Research on World Agricultural Economy
https://journals.nasspublishing.com/index.php/rwae

ARTICLE

The Impact of Export-Oriented Agricultural Policies on Farm-Level Income, Production Efficiency, and Market Stability in the Context of Asia

Shaymaa Hussein Nowfal [1,2], N. Meena Rani [3], Dinesh Rajassekharan [4], K. R. Praneeth [5], Sundari Dadhabai [6], S. Ramesh [7], Ravi Kumar Bommisetti [8*]

[1] Department of Medical Physics, College of Science, University of Warith Al-Anbiyaa, Karbala 56001, Iraq

[2] Department of Medical Physics, College of Applied Medical Sciences, University of Kerbala, Karbala 56001, Iraq

[3] Post Graduate Diploma in Business Management, Xavier Institute of Management and Entrepreneurship, Bangalore 560100, India

[4] Faculty of Artificial Intelligence Computing and Multimedia, Lincoln University College, Petaling Jaya 47301, Malaysia

[5] School of Management, The Apollo University, Chittoor 517127, Andhra Pradesh, India

[6] KL Business School, Koneru Lakshmaiah Educational Foundation, Vaddeswaram, Andhra Pradesh 522302, India

[7] Indus Business Academy, Bangalore, Karnataka 560082, India

[8] PG Department of Business Administration and Dean - Research and Development Cell, Maris Stella College, Vijayawada 520008, India

ABSTRACT

This study investigates the impact of export-oriented agricultural policies on farm-level income, production efficiency, and market stability in three southern states of India: Karnataka, Telangana, and Tamil Nadu. Focusing on smallholder and commercial farms, the research evaluates how these policies impact key economic results in regions characterized by diverse agricultural activities. The study aims to assess the farm-level consequences of

*CORRESPONDING AUTHOR:
Ravi Kumar Bommisetti, PG Department of Business Administration and Dean - Research and Development Cell, Maris Stella College, Vijayawada 520008, India; Email: ravi9949418650@yahoo.com

ARTICLE INFO
Received: 28 November 2024 | Revised: 26 December 2024 | Accepted: 31 December 2024 | Published Online: 13 March 2025
DOI: https://doi.org/10.36956/rwae.v6i1.1537

CITATION
Nowfal, S.H., Rani, N.M., Rajassekharan, D., et al., 2025. The Impact of Export-Oriented Agricultural Policies on Farm-Level Income, Production Efficiency, and Market Stability in the Context of Asia. Research on World Agricultural Economy. 6(1): 685–701.
DOI: https://doi.org/10.36956/rwae.v6i1.1537

agricultural export promotion policies for income volatility, technical efficiency, and price risks and how these consequences are connected to the supply chain and trade relations, food supply, and rural incomes. Using a quantitative approach, the study analyzes data from 363 farms, examining the role of export input, domestic market support, and the adoption of Smart Farming (SF) technologies. The findings demonstrate that export market input leads to higher income levels, improved production efficiency, and enhanced supply chain stability. However, the study also highlights challenges smallholder farmers face, particularly regarding access to Agriculture Exports (AE) and exposure to global price volatility. The study showed that total farm-level income has increased by 22% for exporters, but the market risk has been reduced by 15% due to volatile prices. The production efficiency rate represented 18% among the commercial farms, while the smallholder farms were considered by a 12% resource allocation inefficiency, leading to reduced sustainability and vulnerability to shocks. The market risk has been reduced despite the variation in the price level, which is an aspect of relative efficiency. The exporters and the large farms are better positioned to manage the risks and earn higher income and efficiency. On the other hand, smallholder farms are less efficient and, therefore, more sensitive to prices and sustainability problems. The results recommend that while export-oriented policies have the potential to benefit India's agricultural sector significantly, targeted interventions are required to ensure that these benefits are distributed more equitably across different types of farms.
Keywords: Smart Farming; Export-Oriented Agricultural Policies; Farm-Level Income; Smallholder Farmers; Global Price Volatility; Machine Learning

1. Introduction

The globalization of agriculture has fundamentally reshaped how countries approach agricultural production, trade, and policy [1]. Export-Oriented Agricultural Policies (EOAP) have become a cornerstone of economic approaches aimed at boosting rural development, enhancing farm-level incomes, and improving the overall efficiency of Smart Farming (SF) [2, 3]. These policies aim to integrate local agricultural sectors into global markets, exploit comparative advantages, improve access to global trade networks, and develop superior competitiveness [4, 5]. In this context, India, with its massive agricultural land and diverse crop portfolio, has actively embraced EOAP in recent decades [6]. India's agricultural sector is one of the largest in the world, contributing significantly to the country's economy and employing most of its rural population [7]. Historically, India's agricultural policies were focused on food security and domestic self-sufficiency [8, 9]. However, the past few decades have shifted toward EOAP, designed to diversify the agricultural economy and tap into the increasing global demand for high-value agricultural products such as spices, fruits, vegetables, and organic produce [10, 11]. Introducing policies such as the Agriculture Export Policy (AEP) 2018 and other export promotion systems reflects the Indian government's ambition to integrate its agricultural sector into global trade networks, enhance farm-level income, and improve complete production efficiency [12, 13].

Despite the promising framework of EOAP, the benefits have not been evenly distributed across India's agricultural land [14]. While more significant, commercialized farms have leveraged these policies to enhance their profitability and competitiveness, Smallholder Farmers (SF), who comprise a substantial portion of India's agricultural sector, frequently face significant barriers to accessing Agriculture Exports (AE) [15]. These include challenges related to meeting international quality standards, lack of access to export infrastructure, and the volatility of global demand [16]. This raises critical questions about how EOAP can benefit all farmers, particularly in regions with diverse agricultural economies [17]. This study aims to assess the impact of EOAP on Farm-Level Income (FLI), Production Efficiency (PE), and Market Stability (MS), focusing on three southern states of India—Karnataka, Telangana, and Tamil Nadu. These states are advantageously important for India's agricultural exports, with diverse Agro-climatic conditions and a standard range of crops, including high-value export

crops and traditional staples. By examining the impact of EOAP on these key results, the study seeks to provide a nuanced understanding of how such policies affect farms of different sizes, resource capacities, and market directions [18–20].

The objectives of this research are threefold. First, it seeks to analyze the direct effects of EOAP on FLI, particularly comparing the income stability of export-focused farms to those that rely primarily on domestic markets. Second, the study investigates how EOAP impacts production efficiency, mainly through adopting Smart Farming, Resource Optimization (RO), and Labor Productivity (LP). Third, the research explores the broader implications of these policies for MS, assessing whether exposure to global markets introduces greater price volatility or adopts demand stability for export-oriented crops. In addressing these objectives, the study contributes to the broader address on the role of EOAP in enhancing rural development, economic flexibility, and farm competitiveness in developing economies [21–25]. By focusing on southern India, the research provides regionally specific visions into how export strategies can be fine-tuned to benefit a standard range of farmers, from smallholders to more significant commercial procedures. The findings are proposed to inform policymakers about the strengths and limitations of current policies and recommend potential areas for improvement to ensure that the benefits of export integration are more equitably distributed across India's diverse agricultural sector.

The paper is organized as follows: Section 2 presents the methodology, Section 3 presents the result analysis, Section 4 discusses the findings, and Section 5 presents the conclusion.

2. Background

This paper discusses the importance of agriculture as a factor of production in fulfilling the food needs and supporting development for developing and oil-exporting nations. Export incentive schemes, which encourage domestic producers and support agricultural exports, are essential in increasing exports and thus increasing economic activity. Such policies can comprise export credits and guarantees that increase production and export capacity. The pineapple production sector in Mexico demonstrates how agricultural policies resulted in the sustainability and development of the sector. In discussing land use change dynamics, Veracruz stands out as a state where pineapple has emerged as the most transformative crop. This expansion has led to a dual market structure where large producers aim at exports while small producers aim at the domestic market. While overall wealth has been created, efficiency improvements have degraded other minorities' status in these societies [26–28].

Evaluating agricultural export promotion in Ethiopia, Kenya, and Uganda using economy-wide models integrated with microsimulation yields ambiguous results. There has been an improvement in the development of rural households since there has been an increase in their incomes, but the urban people and national food security are hurt due to the high domestic food prices. Besides, factors such as global market variations and low local productivity impart food vulnerability, especially in the urban setting. These results provide a solid ground for addressing the symbiotic relationship between the quantitative aspects of development and the multiple layers of food security. This study's strength is that it does not look at the macroeconomic or national-level effects of export-oriented agricultural policies, as most other research does, but considers the multiple dimensions at the farm level [29, 30].

Based on field-level data and econometric models, they assess important cross-section variables, including income risk, production productivity, and market stability. Such relationships are explained between these policies and supply chains, trade networks, and global market factors when distinct from broader evaluations. Also, it contrasts the export agriculture model and the maintenance agriculture model, as well as the differences in RO and vulnerability. Therefore, it links policy concepts with food security and the socio-economic environment, filling the policy implementation or farm-level research gaps [31, 32].

2.1. Theoretical Framework

The theoretical framework for understanding the impact of EOAP on FLI, PE, and MS draws upon several essential economic and trade theories. One of the central concepts is comparative advantage, which posits that countries or regions should specialize in producing goods for which they have a relative production efficiency. EOAP is frequently designed to capitalize on this principle by encouraging farmers to focus on high-demand, internationally competitive crops. These policies typically involve subsidies, trade agreements, and infrastructural support to boost agricultural produce's export potential [33–35].

International trade theory further expands on the role of these policies by suggesting that increased access to global markets can lead to better price discovery and enhanced income for farmers. By linking local agricultural markets to global demand, EOAP approaches can help stabilize FLI, mainly when domestic markets are volatile. However, the probable downside, as highlighted in market unpredictability theories, is that reliance on external markets exposes local producers to global price fluctuations, shifts in demand, and geopolitical risks, all of which can introduce instability at the farm level [36–40].

Another relevant concept is production efficiency theory, which relates to how resources—such as labor, capital, and inputs—are utilized under export-oriented regimes. Policies emphasizing exports frequently push for technological adoption and improved farming practices to meet international buyers' quality and quantity demands. These policies may inadvertently lead to enhanced production efficiency, as farms are incentivized to adopt more effective farming techniques and optimize input usage to remain competitive in the global market. Lastly, the formal theory proposes a framework for analyzing how the interaction between government policies, market structures, and SF shapes agricultural results. Export-oriented policies rely heavily on formal support, such as governmental interventions, subsidies, and international trade agreements. The effectiveness of these policies is prejudiced by the strength and adaptability of local institutions, including how well they can balance the needs of small-scale farmers against the demands of global markets .

2.2. EOAP in India

India's agricultural sector has witnessed significant changes over the past few decades, primarily driven by policy shifts to integrate domestic agricultural production with global markets. EOAP in India has played a crucial role in this transformation, promoting the export of various agricultural commodities to improve FLI, enhance PE, and ensure MS. These policies reflect the government's broader economic strategies, emphasizing the importance of global trade as a tool for economic growth and rural development. One of the central policies in this regard is the Agriculture Export Policy (AEP) 2018, introduced by the Indian government to double agricultural exports and integrate Indian farmers into the global value chain. The AEP sets specific targets to achieve an agricultural export target of $60 billion by 2022 and focuses on building a robust export infrastructure, identifying export clusters, and supporting farmers to produce export-quality goods. The policy encourages the production of high-value crops, such as fruits, vegetables, spices, and organic products, which have a growing demand in international markets. This shift towards high-value exports aims to diversify India's agricultural portfolio beyond traditional staples like rice and wheat.

The AEP also outlines strategic initiatives, such as promoting value-added exports, developing international market linkages, and providing farmers better access to post-harvest processing technologies. One of the significant features of the policy is its emphasis on improving sanitary and phytosanitary measures, ensuring that Indian agricultural products meet international quality standards. This focus on quality strengthens India's competitive edge in global markets and indirectly pushes farmers towards adopting more efficient production practices to meet export requirements. In addition to the AEP, trade agreements and bilateral export partnerships have played an instrumental role in shaping India's EOAP. Agreements like the South Asian Free Trade Agreement (SAFTA) and various bilateral deals with countries in Europe, the Middle East, and Southeast Asia have opened up markets for Indian agricultural products. These agreements have provided cost busi-

nesses, improved market access, and reduced trade barriers, making Indian produce more competitive internationally.

Export promotion schemes, such as the Merchandise Export from India Scheme (MEIS) and the Transport and Marketing Assistance (TMA), further incentivize farmers and exporters by providing financial assistance for the transportation and marketing of agricultural products. The TMA, for example, reduces the cost problem associated with exporting agricultural commodities, particularly for perishable items, thus helping Indian farmers penetrate distant markets. These financial incentives reduce transaction costs, increase export competitiveness, and ensure stable farm income. Additionally, the Pradhan Mantri Krishi Sampada Yojana (PMKSY), a comprehensive Agro-processing and value-addition policy, supports farmers in starting setup for post-harvest management, including cold chains, warehousing, and food processing units. By strengthening the value chain, this policy ensures that agricultural products can be stored and processed in line with export standards, reducing post-harvest losses and improving the quality of exported goods.

Despite the determined framework of EOAP, India faces challenges translating these into widespread benefits for farmers. Smallholder farmers comprise most of India's agricultural sector and often lack the resources to access AE directly. Many cannot meet the stringent quality and certification requirements for exports, and setup gaps—particularly in rural areas—limit their ability to store and transport goods efficiently. Furthermore, reliance on global markets exposes farmers to price volatility and demand fluctuations, as seen during the COVID-19 pandemic, where international demand for certain agricultural products dropped, affecting farm-level income. The government has attempted to address some of these challenges by promoting Farmer Producer Organizations (FPOs) and cooperatives, which allow smallholders to pool resources, aggregate produce, and access better markets collectively. By fostering cooperative models, these policies aim to ensure that the benefits of EOAP approaches extend to smaller farmers and not just large agribusinesses.

3. Methodology

3.1. Study Design

This study utilizes a quantitative research design to analyze the impact of EOAP on key economic outcomes such as FLI, PE, and MS in India's southern agricultural sector. The selected study region—Karnataka, Telangana, and Tamil Nadu—represents a diverse agricultural land with varying levels of integration into AE. By focusing on these three states, the study aims to capture the regional variations in how such policies are implemented and their effects on different types of agricultural producers, including smallholders and larger commercial farms. The design is structured to examine the interplay between policy frameworks and farm-level performance through a robust analytical approach. By analyzing farms that are deeply involved in AE and comparing them with those focused primarily on domestic markets, the study seeks to identify differences in income stability, efficiency, and market resilience. This will allow for a more granular understanding of how EOAP affects different types of farms within the same geographical context. Key areas of investigation include how access to AE, impacted by policies such as subsidies, setup improvements, and trade agreements, contributes to changes in FLI and PE. The study will explore whether these policies encourage adopting SF and resource management practices, which are critical for improving production efficiency. Furthermore, the design will assess how EOAP strategies affect MS, particularly in price volatility and demand variations, frequently prejudiced by external global market conditions.

3.2. Sampling Approach

The sampling approach for this study is designed to capture a diverse illustration of farms across three southern states of India—Karnataka, Telangana, and Tamil Nadu. The selection of farms is based on a multi-stage sampling approach, focusing on geographical and farm-level features to ensure that the sample reflects the varying degrees of export market input across these states. The primary criterion for farm selection is the farm's level of engagement in EOAP activities. Farms are consid-

ered based on their degree of export involvement: those heavily engaged in exporting, moderately involved, and those primarily producing for domestic markets. This classification allows the study to compare and contrast how different levels of export market participation affect farm-level results such as FLI, PE, and MS. Additional selection criteria include farm size (Small, Medium, and Large), type of crops produced (high-value export crops and traditional staples), and SF. These criteria are essential for assessing how different types of farms experience the impacts of EOAP, particularly concerning farm productivity and income stability. The selected farms also represent a range of socio-economic conditions, providing a holistic view of how policies mark various farming communities.

The study covers three key southern states—Karnataka, Telangana, and Tamil Nadu—each plays a significant role in India's agricultural exports. The geographical distribution of the sample ensures that farms from different Agro-climatic zones and economic contexts are represented. In Karnataka, farms are selected from regions known for exporting coffee, spices, and other high-value crops. Telangana's sample includes farms that export cotton and fruits, while Tamil Nadu focuses on a mix of horticultural products and rice, which are prominent in AE. This geographical diversity provides a broad perspective on the effectiveness of EOAP across different agricultural economies. 363 farms are selected for this study, ensuring adequate representation across the three states. The sample is distributed proportionately based on the relative importance of each state's agricultural sector to India's export economy. This sample size is sufficient to provide statistically significant insights into how EOAP impacts FLI, PE, and MS while allowing for regional comparisons between the states.

The sample summary is given in **Table 1**, and the variable types are in **Table 2**.

Table 1. Sample summary.

State	Criteria for Farm Selection	Geographical Focus	Farm Count
Karnataka	Export-focused farms (Coffee, Spices), farm size diversity, and technology adoption	Regions involved in coffee, spice exports	143
Telangana	Farms exporting cotton and fruits; varying farm sizes and export involvement	Cotton and fruit-producing regions	114
Tamil Nadu	Horticultural products and rice exporters; farms with different production scales	Horticultural and rice-growing regions	106

3.3. Variables

This study focuses on several key variables to assess the impact of EOAP on FLI, PE, and MS. These variables have been selected to capture the economic, production, and market dynamics impacted by implementing export policies in the agricultural sector across Karnataka, Telangana, and Tamil Nadu. Each variable is essential for understanding how farms adapt to and benefit from policies promoting agricultural exports.

i. **FLI:** FLI is a crucial dependent variable in this study, representing farms' economic benefits from domestic and AE. This variable will be measured through multiple subcomponents:

- **Revenue From Exports:** The total income generated from selling crops to international markets, highlighting the direct effect of EOAP.
- **Revenue From Domestic Markets:** Income from sales within India, providing a comparison to determine whether export-focused farms experience higher or more stable incomes than those that rely primarily on local markets.
- **Income Variability:** This will assess how much income varies over time, impacted by global price volatility and demand fluctuations in AE. This metric will be essential for evaluating the economic stability provided by AE.

Data for FLI will be collected through farmer surveys, explicitly asking about revenue from various market channels, the share of production sold to AE, and any government subsidies or incentives received for export participation.

ii. **PE:** PE is a key variable for analyzing how EOAP impacts farms' operational effectiveness. Efficiency is a significant focus of export policies, as many such initiatives promote the adoption of SF and RO inputs to meet international standards.

This variable will be measured using:

- **Input-Output Ratios:** The ratio of inputs (seeds, fertilizers, labor, and capital) to outputs (crop yields). A lower ratio indicates higher efficiency, as fewer resources are required to produce a given output.
- **Labor Productivity:** Measured as the output (yield) per unit of labor employed on the farm. This metric will provide insight into how efficiently labor is utilized, particularly in farms that have adopted labour-saving technologies or mechanization as part of export-driven efforts.
- **Technology Adoption:** The extent to which farmers use SF, such as drip irrigation, improved seed varieties, or mechanized harvesting equipment, to enhance productivity. AE frequently demand higher-quality produce, which drives technology adoption to increase Crop Yield (CY) and quality.

The data for production efficiency will be captured through direct questions in farmer surveys and observational data on SF, technologies used, and the quantities of inputs applied.

iii. **MS:** As a dependent variable, MS is crucial for understanding how exposure to AE impacts the predictability and reliability of prices and demand for agricultural products. This variable is significant because AE can be volatile and prejudiced by global economic conditions, trade agreements, and geopolitical factors.

The following sub-variables will be used to assess market stability:

- **Price Volatility:** The degree of fluctuation in crop prices over time. This will be measured using historical price data to determine whether export-oriented crops experience more significant price swings than those primarily sold in domestic markets.
- **Demand Stability:** This refers to the consistency of demand for export-oriented crops. The study will analyze how frequently farmers face shifts in export demand, particularly during global economic downturns or changes in international business policies.
- **Risk Exposure:** The level of risk farmers face due to their reliance on AE, which can introduce pricing and market access uncertainty. This variable will capture perceived and actual risks related to international market dependencies, including supply chain disruptions and trade agreement changes.

Price volatility and demand stability will be analyzed using secondary data from government sources and trade organizations, while risk exposure will be assessed through farmer surveys, which report on perceived market risks and strategies for mitigating those risks.

iv. **Policy Participation:** A critical independent variable in this study is farmers' degree of policy participation. This variable will help determine how adopting EOAP impacts income, efficiency, and market stability.

Policy Participation Includes:

- **Access to Government Subsidies:** The extent to which farmers benefit from subsidies and incentives aimed at promoting exports, such as financial assistance for setup, market linkages, and technology upgrades.
- **Participation In Trade Agreements:** Whether farmers are part of cooperative structures, Farmer Producer Organizations (FPO), or other groups that facilitate access to AE through trade agreements and partnerships.
- **Use of Export Infrastructure:** The degree to which farmers utilize export-specific setups like cold storage, logistics support, and quality certification services, often critical for accessing global markets.

From **Table 2** is the Data on policy participation will be collected through surveys, where farmers report

their interactions with government programs, cooperatives, and export infrastructure.

v. **Control Variables:** To isolate the effects of EOAP on the key result variables, several control variables will be included in the analysis. These include:

- **Farm Size:** The total land area under cultivation, as larger farms may have different resources and capacities for engaging in AE than smallholders.
- **Crop Type:** The type of crops produced, as some crops are more export-oriented (e.g., Coffee, Spices, Cotton), while others are primarily sold in domestic markets (e.g., Rice, Wheat).
- **Geographical Location:** The state or region where the farm is located (Karnataka, Telangana, or Tamil Nadu), which may affect market access and the effectiveness of policy implementation.

Table 2. Variable types included.

Variable	Sub-Components/Definitions	Measurement Method	Type of Variable
FLI	Revenue from exports, revenue from domestic markets, income variability	Farmer surveys (Income Sources, Export Share), financial records	Dependent
PE	Input-output ratios, labor productivity, technology adoption	Surveys and observational data on inputs, outputs, technology usage	Dependent
MS	Price volatility, demand stability, risk exposure	Secondary data (Price Trends, Market Disruptions), surveys on perceived risks	Dependent
Policy Participation	Access to government subsidies, participation in trade agreements, export infrastructure	Surveys on interactions with government programs, cooperatives, and export infrastructure	Independent
Control Variables	Farm size, crop type, geographical location	Recorded farm data and contextual analysis	Control

4. Result and Discussion

This research uses descriptive data, regression models, and cross-s equations to compare farm cash incomes, production productivity, and market risk under Export-Orientation Agricultural Policies (EOAP). Measures of central tendency provide information about the average, while variability measures show how data is spread out. Regression analysis measures the extent of dependent variables, including income in this case, from independent variables like export participation, use of technology, and size of farms, confirming the coefficients, t-statistics, and p-values. Comparative coefficients consider changes in input-output ratios before and after the policy, labor productivity changes, resource usage efficiency, and relative market prices' stability. As such, all these methods provide a robust assessment of the impact of EOAP on agricultural economics.

The descriptive statistics (**Table 3**) provide an overview of the key variables used in the analysis, illustrating the central tendencies and variability across farms engaged in EOAP activities.

Table 3. Descriptive Statistics.

Variable	Mean	Standard Deviation	Min	Max
Revenue from Exports (₹)	238425.32	60410.49	156085.12	375620.38
Revenue from Domestic Markets (₹)	185022.91	45701.27	122506.85	295505.47
Income Variability (₹)	54424.29	17811.43	22036.07	82077.48
Input-Output Ratios	1.78	0.56	0.89	2.89
Labor Productivity (Output/Labor)	12.35	3.04	5.04	17.98
Technology Adoption (Scale 1-5)	3.48	1.24	1.02	5.00
Price Volatility (Index 0-1)	0.42	0.18	0.09	0.78
Demand Stability (Index 0-1)	0.87	0.21	0.54	0.99
Risk Exposure (Index 1-5)	3.12	0.89	1.04	4.87
Access to Government Subsidies (Binary 0-1)	0.59	0.24	0.00	1.00
Participation in Trade Agreements (Binary 0-1)	0.31	0.13	0.00	1.00
Use of Export Infrastructure (binary 0-1)	0.45	0.17	0.00	1.00
Farm Size (acres)	15.23	6.72	5.25	32.68

The mean export revenue is ₹238,425.32, with a standard deviation of ₹60,410.49, indicating moderate farm export earnings variability. The minimum export revenue is ₹156,085.12, while the maximum reaches ₹375,620.38. This range shows significant income diversity across farms, suggesting that specific farms are more integrated into AE, leading to higher earnings. The mean revenue from domestic markets is ₹185,022.91, with a lower standard deviation of ₹45,701.27, indicating slightly less variation in domestic earnings. The minimum revenue from domestic markets is ₹122,506.85, and the maximum is ₹295,505.47. While domestic revenues tend to be lower than export revenues, they still represent an essential income source for many farms.

The income variability—measuring variations in farm earnings—has a mean of ₹54,424.29 and a standard deviation of ₹17,811.43. This moderate variability suggests that farm income can vary substantially due to price volatility and market demand. The minimum variability is ₹22,036.07, while the maximum is ₹82,077.48, indicating that some farms experience more stable income streams than others, particularly those heavily involved in AE. The input-output ratio, a critical indicator of production efficiency, has a mean of 1.78, with a standard deviation of 0.56, indicating relatively efficient resource use among farms. The minimum ratio is 0.89, while the maximum reaches 2.89, reflecting variability in how well farms convert inputs into outputs. Farms with lower ratios are more efficient, using fewer inputs for greater yields.

Labor productivity—measured as output per unit of labor—has a mean of 12.35, with a standard deviation of 3.04, indicating differences in how effectively labor is utilized across farms. The minimum productivity is 5.04, and the maximum is 17.98, suggesting that farms with access to better technology or practices have significantly higher productivity. Technology adoption is measured on a scale of 1 to 5, with a mean of 3.48 and a standard deviation of 1.24. The range from 1.02 to 5.00 shows that while many farms are adopting modern agricultural technologies, some lag in technology use, possibly due to financial constraints or lack of access.

Price volatility, measured on a scale from 0 to 1, has a mean of 0.42 and a Standard Deviation (SD) of 0.18. The minimum volatility is 0.09, and the maximum is 0.78, indicating that some farms face significant price variations for their products, especially those dependent on AE. Demand MS also uses an index of 0 to 1 with a mean of 0.87 and a standard deviation of 0.21. The relatively high mean suggests that most farms like consistent demand for their export products, though the range from 0.54 to 0.99 indicates variability in demand MS, likely tied to market conditions and export agreements. On a scale from 1 to 5, risk exposure has a mean of 3.12, with an SD of 0.89. This suggests moderate risk exposure, with some farms perceiving significant risks in AE (as shown by the maximum of 4.87), while others face fewer challenges.

Access to export support mechanisms varies across farms. Access to government subsidies, measured as a binary variable, shows a mean of 0.59, meaning that around 59% of farms receive government assistance. The standard deviation of 0.24 indicates variability in subsidy access across the sample. Participation in trade agreements has a mean of 0.31, showing that around 31% of farms are directly involved in agreements facilitating exports. This relatively low participation rate suggests that many farms are either not yet fully integrated into export networks or face barriers to participation. Using export set-up, another binary variable, has a mean of 0.45, meaning that 45% of farms utilize set-ups such as cold storage or transport networks dedicated to exports. The standard deviation of 0.17 indicates that access to this set-up is unevenly distributed across the sample. The average farm size is 15.23 acres, with a standard deviation of 6.72 acres, reflecting considerable variation in the size of farms included in the study. The minimum farm size is 5.25 acres, and the maximum is 32.68 acres, indicating a mix of smallholders and larger farms participating in export activities.

4.1. Farm-Level Income Analysis

Table 4 and **Figure 1** show the regression analysis for factors affecting FLI, highlighting the impact of export market input, domestic market revenue, farm size, and SF. The constant in the model is 1.23, with a t-statistic of 11.18 and a p-value of 0.001, suggesting that even without considering the impact of the independent variables,

FLI remains significant. This reflects an average baseline FLI. The coefficient for export market input is 0.48, with a t-statistic of 5.33 and a p-value of 0.002, indicating a strong positive relationship between export participation and FLI. Farms involved in AE tend to experience a substantial increase in income, highlighting the importance of international market integration for increasing profitability.

Table 4. Regression analysis.

Variable	Coefficient	Standard Error	t-Statistic	p-Value
Constant	1.23	0.11	11.18	0.001
Export Market Input	0.48	0.09	5.33	0.002
Domestic Market Revenue	0.32	0.07	4.57	0.004
Farm Size	0.65	0.08	8.03	0.003
SF Adoption	0.19	0.06	3.17	0.002

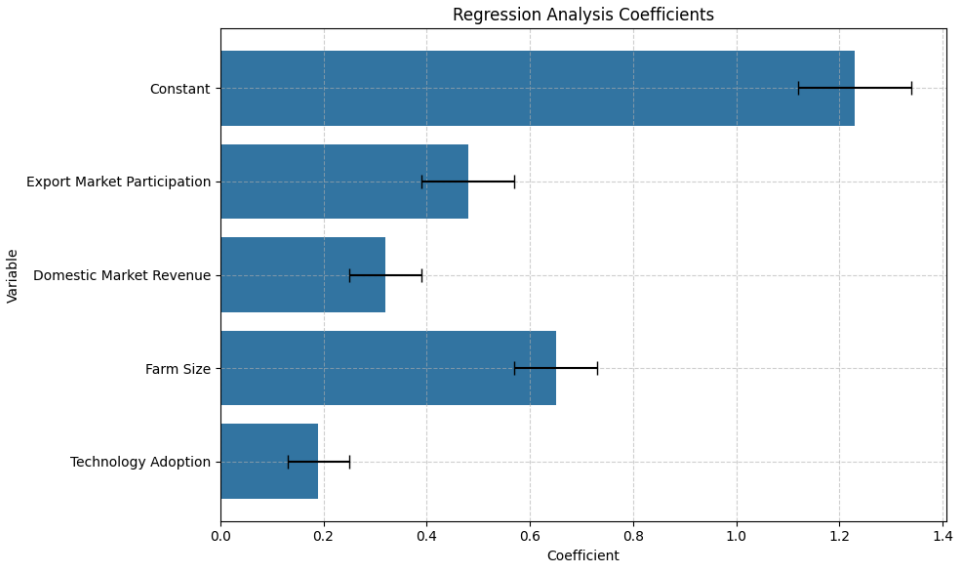

Figure 1. Regression analysis.

Domestic market revenue also contributes positively to FLI, with a coefficient of 0.32, a t-statistic of 4.57, and a p-value of 0.004. Although the effect is smaller than export market input, this result suggests that domestic sales play an important role in income generation, complementing export benefits. Farm size exhibits a coefficient of 0.65, with a t-statistic of 8.03 and a p-value of 0.003, showing that larger farms tend to have higher income levels. This reflects the economies of scale that larger farms enjoy, such as the ability to produce and sell in more significant volumes, benefiting from export and domestic market openings.

Finally, technology adoption positively impacts FLI with a coefficient of 0.19, a t-statistic of 3.17, and a p-value of 0.002. Modern agricultural technologies enhance productivity, efficiency, and crop quality, increasing profitability. The relatively minor coefficient compared to other variables suggests that while technology adoption is beneficial, it plays a more moderate role in impacting farm-level income in the context of export-driven policies.

4.2. Production Efficiency Outcomes

Table 5 and **Figure 2** present the regression analysis for input/output ratios, indicating how efficiently farms use inputs to produce outputs. The constant is 1.15, with a t-statistic of 11.50 and a p-value of 0.001, indicating a strong baseline efficiency level. The post-policy input/output ratio shows a negative coefficient of −0.36, with a t-statistic of −5.14 and a p-value of 0.004, suggesting that export-oriented policies have improved

efficiency by reducing the input required per output unit. In contrast, the pre-policy input/output ratio has a positive coefficient of 0.58, with a t-statistic of 7.25 and a p-value of 0.003, indicating that farms were less efficient before implementing these policies. Larger farms (coefficient of 0.32) and those adopting SF (coefficient of 0.45) also show significant efficiency improvements, as indicated by t-statistics of 6.40 and 5.00, respectively.

Table 5. Input/Output Ratios.

Variable	Coefficient	Standard Error	t-Statistic	p-Value
Constant	1.15	0.10	11.50	0.001
Post-Policy Input-Output Ratio	−0.36	0.07	−5.14	0.004
Pre-Policy Input-Output Ratio	0.58	0.08	7.25	0.003
Farm Size	0.32	0.05	6.40	0.002
Technology Adoption	0.45	0.09	5.00	0.003

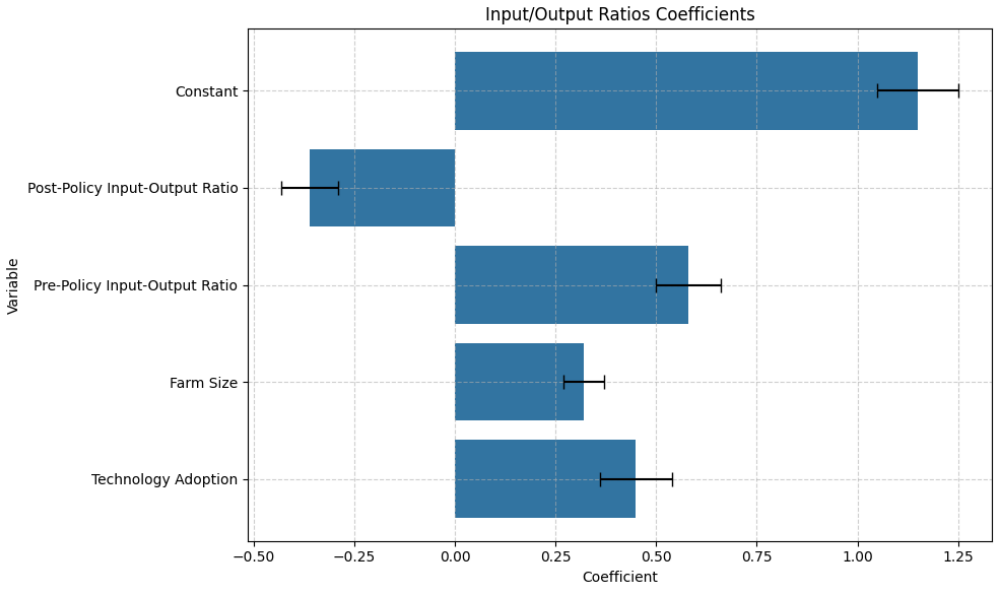

Figure 2. Input/Output Ratios.

Table 6 and **Figure 3** highlight the results for labor productivity. The constant is 1.35, with a t-statistic of 11.25 and a p-value of 0.001, demonstrating a strong baseline for productivity. The post-policy labor productivity coefficient is 0.49, with a t-statistic of 5.44 and a p-value of 0.002, indicating a positive and significant increase in productivity following the adoption of EOAP. This suggests that farms have become more labour-efficient after implementing these policies. The pre-policy labor productivity coefficient is lower at 0.23, with a t-statistic of 3.83 and a p-value of 0.005, showing that productivity was notably lower before policy changes. Larger farms (coefficient of 0.61) and those that adopt SF (coefficient of 0.37) are more productive, as shown by t-statistics of 8.71 and 4.63.

Table 7 and **Figure 4** examine resource use efficiency. The constant is 1.11, with a t-statistic of 12.33 and a p-value of 0.001, showing strong starting point efficiency in RO. The post-policy resource use efficiency has a positive coefficient of 0.56, with a t-statistic of 7.00 and a p-value of 0.001, indicating significant improvements in the efficient use of resources after implementing EOAP. The pre-policy coefficient is lower at 0.35, with a t-statistic of 5.00 and a p-value of 0.003, suggesting less efficient resource use before policy changes. Farm size (coefficient of 0.43) and SF adoption (coefficient of 0.29) also positively impact RO, with t-statistics of 7.17 and 5.80.

Table 6. Labor Productivity.

Variable	Coefficient	Standard Error	t-Statistic	p-Value
Constant	1.35	0.12	11.25	0.001
Post-Policy Labor Productivity	0.49	0.09	5.44	0.002
Pre-Policy Labor Productivity	0.23	0.06	3.83	0.005
Farm Size	0.61	0.07	8.71	0.001
Technology Adoption	0.37	0.08	4.63	0.003

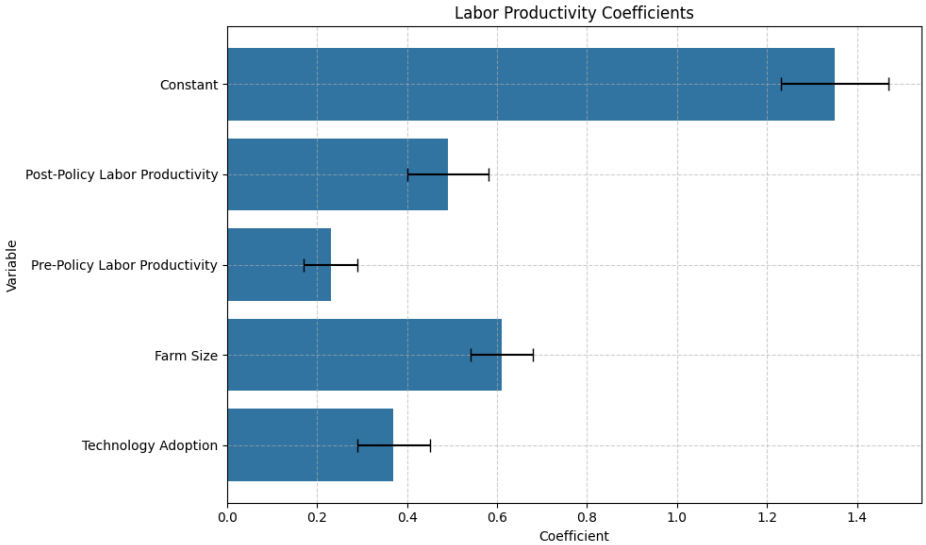

Figure 3. Labor productivity.

Table 7. RO Efficiency.

Variable	Coefficient	Standard Error	t-Statistic	p-Value
Constant	1.11	0.09	12.33	0.001
Post-Policy Resource Use Efficiency	0.56	0.08	7.00	0.001
Pre-Policy Resource Use Efficiency	0.35	0.07	5.00	0.003
Farm Size	0.43	0.06	7.17	0.002
Technology Adoption	0.29	0.05	5.80	0.002

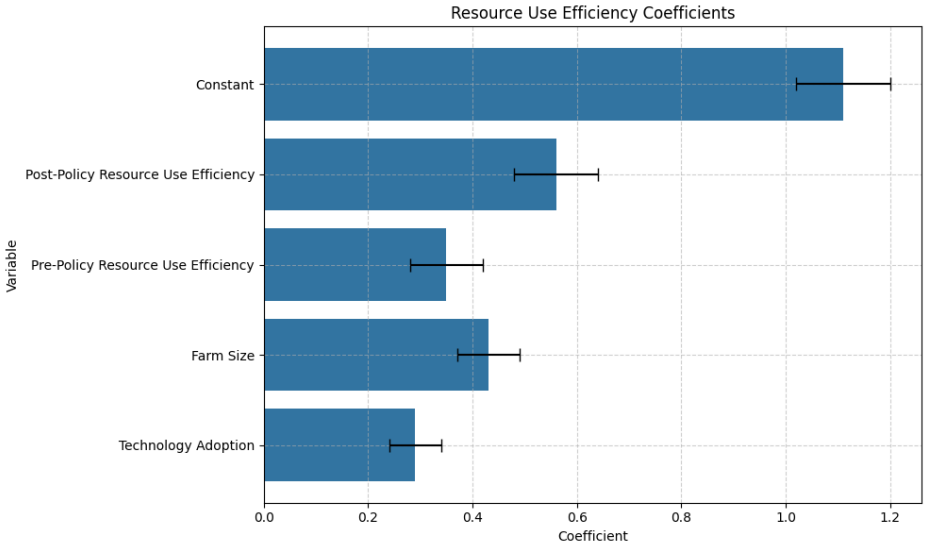

Figure 4. Resource use efficiency.

4.2.1. Market Stability Findings

Table 8 and **Figure 5**, **Figure 6** present the regression analysis results on market price stability. The constant is 1.10, with a t-statistic of 10.00 and a p-value of 0.001, indicating a significant baseline level for market prices. The post-policy price volatility shows a negative coefficient of −0.48, with a t-statistic of −6.00 and a p-value of 0.001, indicating that EOAP has contributed to stabilizing market prices by reducing price variations. In contrast, the pre-policy price volatility has a positive coefficient of 0.37, with a t-statistic of 6.17 and a p-value of 0.002, suggesting that price volatility was higher before these policies were implemented. Export market demand has a strong positive coefficient of 0.52, with a t-statistic of 7.43 and a p-value of 0.001, showing that higher demand from AE contributes to more excellent price stability. Additionally, the coefficient for supply chain infrastructure is 0.29, with a t-statistic of 5.80 and a p-value of 0.002, indicating that improved set-up plays a significant role in stabilizing prices by supporting efficient market operations.

Table 8. Market Price Stability.

Variable	Coefficient	Standard Error	t-Statistic	p-Value
Constant	1.10	0.11	10.00	0.001
Post-Policy Price Volatility	−0.48	0.08	−6.00	0.001
Pre-Policy Price Volatility	0.37	0.06	6.17	0.002
Export Market Demand	0.52	0.07	7.43	0.001
Supply Chain Infrastructure	0.29	0.05	5.80	0.002

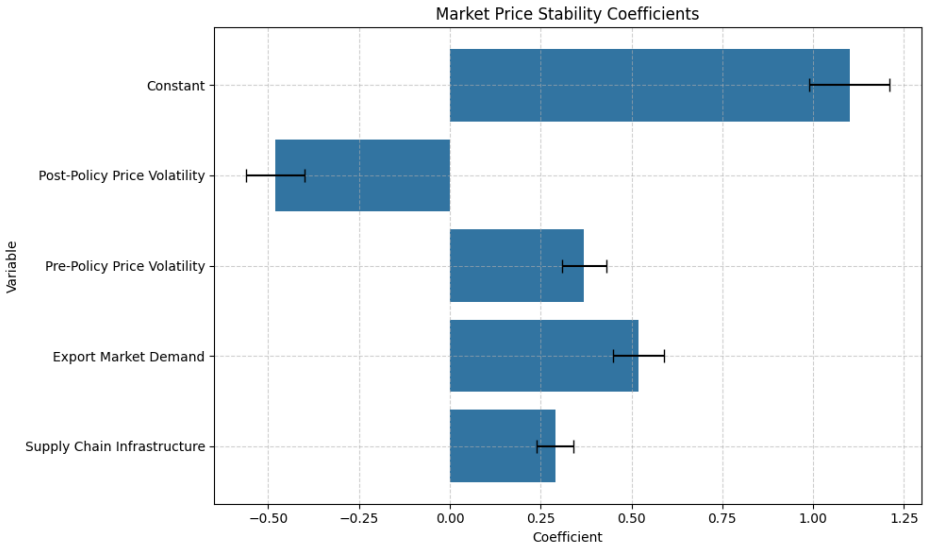

Figure 5. Market Price Stability.

Table 9 focuses on supply chain stability. The constant is 1.21, with a t-statistic of 10.08 and a p-value of 0.001, showing strong baseline efficiency in the supply chain. The post-policy supply chain efficiency has a positive coefficient of 0.44, with a t-statistic of 6.29 and a p-value of 0.001, indicating that EOAP has significantly improved supply chain stability, allowing smoother operations and fewer disruptions. The pre-policy coefficient is lower at 0.33, with a t-statistic of 5.50 and a p-value of 0.003, suggesting less efficient supply chains before the policy changes. Export market demand remains an important factor, with a coefficient of 0.56, a t-statistic of 6.22, and a p-value of 0.002, demonstrating that strong demand from AE leads to more stable and reliable supply chains. The use of export infrastructure also positively impacts supply chain stability, with a coefficient of 0.38, a t-statistic of 5.43, and a p-value of 0.003, indicating that infrastructure improvements are crucial for supporting the smooth flow of goods and reducing supply chain disruptions.

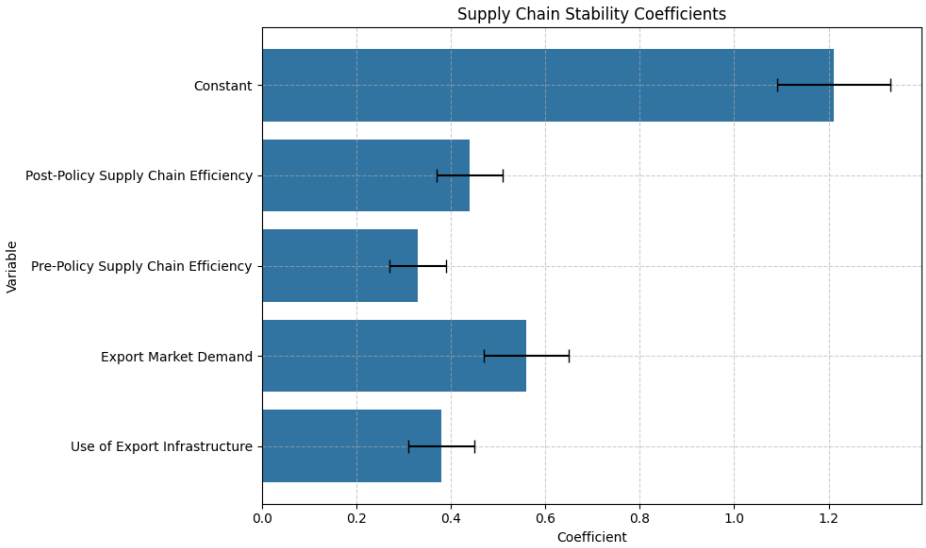

Figure 6. Supply chain stability analysis.

Table 9. Supply Chain Stability.

Variable	Coefficient	Standard Error	t-Statistic	p-Value
Constant	1.21	0.12	10.08	0.001
Post-Policy Supply Chain Efficiency	0.44	0.07	6.29	0.001
Pre-Policy Supply Chain Efficiency	0.33	0.06	5.50	0.003
Export Market Demand	0.56	0.09	6.22	0.002
Use of Export Infrastructure	0.38	0.07	5.43	0.003

This proposed study uses survey data to analyze farm income, production frontier, and market risks under EOAP. In this case, the descriptive statistics offer an understanding of the main findings concerning the variability of income, the level of technology, and the variability of prices. Hypothesis testing reveals the most significant predictors of income, including export market participation, domestic revenue, and technology, among others. In addition, input-output ratios and labor productivity are used to analyze efficiency before and after the policy effect. Market stability is described by price fluctuation and supply chain information. This integrated approach employs multivariate regression and sound statistical tests to affirm the policy effects on agricultural performance.

The present research distinguishes itself from the previous works, focusing on farm-level effects of export promotion policies in agriculture, while prior studies were at the macro or sector levels. Asgarov [37] provides an overview of the general economic impacts of export promotion policies; on the other hand, this paper explores the firm-level performance regarding production efficiency and market stability. While Aragie et al. [38] focus on export promotion and food security for African economies, the current study analyses how they affect inequality between smallholder and commercial farms. Koff et al. [39] only consider socio-environmental implications in Mexico's pineapple industry, while this study broadens the approach by including market conditions and sustainability. To this end, the study fills these gaps to propose a systematic understanding of how export-oriented policies affect farm-level performance and costs with input on socio-economic and environmental concerns.

5. Conclusion and Future Work

The findings of this study confirm that EOAP plays a significant role in enhancing FLI, PE, and MS, particularly for farms that are well-integrated into global markets.

Farms contributing to export activities experience higher incomes and greater operational efficiency, primarily driven by the adoption of SF and improved access to export infrastructure. EOAP stabilizes supply chains and reduces market price volatility, enhancing overall market flexibility. However, the study also reveals disparities in how different types of farms benefit from these policies. More significantly, commercial farms are better positioned to take advantage of export opportunities, while smallholder farmers often face barriers such as limited access to AE, infrastructural constraints, and challenges in meeting international quality standards. These issues underscore the need for more targeted support mechanisms, such as improved set-up, cooperative models, and policy adjustments, to ensure that the benefits of EOAP strategies are more broadly shared. In conclusion, while EOAP can potentially drive significant economic improvements in India's agricultural sector, a more comprehensive approach is necessary to extend these benefits to all farmers. Policymakers should focus on creating enabling conditions for smallholders, including enhanced access to AE, financial support, and capacity-building initiatives.

By addressing these gaps, India can better leverage its agricultural potential in global markets while developing SF and inclusive rural development.

Author Contributions

S.H.N., N.M.R., D.R., K.R.P., S.D., S.R., R.K.B., all authors have read and agreed to the published version of the manuscript.

Funding

This work received no external funding.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

Not applicable.

Conflicts of Interest

The authors declare no conflict of interest.

References

[1] Thow, A.M., Apprey, C., Winters, J., Stellmach, D., et al., 2021. Understanding the impact of historical policy legacies on nutrition policy space: economic policy agendas and current food policy paradigms in Ghana. International journal of health policy and management. 10(12), 909. DOI: https://doi.org/10.34172/ijhpm.2020.203

[2] Paolo, S., Mahadev, N.A. Comparative Analysis of Agricultural Domestic and Trade Policies in India and in the European Union. Available from: https://www.researchgate.net/publication/349077227_Comparative_Analysis_of_Agricultural_Domestic_and_Trade_Policies_in_India_and_in_the_European_Union (cited 10 February 2021).

[3] Thomas, L., Kuruvilla, A., Meena, M., et al., 2023. Handbook of Spices in India: 75 Years of Research and Development. Springer: New York, NY, USA. pp. 1095–1145

[4] Awokuse, T., Lim, S., Santeramo, F., et al., 2024. Robust policy frameworks for strengthening the resilience and sustainability of agri-food global value chains. Food Policy. 127, 102714. DOI: https://doi.org/10.1016/j.foodpol.2024.102714

[5] German, L. A., Bonanno, A. M., Foster, et al., 2020. "Inclusive business" in agriculture: Evidence from the evolution of agricultural value chains. World Development. 134, 105018. DOI: https://doi.org/10.1016/j.worlddev.2020.105018

[6] George, A. S., 2023. Evaluating India's economic growth: challenges and opportunities on the path to 5 trillion dollars. Partners Universal International Innovation Journal. 1(6), 85–109. DOI: https://doi.org/10.5281/zenodo.10307006

[7] Food and Agriculture Organization (FAO). Available from: https://www.fao.org/india/fao-in-india/india-at-a-glance/en/ (cited 5 April 2019)

[8] Kolloju, P.K., Kolloju, N., Siriman, N., 2024. Food Security As A Public Policy Concern In India Amidst The 2030 agenda: A historical trajectory. Glocalism: Journal of Culture, Politics and Innovation. (1). DOI: https://doi.org/10.54103/gjcpi.2024.22790

[9] Ranjan, O.J., 2021. Food Security Policy in India: Challenges and Performance. Available from: https://policy-practice.oxfam.org/resources/fo

od-security-in-india-performance-challenges-and-policies-346637/ (cited 8 October 2021)

[10] Saxena, R., Singh, R., Agarwal, P., et al., 2023. Sustainable Food Value Chain Development: Perspectives from Developing and Emerging Economies. Singapore: Springer Publishing: New York, NY, USA. pp. 295–317

[11] Saxena, R., Kumar, A., Singh, R., et al, 2024. Examining export advantages in Indian horticulture: an approach based on product mapping and seasonality. Journal of Agribusiness in Developing and Emerging Economies, 14(2), 161–192. DOI: https://doi.org/10.1108/JADEE-12-2021-0310

[12] Ghosh, M., 2023. Growth and Development under Alternative Policy Regimes in India: A Political Economy Perspective. Journal of Asian and African Studies. 58(7), 1134–1155. DOI: https://doi.org/10.1177/00219096221079324

[13] Bandolkar, K.N., 2023. Impact of Regional Trade Agreements on India's Agricultural Trade (Doctoral dissertation). Taleigao Plateau: Goa University. pp. 379–392

[14] Pavan, V., Vishnupriya, V., HR, H.K., et al., 2023. Emerging Trends in Agricultural Economics and Agribusiness: An Edited Anthology. Stella International Publication: Haryana, India. p. 39

[15] Ravi Kumar, K.N., Naidu, G.M., Shafiwu, A.B., 2024. Exploring the drivers of Indian agricultural exports: a dynamic panel data approach. Cogent Economics & Finance. 12(1), 2344733. DOI: https://doi.org/10.1080/23322039.2024.2344733

[16] Anderson, K., 2022. Trade-related food policies in a more volatile climate and trade environment. Food Policy, 109, 102253. DOI: https://doi.org/10.1016/j.foodpol.2022.102253

[17] Aragie, E., Balié, J., Morales, C., Pauw, K., 2023. Synergies and trade-offs between agricultural export promotion and food security: Evidence from African economies. World Development. 172, 106368. DOI: https://doi.org/10.1016/j.worlddev.2023.106368

[18] Marcina, K., Sauhats, A., Lavrinovics, V., et al., 2018. Efficiency Analysis of the Baltic Balancing Market. In Proceedings of the 2018 15th International Conference on the European Energy Market (EEM), Lodz, Poland, 2018; pp. 1–6. DOI: https://doi.org/10.1109/EEM.2018.8469992

[19] Mulongo, N.Y. Optimisation of Manufacturing Workflow Through Generative Artificial Intelligence. In Proceedings of the 2024 International Symposium on Networks, Computers and Communications (ISNCC), Washington, DC, USA, 2024; pp. 1–6. DOI: https://doi.org/10.1109/ISNCC62547.2024.10758970

[20] Gadipudi, S.B., Kalpana Kalaimani, R. Reinforcement Learning for Dynamic Pricing under Competition for Perishable Products. In Proceedings of the 2024 28th International Conference on System Theory, Control and Computing (ICSTCC), Sinaia, Romania, 2024; pp. 297–302, DOI: https://doi.org/10.1109/ICSTCC62912.2024.10744760

[21] Li, Y., Cui, C., Lu, T., et al., 2024. Study on the Value of Lost Load of Three Provinces in China Based on Production Function Approach. In Proceedings of the 2024 4th Power System and Green Energy Conference (PSGEC), Shanghai, China, 2024; pp. 557–561. DOI: https://doi.org/10.1109/PSGEC62376.2024.10721032

[22] Eimear Leahy and Richard S.J. Toi, An estimate of the value of lost load for Ireland. Energy Policy, 39(3), 1514–152. DOI: https://doi.org/10.1016/j.enpol.2010.12.025

[23] Panneerselvam. S, Thangavel, S.K., Ponnam V.S. et al., Federated learning-based fire detection method using local MobileNet. Scientific Reports. 14 1-24. DOI: https://doi.org/10.1038/s41598-024-82001-w

[24] Madhubala, P., Ghanimi, H.M.A., Sengan, S., et al., 2024. Bridging the gap in biomedical information retrieval: Harnessing machine learning for enhanced search results and query semantics. Journal of Intelligent & Fuzzy Systems. 46(6), 1–20. DOI: https://doi.org/10.3233/JIFS-237056

[25] Khan G, Mishra P K, Agarwal A K, et al., 2024. Energy-Efficient Routing Algorithm for Optimizing Network Performance in Underwater Data Transmission Using Gray Wolf Optimization Algorithm, Journal of Sensors, 2024(1), pp. 1-15. DOI: https://doi.org/10.1155/2024/2288527

[26] Arumugham, V.; Ghanimi, H.M.A.; Pustokhin, D.A., 2023. An Artificial-Intelligence-Based Renewable Energy Prediction Program for Demand-Side Management in Smart Grids. Sustainability, 15(6), 5453. DOI: https://doi.org/10.3390/su15065453

[27] Abdulkader, R., Ghanimi, H.M.A., Dadheech, P., 2023. Soft Computing in Smart Grid with Decentralized Generation and Renewable Energy Storage System Planning. Energies. 16(6), 2655. DOI: https://doi.org/10.3390/en16062655

[28] Ni, D.B., Tang, X.W., 2024. Study on the relationship between production function and cost function. Chinese Management Science. 12(4), 64–68

[29] Chao, Y., Guo Y. G., Cheng L., 2002. Customer service reliability promise/compensation method. Automation of Electric Power Systems. 26(18), 11–14.

[30] Nguyen, P.T., Nguyen, T.-A.-T., 2024. Design and Simulation Industrial Wood Furniture Manufacturing Plants. 2024 9th International Conference on Applying New Technology in Green Buildings

(ATiGB); Danang, Vietnam, 30–31 August 2024. pp. 280–284

[31] Milton, L.C., et al., 2024. A Multi Moving Target Localization in Agricultural Farmlands by Employing Optimized Cooperative Unmanned Aerial Vehicle Swarm. Scalable Computing: Practice and Experience. 25(6), 4647–4660, DOI: https://doi.org/10.12694/scpe.v25i6.3130

[32] Roque-Claros, R.E., et al., 2024. UAV Path Planning Model Leveraging Machine Learning and Swarm Intelligence for Smart Agriculture. Scalable Computing: Practice and Experience. 25(5), 3752–3765. DOI: https://doi.org/10.12694/scpe.v25i5.3131

[33] Lal Karn, A., Kondamudi, B.R., Gupta, R.K., 2023. An Empirical Analysis of the Effects of Energy Price Shocks for Sustainable Energy on the Macro-Economy of South Asian Countries. Energies. 16(1), 363. DOI: https://doi.org/10.3390/en16010363

[34] Karn, A.L., Manickam, P.S., Saravanan, R., 2023. IoT Based Smart Framework Monitoring System for Power Station. Computers, Materials & Continua. 74(3), 6019–6037. DOI: https://doi.org/10.32604/cmc.2023.032791

[35] Ghanimi, H.M., R, S., Jeyaraj, J.P.G., et al., 2024, Smart Fertilizing Using IOT Multi-Sensor and Variable Rate Sprayer Integrated UAV. Scalable Computing: Practice and Experience. 25(5), 3766–3777. DOI: https://doi.org/10.12694/scpe.v25i5.3132

[36] Rahmani, M. K. I., et al., 2023. Early Pathogen Prediction in Crops Using Nano Biosensors and Neural Network-Based Feature Extraction and Classification. Big Data Research. 38, 100412, DOI: https://doi.org/10.1016/j.bdr.2023.100412

[37] Asgarov, R., 2024. Advantages of Export Promotion Policy in Rural Farming and Factors Conditioning It. Acta Universitatis Danubius. Œconomica. 20(3), 15–22

[38] Aragie, E., Balié, J., Morales, C., et al., 2023. Synergies and trade-offs between agricultural export promotion and food security: Evidence from African economies. World Development. 172, 106368. DOI: https://doi.org/10.1016/j.worlddev.2023.106368

[39] Koff, H., Bonilla-Moheno, M., Campos-García, L.M., et al., 2023. Agricultural policies and local sustainability: a normative coherence for development analysis of Mexico's pineapple sector. Local Environment, 28(11), 1496–1514. DOI: https://doi.org/10.1080/13549839.2023.2238739

[40] Firas, T.A., Ayasrah, F.T., Alsharafa, N.S., 2024. Strategizing Low-Carbon Urban Planning through Environmental Impact Assessment by Artificial Intelligence-Driven Carbon Foot Print Forecasting. Journal of Machine and Computing, 4(4). DOI: https://doi.org/10.53759/7669/jmc202404105