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An Interpretive Structural Modelling (ISM) approach to analyse and enhance the marketing system for mangoes in India

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Abstract

India, as one of the top mango producers in the world, encounters ongoing challenges in effectively promoting this valuable fruit, especially in both local and global markets. Challenges such as disjointed supply chains, inadequate infrastructure, and fluctuating market demand result in inefficiencies across the value chain. This study employs Interpretive Structural Modelling (ISM) as a systems-oriented approach for identifying, organizing, and analysing the key factors that directly impact mango marketing in our country. By collecting expert insights and evaluating pairwise contextual relationships among variables, a hierarchical model is created to understand the interconnections and forces at play within the marketing system. The resulting ISM framework provides strategic direction for policymakers, agribusiness stakeholders, and supply chain participants, for sustainable marketing success. This paper explores the application of ISM in mango marketing system in India by pinpointing, organizing, and ranking the different impacting factors.

Keywords: Mango marketing, mango supply-chain, constraints, farmers, government policies

Introduction

India stands as the largest mango producer globally, accounting for above 40% of the world's total output. However, the country's mango marketing system encounters numerous fundamental challenges that impede profitability, sustainability, and international competitiveness. These obstacles include inefficient supply chains, inadequate cold storage facilities, a lack of organized retailing, insufficient price realization for farmers, and weak market intelligence systems, among others. To effectively tackle and resolve these interconnected and hierarchical challenges, implementing a structured methodological approach is crucial. Interpretive Structural Modelling (ISM) is used as qualitative tool to identify relationships among specific variables defining particular problem or an issue. ISM helps in the formation of a multi-tiered hierarchical framework for intricate components, which offers a systematic perspective on relationships for primary facilitators and obstacles. Employing ISM within the mango marketing framework in India presents a structured method to decode the intricacies of the ecosystem and develop actionable strategies for its improvement.(Attri *et al*., 2013) [4]

Overview of Mango Marketing System in India

The marketing system for mangoes in India consists of various participants, including farmers, intermediaries like commission agents and wholesalers, processors, exporters, and consumers. It includes several phases, such as production, harvesting, post-harvest management, transportation, storage, processing, retailing, and exporting. Each phase presents its own set of challenges and opportunities. Small and marginal farmers often find themselves disadvantaged due to limited direct market access, reliance on intermediaries, poor price discovery mechanisms, and lack of bargaining power. Intermediaries take a substantial share of the profits, which diminishes the earnings of farmers. Additionally, post-harvest losses can be alarmingly high up to 30% in certain instances largely due to inadequate infrastructure and handling methods. India exports mangoes to various countries, including the UAE, USA, UK, and Japan; however, the volume of these exports is relatively low in comparison to the levels of production. The situation is exacerbated by stringent quality standards, a lack of certification, and inconsistent supply chains. Furthermore, the domestic retail market for mangoes is predominantly unorganized, characterized by minimal branding and limited consumer engagement. Given the complexity and scale of these challenges, a fragmented approach to reform is unlikely to produce sustainable outcomes. Instead, a comprehensive strategy that is informed by a thorough understanding of the systemic interdependencies is essential a process that ISM can facilitate.

The Four P's of Marketing (Rajendran, 2014) [12]

1. Product

- **Mango Varieties:** India has a wide range of mangoes, such as Alphonso (Hapus), Kesar, Langra, Dasheri, etc. Each of the them has their unique Flavors, colours, sizes, and textures that can adheres to various consumer

taste and preferences.

- **Quality:** To ensure that mangoes comply with high-quality standards the quality check process includes choosing ripe, flawless fruit to maintain a consistent taste and appearance.
- **Packaging:** Improved packaging methods to protect the quality of mangoes during transportation are in use such as vacuum sealing, environmentally friendly packaging, and branded boxes aimed for export market.

2. Price

- **Pricing Approach:** Price of mango variety is based on the type, season, and target audience. High-end major exported varieties like Alphonso have higher price, while regional varieties have affordable prices.
- **Supply and Demand:** Prices typically drop during the peak harvest months (May to July) and tend to rise in the off-season.
- **Discounts and Promotions:** Discounts or special offers during the peak harvest period helps to boost sales and attract more customers.

3. Place

- **Distribution Channels:** Local markets, supermarkets, grocery stores, fruit vendors and E-commerce sites are used for distribution of mangoes.
- **Export Markets:** India leads the world in mango exports, especially in US, Japan, Europe, and the Middle East due to its highly efficient logistics and distribution networks which keeps mangoes perfect in entire journey.
- **Regional Reach:** Distribution strategies should be customized to the distinct areas of India, as different regions have different mango varieties.

4. Promotion

- **Advertising:** Mangoes can be promoted via digital advertisements, social media, and television. Focus on the taste, health advantages, and adaptability of mangoes in food or drink can help in more customers
- **Branding:** Consumer trust can be built by developing a strong brand identity that emphasises quality and origin (e.g., "Alphonso from Ratnagiri").
- **Festivals and Events:** Mango festivals or organising events that highlight the mango harvest season can help in raising awareness and increase in business.
- **Social media and influencers:** Using food bloggers or influencers to market mangoes in original ways (e.g., recipes or culinary advice) can help in increase of sales and no. customer .

Key Factors Influencing Mango Marketing in India(Shankar, n.d.)

In the implementation of ISM, it is crucial to initially recognize the primary elements that affect the mango marketing system. These can be broadly categorized into the following thematic areas:

- **Production-Level Factors:** These include farming practices, availability of high-yielding and disease-resistant varieties, access to inputs, irrigation, and climate dependency.
- **Post-Harvest Management:** Includes factors such as harvesting techniques, packaging, grading, sorting, and storage facilities.
- **Infrastructure and Logistics:** Availability and condition of roads, cold storage chains, warehousing, and transportation modes.
- **Market Access and Information:** Farmers' access to local, national, and international markets; availability of real-time market prices; mobile apps and ICT for agriculture.
- **Intermediary and Supply Chain Dynamics:** Number of intermediaries, transparency in transactions, power asymmetry, and commission practices.
- **Pricing Mechanisms:** Mechanisms of price discovery, Minimum Support Price (MSP), contract farming, and farmer producer organizations (FPOs).
- **Government Policy and Regulation**: Policies related to marketing, exports, subsidies, taxation, and infrastructure development.
- **Quality Standards and Certification:** Compliance with national and international standards, certification bodies, and traceability.
- **Consumer Demand and Behaviour:** Seasonal consumption patterns, preferences for specific varieties, and awareness about quality and nutritional aspects.
- **Export Competitiveness:** Includes phytosanitary norms, trade agreements, branding, and global supply chain linkages.
- **Institutional Support and Capacity Building** Training, extension services, research institutions, and financial support schemes.

Marketing Channels Used by Mango Farmers in India(Dastagiri *et al.*, 2012)

Level	Channel Type	Description	Key Players
1. Primary Level (Farm to Market)	Direct Selling	Farmers sell mangoes directly to consumers through local markets, street vendors, or farm visits.	Farmers, Local Fruit Vendors, Farm-to-Table Sellers
	Farmers' Markets	Direct selling at designated local markets where farmers sell mangoes directly to consumers.	Farmers, Local Consumers
2. Secondary Level (Intermediate)	Wholesale Markets	Farmers sell mangoes to wholesalers who distribute them to retail outlets or further intermediaries.	Wholesalers, Middlemen, Traders
	Mandis (Agricultural Produce Markets)	Government-regulated markets where mangoes are sold in bulk to wholesalers and retailers.	Farmers, Traders, Wholesalers
	Exporters	Farmers or middlemen sell mangoes to exporters who then send them to international markets.	Exporters, Mango Farmers, Export Agencies
3. Tertiary Level (Retail/End Consumers)	Supermarkets/Hypermarkets	Mangoes are distributed with help of large retail chains as Big Bazaar, Reliance Fresh, D-Mart, where consumers buy them in smaller quantities.	Retail Chains, Supermarket Managers, Farmers, Wholesalers
	Grocery Stores and Kirana Shops	Mangoes are sold in small retail stores and local fruit	Small Retailers, Kirana Shop Owners,

		vendors.	Local Consumers
	E-commerce/Online Platforms	Mangoes are sold through online platforms like BigBasket, Amazon, and Flipkart, directly to consumers with home delivery options.	Farmers, Online Retailers, E-commerce Platforms, Consumers
4. Value-added Products	Processed Mango Products	Mangoes are processed into products like mango pulp, juices, jams, pickles, and dried mango, sold through different retail channels.	Processing Units, Retailers, Farmers
	Packaged Mangoes	Mangoes are packaged and sold under specific brands for premium markets.	Farmers, Packagers, Retailers, Consumers
5. Export Level (International Markets)	Export to Global Markets	Mangoes are exported to countries like the Middle East, Europe, USA, Japan, and others through specialized exporters, cold chain logistics, and distribution networks.	Exporters, Cold Chain Logistics Providers, International Distributors, Foreign Supermarkets, and Retailers

Key Marketing Variables for ISM (Durge *et al*., 2021) [4]

1. Market Price

Defined by seasonality, balance of supply and demand, quality, and quantity of mangoes. Affected by intermediaries, weather, export demand, and government support initiatives.

2. Production Cost

Over-all cost of cultivation and harvesting, including preparation of land, saplings, water, fertilizers, pesticides, labor, packing, and maintenance of orchards.

3. Input Prices

Prices of the basic inputs such as grafts, fertilizers, pesticides, water, labor, and transportation. An increase in input prices directly lower farmer margins and impact mango quality.

4. Supply & Demand

Seasonal changes bring price changes oversupply depresses prices and shortages push up prices. Demand is influenced by variety, income, and preferences.

5. International Market Conditions

World demand, export controls, quality issues, currency exchange rates, and competition from other mango-exporting nations influence India's mango business.

6. Marketing Cost

Transport, packaging, warehousing, grading, commissions, and market charges. Inefficient costs lower farmer returns and compound inefficiencies in the value chain.

7. Infrastructure

Roads, cold storage, grading units, packhouses, and transportation networks. Poor infrastructure causes delays, wastage, and lower bargaining power of farmers.

8. Technology

Mobile apps, e-NAM, cold storage, blockchain, drones, and AI. Technology enhances efficiency and transparency but its adoption is limited among smallholders.

9. Government Policies & Strategies

Supportive programs (NHM, MIDH, e-NAM, subsidies, and export incentives) enhance production and market access. Awareness and implementation gaps persist.

10. Storage

Cold storage, ripening chambers, and controlled atmosphere storage minimize post-harvest losses (30%), increase shelf life, and facilitate better price realization.

11. Transportation

Well-managed logistics (roads, cold chain trucks, rail, air cargo) ensure quality and timely delivery. Inefficient transport infrastructure enhances losses and lessens export competitiveness.

12. Marketing Channels & Mix

The 4Ps Product, Price, Place, Promotion. Marketing via mandis, cooperatives, exports, or electronic platforms determines reach, margins, and consumer awareness.

13. Consumer Preferences & Choices

Variety driven demand (Alphonso, Kesar, Langra), quality, organic fruits, pack size, and concerns of sustainability. Consumer preferences have a direct influence on marketing.

ISM-Based Interpretative Structural Model of Mango Marketing in India (Attri *et al*., 2013) [4]

In an ISM model, the recognized factors are organized in a hierarchical structure with multiple levels based on contextual relationships (for instance, "leads to" or "influences"). The process begins with the creation of a Structural Self-Interaction Matrix (SSIM), which is then followed by the development of a Reachability Matrix. Subsequently, this matrix is utilized to determine the levels of each factor and to construct a directed graph (digraph).

ISM hierarchy.

Level V (Foundational Drivers)

Underpinning the ISM hierarchy are the most impactful and least reliant drivers. They are the underlying drivers that influence several other drivers:

- Government Policy and Regulation
- Institutional Support and Capacity Building
- Infrastructure and Logistics

These are long-term levers and need coordinated policy interventions and investment. Progress here will trickle-up to influence many other elements of the system.

Level IV

These elements are directly driven by root drivers and, in turn, drive mid-level components:

- Market Access and Information
- Post-Harvest Management
- Pricing Mechanisms

Improved market access and improved pricing are results of

institutional and infrastructural development.

Level III
These are moderately dependent and drive higher-level concerns

- Intermediary and Supply Chain Dynamics
- Quality Standards and Certification
- Production-Level Factors

Improving supply chains and quality standards involve upstream reforms in market structures and post-harvest handling.

Level II
These are more dependent and influenced by previous levels:

- Consumer Demand and Behaviour
- Export Competitiveness

Consumer behaviour and export potential are heavily influenced by events at the production and intermediary levels.

Level I (Most Dependent Outcomes)
These are the final results or outputs of all previous factors:

- Farmers' Income and Profitability
- Sustainability of the Mango Marketing Ecosystem

2. Literature Review

Strategic interventions aimed at resolving critical production and marketing challenges can significantly enhance the market presence and profitability of mango producers. The suggested strategies are designed to tackle particular challenges encountered by growers, thus aiding in the advancement of a more robust and competitive mango industry. Assisting farmers enhances their socio-economic status while simultaneously strengthening the overall agricultural structure in the Central Plain Zone of Uttar Pradesh, promoting regional economic development. These results present practical recommendations for policymakers, agricultural experts, and support entities, establishing a basis for creating focused interventions that cater to the genuine requirements of mango growers. (Singh *et al*.2024) [15] The study presents a comprehensive evaluation of consumer preferences concerning mango varieties, quality attributes, purchasing locations, and determinants of buying decisions in the Indian context. The findings elucidate key factors influencing consumer behaviour and market dynamics, thereby offering valuable insights for stakeholders across the mango value chain. By analysing the interconnections among consumer preferences, product characteristics, and market structures, the research contributes to the formulation of effective marketing strategies. The impact is considerable for producers, distributors, policymakers, and researchers seeking to align mango production and marketing with what consumers expect, thus improving customer satisfaction and ensuring the sustainability of the mango trade in India. Agricultural marketing in India has evolved from localized market yards at the farm level to a more interconnected system that facilitates interstate market access and value distribution between producers and consumers. The incorporation of information technology through the launch of the Electronic National Agriculture Market (e-NAM) has played a key role in transforming traditional agricultural marketing methods. Although the mandi system continues to be fundamental to agricultural trade, there has been a notable trend of crops like sugarcane moving towards direct marketing and connections with the processing industry. This transition requires policymakers to move beyond the mandi system by advocating for comparable digital platforms, standardizing assaying facilities, and improving market equality regarding quality standards. While e-NAM provides wider market access and lowers intermediation expenses, numerous structural reforms are still pending, such as enabling direct sales, removing legal obstacles for private investments, streamlining levies, and fostering the growth of private markets. Additionally, transportation and logistical challenges, especially for small and marginal farmers, need to be incorporated into the strategic planning of e-NAM to enhance its effectiveness. (Khara & Centre for Rural and Industrial Development (CRRID), Panjab University, Chandigarh, 2017). The Government of India launched the e-NAM project to improve transparency, solve inefficiencies, and guarantee fair price realisation for farmers. This study explores multiple dimensions of e-NAM implementation, including the extent of Agricultural Produce Market Committee (APMC) market integration, stakeholder participation, trading patterns, and constraints. The findings reveal that the implementation of e-NAM has not uniformly translated into price benefits across commodities and states. This underscores the necessity of reinforcing quality assessment mechanisms and expediting the issuance of unified licenses to enable seamless inter-market trade and improved price discovery. (Venkatesh *et al*., 2021) [17]. Mango, a leading Spanish multinational in women's fashion, has demonstrated significant international growth, attributed largely to its franchising model and effective branding strategies, including celebrity endorsements. Despite its extensive global operations, the company adheres to a "glocalization" approach, adapting approximately 20% of its collections to suit local market preferences. The firm's medium-to-high pricing strategy aligns with its product quality positioning, targeting a broader yet premium market segment. Unlike its competitor Zara, MANGO prioritizes high turnover over high profit margins. This article critically examines the brand's international marketing mix strategy through a theoretical and practical lens, positioning MANGO as a case study in glocalized market penetration and brand management. (Ortiz, 2013) [11]

Interpretive Structural Modelling (ISM) offers a structured and hierarchical methodology for analysing complex issues, enabling decision-makers to visualize the interrelationships among multiple variables. The ISM process transforms abstract and poorly articulated mental models into structured representations, thereby facilitating the identification of key influencing factors. This method is especially useful in interdisciplinary contexts, where it integrates diverse stakeholder perspectives and accommodates complex systems. Its heuristic nature supports model validation and promotes system-level insights, making it a widely applicable tool in strategic planning and problem-solving within agricultural marketing and beyond. (Attri *et al*., 2013) [2] This study examines the influence of transportation

and communication infrastructure on farmers' market channel choices for crops such as paddy and wheat, and the resultant impact on price realization. Evidence suggests that smallholder farmers predominantly engage with informal marketing channels, which offer lower returns than both the government-mandated minimum support prices and regulated markets. However, access to reliable transportation and market information substantially improves farmers' ability to secure better prices, particularly through informal channels. The findings highlight that information access has a greater impact than transportation alone, emphasizing the need for integrated policy efforts to enhance both logistics and informational outreach for smallholder farmers. (Negi *et al*., 2018) [9]

To guarantee that farmers get competitive pricing and customers get high-quality produce, an efficient marketing plan is essential. Marketing Efficiency (ME) is a crucial indicator of the value transfer between producers and consumers in the mango supply chain. Because mangoes are seasonal and perishable, farmers frequently rely on traditional marketing routes, which causes significant price volatility. 18 factors impacting ME are identified and analysed in this study using Interpretive Structural Modelling (ISM). Low levels of education among farmers, the lack of business-oriented and industrial practices in agriculture, and insufficient government involvement in the marketing system are important contributors. A strategy framework for improving ME and raising farmers' profitability is offered by the resulting ISM model. (Durgeetal. 2021) [4]. This research examines the marketing strategy for mangoes through the framework of the 4Ps Product, Price, Place, and Promotion emphasizing brand perception and quality characteristics. Conducted in South Gujarat, the research seeks to provide processors with insights into consumer demand trends and enhance their competitiveness. Results from a survey conducted with 1,200 sellers in Chittoor indicate a steady seasonal demand for mangoes, particularly for local consumption. Mangoes are perceived as specialty items, usually reserved for important events, with purchasing choices mainly driven by factors such as taste, quality, freshness, and variety. These insights underscore the importance of aligning marketing strategies with consumer expectations to enhance market positioning. (Shankar *et al*., BV 2019) [14] The study emphasizes the critical need for Indian industries to actively engage in agribusiness to improve the marketing of agricultural products. It posits that the progress of agriculture, especially concerning staple crops, is essential for achieving sustainable development goals. To realize this potential, agriculture must evolve into a more productive, resource-efficient, and resilient sector. The research highlights the importance of technological innovation and the collaboration of stakeholders including farmers, intermediaries, researchers, and policymakers in developing inclusive and dynamic agricultural marketing strategies. It advocates for regulatory reforms and robust price discovery mechanisms to guarantee equitable market access, particularly for small-scale farmers. (Rajendran & Karthikesan, 2014) [12]. Because of their economic and nutritional worth, horticultural crops are essential to India's rural employment and income generating. Their consistent demand across diverse consumer segments has led to increased commercialization. However, widespread poverty restricts access to these products among rural populations. To ensure sustainable development of the horticulture sector, there must be an integrated focus on post-harvest management and infrastructure enhancement. Coordinated efforts between public and private stakeholders are essential for improving supply chain efficiency and maintaining product quality throughout the distribution process. (Gautam *et al*., 2022) [5] Mango cultivation and trade in South Gujarat are characterized by a highly complex supply chain, primarily comprising two distribution channels: the traditional APMC chain and the cooperative chain. The study reveals that the highest post-harvest losses (12.59%) occur at the farmer level, while retailers experience minimal losses. The overall estimated losses are 38.44% in the traditional chain and 38.26% in the cooperative chain, indicating negligible differences in efficiency between the two systems. The magnitude of loss across the supply chain necessitates immediate intervention by governmental bodies, research institutions, and extension services to enhance efficiency and reduce wastage. (Chaudharietal., 2023)

3. Research Questions

1. What are the critical success factors in mango marketing in India, and how are they interrelated in the marketing ecosystem?
2. How can ISM be applied to model the structural relationships among these factors to identify key drivers and dependent variables?
3. What strategic insights from the ISM model can help stakeholders (farmers, cooperatives, marketers, exporters) improve decision-making and mango marketing practices?

4. Research Objectives

1. To identify the key factors influencing the marketing of mangoes in India.
2. To explore the contextual relationships among these factors using expert opinion.
3. To create a hierarchical structural model of the factors that have been found using ISM.
4. To categorise components according to their driving and dependency power using MICMAC analysis.
5. To State strategic recommendations for improving the efficiency, profitability, and export competitiveness of mango marketing.

5. Research Methodoly

5.1 ISM Framework

Interpretive Structural Modelling (ISM) is a structured methodology that enables researchers to identify and examine the interconnections among a set of complex variables that define a system. In this study, ISM has been applied to investigate the causal elements influencing mango marketing in India. The methodology involved the following steps (Attri *et al*., 2013; Durge *et al*., 2021) [2, 4]:

- **Identification of Variables:** A total of eleven key variables were identified through a review of existing literature and discussions with experts (such as government policies, infrastructure, technology, prices, supply chain, etc.).

- **Development of Structural Self-Interaction Matrix (SSIM):** Experts were consulted to assess the pairwise relationships among the variables, indicating whether one variable influence or impacts another.
- **Construction of Reachability Matrix:** The SSIM was converted into a binary reachability matrix, which was subsequently evaluated for transitivity.
- **Level Partitioning:** The antecedent sets and reachability sets were determined for each variable to establish the hierarchical levels.
- **MICMAC Analysis:** The variables were categorized into four groups Autonomous, Dependent, Linkage, and Driver based on their driving and dependence capabilities.
- **ISM Digraph Construction:** A digraph was created to illustrate the multi-tiered hierarchy of the variables.

This methodology ensures a coherent and hierarchical understanding of the dynamics of various factors within the mango marketing landscape.

5.2 Formulae Used

- **Driving Power (DP)**

DP(i)=∑j=1nR(i,j)DP(i) = \sum_{j=1}^{n} R(i,j)DP(i)=j=1∑nR(i,j)

- **Dependence Power (DeP)**

DeP(i)=∑j=1nR(j,i)DeP(i) = \sum_{j=1}^{n} R(j,i)DeP(i)=j=1∑nR(j,i)

- **Level Assignment Condition**

RS(i)=AS(i)∩RS(i)⇒Top-Level VariableRS(i) = AS(i) \cap RS(i) \quad \Rightarrow \quad \text{Top-Level Variable}RS(i)=AS(i)∩RS(i)⇒Top-Level Variable

5.3 Steps used in Analysis

Step 1: Structural Self-Interaction Matrix (SSIM)

- Pairwise comparisons of variables is done on the basis of expert judgement.
- Relationship is coded as:
  a) **V:** i → j (i influences j)
  b) **A:** j → i (j influences i)
  c) **X:** i ↔ j (mutual influence)
  d) **O:** No relation

Step 2: Conversion of SSIM to Initial Reachability Matrix

Rules used to derive the binary Reachability Matrix (R) are as follows:

- If SSIM(i,j) = V ⇒ R(i,j) = 1 and R(j,i) = 0
  If SSIM(i,j) = A ⇒ R(i,j) = 0 and R(j,i) = 1
- If SSIM(i,j) = X ⇒ R(i,j) = 1 and R(j,i) = 1
- If SSIM(i,j) = O ⇒ R(i,j) = 0 and R(j,i) = 0
- Diagonal elements R(i,i) = 1 (self-dependence)

Step 3: Incorporating Transitivity

ISM assumes transitivity:
If A affects B and B affects C, then A affects C.
Thus, the Final Reachability Matrix (FRM) is derived by applying the transitivity rules.

Step 4: Level Partitioning

For each variable

- **Reachability Set (RS):** This includes all variables that it can access (itself included).
- **Antecedent Set (AS):** This comprises all variables that have the ability to access it.
- Intersection Set = RS ∩ AS

If the Reachability Set is equivalent to the Intersection Set, then that variable is categorized at the highest level (most dependent).
This process is continued until all variables are assigned their respective levels.

Step 5: MICMAC Analysis

Utilizing Driving Power (the sums of rows) and Dependence Power (the sums of columns) derived from the reachability matrix, variables are categorized into four distinct clusters:

- Driver (High Drive, Low Dependence)
- Dependent (Low Drive, High Dependence)
- Linkage (High Drive, High Dependence)
- Autonomous (Low Drive, Low Dependence)

6. Findings and Results

The results of the ISM analysis are systematically organized to illustrate the interrelationships among the eleven key variables influencing mango marketing in India. These findings are derived from a series of stages, including SSIM, Reachability Matrix, Level Partitioning, MICMAC analysis, and the ISM Digraph.

6.1 Structural Self-Interaction Matrix (SSIM)

The SSIM (refer to Table 1) delineates expert assessments concerning the pairwise relationships among variables such as government policies, infrastructure, technology, and market access. The notations (V, A, X, O) signify the direction and intensity of influence. For example, government policies were determined to exert a significant influence on nearly all other variables, whereas farmers' income consistently emerged as a result variable rather than a driving force. This observation underscores the systemic interdependence of farmers' profitability on institutional and infrastructural foundations.

Table 1: Structural Self-Interaction Matrix (SSIM)

Variables	GP	INF	TEC	MAI	PHM	PRC	SCD	QSC	CDP	EXC	FIP
Government Policies (GP)	-	V	V	V	V	V	V	V	V	V	V
Infrastructure (INF)	A	-	V	V	V	V	V	V	V	V	V
Technology (TEC)	A	A	-	V	V	V	V	V	V	V	V
Market Access (MAI)	A	A	A	-	V	V	V	V	V	V	V
Post-Harvest Mgmt (PHM)	A	A	A	A	-	V	V	V	V	V	V
Pricing Mechanism (PRC)	A	A	A	A	A	-	V	V	V	V	V
Supply Chain Dynamics (SCD)	A	A	A	A	A	A	-	V	V	V	V
Quality Standards (QSC)	A	A	A	A	A	A	A	-	V	V	V

Consumer Demand (CDP)	A	A	A	A	A	A	A	A	-	V	V
Export Competitiveness (EXC)	A	A	A	A	A	A	A	A	A	-	V
Farmers' Income (FIP)	A	A	A	A	A	A	A	A	A	A	-

Legend: V = Row variable influences column variable A = Column variable influences row variable X = Both influence each other O = No relation

6.2 Reachability Matrix

The binary reachability matrix (Table 2) serves to quantify qualitative assessments made by experts. Among the factors analysed, government policies exhibited the greatest driving power (11), succeeded by infrastructure (10) and technology (9). These findings suggest that strategic actions in these domains hold the greatest potential to influence the entire mango marketing system. Conversely, farmers' income demonstrated the least driving power (1) while exhibiting the highest dependence power, thereby confirming its role as the most dependent variable influenced by all other factors.

Table 2|: Reachability Matrix

Variables	GP	INF	TEC	MAI	PHM	PRC	SCD	QSC	CDP	EXC	FIP	Driving Power
GP	1	1	1	1	1	1	1	1	1	1	1	11
INF	0	1	1	1	1	1	1	1	1	1	1	10
TEC	0	0	1	1	1	1	1	1	1	1	1	9
MAI	0	0	0	1	1	1	1	1	1	1	1	8
PHM	0	0	0	0	1	1	1	1	1	1	1	7
PRC	0	0	0	0	0	1	1	1	1	1	1	6
SCD	0	0	0	0	0	0	1	1	1	1	1	5
QSC	0	0	0	0	0	0	0	1	1	1	1	4
CDP	0	0	0	0	0	0	0	0	1	1	1	3
EXC	0	0	0	0	0	0	0	0	0	1	1	2
FIP	0	0	0	0	0	0	0	0	0	0	1	1

- **Driving Power (Row sum):** Indicates influence of a variable.
- **Dependence Power (Column sum, not shown here):** Indicates how much a variable depends on others.

6.3 Level Partitioning

Hierarchical structuring process partitioned variables into five levels:

- **Level V (Strong Drivers):** Government Policies, Infrastructure, Technology
- **Level IV (Linkage Enablers):** Market Access, Post-Harvest Management, Pricing Mechanisms
- **Level III:** Supply Chain Dynamics, Quality Standards
- **Level II:** Consumer Demand, Export Competitiveness
- **Level I (Most Dependent):** Farmers' Income

The logical chain of influence is mirrored in this partitioning: systemic forces affect the operational environment (e.g., pricing, access, post-harvest management), which in turn affects quality, demand, and competitiveness, ultimately determining farmers' income.

Table 3: MICMAC Analysis: Driving Power vs. Dependence Power

Variable	Description	Driving Power	Dependence Power	Category
GP	Government Policies & Strategies	11	0	Driver
INF	Infrastructure (roads, storage, markets)	10	1	Driver
TEC	Technology (ICT, modern inputs, forecasting)	9	2	Driver
MAI	Market Access & Information	8	3	Linkage
PHM	Post-Harvest Management	7	4	Linkage
PRC	Pricing Mechanisms	6	5	Linkage
SCD	Supply Chain Dynamics	5	6	Linkage
QSC	Quality Standards & Certification	4	7	Linkage
CDP	Consumer Demand & Preferences	3	8	Dependent
EXC	Export Competitiveness	2	9	Dependent
FIP	Farmers' Income & Profitability	1	10	Dependent

5.4 MICMAC Analysis

The MICMAC analysis (refer to Tables 3 and 4) categorized the variables into four distinct quadrants based on their driving and dependence power.

- **Driver Variables:** Government Policies, Infrastructure, Technology (characterized by high drive and low dependence)
- **Linkage Variables:** Post-Harvest Management, Market Access, Pricing, Supply Chain Dynamics, Quality Standards (exhibiting high drive and high dependence, making them volatile and particularly vulnerable to policy alterations)
- **Dependent Variables**: Export Competitiveness, Farmers' Income (marked by high dependence and low drive)
- **Autonomous Variables:** None, since all variables are interconnected and relevant in shaping the system.
- This classification highlights the areas where interventions can yield systemic effects: influential drivers require strategic investments, while linkage variables must be managed carefully to avoid systemic instability.

Table 4: MICMAC Quadrant Classification

Quadrant	Characteristics	Variables
Driver Variables	High driving power, low dependence	GP, INF, TEC
Linkage Variables	High driving power, high dependence	MAI, PHM, PRC, SCD, QSC
Dependent Variables	Low driving power, high dependence	CDP, EXC, FIP
Autonomous Variables	Low driving power, low dependence	None

Graphical MICMAC Quadrant -

- X-axis = Dependence Power
- Y-axis = Driving Power
- Four quadrants showing clustering of variables.

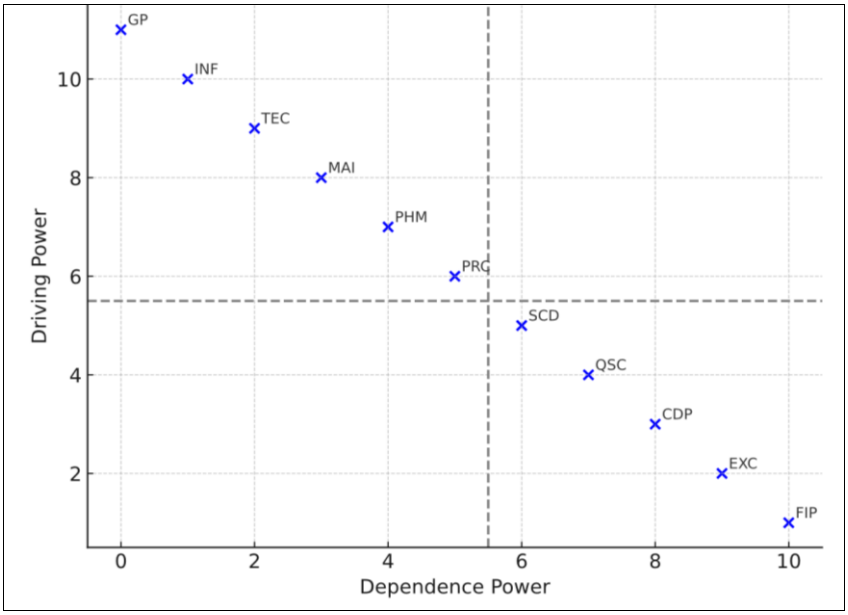

Fig 1: MICMAC Quadrant Analysis

6.5 ISM Digraph

The last ISM digraph (Figure 1) graphically illustrates the hierarchy of relations. The pyramid model indicates government policies, infrastructure, and technology at the bottom the bases of the mango marketing system. In middle layers linkage variables are shown that convey influence along the chain. At the outset, the income of farmers is shown as dependent variable, shaped by the cumulative effectiveness of all preceding factors.

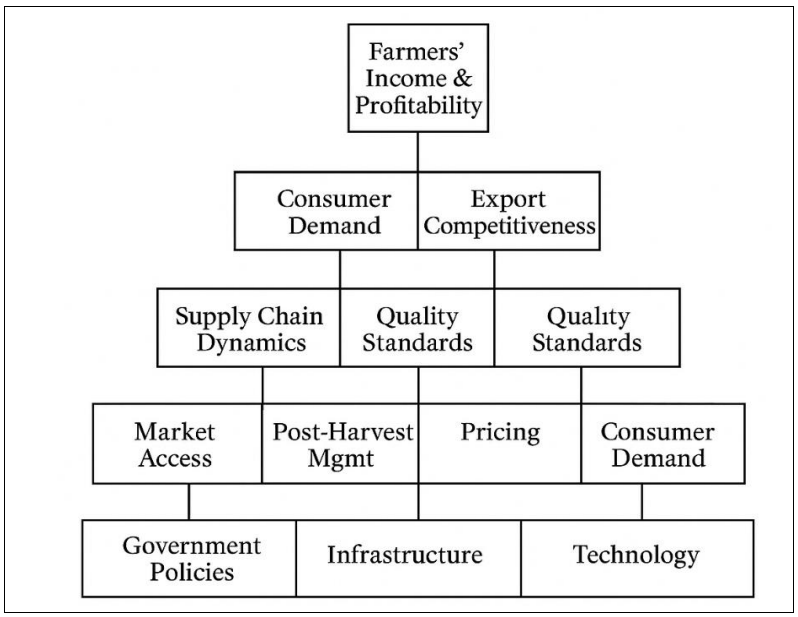

Fig 2: Interpretive Structural Model (Ism) of Mango Marketing Variables in India

7. Discussion

The ISM analysis uncovers the systemic interactions among government policies, infrastructure, technology, market access, post-harvest management, pricing strategies, consumer demand, and farmers' income. The hierarchical framework highlights government policies, infrastructure, and technology as the key factors that underpin the efficiency and competitiveness of the mango marketing system. The results support previous research that underscored the essential role of institutional frameworks and infrastructure investments in mitigating inefficiencies in horticultural marketing. (Durge *et al*., 2021; Negi *et al*., 2018) [4, 9].

The analysis further illustrated how linkage variables, including post-harvest management, pricing, supply chain dynamics, and quality issues, serve as transmission mechanisms. These variables exert influence on one another, revealing a reciprocal relationship. For example, insufficient cold-chain infrastructure not only exacerbates post-harvest losses but also affects pricing mechanisms and export potential (Venkatesh *et al*., 2021) [17]. Similarly, ineffective grading and certification systems have been associated with reduced consumer confidence and price volatility. (Singh *et al*., 2024) [15].

Dependent variables, including farmers' income, export competitiveness, and consumer demand, represent the final results of these systemic interactions. This is consistent with earlier research indicating that improvements in the supply chain, enhanced market access through ICT technology, and superior post-harvest management contribute directly to an increase in producer profitability. (Gautam *et al*., 2022) [5]. Therefore, the ISM and MICMAC model presents not only a theoretical framework but a working guide to the identification of leverage points within the mango marketing system. It highlights the need to aim interventions at root drivers, while maintaining consistency and stability in linkage variables to prevent systemic instability.

Systemic Insights from ISM Analysis

The ISM structure reveals critical insights into the mango marketing system:

- **Focus on Policy and Institutional Strengthening:** Government regulations and policy initiatives have far-reaching impacts on infrastructure, market access, and capacity building. Strategic interventions in these domains can drive systemic improvements.
- **Invest in Infrastructure Development:** Investment in cold storage chains, transportation networks, and agro-processing units should be prioritized. Public-Private Partnerships (PPPs) can significantly contribute to this effort.
- **Enhance Post-Harvest Management:** Capacity building in harvesting, sorting, packaging, and storing mangoes can reduce post-harvest losses and improve market value.
- **Market Linkages:** Use of ICT tools for delivering real-time market data and diminishing information asymmetry can make farmers capable as well as enhancing market efficiency.
- **Promote Farmer Producer Organizations (FPOs):** They can effectively improve bargaining power, facilitate aggregation, & mitigate intermediary exploitation.
- **Branding and Certification for Exports:** Creation of India-specific mango brands, establishing traceability systems, in compliance to international standards can lead to enhance the export potential.
- **Align with Consumer Trends:** This can be done by grasping urban and international consumer preferences so that farmers and traders can align their production and marketing strategies as per the needs.

8. Policy Recommendations and Implications

On the basis of the above findings the various recommended polices and their implications are stated below

8.1 Policy Reforms and Institutional Strengthening

- **Agricultural Marketing Reforms:** Supportive changes which are easier to follow with are needed to be implemented into place, such as expanding e-NAM, removing barriers to direct farmer sales, and making exporting procedures.
- **Price Stabilization Mechanisms:** Implement a Minimum Support Price (MSP) or insurance of prices for mangoes to protect farmers in years of surplus production.
- **Strengthening FPOs:** Empower FPOs through technical training, access to credit, and market connectivity to increase bargaining power and minimize intermediary exploitation.
- **Public-Private Partnerships (PPPs):** Facilitate state government, exporter, and agri-tech company partnership to increase logistics, processing, and branding.

8.2 Infrastructure Development

- **Cold Chain Logistics:** Invest in refrigerated transport, ripening chambers, and pack houses under viability gap funding to minimize post-harvest losses (20-30%).
- **Modernized Market Yards:** Modernize APMC yards with ICT kiosks, grading, barcoding, and e-NAM integration to enhance transparency.
- **Export-Oriented Clusters:** Set up mango export centers in places such as Valsad (Gujarat), Malihabad (U.P.), and Ratnagiri (Maharashtra) with quality testing laboratories and logistics.
- **Mango Processing Clusters:** Encourage Agri-Export Zones with independent mango processing facilities to diversify into pulp, juices, jams, and dried products.

8.3 Technology and Innovation

- **ICT Solutions:** Prepare real-time mobile applications and SMS-based price/weather information for farmers.
- **Blockchain Traceability:** Use blockchain technology to enforce food safety, traceability, and export certification compliance.
- **AI and Forecasting:** Utilize AI and satellite-based technologies for yield prediction, price prediction, and logistics planning.

8.4 Supply Chain and Market Access Improvement

- **Direct-to-Consumer Platforms:** Increase e-commerce

and digital platforms (Amazon Fresh, BigBasket, Ninjacart) to minimize intermediaries and maximize farmer margins.

- **Retail and Export Linkages:** Facilitate exporters in forming alliances with international retailers and supermarket chains, particularly high-demand areas such as the Middle East, Europe, and Southeast Asia.
- **Branding and GI Tagging:** Intensify branding of high-end varieties (e.g., Alphonso, Kesar, Langra) using Geographical Indication (GI) tagging and retail branding initiatives.

8.5 Quality Standards and Certification

- **International Compliance:** Educate farmers in GAP, HACCP, and residue-free farming practices to satisfy international standards.
- **Domestic Grading and Packaging:** Implement standardized grading, barcoding, and branded packaging to minimize price fluctuations and boost consumer confidence.
- **Organic Certification**: Facilitate farmers through organic certification schemes to satisfy health-conscious local and overseas markets.

8.6 Consumer-Focused and Export Drive Strategies

- **Global Promotion Campaigns:** Conduct international mango festivals and campaigns like the "Incredible India Mango Festival" to market Indian mangoes as premium fruits.
- **Value-Addition:** Promote processing industries to innovate pulp, frozen slices, jam, juice, and freeze-dried mangoes for round-the-year consumption and exports.
- **Nutritional Consciousness:** Encourage mangoes as a healthy fruit via health campaigns to increase indigenous demand amongst urban consumers.

8.7 Managerial Implications

- **FPO Alliances:** Agribusiness companies should have direct alliances with FPOs for guaranteed supply, quality control, and equitable farmer prices.
- **Technology Uptake:** Retailers, exporters, and supply chain companies should embrace ICT, blockchain, and AI to be competitive in the domestic and international markets.
- **Agri-Tech Start-Ups:** Opportunities exist for start-ups in logistics, cold storage, and e-marketplaces where efficiency gaps are substantial.
- **Market Diversification:** Dependence on old Middle Eastern markets has to be minimized by accessing Europe, East Asia, and North America.

9. Summary of Recommendations

The ISM model exhibits that systemic reforms are necessary for effective mango marketing in India. Although government policies, infrastructure, and technology provide the platform, managerial interventions in ICT adoption, branding, supply chain management, and quality certification are also crucial. An integrated policy-market approach can enhance farmers' income, minimize wastage, enhance export competitiveness, and ensure India's hold as the "Mango Capital of the World."

10. Conclusion

The ISM and MICMAC analyses are confirming that the marketing of mangoes in India is shaped by a hierarchical structure of interrelated criteria. Fundamental drivers are government policy, infrastructure, and technology, with farmers' income serving as dependent variable. The findings highlights that isolated initiatives are insufficient; a comprehensive transformation is necessary to foster resilience, enhance competitiveness, and provide advantages to producers.

Investments in institutions, ICT-enabled platforms, and infrastructure should be complemented by branding and certification strategies from policy point of view whereas, agribusiness companies, exporters, and cooperatives need to adopt supply chain design innovations, ICT-based tools, and consumer-driven marketing approaches through a managerial point of view.

The entire study makes contribution in the literature by applying ISM to horticultural marketing, offering a structured framework for identifying drivers, linkages, and dependent factors. Future research in future can appreciate and use these findings with quantitative validation and hybrid approaches, such as integrating ISM with DEMATEL or system dynamics, to enrich understanding and practical application of the ISM in marketing of mangoes or any other fruit

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