



An Integrated Analysis Of Economic Viability And Sustainability In Moringa Cultivation: Evidence From Mulanur, Tamil Nadu, India

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ABSTRACT

Moringa oleifera, often referred to as the "miracle tree," has garnered global attention for its nutritional, medicinal, and economic significance. This study examines the economic viability and sustainability of Moringa cultivation, with a specific focus on the Mulanur Murungai variety in Tamil Nadu, India. The research highlights the crop's potential to enhance rural livelihoods, contribute to sustainable agricultural practices, and align with the United Nations Sustainable Development Goals (SDGs). Tamil Nadu, particularly the Mulanur block in Tiruppur district, is a key Moringa-producing region, contributing 24% of India's total production. The study employs a mixed-methods approach, combining primary data from 135 farmers (stratified by landholding size) and secondary data from agricultural reports. Analytical tools like canonical correlation, Translog production function, and Garrett ranking technique are used to assess resource-use efficiency, profitability determinants, and constraints. The study reveals an input-output ratio of 1.9, indicating that for every rupee invested, farmers earn Rs. 1.90, underscoring the crop's profitability. Findings indicate that labor and capital significantly influence yield, with increasing returns to scale. However, external factors like market forces and climate variability also play a critical role. A shift toward genetically modified varieties due to higher yields threatens the traditional variety's survival, necessitating government intervention. In conclusion, Moringa cultivation in Mulanur Block is economically viable and environmentally sustainable, offering a pathway to rural prosperity and global sustainability goals. By addressing production and marketing constraints through targeted strategies, stakeholders can unlock the crop's full potential, transforming it into a high-value agro-enterprise.

Keywords: Moringa oleifera, Economic viability, Sustainable agriculture, Rural livelihoods, Sustainable Development Goals (SDGs)

INTRODUCTION

India's rural economy is a cornerstone of its socio-economic structure, contributing significantly to GDP and providing employment to nearly 65-70 percent of the population¹. It encompasses agriculture, small-scale industries, and non-agricultural rural enterprises. Rural areas are hubs for micro and small enterprises, handicrafts, and cottage industries, which play a pivotal role in local development. However, the rural economy faces challenges such as inadequate infrastructure, limited access to credit, and disparities in education and healthcare, all of which hinder its full potential. Despite the fact that agriculture is the backbone of India's economy, the sector is plagued by issues like fragmented landholdings, dependence on monsoons, low productivity, and inadequate market access. With the integration of technology and sustainable practices, agriculture has the potential to play a transformative role in India's growth.

¹Economic Survey Highlights Thrust on Rural Development (Feb 2025), Ministry of Rural Development, <https://pib.gov.in>

The Value of Agriculture

Agriculture holds immense significance as it forms the backbone of the global food system and sustains livelihoods for millions, particularly in developing countries like India. It provides essential food and raw materials for industries, contributes to economic stability, and plays a critical role in rural development by generating employment. Beyond economic contributions, agriculture ensures food security, fosters biodiversity, and influences cultural traditions. As the world grapples with challenges like climate change and population growth, sustainable agricultural practices are vital to ensuring a balanced and resilient future.

Moringa – ‘The Miracle Tree’

Moringa, commonly referred to as the “drumstick tree,” “miracle tree,” or “horseradish tree,” is a fast-growing, drought-resistant plant native to the Indian subcontinent. Scientifically known as *Moringa oleifera*, it has gained global recognition for its nutritional, medicinal, and economic significance. Every part of the tree – leaves, pods, seeds, bark, and roots – is utilized, making it one of the most versatile crops in the world.

Moringa has a long history of cultivation in India, where it is an integral part of both traditional cuisine and ayurvedic medicine. The cultivation of Moringa has proven to be economically viable for farmers, especially in regions with arid and semi-arid climates. Its low water requirements, adaptability to poor soil conditions, and ability to produce high yields make it a cost-effective crop. Additionally, the global demand for Moringa-based products, such as nutritional supplements, oils, and cosmetics, has increased significantly, creating lucrative opportunities for export.

Economic Viability of Moringa Cultivation

Moringa cultivation offers significant economic benefits due to its versatility, low input requirements, and growing global demand. Below are the key economic advantages:

High Market Demand

➤ **Nutritional Products:** Moringa leaves, powders, and capsules are in high demand globally, particularly in the health and wellness industry. The growing awareness of superfoods has positioned Moringa as a premium product.

➤ **Edible Products:** Pods (drumsticks) are a staple in many cuisines, and their consistent demand ensures a steady income for farmers.

➤ **Oil Production:** Moringa seeds yield ben oil, a high-value product used in cosmetics, pharmaceuticals, and biofuel industries.

Multiple Income Streams: Moringa provides multiple harvestable products – leaves, pods, seeds, and flowers allowing farmers to diversify their income sources and reduce dependency on a single product.

Minimal Input Costs: Moringa is drought-resistant and thrives in marginal soils, requiring minimal water, fertilizers, and pesticides. Its fast growth allows for multiple harvests per year, increasing revenue without proportionate increases in labor or inputs.

Employment Opportunities: Large-scale Moringa plantations create jobs in farming, processing, and value-added product manufacturing, stimulating rural economies.

Export Potential: Moringa products have significant export value, particularly to markets in Europe, North America, and Asia, where the demand for organic and sustainable products is increasing².

Sustainability Benefits: By improving soil fertility and acting as a companion crop, Moringa contributes to sustainable agricultural practices, reducing costs for fertilizers and enhancing the profitability of intercropped systems.

Opportunity Cost of Moringa Cultivation

The opportunity cost of cultivating Moringa refers to the benefits foregone from alternative uses of land, labor, and resources. Key considerations include:

Alternative Crops: Farmers might have to forgo cultivating other cash crops like cotton, sugarcane, or staple food crops that might yield higher returns in certain markets. Moringa’s long-term profitability could be lower compared to crops with higher short-term market demand or government subsidies.

Land Use: Allocating land for Moringa means sacrificing the potential income from other high-yield crops, orchards, or alternative agroforestry systems.

Market Risks: While Moringa’s demand is rising, oversaturation in the market or competition from larger producers may lower profits. Farmers who focus solely on Moringa cultivation might face risks from fluctuating prices, demand changes, or export restrictions.

²<https://www.zionmarketresearch.com/report/moringa-market>

Processing and Value Addition: Cultivating Moringa alone may not maximize profits; significant investments in processing facilities (e.g., drying, powdering, oil extraction) are required for higher returns. Opportunity costs arise from the time and money invested in developing these facilities instead of using them for other ventures.

Knowledge and Training: Farmers may need to invest time and resources in learning best practices for Moringa cultivation, value addition, and marketing. This investment could be diverted from other profitable ventures.

Moringa – at India Level

The largest producer of Moringa is India, which produces 2.6 million tons of fruits annually from 43,600 hectares of land, yielding about 63 tonnes of fruit per hectare. China, the United States, Germany, Canada, South Korea, and European nations are the main importers of Moringa leaves. The world's largest producer of Moringa is Asia-Pacific. India supplies around 80 percent of the world's demand for Moringa, making it the world's leading supplier.

Moringa's Role in Tamil Nadu

Because of its great nutritional content, Moringa (drumstick) and its value-added products have enormous export potential in many nations among the many agricultural commodities produced in Tamil Nadu. Tamil Nadu produces 24 percent of the world's Moringa, which is grown extensively in the districts of Tiruppur, Dindigul and Theni. Six of the 13 most common Moringa types worldwide are found in Tamil Nadu. Because of its high nutrient content and capacity to adapt to any climate, the native Moringa type grown in Tamil Nadu, Mulanur Kuttaimurungai, is the most sought-after kind worldwide.

Table 1 – Area under Moringa in Different Districts of Tamil Nadu

S. No.	Name of the District	Area (ha)	Percentage to the Total area under Moringa in Tamil Nadu
1	Dindigul	5619	27.98
2	Karur	3257	16.22
3	Theni	2850	14.19
4	Tiruppur	2245	11.18
5	Thoothukudi	1907	9.50
6	Ariyalur	1318	6.56
7	Other Districts	2886	14.37
Total		20,082	100.00

Source: Season and Crop Report of Tamil Nadu (2023 – 24)

Moringa Promotion – A Path to Achieve SDGs

Promoting the cultivation of Moringa and its allied activities are significant in achieving the Sustainable Development Goals (SDGs), 2030 framed by the United Nations Organization (UNO)³ in the following way;

1. (1st) No Poverty: Moringa production and processing create new jobs and new sources of income for small scale farmers and landless labourers.

2. (2nd) Zero Hunger:

- Provide access to safe and nutritious food for all
- End malnutrition (children and women)
- Increase productivity and incomes of small-scale farmers (resources and knowledge)
- Ensure sustainable food production systems (climate)
- Maintain and use plant genetic diversity
- Enhance agricultural productive capacity

3. (3rd) Good Health and Well-being: Consumption of micronutrient dense Moringa alleviates diseases linked to malnutrition.

4. (4th) Quality Education: Home and school garden programs offer opportunities to acquire knowledge for sustainable lifestyle.

5. (5th) Gender Equality: Empowering women and girls by promoting in small scale Moringa farming.

6. (6th) Clean Water and Sanitation: Promoting efficient water use for small scale farms, clean water in markets wastewater recycling and sanitation.

7. (8th) Decent Work and Economic Growth: Cost effective production technologies and training courses enhance farmer's economic productivity.

8. (9th) Industry, Innovation and Infrastructure: The centre's innovative technologies facilitate integration of small-scale enterprises into the Moringa value chain.

³<https://avrdc.org/>

9. (12th) Responsible Consumption and Production: Pest management strategies and post-harvest technologies improve production efficiency and reduce food losses.

10. (13th) Climate Action: Robust Moringa lines and adaptable production technology strengthen farmers' resilience to climate change.

11. (15th) Life on Land: The World Vegetable Center Genebank shares and safeguards Moringa genetic resources for the entire world.

12. (17th) Partnerships for the Goals: It influences policy and promote progress through partnerships in agriculture, nutrition and health.

Statement of the Problem

Moringa, also known as the “miracle tree” or “tree of life”, has many potential uses that could help to achieve sustainable development goals (SDGs). India is the world's leading exporter of Moringa powder, accounting for 80 percent of global demand. India exports more than \$100 million in Moringa powder annually. The export market for Moringa products is growing rapidly, with exports of Moringa leaves increasing at a rate of 26–30 percent annually⁴. Export competitiveness was highly available in Tiruppur and offered best price due to its taste because of its natural cultivation made in calcium rich soils. Higher returns from Moringa and sustainable income generation were the factors that made the people of Tiruppur District to involve in Moringa cultivation extensively. ‘Mulanur Kuttai Murungai’ recommended for geographical indication but lack of practical solutions for the local farmers besides it's nutritional and economic significance in achieving the SDG of 2030 induced to the cause of the study.

Objectives of the Study

1. To study the feasibility and economic viability of Moringa production in the Mulanur block.
2. To trace the significance of Moringa cultivation in achieving Sustainable Development Goals, 2030.
3. To identify the constraints faced by the local farmers in production and marketing.

Scope of the Study

The study attempts to familiarize the significance of Moringa production and it's contribution towards achieving sustainable and inclusive development. Further research and development in terms of both economic and scientific means and extending the study at an extensive scale could lead to strengthening it's production – consumption linked value chain with innovation as well as optimality.

REVIEW OF LITERATURE

Sekar et al., (2017)⁵ specified that “In Moolanur block, Moringa is established as an intercrop on field scale and their allies were cropped with vegetables and Sorghum. This system evolved as Moringa based cropping systems offered some protection to alley crops from drying winds during summer and Moringa provided some additional income”. The study provided the steps involved in post-harvest practices in an orderly arranged and sequentially. And suggested that the product quality could be ensured and fetches higher consumer acceptance both in the regional, national and international markets.

Sekar et al., (2018)⁶ revealed that presence of higher returns, sustainable income generation, availability of land and water resources for cultivation, minimal pest problems, good market demand for value added Moringa products in the national and international markets were found to be the principal factors influencing the area under Moringa. And Resource Use Efficiency analysis revealed that four principal variables viz., number of limb cuttings used for planting, quantity of FYM, quantity of fertilizer applied (kg) and the number of human labour used (man days) per ha per annum influenced the yield of Moringa. The following were mentioned about Tiruppur district viz., ‘Export competitiveness was highly available in Tiruppur and offered best price due to its taste because of its natural cultivation made in calcium rich soils. Higher returns from Moringa and sustainable income generation were the factors dearer to the people of Tiruppur District. Drip irrigation and fertigation technique was practiced in most of the Moringa farms to generate their own income in Tiruppur District’.

Kavithambika et al., (2020)⁷ found that in Tiruppur District, about 50 percent of farmers operated in a technical efficiency range greater than 0.90 and technical efficiency varied substantially between 0.67 and 1.00, with a mean of

⁴ Market Intelligence Report: Moringa, Agricultural and Processed Food Products Export Development Authority, <https://agriexchange.apeda.gov.in>

⁵ Sekar. C, Venkatesan. N, Vidhyavathi. A and Muruganathi. M (2017), “Post Harvest Processing of Moringa and Socio-Economic Appraisal of Moringa Orchards in Tamil Nadu”, International Journal of Horticulture, 7(30), pp. 275-287

⁶ Sekar. C, Venkatesan. N, Vidhyavathi. A and Muruganathi. M (2018), “Factors influencing moringa cultivation in Tamil Nadu – an economic analysis”, Horticulture International Journal, 2(5), pp. 223-230

⁷ Kavithambika. S, Indhumathi. V. M and Mahendran. K (2020), “Moringa oleifera: Production and Marketing in Tiruppur District”, Advances in Research, 21(9), pp. 89-97

0.89; Majority of the farmers preferred selling their produce to local traders as this channel saved their time. Marketing Margin of processors were the highest. It was recommended that price fluctuation presented a favorable climate for value addition processes in the study area and processors could expand the existing small-scale activities to meet out the demand.

In the study made by **Mashamaite et al., (2021)**⁸, a systems thinking approach was applied to address complex and conflicting issues linked to the production and overall status (economic, ecological, legal and social) of Moringa in South Africa. The Causal Loop Diagram (CLD) was developed to present a broad insight into the complexity of Moringa in South Africa and assisted in underscoring the feedback mechanisms within the system. The CLD indicated that the position of Moringa within the country comprised a variety of interdependent variables of government policies, environment, and society which are interconnected into a multifaceted system that served as a useful tool for facilitating engagements and decision-making processes among stakeholders in resolving the status of Moringa in South Africa.

Atreya et al., (2023)⁹ compiled scientific evidence through a systematic literature search to highlight the ecological benefits and livelihood opportunities associated with the use of Moringa retrieved from 206 pieces of global literature and extracted information from 22 articles. The study concluded that Moringa's diverse applications could contribute to the livelihood enhancement and economic well-being of poor and marginalized farmers in low-income countries. Planting Moringa trees in abandoned croplands and other degraded areas could have positive ecological and socioeconomic outcomes for rural communities. And suggested that favorable policies, field-based research evidences and products development were crucial to support smallholders in low-income countries.

Talucder et al., (2024)¹⁰ determined the prospects of Moringa-based homestead concerning Sustainable Development Goals. A household survey was conducted following a simple random sampling of 135 farmers and following a semi-structured questionnaire and interview schedule with 100 farmers (40 identified Moringa-based adopters and 60 non-adopters). The perception assessment revealed that 100 percent of adopters and 90 percent of non-adopters believed that Moringa-based homesteads had the potential to increase access to food, nutrition, and medicinal resources. The results disclosed that Moringa-based homestead in Sylhet can be a potential option for attaining SDGs indicators of escalation of household income (SDGI = 90), access to food, nutrition, and medicinal resources (SDGI = 103.6), facilitation of natural treatment of diseases (SDGI = 104.6), de-escalation of gender discrepancy in terms of production activities (SDGI = 103.64), own source of fuel (SDGI = 58.44), both off-farm and on-farm income opportunity (SDGI = 100.52), ecosystem health maintenance by resilient practices (SDGI = 104.6). Farmers ranked food security capacity as a major motivational factor, while the low economic return was a major demotivational factor. The escalation of Moringa-based homesteads needs to be prioritized while facilitating credit, and institutional support to extend encouragement to non-adopters for wider integration of Moringa-based homesteads, and appropriate utilization of the existing resources for greater profitability.

RESEARCH GAP

Despite extensive studies on Moringa Cultivation globally, there remains a critical research gap in understanding the region-specific economic viability, sustainability challenges and market integration of Mulanur Murungai in Tamil Nadu's semi-arid agro-climatic context. Existing literature predominantly focuses on agronomic practices, nutritional benefits or generic value chains often overlooking the socio-economic barriers (e.g., gender disparities in decision-making, youth disengagement) and institutional voids (e.g., ineffective training programs) unique to smallholder farmers in Mulanur Block. Additionally, gaps persist in cost-benefit analyses of hybrid versus traditional varieties and scalable solutions for market asymmetry. This study addresses these gaps by integrating farm-level financial metrics, constraint prioritization and Sustainable Development Goals (SDGs) linkages to propose contextually relevant strategies for enhancing Moringa's socio-economic and ecological resilience in the region.

RESEARCH METHODOLOGY

The key components of the research methodology comprise the research design and method of data analysis which has been systematically depicted in this chapter.

Nature of the Study

⁸ Chuene Victor Mashamaite, Ethel Emmarantia Phiri, Tonderai Clive Mandizvidza, Palesa Natasha Mothapo, Petrus Jacobus Pieterse, Anouk Jasmine Albien (2024), "Assessing a potential conflict associated with the production of Moringa oleifera in the Limpopo Province of South Africa: A Systems thinking approach", *Heliyon* 10, <https://doi.org/10.1016/j.heliyon.2024.e26906>

⁹ Atreya, K., Kattel, K., Tiwari, K. R., Baral, S., Adhikari, R., & Kalwar, O. P. (2023). Nutritional, ecological and Livelihood significance of Moringa oleifera: A review, *Archives of Agriculture and Environmental Science*, 8(3), 452-461

¹⁰ Mohammad Samiul Ahsan Talucder, Umama Begum Ruba, Sanjia Jahir Prova and Md Abu Sayed Robi (2024), Moringa-based homestead to achieve Sustainable Development Goals: A case study from Jaintiapur of Sylhet, Bangladesh, *Heliyon* 10 (2024) e37889

The study is intended to know the socio-economic status of the Moringa farmers and also to analyze the investment and profitability of the Moringa cultivation. Also focuses to figure out the constraints faced by the farmers in production and marketing and to trace the significance of Moringa production in achieving the SDGs. Hence the nature of the study is both descriptive and analytical.

Selection of the Study Area

Among the top producers, Tamil Nadu holds the second place only after to Andhra Pradesh. In Tamil Nadu, Moringa cultivation is been carried out pervasively in many districts. Still villages in and around Tiruppur, Dindigul, Karur, Theni and Thoothukudi holds an indispensable position in the cultivation of Moringa. Mulanur block of Tiruppur district is known for its conventional agricultural practices and Moringa production. The indigenous variety cultivated in this locality is recommended for geographical indication. Hence the Mulanur block is selected as the Study Area.

Selection of Sample Respondents

According to the data collected from the office of the Regional Directorate of Agriculture of the Mulanur block, 6794 farmers are involved in Moringa cultivation of the total 9033 farmers in the Block. It was decided to select 135 sample farmers through stratified random sampling technique by grouping the entire population into marginal, small and large farmers, selecting 2 percent of the population from each stratum as the sample respondents for the study. It is clearly presented in the table below.

Table 2 – Selection of the Sample Respondents

Strata	Population Size	Sample Size
Marginal Farmers	2217	44
Small Farmers	3537	71
Medium Farmers	731	15
Large Farmers	269	5
Total	6794	135

Source: According to the data collected from the office of the Regional Directorate of Agriculture of the Mulanur Block

Nature of the Data

Both primary and secondary were collected and analyzed for the study.

Method of Data Collection

The primary data, upon which the study rests, were collected with the help of structured interview schedule by personal interview method.

The secondary data, which supports and validates the primary data, were collected from the published reports, journals and related sources like Season and Crop Report of Tamil Nadu, Agricultural Statistics of India, Economic Survey, World Vegetable Centre and the like.

Period of Study

The study covered a period of one year that is 2023-2024 for primary data.

Method of Data Analysis

The collected data were analyzed with the help of simple statistical tools like averages, percentage and other analytical tools relevant to the data collected and suitable to achieve the objectives of the study is listed below.

Input – Output Ratio

In this study, the input-output ratio reveals the efficiency of the farming operation by showing how much output (Moringa yield) is produced per unit of input (fertilizer, water, labour, etc.) used, essentially indicating how well resources are being utilized to generate agricultural products; a higher ratio signifies greater efficiency and profitability, while a lower ratio suggests potential procedures for improvement in resource management.

Formula:

$$\text{Input-Output Ratio} = \frac{\text{Total units of Outputs per acre/per tree}}{\text{Total units of Inputs per acre/per tree}}$$

Canonical Correlation

Canonical correlation analysis reveals the strength and direction of the relationship between two sets of variables, identifying linear combinations within each set that maximize the correlation between them, essentially showing how different groups of variables are related to each other across multiple dimensions. In this study, it is employed to study the relation between expenditure and receipt variable sets.

Formula:

The canonical correlation for the i^{th} canonical variate pair is simply the correlation between U_i and V_i is;

$$\rho_i^* = \frac{\text{cov}(U_i, V_i)}{\sqrt{\text{var}(U_i)\text{var}(V_i)}}$$

Translog Production Function

A Translog Production Function in agriculture expresses the complex relationships between various agricultural inputs (like labour, land, fertilizer, water) and the resulting output, allowing researchers to analyze how changing the levels of each input affects production, including crucial details like the elasticity of substitution between different inputs, which is particularly valuable for optimizing resource allocation and understanding the impact of technological advancements on farm productivity.

Formula:

$$\text{LnY} = \beta_0 + \beta_1 \text{LnL} + \beta_2 \text{LnK} + \beta_3 (\text{LnL})^2 + \beta_4 (\text{LnK})^2 + \beta_5 (\text{LnL} * \text{LnK})$$

where:

β_0 – baseline for output

β_1 –Productivity of Labour units

β_2 – Productivity of Capital units

β_3 – Marginal Return on Labour

β_4 – Marginal Return on Capital

β_5 – Degree of complementarity or substitutability among Labour and Capital units

Garrett Ranking Technique

Garrett Ranking reveals the relative importance or priority of various factors or constraints based on respondents' rankings. It assigns scores to each factor, with higher scores indicating greater significance. This method is significant because it helps identify the most critical issues or preferences in a systematic and quantifiable way, enabling targeted interventions. Here, in Moringa cultivation, it ranks the constraints like input scarcity, pest control, or market access, guiding policymakers and farmers on where to focus resources and efforts. This score helps prioritize factors effectively for decision-making.

Formula:

$$\text{Garrett Score} = 100(R_j - 0.5) / N$$

where:

R_j = Rank assigned to the factor by the j^{th} respondent

N = Total number of factors ranked

RESULTS AND DISCUSSION

Uniqueness of the Mulanur Block for Moringa Cultivation

The following points devotes to the unique features of the study area, Mulanur block, which makes it conducive for its indigenous variety of Moringa cultivation, that favours for the application for Geographical Indication (GI).

Calcium rich favouring Moringa Cultivation

Mulanur, situated in the Tiruppur district of Tamil Nadu, India, boasts a diverse range of soil types, with a notable presence of Calcium-rich soil. This unique soil composition creates favourable conditions for the cultivation of Mulanur Kuttai Murungai, also known as Mulanur Dwarf Moringa (*Moringa Oleifera*). The Calcium in the soil helps improve soil structure by enhancing aggregation and reducing soil compaction. This allows for better aeration, water infiltration, and root penetration, supporting healthy root systems in Mulanur Kuttai Murungai.

Optimal Nutrient Availability

Calcium-rich soil ensures the availability of essential nutrients that contribute to the robust growth and health of Mulanur Kuttai Murungai. The adequate presence of Calcium helps in nutrient absorption, leading to higher nutritional content (Calcium) in the leaves, flowers, and fruits of the Moringa trees.

Tolerance to Stress Conditions

The presence of Calcium in the soil contributes to the drought and heat tolerance of Mulanur Kuttai Murungai. As a semi-dwarf variety, it can better withstand adverse conditions and water scarcity, making it well-suited to the arid and variable climate of Mulanur.

Sustainable Farming

The suitability of Mulanur Kuttai Murungai for Calcium rich soil aligns with the principles of sustainable farming. This cultivar, with its ability to thrive in such soil conditions, promotes eco-friendly and efficient use of available resources.

Local Tradition and Heritage

The cultivation of Mulanur Kuttai Murungai in the region reflects the local tradition and heritage of Mulanur. For generations, farmers have recognized the advantages of growing this variety in Calcium-rich soil, preserving the cultural significance of this remarkable tree.

Input-Output Analysis of Moringa Production

Table 3 – Input-Output Analysis of Moringa Production (per annum)

S.No.	Variables	Amount (in Rs.)	Percentage (to the Total)
I. Establishment Cost (Investment)			
1	Ploughing and Preparation of the Land	3,224.04	9.41
2	Purchase of Saplings/Seedlings	1,602.41	4.68
3	Digging Pits	2,265.74	6.61
4	Water Resource / Formation of Irrigation Channels	13,455.57	39.27
5	Fencing Charges	13,718.70	38.46
6	Total (Sum of items 1 – 5)	34,266.46	100.00
II. Operational Cost (Recurring Expenditure) per annum			
7	Application of Manure / Fertilizer	37,158.07	21.85
8	Weeding expenses	8,220.59	4.83
9	Irrigation	1,092.59	0.64
10	Pesticide Expenditure	19,403.75	11.20
11	Harvesting Charges	16,262.96	9.56
12	Packing and Transportation Charges	82,744.44	48.65
13	Other expenses	5,200.67	3.06
14	Total (Sum of items 7 – 13)	1,70,083.08	100.00
Operational Cost per Acre		56,133.03	
Operational Cost per Tree		680.33	
Operational Cost per Yield (in Kg)		4.11	
III. Gross Receipt per annum			
15	Sale of Main Products	2,99,427.41	92.62
16	Sale of Bi-Products	12,577.78	3.89
17	Sale of Value-Added Products	11,275.19	3.49
18	Total (Sum of items 15 – 17)	3,23,280.37	100.00
Gross Receipt per Acre		1,06,693	
Gross Receipt per Tree		1,293.12	
Gross Receipt per Yield (in Kg)		7.81	
IV. Net Receipt per annum (Difference of items 18 & 14)		1,53,197.29	
Net Receipt per Acre		50,560.16	
Net Receipt per Tree		612.79	
Net Receipt per Yield (in Kg)		3.70	

Source: Computed from Primary Data

The input-output ratio was found to be 1.9 which indicates that for every Rs.1 invested in Moringa cultivation, the farmer earns Rs.1.90 in return, reflecting a profitable operation. This suggests that the cultivation practices are efficient, with outputs significantly exceeding inputs, leading to a healthy return on investment. It highlights effective resource management, good yield, and favorable market conditions. However, to further improve profitability, farmers could explore cost-saving measures (e.g., reducing input costs in pesticides and fertilizers by adopting organic practices) or

increasing yields through better techniques (e.g., precision farming, value addition). Overall, a ratio of 1.9 demonstrates a sustainable and economically viable Moringa farming system.

Relationship between the Expenditure and Receipt Variables

Studying the relationship between expenditure variables (e.g., input costs) and receipt variables (e.g., revenue) are crucial to understand the financial dynamics of Moringa cultivation. This analysis through Canonical Correlation, reveals cost-effective practices and areas where expenses can be optimized to maximize returns which is given in the below tables 4;

Table 4.1 – Canonical Correlations

S.No.	Correlation	Eigenvalue	Wilks Statistic	F	Num D.F	Denom D.F	Sig.
1	.987	36.681	.001	2350058.588	21.000	5183675.154	.000
2	.976	20.521	.044	1136904.361	12.000	3610482.000	.000
3	.240	.061	.942	22061.295	5.000	1805242.000	.000

Source: Computed from Primary Data

Table 4.2 – Set 1 Canonical Loadings

Variable	1	2	3
Expenditure on Fertilizer	-.313	.822	-.070
Expenditure on Weeding	-.342	.875	-.116
Expenditure on Irrigation	-.454	.357	-.582
Expenditure on Pesticide	-.334	.875	-.104
Expenditure on Harvesting	-.291	.833	-.313
Expenditure on Packing and Transportation	-.284	.955	.041
OtherExpenditure	-.996	-.087	.008

Source: Computed from Primary Data

Table 4.3 – Set 2 Canonical Loadings

Variable	1	2	3
Receipt from Main Products	-.228	.973	.042
Receipt from Bi-Products	.123	-.148	-.981
Receipt from Value-Added Products	-.994	-.107	.015

Source: Computed from Primary Data

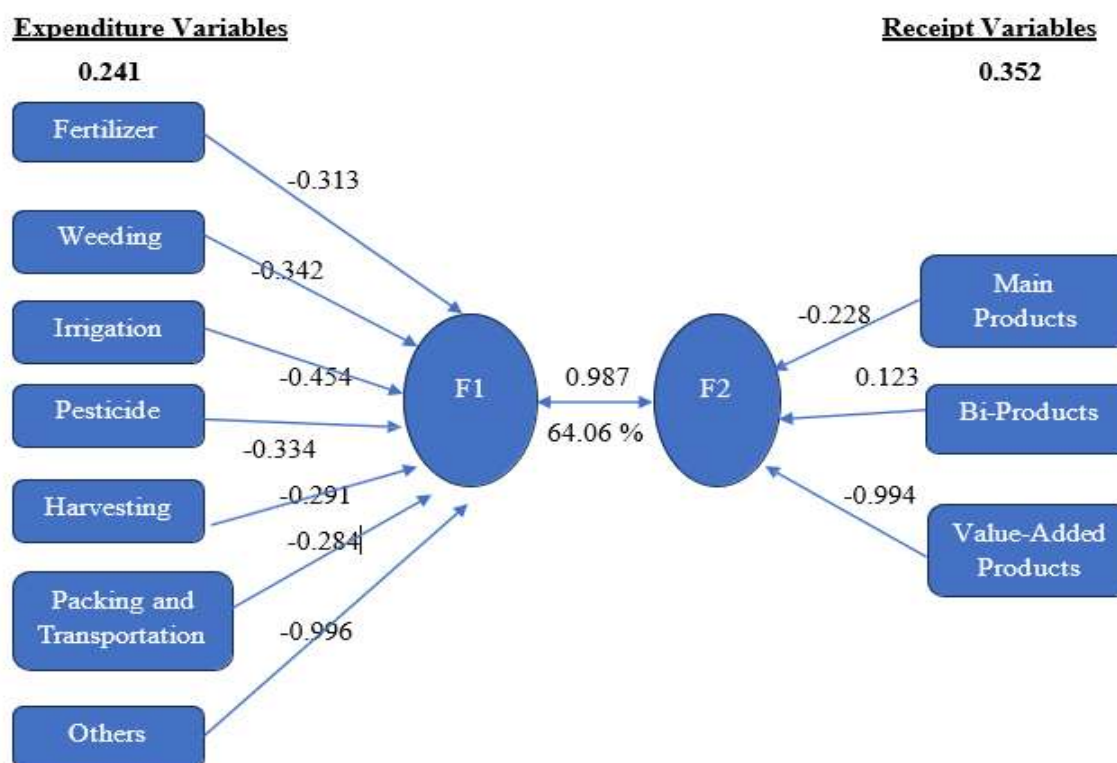
Table 4.4 – Proportion of Variance explained

Canonical Variable	Set 1 by Self	Set 1 by Set 2	Set 2 by Self	Set 2 by Set 1
1	.241	.235	.352	.342
2	.564	.537	.327	.311
3	.067	.004	.322	.019

Source: Computed from Primary Data

- F₁ is a factor made up of the expenditure variables such as fertilizer, weeding, irrigation, pesticide, harvesting charges, packing and transportation and other cost for making the Moringa produce and it explains only 24.1 percent of the variables.
- F₂ is a factor made up of the receipt variables such as revenue from the main product, bi-product and value-added products and it explains only 35.2 percent of the variables.
- The factors F₁ and F₂ are highly correlated with 98.7 percent with a medium proportion of 64.06 percent of the variance explained.
- It is evident that the receipt variables (main product and value-added products) increase / decrease with the expenditure variables (fertilizer, weeding, irrigation, pesticide, harvesting charges, packing and transportation and other cost) and receipt from the bi-products is alone inversely correlated with the variables as the receipt from the main product significantly affects the receipt from the former.
- It is found that though the factors of expenditure and receipt variables are highly correlated, the variables individually are least correlated which exhibits that apart from the financial and controllable inputs made, the output and revenue is greatly determined by uncontrollable and external factors such as market forces and agents, climate change, seasonal variations and quality of the yield.

Figure 1 – Results of the Canonical Correlation



Resource-use Efficiency and Technical Efficiency

Table 5 – Results of the Translog Production Function

Models	Coefficients	t value	Sig. Value
Constant	0.617	21.217	.000
β_1	0.990	145.919	.000
β_2	0.112	20.608	.000
β_3	0.193	183.600	.000
β_4	0.265	311.325	.000
β_5	-0.234	-288.297	.000
R²	0.937		
Adjusted R²	0.937		
F test	5402202.871		
Sig. Value	.000		

Source: Computed from Primary Data

- An R² and Adjusted R² value of 0.937 indicates that 93.7 percent of the variability in the dependent variable (Moringa yield) is explained by the independent variables (labour, capital) in the model. This high value suggests a strong fit, meaning the model effectively captures the relationship between the variables. It implies that the factors included are highly influential in predicting the outcome.
- The f test was found to be significant which indicates that the regression model as a whole is meaningful and the factors being tested have a measurable impact on the outcome.
- The value of β_1 indicates that an 1 percent increase in labour units increases the output by 99 percent, holding capital constant.
- The value of β_2 denotes that an 1 percent increase in capital units increases the output by 11.2 percent, holding labour constant.
- The value of β_3 and β_4 reveals that there is an increasing return to labour and capital as the units of labour and capital increases, the marginal impact of additional units of labour and capital also increases.
- The value of β_5 indicates that the factors labour and capital are substitutable to each other in the process of Moringa production.

Table 6 – Factors Determining Profitability of Moringa Cultivation

Variables	No. of Moringa Farmers	Percentage
Selection and Adoption of High Yielding Varieties of Moringa	24	17.8
Planting and Harvesting Moringa in Appropriate Season	50	37.0
Moringa Produce / Variety that should have Greater Consumer Acceptance	18	13.3
Adoption of Appropriate Post Harvest Management Practices	43	31.9
Total	135	100

Source: Primary Data

From the above table 6, it is evident that among the selected 135 Moringa farmers, majority of them i.e., 50 (37.0 percent) report that planting and harvesting Moringa in appropriate season, 43 (31.9 percent) report adoption of appropriate post-harvest management practices, 24 (17.8 percent) report selection and adoption of high yielding varieties of Moringa and 18 (13.3 percent) report Moringa produce / variety that should have greater consumer acceptance as their major factors that determine the profitability in Moringa cultivation.

Table 7 – Constraints in Marketing Moringa Produce

Constraints	Mean Score	Rank
Asymmetric Information	67.00	I
Lack of timely transaction	51.80	II
Fluctuations in the market conditions	49.60	III
Lack of quick financial settlement	42.40	IV
Improper transportation facilities	37.20	V

Source: Computed from Primary Data

It is evident from the above table that among the five listed and observed constraints in marketing Moringa produce, asymmetric information was ranked first with mean score of 67.00; Farmers often lack access to accurate and timely market information, such as pricing trends, demand patterns, and buyer preferences. This information gap puts them at a disadvantage during negotiations, leading to lower profits and unfair trade practices, lack of timely transaction was ranked second with mean score of 51.80, fluctuations in the market conditions was ranked third with mean score of 49.60, lack of quick financial settlement was ranked fourth with mean score of 42.40 and improper transportation facilities was ranked fifth with a mean score of 37.20. These rankings reflect the critical challenges faced by farmers in marketing Moringa produce, emphasizing the need for interventions like better market access, transparent pricing systems, and improved infrastructure to enhance profitability and sustainability.

Table 8 – Constraints in Moringa Cultivation

Constraints	Mean Score	Rank
Lack of appropriate knowledge	63.00	I
Pre harvest losses	61.40	II
Shortage of labour availability	57.80	III
Inadequate finance	53.00	IV
Unorganized market	43.40	V
Insufficient technical equipment	39.00	VI
Lack of quality saplings	28.40	VII

Source: Computed from Primary Data

➤ Among the observed constraints in Moringa production, Lack of appropriate knowledge was ranked first with mean score of 63.00, Farmers often lack awareness of modern cultivation techniques, pest management, and sustainable practices, leading to suboptimal yields and inefficiencies. This knowledge gap is a major barrier to improving productivity and profitability.

➤ Pre harvest losses were ranked second with a mean score of 61.40, Losses due to pests, diseases, and adverse weather conditions before harvest significantly reduce yields. These losses are a critical concern as they directly impact the quantity and quality of Moringa produce.

➤ Shortage of labour availability was ranked third with a mean score of 57.80, Labour shortages, especially during peak farming activities like planting and harvesting, hinder timely operations and increase production costs. Migration to urban areas and the availability of alternative livelihoods contribute to this issue.

- Inadequate finance was ranked fourth with mean score of 53.00, Limited access to credit, subsidies, or affordable loans restricts farmers' ability to invest in quality inputs, technology, and infrastructure, affecting overall productivity and sustainability.
- Unorganized market was ranked fifth with mean score of 43.40, The absence of structured market systems leads to price volatility, exploitation by intermediaries, and limited access to profitable markets, reducing farmers' income potential.
- Insufficient technical equipment was ranked sixth with a mean score of 39.00, Lack of access to modern tools and machinery, such as irrigation systems or harvesting equipment, limits efficiency and increases reliance on manual labor, which is often costly and time-consuming.
- Lack of quality saplings was ranked seventh with a mean score of 28.40, While important, this constraint ranks lower because farmers may have adapted to using available saplings or have access to local varieties. However, the absence of high-quality, disease-resistant saplings still affects long-term productivity.

CONCLUSION

The study on Moringa cultivation in Mulanur Block establishes its strong economic viability, with an input-output ratio of 1.9, reflecting a profitable return on investment (Rs.1.90 per Rs.1 spent), and an average net income of Rs.50,560 per acre, driven by high yields (41,372 kg/acre) and growing demand for health-focused products. However, systemic challenges hinder scalability: production constraints such as lack of appropriate knowledge, pre-harvest losses and labour shortages limit productivity, while marketing bottlenecks like asymmetric information and reliance on intermediaries suppress profitability. Though the traditional variety of Moringa native to this study area is recommended for GI tagging, it was observed that there is a significant shift towards genetically modified varieties due to the conventional drawbacks of the variety such as perennial in nature, low market price and relatively less yield. Hence, an urgent role of the government is necessitated to protect the variety on farm reality. The crop's alignment with SDGs 2030 – particularly Zero Hunger (SDG 2), Good Health (SDG 3), and Climate Action (SDG 13) remains underutilized due to low awareness, though its drought resilience, nutritional value, and soil-conserving traits position it as a strategic lever for sustainable development.

To unlock its potential, the study advocates multi-pronged interventions: farmer education via localized training on sustainable practices (e.g., integrated pest management, organic fertilization) and SDG linkages; infrastructure modernization, including drip irrigation expansion, rainwater harvesting, and processing units to reduce post-harvest losses (48.65 percent of operational costs); financial inclusion through tailored loans for saplings and subsidies for mechanization to alleviate labour shortages; market reforms such as GI tag utilization for Mulanur Kuttai Murungai, FPO-led direct sales to bypass exploitative intermediaries, and digital platforms for price transparency; policy integration to prioritize Moringa in state agricultural plans, incentivize climate-smart practices, and support youth/women-led entrepreneurship. Addressing these gaps can transform Moringa farming into a resilient, high-value agro-enterprise, boosting rural incomes, enhancing ecological sustainability, and contributing to global development goals. By bridging traditional knowledge with modern agro-enterprise models, Mulanur Block can emerge as a hub for sustainable Moringa production, exemplifying how localized agricultural systems can drive inclusive growth and environmental stewardship in semi-arid regions.

SUGGESTIONS

The following suggestions, grounded in empirical findings, would provide a roadmap for transforming Moringa cultivation into a sustainable, high-value agro-enterprise in Mulanur. By prioritizing education, sustainability, market access, and policy support, stakeholders can mitigate identified constraints and align Moringa farming with global sustainability goals.

1. Strengthening Farmer Education and Awareness

To address the critical gaps in knowledge (e.g., 95.6 percent unaware of SDG linkages, 80.7 percent unaware of GI status), implement targeted awareness campaigns through local agricultural extension services. Develop workshops and multilingual educational materials to explain the role of Moringa in achieving SDGs, emphasizing its contributions to food security (SDG 2), economic growth (SDG 8), and climate resilience (SDG 13). Collaborate with NGOs to raise awareness about the economic and cultural significance of the GI tag for Mulanur Kuttai Murungai, highlighting its potential for premium pricing and market differentiation. Integrate SDG and GI education into existing farmer training modules to ensure holistic knowledge dissemination.

2. Revamping Training Programs for Sustainable Practices

Overhaul ineffective training programs (91.1 percent deemed them inefficient) by partnering with agricultural universities and research institutions to design evidence-based, participatory training modules. Focus on sustainable practices such as integrated pest management (IPM), organic fertilization, and rainwater harvesting to reduce pesticide

dependency and water scarcity challenges. Introduce hands-on demonstrations of precision farming tools (e.g., soil sensors, drip irrigation) to bridge technical gaps. Prioritize youth engagement through digital platforms (e.g., mobile apps, YouTube tutorials) to modernize knowledge transfer and attract younger farmers.

3. Promoting Climate-Resilient and Organic Cultivation

Combat pre-harvest losses (mean score: 61.40) and pesticide overuse by promoting climate-resilient Moringa varieties (e.g., drought-tolerant hybrids) and organic practices. Establish community-led bio-fertilizer production units using livestock manure (reported by 43 percent of farmers) to reduce input costs and environmental degradation. Encourage intercropping with nitrogen-fixing legumes to enhance soil health and diversify income. Pilot climate-smart initiatives, such as micro-insurance for weather risks, to mitigate losses from adverse climatic events.

4. Enhancing Market Linkages and Value Addition

Address asymmetric information (top marketing constraint, mean score: 67.00) by creating farmers' cooperatives or FPOs (Farmer Producer Organizations) to collectively negotiate prices and access bulk buyers. Develop a digital marketplace platform to connect farmers directly with Oddanchatram Market traders, reducing intermediaries (45.9 percent reliance). Invest in local processing units for value-added products (e.g., Moringa powder, oil) to tap into high-margin markets. Provide subsidies for packaging and transportation infrastructure (48.65 percent of operational costs) to reduce post-harvest losses and improve profit margins.

5. Financial Inclusion and Policy Interventions

Tackle inadequate finance (mean score: 53.00) by advocating for tailored financial products, such as low-interest loans for hybrid saplings and drip irrigation systems. Leverage government schemes (e.g., PM-KISAN, NABARD) to expand credit access, particularly for marginal farmers (32.6 percent with <2.5 acres). Introduce subsidy-linked insurance products to cover pest outbreaks and yield fluctuations. Advocate for policy reforms to integrate Moringa into state agricultural plans, ensuring priority access to subsidies for GI-tagged crops.

6. Infrastructure Modernization and Technology Adoption

Address labor shortages (mean score: 57.80) and technical inefficiencies by promoting cost-effective mechanization (e.g., portable harvesters, seed processors) tailored for smallholders. Invest in rural infrastructure, including rainwater harvesting systems (12.6 percent adoption) and solar-powered cold storage, to reduce water and post-harvest losses. Partner with tech startups to deploy IoT-based solutions (e.g., soil moisture sensors, pest fore-warning systems) for precision farming. Strengthen linkages between research institutions and farmers to pilot scalable innovations, such as disease-resistant saplings (lacking in 28.40 percent cases), ensuring long-term productivity.

“In essence, Moringa cultivation is both viable and vital – a crop of the present for a sustainable future”

LIMITATIONS OF THE STUDY

1. The study is confined to the Moringa farmers of a particular block which constitute a smaller sample size. Hence the results cannot be generalized.
2. The cultivation and market conditions of Moringa is immensely influenced by climatic factors that tend to keep the production – consumption chain in an irregular cycle, hence the accurate value cannot be ascertained.

List of Abbreviations

APCMS – Agricultural Producers Cooperative Marketing Societies
 APEDA – Agricultural and Processed Food Products Export Development Authority
 cm – Centimetres
 DGFT – Directorate General of Foreign Trade
 FIEO – Federation of Indian Export Organization
 FPO – Farmer Producer Organization
 g – Grams
 GAP – Good Agricultural Practices
 GDP – Gross Domestic Product
 GI – Geographical Indications
 GoI – Government of India
 GPS – Global Positioning System
 Ha – Hectares
 IMF – International Monetary Fund
 IPM – Integrated Pest Management
 ISHS – International Society for Horticultural Science

kg – Kilograms
 m – Metres
 MEZ – Moringa Export Zone
 MSDA – Mission on Sustainable Dryland Agriculture
 MSP – Minimum Support Price
 MT – Metric Tonnes
 NABARD – National Bank for Agriculture and Rural Development
 NBFI – Non Banking Financial Institutions
 NIFTEM – National Institute of Food Technology Entrepreneurship and Management
 NMSA – National Mission for Sustainable Agriculture
 NPC – Non Profit Centre
 PKM – Periyakulam (High-Yield Moringa Variety)
 PPP – Purchasing Power Parity
 R & D – Research and Development
 RIDF – Rural Infrastructure Development Fund
 SDG – Sustainable Development Goals
 SEFC – Special Export Facilitation Centre
 TNAU – Tamil Nadu Agricultural University
 TNOCD – Tamil Nadu Organic Certification Department
 TTM – Trailing Twelve Months
 UNO – United Nations Organization

DECLARATIONS

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Ethical Approval and Consent to participate/for publication

The authors do not have any conflict of interest to declare and no ethical issues. The authors provide consent to participate/for publication.

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