity and sustaining long-term growth [20-24]. More recent research has highlighted the importance of climate resilience, technological innovation, and agricultural diversification in improving agricultural sustainability [23,24].

Although these studies have significantly advanced understanding of Bihar's agricultural development, most have evaluated agricultural performance through aggregate production, investment, or productivity indicators. Comparatively little attention has been devoted to analysing the changing composition of agricultural Gross Value Added or to quantifying the relative contributions of crop production, livestock, fisheries, and horticulture to agricultural value creation. Furthermore, existing studies rarely integrate growth decomposition with econometric analysis to examine the underlying drivers of structural transformation. Addressing these gaps is essential for understanding how Bihar's agricultural economy is evolving and for identifying policy interventions capable of promoting higher agricultural value addition and sustainable rural development.

## 1.5. Research Gap

Although a substantial body of literature has examined agricultural growth, productivity, investment, technological change, diversification, and rural development, several important knowledge gaps remain. International studies have primarily focused on the determinants of agricultural Gross Value Added (GVA), structural transformation, institutional quality, and production efficiency across countries [5,6,8,9,14]. At the regional level, existing studies on Bihar have largely concentrated on public investment, technological progress, irrigation development, agricultural productivity, and sectoral growth [19-24]. While these studies have generated valuable insights into the state's agricultural development, they have generally evaluated performance using aggregate production or investment indicators rather than agricultural value creation.

More importantly, little empirical evidence exists on how the composition of agricultural value addition has evolved during Bihar's recent phase of economic transformation. The relative contributions of crop production, livestock, fisheries, horticulture, and other allied activities to agricultural GVA have not been systematically quantified. Likewise, previous studies have rarely combined structural composition analysis with growth decomposition techniques to identify the principal sources of agricultural growth and changing production patterns over time. Existing analyses also provide limited econometric evidence on the relative contribution of different agricultural subsectors to overall agricultural value added.

Consequently, the dynamic relationship between agricultural diversification, structural transformation, and value creation remains insufficiently understood. This knowledge gap limits the formulation of evidence-based policies aimed at improving agricultural productivity, strengthening value chains, and promoting sustainable rural development. Addressing this gap is particularly important for Bihar, where agriculture continues to employ a large proportion of the workforce despite its declining share in Gross State Value Added (GSVA).

The present study addresses these deficiencies by integrating structural composition analysis, growth decomposition, and econometric modelling within a unified analytical framework. By examining agricultural Gross Value Added alongside changes in sectoral composition during 2000–2024, the study provides new empirical evidence on the evolving drivers of agricultural value addition and structural transformation in Bihar.

Existing studies have largely examined agricultural production, productivity or investment. Few studies jointly analyse Agricultural Gross Value Added, structural transformation, growth decomposition and sub-sectoral determinants within a unified empirical framework.

### 1.6. Objectives

Against this background, the study aims to examine the changing structure of agricultural value addition in Bihar and identify the principal factors influencing agricultural Gross Value Added during the period 2000–2024. Specifically, the objectives are to:

1) examine the changing composition of agricultural value addition across major agricultural subsectors in Bihar;
2) analyse the structural transformation of Bihar's agricultural economy through changes in Gross Value Added and sectoral diversification;
3) evaluate the relative contributions of area expansion, yield improvement, and crop composition to agricultural growth using growth decomposition analysis;
4) estimate the contribution of crop and allied agricultural activities to agricultural Gross Value Added using econometric techniques; and
5) derive policy implications for enhancing agricultural value addition, productivity, and sustainable structural transformation in Bihar.

### 1.7. Contributions of the Study

This study makes several important contributions to the literature on agricultural economics and regional development.

First, it shifts the analytical focus from conventional measures of agricultural output to Gross Value Added (GVA), thereby providing a more comprehensive assessment of agriculture's net contribution to Bihar's economy. Because GVA measures value creation after deducting intermediate consumption, it offers a more meaningful indicator of productivity, efficiency, and structural change than gross production alone [7,8].

Second, the study develops an integrated analytical framework that combines structural composition analysis, growth decomposition, and econometric estimation. Unlike previous studies that examine these dimensions separately, this integrated approach enables a comprehensive evaluation of how changes in agricultural structure influence value creation and economic performance.

Third, the study quantifies the relative contribution of major agricultural subsectors—including crop production, livestock, fisheries, horticulture, and other allied activities—to agricultural Gross Value Added. This provides new empirical evidence on the changing sources of agricultural growth and identifies those subsectors with the greatest potential to enhance value addition.

Fourth, by analysing more than two decades of agricultural transformation (2000–2024), the study offers a long-term perspective on the evolution of Bihar's agricultural economy. The analysis captures important structural shifts in production patterns, diversification, and sectoral contributions that are often overlooked in studies focusing solely on short-term production trends.

Finally, the findings provide evidence-based policy insights for promoting sustainable agricultural transformation through productivity enhancement, diversification toward higher-value agricultural activities, improved value-chain integration, and more efficient resource allocation. The analytical framework developed in this study may also be applied to other agriculturally important regions experiencing similar structural transitions, thereby extending its relevance beyond Bihar.

Collectively, these contributions advance the empirical literature on agricultural value addition and structural transformation while providing a stronger analytical basis for designing policies that improve agricultural competitiveness, rural incomes, and sustainable economic development.

The study is grounded in the structural transformation literature, which predicts that sustainable agricultural development in labour-surplus economies increasingly depends on productivity growth, diversification, and value-chain upgrading rather than expansion of cultivated land.

## 2. CONCEPTUAL FRAMEWORK

This study is founded on the premise that agricultural development is driven not only by increases in production but also by improvements in value creation, productivity, and structural transformation. The conceptual framework integrates agricultural production theory, structural transformation theory, and the Gross Value Added (GVA) approach to explain the sequential pathways through which agricultural resources generate production, create value added, and contribute to sustainable economic development [13,25-27].

Agricultural production begins with the utilization of natural resources, labour, capital, technology, and institutional support to generate outputs from four major subsectors: crop production, livestock, forestry, and fisheries. These subsectors differ considerably in their productivity, value-added potential, employment intensity, and market integration. While crop production remains the dominant component of agricultural output in many developing economies, livestock, fisheries, and horticulture generally generate higher value addition through greater product diversification, processing opportunities, and stronger forward and backward linkages within the agri-food system [5,6,26].

The aggregate output generated by these subsectors forms the production base from which Agricultural Gross Value Added is derived after deducting intermediate consumption. Unlike gross output, GVA measures the net economic value created through production activities and therefore provides a more appropriate indicator of agricultural productivity, efficiency, and economic performance. Although agricultural output and Agricultural GVA are conceptually distinct, they are closely related because changes in production volume, productivity, and sub-sectoral composition influence the level of value created. Consequently, improvements in agricultural production constitute an important production-side pathway through which Agricultural GVA is enhanced, while changes in intermediate consumption determine the difference between gross output and value added [7-9].

Structural transformation within agriculture is expected to occur as sustained improvements in Agricultural GVA stimulate higher labour productivity, technological adoption, resource-use efficiency, and diversification towards higher-value agricultural activities. These changes subsequently generate wider economic benefits by increasing farm incomes, creating productive employment, strengthening agro-industrial linkages, improving resource productivity, and enhancing rural livelihoods. Together, these processes contribute to sustainable economic development through greater agricultural competitiveness, improved food security, poverty reduction, and increased resilience to climatic and market shocks. Agricultural value addition therefore serves as the principal transmission mechanism linking production performance with long-term structural transformation and inclusive economic development [2,10,25].

Guided by this conceptual framework, the present study empirically examines how changes in the composition of agricultural production influence Agricultural Gross Value Added in Bihar. Three complementary analytical approaches are employed. First, structural composition analysis evaluates changes in the relative importance of crop production, livestock, forestry, and fisheries within Bihar's agricultural economy. Second, growth decomposition identifies the principal production-side sources of agricultural growth by examining the contributions of area expansion, productivity improvement, diversification, price effects, and interaction effects. The decomposition analysis is therefore interpreted as explaining the underlying drivers of agricultural production rather than directly decomposing Agricultural GVA. Third, econometric modelling quantifies the contribution of the major agricultural subsectors to Agricultural GVA. The integration of these complementary approaches provides a comprehensive assessment of the production processes, value creation, and structural transformation underpinning Bihar's agricultural development during 2000–2024.

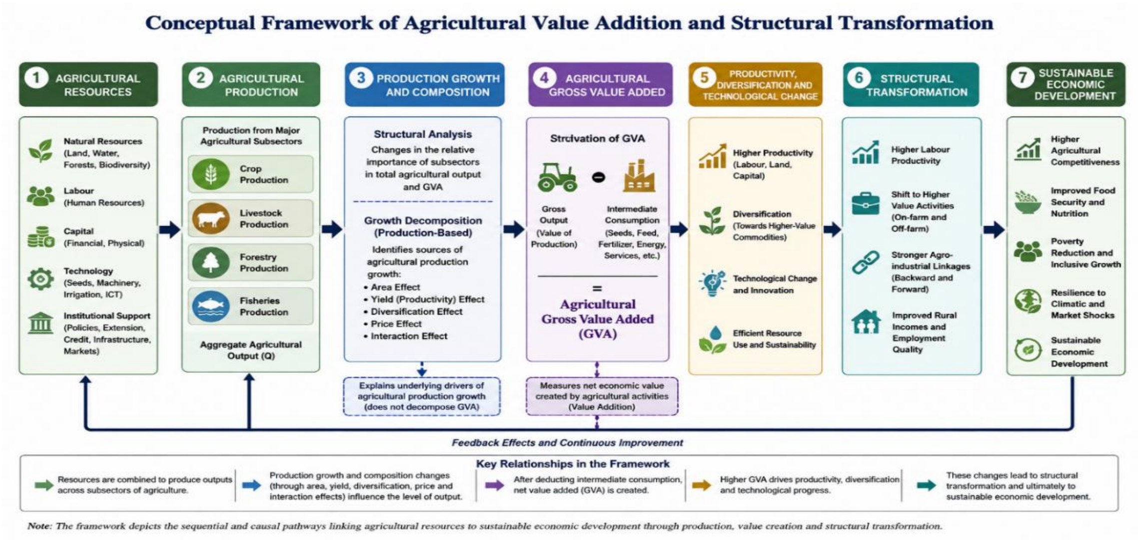


**Figure 1.** Conceptual Framework of Agricultural Value Addition and Structural Transformation

The conceptual framework provides the analytical foundation for the empirical investigation undertaken in this study. It hypothesizes that changes in the composition and productivity of agricultural production influence Agricultural Gross Value Added directly through value creation and indirectly through productivity enhancement and diversification. Growth decomposition is employed to identify the production-side sources of agricultural growth, whereas econometric analysis evaluates how the major agricultural subsectors contribute to Agricultural Gross Value Added. Together, these complementary analytical approaches provide an integrated assessment of agricultural value addition and structural transformation in Bihar.

## 3. MATERIALS AND METHODS

### 3.1. Study Area

The study focuses on the state of Bihar, located in the eastern Indo-Gangetic Plain of India between 24°20′–27°31′ N latitude and 83°19′–88°17′ E longitude. Covering an area of approximately 94,163 km², Bihar is one of India's most densely populated states and possesses fertile alluvial soils, extensive river systems, and favourable agro-climatic conditions for diversified agricultural production. Agriculture continues to constitute the backbone of the state's economy by providing livelihood to more than two-thirds of the working population and supporting food security, rural employment, and agro-based industries [15].

Despite sustained economic growth since the early 2000s, Bihar remains predominantly agrarian, characterized by fragmented landholdings, low mechanization, recurrent flood and drought risks, and limited value addition beyond primary production. Small and marginal farmers account for nearly 96% of operational holdings, making improvements in agricultural productivity and value creation essential for inclusive rural development. At the same time, the agricultural sector has undergone gradual structural transformation through the increasing contribution of livestock, fisheries, horticulture, and other allied activities. These characteristics make Bihar an appropriate case for analysing the evolution of agricultural Gross Value Added (GVA), structural change, and the determinants of agricultural value addition [15,16,24].

### 3.2. Data Sources

The study employs secondary time-series data obtained from authoritative government publications. The principal source is the Ministry of Statistics and Programme Implementation (MoSPI), Government of India, which provides activity-wise Gross Value Added estimates under the National Accounts Statistics (NAS). Additional information on agricultural production, crop statistics, livestock, fisheries, horticulture, land use, and state income has been compiled from the Directorate of

Economics and Statistics, Government of Bihar, the Economic Survey of Bihar, the Department of Agriculture, Government of Bihar, and other official statistical publications [15,16,30].

The analysis primarily covers the period 2000–2024 for examining long-term trends in agricultural value addition and structural transformation. However, econometric estimation is restricted to 2007–2023 because consistent disaggregated Gross Value Added data for the major agricultural subsectors are available only for this period. Restricting the regression analysis to a balanced dataset improves statistical reliability and ensures comparability across variables.

Gross Value Added (GVA) is adopted as the principal indicator because it measures the net value created by production activities after deducting intermediate consumption and therefore provides a more accurate measure of sectoral economic performance than gross output alone. Consistent with the System of National Accounts (SNA 2008), GVA is internationally recognised as the standard indicator for evaluating productivity, structural transformation, and sectoral contribution to economic growth [7,31].

Because the study integrates descriptive, decomposition, and econometric analyses, different data series are used according to their analytical purpose. Agricultural Gross Value Added (AGVA) serves as the principal indicator of economic performance and is employed in the structural composition and econometric analyses. By contrast, the growth decomposition analysis uses agricultural production statistics because decomposition techniques are designed to identify the production-side sources of agricultural growth through changes in cultivated area, productivity, and crop composition. The decomposition results are therefore interpreted as explaining the underlying production processes that contribute to Agricultural Gross Value Added rather than directly decomposing GVA itself.

### 3.3. Variables

Agricultural Gross Value Added (AGVA) is specified as the dependent variable representing the overall economic contribution of agriculture and allied activities. The explanatory variables comprise the major components of agricultural production that collectively determine value creation within the agricultural sector. These include plant production, livestock production, forestry, fisheries, and selected indicators describing structural change and productivity. The variables are defined in accordance with the National Accounts classification adopted by MoSPI.

**Table 1.** Description of variables used in the empirical analysis

| Variable | Definition | Data Source | Expected Sign |
|---|---|---|---|
| Agricultural GVA (AGVA) | Gross Value Added generated by agriculture and allied sectors (Dependent variable) | MoSPI, Government of India | — |
| Plant Production (PP) | Value of cereals, pulses, oilseeds, fruits, vegetables and other crops | MoSPI; Directorate of Economics & Statistics, Bihar | + |
| Livestock Production (LP) | Value of milk, meat, eggs, poultry and other livestock products | MoSPI; Animal Husbandry Directorate | + |
| Forestry (FOR) | Value added generated from forestry and logging activities | MoSPI | + |
| Fisheries (FIS) | Value added from inland fisheries and aquaculture | MoSPI; Department of Fisheries | + |
| Agricultural Output (AO) | Aggregate value of agricultural production | MoSPI | + |
| Crop Yield (YLD) | Average productivity of major crops | Department of Agriculture, Bihar | + |

| | | | |
|---|---|---|---|
| Gross Cropped Area (GCA) | Total cropped area including multiple cropping | Directorate of Economics & Statistics, Bihar | + |

Plant production and livestock production constitute the principal explanatory variables in the econometric model because they account for the overwhelming share of agricultural Gross Value Added during the study period. Forestry and fisheries are analysed primarily to evaluate structural diversification and changing sectoral composition. The remaining variables are incorporated in the descriptive and production-decomposition analyses to explain changes in agricultural productivity, diversification, and long-term growth.

All monetary variables are expressed in current prices as reported in the official National Accounts Statistics. Where appropriate, values are also analysed in constant-price terms to facilitate temporal comparisons and eliminate the influence of inflation. Descriptive statistics are computed to summarise the central tendency and dispersion of each variable before undertaking decomposition and econometric analyses.

### 3.4. Analytical Framework

The analytical framework is based on the premise that agricultural value addition is determined by both the magnitude and composition of agricultural production. Structural transformation within agriculture is reflected by changes in the relative contributions of crop production, livestock, forestry, and fisheries to Agricultural Gross Value Added (AGVA). Accordingly, the analysis integrates three complementary approaches: (i) structural composition analysis, (ii) growth decomposition analysis, and (iii) econometric estimation.

The analysis proceeds in three complementary stages. First, structural composition analysis examines long-term changes in the relative contributions of crop production, livestock, forestry, and fisheries to Agricultural Gross Value Added, thereby identifying the nature and extent of structural transformation within Bihar's agricultural economy during 2000–2024. Second, growth decomposition is applied to agricultural production data to identify the principal production-side sources of agricultural growth through area expansion, yield improvement, crop diversification, price effects, and interaction effects. Although this decomposition does not directly partition Agricultural Gross Value Added, it explains the underlying production dynamics that influence value creation. Third, an econometric model is estimated to quantify the contribution of the principal agricultural subsectors to Agricultural Gross Value Added after accounting for the interrelationships among the explanatory variables. The integration of these complementary approaches provides a comprehensive assessment of agricultural production, value creation, and structural transformation [9,27,29].

### 3.5. Growth Decomposition

Agricultural growth is a multidimensional process arising from expansion of cultivated area, improvements in crop productivity, and structural changes in cropping patterns. Because Gross Value Added is derived from agricultural production after deducting intermediate consumption, the decomposition framework is applied to agricultural output rather than directly to Agricultural Gross Value Added. Consequently, the decomposition analysis is intended to identify the production-side sources of agricultural growth that subsequently influence Agricultural Gross Value Added through changes in productivity, diversification, and production composition. The results should therefore be interpreted as explaining the underlying drivers of agricultural production rather than as a direct decomposition of GVA [33,34].

Agricultural output may be expressed as

$$Q = \sum_{i=1}^{n} A_i Y_i$$

where

- $Q$ denotes total agricultural output;
- $A_i$ represents the cultivated area under the $i$th crop; and
- $Y_i$ denotes the corresponding crop yield.

Following decomposition techniques proposed in the agricultural growth literature, the total change in agricultural output $\Delta Q$ is decomposed into three principal components:

$$\Delta Q = \Delta Q_A + \Delta Q_Y + \Delta Q_I$$

where

- $\Delta Q_A$ = Area effect,
- $\Delta Q_Y$ = Yield (productivity) effect,
- $\Delta Q_I$ = Interaction effect.

The **area effect** measures output growth attributable to changes in cultivated area while holding productivity constant. The **yield effect** captures productivity improvements resulting from technological progress, improved inputs, irrigation, mechanisation, and better management practices. The **interaction effect** reflects the simultaneous influence of changes in both cultivated area and crop productivity. Together, these components provide valuable insights into the underlying sources of agricultural growth and facilitate the interpretation of structural transformation within the sector.

To complement the decomposition analysis, compound annual growth rates (CAGR) are estimated for Agricultural Gross Value Added and its major subsectors. The CAGR is calculated as

$$\text{CAGR} = \left(\frac{Y_t}{Y_0}\right)^{\frac{1}{n}} - 1$$

where $Y_t$ and $Y_0$ denote the final and initial values, respectively, and (n) represents the number of years.

**3.6. Econometric Model**

The determinants of Agricultural Gross Value Added are examined using the Ordinary Least Squares (OLS) regression technique. OLS remains one of the most widely applied estimation methods in empirical agricultural economics because it provides unbiased and efficient parameter estimates when the classical linear regression assumptions are satisfied [36,37]. Given the relatively short annual time series (2007–2023) and the study's objective of estimating contemporaneous relationships between production components and Agricultural Gross Value Added, OLS was considered the most parsimonious and interpretable specification. Prior to estimation, the time-series properties of the variables were examined using the Augmented Dickey–Fuller (ADF) unit root test to minimise the possibility of spurious regression. The ADF results are reported in Section 4.7.1. The estimated model was subsequently evaluated using standard diagnostic tests for multicollinearity, autocorrelation, heteroscedasticity, and residual normality to verify the validity of the OLS assumptions.

The general multiple regression model is specified as

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \varepsilon$$

where

- $Y$ = Agricultural Gross Value Added (AGVA);
- $\alpha$ = intercept;
- $X_i$ = explanatory variables;
- $\beta_i$ = regression coefficients; and
- $\varepsilon$ = stochastic error term.

For the present study, the empirical specification is

$$\text{AGVA} = \alpha + \beta_1 \text{PP} + \beta_2 \text{LP} + \varepsilon$$

where

- **AGVA** = Agricultural Gross Value Added;
- **PP** = Plant Production;
- **LP** = Livestock Production.

Plant production and livestock production are selected because they constitute the dominant components of Bihar's agricultural economy and account for the largest proportion of agricultural value added during the study period. Forestry and fisheries are analysed separately within the structural composition analysis because their relatively smaller shares reduce their explanatory power in the aggregate regression model while remaining important indicators of agricultural diversification.

The estimated regression coefficients ((\beta_i)) measure the marginal contribution of each agricultural subsector to Agricultural Gross Value Added. Positive and statistically significant coefficients indicate that increases in the respective subsector are associated with higher agricultural value creation. Statistical significance is evaluated at the conventional 1%, 5%, and 10% significance levels using two-tailed t-tests.

Model adequacy is assessed using the coefficient of determination ((R^2)) and the adjusted coefficient of determination (Adjusted (R^2)), which measure the proportion of variation in Agricultural Gross Value Added explained by the explanatory variables. The overall significance of the regression equation is evaluated using the F-statistic. Together with the diagnostic tests presented in Section 3.7, these statistics provide evidence regarding the validity, explanatory power, and robustness of the estimated econometric model.

### 3.7. Diagnostic Tests

To ensure the validity and robustness of the estimated regression model, a series of diagnostic tests are performed prior to and following model estimation. These tests examine whether the assumptions underlying the Ordinary Least Squares (OLS) estimator are satisfied and whether the estimated coefficients are reliable for statistical inference [35-37].

Descriptive statistics, including the mean, standard deviation, minimum, maximum, and coefficient of variation, are first computed to summarize the distribution and variability of the study variables. Pearson's correlation coefficients are subsequently estimated to examine the direction and strength of linear relationships among the variables and to provide preliminary evidence regarding potential multicollinearity.

Multicollinearity among the explanatory variables is assessed using the Variance Inflation Factor (VIF) and Tolerance (TOL) statistics. Following conventional practice, VIF values below 10 (preferably below 5) and Tolerance values greater than 0.10 indicate that multicollinearity is not sufficiently severe to bias the regression estimates [37,38].

The presence of autocorrelation in the regression residuals is examined using the Durbin–Watson (DW) statistic. A DW value close to 2 indicates the absence of first-order serial correlation, whereas values substantially below or above 2 suggest positive or negative autocorrelation, respectively [38].

Homoscedasticity of the residuals is evaluated using the Breusch–Pagan test. The null hypothesis assumes constant error variance. Failure to reject the null hypothesis ($p > 0.05$) indicates that heteroscedasticity is not statistically significant and that the OLS estimators remain efficient [39].

Because the study employs annual time-series data, the stationarity properties of the variables are first examined using the Augmented Dickey–Fuller (ADF) unit root test. Variables are initially tested at levels and, where necessary, at first differences to determine their order of integration and reduce the possibility of spurious regression results [40]. The ADF results are presented together with the regression diagnostics in the Results section to justify the appropriateness of the Ordinary Least Squares estimation. The normality of regression residuals is further assessed using the Jarque–Bera test [41], while model specification is verified through graphical examination of residual plots and standard goodness-of-fit measures. Collectively, these diagnostic procedures provide confidence that the estimated relationships are statistically reliable and suitable for empirical interpretation.

### 3.8. Research Hypotheses

The empirical analysis is guided by the conceptual framework presented in Section 2, which postulates that changes in the composition of agricultural production influence Agricultural Gross Value Added through value creation and structural transformation. Based on the theoretical framework and the existing empirical literature, the following hypotheses are formulated:

$H_1$: Plant production has a positive and statistically significant effect on Agricultural Gross Value Added in Bihar.

$H_2$: Livestock production has a positive and statistically significant effect on Agricultural Gross Value Added in Bihar.

In addition to these principal hypotheses, the descriptive and decomposition analyses are undertaken to examine broader structural changes in Bihar's agricultural economy. Accordingly, the study also evaluates the following analytical propositions:

$H_3$ Agricultural production growth in Bihar has increasingly been driven by productivity improvement rather than expansion of cultivated area.
$H_4$: The contribution of allied agricultural activities, particularly livestock and fisheries, to Agricultural Gross Value Added has increased over time, indicating progressive structural diversification.

These hypotheses are evaluated using structural composition analysis, growth decomposition techniques, and Ordinary Least Squares regression. Statistical significance is assessed at the 1%, 5%, and 10% levels. Acceptance or rejection of the hypotheses is based on the estimated regression coefficients, associated t-statistics, p-values, and supporting diagnostic statistics.

The overall methodological framework adopted in this study integrates descriptive analysis, growth decomposition, and econometric modelling to provide a comprehensive assessment of agricultural value addition and structural transformation in Bihar. By combining these complementary analytical approaches, the study identifies both the sources of agricultural growth and the principal determinants of Agricultural Gross Value Added, thereby providing a robust empirical basis for evaluating the changing structure and performance of Bihar's agricultural economy.

## 4. RESULTS

### 4.1. Structural Transformation of Bihar's Economy

Bihar's economy has undergone substantial structural transformation during the past two decades, although the pace of change has remained slower than that observed in many rapidly developing economies [42,43]. As shown in Table 1 and Figure 2, agriculture and allied activities continue to constitute the foundation of the state's economy, but their contribution to Gross State Value Added (GSVA) has steadily declined. Agriculture's share decreased from 36.28% in 2000 to 18.29% in 2024, whereas the shares of industry and services increased from 11.31% to 21.17% and 52.34% to 60.64%, respectively. These trends reflect the gradual diversification of Bihar's production structure towards manufacturing and service activities.

Despite this structural shift in output, the agricultural workforce has remained persistently high, accounting for more than 70% of total employment throughout the study period and increasing marginally to 76.22% in 2024 (Table 2). The coexistence of a declining output share with sustained dependence on agricultural employment indicates a significant structural imbalance and relatively low labour productivity within the sector. This divergence between employment and value added suggests that the transition of labour from agriculture to higher-productivity non-agricultural activities has been considerably slower than the transformation of the state's output structure.

The evidence indicates that Bihar is experiencing an incomplete structural transformation, characterized by a declining contribution of agriculture to Gross State Value Added without a corresponding reduction in the reported agricultural workforce. This divergence suggests that labour productivity in agriculture remains substantially lower than in the industrial and service sectors. However, the agricultural employment share should be interpreted with caution because Bihar is one of India's largest sources of seasonal and long-term inter-state migrant labour. Many rural households continue to report agriculture as their principal occupation while deriving an increasing proportion of household income from non-farm employment outside the state. Consequently, the reported agricultural workforce may overstate the extent to which labour remains economically dependent on local agricultural production.

Accelerating productivity growth within agriculture, expanding rural non-farm employment, strengthening agro-processing and value chains, and improving labour mobility into higher-productivity activities will therefore be essential for narrowing the productivity gap and promoting inclusive structural transformation.

**Table 2.** Share of subsectors in NSDP and workforce (in %).

| Year | Agri. & Allied | Industries | Services | Agricultural workforce |
|---|---|---|---|---|
| 2000 | 36.28 | 11.31 | 52.34 | 71.49 |
| 2010 | 25.93 | 18.40 | 55.66 | 74.14 |
| 2020 | 21.41 | 19.13 | 59.46 | 73.34 |
| 2024 | 18.29 | 21.17 | 60.64 | 76.22 |

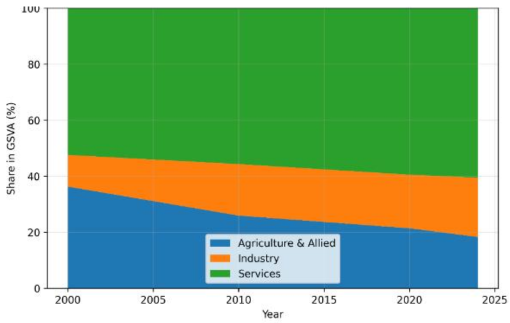


**Figure 2.** Structural Transformation of Bihar's Economy, 2000- 2024

### 4.2. Structural Changes in Agricultural Value Addition

The composition of Agricultural Gross Value Added (AGVA) has also changed considerably during the study period, reflecting gradual diversification within Bihar's agricultural economy. Table 2, together with Figures 3(a) and 3(b), illustrates changes in both the relative contribution and growth performance of the principal agricultural subsectors between the early 2000s and the most recent period.

Crop production continues to dominate agricultural value addition, although its share declined moderately from 60.9% during 2000–2004 to 57.6% during 2020–2024 (Table 3). In contrast, livestock strengthened its contribution from 28.0% to 31.2%, becoming the fastest-growing major subsector after fisheries. Fisheries increased its share from 4.2% to 5.0%, while forestry experienced a slight decline from 6.9% to 6.2%. Collectively, these changes indicate a gradual movement away from exclusive dependence on crop production towards a more diversified agricultural value-creation system.

Growth performance also differed substantially across subsectors. Crop production, which recorded negative growth during the initial period, recovered strongly during the later years. Livestock maintained consistently high growth throughout the study period, while fisheries recorded the highest recent growth rate, indicating increasing commercial importance. Forestry, despite its rapid initial expansion, experienced slower growth in the later period. Overall agricultural growth accelerated from 1.4% during the early years to 6.9% during 2020–2024, demonstrating significant improvement in sectoral performance.

The changing composition of Agricultural GVA suggests that Bihar's agricultural economy is gradually shifting from a predominantly cereal-based production system towards a more diversified structure characterized by increasing contributions from livestock and fisheries [26,51]. This diversification is likely to enhance income stability, generate additional employment opportunities, and strengthen resilience against climatic and market-related risks. Nevertheless, crop production remains the principal source of agricultural value creation, underscoring the continuing importance of improving crop productivity alongside diversification into higher-value agricultural activities.

**Table 3.** Changes in the composition of the value of the agricultural sector (2011–2012 prices).

| Sub-sectors of Agri. & Allied. | % Share | | % Annual Growth | |
|---|---|---|---|---|
| | 2000-01 to | 2020-21 to | 2000-01 to | 2020-21 to |

| | 2003-04 | 2023-24 | 2003-04 | 2023-24 |
|---|---|---|---|---|
| Crops | 60.9 | 57.6 | -1.9 | 6.1 |
| Livestock | 28.0 | 31.2 | 5.4 | 8.6 |
| Forestry | 6.9 | 6.2 | 16.4 | 4.8 |
| Fisheries | 4.2 | 5.0 | 1.2 | 10.3 |
| All | 100.0 | 100.0 | 1.4 | 6.9 |

Source: Authors' calculation

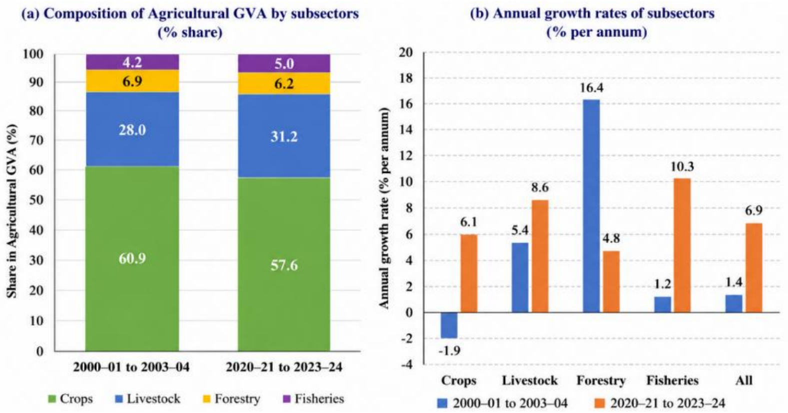


**Figure 3.** Changing composition and growth of Agricultural Gross Value Added in Bihar

**Interpretation:** Figure 3(a) shows that crop production remains the largest contributor to Agricultural GVA in Bihar, though its share declined from 60.9% during 2000-01 to 2003-04 to 57.6% during 2020-21 to 2023-24. Livestock's share increased from 28.0% to 31.2%, indicating its growing importance. Fisheries also registered a modest rise, while forestry's share declined slightly.

Figure 3(b) indicates that the growth of all subsectors accelerated in the recent period. Livestock (8.6% p.a.) and fisheries (10.3% p.a.) recorded the highest growth, followed by crops (6.1% p.a.). Forestry growth slowed to 4.8% p.a. Overall agricultural GVA grew at 6.9% per annum in the recent period, compared with 1.4% per annum in the early 2000s.

**Source**: Computed by the authors from Gross State Value Added estimates of the Ministry of Statistics and Programme Implementation (MoSPI), Government of India, and Directorate of Economics and Statistics, Government of Bihar.

**4.3. Growth Decomposition of Agricultural Production**

To better understand the production-side drivers underlying agricultural value creation, changes in agricultural output were decomposed into the contributions of area expansion, yield improvement, price changes, diversification, and interaction effects. Because the decomposition framework is designed to analyse agricultural production rather than Gross Value Added, the results should be interpreted as explaining the underlying sources of production growth that subsequently influence Agricultural Gross Value Added through productivity improvement and structural change. The results are summarized in **Table 4** and illustrated in **Figure 4**.

The decomposition analysis reveals a clear shift in the sources of agricultural growth over time. Expansion of cultivated area made a negative contribution throughout the study period, declining from **-10.9%** during 2000–2005 to **-1.6%** during 2020–2024. This finding indicates that the scope for increasing agricultural production through horizontal expansion has become increasingly limited because of land scarcity, fragmentation, and competing non-agricultural land uses.

By contrast, yield improvement consistently emerged as the dominant source of agricultural growth. It accounted for **95.2%** of total growth during 2000–2005, **46.8%** during 2012–2017, and **52.8%** during 2020–2024, demonstrating that technological progress, improved crop management, irrigation expansion, and better input utilization have become the principal drivers of agricultural productivity. The sustained importance of yield enhancement suggests that future agricultural growth will depend primarily on increasing productivity rather than expanding cultivated land.

Price effects also became increasingly important during the later periods. While price changes contributed negatively during the early years, their positive contribution subsequently increased, reflecting improved market conditions, stronger demand, and higher producer prices for agricultural commodities. Likewise, diversification remained a significant contributor throughout the study period, although its relative importance declined compared with the early 2000s. Interaction effects were comparatively small, indicating that simultaneous changes in cultivated area and productivity exerted only a limited influence on overall agricultural growth [44-46,17].

Overall, the decomposition analysis demonstrates that Bihar's agricultural production has gradually shifted from an area-based growth pattern towards a productivity-driven and increasingly diversified production system. These production-side changes provide the foundation for subsequent improvements in Agricultural Gross Value Added but should not be interpreted as a direct decomposition of GVA itself.

**Table 4.** Sources of Agricultural Growth in Bihar, 2000–2024 (% Contribution to Total Agricultural Growth)

| Source of Growth | 2000–2005 | 2012–2017 | 2020–2024 |
|---|---|---|---|
| Area expansion | -10.9 | -1.2 | -1.6 |
| Yield improvement | 95.2 | 46.8 | 52.8 |
| Price increase | -42.3 | 37.9 | 28.0 |
| Diversification | 59.5 | 14.1 | 23.4 |
| Interaction effect | -3.1 | 1.2 | 0.4 |

**Note:** The decomposition explains the sources of agricultural production growth and is interpreted as an indirect explanation of Agricultural Gross Value Added through changes in productivity and production composition.

Growth decomposition was undertaken using a decomposition framework that partitions total agricultural growth into the contributions of cultivated area expansion, yield improvement, price effects, crop diversification, and interaction effects. Positive values indicate contributions that enhanced agricultural growth, whereas negative values denote factors that constrained growth during the respective period.

**Source:** Authors' estimates based on agricultural production statistics of the Directorate of Economics and Statistics, Government of Bihar, and the Ministry of Statistics and Programme Implementation (MoSPI), Government of India.

Figure 4 illustrates the relative contributions of area expansion, yield improvement, price increase, diversification, and interaction effects to agricultural growth across the three study periods. Yield improvement consistently emerged as the dominant source of growth, whereas area expansion contributed negatively throughout, indicating that recent agricultural growth has been primarily productivity-driven rather than land-driven. Diversification and favourable price effects became increasingly important during the later periods, reflecting a gradual transition towards higher-value agricultural production.

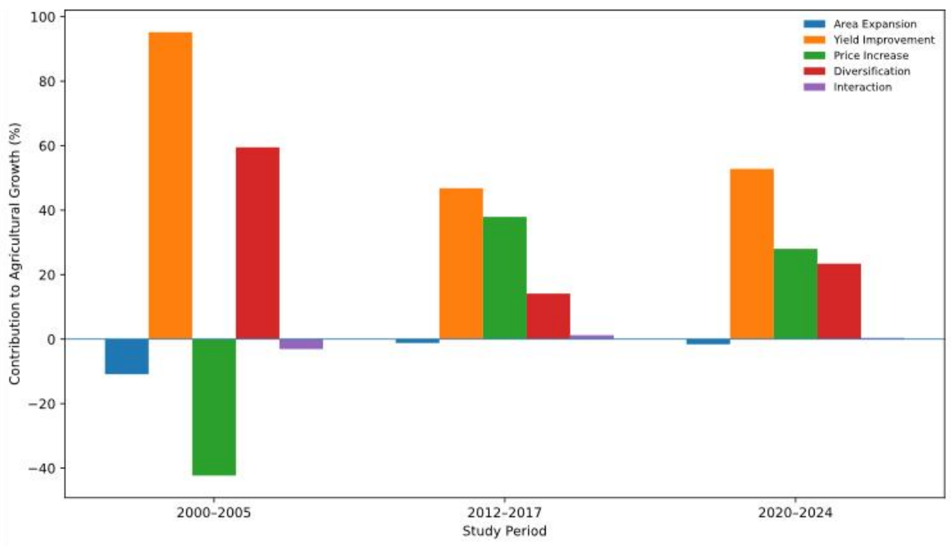


**Figure 4.** Decomposition of Agricultural Growth in Bihar by Major Sources, 2000- 2024

**Source:** Authors' estimates based on data from the Ministry of Statistics and Programme Implementation (MoSPI), Government of India, and the Directorate of Economics and Statistics, Government of Bihar.

### 4.4. Crop Diversification and Value Composition

Changes in cropping patterns further illustrate the structural transformation occurring within Bihar's agricultural sector. **Table 5** together with **Figures 5(a)** and **5(b)** compares the distribution of gross cropped area with the value of agricultural production for the major crop groups between 2000–01 and 2023–24.

Cereals continue to dominate land use, occupying approximately three-fourths of the gross cropped area throughout the study period. Rice remained the principal crop despite a marginal decline in its area share, while wheat and maize increased their relative importance. Collectively, cereals accounted for **75.8%** of cropped area in 2000–01 and **74.7%** in 2023–24, indicating that the overall cropping pattern has remained relatively stable despite modest adjustments among individual cereal crops.

A markedly different pattern emerges when production value is considered. Fruits and vegetables generated the largest share of agricultural output value despite occupying only a small proportion of cultivated land. Although their value share declined modestly over time, they continued to contribute substantially more value per unit of land than cereal crops. Meanwhile, cereals increased their contribution to total production value, reflecting improvements in productivity and market performance. Pulses, oilseeds, and sugarcane accounted for relatively small shares of both cultivated area and production value.

The comparison between area and value composition demonstrates that land allocation alone provides an incomplete measure of agricultural performance [25,47-49]. High-value horticultural crops generate considerably greater economic returns than their area share would suggest, highlighting the importance of value-oriented agricultural development. These findings indicate substantial opportunities for increasing Agricultural Gross Value Added through diversification towards horticulture, improved post-harvest management, and stronger market integration rather than through further expansion of cereal cultivation.

Overall, the evidence suggests that Bihar's agricultural transformation is increasingly characterized by a gradual shift from land-intensive production towards value-intensive agriculture. Continued diversification into high-value crops, supported by technological innovation and efficient value chains, has considerable potential to enhance farm income, resource productivity, and agricultural competitiveness.

**Table 5.** Share of major crops in gross cropped area and gross value of production.

| Major Crops | % Share of Area | | % Share of Value of Production | |
|---|---|---|---|---|
| | 2000-01 | 2023-24 | 2000-01 | 2023-24 |
| Rice | 42.17 | 40.20 | 21.91 | 22.47 |
| Wheat | 24.78 | 26.55 | 14.09 | 16.77 |
| Mazei | 2.42 | 7.68 | 4.90 | 5.01 |
| All Cereals | 75.76 | 74.68 | 40.33 | 46.53 |
| Pulses | 8.37 | 7.61 | 4.96 | 4.14 |
| Oilseeds | 1.47 | 1.46 | 1.11 | 1.62 |
| Sugarcane | 1.90 | 1.78 | 1.50 | 1.41 |
| Fruits & Vegetables | 11.65 | 13.25 | 51.93 | 42.92 |
| All Crops | 100.00 | 100.00 | 100.00 | 100.00 |

**Source:** Authors' estimate

Figure 5(a) compares the percentage share of gross cropped area under major crop groups, illustrating the declining share of rice, the expansion of maize cultivation, and the modest increase in the area devoted to fruits and vegetables over the study period.

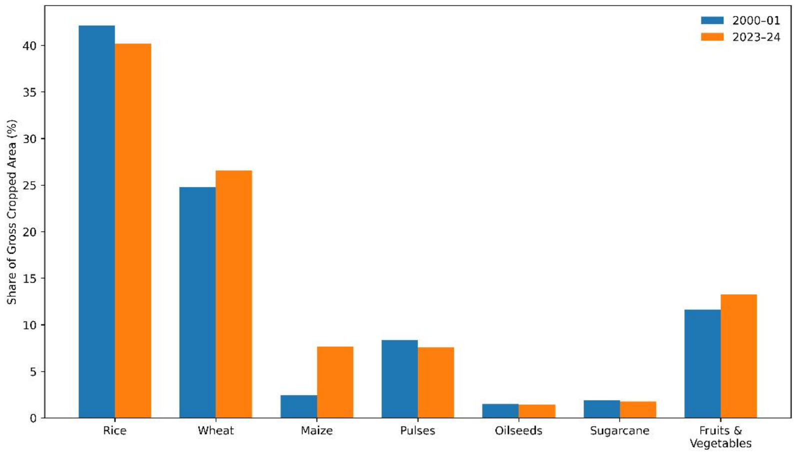


**Figure 5(a).** Distribution of Gross Cropped Area by Major Crops in Bihar, 2000–01 and 2023–24

Figure 5(b). shows changes in the value composition of agricultural production. Cereals increased their contribution to total production value despite little change in cultivated area, whereas the share of fruits and vegetables declined, highlighting differences between land allocation and value generation.

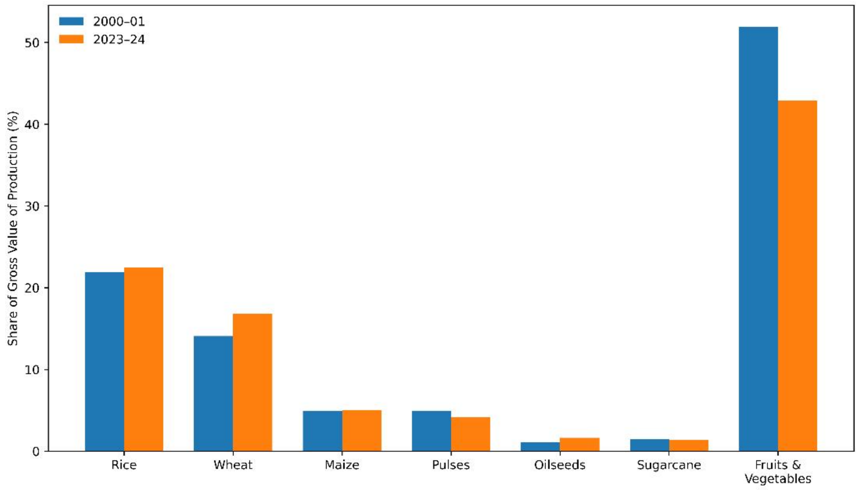


**Figure 5(b).** Distribution of Gross Value of Agricultural Production by Major Crops in Bihar, 2000–01 and 2023–24.

**Source:** Authors' estimates based on the Directorate of Economics and Statistics, Government of Bihar.

### 4.5. Drivers of Agricultural Value Addition

The preceding structural, production-decomposition, and value-composition analyses indicate that Bihar's agricultural transformation is increasingly driven by improvements in productivity, diversification, and structural reallocation within agriculture rather than by expansion of cultivated land. Together, the evidence from the sectoral composition, growth decomposition, and crop-value analyses identifies several interrelated drivers of Agricultural Gross Value Added (AGVA).

First, production-side productivity improvement has emerged as the principal engine of agricultural growth. The dominance of the yield effect in the decomposition analysis demonstrates that technological progress, improved seed varieties, irrigation expansion, mechanization, balanced input use, and improved crop management have contributed more to agricultural growth than increases in cultivated area. This transition from land-based to productivity-based growth reflects the growing importance of efficiency gains in sustaining agricultural development.

Second, diversification has strengthened agricultural value creation. Although cereals continue to dominate land use, higher-value activities—including horticulture, livestock, and fisheries—have gradually increased their contribution to Agricultural GVA. The disparity between cropped area and production value illustrates that economic returns depend not only on land allocation but also on the value generated per unit of output. Consequently, diversification towards high-value commodities provides considerable opportunities for increasing farm income without requiring additional agricultural land.

Third, changing market conditions have become increasingly important in supporting agricultural growth. The positive contribution of price effects during the later years suggests improved commercialization and stronger market incentives. Greater integration of production with processing, storage, and marketing systems has the potential to further increase agricultural value addition through reduced post-harvest losses and higher producer prices.

Finally, the observed structural transformation reflects gradual movement towards a more balanced agricultural economy. While crop production remains the dominant source of Agricultural GVA, the expanding contributions of livestock and fisheries indicate increasing diversification of rural income sources. These changes collectively suggest that future agricultural growth in Bihar will depend primarily on productivity enhancement, technological innovation, value-chain development, and greater integration among agricultural subsectors.

### 4.6. Volatility and Resilience of Agricultural Growth

Although Bihar's agricultural sector has recorded sustained long-term growth, considerable differences exist in the stability of individual subsectors. Crop production continues to exhibit relatively high year-to-year variability because of its dependence on monsoon rainfall, recurrent floods, droughts, and other climatic shocks. Such fluctuations contribute to instability in farm income and increase production risk for smallholder farmers.

By contrast, livestock has demonstrated comparatively greater stability throughout the study period. The gradual increase in livestock's contribution to Agricultural GVA indicates its important role in reducing household vulnerability by providing relatively stable income, regular cash flow, and productive use of crop residues. Similarly, fisheries have experienced rapid expansion and represent an increasingly resilient component of Bihar's agricultural economy owing to rising domestic demand and favourable market conditions.

The evidence therefore suggests that diversification beyond traditional crop production enhances both agricultural resilience and economic stability. A more balanced production structure combining crops, livestock, fisheries, and horticulture can reduce dependence on a single source of income while improving resource-use efficiency and employment opportunities. Such diversification also strengthens the sector's capacity to withstand climatic and market-related shocks.

Overall, Bihar's agricultural sector is becoming progressively more resilient; however, continued investment in irrigation, climate-resilient technologies, integrated farming systems, improved extension services, and agricultural risk-management mechanisms remains essential for sustaining long-term growth. Strengthening these resilience-enhancing measures will complement productivity improvements and support the transition towards a more diversified, value-oriented, and sustainable agricultural economy.

### 4.7. Econometric Results

#### 4.7.1. Stationarity Tests

Prior to estimating the regression models, the time-series properties of the variables were examined using the Augmented Dickey–Fuller (ADF) unit root test to reduce the possibility of spurious regression results. The ADF results indicate that the variables satisfy the stationarity requirement adopted for the Ordinary Least Squares estimation. The results therefore support the use of OLS for analysing the contemporaneous relationship between Agricultural Gross Value Added and its principal production components.

**Table 6.** Augmented Dickey–Fuller Unit Root Test Results

| Variable | Level ADF Statistic | p-value | First Difference ADF Statistic | p-value | Order of Integration |
|---|---|---|---|---|---|
| Agricultural Gross Value Added (AGVA) | -1.408646 | 0.1013 | -5.244630 | 0.0045 | I(1) |
| Crop Production (CP) | -1.867778 | 0.1008 | -7.553897 | 0.0041 | I(1) |
| Livestock Production (LP) | -1.643348 | 0.1009 | -4.874532 | 0.0052 | I(1) |
| Forestry Production (FP) | -2.004531 | 0.1032 | -5.466752 | 0.0044 | I(1) |
| Fisheries Production (FiP) | -2.875923 | 0.1056 | -7.239874 | 0.0042 | I(1) |

**Note:** The Augmented Dickey–Fuller (ADF) test was applied to examine the stationarity properties of the annual time-series variables used in the regression analysis. Variables that were non-stationary at levels were subsequently tested at first differences. The order of integration was determined at the 5% significance level. The stationarity results provide the statistical basis for the Ordinary Least Squares (OLS) estimation adopted in this study.

#### 4.7.2. Diagnostic Tests

Before estimating the regression models, a series of diagnostic tests was conducted to examine the validity of the Ordinary Least Squares (OLS) assumptions. Multicollinearity was assessed using the

Variance Inflation Factor (VIF) and Tolerance (TOL), while heteroscedasticity and serial correlation were examined using the Breusch–Pagan and Durbin–Watson tests, respectively [35-37,50].

The results indicate that the estimated models satisfy the principal assumptions of OLS estimation (Table 6). The average VIF remained below the conventional threshold of 10 and the corresponding tolerance exceeded 0.10, indicating the absence of serious multicollinearity among the explanatory variables. The Breusch–Pagan statistic was statistically insignificant ($p>0.05$), confirming homoscedastic residual variance. Likewise, the Durbin–Watson statistic was sufficiently close to the benchmark value of two, suggesting that serial correlation is unlikely to affect the regression estimates. Collectively, these diagnostics confirm that the estimated coefficients are statistically reliable and suitable for inference.

**Table 7.** Diagnostic tests for the regression models

| Diagnostic test | Test statistic | Reference value | Interpretation |
|---|---|---|---|
| Mean VIF | 9.53 | <10.00 | No serious multicollinearity |
| Mean Tolerance | 0.120 | >0.10 | Acceptable independence among regressors |
| Breusch–Pagan $\chi^2$ | 0.155 | p = 0.953 | Homoscedasticity accepted |
| Durbin–Watson | 1.560 | ≈2.00 | No significant first-order autocorrelation |

Source: Authors' calculations.

### 4.7.3. Model 1: Determinants of Agricultural Gross Value Added

Table 8 presents the results of the first regression model, where Agricultural Gross Value Added (AGVA) is explained by aggregate crop and livestock production.

The model exhibits excellent explanatory power, with an adjusted $R^2$ of 0.9569, indicating that approximately 96% of the variation in Agricultural GVA is explained by the two explanatory variables. The highly significant F-statistic confirms the overall robustness of the model.

Crop production exerts a strong and statistically significant positive influence on Agricultural GVA. The estimated coefficient (0.5686; $p < 0.001$) implies that a one-unit increase in crop production is associated with an average increase of approximately 0.57 units in Agricultural GVA, holding other factors constant. This finding confirms that crop production remains the dominant source of agricultural value creation in Bihar.

Livestock production also exhibits a positive coefficient (0.5381), although statistical significance is achieved only at the 10% level ($p = 0.0682$). This result suggests that livestock contributes positively to agricultural value addition, but its influence remains comparatively weaker than that of crop production during the study period.

**Table 8.** Model 1: Determinants of Agricultural Gross Value Added

| Variable | Coefficient | Standard error | p-value |
|---|---|---|---|
| Constant | 0.8861 | 51.4720 | 0.9782 |
| Crop production | 0.5686 | 0.0962 | 0.0000 |
| Livestock production | 0.5381 | 0.2453 | 0.0682 |
| Model statistics | | Value | |
| $R^2$ | | 0.9695 | |
| Adjusted $R^2$ | | 0.9569 | |
| F-statistic | | 864.00 | |
| Prob. (F) | | 0.0000 | |
| Standard error | | 56.56 | |

| | |
|---|---|
| Observations | 24 |

Source: Authors' calculations.

#### 4.7.4. Model 2: Contribution of Major Plant Production Activities

To identify the individual contribution of plant-production subsectors, a second regression model was estimated using cereal production, fruit production, and other crop production as explanatory variables (Table 8). Vegetable production was excluded from the estimation because of severe multicollinearity with cereal production.

The estimated model demonstrates high explanatory power (Adjusted $R^2 = 0.9578$) and is highly significant overall ($p < 0.001$). Cereal production emerges as the principal determinant of Agricultural GVA, with a positive and highly significant coefficient (0.7614; $p < 0.001$). This finding highlights the continuing importance of cereal cultivation in Bihar's agricultural economy despite increasing diversification.

Fruit production also contributes significantly to Agricultural GVA (coefficient = 0.9736; $p = 0.0468$), indicating that expansion of horticultural production has considerable potential to increase agricultural value addition. In contrast, the coefficient for other crops is statistically insignificant, suggesting that these activities currently make only a limited independent contribution to overall Agricultural GVA.

A separate regression model was also estimated using disaggregated livestock subsectors (cattle, poultry, pigs, and other livestock). However, the model lacked overall statistical significance and was therefore excluded from further interpretation. Consequently, livestock is interpreted at the aggregate level as reported in Model 1.

Overall, the econometric evidence indicates that Agricultural Gross Value Added in Bihar continues to depend primarily on crop production, while horticultural diversification represents an important opportunity for future value creation. The regression results complement the structural and production-decomposition analyses by identifying the principal subsectoral contributors to Agricultural Gross Value Added rather than the sources of agricultural production growth.

**Table 9.** Model 2: Contribution of major plant-production activities to Agricultural Gross Value Added

| Variable | Coefficient | Standard error | p-value |
|---|---|---|---|
| Constant | 77.6313 | 81.9082 | 0.3972 |
| Cereal production | 0.7614 | 0.1321 | 0.0000 |
| Fruit production | 0.9736 | 0.4640 | 0.0468 |
| Other crops | 0.2417 | 0.5971 | 0.6540 |

| Model statistics | Value |
|---|---|
| $R^2$ | 0.9634 |
| Adjusted $R^2$ | 0.9578 |
| F-statistic | 379.47 |
| Prob. (F) | 0.0000 |
| Standard error | 72.59 |
| Observations | 24 |

Source: Authors' calculations.

## 5. DISCUSSION

The findings demonstrate that Bihar's agricultural sector is undergoing a gradual but incomplete structural transformation. Three interrelated conclusions emerge from the analysis. First, although agriculture's contribution to Gross State Value Added has steadily declined, it continues to absorb a disproportionately large share of the workforce, indicating persistent structural imbalance. Second, agricultural growth has increasingly been driven by productivity improvement rather than expansion of cultivated area, reflecting a transition from extensive to intensive agricultural development. Third, while crop production remains the principal contributor to Agricultural Gross Value Added (AGVA), livestock, fisheries, and horticulture are gradually strengthening their role as complementary sources of agricultural value addition, indicating the early stages of production diversification.

These findings are broadly consistent with India's national experience of structural transformation, where agriculture's share in Gross Value Added has declined more rapidly than its share in employment, giving rise to substantial inter-sectoral productivity differentials. Bihar, however, exhibits a more pronounced form of this imbalance. The persistence of a large agricultural workforce reflects not only limited industrialization and insufficient rural non-farm employment opportunities but also the state's long-standing pattern of seasonal and permanent out-migration. A considerable proportion of rural households continue to identify agriculture as their principal occupation while simultaneously depending on migrant earnings from employment outside Bihar. Consequently, the observed employment structure should be interpreted as reflecting both local agricultural dependence and migration-induced livelihood diversification rather than labour exclusively engaged in agricultural production. This pattern is broadly consistent with the classical theories of structural transformation, which emphasize that sustainable economic development requires the gradual movement of labour from low-productivity agriculture to higher-productivity industrial and service activities [42,43].

The increasing importance of productivity improvement as the principal source of agricultural growth also reflects a broader international pattern. Similar experiences have been observed in China and Vietnam, where opportunities for expanding cultivated land have become increasingly limited, making technological progress, irrigation, improved seed varieties, mechanization, and more efficient input use the principal drivers of agricultural growth. Nevertheless, the pace of transformation differs substantially across countries. China's agricultural modernization was supported by sustained investment in rural infrastructure, agricultural research, agro-processing industries, and market reforms, while Vietnam successfully combined productivity growth with export-oriented diversification. Bihar has achieved measurable productivity improvements, but fragmented landholdings, relatively low mechanization, inadequate post-harvest infrastructure, limited agro-processing, and weak market integration continue to constrain the conversion of production gains into higher agricultural value addition [51].

The gradual expansion of livestock, fisheries, and horticulture likewise reflects a broader process of agricultural diversification observed across developing economies. Experiences from Bangladesh demonstrate that diversification towards livestock and aquaculture can strengthen household resilience, broaden rural income sources, and reduce dependence on cereal production [26,52]. Similar trends are evident in Bihar, although commercialization remains comparatively limited. Inadequate veterinary and breeding services, insufficient cold-chain infrastructure, weak producer organizations, and limited integration between crop and livestock systems continue to restrict the contribution of these subsectors to Agricultural Gross Value Added. Their relatively modest statistical contribution should therefore be interpreted as reflecting the current stage of structural transformation rather than limited long-term potential.

Comparable structural characteristics have also been reported in Serbia and Romania, where increases in Agricultural Gross Value Added have depended less on expanding production volume than on improving productivity, product quality, and value-chain integration [53]. These experiences reinforce the present findings that sustained agricultural transformation requires not only higher production but also stronger institutional support, technological modernization, efficient marketing systems, and closer linkages between primary production, processing industries, and final markets. Similarly, the experience of European Union member states demonstrates that internationally competitive agriculture increasingly depends on innovation, product differentiation, quality standards, integrated value chains, and agro-processing rather than on production expansion alone. Bihar has initiated this transition through gradual diversification, but institutional and infrastructural constraints continue to limit the realization of comparable levels of agricultural value addition.

The econometric results further support these structural observations. Crop production remains the strongest contributor to Agricultural Gross Value Added, confirming the continuing importance of cereals within Bihar's agricultural economy. At the same time, the significant contribution of fruit production suggests that relatively modest shifts towards higher-value horticulture can generate substantial increases in agricultural value creation. Similar transitions have been documented in China, the European Union, and several middle-income economies, where horticulture has emerged as an important source of agricultural income because of its higher productivity, stronger market demand, and greater integration with processing and modern retail supply chains [54,55]. These findings indicate that future agricultural growth in Bihar will increasingly depend on diversification towards higher-value commodities while sustaining productivity improvements in staple crop production.

The findings also highlight several institutional constraints that continue to impede structural transformation. The relatively weak manufacturing base limits the development of agro-processing industries capable of generating additional value from primary agricultural production. Limited rural industrialization reduces opportunities for labour mobility from agriculture to higher-productivity activities, thereby slowing improvements in labour productivity. In addition, fragmented landholdings, inadequate market infrastructure, limited access to quality inputs, weak extension services, and insufficient farmer organizations constrain both technological adoption and commercialization. Addressing these institutional barriers is therefore essential for accelerating the transition from production-oriented agriculture towards value-oriented agriculture.

Overall, the evidence suggests that Bihar has entered the early stages of agricultural value-based structural transformation, but the process remains incomplete. Productivity improvement has become the principal source of production growth, while diversification towards livestock, fisheries, and horticulture has begun to broaden the sources of agricultural value addition. However, sustained increases in Agricultural Gross Value Added will depend not only on continued technological progress but also on stronger institutional support, expanded agro-processing, improved market integration, enhanced cold-chain infrastructure, greater rural industrialization, and more productive labour mobility. Strengthening these complementary factors would enable Bihar to capture greater value from existing agricultural resources, enhance labour productivity, improve resilience to climatic and market shocks, and promote more inclusive and sustainable rural development.

## 6. POLICY IMPLICATIONS

The empirical evidence indicates that Bihar's agricultural transformation is increasingly driven by productivity improvement, gradual diversification, and structural changes in agricultural value addition rather than by expansion of cultivated land. Accordingly, agricultural policy should shift from production-centred strategies towards value-oriented interventions that strengthen productivity, market integration, rural employment, and climate resilience.

### 6.1. Enhancing Agricultural Value Addition

The econometric results identify crop production as the strongest determinant of Agricultural Gross Value Added (AGVA), while fruit production exerts a significant positive influence despite occupying a relatively small proportion of cultivated land. These findings suggest that future gains in agricultural income are likely to arise from increasing value addition rather than simply expanding output. Policies should therefore prioritize modernization of production systems, post-harvest management, grading, packaging, agro-processing, and value-chain development. Investments in food-processing industries, Farmer Producer Organizations (FPOs), and rural enterprises would enable farmers to capture a larger share of consumer expenditure while simultaneously generating productive rural employment [53].

### 6.2. Accelerating Productivity-Led Crop Diversification

The production-decomposition analysis demonstrates that yield improvement accounted for the largest share of agricultural growth during the most recent period, whereas expansion of cultivated area contributed negatively throughout the study period. This implies that future agricultural growth will depend primarily on raising productivity rather than extending cultivated land. Consequently, policies should emphasize irrigation efficiency, improved seed adoption, precision nutrient management, mechanization, digital extension services, and climate-smart agronomic practices. Diversification towards horticulture, pulses, oilseeds, and other high-value crops should complement cereal production according to agro-climatic suitability and market demand, thereby improving resource-use efficiency and farm profitability [56].

**6.3. Strengthening Livestock, Fisheries, and Integrated Farming Systems**

Although livestock production exhibited only marginal statistical significance in the regression analysis, the empirical evidence demonstrates its important contribution to income stabilization and agricultural resilience. International experience indicates that livestock becomes a major contributor to agricultural value addition when supported by improved breeds, veterinary services, quality feed, dairy infrastructure, and organized marketing systems. Bihar should therefore strengthen integrated crop–livestock systems, expand dairy cooperatives, improve animal health services, and promote scientific livestock management. Similar policy attention should be directed towards fisheries, which recorded the fastest growth among the allied sectors and offer considerable potential for employment diversification, nutritional security, and climate resilience [57].

**6.4. Strengthening Agricultural Value Chains and Market Integration**

The gradual transition towards value-oriented agriculture cannot be sustained without stronger market integration. The relatively high contribution of horticultural products to Agricultural GVA suggests that considerable value is lost because of weak post-harvest management and inadequate processing capacity. Investment in cold-storage facilities, warehouses, rural logistics, agro-processing clusters, digital marketing platforms, and quality certification systems would reduce post-harvest losses, improve price realization, and strengthen producers' participation in domestic and export markets. Expanding Farmer Producer Organizations and well-regulated contract farming arrangements can further improve bargaining power, reduce transaction costs, and accelerate technology adoption among smallholders [58].

**6.5. Building Climate-Resilient Agricultural Systems**

The volatility analysis indicates that crop production remains considerably more vulnerable to climatic shocks than livestock and fisheries. Enhancing climate resilience therefore requires greater investment in efficient irrigation, water harvesting, climate-resilient crop varieties, weather-based advisory services, integrated farming systems, and comprehensive crop insurance. Sustainable soil and water management, conservation agriculture, and digital climate information systems would simultaneously improve productivity, reduce production risks, and strengthen long-term agricultural sustainability [59].

**6.6 Promoting Rural Non-farm Employment and Labour Mobility**

The structural analysis demonstrates that agricultural employment has declined much more slowly than agriculture's contribution to Gross State Value Added, reflecting limited labour mobility from low-productivity agriculture to higher-productivity sectors. This challenge is further compounded by Bihar's substantial seasonal and long-term out-migration, where many rural households continue to identify agriculture as their principal occupation while relying increasingly on non-farm income earned outside the state. Sustainable structural transformation therefore requires expanding productive rural employment opportunities within Bihar itself.

Policy priorities should include the development of agro-processing industries, food manufacturing, rural logistics, storage and warehousing services, input supply enterprises, agricultural machinery services, and other rural manufacturing activities. Investments in vocational education, entrepreneurship development, digital skills, and value-chain management would improve the employability of rural youth while supporting the growth of small and medium rural enterprises. Strengthening linkages between agriculture, manufacturing, and services would facilitate labour mobility into higher-productivity activities, reduce distress migration, broaden rural income sources, and accelerate inclusive structural transformation.

Overall, the empirical findings indicate that Bihar's future agricultural transformation should be driven not only by productivity enhancement and diversification but also by stronger value chains, expanded rural non-farm employment, improved labour mobility, and climate-resilient production systems. Such an integrated strategy would increase Agricultural Gross Value Added, improve labour productivity, strengthen rural livelihoods, and promote sustainable and inclusive economic development.

### 6.7. Synthesis of the Principal Results

To facilitate interpretation of the empirical findings and their practical relevance, Table 10 synthesizes the principal results of the study and the corresponding policy priorities. The table highlights the direct linkage between statistical evidence and recommended interventions, providing an integrated framework for evidence-based agricultural policy in Bihar.

**Table 10.** Summary of Major Findings and Policy Implications

| Empirical finding | Evidence | Interpretation | Policy implication |
|---|---|---|---|
| Agriculture's share in Gross State Value Added declined from 36.3% (2000) to 18.3% (2024), while more than 70% of the workforce remained dependent on agriculture. | Table 1 | Structural transformation has progressed more slowly in employment than in output, indicating low agricultural labour productivity. | Promote rural industrialization, non-farm employment, skill development, and higher agricultural value addition. |
| Crop production continues to dominate Agricultural Gross Value Added, although its share declined from 60.9% to 57.6%, while livestock increased from 28.0% to 31.2%. | Table 2; Figures 3(a)–3(b) | Bihar's agriculture is gradually diversifying towards allied activities, but crop production remains the economic backbone. | Strengthen crop productivity while accelerating investments in dairy, fisheries, horticulture, and integrated farming systems. |
| Yield improvement consistently accounted for the largest share of agricultural growth (95.2%, 46.8%, and 52.8%), whereas area expansion contributed negatively throughout the study period. | Table 4; Figure 4 | Future agricultural growth will depend primarily on productivity enhancement rather than expansion of cultivated land. | Prioritize irrigation efficiency, improved seed systems, mechanization, precision agriculture, digital extension services, and climate-smart technologies. |
| Diversification and favourable price effects became increasingly important contributors to agricultural growth during recent years. | Table 4 | Agricultural transformation is shifting towards higher-value production and market-oriented agriculture. | Promote crop diversification, value-chain development, agro-processing, storage infrastructure, and market integration. |
| Crop production exerted the strongest positive influence on Agricultural Gross Value Added ($\beta = 0.5686$; $p < 0.001$). | Table 6 | Cereals remain the principal driver of agricultural value creation. | Sustain investments in crop productivity through improved technology, efficient input use, and sustainable resource management. |
| Fruit production showed a statistically significant positive effect on Agricultural Gross Value Added. | Table 7 | High-value horticulture generates disproportionately greater value relative to land use. | Expand horticulture through improved planting material, protected cultivation, cold-chain infrastructure, processing, and export-oriented marketing. |

| | | | |
|---|---|---|---|
| Livestock production contributed positively but exhibited comparatively weaker statistical significance. | Table 6 | Livestock remains underdeveloped but offers considerable potential for income diversification and resilience. | Invest in dairy cooperatives, veterinary services, genetic improvement, feed resources, and integrated crop–livestock systems. |
| Crop production exhibited considerably greater volatility than livestock and fisheries. | Section 4.6 | Allied activities enhance resilience against climatic and production risks. | Promote diversified farming systems, climate insurance, fisheries development, water management, and risk-resilient agricultural practices. |

Source: Synthesized by the authors from the empirical results presented in Tables 1–7.

Table 9 demonstrates that the recommended policy interventions emerge directly from the empirical evidence rather than from generalized development strategies. Collectively, the findings indicate that future agricultural transformation in Bihar should be driven by productivity enhancement, diversification into higher-value enterprises, stronger value-chain integration, and climate-resilient production systems. These priorities provide a coherent roadmap for increasing Agricultural Gross Value Added, improving rural incomes, and accelerating sustainable structural transformation.

## 7. LIMITATIONS AND FUTURE RESEARCH

While the present study provides a comprehensive assessment of agricultural value addition and structural transformation in Bihar, several limitations should be acknowledged.

First, the production-decomposition analysis is based on agricultural production rather than Agricultural Gross Value Added because decomposition techniques are designed to identify the production-side sources of agricultural growth. Accordingly, the decomposition results should be interpreted as explaining the underlying production processes that contribute to Agricultural Gross Value Added rather than as a direct decomposition of value added itself.

Second, the econometric analysis is based on annual time-series observations for 2007–2023. Although the diagnostic tests support the validity of the Ordinary Least Squares estimation, the relatively limited number of observations constrains the examination of more complex dynamic relationships and long-run adjustment mechanisms.

Third, the analysis primarily relies on officially published macro-level agricultural statistics. Variables reflecting labour migration, household income diversification, institutional quality, market access, agro-processing capacity, and value-chain integration were not available in consistent annual time-series form and therefore could not be incorporated into the empirical models. Their inclusion would provide a more comprehensive understanding of the mechanisms underlying structural transformation.

Fourth, although the study discusses improvements in agricultural labour productivity as an important dimension of structural transformation, labour productivity itself is not modelled explicitly because of limitations in consistent long-term employment data at the sub-sectoral level.

Future research may extend the present analysis by incorporating district-level panel datasets, explicitly modelling labour productivity and migration dynamics, and applying dynamic econometric techniques such as Autoregressive Distributed Lag (ARDL), Vector Error Correction Models (VECM), or panel-data approaches to examine both the short-run and long-run determinants of agricultural value addition. Additional research on agro-processing, rural industrialization, digital agriculture, and climate-resilient value chains would further strengthen the evidence base for sustainable agricultural transformation in Bihar.

## 8. CONCLUSIONS

This study examined the dynamics of agricultural value addition and structural transformation in Bihar during 2000–2024 by integrating structural composition analysis, production-decomposition techniques, and econometric modelling within a unified analytical framework. By combining these complementary approaches, the study provides a comprehensive assessment of the production processes, value creation, and structural changes shaping agricultural development in one of India's largest agrarian economies.

The empirical findings indicate that Bihar has entered the early stages of agricultural structural transformation, although the process remains incomplete. Agriculture continues to support a disproportionately large share of the workforce despite its declining contribution to Gross State Value Added, reflecting persistent structural imbalance and relatively low labour productivity. The production-decomposition analysis demonstrates that agricultural growth has increasingly become productivity-driven, with yield improvement replacing cultivated area expansion as the principal source of production growth. Diversification towards livestock, fisheries, and horticulture has gradually broadened the production base, while the econometric analysis confirms that crop production remains the principal contributor to Agricultural Gross Value Added, with horticultural production emerging as an important source of future value creation.

The study makes two principal contributions to the literature. First, it demonstrates how structural composition analysis, production-decomposition techniques, and econometric estimation can be integrated to evaluate agricultural value addition and structural transformation within a coherent analytical framework. Second, it provides empirical evidence that sustained increases in Agricultural Gross Value Added depend not only on production growth but also on productivity enhancement, diversification, value-chain development, and institutional strengthening. These findings contribute to the growing literature on agricultural transformation in developing agrarian economies by highlighting the importance of value creation as a pathway to sustainable rural development.

The policy implications extend beyond increasing agricultural production. Future agricultural development in Bihar should prioritize productivity-enhancing technologies, climate-smart agriculture, agro-processing, value-chain integration, rural infrastructure, and stronger linkages among crop, livestock, fisheries, and horticultural enterprises. Equally important is the expansion of rural non-farm employment through agro-processing, food industries, rural manufacturing, logistics, and skill development, thereby facilitating labour mobility from low-productivity agriculture to higher-value economic activities. Such an integrated strategy would strengthen Agricultural Gross Value Added, improve rural incomes, enhance climate resilience, and accelerate inclusive structural transformation.

Future research should extend the present analysis by incorporating district-level panel data, explicitly modelling labour productivity and migration dynamics, and applying dynamic econometric approaches to examine both the short-run and long-run determinants of agricultural value addition. Additional investigation of agro-processing, rural industrialization, digital agriculture, and climate-resilient value chains would further strengthen the evidence base for agricultural transformation in Bihar and other developing regions.

Although the empirical analysis focuses on Bihar, the analytical framework and broader policy lessons are relevant to many developing agrarian economies where sustained improvements in agricultural productivity, value addition, and diversification—rather than expansion of cultivated land—represent the principal pathway towards structural transformation, inclusive rural development, and long-term economic sustainability.

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