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Navigating The Journey: Progress And Constraints In India's Agricultural Transformation

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Abstract
The United Nations Sustainable Development Goals (SDGs) call for transformative changes to achieve a world free from hunger, malnutrition, and extreme poverty. Agriculture has immense potential to promote food security, generate employment, and foster economic growth. The agricultural sector can drive significant positive change by implementing a strategic framework and embracing sustainable practices. Indian agriculture, with its diverse landscape, is the cornerstone of the economy. Although impressive in some areas and states, India's achievements in agriculture have fallen short of its potential. This will require a shift from incremental changes to bold, revolutionary advancements that can truly reshape the future of farming. The study utilizes a secondary database that showcases important indicators, including the Agricultural Transformation Index (ATI), Gross Domestic Product (GDP), and workforce participation rates in various countries, with a special emphasis on India. It examines the ongoing agricultural transformation in India, assessing its current status and recent advancements. It places India's progress in the context of other countries across various income groups, allowing for a comparative analysis of agricultural development. It highlights the relationship between the nation's GDP and its ATI. It also examines the significant challenges that limit the progress of agriculture in comparison to other countries. Furthermore, the study aims to identify potential opportunities for enhancing the sector's performance.
Keywords: *Agricultural Transformation Index, Gross Domestic Product, Structural Transformation, Sustainable Development, Food Security*

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I. Introduction

The United Nations Sustainable Development Goals (SDGs) emphasize the importance of inclusivity and fairness, underscoring the commitment to "Leaving No One Behind." These goals advocate for significant transformational changes to create an inclusive, just, and resilient world. This vision encompasses eradicating hunger and extreme poverty, while ensuring the sustainable use and protection of biodiversity and natural resources (Singh, 2019). Being universal in scope, the SDGs call upon all countries to improve the lives of their citizens. For India to achieve prosperity, inclusivity, sustainability, fairness, and peace, it must enhance overall economic growth and eliminate extreme poverty, hunger, and malnutrition. To achieve robust overall economic growth, a structural transformation is imperative. This change requires reducing the relative contribution of agriculture to GDP, which will allow other sectors of the economy to grow. This shift is important for improving overall prosperity (Lewis, 1954). A key goal for developing countries is to achieve high-income status. Agriculture plays a vital role in economic transformation, ensuring food security and improving nutrition (van Arendonk, 2015). It offers a variety of food options throughout the year, contributing to consistent availability and stability. Additionally, agriculture is a significant source of employment, enhancing accessibility to food resources (Gogia & Sikarwar, 2019). Indian agriculture, in a comprehensive sense encompassing all allied sectors, serves as the foundation of the national economy, reflecting the country's diverse landscape. Agriculture plays a crucial role in a nation's development, and its importance is widely acknowledged. Although some regions and states have made significant strides in this sector, India has yet to realize its agricultural potential fully. Agriculture is currently facing three interconnected challenges. First, there is the need to ensure food and nutrition security for a growing population. Second, farmers must adapt to and mitigate the impacts of climate change. Lastly, there is a pressing requirement for the sustainable management of vital resources, including water, energy, and land. Agriculture must adapt to changing environments and new requirements to address current challenges. This requires a change in approach from small improvements to transformational changes in agriculture (Chand, 2019).

We often compare today's food situation with the food scarcity experienced nearly five decades ago, rather than assessing agricultural achievements alongside those of India's other sectors and nations (Chand, 2019).

Agricultural transformation involves a comprehensive shift towards a more modern, efficient, and sustainable agricultural system. This transformation aims to improve farm productivity and profitability while connecting agriculture to other economic sectors. Such integration is a powerful driving force for extensive economic growth and transformative structural changes (Diao et al., 2024). The study provides a deeper understanding of agricultural transformation in India and helps shape policies that lead to a more sustainable, equitable, and prosperous agricultural sector.

II. Material And Methods

The study comprehensively analyses the current status and advancements in Indian agricultural transformation. It examines the key challenges hindering progress in comparison to other countries. Additionally, the research seeks to identify potential opportunities for improvement in this sector.

A thorough review of relevant scholarly literature has been conducted. This study primarily utilizes a secondary database that focuses on the Agricultural Transformation Index (ATI), Gross Domestic Product (GDP), and workforce participation of various countries, with a specific emphasis on India. The data has been sourced from the International Food Policy Research Institute (IFPRI), the World Bank, and the Ministry of Statistics and Programme Implementation.

Countries with their ATIs are categorized into different income levels based on World Bank criteria. The classification indicates a significant global economic divide, with 53 nations classified as high-income, 49 as upper-middle-income, 53 as lower-middle-income, and 26 struggling with low-income status. From a total of 181 countries, the top three nations from each income group, ranked by the Agricultural Transformation Index, were identified. The study excluded countries with a consistently high ATI score of 1.0. Notably, 13 countries in the high-income group maintained the highest ATI of 1.00 consistently from 2000 to 2021.

Time series data has been analyzed, and descriptive statistics have been calculated to evaluate India's position and progress relative to other countries. A correlation has been established between GDP and ATI. Furthermore, an extensive literature review was performed to identify the challenges facing Indian agriculture and to explore potential strategies for addressing these issues.

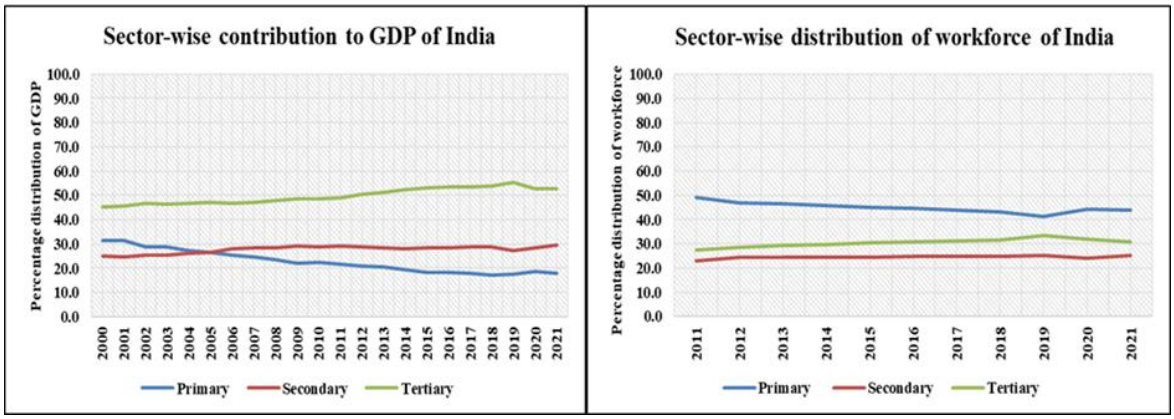
III. Results And Discussion

India, as an agrarian economy, relies heavily on agriculture. Therefore, improving productivity, efficiency, and sustainability is crucial for enhancing food security, reducing poverty, stimulating economic growth, and allowing agriculture to flourish in the global marketplace.

The Structural Transformation of the Indian Economy: Economic growth can be analyzed by breaking it down into two components. The first part, referred to as the within-sector component (agricultural transformation), refers to the changes and improvements in productivity that occur within specific economic sectors. The second component is the between-sector component (structural change), which reflects the shift of workers from one sector to another. This decomposition helps in understanding the dynamics of economic growth as highlighted by McMillan et al. (2014). Agricultural transformation and structural change processes reinforce intersectoral linkages between agricultural and non-agricultural sectors and contribute to economy-wide development (Diao et al., 2024). The structural transformation of an economy is characterized by a decrease in the share of the primary (agriculture and allied activities) sector in national income and employment. In contrast, the secondary (manufacturing) and tertiary (services) sectors experience growth (Timmer, 2009). However, the GDP share of agriculture often declines faster than its employment share (Anderson & Ponnusamy, 2019).

The contributions of the three sectors—primary, secondary, and tertiary—to India's GDP and employment are illustrated in Figure 1. The Indian economy is clearly on a developmental trajectory, as evidenced by the consistent decline in the primary sector's contribution to GDP. While the non-agricultural sector has experienced faster growth, the transformation remains gradual; the primary sector's share declines slowly. Despite its relatively low contribution to GDP, the primary sector continues to be the main source of employment, engaging approximately 43.96 percent of the nation's workforce, compared to 25.34 percent in the secondary and 30.70 percent in the tertiary sector as of 2021.

Figure 1: Sector-wise contribution to GDP of India and distribution of Indian workforce



Source: GoI 2024a; GoI 2024b; GoI n.d.

Understanding the Agricultural Transformation: The assessment of agricultural transformation has evolved, moving beyond simply measuring food quantity. The IFPRI (2024) conducted a comprehensive evaluation to assess the agrarian transformation performances of various countries. Figure 2 illustrates the four key stages of the Agricultural Transformation Index.

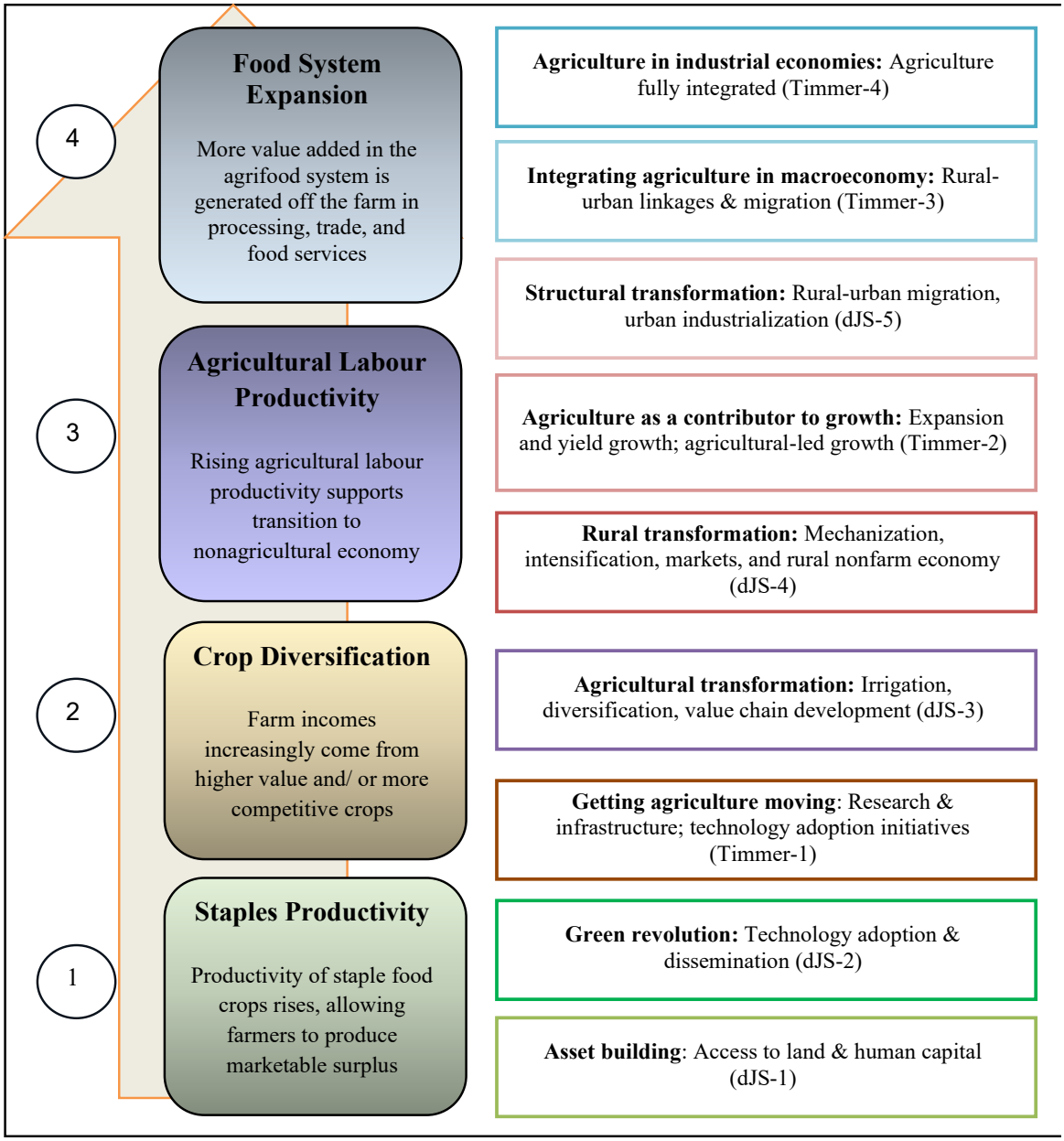
The *staples productivity stage* aligns with the "asset building" and "green revolution" phases identified in de Janvry and Sadoulet's (2019) framework for agricultural modernization, as well as Timmer's (1998) "getting agriculture moving" phase, which presents an opportunity to enhance agricultural development. By focusing on investments in infrastructure and improving access to agricultural technologies, stakeholders can effectively drive staple productivity. This proactive approach is essential for stimulating the agriculture transformation process and promoting sustainable growth in the sector.

The *crop diversification* stage is crucial, emphasizing the shift towards higher-value crops. This strategy delivers substantial socioeconomic advantages by boosting household incomes through cash crops and high-value food crops and improving food security and nutrition by increasing the quantity and variety of food to households. Crop diversification helps tackle agricultural issues like soil degradation, salinity, pests, diseases, and pollution (de Janvry & Sadoulet, 2019). It enhances food system resilience by promoting biodiversity (Barman et al., 2022; Mango et al., 2018). This stage aligns with Timmer's "getting agriculture moving" phase and closely connects with de Janvry and Sadoulet's concept of "agricultural transformation".

The third stage looks at *agricultural labour productivity.* Labour-saving technologies greatly affect the productivity of labour (Timmer, 1998; Bustos, 2016). These innovations not only enhance productivity in agriculture but also facilitate the transition of workers into non-agricultural sectors, where they can achieve higher economic returns. This stage aligns with "rural transformation" by de Janvry and Sadoulet, incorporating mechanization, labour intensification, and strong markets. Timmer also emphasizes agriculture's role in driving growth through increased productivity, highlighting its importance in overall economic development.

The final stage of the ATI is *food system expansion*, which becomes evident through the impacts of rural-urban migration and increasing incomes on dietary habits. Research conducted by Cockx et al. (2018) highlights a significant trend among individuals migrating from rural to urban areas. This migration is accompanied by a shift in dietary habits, with these individuals increasingly moving away from primary foods like staple crops. Instead, they are opting for more processed and prepared food options. This shift may reflect broader changes in lifestyle and accessibility associated with urban living.

Figure 2: Four Stylized Stages of Agricultural Transformation



Source: Adapted from Diao et al. 2024

Note. dJS 1-5 refer to the five stages of agriculture modernization identified by de Janvry and Sadoulet (2019), while and Timmer 1-4 refer to the four stages of agricultural transformation defined by Timmer (1998)

Agrifood systems consist of both on-farm and off-farm components. The on-farm component includes aspects of agriculture, while the off-farm elements encompass agro-processing, food trade and transportation, and food services, as outlined by Diao et al. (2023). In response to shifting dietary patterns, modern agrifood systems adjust by reallocating productive resources from primary agriculture to these off-farm segments, thereby better meeting consumer demands.

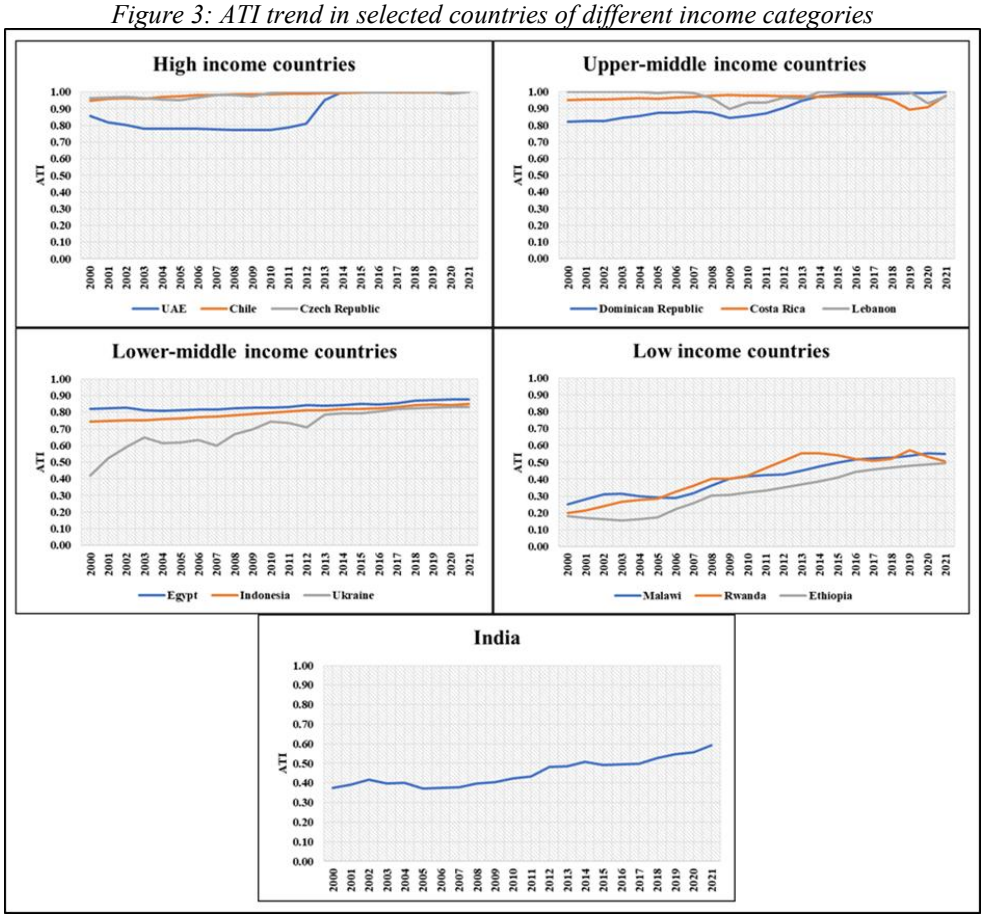
The ATI's food system expansion stage marks a phase of development where an increasing proportion of value added within the overall agrifood system arises from off-farm activities. This stage aligns with concepts such as "structural transformation" described by de Janvry and Sadoulet (2019), as well as Timmer's (1988) notion of "integrating agriculture into the macroeconomy." Both frameworks highlight a period characterized by enhanced rural-urban connections, improved market efficiencies, rural-urban migration, and growth in the industrial and services sectors.

While this stage of development has broad implications for structural changes across the economy, the focus here remains on the agrifood system. Accordingly, the ATI food system expansion indicator underscores the significant transitions occurring specifically within the agrifood sector as it evolves.

The status of Agricultural Transformation: Figure 3 highlights the significant trends and shifts that have shaped agricultural progress from 2000 to 2021. High-income countries such as the UAE, Chile, and the Czech Republic exhibited a constant rise in their ATI scores, ultimately reaching the highest levels by 2021. In the upper-middle-income category, countries such as Costa Rica and Lebanon exhibited notable fluctuations over the years, while the Dominican Republic showed a steady rise, culminating in peak performance in 2021. Conversely, lower-middle-income nations, including India, have struggled to reach optimal ATI levels despite an upward trend. In contrast, low-income countries have shown significant growth in their ATI, indicating their commitment to agricultural transformation.

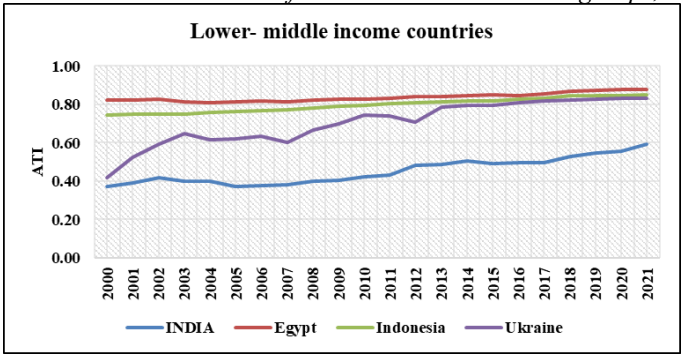
India's Agricultural Transformation Index (ATI) was 0.592, ranking 122nd out of 181 countries and positioned 28th within the lower-middle-income category of countries in 2021. India's Agricultural Transformation Index (ATI) score has shown an upward trend due to reforms and policy changes in the agricultural sector. However, its overall position compared to other countries is still lacking (Figure 4). The ATI score remains significantly lower than other nations within India's income category.

Figure 3: ATI trend in selected countries of different income categories



Source: IFPRI, 2024

Figure 4: ATI trend in selected countries from lower-middle income groups, including India.



Source: IFPRI 2024

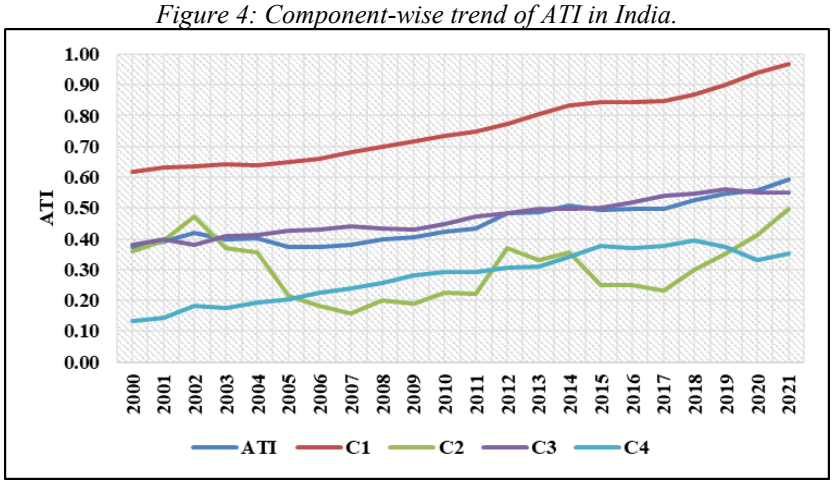
Table 1 highlights India's component-wise agricultural transformation index, revealing a modest change of only 0.218 units in the composite ATI since 2000. Notably, there has been significant progress in staple productivity, bringing it close to an ATI score of 1.0. However, there remains a pressing need for India to focus on key areas such as crop diversification, agricultural labour productivity, and food system expansion (Figure 4). These three factors currently exhibit lower individual ATIs compared to the composite score, indicating opportunities for further enhancement in agricultural transformation.

Table 1: Component-wise Agricultural Transformation Index of India

Years	ATI Composite	Staples productivity C1	Crop diversification C2	Agricultural labour productivity C3	Food system expansion C4
2000	0.374	0.619	0.361	0.381	0.134
2001	0.392	0.632	0.396	0.398	0.143
2002	0.418	0.636	0.474	0.381	0.182
2003	0.399	0.642	0.370	0.408	0.175
2004	0.400	0.639	0.357	0.412	0.193
2005	0.373	0.650	0.213	0.427	0.203
2006	0.375	0.660	0.184	0.430	0.226
2007	0.380	0.680	0.159	0.440	0.240
2008	0.397	0.698	0.200	0.435	0.256
2009	0.404	0.717	0.188	0.430	0.281
2010	0.425	0.733	0.225	0.448	0.292
2011	0.434	0.749	0.222	0.471	0.293
2012	0.483	0.774	0.369	0.483	0.307
2013	0.486	0.806	0.330	0.497	0.311
2014	0.507	0.832	0.356	0.498	0.343
2015	0.493	0.844	0.249	0.501	0.377
2016	0.497	0.845	0.250	0.520	0.372
2017	0.498	0.849	0.231	0.538	0.376
2018	0.527	0.868	0.298	0.547	0.395
2019	0.547	0.902	0.352	0.560	0.375
2020	0.558	0.938	0.413	0.550	0.332
2021	0.592	0.968	0.499	0.551	0.351

Source: IFPRI 2024

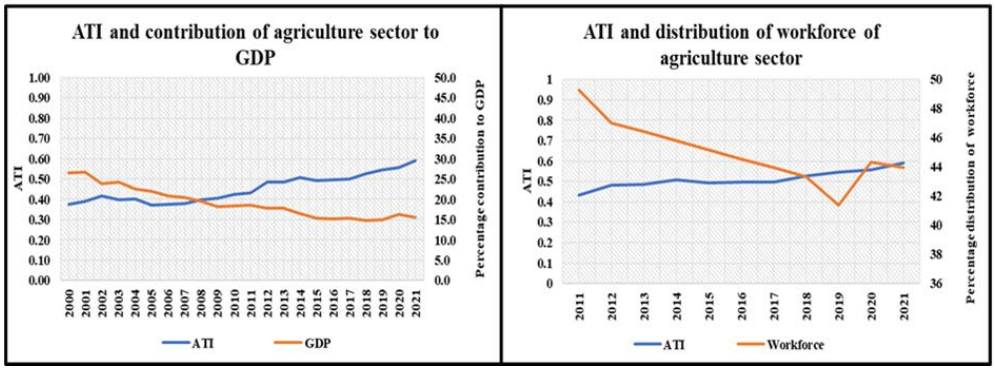
Figure 4: Component-wise trend of ATI in India.



Source: IFPRI 2024

As countries develop, the role of agriculture in the economy and employment changes. In developing countries, agriculture has a large but shrinking share, while in developed countries, it has a smaller but more stable share (van Arendonk, 2015). Agricultural transformation is closely linked to a country's GDP, as a successful transformation can significantly contribute to economic growth by increasing productivity, generating surplus food for export, and freeing up labour to move into other industries, ultimately leading to a decrease in the agricultural sector's share of overall GDP as the economy diversifies; essentially, a more productive agriculture sector can facilitate a shift towards a higher GDP overall. Figure 5 depicts that ATI of India is increasing with a decreasing contribution of the agriculture sector to GDP and distribution of workforce in agriculture. Shifts in workforce from the agriculture to other sectors are not significant in India therefore, the absorption of labour force in agriculture is more than its potential.

Figure 5: ATI and contribution of the agriculture sector to GDP and distribution of workforce to the agriculture sector.



Source: IFPRI 2024; GoI 2024a; GoI 2024b; GoI n.d.

Table 2 illustrates the correlation coefficients between the Agricultural Transformation Index (ATI) and three essential economic indicators: GDP, the percentage of agricultural share in GDP, and the absolute monetary value of the agriculture share in GDP across various income groups. A significant positive correlation is observed between ATI and both GDP and the absolute agricultural share in GDP. However, a significant inverse relationship was identified between ATI and the percentage of agriculture share in GDP. This correlation does not hold for Costa Rica and Lebanon, which fall under the upper-middle-income category, although the reverse relationships were not deemed significant at the 0.05 percent level. Interestingly, a significant positive relationship was found between ATI and the percentage of agricultural share in GDP, specifically in the Dominican Republic.

Table 2: Correlation between ATI and GDP

	Countries		GDP	Percentage of agriculture share to GDP	Absolute agriculture shares to GDP
Agricultural transformation index	HIC	UAE	0.688*	-0.425*	0.706*
		Chile	0.945*	-0.462*	0.923*
		Czech Republic	0.784*	-0.494*	0.823*
	UMIC	Dominican Republic	0.925*	0.582*	0.927*
		Costa Rica	-0.115	0.200	-0.213
		Lebanon	-0.068	0.180	-0.087
	LMIC	Egypt	0.890*	-0.794*	0.848*
		Indonesia	0.984*	-0.720*	0.980*
		Ukraine	0.631*	-0.251	0.790*
		India	**0.939***	**-0.799***	**0.949***
	LIC	Malawi	0.867*	-0.806*	0.794*
		Rwanda	0.951*	-0.855*	0.935*
		Ethiopia	0.958*	-0.577*	0.962*

Source: Authors' Calculations based on World Bank (n.d.-a), World Bank (n.d.-b)
Note. Values with (*) show significance at the 0.05 level
HIC-High-income countries, UMIC- Upper-middle income countries, LMIC- Lower-middle income countries, LIC- Low-income countries

Key Constraints to India's Agricultural Transformation: India is set to become the most populous country, presenting a significant challenge for its agriculture to feed this growing population. This challenge is further compounded by emerging issues such as climate change and the degradation of natural resources like air, water, and land.

Indian agriculture is lagging in three out of four components of the agricultural transformation index. The sector encounters numerous challenges, including small and fragmented land holdings, limited physical, human, and financial resources, and inadequate access to essential information and expertise. The availability of advanced technology and infrastructure is insufficient, and there is a lack of markets for diversified crops. Additionally, farmers often encounter limited crop insurance and credit access and insufficient institutional support. Tackling these challenges is vital for enhancing the sustainability and productivity of agriculture in India. (Keller et al., 2024; Shah et al., 2020).

Though agriculture in India is a main source of livelihood, a significant portion of the farming community consists of small landholders. The average size of farms is approximately 1.08 hectares (2.67 acres) according to the Agriculture Census of 2015-2016. Unfortunately, the advantages of mechanization are largely limited to farmers with larger land holdings, as the small and fragmented nature of many farms makes it economically unfeasible to adopt such technology.

As individual farm sizes continue to decrease, the ownership of agricultural machinery becomes less viable, leading many small landholders to rely on traditional farming methods and a limited variety of crops. A considerable amount of agricultural land in India is dedicated to staple crops such as rice and wheat. Factors such as limited awareness of technological benefits, resistance to change, high costs, and insufficient infrastructure obstruct the acceptance of advanced farming practices. This ultimately hinders efforts to enhance sustainable agricultural production (Damerji & Salimi, 2021; Gulati et al., 2023; Khaspuria et al., 2024; Pandya & Lal, 2023).

Efficiency in agriculture is largely driven by strong and vibrant research and development (R&D) as well as robust infrastructure (Gulati et al., 2023). These elements are essential for meeting the demand for diversified food supplies. However, R&D and infrastructure projects in agriculture require significant upfront capital, long development periods, and ongoing financial support. These factors are often viewed as high-risk with low returns on investment, which can lead to a lack of motivation and inspiration in these areas (Chand, 2019). Additionally, the National Agricultural Research System (NARS) in India faces structural challenges that hinder the establishment of a globally competitive R&D infrastructure (Jha, 2022).

An assessment conducted by the Central Groundwater Board (CGWB) in 2017 evaluated the groundwater table in 6,584 units (blocks) across various states in India. The findings revealed that 1,034 units are classified as 'over-exploited,' 253 as 'critical,' and 681 as 'semi-critical' (CGWB, 2017). Several factors are restricting agricultural growth, including the depletion of the water table, uneven rainfall distribution, inefficient irrigation practices, a significant and growing gap between the irrigation potential created and utilized, frequent droughts, and the overuse of groundwater (Jain et al., 2019).

Value chain development and marketing platforms are essential for connecting food from farm to fork. This involves strategies to minimize post-harvest losses and waste, enhance value through on-farm processing, and ensure effective warehousing and storage. Establishing cold chains and maintaining high product quality is vital, all while striving for a goal of zero waste.

India's agriculture market remains fragmented due to numerous intermediaries, which leads to high transaction costs. Several factors contribute to this issue, including high commissions for agents, mandi charges, insufficient investments in supply chains, poor logistics, information asymmetries, and inadequate storage. The connection between producers and markets is weak, particularly in both rural-to-rural and rural-to-urban settings (Gulati et al., 2023), especially affecting non-staple crops. This situation is further complicated by the absence of processing facilities, which play a significant role in undermining the development of strong value chains. Such weaknesses hinder efforts toward crop diversification and the overall expansion of food systems. India currently has a surplus in many agricultural commodities and needs to access foreign markets to sell this excess produce, thereby preventing a decline in agricultural product prices. Farmers often do not receive fair prices for certain crops because the markets are not competitive. Furthermore, a lack of sufficient data on market prices and trends restricts farmers' ability to make informed decisions (Jashwant, 2024).

A significant portion of the rural workforce remains dependent on agriculture, which leads to an over-reliance on this sector and limits diversification into non-farm activities (Pandey & Raman, 2012). This dependency exacerbates issues of unemployment and underemployment, especially during the off-season in agriculture. The weak integration between agriculture and the rural non-farm economy restricts opportunities for income diversification through non-farm activities (Kumar et al., 2020) and reduces incentives for productivity improvements.

India is currently experiencing severe climate change impacts, including frequent droughts, floods, and temperature fluctuations. These uncertainties disrupt agricultural livelihoods, driving many rural youths to migrate to urban areas (Divakar et al., 2019). Meanwhile, the expansion of urban areas and industrial activities often encroaches on agricultural land, reducing the availability of arable land and creating potential conflicts over resource use. Additionally, the lack of integration between agriculture and other economic sectors limits opportunities for value addition.

IV. Conclusion

Transformation in Indian agriculture is a complex and ongoing process. While significant progress has been made in recent decades, challenges remain. It is needed to focus on crop diversification, enhancing agricultural productivity (land and labour), and food expansion systems to upgrade the agricultural transformation index and attain a sustainable agriculture system. India has made considerable strides in enhancing access to cereals, yielding notable successes in this area. However, diversifying agricultural practices on farms could serve as an effective strategy. This shift from solely focusing on cereals towards a more varied approach could better support farmers and improve their livelihoods. Transforming agriculture from a low-productivity subsistence-based method to a high-productivity market-oriented approach to enhance the livelihood and income of farmers is vital. Farming must be treated as an enterprise, and future agricultural development will have returns, not just the output from the farm, as its primary objective.

Enhancing budgetary allocation to the agriculture sector, including water resources, related infrastructure, and institutions, especially in research, education, and extension for agrarian development; streamlining the various linkages is required to ensure international collaborations and sound institutional support.

Agricultural constraints in India are impeding growth, resulting in widening income disparities and inequality. Although the intensification of inputs has considerably boosted yields and ensured cereal security, it has also led to significant environmental challenges. This creates a dilemma between productivity and sustainability. To promote long-term health in India's agriculture and economy, a comprehensive approach that addresses technology, infrastructure, markets, diversification, credit, and sustainability is essential.

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