Logistics in India's Farm Sector

Logistics in India's Farm Sector:

An Input-Output Approach

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Dedicated to my Family

You can’t build a peaceful world on empty stomachs
and human misery.”
—Norman Borlaug

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PREFACE

This book is composed of eight chapters. The first chapter motivates the study of India's logistics services phenomenon and questions its relevance to the primary sector. The second chapter analyses the development theories related to the interaction of sectors. Chapter third states the compilation of the Input-Output Table of India, focusing on the 2019 data. The fourth chapter states the overall logistics performance in India in the context of global indicators with the help of appropriate data and analysis. The findings argue that India's logistics performance lags behind top countries, necessitating improved logistics infrastructure to enhance agricultural efficiency, food security, market access, and global competitiveness. The fifth chapter establishes the backward and forward linkages between the farm sector and logistics based on Hirschman's backward and forward linkages theoretically and Leontief and Ghosh's Model mathematically. The findings show that backward and forward logistics linkages emphasize the critical role of road and financial services in agriculture, highlighting the need for better storage, warehousing...etc., to improve efficiency. The sixth chapter empirically states the functional efficiency of the highly linked primary products to logistics based on the Input-Output model. The findings argue that strong linkages between agriculture and road transport stress the need for efficient rural infrastructure and logistical flexibility. The increasing reliance on financial and communication services and minimal use of water and air transport indicate areas for operational adaptation. The seventh chapter identifies the high elasticity of primary products to the logistics costs in India. Chapter eight presents the concluding remark of the study. The study concludes that in scenarios where resources are limited and certain sectors show strong sectoral linkages, the focus should be on those sectors. However, this should not completely overshadow the importance of other sectors, especially in maintaining long-term stability and inclusive growth and development. The organization of the chapters in the thesis is such that each objective of the study has its separate introduction, methodology, models, and tools, followed by analysis and conclusion. This is necessary as each objective has its own methodology and technique.

CHAPTER I

INTRODUCTION

1.1 Status of Agriculture in India

The farm sector in India plays a quintessential mantle in the exercise of poverty alleviation, ensuring food security, employment generation and accomplishing Sustainable Development Goals (SDGs) (Nookathoti, 2012; Swaminathan, 2015). Agricultural sustainability is the base of sustainable development (Nookathoti et al., 2023). Transforming traditional societies commanded by conventional farming is indispensable to spearheading inclusive growth[1] (Pingali, 2012). The expansion of market avenues is very much crucial for agricultural growth (Barrett et al., 2017). A robust agrarian sector is vital for the overall advancement of the economy. Agriculture plays a paramount role not only in providing sustenance but also in ensuring adequate nutrition for a healthy and active life (Hawkes & Ruel, 2006). The phenomenon of agriculture extends beyond mere survival, as it significantly contributes to revamp rural livelihoods. The practice of agriculture is very much central in maintaining the agro-ecological[2] balance and biodiversity[3]. It ensures the optimum utilization of scarce natural resources, which leads to sustainability[4] and social security[5] (Food and Agriculture Organization, 2013; Sharma & Bhaduri, 2009).

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[1]**Inclusive Growth:** It means that all members of the society benefit from the economic expansion in the economy. It ensures equal access to opportunities and resources.

[2]**Agro-ecological:** Sustainable way of farming practices combining natural processes-which reduce the risk of biodiversity loss.

[3]**Biodiversity:** Biodiversity refers to all living organisms on the earth, including different species, genetic variations, and ecosystems.

[4]**Environmental Sustainability:** Sustainable way of managing the natural resources without compromising the ability of future generations to meet their needs.

[5]**Social security:** Social security is a system of government programs to provide financial support to the needy person in society.

Further, agriculture supplies raw materials for various economic activities, like industries to trade and commerce, reflecting its critical role in the global economic ecosystem. They have been described as the forward linkages (World Bank, 2012). However, the farm sector also plays a dual role concerning climate change[6]. In fact, it has been a victim of climate change as it has been a significant contributor to Green House Gas (GHG)[7] emissions (FAO, 2016; Intergovernmental Panel on Climate Change, 2014; Smith et al., 2014; Vermeulen et al., 2012). This dichotomy indicates the dire need for the agricultural sector to adapt to the spillover effects of climate change and implement practices to mitigate the carbon footprint (IPCC, 2014).

The challenges and opportunities within the farm sector are also dynamic. It varies significantly across regions and countries. While some challenges are universal, others are specific to particular countries or regions due to the diverse nature of agricultural systems and contexts (FAO, 2013). Significant export growth[8] from developing countries driven by the expansion of the global economy has been on the rise (Hanson, 2012; United Nations Conference on Trade and Development, 2019). However, the growth rate[9] of the agricultural sector often lags behind that of the manufacturing and service sectors. These are the areas for development and policy focus (World Bank, 2012).

[6]**Climate Change:** Climate change is the significant change in temperatures and weather patterns over time. It is largely driven by human activities such as burning fossil fuels, deforestation...etc.
[7]**Green House Gas (GHG):** Gas that traps heat in the Earth's atmosphere. It leads to global warming.
[8]**Export Growth:** The increase in the value or volume of goods and services that a country sells to foreign markets over a specific period.
[9]**Growth Rate:** This is an indication of the speed at which a matric grows. It measures the change in value or volume of a specific metric, which can be expressed as a percentage change over a period of time.

Table 1-1

Structure of the Economy-Gross Domestic Product (GDP) and Employment

Year	Primary		Industry		Service	
	% GDP	% Employment	% GDP	% Employment	% GDP	% Employment
2011	17.2	49.3	30.2	23.1	45.4	27.6
2012	16.8	47.0	29.4	24.4	46.3	28.6
2013	17.1	46.4	28.4	24.4	46.7	29.1
2014	16.8	45.8	27.7	24.5	47.8	29.7
2015	16.2	45.2	27.3	24.6	47.8	30.3
2016	16.4	44.5	26.6	24.7	47.7	30.8
2017	16.6	43.9	26.5	24.8	47.7	31.2
2018	16.0	43.3	26.4	24.9	48.4	31.7
2019	16.8	41.4	24.6	25.4	50.1	33.2
2020	18.6	44.3	25.0	23.9	48.1	31.8
2021	17.3	44.0	26.1	25.3	47.9	30.7
2022	16.7	45.8	25.7	24.0	48.4	30.2
2023	17.6	43.0	27.6	24.3	54.9	32.7

Source: World Bank Indicator, 2024; Statista, 2024; MoSPI, 2024; Economic Survey of India, 2022-23

The transition in the Indian economy can be assessed from the sector's respective shares in Gross Domestic Product (GDP)[10] and employment across the observed period. There has been a shift in the broader economic structure of the Indian economy. This is the broader global trend typically

[10]**Gross Domestic Product (GDP):** The total monetary value of all goods and services produced within a country in a specific time period.

observed in transitioning economies. Specifically, the agriculture sector experiences fluctuations over the period. There has been a gradual decline in the agricultural sector's share of GDP from 17.2 per cent in 2011.

Despite this, agriculture remains a significant employment hub, initially encompassing 49.3 per cent of the workforce, with a decreasing trend towards 43 per cent by 2023. This dichotomy between GDP contribution and employment share emphasizes the sector's lower productivity[11] and a persistent challenge in reallocating labour to more productive sectors (Gollin et al. 2002). The decline in agriculture's share of GDP also states the sector's diminishing role as an economy develops (McMillan & Rodrik, 2011). However, the decreasing trend contrasts with the rapid transitions in some East Asian economies, indicating a more gradual or incomplete structural transformation[12] (Byerlee et al., 2009) (See Table 1-1).

Conversely, the industrial sector has shown a decelerating trend in its GDP share. The share decreased from 30.2 per cent in 2011 to a low of 25.7 per cent in 2022. There has been a recovery beyond 2022. Despite the reduced GDP contribution, the sector's employment share has witnessed a surge. There has been a misalignment between labour intensity and value addition. These inefficiencies are in a transitional phase where the industry is struggling to improve productivity while absorbing more labour. The significant decline in the industrial sector's GDP share reflects broader trends of de-industrialization in certain developing contexts before achieving higher income levels (Rodrik, 2016). This premature de-industrialization of rising employment share despite a falling GDP share, could hinder growth prospects due to labour-intensive growth without corresponding productivity gains (Szirmai, 2012) (See Table 1-1).

The service sector has emerged as the backbone of the economy. The sector maintains a progressively increasing share of 45.44 per cent in 2011 to 50.08 per cent in 2019. This growth is the sector's rising dominance and alignment

[11]**Productivity:** A measure of the efficiency of production, often quantified as the ratio of output to inputs.

[12]**Structural Transformation:** Structural Transformation refers to the shift of economic activity from agriculture to industry and services, which is commonly linked to economic development.

with global trends toward service-oriented economic structures. Correspondingly, employment in the service sector expanded from 27.63 per cent to 33.24 per cent during the same period (See Table 1-1).

Hence, the sector has a growing role in the output and job creation. The structural transformation, where economies evolve from primary to secondary and then services—is a step toward modern economic development. The growing service sector signifies the global trends and theoretical expectations of advanced economic stages of development (Clark, 1940; Fisher, 1935). The increasing share of employment in the service sector further confirms its expanding role in transitioning economies (Cuñat & Melitz, 2012). However, the productivity and development impact of service sector growth can vary significantly depending on the sector's composition and knowledge intensity (Eichengreen & Gupta, 2013).

The observed sectoral shifts correlate with the structural change theory proposed by Lewis (1954) and later expanded by Kuznets (1966). These theories suggest that economic development is characterized by labour moving away from traditional agricultural activities to more productive industrial and service sectors. The transition accompanied by urbanization and technological advancement is theorized to increase overall productivity and economic growth[13] (Timmer et al., 2014). Herrendorf, Rogerson, and Valentinyi (2013) reinforce this model by demonstrating how countries with significant movements from agriculture to services have experienced growth.

Hence, strategies should focus on increasing productivity and facilitating labour reallocation in agriculture (Dethier & Effenberger, 2012). This involves investments in rural infrastructure, education, and agricultural technology. For the industrial sector, policies aim to enhance higher-value-added manufacturing and address skill mismatches (Lin & Monga, 2011). For services, there has been a dire need to promote high-productivity sectors such as IT and financial services (Ghani & O'Connell, 2014).

[13]**Economic Growth:** An increase in the production of goods and services in an economy over a period of time measured by GDP.

Table 1-2

Sectoral Growth Rate and GDP

(Unit = %)

Year	Primary	Industry	Service	GDP
2011	6.4	3.6	5.9	5.2
2012	1.5	3.3	8.3	5.5
2013	5.6	3.8	7.7	6.4
2014	-0.2	7.0	9.8	7.4
2015	0.6	9.6	9.4	8.0
2016	6.8	7.7	8.5	8.3
2017	6.6	5.9	6.3	6.8
2018	2.1	5.3	7.2	6.5
2019	6.2	-1.4	6.4	3.9
2020	4.1	-0.9	-8.2	-5.8
2021	3.5	11.6	8.8	9.1
2022	4.0	4.4	9.5	7.2
2023	4.4	2.1	10.0	7.6

Source: World Bank Indicator, 2024; PIB Report, 2024; MoSPI, 2023

The sectoral growth rates impact the overall GDP in the economy. The annual growth rates[14] of three broad sectors-agriculture, Industry, and Services against the backdrop of general GDP growth identify the underlying patterns and their wider economic implications. The agricultural sector shows varied growth rates, such as 6.8 per cent in 2016 and declining to -0.22 per cent in 2014. The sector's fluctuations exhibit sensitivity to external factors such as climatic conditions, global commodity prices, and domestic agricultural policies. Agriculture's role in providing the initial capital and labour force necessary for industrial growth suggests that fluctuations in this sector can have far-reaching implications on overall economic stability and development (Timmer, 1988) (See Table 1-2).

The industrial sector has shown significant growth in India, particularly in 2015, with a 9.58 per cent increase. However, the sector faced a downturn in 2019 and 2020 due to global economic slowdown or internal structural issues. The industrialization process is central to economic catch-up and

[14]**Annual Growth Rate:** The percentage change in the value of a variable annually.

transformation despite the challenges like technological adoption and global competition (Szirmai, 2012). The services sector consistently shows strong growth, especially during 2014 and 2015, with growth rates exceeding 9 per cent. This sector's resilience, despite other sectors' downturn underlines its growing importance in modern economies. Services can act as a leading sector for growth in the later stages of development (Gollin et al., 2002). The trend of GDP growth is the combined impact of all three sectors, with noticeable contractions in 2020. This shows the economy's vulnerability to external shocks, such as global financial downturns or pandemics. The recovery in 2021 with a 9 per cent growth rate is possibly the result of policy interventions or global economic recovery. This pattern emphasizes the interlinkages and overall economic health (See Table 1-2).

The varying performance of the agricultural sector and its implications for economic stability can be contextualized within the debates on farm modernization and its role in economic development (Johnston & Mellor, 1961). Similarly, the industrial sector's trends reflect theories of industrialization and structural change (Lewis, 1954; Rodrik, 2016). In comparison, the growth of the services sector aligns with the post-industrial economy theories (Bell, 1973). These concepts derive from different views on economic development and sectoral growth. Classical economist Rostow (1960) states stages of economic growth. The theory states that shifts in sectoral dominance are a natural progression of economic maturity. This perspective is complemented by more modern theories like the Structural Change Theory (Herrendorf et al., 2014). This theory emphasizes reallocating labour and capital from less to more productive sectors as a crucial factor in growth.

The economic transition from traditional agriculture to a more diversified economic structure where industry and services play pivotal roles is advisable. However, this transition has its challenges, as indicated by the changes in sectoral growth rates and their impacts on overall GDP. Though the salience of the agricultural sector in India has declined since 1991, it still has a quintessential role from a socio-economic point of view (Saikia et al., 2024). It shows the importance of balanced growth across sectors. Moreover, there is a need for strategies to address sector-specific challenges

and the potential of the services sector as a key element for future economic growth.

Table 1-3

Land Use Pattern in Agriculture

Years	Arable land	Forest area	Permanent Cropland	Total Agricultural Land	Irrigated Land
2011	52.8	23.5	4.2	35.4	35.4
2012	52.7	23.6	4.3	36.3	36.3
2013	52.6	23.6	4.4	36.8	36.8
2014	52.6	23.7	4.4	37.9	37.9
2015	52.6	23.8	4.4	38.1	38.1
2016	52.6	23.9	4.4	37.5	37.4
2017	52.4	24.0	4.4	38.3	38.3
2018	52.3	24.1	4.5	38.8	38.8
2019	52.3	24.2	4.5	40.0	40.0
2020	51.9	24.3	4.6	42.3	42.3
2021	51.9	24.4	4.6	42.3	42.3
2022	51.8	24.5	4.7	43.2	43.2
2023	51.7	24.6	4.7	43.5	43.5

Source: World Bank Indicator, 2024; Agricultural Statistics at a Glance 2022: MoSPI Agricultural Statistics. (Unit = Arable land, Forest area, Permanent cropland and Total Agricultural land = Percentage of land area; Irrigated land = Percentage of total agricultural land)

The agricultural land use patterns show the changes observed in the percentage of arable land. Over the observed period, there has been a gradual decrease in arable land while forest areas gradually increase. Permanent cropland also experiences a steady rise. These changes contrast with a significant increase in total agricultural land and irrigated agricultural

land. The stability in the percentage of forest area shows the effectiveness of forest conservation policies and sustainable management practices in preserving forest ecosystems and biodiversity (Angelsen et al., 2014; Liu et al., 2018). This stable forest area percentage supports the Environmental Kuznets Curve hypothesis. This hypothesis states an inverted U-shaped relationship between environmental degradation and income levels. Hence, the effort to conserve forests may become more intense as countries reach higher income levels (Stern, 2004) (See Table 1-3).

The gradual increase in the percentage of permanent cropland enhances agricultural resilience and adaptation to climate change (Mueller et al., 2012; Rosenzweig et al., 2013). The information obtained from changes in arable land can be contextualized within the framework of the Von Thünen model. This model explains how land use decisions are influenced by proximity to markets, transportation costs, and fertility of the land (Von Thünen, 1826). The analysis emphasizes the importance of integrated land use planning approaches that consider socio-economic, environmental, and policy factors (Lambin et al., 2014; Verburg et al., 2015). This approach will optimize land use efficiency and promote sustainable agricultural development. Strengthening forest conservation policies is also crucial for preserving forest ecosystems, mitigating climate change, and safeguarding biodiversity (Chazdon et al., 2009; Gaveau et al., 2016) (See Table 1-3).

The increase in the Agricultural Total Factor Productivity (Ag TFP) index from 92 to 116 between 2011 and 2021 indicates a significant improvement in the efficiency of input usage. This matches the theoretical expectations of enhanced productivity through technological and managerial advancements. The output index's growth from 92 to 126 over the same period indicates the increased agricultural production, potentially due to better farm practices, crop diversification, and expansion in areas like aquaculture and livestock. This growth is particularly noteworthy given the relatively moderate increase in the input index from 100 to 109. This states that the output growth has been achieved with a less than proportionate spurt in inputs. This is a positive indicator of rising productivity and efficiency. The Labour trends in the table show a reduction from 108 to 104. This indicates labour migration from rural to urban areas or from agricultural to non-agricultural sectors (See Table 1-4).

Table 1-4
Growth in Agricultural Output, Input, and Total Factor Productivity

Year	Agri TFPG	Output	Input	Labour	Capital	Material
2011	92	92	100	108	78	92
2012	95	94	99	104	85	92
2013	99	98	99	103	91	94
2014	101	101	100	101	96	101
2015	100	100	100	100	100	100
2016	104	104	100	99	105	104
2017	110	110	101	97	110	110
2018	115	115	101	96	115	111
2019	114	118	104	98	121	120
2020	115	122	106	100	128	128
2021	116	126	109	104	132	123

Source: World Bank Indicator, 2024. (Units: Agri TFPG (Total Factor Productivity Growth): Index (2015=100); Output: Index (2015=100); Input: Index (2015=100); Labour: 1000 persons; Capital: 1000 constant 2015 USD; Material: Index (2015=100)

The strong increase in the capital index from 78 to 132 indicates a significant investment in agriculture through government policies and private sector engagement. Additionally, the increase in the materials index from 92 to 123 indicates the enhanced use of inputs such as seeds, fertilizers, and pesticides. These inputs, combined with the increased capital investments, could have contributed to the overall growth in agricultural output. The theoretical basis of agricultural productivity and growth can be traced back to agricultural development models proposed by Schultz (1964) and Binswanger-Mkhize (2010). These theories emphasize the role of technological innovation, capital and efficient resource allocation in enhancing agricultural productivity (See Table 1-4).

Total Factor Productivity (TFP), which measures the output growth relative to the growth of all inputs used in production, is central to this discourse. According to these theories, TFP growth is crucial for sustainable agricultural development as it signifies improvements in efficiency and technological advancement. The significant determinants of agrarian

productivity include Labour dynamics, investments, and material inputs. The impact of infrastructure development and technology adoption in the agricultural sector is also substantial (Birthal et al., 2005; Kumar et al., 2012). Moreover, the market reforms also shape the patterns of farm inputs and outputs in India (Chand et al., 2017). The improvements in TFP and output, along with Labour and capital investment dynamics, reflect the complex interplay of policy, market forces, and technological advancements. This analysis stresses the importance of continued investment in agricultural technologies, effective policy frameworks, and infrastructure development to sustain and further enhance productivity and growth in India's agricultural sector (See Table 1-4).

1.2 Climate Change and Agriculture

India's exposure to natural disasters is significant, with a considerable population of the country vulnerable to various calamities. Specifically, 59 per cent of India's landmass is at risk of earthquakes, 8.5 per cent is vulnerable to cyclones, and 5 per cent is susceptible to river basin floods. Additionally, droughts have significantly impacted the country's agricultural output, particularly during the early and mid-2000s and also in recent years (Ranuzzi & Srivastava, 2012). Climate change is expected to worsen these challenges considerably. Projections for India by mid-century include an increase in the average surface temperature by 2 to 4 degrees Celsius, fluctuations in the rainfall patterns during monsoon and non-monsoon months, and an increase in the frequency and intensity of droughts and floods. These aberrations are expected to cause shifts in the ecosystem, with the northeastern region of India becoming wetter and the northwestern region becoming drier (Ranuzzi & Srivastava, 2012).

The agricultural sector in India is already up against a significant stress due to the widening gap between water supply and demand, land degradation, and air pollution. This sector is particularly vulnerable to the impacts of climate change. Most of India's agricultural land relies on rainfall, making it highly sensitive to changes in monsoon patterns. Additionally, the prevalence of small and marginal farmers, who typically have lower capacities to adapt to climate change, exacerbates the challenges confronted by the agricultural sector. Without adaptation or mitigation, land productivity

for most crops is expected to decrease by 10 per cent to 40 per cent by the end of the century, with significant reductions anticipated for vital crops such as rice, wheat, maize, cotton, sugarcane and vegetables. For instance, irrigated rice yields in Haryana and Punjab are projected to decline by about 16 per cent by 2050. Higher temperatures and more intense monsoons are expected to stimulate the development of pests and parasites, which will adversely affect crop yields. This is particularly concerning for rainfed rice in the north-west region, where yield declines are projected to range from 7 to 22 per cent by 2080 (Shrivastava, 2016; Soora et al., 2013).

Kharif crops, grown during the monsoon season, are likely to witness increased exposure to rainfall volatility and droughts. Conversely, Rabi crops, sown in winter, are expected to be particularly sensitive to low-temperature stress. Under various irrigation stress and climate change scenarios, the production of sugarcane, cotton, and vegetables could decrease by 15 to 25 per cent by 2050 compared to a scenario without water stress or climatic shocks (Central Research Institute of Dryland Agriculture, 2013; Organization for Economic Co-operation and Development, 2017). The livestock sector, which significantly contributes to GHG emissions in India, is also impacted by climate change. Temperature is expected to cause distress to dairy animals, potentially resulting in a 10 to 25 per cent loss in milk production in Haryana by mid-century. Heat stress from high ambient temperatures and excess humidity during summer is also likely to adversely affect the reproductive performance of farm animals (Government of Haryana, 2011).

Economically, India is expected to suffer more from the perils of climate change than many other regions. Yield losses for wheat and rice could be nearly twice as high in India compared to Southeast Asia, China, or the global average. This will significantly impact trade, with exports projected to contract by 6 per cent and imports by 4 per cent, relative to worldwide average. Additionally, production costs in India are forecast to increase significantly more than those of its trading partners, negatively affecting the country's overall competitiveness in the global market (Delink et al., 2017). The combined effects of climate change could create a formidable challenge to the economy in general and farming in particular. Addressing these issues requires detailed strategies that include climate adaptation and mitigation

measures, as well as support for the agricultural sector and small-scale farmers.

1.3 Background and Motivation

The major sectors of an economy are interlinked in terms of mutual supply of inputs and output. There are two types of linkages: Consumption or Demand and Production or Technological linkages (Bhardwaj, 1973; Dhawan & Saxena, 1992; Hirschman, 1981; Rasmussen, 1956). The demand linkages arise from the interdependence of the sectors for meeting final consumption. This linkage among the sectors operates through factor incomes. For instance, as agricultural income increases, there will be a corresponding increase in the demand for industrial consumption[15] and capital goods[16], such as water pumps, tractors, fertilizers, pesticides as well as different services such as trade, transport, communication, banking and insurance, hotel and restaurant...etc. (Keynes, 1936; Kuznets, 1966; Samuelson, 1952). It is a Keynesian framework that argues for the stimulation of effective demand[17] by expanding complex industries.

Industrial expansion generates and distributes income among various stakeholders, which further increases the demand for the output produced by industries. For example, a good harvest in a given year would increase income for farmers, who in turn, with their higher income, would stimulate demand for products manufactured by industries, such as tractors and motorbikes (Hirschman, 1958; Murphy et al., 1989; Rosenstein-Rodan, 1943). Similarly, an increase in the demand for output produced by the secondary sector would lead to income generation for industrial workers, who, in turn, would create demand for goods such as electrical appliances and further expenditure on services offered by the tertiary sector (Blanchard, 2017; Mankiw, 2014; Samuelson & Nordhaus, 2009).

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[15]**Consumer goods:** Consumer goods refer to products purchased by individuals for household consumption.

[16]**Capital Goods:** Capital goods are those which are used in the production of other goods and services.

[17]**Effective demand:** The total demand for goods and services in an economy supported by the purchasing power and willingness to pay of consumers.

On the other hand, production or technological linkages refer to the methods by which output is produced across various sectors. These linkages arise from the interdependence of sectors to meet the needs of their productive inputs (Arrow, 1962; Romer, 1986; Rosenstein-Rodan, 1943). Understanding these linkages is essential for grasping the structural dynamics of economic development and industrialization (Chenery & Taylor, 1968; Young, 1928). They state the importance of coordinated sectoral growth and the role of government in facilitating such coordination (Lewis, 1954; Prebisch, 1950; Singer, 1950;). Empirical studies have validated the significance of these linkages in promoting overall economic growth and development (Balassa, 1985; Feder, 1982; Hirschman, 1958; Krugman, 1991; Nurkse, 1953; Singer, 1950).

A production activity absorbs inputs from other sectors; whenever it operates at a positive output level, it stimulates the production of the input-providing industries. This type of linkage is termed a backward linkage (Bhardwaj, 1966; Hirschman, 1958). If the sector that provides inputs to other sectors can reduce the price of its output through greater efficiency of production or economies of scale, it can initiate or increase the output levels of the industries that use its output. This type of linkage is known as a forward linkage (Leontief, 1963; Rasmussen, 1956). In this context, sectors with the strongest backward linkages are identified as key sectors; these sectors stimulate the expansion or initiation of new firms more rapidly, and therefore, it is argued that investment policies should focus more on such key sectors (Chenery & Watanabe, 1958). This contrasts with the views of Ragnar Nurkse (1953), who advocates for simultaneous growth in all sectors of the economy. While the conceptual framework of linkages is logical, quantifying such linkages is challenging (Jones, 1976; Tiffin & Irz, 2006).

Agricultural products are essential in the world economy (FAO, 2019). Farm produce serves various customer demands, such as food and biofuel (Bauen et al., 2009; Smith, 2017). However, if the escalating demand for agricultural products is not complemented by good post-harvest handling and management of agrarian waste, it can become entangled (Parfitt et al., 2010). A significant portion of agricultural waste consists of harvest residues, including stalks, straws, leaves, roots, and husks, as well as perishable leftovers and unconsumed products (Gunders, 2012; Stuart,

2009). These residues could be valuable resources if appropriately utilized. They can be converted into heat, steam, charcoal, methanol, ethanol, or biodiesel (Bridgwater, 2012; Kumar et al., 2009). Utilizing these residues and reducing agricultural waste can significantly precipitate farmers' revenue (Klerkx & Proctor, 2013). Additionally, production costs can be dipped down by leveraging buyers' resources, such as the transfer of technical expertise, specialized inputs, or credit to farmers (Poulton et al., 2010; Swinnen & Maertens, 2007).

It should also be noted that many agricultural activities are a series of linked interactions or activities that involve multiple actors, such as supplying agricultural inputs, cultivating, harvesting, post-harvest handling, transporting, processing, marketing, and distributing (Barrett, 2008; Kumar & Post, 2012). Coordination within the supply chain chain is crucial, as it focuses on various functions (Swinnen & Maertens, 2007). In the agriculture sector, effective coordination is critical due to the unique characteristics of the agri-chain, including seasonality, perishability, safety, and traceability factors throughout an end-to-end supply network (Taylor, 2006; Van, 2000). Bijman et al. (2006) have noted that increased inter-organizational collaboration in the food supply chain should be emphasized due to the rise of food safety as a prominent societal issue, the close resemblance of raw materials in food distribution to the final product, and the inherent perishability of agricultural products.

The supply chain of agricultural products has become a significant issue due to the expanding public awareness and concern about the availability and safety of the food they consume (Aung & Chang, 2014). The shifting behavior of consumers indicates that they are highly aware of their needs and the value they expect from products. Today, consumers of agricultural products demand more information not only on the availability of products but also on the cultivation, marketing, distribution, transportation, and processing activities (Hobbs, 2020; Vermeulen et al., 2012). The growing demand for transparency is closely tied to the concerns about public health, especially in the light of historical instances of product contamination. This has significantly influenced consumer behavior (Caswell & Mojduszka, 1996; Jaffee & Henson, 2005).

Therefore, a firm needs to facilitate value creation. Under certain circumstances, a firm has an opportunity to create value with its consumers. In the process of co-creation of the value, firms and consumers interact and have opportunities to influence each other's prospects.

> Ballantyne and Varey (2008) define value co-creation as ''An interactive process where both firms and customers are actively involved, learning mutually and influencing each other through coordinated actions."

This emphasizes the significance of effective coordination among actors within a supply chain, especially in agriculture, to successfully implement value co-creation. The quality of interactions between actors in value co-creation affects the overall supply chain performance (Bonney, 2007; Pedrosa, 2009).

To improve the overall performance of the agricultural supply chain, every stakeholder should be able to manage and execute their actions effectively. Hence, each party could receive proper dividends as a result of compromises made during coordination (Simatupang, 2000; Sirias, 2005). Coordination refers to managing interdependencies between activities involving different entities working together towards a mutually defined goal (Malone, 1994). Terms like cooperation, integration, and collaboration also involve managing interdependencies between activities. However, in the supply chain context, these terms can be considered integral parts of supply chain coordination (Barbarosolu, 2000). Supply chain coordination involves redesigning decision rights, decision workflows, and resource allocation among members to achieve higher profit margins, improved customer service, and faster response times (Lee, 2000). A supply chain that implements effective coordination is characterized by clear communication, information exchange, collaboration, and regular performance evaluation (Stank, 1999).

Supply chain inefficiencies concerning perishable goods significantly contribute to food loss and wastage. Major factors include technical inefficiencies within supply chains, high facility costs, and a lack of legislation and standards. These inefficiencies occur at various stages along the supply chain and must be conceptualized through separate accounts of food loss, waste, and supply chain management. Food loss and wastage refer