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ARTICLE

A Mixed-Methods Approach to Discover the Relationship of Sustain-able Agriculture-Based Value Chain Integration and Market Access for Smallholder Farmers

Hayder M. Ali [1] ***, Deeptha Ramamurthi*** [2] ***, Santhi Sri Tatavarthy*** [3] ***, Srinivasarao Bhukya*** [4] ***, Aseel Smerat*** [5,6] ***, Chandra Balasubramanian*** [7] ***, Ashurali Avliyakulov*** [8] ***, Sudhakar Sengan*** [9*]

[1] *Department of Information Technology, College of Science, University of Warith Al-Anbiyaa, Karbala 56001, Iraq*

[2] *Department of Information Technology, School of Computer Science and Engineering, SRM Institute of Science and Technology, Chennai 600089, India*

[3] *Department of Computer Science and Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram 522502, India*

[4] *Department of Computer Science and Engineering (AI-ML), Lakireddy Bali Reddy College of Engineering, Mylavaram 521230, India*

[5] *Faculty of Educational Sciences, Al-Ahliyya Amman University, Amman 19328, Jordan*

[6] *Centre for Research Impact and Outcome, Chitkara University, Rajpura 140401, India*

[7] *Department of Information Technology, Easwari Engineering College, Chennai 600089, India*

[8] *Department of Finance and Tourism, Termez University of Economics and Service, Termez 190100, Uzbekistan*

[9] *Department of Computer Science and Engineering, PSN College of Engineering and Technology, Tirunelveli 627152, India*

ABSTRACT

Market access (MA) and value chain integration (VCI) are problematic in India, but smallholder farmers (SF) are vital for multiple developing countries' agricultural sectors. Differences between regions in agricultural envi-

*CORRESPONDING AUTHOR:
Sudhakar Sengan, Department of Computer Science and Engineering, PSN College of Engineering and Technology, Tirunelveli 627152, India; Email: sudhasengan@gmail.com

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ronments, socioeconomic setups, education levels, and formal support mechanisms have limited Indian farmers' VCI. Farmers in Nimar and Vindhya have more logistical problems and low-income participation relative to those in the Malwa Plateau, who have better organizational skills and MA. Cultural and social standards limit studies for women in traditional regions. This mixed-methods study addresses how agricultural mediators and organizations impact MA and VAI's benefits and drawbacks in the Malwa Plateau, Nimar, and Vindhya districts. In Nimar and Vindhya, VAI can be boosted by investing in physical infrastructure, adopting a cross-sectional method, minimizing transportation costs (TC), improving MA, cultivating network collaboration, and providing proper farming support. While VCI has significantly increased farmers' income, regional disparities impede the establishment and implementation of MA. This study groups farmers by region, organization, and crop yield using random samples' quantitative and qualitative data. Surveys, interviews, and market data from 236 Madhya Pradesh SF with > 2 ha were collected to ensure data reliability. Sample data show 40% of farmers are from the Malwa Plateau and 35% from Nimar. The findings show that MA needs supportive relationships and specific methods to lower TC, improve setups, and increase farmers' market participation. The study proposes measures to optimize VCI and boost economic development for SF in India's unique agricultural environment to increase farmer income by 15% while minimizing TC by 20%.

Keywords: Smallholder Farmers; Agricultural Value Chains; Optimize; Market Access; Agricultural Landscape

1. Introduction

In developing countries like India, smallholder farmers (SF) play a key role in the agricultural system. However, they have problems with market access (MA), earning money, and value chain integration (VCI) [1]. A possible solution to these problems is to integrate SF into VCI [2]. Value chains connect buyers and sellers to suppliers, allowing production and income to increase [3]. Short setup time, lack of MA, and improper application of agricultural mediators (AM) are common problems that prevent SF from fully utilising VCI's profits [4].

When it comes to marketing produce at affordable prices and reaching an additional farmer base, MA is a significant issue for SFs [5]. Many farmers work in lower-quality, increasingly unpredictable markets because they cannot depend on legal markets. Accessing official markets requires physical setup, financial backing, dependable MA [6], and improved selling control. AM in the agricultural sector exploits farmers by imposing unbalanced costs and maintaining an unequal control over benefits. The ability of organisations to combine resources and operate effectively has made them significant participants in minimising the impact of these risks [7]. Through their efforts, MA is of higher quality, superior profitability is attained, and SF is provided, resulting in higher productivity. Changes in regional business create a favourable environment for farmers, foremost, to improve performance and greater trust in AM [8].

There is a high level of market evolution and VCI in India's agricultural regions, evident in the Vindhya, Nimar, and Malwa Plateau [9]. In some places, SFs' skill increased income and improved MA as a result of VCI, while in others, issues such as restricted MA, high transportation costs (TC), and limited negotiating power prevent development [10]. The primary goals of the present study are to develop a better understanding of the specific environments and difficulties encountered by farmers across various zones, and of how the United Nations security forces and collectives affect market outcomes. The results of the current investigation propose models to boost MA and SF income through VCI optimisation, by analysing the supposed benefits of VCI, the drawbacks of MA, and the roles of AM and organisations [11].

The economic and social impacts of VCI and MA are significant, changing the rural environment's gender and equity relations. Methods can boost productivity and profits, but this threshold does not always correspond to a higher proportion of the associated advantages across socioeconomic groups [12]. Members of marginal populations, including women, generally hold

minor roles in the chain due to their positions, limited transportation, limited access to financial services, and limited land ownership. Incorporating balanced training, access to digital marketplaces, and active decision-making, gender-responsive and environmentally accessible VCI can mitigate these imbalances.

Other exclusion-magnifying factors, such as caste, ethnicity, and economic status, require multilevel interventions to promote inclusiveness [13]. With the help of ICT-based platforms and collaborative methods, Equitable MA can enable smallholders to become autonomous economic actors, thereby promoting social mobility and resilience. Thus, it is essential to incorporate gender and social equity issues into VCI and MA policies to change agricultural modernisation into a tool of inclusive and sustainable rural development [14].

The identified research gap is in the lack of understanding of the impact of regional heterogeneity on the integration of SF in value chains and their MA in India. Based on the literature, VCI and MA are key factors for increasing SF yield and income while enhancing competitiveness; however, the heterogeneity of regional agricultural contexts remains poorly understood. For instance, the features of setup, MA, negotiating control, and the roles of AM and organisations differ across zones such as the Malwa Plateau, Nimar, and the Vindhya. Researchers' work has captured prior results on VCI and MA implementations, but has failed to provide a synthesis of the region-level factors that impact their value addition.

Structural inequalities in the Indian agricultural sector are experimental in terms of gender and landholdings. Indian farmers are small and marginal, accounting for about 86% of total farms but controlling approximately 47% of the total operated area. The agricultural labour force is composed of almost 64.4% women, but only 6–10% are working in formal agribusiness sectors, indicating a significant gap between labour force participation and economic empowerment. Despite their 75% contribution to primary crop production and 79% to horticulture, women control only 11.7% of the total agricultural land. These statistics highlight the long-term marginalisation of value-chain gains and market acculturation.

It has also been recognised that the complementary roles of AM and organisations in managing challenges are not universally well understood, and their success varies depending on local economic and physical conditions. This gap in research addresses regional differences in the efficacy of VCI, the local functions of organisations and AM, and the challenges that SFs encounter when entering the formal market. This will address the gap and provide recommendations on successfully increasing VCI, improving MA, and increasing SFs' income; thus, it is valuable for policymakers and developing agricultural ecosystems programs.

This article is organised as follows: Section 2 presents the theoretical model; Section 3 presents the methodology; Section 4 presents the data analysis; and Section 5 concludes the article.

2. Theoretical Model

The current research uses VCI and MA ideas to investigate the integral steps of farming, processing, and sale. The design highlights the vital role of SF integration into these supply chains in improving profits, product quality, and productivity [15]. VCI provides SF with better inputs, experience, and technology, resulting in more effective farming practices and improved crop yields. In this context, Porter's concept of the value chain is most important because it emphasises the significance of each link and how integration can lead to economic benefits.

Because rural areas have been particularly susceptible to environmental degradation, resource depletion, and social and economic unpredictability, sustainable agriculture (SA) has become vital for their future [16]. Adaptive farming practices, seeds that endure extreme weather conditions, and water-efficient irrigation methods, including drip and sprays, are all facets of climate-smart agriculture, an additional significant SA approach. Soil fertility and biodiversity are both improved by SA practices such as crop rotation, minimal soil disturbance, and the preservation of organic waste [17].

Diversification of profits and sustainability balancing are the results of agricultural land use combined with conventional farming methods. Also, there is integration of renewable energy, including solar-powered irrigation and bioenergy, which reduces reliance on fos-

sil fuels. Optimal resource management through precision agriculture, enabled by Internet of Things (IoT) sensors, Geographic Information System (GIS) mapping, and remote sensing, is possible. Sustainable value chain development also supports waste minimisation, local processing, and circular bioeconomy models. All these measures bolster the resilience of the environment, stabilise rural incomes, and afford climate-adaptive economic sustainability that aligns with global frameworks such as the United Nations (UN) Sustainable Development Goals (SDGs) and the Food and Agriculture Organisation (FAO) Climate-Smart Agriculture paradigm.

MA motivations include determining a producer's ability to engage with and benefit from different markets, and examining factors such as setup, data asymmetry, formal support, and market system [18]. SF frequently faces barriers to MA, including a poor transportation setup and limited control over sales. New institutional economics (NIE) emphasises reducing transaction costs and improving the organisation of contexts to enhance market input. SF efforts focus on factors that lower transaction costs and improve market institutions, providing more efficient support structures that better reflect market value and reduce problems in market integration.

Transaction cost economics is beneficial for understanding how the costs associated with market input—such as negotiating contracts, enforcing agreements, and MA—can limit smallholders' ability to integrate effectively into VCI.

The study of VCI and MA in SA methods becomes more comprehensive when environmental change and sustainability research are integrated. The effects of climate change have a direct impact on the agricultural sector's (in particular smallholders') financial stability, supply chain stability, and crop productivity, as reported by research [19]. Significant SA practices that can boost adaptation and mitigate climate impact risks include weather-smart farming, precision irrigation, and integrated fertiliser management [20]. SA development in the future is currently promoted by the adaptive value chain, which incorporates renewable energy, ecologically friendly supply chains, and lowering waste production, according to other sources in the literature [21]. Appropriate VCI may also support sustainable adaptation by increasing the likelihood that economically poor farmers and women will become involved in sustainable finance, carbon credit markets, and technological developments that can weather changes [22]. Accordingly, an integrated model for SA to develop a resilient, emission-free, and inclusive system is proposed by integrating SA and environmental change into VCI and MA research ideas [23].

When aiming to raise awareness of the potential and risks SF faces when attempting to connect with major financial firms, the VCI and MA ideas emerge as of paramount significance [24]. The findings shed light on the connection between VCI and MA, signifying how to avoid or mitigate the impact of financial problems while maximising feasible chances to boost productivity and, by further development, revenue, and efficiency [25].

2.1. VCI for SF

The level of significance of the connection between SF across the complete agricultural value chain—from cultivation to processing and marketing—is known as the VCI. The ideas behind the proposal offer a crucial opportunity for smallholders to shift their focus from SA to profit-oriented agricultural production. Seeds, fertilisers, and technology are inputs that SF develops through VCI; essential services such as capital and training are outputs. When it comes to regular methods and quality control checks, such measures are reasonable as well [26].

Robust agricultural organisations, cohesiveness, and access to a proper set-up have been emphasised in the available research on VCI as key drivers of profitable integration. One approach to assisting smallholders is to develop more involved VCI, secure guaranteed markets and costs, and mitigate demand risk through land leasing and organisation. The goods produced by SF must meet the marketplace's VCI requirements to ensure access [27,28].

Due to a lack of funds, limited MA, and vain sales control, SF skills integration problems. As a result of limited MA and the AM scam, farmers frequently market their agricultural goods at low costs, irrespective of their proper integration into society. The adoption of VCI boosts income, productivity, and suppleness in responding to economic deviations, which in turn enables

the shift to SF.

2.2. Impact of MA

From **Figure 1**, the MA is accountable for measuring product value; it is vital for SF. Set-up, financial support, data services, and market strategies all impact MA. With improved MA, SF might increase into higher-income regions, enhancing productivity and financial gains while reducing.

Reduced reliance on AM and greater accuracy in setting costs permit farmers who sell their agricultural products at official marketplaces to frequently obtain higher selling prices, according to the available research, which highlights the significant impact of higher MA on SF quality of life. Furthermore, MA helps modernisation by enabling farmers to explore value-added processing and novel product lines, and to generate profit and finance capital for enhanced farming.

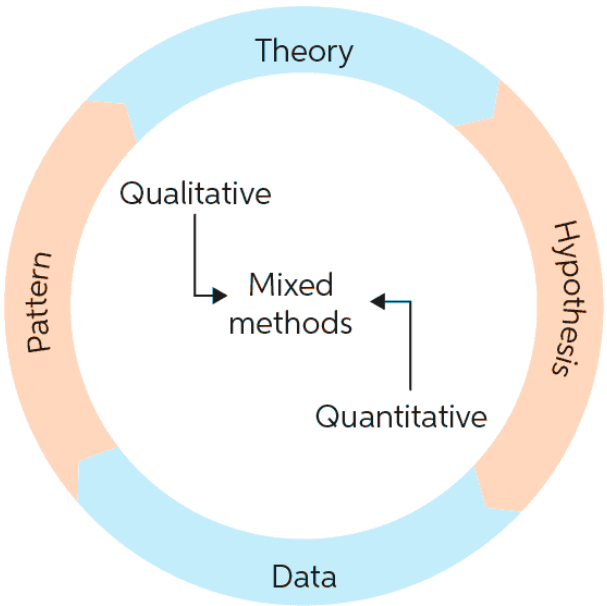


Figure 1. Mixed-Methods Approach (MMA).

Poor highways, a shortage of cold storage, and restricted access to MA may restrict farmers' economic development in agricultural regions. High TC and low marketing profits are merely a few of the organisational and policy drawbacks that make it difficult for smallholders to sell their products at fair prices. To improve MA while maintaining SF's significance in international agricultural markets, it is essential to address capital expenditures, farmer training, and institutional restructuring[24].

3. Methodology

3.1. Research Design

By combining statistical data with environmental findings, the present investigation uses an MMA to analyse the relationship between agricultural VCI and MA for SF. The design integrates qualitative and quantitative methods to examine the multiple variables that impact VCI and MA.

The method's level of complexity controls an MMA's value in VCI and MA. While statistical data like profitability and the number of farmers helping are practical, they fail to provide the details on how social factors, unique experiences, and decisions play a vital role in farmers' decision-making and the extent of the challenges they face. This means that qualitative data are necessary to measure the social, economic, and organisational factors that impact SF's lived experiences. The MMA collects and analyses qualitative and quantitative data concurrently via a progressive parallel design. Analysing the results collectively enables cross-validation and a deeper understanding of key research challenges, and ensures that the two methods' merits support each other.

Analysing the statistical connection between VCI and MA across a range of SF data is one of the main aims of the quantitative method.

A significant and demonstrative group of farmers will be questioned using systematic surveys that collect data on significant factors, such as the following:

- Participation in VCI (e.g., crop types, processing levels, involvement in organisations).
- MA (e.g., frequency of MA transportation distances).
- Economic results (e.g., income levels, price premiums, farm productivity).
- Demographic factors (e.g., Farm Size (FS), education level, household composition).

The survey will be developed using validated measures from previous studies, ensuring the reliability and comparability of data. To measure associations at a single point in time, a cross-sectional design will be used. To examine the link between VCI and distinct MA indicators, statistical techniques such as Multiple Regression Analysis (MRA) and Correlation Analysis (CA) will be applied. Empirical methods help to key variables for MAs, whereas graphical data highlight overall development.

How the analytical model predicts the effects of VCI and MA on SF's financial results. Income, cost increases, and agricultural productivity are examples of financial outcomes that act as dependent variables. The independent factors include VCI input, which is considered by crop type, cultivation level, and participation in organisations, and MAs, which are determined by market value frequency, shipping travel distance, and access type. Factors such as family size, education level, and income level serve as control variables. The MRA investigates how VCI and MA are affecting the bottom line.

Significant environmental facts about farmers' experiences and perceptions of VCI and MA will be provided via the qualitative aspect of the research, which will complement the quantitative data. A selected number of people who completed a questionnaire will be questioned in more detail by semi-structured interviews and focus groups. Participants will include SF and AM, as well as helpful businesspeople and government officials.

The qualitative design will focus on capturing the following:

- Farmers' perceptions of the benefits and challenges of VCI.
- Barriers to MA (e.g., transportation problems, MA gaps, institutional challenges).
- The role of AM, organisations, and government policies in helping MA.
- Social dynamics, such as trust between farmers and buyers, and how these relationships impact VCI.

After considering the research objectives and reviewing the literature, a conceptual model will be developed to guide discussions and interviews. This study can apply thematic classification and data analysis to identify correlations and generate insights from the qualitative data. Because of these variables, researchers can learn more about the systems by which business and socioeconomic factors impact quantitative data at the district level.

3.2. Random Sampling Approach (RSA)

Given its diverse SA practices and their significant impact on India's rural financial system, the Indian state of Madhya Pradesh is a vital focus of this research investigation's RSA, which emphasises the SF area. Small and medium-sized farms survive in Madhya Pradesh, where a significant portion of the population makes a living from farming. The primary aim of this study is to collect SF across multiple VCI and MA levels. Farmers in Madhya Pradesh who maintain farms with less than 2 ha are deemed SF and constitute a section of the target population. These farmers frequently face serious problems with VCI and MA and are less resistant to market changes. The research study will focus on farmers cultivating high-value crops, including agricultural products, pulses, staple crops (such as wheat and soybeans), and other crops with the potential to generate VCI.

The analysis will focus on three key agricultural regions in Madhya Pradesh to ensure an accurate illustration. The Malwa Plateau area has an average MA and a farming setup; it is renowned for wheat and soybean exports. The region is suitable for studying MA challenges because farmers there exhibit distinct levels of VCI. Farmers in the Nimar region, which is noted for its agricul-

ture and business crops, provide insight into the precise problems faced by high-value agriculturalists compared with those who emphasise basic agricultural products. The less evolved Vindhya region offers smallholders limited access to official markets, unlike the highly market-integrated farmers in the other two regions.

A layered RSA sampling method will be employed to ensure that the heterogeneous smallholder group is included. Type of crop (staple vs. high-value), region, and FS are the primary factors that set the level of segmentation. To include all potential experiences, farmers from each level will be selected at random from the group. A total of 236 SF from all three regions will be randomly selected for this research. The sample will consist of 35% from the Nimar region, 40% from the Malwa Plateau, and the remaining percentage from the Vindhya region. A typical range of results can be identified by the research project, owing to this range, which demonstrates the agricultural range and various levels of MA in such regions. After taking into account the research project's aims and its requirement for statistical reliability, a control analysis was performed to find out the sample population of 236 farmers. Also, they are capable of detecting significant relationships between VCI and MA with this number of samples, as it provides appropriate control. A subset of 30 to 40 farmers was also permitted to participate in interesting thoughts and in-depth interviews, providing valuable qualitative analysis.

Participating farmers will be those who are actively involved in agricultural production on land of less than 2 hectares (ha) and who sell part or all of their yield at regional markets. Since the study focuses on VCI and MA, it will not include farmers whose individual economic activity is SF and who do not contribute to MA. To find suitable farmers, the selection method involves collaborating with regional AM groups and extension agencies. Farmers will be selected at random from each level once the sampling frame has been identified. To maintain an objective, accurate selection method, analysts will meet with the selected farmers to conduct interviews and surveys. **Table 1** summarises the features of the specimen in question.

Table 1. Sample features.

Region	FS	Crop Type Cultivated	Farmers in Each Type	Farmers (%)
Malwa Plateau	<1 ha	Staple	25	26.6%
	1–2 ha	Staple	35	37.2%
	>2 ha	High-Value	34	36.2%
Nimar	<1 ha	Staple	28	33.7%
	1–2 ha	High-Value	38	45.8%
	>2 ha	High-Value	17	20.5%
Vindhya	<1 ha	Staple	36	61.0%
	1–2 ha	Staple	15	25.4%
	>2 ha	High-Value	8	13.6%

3.3. Data Collection

Quantitative and qualitative data from SF in the Indian state of Madhya Pradesh are collected using a structured approach in the present investigation. To examine how VCI relates to MA, the researchers employed a combination of surveys, in-depth interviews, and focus groups. The initial phase is to conduct systematic questionnaires with 236 SF from the Vindhya, Nimar, and Malwa Plateau districts. Significant variables such as FS, CY, and VCI levels, along with MA factors such as travel expenses and market prices, are collected in the questionnaire. The interview subjects will be further developed using tested tools from past cultivation MA and VCI research, and demographic data (including educational level, family size, and years of experience, or YoE) will be collected.

Since the main objective of the present research was to quantify the relationship between VCI and MA using empirical measures, qualitative methods, such as interviewing and focus groups, were not required. To ensure accuracy and validity, the experiment used an ordered quantitative model to find quantitative links, regional evaluations, and variable connections. The research's emphasis on validation by proof and practical results rendered qualitative methods inappropriate, as

they were assumed to add less environmental value. Using quantitative methods enabled reliable measurements across regions, thereby allowing precise evaluation of the socio-economic impacts and ensuring that the research methodology aligned with its analytical aims.

Fieldwork respondents, well-versed in the regional language and social contexts, analysed rural farming systems. Researchers and local agricultural allowance agents form data collection teams to prevent interruptions to farmers' regular activities. Participants have access to 45 minutes to 1 hour per session to respond to questions and elucidate data as required. Electronic devices with data-entry software can store data in real time and protect it from unauthorised use. Phase two consists of collecting qualitative data through methods such as focus group discussions and semi-structured interviews with market agents, farmers, and other SF involved in implementing the research. A total of 30 to 40 farmers will be advanced for detailed discussions on agricultural VCI skills, problems related to MA, and how AM, businesses, and local entities have affected their market value.

Farmers, primarily those involved in harvesting high-value and principal crops, have been interviewed in focus groups to collect their views on VCI, MA problems, and the benefits and drawbacks of the method. The discussions have been identified, recorded, and classified for future review and analysis, in accordance with the control of qualified organisers. To gain a better understanding of how official models, policies, and market dynamics impact SF'-MA and VCI, interviews are also conducted with market agents, helpful individuals, and government officials.

By increasing our vantage point to include these SFs, researchers better understand the local VCI and the systemic factors that impact market input. Each phase of the data collection method follows the highest ethical standards. This study ensures that everyone who expresses interest in the investigation understands the study's objectives, their rights, and that participation is entirely voluntary. This work attained informed consent before data collection, ensuring that participants understood their responses would remain confidential. Data security protocols ensure the transparency of interview and survey responses. The data type and resource are stated in **Table 2**.

Table 2. Data type and source.

Data Type	Data Source	Duration per Session	Sample Size
Quantitative	Structured Surveys	45–60 min	236 farmers
Quantitative	Demographic Information	Part of the survey	236 farmers
Qualitative	Semi-Structured Interviews	60–90 min	30–40 farmers
Qualitative	Focus Group Discussions	90–120 min	Groups of 6–8 farmers

4. Data Analysis

Key buyers explain their reasons for selecting CY, MA, and the financial advantages associated with SFs. Geographical diffusion, which the region incorporates, determines differences in setup and socioeconomic features. Based on crop type, we differentiate between basic and high-value crops and explain the differences in MA. Age and farming experience control decision-making and adaptability, while FS provides data on resource availability and production capacity. While the MA score analyses farmers' connections to value chains, annual revenue provides data regarding the sustainability of the economy. Finally, logistical challenges to servicing the market, such as geographical distance, impact profitability and market inputs. The mean, median, and standard deviation can be used to describe all of these variables. This information provides the basis for a complete analysis by region and crop, which, in turn, permits greater emphasis on efforts to enhance VCI and MA.

Table 3's descriptive data indicate an outline of SF by crop type (staple vs. high-value crops), region (Malwa Plateau, Nimar, and Vindhya), and additional data. The following variables have been included in the study: FS, age, years of farming skill, annual income, MA score, and distance to market.

Table 3. Descriptive statistics.

Region	Crop Type	FS (*ha*)			Age of Farmer (Years)			YoE			Annual Income (₹)			MA Score (1-10)			Distance to Market (km)		
		Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
Malwa Plateau	Staple	1.37	1.34	0.23	45.3	44.9	8.4	16.3	16.2	5.1	83,535	82,950	15,810	6.3	6.1	1.4	16.3	16.1	4.1
	High-Value	1.53	1.46	0.28	43.9	44.1	8.8	15.2	15.1	4.6	92,750	91,650	17,625	7.1	6.9	1.5	15.2	15.1	3.6
Nimar	Staple	1.18	1.16	0.21	46.1	46.3	7.7	17.1	17.2	5.3	76,510	74,925	14,920	6.1	6.2	1.3	19.3	19.2	4.3
	High-Value	1.31	1.29	0.24	44.7	44.6	8.1	16.2	16.1	5.1	88,750	87,555	16,835	6.6	6.5	1.4	17.4	17.3	4.1
Vindhya	Staple	1.09	1.07	0.18	47.2	47.3	9.3	18.3	18.1	5.9	65,950	64,950	13,960	5.7	5.6	1.7	20.4	20.2	4.9
	High-Value	1.27	1.21	0.22	45.6	45.7	9.0	17.2	17.3	5.7	77,750	76,950	14,850	6.4	6.3	1.6	18.3	18.1	4.6

i. **FS:** On average, farmers whose work produces high-value crops instead of basic crops have a greater number of crops (FSs). Farmers producing high-value crops on the Malwa Plateau have a median FS of 1.53 ha, but farmers producing basic crops have a median FS of 1.37 ha. Both Nimar and Vindhya follow this approach, with 1.31 ha designated to high-value crops and 1.18 ha to basic crops. Developing larger areas of land to support crops with higher FSs indicates an increased emphasis on crops with a higher chance of producing higher returns on investment.

ii. **Age of Farmers:** The median age of farmers varies considerably across regions but remains nearly identical across crop types. Nimar and Vindhya farmers are older than the median at 46.2 and 46.1 years, respectively, and basic crop farmers on the Malwa Plateau are slightly older than high-value crop farmers at 43.9 years. A potential cause of the age difference is that less developed farmers place greater emphasis on high-value, profitable crops, which typically require larger initial investments. Nimar and Vindhya are also experiencing this particular pattern.

iii. **YoE:** The YoE of farmers follows a business similar to that of other age groups. Across all areas, farmers who specialise in basic crops have relatively higher YoE than those who cultivate high-value crops. Farmers on the Malwa Plateau who produce basic crops have an average YoE of 16.3, while those producing high-value crops have an average YoE of 15.2. The average number of YoE for farmers in Nimar producing basic crops is 17.1, compared to 16.2 for farmers producing crops with considerable value. In Vindhya, the difference is more evident; farmers focusing on basic crops have a median of 18.3 YoE, while those focusing on high-value crops have a median of 17.2 YoE. Research suggests that older, more practised farmers prefer primary crop farming, while newer, less skilled farmers may be more inclined to participate in high-value crop research.

iv. **Annual Income:** In all regions, there is a significant income gap between farmers who cultivate basic crops and those who produce high-value crops. The median income for farmers in the Malwa Plateau who cultivate high-value crops is ₹92,750, while that for agriculturalists who cultivate basic crops is ₹83,535. Vindhya (₹750 for high-value crops vs. ₹65,950 for basics) and Nimar (₹88,750 for high-value crops vs. ₹76,510 for basics) both validate a comparable pattern. The higher demand and profitability of high-value crops, which typically command higher prices, contribute to this income difference.

v. **MA Score:** On a scale of 1 to 10, MA also helps farmers who cultivate high-value crops across several regions. Farmers in the Malwa Plateau who emphasise high-value crops have an improved MA score (7.1) compared to people who cultivate basic crops (6.3). Similarly, farmers in Nimar and Vindhya who focus on high-value crops have higher scores (6.6 and 6.4) than those who emphasise basic crops (6.1 and 5.7). Because they have superior access to regulated markets, agencies, and export opportunities, high-value crop farmers may have higher MA.

vi. **Distance to Market:** The distance between farmers' premises and nearby markets is another significant factor in MA and income. Farms produc-

ing high-value crops typically are located closer to markets than those growing staple crops, regardless of region. The average distance to market for farmers in the Malwa Plateau who produce high-value crops is 15.2 km, while farmers who produce basic crops have a distance of 16.3 km. In Nimar, farmers who produce high-value crops are located 17.4 km from markets, while those who cultivate staple crops are 19.3 km away. On average, farmers in Vindhya who produce high-value crops are just 18.3 km from marketplaces, while those who produce basic crops are 20.4 km away. As a result of the lower TC and improved MA, the total revenue of high-value crop farmers is likely to increase due to the geographical proximity.

The data in **Table 4** present only the correlation coefficients, which do not allow us to determine whether the acknowledged relationships between the variables are statistically significant. In other words, while correlation analysis enables us to identify linear relationships, it does not address causality or the strength of the links. To this end, *t*-tests for correlation coefficients or ANOVA should be used to check the significance of these correlations. For example, a *t*-test for correlation can find whether a correlation (such as the 0.42 experimental for FS and MA scores) differs from zero at a particular confidence level (e.g., 95%). Similarly, the independent-samples *t*-tests currently applied to compare the means between the groups (i.e., farmers with high and low MA scores) enhance the reliability of the conclusion. If those analyses are not performed, the reported correlations will lack statistical significance, potentially causing a significant loss for the research project. To improve the validity and reliability of the research and to collect valuable data on the relationship between VCI and MA, it is endorsed that such tests be conducted.

Table 4. Correlation Analysis.

Variable	MA Score Correlation Coefficient	Annual Income Correlation Coefficient	Distance to Market Correlation Coefficient
FS (ha)	0.42	0.61	−0.35
Age of Farmer (Years)	−0.18	−0.25	0.20
YoE	−0.22	0.12	0.15
Annual Income (₹)	0.56	1.00	−0.44
MA Score	1.00	0.56	−0.33
Distance to Market (km)	−0.33	−0.44	1.00

Table 4's correlation analysis presents the relationships among significant factors, including FS, age, YoE, annual income, MA rating, and market proximity. A larger farm is predicted to have a higher MA and more revenue if FS is positively correlated with the MA score ($r = 0.42$) and yearly income ($r = 0.61$). This is probably because farmers can increase their agricultural output by investing in higher-quality products, as they have access to more formal, highly profitable markets.

Larger farms are usually closer to wholesale markets, indicating that farmers incur lower logistical and TC costs, as the investigation finds a negative correlation between FS and market distance (−0.35).

The elderly farmers may have less money to make because they adhere to traditional methods and are unable to adopt new market practices, according to the study, which validates a small negative association between a farmer's age and MA rating. Elderly farmers tend to be farther from agricultural markets, signifying a positive correlation between age and distance to the market. More qualified farmers may occasionally have lower MA scores, since there is a weak negative correlation between YoE and MA scores. Still, as farming methods become more active over time, practice might yield significantly higher profits. The experimental correlation between yearly revenue and MA score is the most significant, highlighting the tight relationship between better MA and higher revenue. It is more challenging for farmers farther from marketplaces to achieve higher market prices and earn superior profits, as there is a negative correlation between MA and income and between MA and distance to the marketplace.

The main findings of the linear regression analysis (LRA) investigating how several uncorrelated variables affect the MA score, annual income, and distance to market are accessible in **Table 5**. A higher MA score

generally corresponds to more significant farms, as verified in the first model, where FS significantly impacts the final result (coefficient = 0.37, *p*-value = 0.003, R-squared = 0.44). This opinion validates the correlation results and further proves that FS improves farmers' links to marketplaces. The reverse scenario is also actual for the farmer's age; it harms MA (−0.15, *p*-value = 0.140, R-squared = 0.31), but the result is not statistically significant. But the business proposes that older farmers in MA may encounter fewer problems because they are not as up to date with the latest marketing methods.

Table 5. Regression Analysis.

Dependent Variable	Independent Variable	Coefficient	Standard Error	*t*-Statistic	*p*-Value	R-squared
MA Score	FS (ha)	0.37	0.12	3.08	0.003	0.44
MA Score	Age of Farmer (years)	0.15	0.10	1.50	0.140	0.31
Annual Income (₹)	FS (ha)	0.59	0.18	3.28	0.002	0.51
Annual Income (₹)	YoE	0.21	0.09	2.33	0.022	0.35
Distance to Market (km)	Age of Farmer (years)	0.18	0.07	2.57	0.013	0.29

From **Table 6**, there is a favourable association between FS and YoE in terms of yearly income. Coefficient = 0.59, *p*-value = 0.002, R-squared = 0.51) demonstrates that FS has a substantial impact on income, proving that more expansive farms yield higher earnings. From **Table 7** shows that farmers with more experience continue to increase their earnings, even in the absence of improved MA (coefficient = 0.21, *p*-value = 0.022, R-squared = 0.35). From **Table 8**, as a function of distance to the market, regression analysis indicates that age significantly affects it (coefficient = 0.18, *p*-value = 0.013, R-squared = 0.29), signifying that older farmers are more likely to live farther from markets. Because distance imposes logistical and financial limits, these findings may explain why age negatively affects MA and income in the correlation analysis.

Table 6. Region-based perceived benefits of VCI.

Region	Perceived Benefit	Respondents (%)
Malwa Plateau	Increased Income	72.3
	Better MA	63.1
	Improved Quality of Inputs	54.6
Nimar	Increased Income	66.8
	Stable Market Demand	60.2
	Knowledge and Training	41.7
Vindhya	Increased Negotiating Control	49.8
	Better MA	51.9
	Stable Market Demand	47.6

Table 7. Region-based barriers to MA.

Region	Barrier	Respondents (%)
Malwa Plateau	High TC	66.2
	Lack of MA	57.8
	Limited Negotiating Control	50.3
Nimar	High TC	61.1
	Poor Set-up	54.7
	AM Exploitation	45.9
Vindhya	Limited Negotiating Control	53.6
	High Competition	42.3
	Poor Set-up	49.8

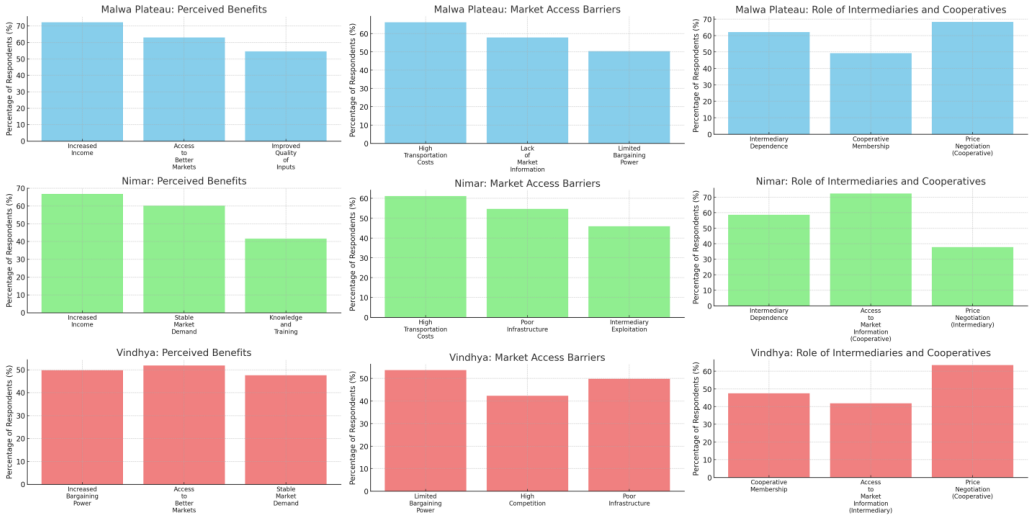
Table 8. Region-based role of AM and organisations.

Region	Factor	Respondents (%)
Malwa Plateau	AM Requirement	62.1
	Supportive Membership	49.3
	Price Negotiation (Cooperative)	68.2

Table 8. *Cont.*

Region	Factor	Respondents (%)
Nimar	AM Requirement	58.7
	MA (Cooperative)	72.3
	Price Negotiation (AM)	37.8
Vindhya	Cooperative Membership	47.5
	MA (AM)	41.9
	Price Negotiation (Cooperative)	63.4

Figure 2 includes a description of the perceived beneficial features of VCI, the problems associated with MA, and the respective functions of AM and agencies.



(**a**) (**b**) (**c**)

Figure 2. Key regional differences: (**a**) VCI; (**b**) barriers to MA; (**c**) Roles of AM and organisations.

Figure 3 presents an overview of the findings, which are primarily valid, and the interpretation accurately identifies the primary variables that have an impact on MA and VCI.

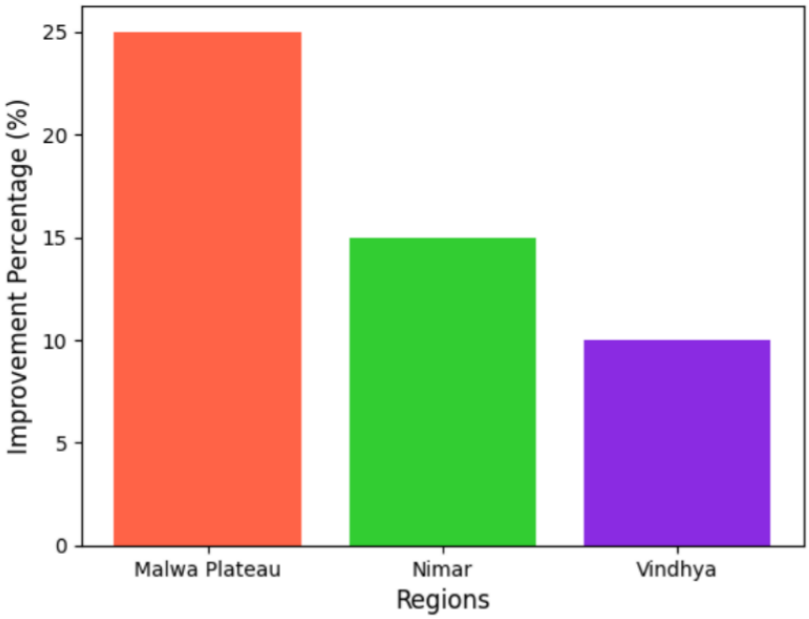


Figure 3. Product Portion Improvement in Different Regions.

The results are typically valid, and the interpretation accurately determines the primary variables that impact MA and VCI. To render the analysis more coherent, researchers need additional contextual validation of the negative correlation between age and the MA score. While there is some validity to the idea that this development is predominantly due to elderly farmers' reliance on traditional methods, this generalises a complex problem.

Elderly farmers' reduced market involvement may stem from several factors, including limited experience with digital tools, resistance to environmental change, and infrequent exposure to organised revolutions such as online marketing, value-added methods, and contract-based farming systems. Age differences in risk aversion, technology adoption, and data utilisation may also delay integration into dynamic value chains. On the other hand, newer farmers are performing higher in MA because they are inclined to respond to digital tools, sustainable inputs, and business ideas.

Rather than relying solely on cultural factors, it would be more reliable to situate the negative age-MA relationship within deeper socio-technical and cognitive factors. Incorporating data from relevant research on digital inclusion and age-related educational gaps in rural agricultural environments could strengthen this conclusion. The following recommendations would make the approach more reasonable, practical, and logical, aligning with current research on agricultural reform.

Focused policy interventions to enhance rural incomes and SA can be based on the empirical proof presented in the research study on VCI and MA. The study's findings indicate that implications for training, access to setup, social and MA, and farmers' input into integrated value chains are significant. In helping SF respond to changing agricultural market environments, these research results emphasise the need for training policies, such as programs in financial organisation, digital literacy, and market analytics.

Furthermore, there needed to be policy models specific to each context, because VCI and MA performance differ across the financial resources that are truly realised. Developed regions, like the Malwa Plateau, provide chances for value addition and export-based development, whereas less developed regions, like Nimar and Vindhya, focus on capital expenditures for cold-chain systems, storage, and logistics. For policymakers to acknowledge differences in regional development requirements, VCI must create opportunities for regional sources.

Furthermore, the study indicates that social and gender gaps persist in VCI. Land ownership, access to financing, and the possibility for leadership are severely restricted for women and other underprivileged farmers. Achieving gender equality in the marketplace requires legislative tools like priority lending programs, inclusive organisations, and subsidies that take gender into account. A different method to oppose this idea and promote inclusivity is to support women-producer organisations and find ways to incorporate them into digital marketing platforms.

In addition, the research results highlight the importance of digital setup and institutional coherence. Farmers may obtain greater impact in negotiations if digital procurement systems, mobile-based extension services, and e-market platforms are reinforced. Finally, for these interventions to be truly useful in the future, they must be aligned with SA policies that adapt to environmental changes. These policies should include measures to reduce carbon emissions, increase the use of renewable energy, and enforce practices that minimise resource waste. To achieve a balance among increased productivity, equitable resource distribution, and environmental sustainability, the study's results can inform inclusive, adaptive policy approaches.

5. Discussion

A predictive model that aims to measure the impact of VCI on SF excludes qualitative factors from its demonstration. Changes in income, development in MA, control over price discussions, and reduced TC should all be among those factors. Variables used to evaluate VCI include the following: business adoption rate, cost variance before and after VCI implementation, and the percentage of revenue generated by VCI networks. In districts where VCI is not highly efficient, researchers may find its benefits and problems through surveys,

interviews, and geographic analysis. By correlating these tests with socio-economic results, an LRA may strengthen the model's predictions for precise interventions.

This study provides a robust basis for examining the VCI-MA relationship among Madhya Pradesh SFs by collecting data in a linear, methodical manner. The quantitative segment uses 236 personal surveys of farmers from the Malwa Plateau, Nimar, and Vindhya regions to determine key indicators for farm features, farmer data, and economic inputs. This technique enables the development of a large dataset that captures a diverse range of farming practices and socio-economic environments.

To minimise confusion and ambiguity, survey respondents use regional dialects to conduct these questionnaires, and smart devices are used to record data, helping maintain coherence. 30 to 40 farmers and other relevant SF in indirect interviews and focus groups during the qualitative phase, which reinforced this dataset. The subjects addressed during these sessions include the problems of MA, the challenge of VCI, and the tasks of AM, which were not addressed in the questionnaires. Crop-based focus groups provide additional group viewpoints, along with interviews with applicable authorities and leaders who assess the current frameworks.

Several patterns emerged from statistical analysis, incidence (**Table 3**), and correlation (**Table 4**). It appears that FS and income are positively correlated, and that FS is negatively correlated with market distance. The projected impacts of FS on MA and income are verified by the regression results presented in **Table 5**, while the decreased MA due to location is also corroborated. Factors such as high TC and weak purchasing control, as evidenced by the geographically based advantages and drawbacks (**Tables 6–8**), may indicate weak negotiating power. These findings, considered collectively, provide a method for reasoning about and addressing VCI-MA problems.

Perceived positive aspects of VCI (**Figure 2a**), problems related to MA (**Figure 2b**), and the respective functions of AM and agencies (**Figure 2c**) differ significantly across regions, as shown by the analysis of **Tables 6** and **8**. A good deal of farmers in the Malwa Plateau view increased income (72.3%), better MA (63.1%), and improved input quality (54.6%) as the most significant advantages of VCI. A substantial boost in market value has an additive impact on economic activity. However, farmers in the area find it challenging to increase profits due to issues such as high TC (66.2%), lack of availability of MA (57.8%), and limited negotiation capacity (50.3%). SF in the Malwa Plateau relies heavily on AM (62.1% for MA), but being a member of a cooperative (49.3%) helps reimburse for this, particularly when it comes to settling prices (68.2% by businesses), which allows farmers to get lower rates. Benefits emphasised by Nimar people include greater revenue (66.8% of the total) and more regular market demand (60.2%), with an emphasis on training and learning (41.7%), demonstrating that VCI helps secure more markets and improve farmers' skills. High shipping costs (61.1%), improper setup (54.7%), and agent scams (45.9%) are the main problems for MA in Nimar, as in the Malwa Plateau. It appears that AM does not offer much assistance to Nimar farmers in discussing favourable market conditions, as 72.3% of farmers in the region depend on organisations for MA, and only 37.8% use agents. The primary benefits that farmers in Vindhya perceive from VCI are threefold: improved market access (51.9%), superior control over negotiations (49.8%), and predictable demand (47.6%). However, limited negotiating leverage (53.6%), close rivalry (42.3%), and insufficient facilities (49.8%) continue to restrict market value in the region. In Vindhya, cooperative membership is required (47.5%), but a vital factor for improved farmers' market outcomes is price negotiation through organisations (63.4%). The need for stronger collaborative methods to assist farmers is evident, as AM remain useless in providing MA (41.9%).

Since large farms frequently have better MA and higher returns due to scale advantages, the results typically indicate that FS is an essential factor in improving MA scores and annual revenue. These results highlight the importance of marketing and farming skills by demonstrating a positive correlation between the two. Despite a negative correlation between age and MA score, the results do not reach statistical significance. This recommends that other factors, such as market experience or proficiency with digital tools, may be more critical to MA success than age alone. Furthermore, the

results indicate that MA and income are negatively correlated with distance to market, lending credence to the idea that TC remains a significant problem for farmers, particularly those in rural regions. For older farmers whose farms are located further from markets, VCI presents a double whammy. Despite the importance of the tested variables, the LRA indicates a moderate fit (R-squared values), suggesting that they alone cannot account for all the factors determining MA and income. Policies designed to spur growth, farmer groups, and MA are crucial, according to this study, for developing a better agricultural value chain.

6. Conclusion and Future Work

In the Malwa Plateau, Nimar, and Vindhya regions, the research finds that VCI affects GDP and FI. The results validate that revenue, MA, and selling control are all increased with VCI input. On the other hand, because of factors such as AM, climate change, and access to MA, the benefits differ across geographic areas. Significant problems continue, including high TC and the absence of MA. VCI improves market reliability in Nimar, but its probable income is hindered by problems such as improper setup and the improper use of AM, which predominantly affect Vindhya farmers. Companies remain dynamic in their pursuit of better market results despite the difficulties they face. Localised problems, such as inadequate setup and TC, can be addressed by specific measures. To reduce corrosion and cut costs, enhancements include enhanced transport networks, storage facilities, and roads. Data centres, smartphone applications, and improvements all work together to make MA superior. Boosting businesses by member training, financial support, accountability promotion, and shareholder involvement improves income security and profitability in agricultural markets. To help SF get the most out of their agricultural VCI participation, the developers may build stronger networks of support and use fewer AM.

By addressing these barriers, SF in India can achieve superior economic resilience and improve income in an increasingly competitive, SA environment.

There is a requirement for further studies on other technologies, such as blockchain, IoT, and AI, to improve transparency and operational efficiency in the VCI of production. Farm organisations, which have been advocating for the use of policies and public-private partnerships, require assessment to increase MA for SF. Therefore, including sustainability indicators and equity factors, such as gender, for women farmers will help ensure equitable access to these benefits. Cross-sectional surveys could help assess the long-term effects on agricultural income volatility and stability development, while geospatial statistics could pinpoint low-income areas for early intervention. Such improvements can aid policymaking, the development of SA economic indicators, and improvements in food safety by detecting significant challenges posed by climate change and increasing the availability of SA-based VCI for small-scale manufacturers.

Author Contributions

Conceptualisation, Methodology, Formal analysis, Writing—Original Draft, Writing—Review & Editing, Investigation: S.S.; Software, H.M.A. and D.R.; Validation, S.S.T.; Resources, S.B.; Data Curation, A.S. and C.B.; Visualisation, A.A. All authors have read and agreed to the published version of the manuscript.

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Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

The data supporting the reported results in this study are available upon request from the corresponding

author. The datasets analysed or generated during the study are not publicly available due to privacy and ethical restrictions. However, data can be made available for academic research purposes upon reasonable request.

Conflicts of Interest

The authors declare that they have no conflict of interest.

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