Dr. Atheek Ur Rehaman H.M. graduated from University of Agricultural Sciences, Bangalore in 1998 and completed Masters in Agronomy (2000) and doctoral program (2015) from the same university. His specialization is agro-industrial waste recycling, organic agriculture and mechanization. He has fifteen years of experience in teaching, research and extension. Spent a decade in service of farmers as subject matter specialist in Krishi Vigyan Kendra. About two years taught agronomy to under graduate and post graduate courses in Agriculture college, GKVK Bangalore. Presently, he is working as Scientist Agronomy in AICRP on pigeonpea, GKVK, Bangalore. He developed for drum seeding of hybrid paddy technology and involved in development of many Agro-techniques (15) and varieties (13) as collaborator. He has guided 5 M.Sc. students as chairman about 18 Ph.D. and MSc students as Co- Chairman / advisory committee member in Agronomy and other disciplines of agriculture. He published about 45 research articles in various national and international journals. Apart from this he authored numerous extension literatures, articles in agriculture magazines, books and given talks / programs on Radio / Television / YouTube / OTT platforms in vernacular language for the benefit of farming community.

Dr. Laxman Navi did his B.Sc. (Agriculture) from College of Agricultural Sciences, UAS, Raichur and completed M.Sc. (Agriculture) and Ph.D. in Agronomy from Department of Agronomy, College of Agricultural Sciences, UAS, GKVK, Bengaluru. He has qualified ARSB NET (Agronomy) in 2023. He has actively participated in national and international conferences, seminars and workshops. With valuable research experience, he has contributed to numerous publications, including research papers, review articles, popular articles and book chapters. He has been recognized with several awards, including the Best M.Sc. Thesis Award, Young Agronomist Award and Young Researcher Award. He is also a reviewer in the reputed journals. The author is an aspiring researcher with a keen interest in agronomy and sustainable agricultural practices.

Devika A. R. is a Ph.D. scholar in the Division of Agronomy at ICAR-IARI, New Delhi. She completed her B.Sc. (Agriculture) from Professor Jayashankar Telangana Agricultural University, Hyderabad and earned her M.Sc. in Agronomy with the prestigious ICAR-JRF from UAS, GKVK, Bengaluru. In 2023, she qualified the ICAR-SRF examination with an AIR-10 and also cleared the ASRB NET (Agronomy), reflecting her scholastic distinction and domain expertise. She has been conferred with Best Poster Presentations, and Oral presentation awards, and has made notable contributions to agricultural science through peer-reviewed research publications, review articles, and book chapters. Her doctoral research focuses on precision nutrient management integrated with IoT-enabled micro-irrigation technology to optimize resource-use efficiency and develop resilient, sustainable cropping systems.

Dayanandanaik S has completed B.Sc. (Hons.) Agriculture in University of Agricultural and Horticultural Sciences, Shivamogga and M. Sc. (Ag.) in Agronomy from University of Agricultural Sciences, GKVK, Bengaluru. He is currently pursuing his Ph.D. in Agronomy in University of Agricultural Sciences, GKVK, Bengaluru. He has cleared UGC NET-JRF in 2024. He has made significant contribution to the field through his publication including abstracts, popular articles, research paper, book chapter and conference presentation in various seminar and conferences.

Rashmi S Patil has completed B.Sc. (Hons.) Agriculture from the College of Agriculture, Vijayapura, under the University of Agricultural Sciences, Dharwad. She obtained her M.Sc. (Ag.) in Agronomy from the University of Agricultural Sciences, GKVK, Bengaluru and is presently pursuing her Ph.D. in Agronomy at the University of Agricultural Sciences, GKVK, Bengaluru. She has made notable academic contributions through the publication of research abstracts, popular articles and book chapters. She has actively participated in scientific seminars, conferences and academic forums.

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Contents

CHAPTER-12

AGRICULTURAL TRANSFORMATION IN TAMIL NADU UNDER RESOURCE AND CLIMATE CONSTRAINTS: A DECADAL PERSPECTIVE ON GROWTH, POLICY, AND FUTURE PATHWAYS

Ammaiyappan A[1], Manibharathi S[2] And Surendhar A[3].

[1]Tamil Nadu Chief Minister's Fellow, Department of Agriculture and Farmers Welfare, Chennai-600009, Tamil Nadu, India.

[2]Assistant Professor (Agronomy), School of Agriculture, Vels Institute of Science, Technology & Advanced Studies, Chennai-600117. Tamil Nadu.

[3]Assistant breeder, Rasi Seeds, Attur -636147, Tamil Nadu, India.

Abstract

Agriculture in Tamil Nadu has undergone significant structural change over the past decade amid increasing pressure from climate variability, water scarcity, and land constraints. Although the sector's relative contribution to the state economy has declined, it continues to play a critical role in rural livelihoods, food and nutritional security, and allied sector development. Growth during the period has been driven largely by productivity improvements, higher cropping intensity, and diversification towards horticulture, livestock, and fisheries rather than expansion of cultivated area. Important technological and structural shifts are evident in the adoption of improved crop varieties, mechanisation, integrated farming systems, and emerging digital interventions. The policy landscape has also evolved, marked by the introduction of a dedicated Agriculture Budget and a stronger emphasis on farmer welfare and income security. At the same time, persistent challenges related to climate change, groundwater depletion, land fragmentation, labour shortages, and market volatility continue to constrain inclusive growth. The chapter outlines future pathways centred on sustainable intensification, climate-smart agriculture, value addition, and

strengthened science policy linkages to enhance resilience and long-term agricultural sustainability in Tamil Nadu.

Keywords: Agricultural Transformation, Climate Resilience, Resource-Use Efficiency, Policy Reform, Tamil Nadu.

1. Introduction

Agriculture has long been central to Tamil Nadu's socio-economic development, providing livelihoods for nearly 48% of the state rural population and contributing approximately 13% to the Gross State Domestic Product (GSDP) in recent years (Yoganandham, 2025). Despite rapid urbanisation and a gradual structural transition towards industry and services where the services sector now accounts for more than half of the state GSDP, agriculture continues to play a vital role in ensuring food and nutritional security and generating rural employment. The sector strategic importance is further reinforced by its strong forward and backward linkages with allied activities such as livestock, fisheries, input supply systems, and agro-processing, which together support rural incomes and value chain development (IFPRI, 2021).

Historically, agricultural growth in Tamil Nadu has been supported by sustained public investment in irrigation infrastructure, agricultural research and extension systems. These investments have enabled productivity enhancement and gradual intensification under conditions of severe land constraints. Evidence of this intensification is reflected in the increase in gross cropped area from 146.77 lakh acres to about 151 lakh acres, alongside the expansion of double cropped area from 29.74 lakh acres to 33.60 lakh acres over the recent period (Yoganandham, 2025). Rather than horizontal expansion, growth has thus been driven by improved cropping intensity and technology adoption. Tamil Nadu continues to rank among the leading states in the production of rice, maize, sugarcane, banana, and

ragi, indicating relatively high productivity levels despite limited land availability. However, the sustainability of this growth trajectory is increasingly challenged by climate stress, tightening land and water resources, rising input costs, and persistent labour shortages (Birthal *et al*., 2020).

Recent studies emphasise that these structural and environmental pressures pose significant risks to long-term agricultural growth and farmer livelihoods, particularly in intensively cultivated states such as Tamil Nadu (Pingali, P & Abraham, M. 2022). The contemporary agricultural landscape reflects a growing divergence between relatively high productivity levels and increasing environmental vulnerability. Tamil Nadu is among the most water-stressed states in India, with agriculture accounting for nearly 90 per cent of total freshwater withdrawals (Mahato *et al*., 2022). Despite this high level of resource use, agricultural production remains heavily dependent on the monsoons, exposing farming systems to substantial climatic risk. These vulnerabilities are compounded by a steady decline in average landholding size is now below 0.8 hectares in Tamil Nadu**,** along with rising concerns related to soil degradation, groundwater depletion, and climate-induced market volatility (Anushiya *et al*., 2021). Collectively, these factors place considerable pressure on the sustainability of agricultural livelihoods and production systems.

In response to these evolving challenges, the Government of Tamil Nadu initiated a major policy and institutional reorientation by presenting the state's first exclusive Agriculture Budget in 2021-22 and subsequently renaming the department as the Agriculture and Farmers Welfare Department. Together, these measures signal a deliberate shift towards a farmer-centric governance framework that prioritises income security, resilience, and the overall socio-economic wellbeing of farming households. This transition extends beyond a symbolic change, representing a substantive policy shift that moves

away from a narrow focus on yield enhancement towards addressing structural constraints, improving access to technology and services, and strengthening risk management and income stabilisation mechanisms. Empirical studies on sustainable agriculture in Tamil Nadu reinforce that addressing environmental degradation, water scarcity, climate change, and market volatility is essential for the long-term viability of the sector, underscoring the need for inclusive and climate-responsive policy approaches (Jabereldar *et al*., 2017).

To adequately capture these evolving dynamics, a long-term analytical perspective is essential. Agricultural transformation is an inherently dynamic process shaped by gradual shifts in technology, institutions, and markets. Short-term analyses often reflect transitory fluctuations driven by weather variability or price movements, but they fail to reveal deeper structural changes that determine long-term development trajectories (Deininger *et al*., 2022). A decadal analytical framework provides a more robust temporal basis for distinguishing sustained structural trends from short-term cyclical variations. In Tamil Nadu, the past decade has witnessed notable shifts in cropping patterns and land use driven by climate-induced stress, adaptive strategies, and changing market incentives, alongside increasing emphasis on climate resilience and farmer welfare. Studies on cropping pattern dynamics and climate-smart agriculture confirm these long-term structural adjustments and the growing role of policy support in facilitating farmer adaptation (Selvi *et al*., 2025).

A decadal perspective is also critical for assessing the cumulative impact of public investments in irrigation, agricultural research, and extension systems. The benefits of such investments materialise gradually, influencing productivity growth, diversification, and value-chain development over extended periods (Birthal *et al*., 2020). Moreover, long-term analysis facilitates meaningful inter-regional comparisons by smoothing short-term volatility and highlighting

persistent disparities across agro-ecological zones. District-level studies of agricultural development in Tamil Nadu reveal enduring spatial differences in productivity and resilience linked to variations in resource endowments, infrastructure, and adaptive capacity (Muthumurugan, 2021).

2. Conceptual Framework of Agricultural Transformation

2.1. Definition and Dimensions of Agricultural Transformation

Agricultural transformation refers to a long-term process of structural and functional change within the agricultural sector, characterised by sustained improvements in productivity, shifts in production systems, and stronger integration with markets and the broader economy. It goes beyond simple output growth to encompass changes in technology use, institutional arrangements, labour allocation, and value-chain linkages (FAO, 2020). In developing and emerging economies, agricultural transformation is closely associated with rising farm incomes, improved food security, and the gradual movement of labour and resources from low-productivity activities to higher-value uses within and outside agriculture. The transformation process is multi-dimensional. Key dimensions include productivity enhancement through improved inputs and practices, diversification towards high-value crops and allied activities, commercialisation and market integration, and institutional and policy reforms that support sustainability and inclusiveness. These dimensions interact over time and are shaped by agro-ecological conditions, socio-economic structures, and governance systems (Pingali *et al*, 2019).

2.2. Structural Transformation: Productivity, Diversification, and Commercialisation

At the core of agricultural transformation lies structural change driven by productivity growth. Rising land and labour productivity enable agriculture to meet growing food demand while releasing resources for non-farm sectors (Timmer, 2017). Productivity gains are often

accompanied by diversification away from traditional staple crops towards horticulture, livestock, fisheries, and other high-value enterprises, reflecting changing consumer demand, urbanisation, and income growth (Birthal *et al*., 2020). Commercialisation represents another critical aspect of structural transformation. As agriculture becomes more market-oriented, farm households increasingly engage with input, output, and factor markets. This process strengthens value chains, encourages private investment, and creates opportunities for value addition and income growth. However, it also exposes farmers to market risks and price volatility, highlighting the need for supportive institutions and risk management mechanisms

2.3. Role of Technology, Institutions, and Markets

Technological change is a central driver of agricultural transformation. The adoption of improved crop varieties, mechanisation, precision farming, digital advisory services, and climate-resilient technologies has been shown to significantly enhance productivity and resource-use efficiency. However, technology alone is insufficient. Effective institutions such as research systems, extension services, credit mechanisms, and producer organisations play a crucial role in enabling access to technology and ensuring its equitable adoption (Anderson & Feder, 2007). Markets also shape the pace and direction of transformation. Efficient input and output markets, supported by infrastructure, information systems, and regulatory frameworks, facilitate commercialisation and diversification. Conversely, market imperfections can constrain farmer participation and exacerbate inequality (Pingali *et al*., 2019). Thus, agricultural transformation is best understood as the outcome of interactions among technology, institutions, and markets rather than isolated interventions.

2.4. Science Policy Interface in Agricultural Development

The science–policy interface plays a critical role in guiding agricultural transformation by linking research generated knowledge with policy formulation and implementation. Evidence based policymaking relies on timely and context specific research to address emerging challenges such as climate change, resource degradation, and market instability. Strong science policy linkages enhance the relevance of research, improve programme design, and support adaptive governance. In agriculture, the effectiveness of the science policy interface depends on institutional coordination among research organisations, extension systems, and policymaking bodies. Weak linkages can result in gaps between technological potential and field-level outcomes, while effective integration can accelerate innovation diffusion and improve policy responsiveness.

2.5. Relevance of the Framework to Tamil Nadu

The conceptual framework of agricultural transformation is particularly relevant to Tamil Nadu, given the state's distinctive demographic profile, constrained natural resource base, and diverse agro-ecological conditions. Tamil Nadu, the 11th largest state in India, spans approximately 1.30 lakh sq. km and is located predominantly within the semi-dry sub-humid to dry humid tropical zone. According to the 2011 Census, it is the seventh most populous state, with a population of 7.21 crore, accommodating nearly 6 per cent of India's population within only 4% of the country's geographical area and about 3% of national water resources. This high population density combined with limited land and water availability places sustained pressure on agricultural systems and resource use.

In this context, the application of a comprehensive conceptual framework of agricultural transformation encompassing productivity enhancement, diversification, market integration, and institutional change is essential for understanding both the achievements and the emerging constraints of Tamil Nadu agriculture. Such a framework

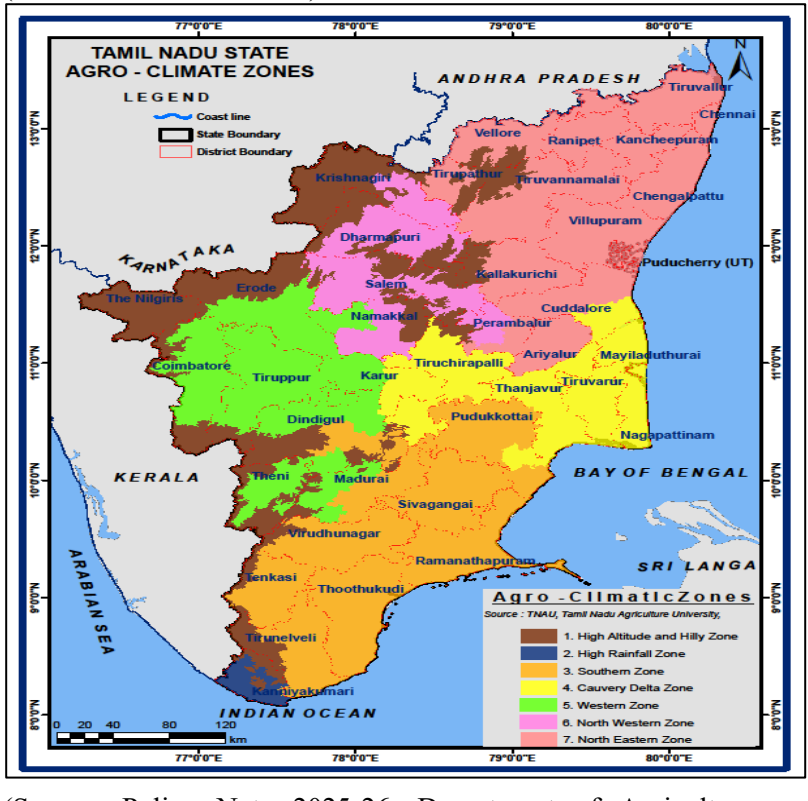
facilitates a nuanced examination of how structural factors, policy interventions, and environmental pressures interact over time, thereby providing a robust analytical basis for assessing growth trajectories, policy responses, and future pathways for sustainable and inclusive agricultural development. Understanding agricultural transformation in Tamil Nadu therefore requires an integrated analytical approach that captures long-term productivity trends, diversification dynamics, market integration, and policy shifts within a resource-constrained environment. The science policy interface assumes particular importance in this setting, where the effective translation of research evidence into farmer centric and sustainability-oriented policies is critical for sustaining agricultural growth, enhancing resilience, and improving farmer welfare. This conceptual framework thus provides the foundation for examining growth trajectories, institutional responses, and future development pathways of agriculture in Tamil Nadu.

3. Agro-Ecological and Institutional Context of Tamil Nadu

3.1. Agro-Climatic Zones and Natural Resource Base

Tamil Nadu exhibits pronounced agro-ecological diversity arising from variations in rainfall distribution, temperature regimes, soil characteristics, topography, irrigation patterns, and cropping systems. Based on these factors, the state is classified into multiple agro-climatic zones, including the Cauvery Delta Zone, North Eastern Zone, North Western Zone, Western Zone, Southern Zone, High Rainfall Zone, and Hilly Zone (Fig.1.). This zonal diversity supports a wide spectrum of agricultural systems, enabling the cultivation of cereals, pulses, oilseeds, cotton, sugarcane, millets, and a broad range of horticultural crops, contributing to both food security and income diversification. Despite this diversity, the state's natural resource base is inherently constrained and increasingly vulnerable to climate variability. Empirical analysis of long-term climatic data across agro-

climatic zones reveals ***a*** state-wide warming trend**,** with both maximum and minimum temperatures showing consistent increases over time. At the same time, annual rainfall exhibits a declining trend in most agro-climatic zones**,** with the exception of limited high-rainfall and hilly regions that occupy a relatively small geographical area. Of particular concern is the declining trend in rainfall during the Southwest and Northeast monsoon seasons**,** which are critical for Tamil Nadu predominantly monsoon dependent agriculture (Vinothkumar *et al.,* 2023)



(Source: Policy Note 2025-26, Department of Agriculture and Farmers Welfare, Government of Tamil Nadu.)

These climatic shifts have direct implications for the sustainability of agricultural production systems. Tamil Nadu is among the most water-stressed states in India, characterised by limited per capita water availability and heavy dependence on seasonal monsoons. Declining surface water storage, increasing reliance on groundwater extraction, and observed reductions in monsoon rainfall across several agro-climatic zones have intensified pressure on water resources. The combined effect of rising temperatures and declining rainfall poses significant risks to crop productivity, particularly in rainfed and semi-arid regions, and underscores the urgency of developing climate-resilient varieties, adaptive cropping strategies, and efficient water-management practices (Devadharshini *et al*., 2023).

3.2 Land Use Pattern and Irrigation Infrastructure

Land use in Tamil Nadu is characterised by a high intensity of cultivation and very limited scope for horizontal expansion, as a large proportion of cultivable land is already under agricultural use. The predominance of small and marginal holdings, with the average operational landholding declining to around 0.80 hectares, reflects increasing land fragmentation and structural constraints on farm expansion (Muthumurugan, 2021). Irrigation infrastructure plays a pivotal role in sustaining agricultural production in the state. Major sources of irrigation include canals, tanks, reservoirs, and groundwater, with groundwater through wells and borewells emerging as the dominant source in recent decades. Canal irrigation continues to be concentrated in the Cauvery Delta, while traditional tank irrigation systems remain important in rainfed and semi-arid regions, supporting supplemental irrigation and drought mitigation. However, empirical studies indicate a growing dependence on groundwater due to monsoon variability and declining surface water availability. This increasing reliance on groundwater has raised concerns related to declining water tables, rising energy consumption,

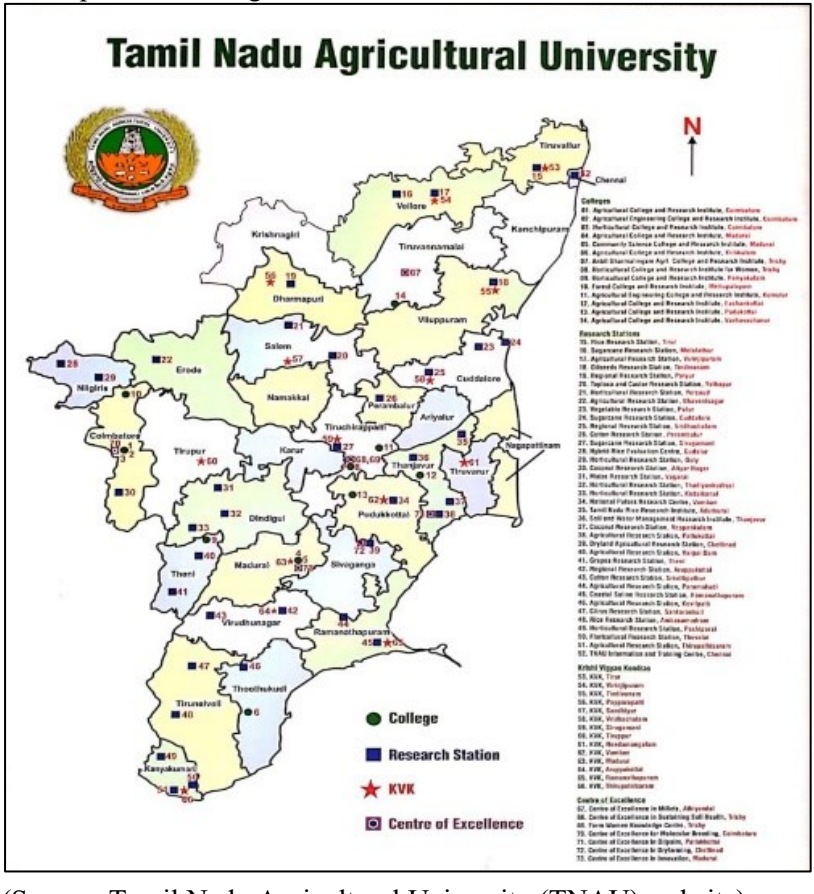
and the long-term sustainability of irrigated agriculture (Ammaiyappan *et al.*, 2023). Together, land fragmentation and water stress significantly influence cropping patterns, productivity outcomes, and regional disparities in agricultural growth across Tamil Nadu, underscoring the need for efficient water management and region-specific irrigation strategies.

3.3. Institutional Architecture for Agricultural Development

Tamil Nadu has developed a relatively strong and multi-tiered institutional architecture to support agricultural development, encompassing research and education, extension and advisory services, market and storage infrastructure, producer organisations, and state-level governance mechanisms. This institutional framework has historically played a pivotal role in enhancing agricultural productivity, facilitating technological diffusion, and promoting value-chain development under conditions of land and water scarcity. However, increasing climate variability, groundwater depletion, land fragmentation, and the growing complexity of market-oriented agriculture have placed new demands on institutional effectiveness and coordination (Birthal *et al.*, 2020)

Agricultural research and knowledge generation in Tamil Nadu are led by Tamil Nadu Agricultural University (TNAU), which anchors the state's agricultural innovation system. TNAU develops location specific crop varieties, climate-resilient technologies, and improved agronomic practices suited to diverse agro-climatic conditions. Strong linkages with the Indian Council of Agricultural Research (ICAR) have strengthened research quality and innovation dissemination. The university operates 19 constituent colleges across Tamil Nadu. It administers 15 Krishi Vigyan Kendras (KVKs) that serve as the primary interface between research and farmers through demonstrations and capacity building. TNAU also manages 39 agricultural research stations, including specialised research centres

and Centres of Excellence (Fig.2.) Together, this integrated research–education–extension system has contributed to higher adoption of improved varieties and modern production technologies in the state. Sustained public investment in these institutions has enhanced technology diffusion and farm-level productivity. Overall, TNAU's institutional network forms the backbone of Tamil Nadu's agricultural development and long-term transformation.



(Source: Tamil Nadu Agricultural University (TNAU) website)

Tamil Nadu has invested in a broad network of regulated markets, storage facilities, and cold chains to strengthen post-harvest

management and value-chain integration, particularly for horticulture, livestock, and fisheries (Kumar et al., 2021). Despite these advances, research highlights persistent challenges related to uneven regional coverage, staffing constraints, limited integration of digital tools, and unequal access to market infrastructure for small and marginal farmers (Anderson & Feder, 2007).

4. Growth Trajectories of Agriculture in Tamil Nadu

Agriculture in Tamil Nadu has experienced moderate but uneven growth, shaped by structural constraints, climatic variability, and evolving policy priorities. While the relative contribution of agriculture and allied sectors to the state economy has declined to around 13% of GSDP, this trend aligns with the classical pattern of structural transformation observed in developing economies, where agriculture's role shifts from income dominance to livelihood stability and food security (Kashyap *et al*., 2022). Despite this decline in relative share, agriculture remains resilient in absolute terms and continues to support rural livelihoods and allied sector expansion. A growing body of research emphasises that in land and water scarce states such as Tamil Nadu, agricultural growth is increasingly driven by productivity gains, cropping intensity and diversification, rather than expansion of cultivated area (Ramasamy *et al*., 2021). With average operational holdings declining, horizontal expansion has been largely exhausted, shifting growth strategies towards mechanisation, improved seed adoption, and irrigation efficiency. Crop wise analyses indicate relative stability in paddy output, gradual yield improvements in pulses and oilseeds, and rising production of maize and cotton, reflecting changing market incentives and technological adoption (Chand & (Parappurathu *et al*., 2020).

Horticulture has emerged as a key growth driver, reflecting changing consumption patterns, urban demand, and improved market connectivity. Research Evidences consistently highlights horticulture

potential to generate higher returns per unit of land and water, making it particularly relevant for a resource constrained state such as Tamil Nadu. However, the sector remains vulnerable to price volatility and post-harvest losses, underscoring the importance of market and institutional support. Allied sectors have played a pivotal role in shaping the overall growth trajectory of agriculture in Tamil Nadu. Livestock, particularly dairy and poultry, has shown relatively steady growth, supported by institutional credit, cooperative networks, and private-sector integration (Birthal *et al*., 2020). Fisheries both inland and marine have benefited from investments in infrastructure, cold chains, and value addition, contributing to income diversification in coastal and deltaic regions.

However, several scholars document pronounced regional disparities in agricultural growth within the state. Irrigated regions such as the Cauvery Delta and parts of the Western Zone exhibit higher productivity and diversification, while rainfed and drought-prone regions face greater yield variability and slower growth due to limited irrigation access and higher climate sensitivity (Muthumurugan, 2021). Overall, the literature characterises Tamil Nadu's agricultural growth as an incremental transformation under resource and climate constraints, highlighting the need for region-specific, sustainability-oriented strategies that integrate productivity, diversification, and farmer welfare.

5. Technological and Structural Changes in Agriculture

5.1. Adoption of Improved Varieties, Hybrids, and Climate-Resilient Crops

The adoption of improved crop varieties and hybrids has been a central driver of agricultural change in Tamil Nadu over the past decade. Given the state limited scope for area expansion and increasing climatic uncertainty, productivity enhancement through varietal improvement has assumed particular importance. Public

sector breeding programmes, complemented by private seed systems, have facilitated the diffusion of high-yielding, short-duration, and stress-tolerant varieties in major crops such as paddy, maize, cotton, and pulses. Recent studies indicate that improved varietal adoption has contributed to yield stabilisation rather than dramatic yield acceleration, especially in irrigated and semi-irrigated regions (Pingali *et al*, 2019). Climate-resilient crop varieties such as drought tolerant millets, salt-tolerant paddy lines, and pest-resistant hybrids have gained policy attention in response to increasing climate variability. However, evidence suggests that adoption remains uneven, with higher uptake in regions supported by targeted extension and input supply, and limited penetration among small and marginal farmers in rainfed areas. This highlights the importance of institutional support alongside technological availability.

5.2. Mechanisation, Precision Farming, and Digital Interventions

Mechanisation has expanded significantly in Tamil Nadu, driven by rising labour scarcity, increasing wage rates, and the need to improve operational efficiency. The use of tractors, harvesters, transplanters, and custom hiring centres has increased, particularly in paddy-dominated and commercially oriented regions. Research indicates that mechanisation has reduced labour bottlenecks and timeliness losses, though its benefits are disproportionately concentrated among medium and large farms and better-irrigated zones (Birthal *et al*., 2020). Precision farming and digital interventions represent an emerging, though still evolving, dimension of technological change. Initiatives related to soil health cards, GPS enabled machinery, remote sensing, and mobile-based advisory services have been introduced to improve input-use efficiency and decision-making. While pilot studies show promising outcomes in terms of fertiliser efficiency and yield response, large-scale adoption remains constrained by knowledge gaps, cost barriers, and institutional readiness.

Nevertheless, digital agriculture holds significant potential in a state with high literacy and institutional capacity, provided it is integrated with extension systems.

5.3 Transition towards High-Value Crops and Resource Efficient Integrated Farming Systems

Structural change in Tamil Nadu's agriculture is increasingly reflected in a gradual shift towards high-value crops and diversified production systems. Horticulture, livestock, and fisheries have expanded due to higher returns per unit of land and water, changing dietary preferences, and improved market linkages. Crop diversification into fruits, vegetables, dairy, and poultry has contributed to stabilising farm incomes, particularly under climatic and price uncertainties. Integrated Farming Systems (IFS), which combine crops with livestock, fisheries, and horticulture, have emerged as effective risk-mitigation strategies for small and marginal farmers. Evidence indicates that IFS improves income stability, enhances nutrient recycling, and increases overall resource-use efficiency. However, adoption remains limited by knowledge-intensive management requirements and initial investment costs. Alongside diversification, changes in input use patterns mark an important dimension of structural transformation. Tamil Nadu's agriculture continues to exhibit high input intensity, especially in water, fertilisers, and energy use. Policy initiatives promoting micro-irrigation, balanced nutrient management, and integrated pest management have yielded modest gains in resource-use efficiency. Nevertheless, persistent challenges such as groundwater overexploitation, fertiliser imbalance, and limited uptake of conservation practices highlight the need for a systems-level approach integrating technology, institutions, and farmer behaviour (Birthal *et al*., 2020).

5.4. Major Schemes and Programmes Implemented During the Decade

Irrigation and water management occupy a central place in Tamil Nadu's agricultural strategy due to high monsoon dependence and increasing groundwater stress. The Pradhan Mantri Krishi Sinchayee Yojana promotes micro-irrigation systems such as drip and sprinklers through substantial subsidies, improving water-use efficiency and reducing cultivation costs. State-specific initiatives complement this by supporting farm ponds, water-harvesting structures, and on-farm water storage to manage rainfall variability. Productivity enhancement is pursued through quality seed distribution, the Seed Village Programme, and demonstrations of improved crop practices. These efforts aim to raise yields and reduce dependence on low-quality seed material. Integrated pest management, soil health management, and balanced fertiliser use are promoted to ensure sustainable input use. Subsidised inputs under state and centrally sponsored schemes encourage adoption of modern agronomic practices. Farmer welfare and risk mitigation are strengthened through crop insurance coverage under the Pradhan Mantri Fasal Bima Yojana, providing protection against crop losses. Increased Agriculture Budget allocations support mechanisation subsidies, helping farmers address labour shortages and reduce production costs. Diversification into horticulture, organic farming, and high-value crops remains a policy priority. Farm-to-market linkages are strengthened through Uzhavar Santhai, enabling direct sales and better price realisation. Recent initiatives such as Farmers Welfare Centres and the Tamil Nadu Cashew Board further reflect the expanding scope of state agricultural interventions.

6. Challenges and Emerging Issues

6.1. Climate Change and Water Scarcity

Climate change and water scarcity have emerged as the most binding constraints on the long-term sustainability of agriculture in Tamil Nadu. The state's strong dependence on the Southwest and Northeast monsoons, combined with rising temperatures and increasing rainfall variability, has significantly heightened production risks, particularly in rainfed and semi-arid regions. Empirical studies document a marked increase in climate-induced yield instability over recent decades, with disproportionately severe impacts on smallholder-dominated districts (Pingali *et al*., 2019). Tamil Nadu is among the most water-stressed states in India, where agriculture accounts for nearly 90 per cent of total freshwater withdrawals, resulting in chronic groundwater depletion and declining surface water storage, especially in tank-irrigated systems. Recent district-level evidence further indicates that water stress not only constrains crop productivity but also accelerates structural shifts towards less water-intensive crops, mechanisation, and allied activities. However, these adjustments often yield uneven income outcomes across farm categories, reflecting differences in resource access and adaptive capacity. Review literature emphasises that, in the absence of coordinated investments in climate-resilient technologies, improved water governance, and institutional reform, existing adaptive responses may intensify regional and social inequalities rather than alleviate them (Birthal *et al*., 2020).

6.2. Declining Farm Sizes and Labour Constraints

A persistent structural challenge confronting Tamil Nadu's agriculture is the steady decline in average farm size, driven by land fragmentation and demographic pressures. With operational holdings falling below one hectare on average, achieving economies of scale has become increasingly difficult, constraining mechanisation,

investment, and effective participation in markets particularly for small and marginal farmers (Timmer, 2017). Fragmented landholdings also raise transaction costs and reduce the economic viability of technology adoption at the individual farm level. At the same time, agriculture faces acute labour constraints arising from rural urban migration, rising real wages, and demographic shifts in the rural workforce. Field based studies from Tamil Nadu show that labour scarcity has become a primary driver of mechanisation and crop choice adjustments. However, mechanisation adoption remains uneven due to high capital costs, limited access to credit, and inadequate service infrastructure, especially in low-irrigation and rainfed districts. Such uneven adoption patterns risk widening productivity and income disparities across farm categories (Birthal *et al*., 2020).

6.3. Market Volatility and Price Risks

Increasing market integration has exposed Tamil Nadu's farmers particularly those engaged in commercial and high-value agriculture to heightened price volatility. Fluctuations in global commodity markets, domestic supply demand imbalances, and policy-induced shocks, including export restrictions, have amplified income uncertainty (Gulati and Juneja, 2021). Empirical evidence consistently indicates that price risks often exceed production risks for smallholders, undermining income stability even during years of favourable output. State-level studies further reveal that limited access to storage, processing facilities, and collective marketing platforms weakens farmers bargaining power and contributes to distress sales, especially for perishable commodities. Strengthening value-chain infrastructure, expanding price-risk management instruments, and promoting farmer aggregation through producer organisations are therefore critical for reducing market-related vulnerabilities (Barrett *et al*., 2021).

7. Future Prospects and Strategic Pathways

7.1. Opportunities for Sustainable Intensification

Sustainable intensification offers a critical pathway for Tamil Nadu to enhance agricultural productivity without exacerbating pressure on land and water resources. Given the limited scope for area expansion and increasing environmental constraints, future growth must rely on improving yield efficiency, cropping intensity, and system productivity while maintaining ecological balance. The sustainable intensification through improved varieties, better agronomic practices, and integrated farming systems can simultaneously enhance productivity and environmental outcomes when supported by appropriate institutional frameworks (Pretty *et al*., 2018). In Tamil Nadu, such approaches are particularly relevant for smallholder-dominated systems operating under water and land scarcity.

7.2. Climate-Smart and Resource-Efficient Agriculture

Climate-smart agriculture (CSA) is increasingly recognised as a central strategy for enhancing resilience to climate variability while reducing environmental footprints. CSA practices including water-saving technologies, stress-tolerant crops, diversified farming systems, and improved soil management have demonstrated positive impacts on yield stability and income resilience in climate-vulnerable regions (Lipper *et al*., 2014). For Tamil Nadu, scaling up climate-smart interventions such as micro-irrigation, precision nutrient management, and drought-resilient cropping systems will be essential to address recurring droughts, groundwater depletion, and climate induced.

7.3. Strengthening the Science Policy Practice Interface

Strengthening the interface between scientific research, policy formulation, and field-level practice is a key strategic priority for the next decade. Agricultural transformation increasingly requires evidence-based policymaking that draws on timely research and

feedback from implementation experience. The weak linkages between research institutions, extension systems, and policymakers often limit the effectiveness and scalability of innovations. In Tamil Nadu, enhancing coordination among agricultural universities, extension agencies, and policymaking bodies can improve technology relevance, accelerate adoption, and ensure that policies remain responsive to evolving challenges (Anderson & Feder, 2007).

7.3 Digital Agriculture for Income Enhancement and Value Addition

Digital agriculture offers strong potential to improve decision-making across the agricultural value chain. Digital platforms providing weather forecasts, pest surveillance, market prices, and advisory services can enhance farm-level efficiency and reduce information gaps. Evidence shows that such tools improve input-use efficiency, risk management, and market integration when supported by institutions and capacity building. Tamil Nadu's relatively advanced digital infrastructure and institutional capacity provide a strong foundation for scaling digital agriculture. Integrating digital tools with extension systems and governance mechanisms can accelerate modern, data-driven farm management. Enhancing farmer income remains a core policy objective. Studies indicate that income growth is better achieved through diversification, value addition, and market integration than yield gains alone. Strengthening value chains in horticulture, livestock, fisheries, and agro-processing can raise returns and reduce post-harvest losses (Gulati *et al.*, 2018). Promotion of Farmer Producer Organisations and cooperatives can improve smallholder access to markets and finance. Greater private sector participation is also essential for expanding processing and value addition opportunities.

7.4. Policy Priorities for the Next Decade

Looking ahead, policy priorities for Tamil Nadu's agricultural sector must balance productivity growth with sustainability, resilience, and equity. Key priorities include scaling climate-smart technologies, improving water governance, strengthening extension and institutional capacity, and promoting inclusive value-chain development. Policy coherence across agriculture, water, energy, and rural development sectors will be essential to address interconnected challenges. The continued emphasis on farmer welfare reflected in the mandate of the Agriculture and Farmers' Welfare Department under the Government of Tamil Nadu provides a strong institutional foundation for implementing these priorities. Review literature underscores that sustained political commitment, adequate investment, and robust monitoring frameworks are crucial for translating strategic intent into long-term development outcomes.

8. Conclusion

This chapter examined the agricultural transformation of Tamil Nadu through a decadal analytical lens, focusing on growth trajectories, policy shifts, and future prospects. The analysis shows that although agriculture's relative contribution to the state economy has declined in line with broader structural transformation, the sector has remained resilient in absolute terms and continues to play a vital role in rural livelihoods, food and nutritional security, and allied sector development. Agricultural growth during the period was characterised by modest productivity gains, increasing diversification towards horticulture, livestock, and fisheries, and gradual strengthening of value-chain linkages. However, these gains were uneven across regions and farm categories, reflecting persistent agro-ecological constraints, institutional limitations, and socio-economic disparities. The chapter highlighted important technological and structural changes, including the adoption of improved crop varieties, expanded

mechanisation, emerging digital interventions, and the gradual spread of integrated farming systems. At the same time, policy and institutional reforms most notably the shift towards farmer welfare-oriented governance have reshaped the development approach of the agricultural sector. Despite these advances, challenges related to climate change, water scarcity, land fragmentation, market volatility, and extension gaps continue to constrain inclusive and sustainable growth.

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