

PRICE BEHAVIOUR AND VALUE CHAIN ANALYSIS OF PIGEON PEA IN INDIA

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UNDER GUIDANCE OF
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PRICE BEHAVIOUR AND VALUE CHAIN ANALYSIS OF PIGEON PEA IN INDIA

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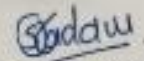
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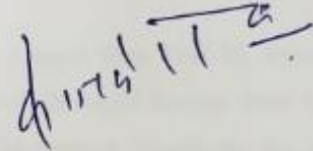
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CERTIFIED that the work incorporated in this thesis entitled "**Price Behaviour and Value Chain Analysis of Pigeon pea in India**" submitted by **Sachin Kisan Kadam** was carried out by candidate under my supervision. It is an original contribution and has not been submitted elsewhere for the award of any other degree. Such material as has been obtained from other source has been duly acknowledged in this thesis. I recommend that the thesis should be considered for the award of the degree of 'Doctor of Philosophy'.



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List of Abbreviations

ADF – Augmented Dickey-Fuller

AGMARKNET – Agricultural Marketing Information Network

AIC - Akaike Information Criteria

APMC - Agriculture Produce Marketing Committee

ARIMA – Autoregressive Integrated Moving Average

CAGR – Compound Annual Growth Rate

CIPHET – Central Institute of Post Harvest Engineering and Technology

CV – Coefficient of Variation

DMI – Directorate of Pulses Development

ECT – Error Correction Term

FAO – Food and Agriculture Organization

FPE - Final Prediction Error

GoI - Government of India

GoM -Government of Maharashtra

HH – Household

HQ- Hannan -Quian

ICAR- India Council of Agriculture Research

ILO – International Labour Organization

INR – Indian Rupee

Kg – Kilogram

LOP – Law of One Price

MMT - Million Metric Tonnes

MoA&FW – Ministry of Agriculture and Farmers Welfare

MSP -Minimum Support Price

NITI Aayog – National Institution for Transforming India

NT – Nomadic Tribes
OBC – Other Backward Classes
PP- Phillips-Perron
SC – Schedule Casts
SD – Standard Deviation
SDG – Sustainable Development Goals
SIC- Schwarz Information Criteria
ST – Schedule Tribe
UAE -United Arab Emirates
UN – United Nation
UNDP- United Nation Development Program
USA -United State of America
USDA – United State department of Agriculture
VCA – Value Chain Analysis
VECM – Vector Error Correction Model
WPI – Wholesale Price Index

EXECUTIVE SUMMARY

1. Introduction

Pulses play an important role in India's agricultural sector and they are an integral part of the Indian diet, contributing significantly to food and nutritional security, enhancing soil health and economic well-being of the small and marginal farmers (Government of India (GoI), 2021a). India produces one fourth (25%), consumes marginally higher than one fourth (27%) and imports 14 per cent of the global pulses. (GoI, 2024b, *FAOSTAT*, 2022). The year 2016 was declared the 'International Year of Pulses' to increase public awareness of the nutritional benefits of pulses by the UN General Assembly (Sharasia et al., 2017). In India, the production of pulses has increased from 22.01 million tonnes in 2001-02 to 31.03 million tonnes in 2021-22 and at the same time, the per capita net availability of pulses has increased from 10.9 kg per annum in 2001 to 19.6 kg per annum in 2022 (GoI,2023).

Pigeon pea (*Cajanus Cajan*) is one of the important legume crops (pulses) cultivated in India. It is significant in terms of being the most important source of protein and nutritional value (Sah et al., 2022). It is known as red gram /Tur/Arhar and it is a rainfed and drought-tolerant crop mainly grown by small farmers and harvested from December onwards (GoI, 2021a). Globally pigeon pea is cultivated in tropical areas, primarily semi-arid and tropical regions (Sah et al., 2022). Globally it is cultivated on 6.03 million hectares, producing 5.32 million tonnes with a yield of 833 kg/hatare in 2022 (*FAOSTAT*, 2022). The world production of pigeon pea increased by 2 percent annually, while India's production increased by 3.1 percent with an increase in the area under pigeon pea from 1961 to 2022 (*FAOSTAT*, 2022). India is a leading producer, consumer and importer of pigeon pea in the world and it accounted for 79.2 percent of the global pigeon pea production in 2022, followed by Malawi (8.4%), Myanmar (6.76%), Tanzania (3.1 %) and Kenya (1.6%) (*FAOSTAT*, 2022).

In India pigeon pea is cultivated on 5.05 million hectares and its production was 4.34 million tonnes in 2021-22, which was 17 percent of the total production of pulses in the country (GoI, 2023). Despite this, India imported 7.71 lakh pigeon pea during the financial year 2023-24 (GoI, 2024c). Within India, Maharashtra is the largest producer of pigeon pea, accounting for one-third of the total production, followed by Karnataka (28.90%) and

Madhya Pradesh (5.98%) (GoI, 2021a). Despite India being the world's major producer, consumer and importer of pigeon pea, the price volatility has increased recently (Bisht and Kumar, 2019; Kulkarni, 2019). However, price variation in agricultural commodities has significantly impacted the area, production and yield of pigeon pea (Blay et al., 2015). It has emerged as a concern, impacting producers and other stakeholders involved in the value chain of pigeon pea (Muflikh et al., 2021). Hence, the present study proposes to investigate the factors influencing the prices of pigeon pea.

Effective marketing integration would reduce price differential across the country mainly due to regional demand inconsistency and “greater market integration is essential for farmers to get higher farm-gate prices” (GoI, 2017). Market integration occurs when prices of the same commodity in one market reflect a change in another or follow the same pattern over a long period (Goodwin and Schroeder, 1991). This situation indicates the co-movement in prices, price signals and smooth information transmission across different markets (Reddy, 2012). Grace et al. (2013), in their study of gram and arhar noted that the markets are not closely integrated but are interlinked, because of lack of infrastructure, market information, transport and storage facilities. However, works by Hora et al. (2019) and Wavdhane et al. (2019) argue that pigeon pea markets are cointegrated in the long run and improve spatial integration. Therefore, the present study focuses on examining the market integration of pigeon pea in major markets located in key producing states in India and will examine the speed of adjustment in prices in short-run and causality (directions) between prices of pigeon pea in selected markets and examine the short-run speed of adjustment in prices and causality (direction) between prices of pigeon pea.

The value chain concept was introduced first in 1985 by Porter and the term 'value chain' used to ‘describe a series of value-adding activities including value-creation opportunities through primary and support activities’ (Porter, 1985). The term value chain defines “the full range of activities that are required to bring a product or service from conception through the different phases of production, delivery to final consumers and final disposal after use, which includes all the activities such procurement of raw materials, seed and inputs aggregation, assembly, transformation, transport and other services, and finally consumers” (Kaplinsky and Morris, 2002; Hellin and Meijer, 2006). The value chain

analysis deals with its structure, conduct and performance (FAO, 2013). Besides, the value chain analysis effectively examines the interaction among different players (Zamora, 2016). The value chain analysis can be conducted by using both qualitative and quantitative approaches (Hellien and Meijer, 2006). Likewise, value chain mapping technique is widely used in analyzing the value chain of agricultural commodities (Pavitra et al., 2018; Udhayan et al., 2023, Mohapatra and Ramadas., 2022, Reddy, 2013, Ganguly and Gulati (2022). In India, the markets are inefficient due to multi-layers of intermediaries in the value chain of pulses, resulting in marketing costs varying in different marketing channels and producers' shares in the consumer's rupees being very low (Shalendra, 2012). The farmers' share in consumer rupee is 65 percent in the case of pigeon pea which is low as compared with chickpea (75%) and moong (70%) in India (Jose et al., 2024). However, access to finance, lack of market intelligence at the farmers' level, infrastructure, non-availability of processing units, low market efficiency, long marketing chain, high-profit margin of intermediaries, knowledge of new technology, branding and market access are key issues in value chain of agricultural commodities (Kumar and Sharma, 2016; Sah et al., 2021). Therefore, understanding the complex value chain of pigeon pea is crucial. Hence, the present study focuses on the complete mapping of this subject. The study examines questions such as: How is the value distributed across the value chain of pigeon pea and who are the key actors involved in the value chain? It analyzes the farmer's share in consumer rupees.

Further, mitigating the food loss in the supply chain and post-harvest losses are significant concerns to increase the farmer's income and improve their livelihood standard (GoI, 2017). One of the most important factors behind increasing food inflation in India is product waste because of inefficient post-harvest practices and wastages at different value chain levels (Yigezu et al., 2021). Reduction in losses will enhance food availability and decrease food price volatility, which will benefit farmers and consumers alike (Mukherjee et al., 2022). Overall, the post-harvest losses disrupt the supply of products and increase volatility in prices. Therefore, despite the importance of pulses in the livelihood of millions of farmers and India's food security, the high post-harvest losses in pigeon pea remain policy concern. There are studies on post-harvest losses at the farm level, but the losses at the marketing, processing, wholesale and retail levels are addressed inadequately.

Therefore, this study systematically investigates the post-harvest losses of the pigeon pea crops at different stages of the value chain. Its results can benefit the value chain stakeholders by improving post-harvest practices, enhancing efficiency, forming a price stabilization policy, disseminating price information and improving the sustainability of the agricultural sector. Thus, based on the literature, the following four objectives for the study are laid down.

2. Objectives of the study:

The present study aims to investigate the price behaviour and value chain analysis of pigeon pea in India. The key objectives of the study are as follows.

1. To identify the factors influencing the prices of pigeon pea.
2. To study the market integration of pigeon pea markets.
3. To study the value chain of pigeon pea.
4. To study the losses incurred in the value chain of pigeon pea.

3: Data and methodology

The data was obtained from both primary and secondary sources. The secondary data was collected from *Agricultural statistics at glance*, Ministry of Agriculture and Farmers' Welfare, AGMARKNET portal, by DMI, GoI, etc. The primary data covering both qualitative and quantitative aspects of various parameters such as the perceptions of value chain stakeholders regarding factors influencing prices, mapping the value chain, actors involved in the value chain, farmer's share in consumer rupee, marketing and cost of production, and post-harvest losses incurred in the pigeon pea value chain were collected through field survey. The objective-wise details of the studied area, sampling procedure and statistical and econometric analytical techniques used for analysis are presented below.

3.1 Objective 1: To identify the factors influencing the prices of pigeon pea

The secondary data was obtained from various sources and used for the empirical analysis. The factors influencing prices were determined using annual data from 2005 to 2022. The marketing year of pigeon pea (January to December) was considered for all the data sets. Eighteen-year data was used in the regression model. The annual wholesale prices of

pigeon pea in Latur market of Maharashtra were collected from online portal AGMARKNET, by the Directorate of Marketing and Inspections (DMI), Government of India (GoI). Latur market is one of the leading markets in India's and Latur district is popular for quality and quantity of pulses especially pigeon pea (Government of Maharashtra (GoM), 2024). Latur market prices of pigeon pea are correlated with prices in other markets and prices in this market show bidirectional influence on prices of other markets in Maharashtra (Patil and Bhurke, 2014; Wavdhane et. al, 2020). Therefore, the prices of pigeon pea prevailing in it were considered a dependent variable for conducting formal analysis to quantify the factors influencing the prices. The data on area, production, yield, minimum support prices (MSP) were collected from various issues of *Agricultural statistics at a glance* published by the MoA&FW, Economics and Statistics Division, GoI (2023). The data on imports and exports of pigeon pea were collected from various annual reports published by the Directorate of Pulses Development, MoA&FW, Department of Agriculture & Farmers' Welfare, GoI.

Also, the data on procurement was collected from price policy for kharif crops (various reports), published by the Commission for Agricultural Costs and Prices (CACP), MoA&FW, GoI (2021). The per capita income and exchange rate data is sourced from the *Handbook of Statistics on the Indian Economy* (2024), Reserve Bank of India (RBI) The data on wholesale price index (WPI) of pigeon pea was collected from the website of the Office of the Economic Adviser, Department for Promotion of Industry and Internal Trade, GoI (2024b). The present study used green gram price as an independent variable in the model to determine the influence on pigeon pea price due to its being used as a substitute for pigeon pea. The prices of green gram in Latur market were sourced from the AGMARKNET portal, DMI, MoA&FW, Government of India. The data on international prices of pigeon pea at producer level was collected form online portal by FAO (2024). Apart from this the primary data regarding stakeholders' perceptions about factors influencing the prices of pigeon pea was collected through field survey, from farmers (560), traders/commission agents, processors, wholesalers and retailers (32 from each category), and importers (5) in Maharashtra. Details of the sampling procedure adopted for the field survey are presented in Chapter 4.

A multivariate linear regression model was used to identify the factors influencing the prices of pigeon pea and quantify the relationship between dependent and independent variables. The annual average modal price of pigeon pea in Latur is considered as a dependent variable and expressed in rupees per quintal. The data for independent variables including production, export, import, WPI, green gram prices, procurement quantity, etc., were collected from published sources.

To determine the appropriate set of independent variables for the model, the step-wise backward or forward regression method can be used to add or drop the explanatory variables based on the F test (Gujarati et al., 2015). This study employed the step-wise backward regression method to select the best-fit model by sequentially removing the most non-significant explanatory variable. One variable dropped at a time and this process continued until the best-fit model was obtained. The independent variables considered in the model include area, production, yield, export, import, government procured quantity, per capita income, population, exchange rate, WPI, prices of other pulses, international prices and MSP. The final best-fit model is presented along with a justification for including each explanatory variables.

Regression model:

Annual price of pigeon pea (Y) = f (total availability (X1) + trend (X2) + price of green gram (X3)

Thus, the multiple regression model can be expressed as –

$$\ln Y = a + b \ln X1 + b1 \ln X2 + b2 \ln X3 + e$$

Dependent variable (lnY): The annual price of pigeon pea in Latur market is expressed in rupees per quintal. All variables are expressed in natural logarithms (ln). The independent variables are defined as follows:

Total availability (lnX1) – It includes the production plus the import quantity minus the export quantity of pigeon pea. It represents the availability for domestic consumption, expressed in million tonnes.

Trend (lnX2): The linear trend is used as an independent variable in the analysis. It reflects the demand for pigeon pea. The values of the trend are expressed as 1,2,3,4, etc., for each year.

Annual price of green gram (lnX3): Green gram and pigeon pea are used in the Indian diet. While not a perfect substitute for pigeon pea, green gram is often used as an alternative. Therefore, the annual price of green gram in Latur market is included as an independent variable to quantify its influence on pigeon pea prices. It is expressed in rupees per quintal.

4.2 Objective 2: To study the market integration of pigeon pea

The study focuses on the spatial market integration of pigeon pea in India. Nine markets were selected based on maximum arrivals and availability of price data from three major pigeon pea producing states, i.e., Maharashtra, Karnataka and Madhya Pradesh, which together account for 63 percent of total pigeon pea production (GoI, 2023). Three markets from each selected state were chosen using the same criteria. The markets selected from Maharashtra are Latur, Amravati and Akol; from Karnataka, Bidar, Raichur and Kalaburagi (Gulbarga); and Pipariya, Jabalpur and Gadarwara from Madhya Pradesh. The selected markets are Agricultural Produce Market Committee (APMC) markets, regulated and controlled by the state governments (GoI, 2024). The study used monthly average wholesale prices from January 2003 to December 2022. The data were downloaded from the AGMARKNET portal, DMI, GoI, and the websites of mandi boards of respective states.

The present study applied a multivariate cointegration approach (Johansen Cointegration Test) to examine price integration. The market integration analysis involved five steps. The first step consists of a time series analysis of prices, including descriptive statistics, trends and correlation to understand price series and price variation. In the second step, to check the stationarity, Augmented Dicky-Fuller (ADF) test and Phillips-Perron (PP) test were used. In the third step, Johansen Cointegration Test was used, and Trace statistics and Maximum Eigenvalue Test results were used to investigate the number of cointegrations. Further, the Vector Error Correction Model (VECM) was applied to examine the speed of adjustment in the short run towards equilibrium in the long run. Finally, Granger Causality

Test was applied to explore the pair-wise unidirectional and bidirectional causal relationship in the prices of pigeon pea in selected markets in India.

4.3 Objective 3: To study the value chain of pigeon pea

Maharashtra is the leading state both in area and production of pigeon pea in India, accounting for 30.84 percent share in total pigeon pea production in 2021-22 (GoI, 2023). Therefore, it is selected as the studied area. A multi-stage stratified sampling method was used to select the location. In the first stage, Marathwada and Vidarbha regions were selected based on the highest area and production of pigeon pea. The top two districts from each selected region were chosen using the same criteria in the second stage. In the third stage, the top two talukas (blocks) from each selected district were selected using the same criteria. A total of eight talukas (blocks) were selected. In the fourth stage, two villages were selected from each selected taluka (blocks). The selected talukas and villages have large areas under the pigeon pea crop. Sixteen villages were selected for the study. Finally, a list of pigeon pea growers was prepared during the field survey and 35 farmers were randomly selected from each village. A total of 560 farmers were covered under the study. Apart from this, data on marketing and post-harvest losses were collected from actors involved in the value chain of pigeon pea. Commission agents/traders (32) at the Agriculture Produce Marketing Committee (APMC) were selected using a random sampling method from available lists with APMC offices. Processors (32), wholesalers (32) and retailers (32) were selected randomly from the lists prepared during the field survey. From each selected district, eight samples of processors, wholesalers and retailers were selected from each category. The transporters (eight) were interviewed using the convenience method during the field survey. Furthermore, farmer producers' companies (FPCs) involved in pigeon pea marketing and processing were selected using the convenient method and a total of eight FPCs were surveyed (two from each selected district) and finally five exporters/importers of pigeon pea were selected for the study. An overview of the sample covered in the study is presented in chapter 4.

The primary data was collected through conducting field surveys using semi-structured questionnaires. The field survey was done in four districts of two regions in Maharashtra, viz., Latur, and Nanded from Marathwada, and Yavatmal and Amravati from Vidarbha. The

field data was collected from October 2021 to March 2022. The data on pigeon pea's cost of production, marketing, methods used for harvesting, knowledge about factors influencing prices, price received and post-harvest losses were collected and used for analysis. Besides, data on price spread, and losses during marketing and processing operations such as losses incurred during trading, processing, storage, handling, loading and unloading and transportation were collected from actors involved in the value chain of pigeon pea. The value chain of pigeon pea was analyzed using mapping techniques which helped to identify the actors involved, track the flow of products from farm to consumer, calculate price spread and assess value addition at each stage. A similar methodology was used by Sah et al. (2022) in their study. The analysis focused on understanding the perceptions of value chain actors regarding factors influencing prices, cost of production, marketing of pigeon pea, price spread at each stage of the value chain, farmers' share in the consumer rupee and challenges faced by the farmers regarding production and marketing.

4.4 Objective 4: To study the losses incurred in the value chain of pigeon pea

The methodology was used for objective three, which has been employed to address objective four for data collection, encompassing sampling, studied area and the respondents surveyed in the field survey. Information is presented in the previous section (Objective 3). The data collected during the field survey was used to calculate the post-harvest losses incurred throughout the pigeon pea value chain. The total post-harvest losses at various stages, including farm-level operations, marketing, storage, processing, wholesale and retail levels were calculated separately. Total post-harvest losses incurred in the value chain were calculated using the sum of losses incurred at each operational stage. Additionally, the monetary value of post-harvest losses was calculated using three-year average prices in Latur market.

5. Discussion of the Results

The objective-wise results of the study are presented below:

5.1 Results of Objective 1:

5.1.1 Trends in annual prices of pigeon pea

The annual wholesale prices of pigeon pea had an increasing trend from 2005 to 2022 with year-to-year fluctuations. The price reached Rs. 4523 per quintal in 2009 and declined to Rs.3536/quintal in 2011. It started increasing and peaked at Rs.8604 in 2015 due to

production shocks caused by drought in major producing states. Then it declined, reaching Rs. 4089 per quintal in 2017 due to an increase in production, and after that it showed an increasing trend. The price reached Rs.6690 per quintal in 2022. Thus, the trend exhibits 51 percent variation in prices of pigeon pea.

5.1.2 Factors influencing prices of pigeon pea:

Factors influencing the prices of pigeon pea are analyzed using multiple regression analysis. The annual price of pigeon pea prevailing in Latur market is the dependent variable, expressed in rupees per quintal. The total availability of pigeon pea (production+ imports -export), annual prices of green gram and trends were used as an independent variable. Results of the multiple regression model obtained indicates that all the explanatory variables are statistically significant at 0.05 percent level. The coefficient of total availability is -0.68 percent. It shows a negative relationship with pigeon pea prices indicating that a one percent increase in availability decreases prices by 0.68 percent. In comparison, a one percent increase in demand raises prices by 0.36 percent. The prices of green gram positively influence pigeon pea prices. Even one percent increase in green gram prices leads to 0.60 percent increase in pigeon pea prices. Overall, the model explains 88.58 percent price variation due to changes in independent variables. The Durbin-Watson statistic indicates moderate autocorrelation and the LM test shows no autocorrelation. Hence, the model fits well and provides statistically significant results.

5.1.3 Perceptions of value chain actors about factors influencing on prices:

The perceptions of value chain actors about factors influencing the price of pigeon pea differed from respondent to respondent. However, all respondents agreed that production, demand, imports, quality of produce and government policies regarding MSP and trade are the most significant factors influencing the market prices of pigeon pea in India.

5.2 Results of Objective 2

5.2.1 Trend in monthly prices of pigeon pea in selected markets:

The monthly average wholesale prices of pigeon pea in selected markets from January 2003 to December 2022 were used to study market integration. Prices show an increasing trend with wide fluctuations over space and time. The highest prices were recorded in

October 2015 due to production shocks, as many producing states experienced droughts in consecutive years resulting in reduced production. Later, in 2017 production increased, leading to a decline in prices. However, prices continue to rise after 2018 due to lower production and high demand. The prices exhibit co-movement in the same way. The maximum correlation coefficient value is 0.99 and the minimum value is 0.97, suggesting a possibility of cointegration among prices. The value of SD was higher in Latur market (1984) and lowest in Jabalpur market (1709) with SD varying in different markets. The CV ranged between 46 and 48 percent, indicating that price volatility differs across markets.

5.2.2 Results of Unit Root Test and Selection of Lag Length

It is necessary to test stationarity in time series before conducting Johansen Cointegration Test. Augmented Dicky- Fuller (ADF) and Phillips-Perron (PP) Tests were done to check the stationarity in the price series. Results of the tests show that the price series in the selected markets is non-stationary at the level but becomes stationary at the first-order difference with statistically significant results. Additionally, the minimum lag (i.e., one month) is considered when conducting the formal analysis of Johansen Multivariate Cointegration Test as suggested by the SIC and HQ information criteria.

5.2.3 Results of Johansen Multivariate Cointegration Test

After examining stationarity in price series and determining the lag length, the study applied the Johansen Cointegration Test to investigate cointegration among prices of pigeon pea in selected markets. The study assumes that all the variables (price series) are stationary at the first difference [I (1)] and based on the VAR model, one lag is being considered while performing the test. The results of trace statistics and maximum eigenvalues were used in the study. The null hypothesis is rejected if these tests exceed the critical value at the 0.05 percent significant level. The trace statistics and maximum eigenvalue test results indicate that eight vector cointegration equations were found which indicates that all the pigeon pea markets are integrated. The trace and maximum eigenvalues are greater than the critical values at a 0.05 percent significant level. Hence, we can reject the null hypothesis and accept the alternative hypothesis that the markets are cointegrated. A long-run relationship may likely to exist between pigeon pea wholesale prices in selected markets. Studies by Paul et al., (2016), Horo et al., (2019), and Wavdhane

et al., (2019) found similar results. Prices will adjust over time and equilibrium exists in the long run. Therefore, pigeon pea markets in India are integrated.

Results of the normalized cointegrating equation of Johansen Cointegration Test represent the long-run relationship among the variables. The study assumes that the price series of Latur market is the dependent variable, while the price series of other markets are independent variables. Prices of Akola, Amaravati, Kalaburagi, Pipariya and Gadarwara markets have a positive and significant impact on the prices of pigeon pea in Latur market in the long run. It indicates that an increase in the prices of pigeon pea in these markets leads to an increase in prices in Latur market. On the other hand, the price series of Bidar, Raichur and Jabalpur markets negatively and significantly impact Latur prices in the long run.

5.2.4 Results of Vector Error Correction Model (VECM)

The speed of adjustment among variables was measured using the VECM in the short run. Johansen Cointegration Test results indicate that the prices in spatially located markets are cointegrated, suggesting a long-run relationship. Once long-run associations between variables are established, the VECM was employed to examine the short-run relationship between price series. Results of the VECM model show that most of the market price coefficient values (ECT) are negative and statistically significant. However, in the case of Latur market, the coefficient value of ECT is negative but not statistically significant. The speed of price adjustment was 0.28 to 0.82 percent. In the case of Akola, it was 0.47 percent, Amaravati 0.50 percent, Kalaburagi 0.53 percent, Bidar 0.82 percent, Pipariya 0.63 percent, Raichur 0.28 percent and Latur 0.05 percent). In Bidar market at 82 percent, the highest price recovery was in the short run, while the lowest recovery was in Raichur market (0.28 percent). It is estimated around three months are taken to adjust to the equilibrium level. It may be due to the distance among the markets. However, according to Grace et al. (2013), the error correction coefficient values are between 0.24 to 0.75 percent in the short-run in pigeon pea markets in India. The present study shows that an enhancement in the speed of adjustment in the prices of pigeon pea may be due to recent government policies or technological development. All the markets are well integrated in the long run.

5.2.5 Results of causality test:

The Granger Causality test is applied to examine the directions of price transmission among selected pigeon pea markets after performing Johansen Cointegration and VECM Tests. A bidirectional causal relationship suggests that both the markets transmit price information to each other, whereas unidirectional price transmission indicates that the price from one market is transmitted to the other but not vice versa. The selected markets are cointegrated and unidirectional and bidirectional price transmission is observed among them. All pairwise Granger causality results were statistically significant. The price in Latur market Granger causes changes in pigeon pea prices in Akola, Bidar, Kalaburagi, Raichur, Pipariya, Jabalpur and Gadawara markets, indicating the unidirectional price transmission from Laur to other markets. Likewise, the price of Akola market causes changes in prices in Amravati, Bidar, Kalaburagi, Raichur, Pipariya and Gadawara markets. Correspondingly, the price in Amravati market causes price changes in Bidar, Kalaburagi, Raichur, Pipariya, Jabalpur and Gadawara markets. Furthermore, the price in Kalaburagi causes changes in Bidar, Raichur and Gadawara markets. Similarly, Bidar market price is caused by Raichur market price. Additionally, the price in Jabalpur causes price changes in Kalaburagi, Pipariya and Gadawara markets. These results show high cointegration among India's selected pigeon pea markets, indicating significant market price linkages.

Results of the pairwise Granger causality tests reveal bidirectional influence, indicating price transmission among market pairs such as Latur - Amravati, Jabalpur - Akola, Pipariya - Bidar, Jabalpur - Bidar, Gadawara - Bidar, Pipariya - Kalaburagi, Pipariya -Raichur, Jabalpur - Raichur, Gadawara - Raichur and Gadawara - Pipariya. In other words, these pairs of prices in one market cause price formation in the other market and vice-versa. It indicates a high degree of interlinkage among pigeon pea markets in India with price signals being effectively transmitted among selected markets. The study confirms that these markets are cointegrated, meaning that the price change in one market influences the prices in the other markets. The study results are aligned with earlier studies by Horo et al. (2019) and Wavdhane et al. (2019).

5.3: Results of Objective 3

The present study provides a complete mapping of the value chain of pigeon pea in Maharashtra. Specifically, it examines the key problems such as how is the value distributed across the pigeon pea value chain? Who are the key actors involved and what is the farmer's share in consumer rupees?

5.3.1. Cost of production and net returns of pigeon pea

The results of cost of production and net return from pigeon pea cultivation show that the total cost of production was Rs.18129 per acre. The average yield was 4.79 quintals per acre and the cost of pigeon pea production was Rs. 3785 per quintal. The operational cost for pigeon pea was higher than input costs. Among various sub-components under input cost, the cost incurred for pesticides was higher at Rs. 2332 per acre. The average price received by the farmers was Rs. 5958 per quintal. Therefore, the gross income from pigeon pea was Rs.28539 per acre and average net return was Rs.10,409 per acre. The benefit-cost (BC) ratio for pigeon pea cultivation was 1.57. According to the Commission for Agricultural Costs and Prices (CACP), the average cost of production for pigeon pea was Rs. 3886 per quintal at all-India level for the marketing season 2022-23 (GoI, 2021).

5.3.2 Marketing of pigeon pea:

Most farmer respondents (88.8%) sell pigeon pea to commission agents or traders in the APMC markets due to better prices, instant payment and credit facilities. A lesser proportion of them (2.4%) sells to FPCs attracted by better prices and FPCs situated in the nearest place. Besides, 3.4 percent farmers sell to village traders, reporting timely payment and financial support. Another group of 3.6 percent sells to the government procurement agencies as they receive MSP. Only around 2 percent farmers sell directly to the processors. The average distance from farm to market was 23 km. In terms of transportation, most of the farmers used tractors (52.68%), followed by light motor vehicles (LMV) having capacity of 3 to 5 tonnes (36.07%), while very few used trucks (4.46%) for transporting pigeon pea to the market. In particular, 97 percent farmers sell their produce individually, highlighting the scope for farmers' collectivization. Regarding the post-harvest practices, 67 farmers clean their pigeon pea before selling. This takes place at various locations such

as at the farm (12.23%), APMC market (74.82%), FPC facilities (2.15%) and storage place (10.79%).

5.3.3 Mapping of value chain of pigeon pea

The mapping technique is used to analyze the value chain of pigeon pea. Five major marketing channels exist. Existing marketing channels have minimum one and maximum five intermediaries between farmers and consumers. The net return to the farmers from selling pigeon pea through marketing channels are varied. Farmers realized a higher net return (Rs. 2276 per quintal) when selling through Channel III (farmers – processors – wholesalers – retailers - consumers), followed by Channel IV (Rs. 2202 per quintal). In contrast, the net return was lower in the case of Channel II (Rs.1741 per quintal). This indicates that farmers using channels III and IV tend to get better net returns than those using other channels. However, Channel I (farmer - commission agents - processors – wholesalers – retailers - consumers) is the most popular marketing channel with 88.8 percent farmers selling their produce through it.

The price spread among pigeon pea marketing channels is the highest in Channel II (55%), i.e., farmers – village traders – commission agents – processors – wholesalers – retailers – consumers. The higher price spread can be attributed to the number of actors involved in this channel compared to other channels. In addition, farmers received lower prices when selling through this channel. However, 3.4 percent farmers sell their pigeon pea to village traders due to instant payment and credit facilities provided. Among the existing marketing channels, the lowest price spread (35%) is found in Channel IV where farmers sold pigeon pea to the FPC. It has minimum intermediaries between farmers and consumers. The price spread varies among the channels between 35 percent and 55 percent. However, the farmers' share in the consumers' rupees is higher in the case of produce sold through marketing Channel IV, i.e., the farmers selling pigeon pea to FPCs (72.93%). Also, farmers get additional benefits in terms of inputs and cleaning facilities from them.

5.4: Results of Objective 4

5.4.1 Post-harvest losses of pigeon pea at farm level operations

Post-harvest losses at harvesting and threshing are major contributors to total post-harvest losses at farm level. This suggests the need for better practices and improved threshing

techniques during these operations. The total post-harvest losses at farm level in Vidarbha (7.51%) were slightly higher compared with Marathwada (7.07%), mainly because of higher losses in harvesting and drying. The post-harvest losses at storage and transportation operations are relatively low at the farm level. District-wise post-harvest losses at farm level show that out of the four selected districts, the highest losses were in Amravati district (7.52%), followed by Yavatmal (7.51%), Nanded (7.26%) and Latur (6.88%). However, the recent study by NABCONS (2022) shows overall post-harvest losses of pigeon pea in Maharashtra (6.9%) and that the highest losses were in Yavatmal (7.63%) due to improper harvesting, manual threshing, diseases and pest infestation. The present study results are broadly aligned with the findings of a recent study by NABCONS (2022). The average losses of 7.30 percent at farm level are significant and show they could be reduced through encouraging awareness and use of improved practices in harvesting, threshing, cleaning and drying operations.

5.4.1 Results of overall post-harvest losses incurred in the value chain of pigeon pea

The overall losses estimated at different stages of the value chain of pigeon pea: farm level operations, marketing and processing activities. While performing harvesting, threshing and winnowing/cleaning activities, the losses were 1.60 percent, 1.89 percent and 1.43 percent respectively. Drying activity contributed 1.20 percent in total post-harvest losses at farm level operations. Total post-harvest losses of pigeon pea were estimated at 7.29 percent at the farm level. Earlier studies reported that the total post-harvest losses at farm level were 4.67 percent (NABCONS, 2022), 6 percent by Shah (2014), 11.26 kg/quintal by Kannan et al. (2013), 4.78 and 5.72 percent by Nanda et al., (2012); Jha et al., (2015) respectively. The post-harvest losses incurred are estimated at 4.76 percent at marketing and processing levels, 1.2 percent at commission agents/traders' level, 2.3 percent at processing level and 0.79 percent and 0.47 percent at the wholesalers and retailers' levels respectively.

The overall post-harvest losses of pigeon pea were estimated at 12.05 percent. Up to processing stage they were 8.49 percent, during pigeon pea dal processing they were 2.3 percent and at selling of tur dal 1.26 percent. The use of modern and appropriate post-harvest technologies is essential to reduce post-harvest losses.

5.4.2 Results of harvesting methods used and post-harvest losses:

Proper harvesting methods reduce losses. Data on methods used for harvesting, costs incurred and losses were analyzed. Harvesting, threshing and winnowing were performed manually, semi-manually and through harvesting machines (harvesters). The study shows that the activities performed using manual methods resulted in losses of 2.52 percent, semi-manual (cutting manually but threshing and winnowing by machine) method 3.27 percent, and using combined harvesters (cutting, threshing and winnowing by harvester) 3.89 percent. Farmers reported that the post-harvest losses are higher when using a combined harvester than when harvesting crops manually or semi-manually.

5.4.3 Results of reasons for post-harvest losses incurred in the pigeon pea value chain:

The value chain actors reported the reasons for losses. It found that 79 percent farmers reported manual harvesting and threshing, lack of storage facilities (32%) and packaging (43%) as important causes of post-harvest losses at farm level. At the marketing channel, high moisture content during peak marketing days (87%), loading and unloading process (69%), removing foreign matters (81%), packaging (64%) and transportation from trading place to dal mill or storage place (76%) were reported by the traders and commission agents as the reasons. In the processors' view, 93 percent losses occurred due to high moisture content (77%), removing foreign matters (86%), transportation (45%) and improper storage (70%). At the point of selling pigeon pea dal, wholesalers and retailers reported mishandling as the causes of post-harvest losses. In contrast, the loading and unloading process (79%), transportation (76%) and improper storage methods (40%) are reported by the wholesalers as responsible for losses. Eighty-one percent retailers reported that rodents and insects cause losses in handling and 74 percent in storage.

5.4.4 Results of precautions to be taken during harvesting time:

It was found that 49 percent of the respondents took proper precautions during harvesting to minimize losses. The types of precautions taken by the farmers are not harvesting before maturity (43%), using proper equipment to harvest (57%), not harvesting during adverse climate conditions (55%), and keeping harvested crops separately (49%). However, 51

percent of farmers still need to take proper precautions during harvesting to minimize losses.

5.4.5 Post-harvest constraints faced by farmers:

Most farmers (49%) faced low prices for their produce after harvesting, transport facilities were not available on time (48%), market was far (45%), timely non-availability of packaging material (43.6 %) and lack of storage facilities (33%).

6. Conclusion and recommendations

Pigeon pea occupies a significant place in India's agricultural sector, augmenting soil quality, and promoting nutritional and economic well-being. The country is a major producer, consumer and importer of pigeon pea worldwide. However, volatility in its prices has become a serious problem in recent years, affecting not only producers and other stakeholders in the value chain but also consumers. Hence, the study examined factors influencing their price volatility, integration of their market with major markets in India, speed of adjustment in prices in short-run and causality (directions) between prices of pigeon pea in selected markets.

The study was conducted using both primary and secondary data. The data on the cost of production, marketing, methods used for harvesting, knowledge about factors influencing prices, price received and post-harvest losses during marketing were collected from farmers and the same has been used for analysis. On the other hand, data on price spread and losses during marketing and processing operations- trading, processing, storage, handling, loading and unloading and transportation were collected from actors involved in their value chain using checklists. Secondary data relating to the prices of pigeon pea was used from 2005 to 2022. Appropriate, analytical techniques like statistical methods and econometric models were used to analyze the data. Results of the regression model of pigeon pea prices show that factors such as total supply (production + import - export) of pigeon pea, Demand (trend) and price of substitute commodity (green gram) significantly influence their prices. Overall, the model explains 88.58 percent of the price variation due to changes in independent variables and the results are statistically significant.

Pigeon pea markets are integrated and have a long-run price relationship. Prices are transmitted across the markets and closely interlinked markets exist. The speed of price adjustment ranged between 0.28 and 0.82 percent in selected markets in the short run. Grace et al. (2013) found that the price adjustment speed was 0.11 to 0.28 percent. However, the present study shows an improvement in the speed of adjustment in the prices of pigeon pea in the country. This may be due to recent government policies or technological developments. The pairwise Granger Causality Test confirmed the bidirectional and unidirectional causalities across the selected markets. Among them, Latur market was the price leader, influencing market prices in other selected markets.

Most farmers (88.8%) sold their produce to commission agents/arthritis in the nearest APMC markets due to better price realization, credit, and instant payment, while few of them sold their produce directly to the processors, village traders, government procurement centers and FPCs. A majority of the farmers (97%) sell the produce individually which indicates scope for aggregation of produce and 67 percent undertake cleaning activity before selling pigeon pea. The benefit-cost ratio of pigeon pea cultivation is 1.57.

In the study area five major marketing channels involved multiple intermediaries. Among them, the farmers using Channel IV (farmers – farmers' producer company – consumer) realized a higher return because of the lowest price spread and minimum intermediaries between the farmers and consumers. Farmers also got additional benefits in terms of inputs and cleaning facilities from FPCs. However, the Channel I (farmers - commission agents – processors – wholesalers – retailers – consumers) was more popular. Apart from them, the price spread among marketing channels was higher (55 %) in the case of Channel II (farmers – village traders – commission agents – processors – wholesalers – retailers – consumers).

The study results show that the post-harvest losses incurred in the value chain varied in regions and districts. Also, post-harvest losses vary by landholding size, decreasing as landholding size increases. It estimated that total post-harvest losses incurred at farm-level operations were 7.29 percent and 4.76 percent at the marketing and processing levels. Overall, post-harvest losses incurred in the value chain for pigeon pea were estimated to be 12.05 percent, with higher losses at farm-level operations than at the processing and

marketing stages. Also, the losses are higher when using a combined harvester than when harvesting the crop manually or semi-manually. Hence, there is a need to reduce the post-harvest losses at the farm level and the entire value chain. The economic value of post-harvest losses for pigeon pea was more than 60 percent of the value of imported pigeon pea. The value chain actors reported that the manual harvesting and threshing, lack of storage facilities, pests and diseases contributed to losses. Despite some farmers taking precautions during farm-level operations, there is room for improvement in reducing the losses. Then, after harvesting, farmers faced constraints such as low prices, transportation, distance to markets and lack of storage facilities. Overall, the study highlights the importance of modern post-harvest technologies and disseminating knowledge about good agricultural practices to minimize losses and avoid economic loss in the country. Its empirical results will help mitigate price volatility and sustainability of the production of pigeon pea by adopting long-term policies to enhance domestic production and reduce post-harvest losses. The strengthening of FPCs will be beneficial to value chain actors involved in the pigeon pea business.

7. Limitation of the study

The present study covers select markets and the data collected from the more respondents from different states would help strengthen it. The farmers reporting and simultaneously actual measurement would have strengthened the study further. The study does not estimate the actual post-harvest losses incurred in the various operations conducted by value chain actors. There are limitations to generalizing research findings beyond the commodity under study and regions. However, this opens new avenues further in the area of determinants of market integration of pigeon pea, actual measurement of post-harvest losses incurred in the value chain and so on.

CHAPTER 1: INTRODUCTION

1.1 Background

The rise in volatility of agricultural prices has become a serious policy concern (Huchet-Bourdon, 2011; Subramanian and Ministry of Finance, 2016; Bisht and Kumar, 2019; Kulkarni, 2019). It has affected not only producers and other stakeholders in the value chain of agricultural commodities (Muflikh et al., 2021) but has significantly impacted their area, production and yield (Blay et al., 2015). The prices of agricultural commodities are primarily determined by the interaction between the supply of and demand for commodities (Borychowski and Czyżewski, 2015; Schnepf, 2005). While the wider studies covering factors contributing to price volatility such as supply and demand-side factors, macroeconomic factors and non-farm commodity prices have been conducted (FAO et al., 2011; European Commission, 2015; Gilbert and Morgan, 2010; Schnepf, 2005; Ingram, 2014; Ai et al., 2006; Choudhari and Pawar, 2010; Patil and Burkee, 2014; Ai-Hua, 2012; Tothava, 2011; Baffes and Haniotis, 2016; Nigatu et al., 2020; Tadesse et al., 2014; Imai et al., 2011), the limited studies attempted to quantify each factor's influence on price volatility. (FAO et al, 2011). The present study examines the factors influencing prices, market integration, value chain and post-harvest losses as influencing prices of pigeon pea.

Market integration occurs when prices of the same commodity in one market reflect a change in another or follow the same pattern over a long period (Goodwin and Schroeder, 1991). This situation indicates the co-movement in prices, price signals and smooth information transmission across different markets (Reddy, 2012). Effective market integration would reduce price differential across the country and greater market integration is essential for farmers to get higher farm-gate prices (GoI, 2017). In the Indian context, studies have shown that many agricultural markets, including those for pulses, are often not fully integrated due to infrastructural deficits, inadequate storage facilities, lack of market intelligence and lack of transportation (Grace et al., 2013). The study of market integration is crucial to understand the market efficiency, performance of spatially located markets, possible arbitrage chances, efficient price transmission and better price realization (Rapsomanikis et al., 2003; Reddy, 2012). This study examines the market integration of

pigeon pea in major markets located in key producing states and the speed of adjustment in prices in short-run and causality (directions) between prices.

The value chain describes the full range of activities that are required to bring a product or service from conception through the different phases of production, delivery to final consumers and final disposal after use (Kaplinsky and Morris, 2002; Hellin and Meijer, 2006). Understanding the value chain of pigeon pea is crucial to identify where value is added, where it is lost and who are the key actors involved in the value chain. The value chain analysis of agricultural commodities can be conducted by using both qualitative and quantitative approaches (Hellien and Meijer, 2006) and mapping technique (Farole et al., 2018; Pavitra et al., 2018; Udhayan et al., 2023, Mohapatra and Ramadas., 2022, Reddy, 2013, Ganguly and Gulati (2022). In the context of India, key challenges in the pulses value chain have been studied and reported presence of long marketing channel, presence of multiple actors, high marketing costs, low farmers' share in the consumer rupee, lack of adoption of technologies, lack of market access and inadequate infrastructure (Shalendra, 2012; Kumar and Sharma, 2016; Sah et al., 2022). The mapping technique is used in this study to conduct value chain analysis of pigeon pea. It has addressed questions such as: how is the value distributed across the value chain of pigeon pea and who are the key actors involved in the value chain? And what is the farmer's share in consumer rupees?

Mitigating the post-harvest losses are one of the significant concerns to increase the farmer's income and improve his livelihood standard (GoI, 2017). The post-harvest loss of pigeon pea significantly affects the overall availability and profitability. Despite the importance of pulses in the livelihood of farmers and India's food security, the high post-harvest losses in pigeon pea remain a neglected policy concern. According to the FAO (2011) report, 1.3 million tonnes of food loss and waste globally with an exceptionally high percentage occurring in fruits and vegetables (44%) take place. Food losses commonly occur post-harvest, during transit and before reaching the consumer, while food waste occurs at the end - consumer post-retail (FAO, 2011). Food losses are more prominent in developed countries after the farm gate, whereas in less developed countries they occur predominantly before the farm gate (Hodges, 2011). One of the most important factors behind increasing food inflation in India is product waste because of inefficient post-

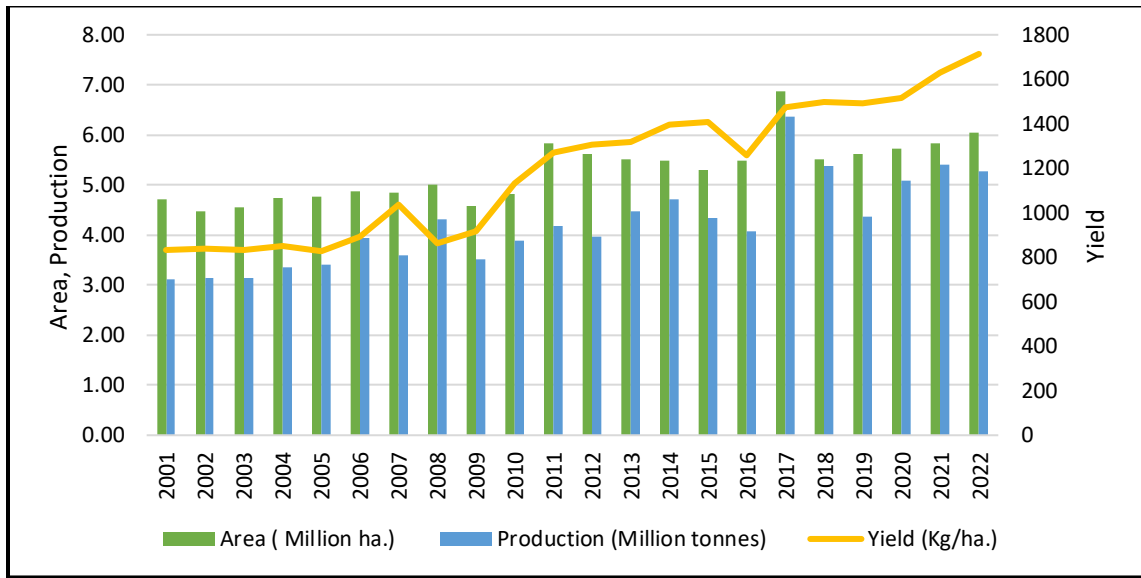
harvest practices and wastages at different value chain levels (Yigezu et al., 2021). Recent studies estimated that overall post-harvest losses for pigeon pea are about 5-7 percent of all-India production (Nanda et al., 2012; Jha et.al., 2015; NABCONS, 2022). Reduction in losses will enhance food availability and decrease food price volatility, which will benefit farmers and consumers (Mukherjee et al., 2022). However, most studies of post-harvest losses focused on losses incurred either at farm operations and storage at marketing channels or up to the marketing stage overlooking losses incurred in the entire value chain of the pulses covering marketing, processing and transportation operations during marketing to the end users. The present study comprehensively has investigated the losses incurred throughout the pigeon pea value chain.

The study is significant for various value chain actors - farmers, consumers, traders, processor, importer, exporters, retailers, researchers and policy makers. While it would be significant to farmers in better planning of their production, marketing and storage, the consumers would benefit from an efficient market. The knowledge and insight gained from the study could prove to be useful to tackle the issue of price volatility in the long run and would help policy-makers to frame evidence-based policies regarding price stabilization, sustainability of production and trade in the future.

1.1 Global Scenario

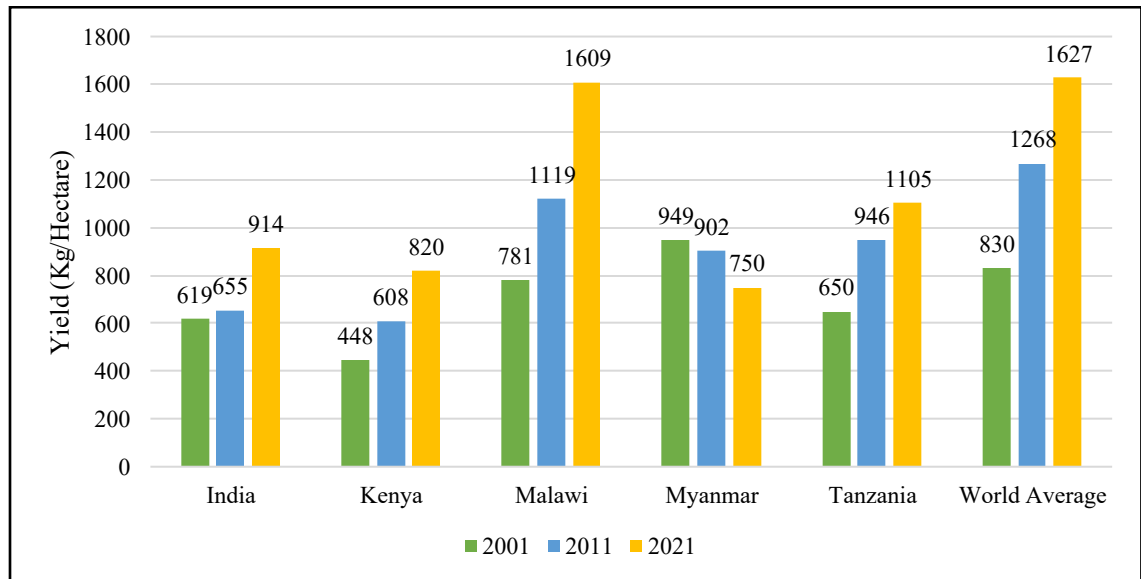
The world area, production and yield of pigeon pea have increased significantly with year-on-year fluctuations. The global area, production and yield have revealed mixed trend over the time (Figure 1.1). Globally the area under pigeon pea has grown from 4.71 million tonnes in 2001 to 6.0 million tonnes in 2022, with a compound annual growth rate (CAGR) at 1.1 percent. The production of pigeon pea has increased from 3.1 million tonnes in 2001 to 5.3 million tonnes in 2022 in the world with CAGR by 2.4 percent. The yield of pigeon pea also shows an increasing trend from 831 kilograms per hectare in 2001 to 1714 kilograms per hectare in 2022.

Figure 1. 1: Global area, production and yield of pigeon pea (2001 to 2022)



Source: FAOSTAT, 2022.

Figure 1. 2: Productivity of pigeon pea in major producing countries



Source: FAOSTAT, 2022

Figure 1.2 shows that the major pigeon pea producing countries have experienced growth in yield except Myanmar from 2001 to 2021. However, India had the lowest yield (914 Kg/ha.) vis-à-vis Malawi and Tanzania in 2021. However, these countries have increased the yield of pigeon pea significantly from 2001 to 2020. However, pigeon pea yield has

decreased from 949 in 2001 to 750 Kg/hectare in 2021 in Myanmar. Overall, the global average yield of pigeon pea has shown an increasing trend due to the growth in yield of major producing countries.

Table 1. 1: Major global pigeon pea producing countries (2020)

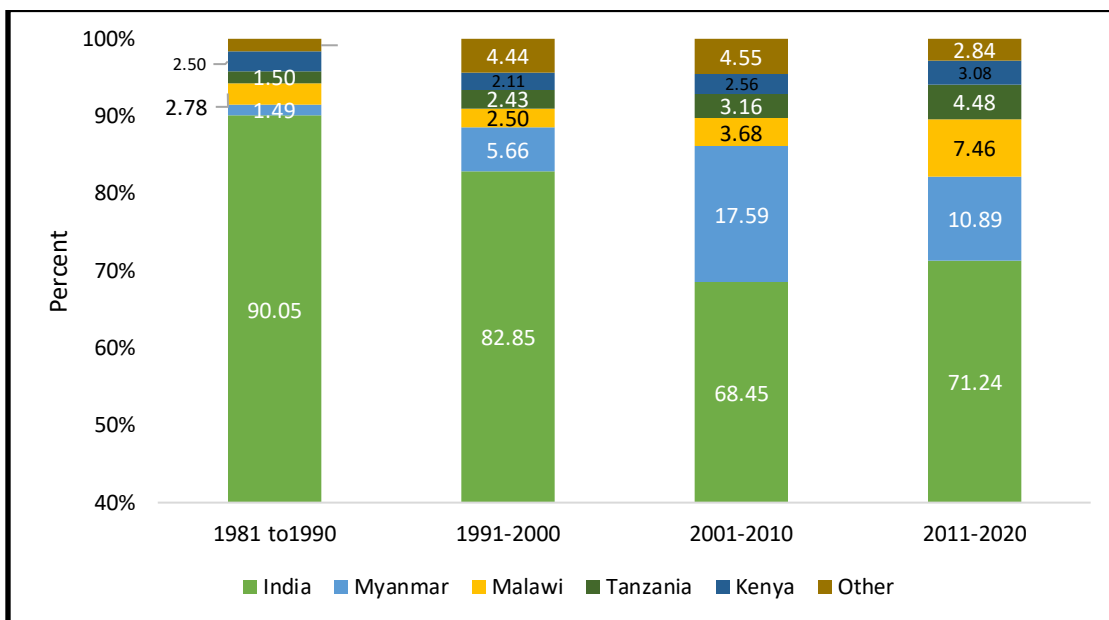
Sr. No.	Countries	Production (million tonnes)	% share in total production
1	India	3.89	77.63
2	Malawi	0.42	8.46
3	Myanmar	0.34	6.77
4	Tanzania	0.14	2.72
5	Kenya	0.12	2.47
6	Dominican Republic	0.02	0.48
7	Haiti	0.02	0.44
8	Uganda	0.02	0.36
9	Nepal	0.02	0.34
10	Congo	0.01	0.13
11	Other countries	0.01	0.20
Total		5.01	100.00

Source: FAOSTAT, 2022.

Country-wise percentage share in global production of pigeon pea has been shown in Table 1.1. India's share in global production was 77.63 percent, with 3.89 million tonnes in 2020, followed by Malawi (8.46%), Myanmar (6.77%), Tanzania (2.72%) and Kenya (2.47%), together accounted more than 98 percent of the total global production.

Figure 1.3 shows the share of major pigeon pea producing countries in global production during the last four decades. India, Myanmar, Malawi and Kenya are the major producers of pigeon pea in the world. India's share in production has decreased from 90.05 percent in 1981-1990 to 71.24 percent in 2011-2020. However, Myanmar shows significant growth in production and its share in production increased from 1.49 to 10.89 percent, Malawi from 2.78 to 7.46 percent and Tanzania from 1.50 to 4.48 percent during 1981-1990 to 2011-2020.

Figure 1. 3: Country-wise share in global pigeon pea production (%)



Source: FAOSTAT, 2022.

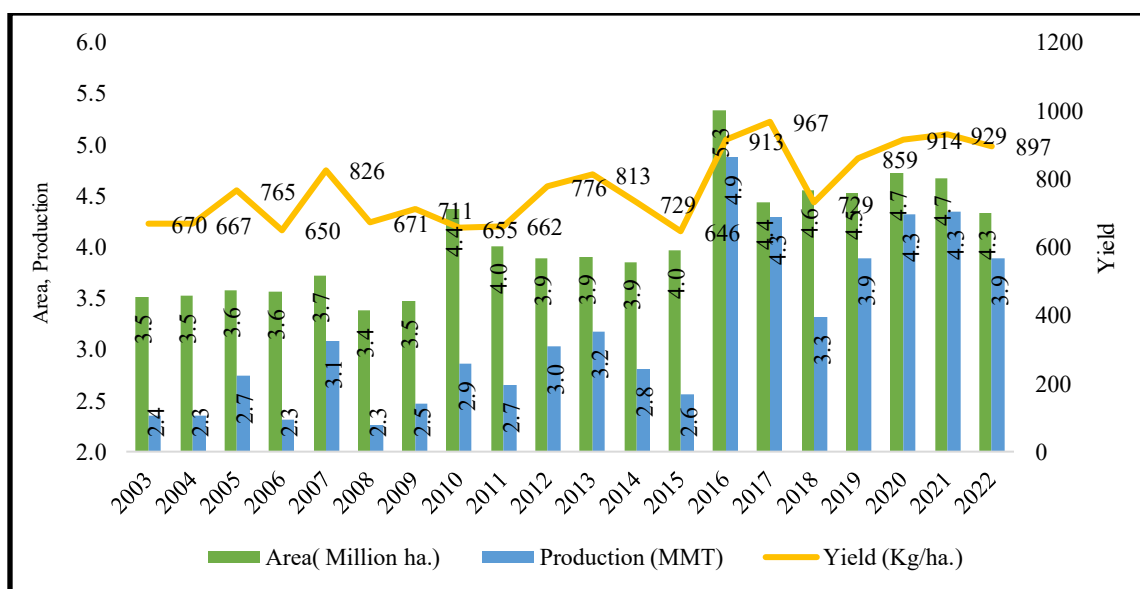
1.2 Indian Scenario

Pulses play a vital role in India's agricultural sector and they are an integral part of the Indian diet, contributing significantly to food and nutritional security, and economic well-being of the small and marginal farmers (Government of India/GoI, 2024c). India is the largest producer, consumer and importer of pulses in the world (FAOSTAT, 2022, GoI, 2023). Its production of pulses increased from 22.01 million tonnes in 2001-02 to 31.03 million tonnes in 2021-22 (GoI, 2023). However, its per capita intake and availability have declined over the years (NITI Aayog, 2015). Among the pulses, pigeon pea is one of the important legume crops cultivated in India, and it is significant in terms of being the most important source of protein (22%) (GoI, 2021a; Sah et al., 2022). Globally, it is cultivated on 6.03 million hectares, producing 5.32 million tonnes with a yield of 833 kg/hectare in 2022 (FAOSTAT, 2022). India accounted for 79.2 percent of the total global production in 2022 (FAOSTAT, 2022).

India is the major pigeon pea producing country in the world. The area and production of pigeon pea have increased during 2003 to 2022. The information on area, production and yield of pigeon pea in India is presented in Figure 1.4. The average area under pigeon pea

was 4.1 million hectare and it has grown from 3.5 million hectare in 2003 to 4.3 million hectare in 2022 with a year-to-year variation. It has increased 6.9 percent annually. Similarly, the average production of pigeon pea was 3.2 million tonnes and it increased from 2.4 million tonnes in 2003 to 3.9 million tonnes in 2022, with a CAGR 1.1 percent. The production of pigeon pea in the domestic market showed a mixed trend during the last decade. The production of pigeon pea shows yearly fluctuations which might be because of variations in area and yield. In the case of yield of pigeon pea yearly cyclical variations were observed. It has increased from 667 kg/hectare in 2003 to 897 kg/ha in 2022. The average yield of pigeon pea was 777.8 kg/hectare at all-India level. In area, production and yield of pigeon pea, higher coefficient of variation (CV) was observed in production (25%), followed by yield (14%) and area (12.9%).

Figure 1. 4: Trend in area, production and yield of pigeon pea



Source: Government of India, (2023).

Table 1. 2: State-wise area, production and yield of pigeon pea

Sr. No	State	2001-02					2011-12					2021-22				
		Area	% to total	Production	% to total	Yield	Area	% to total	Production	% to total	Yield	Area	% to total	Production	% to total	Yield
1	Maharashtra	1.0	30.7	0.8	34.2	756	1.23	30.67	0.87	32.83	707	1.34	26.44	1.37	31.49	1023
2	Karnataka	0.5	14.5	0.1	6.5	306	0.53	13.22	0.33	12.45	623	1.72	34.05	1.14	26.39	666
3	Uttar Pradesh	0.4	11.8	0.5	20.2	1157	0.77	19.2	0.35	13.21	455	0.29	5.74	0.35	8	1196
4	Madhya Pradesh	0.3	9.2	0.3	11.1	821	0.32	7.98	0.33	12.45	1031	0.37	7.33	0.35	7.99	936
5	Gujarat	0.3	10	0.2	8.3	563	0.24	5.99	0.26	9.81	1083	0.25	4.97	0.29	6.71	1160
6	Jharkhand	0.0	0.5	0	0.7	914	0.11	2.74	0.1	3.77	909	0.25	5.02	0.29	6.6	1129
7	Telangana	-	-	-	-	-	-	-	-	-	-	0.31	6.22	0.24	5.49	758
8	Odisha	0.1	3.8	0.1	3.6	646	0.14	3.49	0.12	4.53	857	0.13	2.5	0.13	3.01	1036
9	Others	0.6	19.5	0.3	15.4	742	0.67	16.71	0.29	10.94	854	0.39	7.72	0.19	4.33	482
10	Total (All-India)	3.0	100.0	2.0	100.0	679.0	4.0	100.0	2.7	100.0	656.0	5.1	100.0	4.3	100.0	859.0

Note: Area (million hectare), Production (million tonnes), Yield (kg/ha.).

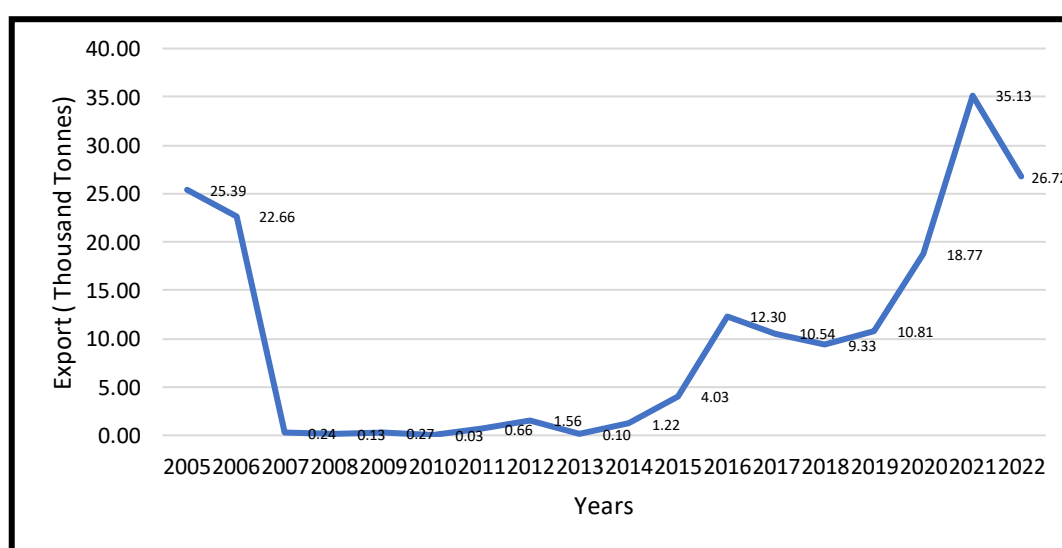
Source: Government of India, (2023).

Table 1.2 shows that Maharashtra accounted 31.49 percent share in production during 2021-22, followed by Karnataka (26.39%), Uttar Pradesh (8 %), Madya Pradesh (8 %), Gujarat (6.71%), Jharkhand (6.6%), Telangana (5.49 %) and Odisha (3.01%). These states together contributed more than 95 percent in the production of pigeon pea. However, Maharashtra, Uttar Pradesh, Madhya Pradesh and Gujarat have experienced a decrease in the share in production because of a decrease in area under pigeon pea. On the other hand, Karnataka has a higher percentage share in production because of an increase in the area under pigeon pea. States such as Maharashtra, Uttar Pradesh, Madhya Pradesh and Gujarat have experienced declining percent shares. The highest yield of pigeon pea was in Uttar Pradesh.

1.3 Export -Import

Exports of pigeon pea show a mixed trend from 2005 to 2022 (Figure 1.6). They declined from 2007 to 2014 and later showed an increasing trend till 2021. However, the quantity of exports was very low as compared with imports. The average annual export of pigeon pea was 9.99 thousand tonnes, demonstrating a CAGR 0.3 percent. In 2021-22, India exported pigeon pea to the United Arab Emirates (60% of the total exports), followed by the United State of America (13%), Nepal (9%), Canada (6%) and Malaysia (2%) (GoI 2023). These five countries accounted for 90 percent in the total exports of pigeon pea from India. The annual export-import of pigeon pea are shown in Figure 1.5.

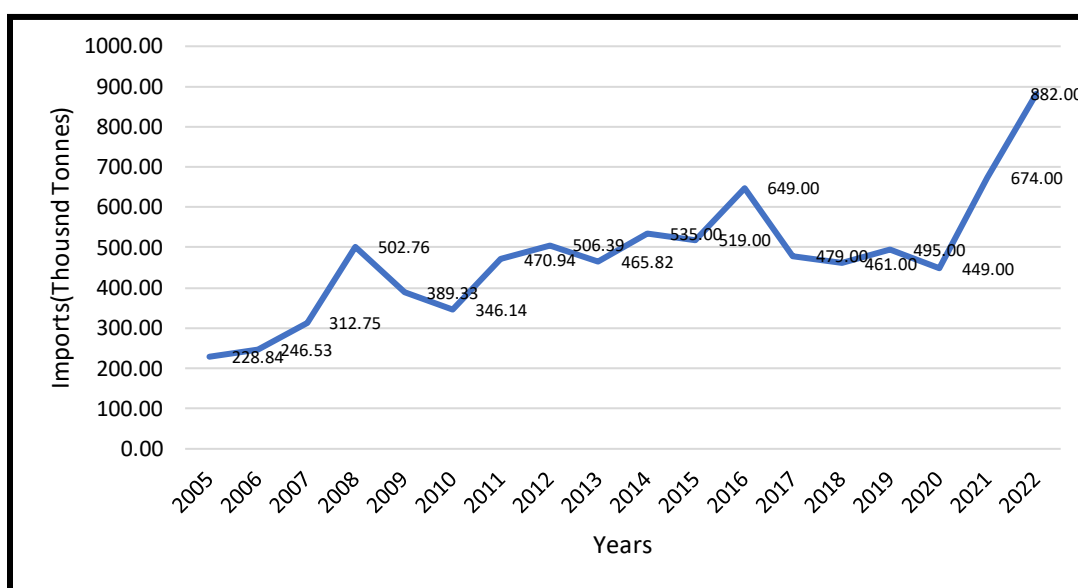
Figure 1. 5: India’s exports of pigeon pea (2005 to 2022)



Source: Government of India, (2024d).

Similarly, India's imports of pigeon pea show an increasing trend from 2005 to 2022 (Figure 1.7). The major sources of import during 2021-22 were Mozambique (38%), Myanmar (24%), Tanzania (23%), Malawi (7%) and Sudan (6%) (GoI, 2023). The average annual imports of pigeon pea are 478 thousand tonnes, with a CAGR of 7.8 percent. Annual imports of pigeon pea are shown in Figure 1.6.

Figure 1. 6: India's Imports of Pigeon pea (2005 to 2022)

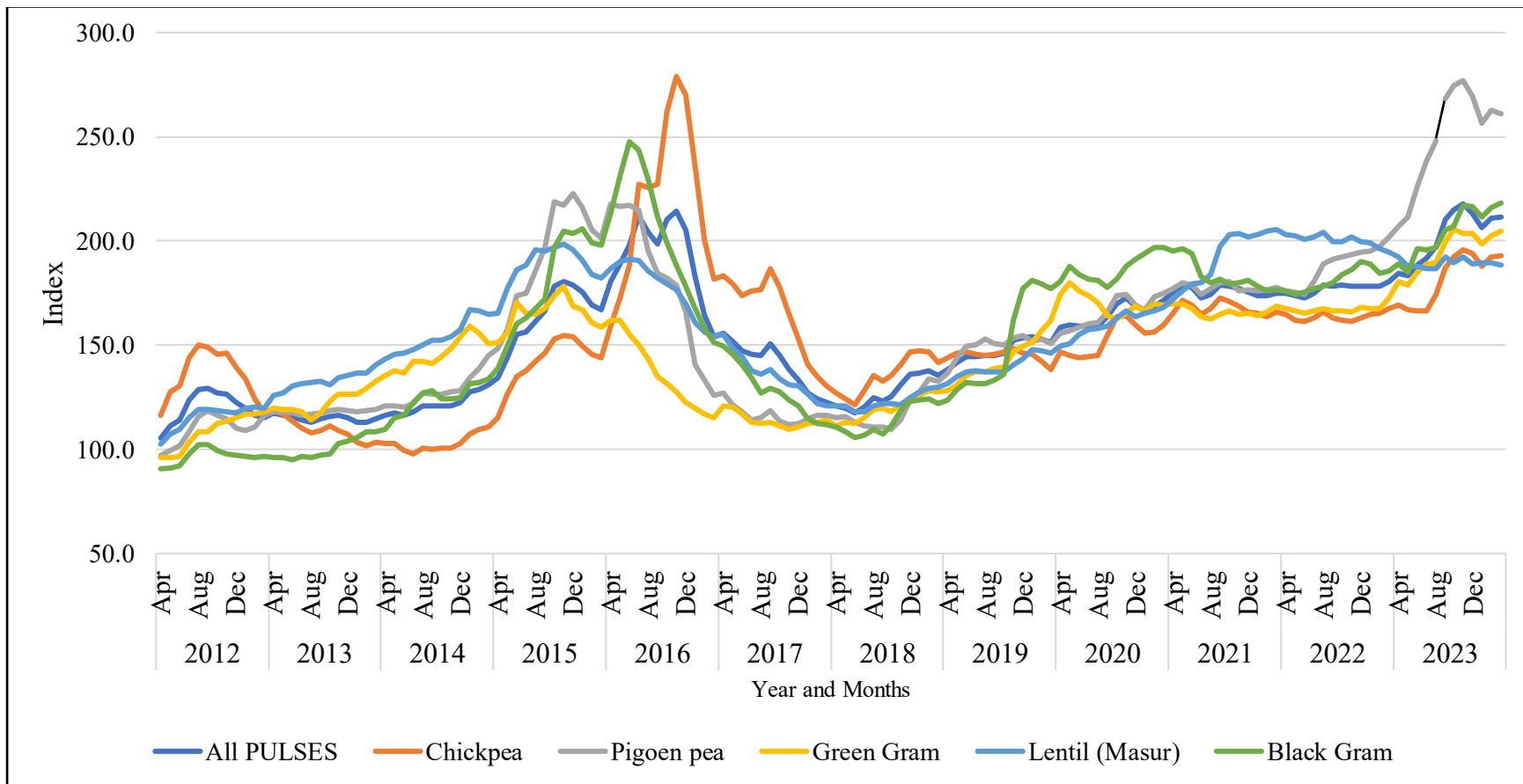


Source: Government of India, (2024d).

1.4 Wholesale Price Index of Pulses

The Office of the Economic Adviser, Government of India, published the wholesale prices index (WPI) of the agricultural commodities for every month. It is one of the important indicators of food inflation which represents the average movement of prices of agricultural commodities. Monthly WPI of pulses from April 2012 to March 2023 are shown in Figure 1.7.

Figure 1. 7: Monthly wholesale price index of pulses (2012 to 2023)



Source: Government of India, website of Office of the Economic Adviser, (2024b).

The WPI of major pulses shows fluctuations on a month-to-month basis and increasing trend after April 2018 (Figure 1.7). The coefficient variation (CV) in WPI of pigeon pea (27.4 %) was higher as compared with other pulses (Table 1.4), indicating higher volatility, followed by black gram (26.6%), chickpea (22.0%%), lentil (18.6%), green gram (18.5%) and all pulses (19.5%). Chickpea shows a moderate variability. The prices of green gram and lentil show less variability as compared with other pulses.

Table 1. 3: Coefficient of Variation in WPI of pulses

Sr. No	Variables	All pulses	Chickpea	Pigeon pea	Green gram	Lentil	Black gram
1	Mean	154.1	151.7	158.1	146.1	159.0	154.3
2	SD	30.01	33.34	43.25	27.05	29.61	41.05
3	CV	19.5%	22.0%	27.4%	18.5%	18.6%	26.6%

Source: Office the Economic Adviser, Government of India, (2024b).

1.2 Major Policy Interventions

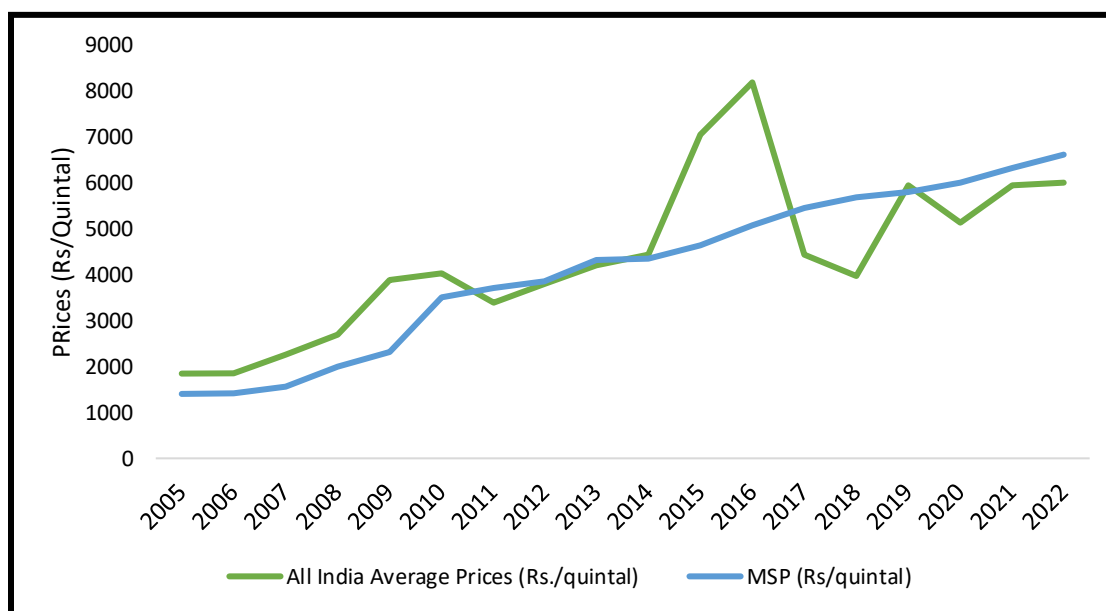
The Government of India has accorded a priority to pulses policies and programmes given their nutritional importance, benefits to soil health and farming sustainability for a long time (Roy et al., 2022). Policies and programmes have evolved over a long period beginning with the Pulses Development Scheme (1969–1974), National Pulses Development Project (1985–1989), Special Food Grain Production Programme (1988–1989), Integrated Scheme of Oilseeds, Pulses, Oil Palm and Maize, National Food Security Mission and price stabilization fund (GoI, 2015; Monga et al., 2022). The Government has been pursuing a multi-pronged policy strategy to deal with suboptimal production and availability of pulses including pigeon pea. These are: national food security mission, MSP, price stabilization fund and buffer stocks and import –export policy initiatives.

The National Food Security Mission (NFSM) was announced in 2007 to enhance the production of pulses including pigeon pea by adopting improved technologies (GoI, 2010). Both area and production of pigeon pea recorded positive growth in the aftermath of launching the mission (Naik et al., 2019). The production of pulses increased by 19.95 percent during 2006-07 to 2014-15, mainly on account of increased productivity by 17.38 percent (Manjunatha, and Kumar, 2018). Some recent studies found that technological

interventions under NFSM contributed to the growth in total factor productivity and overall production of pigeon pea in India (Monga et al., 2022).

Minimum support prices (MSP) is one of the key initiatives undertaken by the government to minimize price volatility and stabilize the prices of pulses in the interest of farmers and consumers. MSP is a policy instrument used by the central and state governments in India to ensure that farmers get fair and remunerative prices for their produce (Mundhe, 2017). As a part of this mandate, the central government decides every year statutory prices of 22 crops and makes it binding on procurement agencies to buy them at fixed prices (GoI, 2021c). Figure 1.8 shows that all-India actual annual average prices and MSP for pigeon pea increased significantly over the years. While market prices displayed with wide fluctuations, the market prices for pigeon pea ruled below MSP in 2011, 2012 and after 2017. However, market prices show an increasing trend during this period. The CAGR in MSP was found to be growing at 9 percent per annum which stood higher than the market price (6.8%).

Figure 1. 8: Minimum support prices and market prices of pigeon pea



Source: MSP: Government of India (2023), Prices- DMI, AGRMARKNET Portal, GoI, 2024.

Apart from this, the Indian government launched the price stabilization fund (PSF) scheme in March 2015 to control the price volatility in agricultural commodities in India (GoI,

2015). A total budget of Rs. 37,489.15 crore was allotted to PSF corpus from 2014-15 to 2024-25 (GoI, 2024). This fund has been used to create buffer stocks and procurement of agriculture commodities to make them available to consumers at affordable prices.

The policy initiative that the Indian government is actively pursuing to improve domestic availability of pulses and thereby stabilize prices is import –export policy. India signed a MoU with Mozambique on co-operation in the production and marketing of pigeon pea for a period of five years (2016-17 to 2020-21) to curb domestic price fluctuations and address availability concerns and enhance production in Mozambique. The quantitative restrictions on import were imposed for safeguarding the farmers’ interest due to bumper production of pulses in 2017-18 and 2018-19. The import policy stance on tur, moong and urad changed from ‘Free to Restricted’ (GoI, 2019).

Beside these initiatives, especially state governments, tried Price Deficit Scheme to control price volatility in pulses (GOI, 2024). Recently, the government has integrated PSS and PSF into Pradhan Mantri Annadata Aay Sanrakshhan Abhiyan (PM-AASHA) with the aim of providing remunerative prices to farmers and to attend to the farmers and consumers more efficiently (GOI, 2024e).

1.3 Statement of the Problem

The problem addressed by this study is the factors affecting volatility of pigeon pea prices in India. Agricultural commodity prices have become more volatile in the recent past (Tomek and Kaiser, 2014; Bisht and Kumar, 2019; Kulkarni, 2019). This study seeks to analysis the factors affecting volatility of pigeon pea prices in India. As a result, the stakeholders in the value chain have to deal with extreme variations in prices. The volatility in the prices may have significant implications for resource allocation as well as consumer and producer welfare (Huchet-Bourdon, 2011). It may have a negative consequence at sector level on growth and nutritional requirements of poor people as pigeon pea contributes significantly to food and nutritional security, enhancing soil health and economic well-being of the small and marginal farmers (GoI, 2024c). Price variation in agricultural commodities has adverse implications for the area, production, and yield of pigeon pea (Blay et al., 2015). However, effective market integration would reduce price

differentials across the country. Regional demand inconsistency and better market integration are crucial for farmers to get remunerative prices (GoI, 2017).

The current literature on the topic does not adequately address the issues of the factors affecting volatility of pigeon pea prices. It is thus important to understand factors contributing to price volatility, market integration, value chain and post-harvest losses incurred in the value chain of pigeon pea to help policy makers to formulate appropriate policies and to help value chain actors to better navigate these phenomena. Some studies have investigated the impact of reduction in post-harvest losses and corresponding decrease in food price volatility benefitting both farmers and consumers (Mukherjee et al., 2022).

1. 4 Objectives of the Study

The present study aims to investigate the price behavior and value chain analysis of pigeon pea in India. The key objectives of the study are as follows.

1. To identify the factors influencing the prices of pigeon pea.
2. To study the market integration of pigeon pea.
3. To study the value chain of pigeon pea.
4. To study the losses incurred in the value chain of pigeon pea.

The analysis of the factors influencing prices, market integration, value chain and post-harvest losses of pigeon pea is conducted by drawing both primary and secondary data. For empirical analysis of factors determining the prices, the requisite data was extracted from the annual reports of *Agricultural Statistics at Glance*, Ministry of Agriculture and Farmers' Welfare, GoI, of various years from 2005 to 2022; the annual wholesale prices of pigeon pea and green gram in the Latur market of Maharashtra from online portal AGMARKNET; the Directorate of Marketing and Inspections (DMI), Government of India (GoI). To investigate stakeholders' perceptions about factors influencing the prices of pigeon pea, the primary data was collected during the field survey. The spatial market integration was tested using monthly price data for the period 2003 to 2022 from nine APMC markets spread across Maharashtra, Karnataka and Madhya Pradesh. The Johansen Cointegration, VECM and Granger causality tests were employed to assess price linkages (see chapters 2 and 3 for detail discussion on regression analysis and econometric models). The primary data for analyzing pigeon pea's cost of production, marketing, harvesting

practices, knowledge about factors influencing prices, price received and post-harvest losses was gathered by conducting field survey with 560 sampled farmers and 149 other stakeholders from Maharashtra by using the multi-stage sampling method (see chapters 4 and 5 for discussion on sampling). The field survey was conducted during October 2021-March 2022 to identify marketing channels, price spread and farmers' share in consumer prices by undertaking mapping of pigeon pea value chain. The post-harvest losses at different stages of the value chain of pigeon pea were estimated using primary data.

1.5 Rationale of the Study

The present study focuses on the price behavior and value chain analysis of pigeon pea. Few studies address the issues related to price behaviour and value chain of pigeon pea. The present study quantifies the supply and demand side factors that influence pigeon pea prices, marketing channels, post-harvest losses and value chain. The study provides valuable insights to policy makers for framing suitable long-term measures to reduce the volatility. Its empirical results help mitigate price volatility and ensure the sustainability of production of pigeon pea through adoption of policies that promote domestic production and reduce post-harvest losses.

1.6 Structure of the Thesis

The present study is divided into six chapters. The first chapter provides the background of the study, global, national and regional overview of pigeon pea objectives of the study, statement of the problem, brief review of literature and research methodology. The second chapter deals with examination of the factors influencing the prices of pigeon pea, the importance of pigeon pea in the Indian agricultural sector, review of literature related to factors influencing agricultural commodity prices, data and methodology, results and discussion of the study and finally conclusion and policy implications. The third chapter focuses on the market integration and price transmission across spatially distributed markets. The chapter provides the importance of the study of market integration, literature review and methodology used to study market integration. The results and discussion of the conclusions and policy implications are explained too. The fourth chapter deals with complete mapping of the value chain of pigeon pea in Maharashtra. The value chain analysis (VCA) includes the price spread across the value chain of pigeon pea and activities

carried out at each stage, marketing channels and farmers' share in consumer rupee. It explains the importance of VCA, review of literature, methodology, including studied area, sample covered, analytical techniques, results and discussion. The fifth chapter provides the findings of the post-harvest losses incurred in the pigeon pea value chain based on field survey. This chapter includes post-harvest losses estimated at farm level operations, marketing and processing stages with respect to farmers and other actors involved in the value chain of pigeon pea perspectives using primary data collected through semi-structured questionnaires. The final chapter presents conclusions and recommendations.

CHAPTER 2: FACTORS INFLUENCING THE PRICES OF PIGEON PEA

2.1 Introduction

Pigeon pea (*Cajanus Cajan*) is the second largest pulse produced in India after Chickpea (Sarkar et al., 2018). It is the major source of protein and plays an important role in the country's nutritional security (GoI, 2002, Sah, et al., 2022). Globally, pigeon pea is cultivated on 6.03 million hectares, producing 5.32 million tonnes and yield of 833 kg/ha. in 2022 (FAOSTAT, 2022). India ranked first in production (77.61 % share in total global production), consumption, and importer (92.25 %) of pigeon pea in the world in 2022 (FAOSTAT, 2022). However, India's share in global production of Pigeon pea has decreased from 90.04 percent in 1961 to 71.24 percent in 2022, and the share of Malawi (3.40 to 7.46%), Myanmar (1.3 to 10.89), Tanzania (0.63 to 4.28%) has increased in the same period. (FAOSTAT, 2022).

The United Nations General Assembly declared 2016 as the 'International Year of Pulses' (Shatasia et al, 2017; FAO, 2016) to increase public awareness of the nutritional benefits of pulses. In India, the area under pulses and production has significantly increased (GoI, 2018, GoI, 2024c). The area under major pulses has increased by 5.36 percent (24.91 To 31.03 million ha.), and production increased by 19.71 percent (from 23.13 to 27.69 million tonnes) during 2016-17 to 2021-22 (GoI, 2023). Despite this, India imports pulses equivalent to one-fifth of domestic demand. However, India's per capita intake and availability have declined over the years (NITI Aayog, 2016). At the same time the prices of pulses have been volatile. In India, per capita pulses and their product consumption have increased from 7.92 to 9.53 kg per annum in rural areas and 9.60 to 10.96 kg per annum in urban areas from 2009-10 to 2011-12 (GoI, 2023).

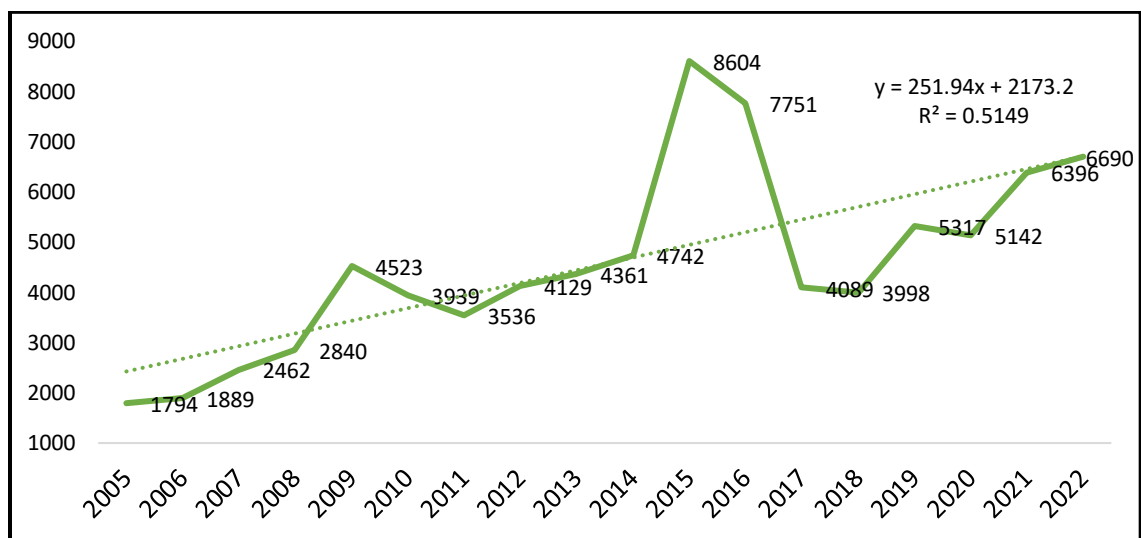
In recent decades, the volatility in agricultural commodity prices has increased over the past decade (FAO *et al*, 2011). The volatility is higher in monthly prices than annual price change, and most agricultural commodities experienced in international markets in the 1970s and in recent years (2006-09) and in the case of India, it is observed in the 1990s (Huchet- Bourdon, 2011; Sekhar, 2003). The high prices and volatility in food prices have

adversely affected the stakeholders involved in the value chain of commodities as well as the food security of the nation (Jayasuriya et al., 2012, Sekhar, 2003). The wholesale price Index (WPI) indicates the movement of commodity prices and is used to measure the inflation in the economy (GoI, 2024).

2.1.1 Trends in Annual Wholesale Prices of Pigeon pea

The graphical presentation of annual average wholesale prices of pigeon pea in the Latur market is presented in Figure 2.1.

Figure 2. 1: Trends in Annual Wholesale Prices of Pigeon Pea (Rs. /quintal)



Source: Government of India, Office of Economic Adviser, (2024)

Figure 2.1 depicts the annual prices of pigeon pea show an increasing trend during the study period with year-on-year fluctuations. The price reached Rs.4523 per quintal in 2009 and declined to Rs.3536/quintal in 2011; it started increasing and peaked at Rs.8604 in 2015 due to production shocks due to drought in major producing states. Further, it declined, reaching Rs. 4089 per quintal in 2017 due to an increase in production, and thereafter it shows a continuous increasing trend, and the price reached Rs 6690 per quintal in 2022. The trend explains 51 percent variation in the prices of pigeon pea.

The compound annual growth rate in prices of pigeon pea is 7.1 percent. The price trend shows the effect of increased demand and a rise in inflation of agricultural commodities. During the study period, the Wholesale Prices Index (WPI) for agricultural commodities rose at a compound annual growth rate of 5.6 percent. Thus, the increase in demand can

influence the price of pigeon pea. As per the population census 2011, in India, 68.9 percent of the rural population still depends on farming, and agricultural commodity prices play a significant role in determining farm income (NSSO, 2021, GoI, 2023). The volatile prices complicate decision-making for farmers and other food chain agents (FAO *et al.*, 2011).

According to the Food and Agriculture Organization (FAO, 2011) "Volatility refers to variations in Agricultural Prices over time". Price volatility affects the income of farmers and other value chain stakeholders, and this may lead to risk and uncertainty at the farmer as well as consumer ends and overall market stability (FAO, 2011, Gu, *et al.*, 2022). Due to significant price fluctuations, the producers cannot change their production decisions in the short run (FAO *et al.*, 2011; Nigatu *et al.*, 2020). Therefore, understanding the factors influencing the prices of pigeon pea is crucial for all stakeholders in its value chain. The study's empirical results will help in quantifying the influence of independent factors in price variation of pigeon pea. Therefore, the objective of the study is to examine the factors influencing the prices of pigeon pea and quantify the influence of each factor on price.

This chapter is divided into five sections: an introduction highlighting the importance of Pigeon pea in the Indian agriculture sector presented in section I and a review of literature presented in section II; The Data and Methodology, including independent and dependent variables used and analytical techniques used for the study are presented in section III; The results and discussion of the study are presented in section IV, and finally conclusion and policy implications are presented in the section V.

2.2 Literature Review

The prices of agricultural commodities are primarily determined by the interaction between the supply of and the demand for commodities (Borychowski and Czyżewski, 2015; Schnepf, 2006). The factors affecting agricultural commodities prices include endogenous and exogenous factors (Deaton and Laroque, 1990; Tadesse *et al.*, 2014). The Cobweb Model (Ezekiel, 1938) explains that price variations are the results of endogenous factors such as Naïve expectations of the market participation, and the storage model explains the exogenous factors such as rational expectations of market participants about future prices

and shocks in the quantity of supply will be transmitted into price movement (Deaton and Laroque, 1990;). However, the storage model is best for storable commodities whose production is unpredictable and non-perishable crops (Stigler, 2011).

Further, several studies explained variation in agricultural commodity prices using time series properties such as trend, seasonality, cycles, and random fluctuations (Schnepf, 2006; Rahman, 2012). A negative relationship is observed in arrivals and prices, and also seasonality observed in market arrivals and prices of pigeon pea (Chaudhari and Pawar, 2010; Patil and Burkee, 2014). The cyclical behaviour of agricultural commodities prices varies from crop to crop (Rahman, 2012). The several studies focus on examining the factors contributing to price volatility in agricultural commodities, which emphasize identifying the supply and demand-side factors, macroeconomic factors, non-farm commodity prices such as oil prices, demand for biofuel (FAO, *et al.*, 2011; European Commission, 2015; Gilbert and Morgan 2010; Schnepf 2006; Ingram, 2014; Ai *et al.*, 2006; Patil and Burkee, 2014; Ai-Hua, 2012; Tothova, 2011; Baffes and Haniotis, 2016, Nigatu *et al.*, 2020; Tadesse *et al.*, 2014).

The biological nature and inelastic demand for agricultural commodities cause price instability (Schnepf, 2006). Market supply and demand are important factors that affect the prices of agricultural commodities (Imai *et al.*, 2011). However, the supply may affect due to production shocks, because of inconsistency in the area under crop, yield variability, weather, cost of production, input prices, speculation, marketing cost, lack of risk management tools, small-scale farming, arrivals in markets, low level of stocks, trade policies, climate change, stock holding, supply elasticities (FAO *et al.*, 2011; Borychowski and Czyżewski, 2015; Gilbert and Morgan, 2010; Imai *et al.*, 2011; Schnepf, 2006; Ingram, 2014; Ai *et al.*; 2006; Choudhari and Pawar, 2014; Patil and Burkee, 2014; Ai-hua, 2012; Tothova, 2011; Baffes and Haniotis, 2016; Nigatu *et al.*; 2020, Cuaresma, *et al.*; 2021; Tadesse *et al.*; 2014, Reddy, 2015). Therefore, an increase or decrease in the supply of agricultural produce is one of the important factors that lead to the variation in prices. On the other hand, the prices of agricultural commodities are affected by several demand-side factors such as consumption habits, increasing population, per capita income, change in

prices of substitute goods, change in tastes, household size, strong demand for protein (Schnepf, 2006; FAO et al., 2011; Joshi and Rao (2017); Borychowski and Czyżewski, 2015, Lokuge and Edirisinghe (2015); Gilbert and Morgan, 2010; Hermawan et al., 2017).

Recent studies focus on identifying the influence of macroeconomic factors such as Gross Domestic Product (GDP), Interest rate, Inflation rate, exchange rate, cost of capital, global warming, Biofuel demand, Sensex, Oil Prices, Forex, Investment in future markets on agricultural commodity prices (Baffes, and Haniotis, 2016; Gilbert and Morgan, 2010; Keatinge, 2015; Huchet-Bourdon, 2011; Nigatu *et al.*, 2020; Varma, 2019; Borychowski and Czyżewski, 2015; Byrne *et al.*, 2011; Bodhawala *et al.*, 2020; Frankel and Rose, 2010; Hermawan *et al.*, 2017).

Agricultural commodity prices have recently been much more volatile than most non-farm goods and services (Tomek and Kaiser, 2014). Besides the supply and demand and macroeconomic factors, several studies in the last decade focus on examining the relationships between farm and non-farm commodity prices (Koirala et al., 2015; Huchet-Bourdon, 2011; Keatinge, 2015; Nigatu et al., 2020). Non-farm commodity refers to commodities not of an agricultural nature, such as industrials and manufactured products (WTO, 2024). However, the change in the fundamental factors of the agricultural market has contributed to upward or downward pressure on price and rising volatility, but they do not give the whole picture; however, the factors outside of agriculture, including the increasing co-movement with energy markets and across commodity markets also strongly influence the price volatility (European Commission, 2015, Koirala *et al.*, 2015; Miljkovic and Vatsa 2023). Factors such as crude oil prices, Input prices, and fertilizers prices are drivers of the change in prices of agricultural commodities (Huchet-Bourdon, 2011; Keatinge, 2015; Koirala *et al.*, 2015). Other factors, such as trading agricultural commodities in future markets, are causing agricultural commodity price variations (Nigatu *et al.*, 2020). The study by Nath and Lingareddy (2008) found that the spot prices of pulses have increased significantly during the futures trading period, and the prices show a moderate trend during the post-trading period in India. Some studies found that agricultural policies regarding production, trade, prices, and inappropriate economic

policies are also influencing the prices of agricultural commodities (Nigatu *et al.*, 2020; Borychowski and Czyżewski, 2015; Varma, 2019; Byrne *et al.*; 2011). Further, several studies focus on factors influencing the supply, demand, and consumption of pulses in India, with the help of price and non-price factors influence on it (Abraham and Pingali, 2021; Varma, 2019; Bhatnagar *et al.*,2016; Savadatti, 2018; John, 2021; Lokuge and Edirisinghe, 2015). However, factors influencing the prices of pulses have been given inadequate attention. Some of the studies are focused on factors influencing prices, both the demand and supply side, but these studies are focused on cereals and oilseed crops (Keatinge, 2015; Ogbonna, 2020). The study by Reddy (2015), found that the production, trend, import quantity, production, and seasonality affect the wholesale prices of pulses in India. FAO *et al.*, (2011), report highlighted the necessity of quantifying each factor's influence on price volatility, because supply and demand-side constraints influence agricultural commodity prices, but the fundamental factors do not fully explain price volatility. Therefore, the present study focuses on identifying the factors influencing pigeon pea prices using the econometric model and the perceptions of value chain stakeholders about factors influencing the prices. This study focuses on supply and demand-side factors along with other factors such as substitute commodity prices.

2.3 Data and Methodology

The present study used mixed methodology, both qualitative and quantitative data was used. The multivariate regression model was used to identify and quantify the influence of independent factors on price variation. The qualitative data on perceptions of value chain stakeholders about factors influencing the prices were collected through questionnaire and checklists during the field survey. The required secondary data was obtained from various sources and used for the empirical analysis. The factors influencing prices were determined using annual data from 2005 to 2022. The marketing year of pigeon pea (January to December) was considered for all the data sets. Eighteen years data was used in the regression model. The wholesale prices of pigeon pea in the Latur market of Maharashtra were collected from online portal AGMARKNET, by the Directorate of Marketing and Inspections (DMI), Government of India (GoI). Modal prices of pigeon pea have been used in the study. The Latur market is one of the leading markets in India's major pigeon

pea producing district and the Latur district is popular for quality and quantity of pulses especially pigeon pea (Government of Maharashtra (GoM), 2024). The Latur market prices of pigeon pea are correlated with prices in other markets and prices in this market show bidirectional influence on prices of other markets in Maharashtra (Patil et al., 2014). Therefore, the annual average modal prices of pigeon pea prevailing in the Latur market were considered a dependent variable for conducting formal analysis to quantify the factors influencing the prices. The data on Area, Production, Yield, Minimum Support Prices (MSP) were collected from various issues of Agricultural Statistics at a glance published by the MoA&FW, Economics and Statistics Division, GoI (2022). The data on imports and exports of pigeon pea were collected from various annual reports published by the Directorate of Pulses Development, MoA&FW, Department of Agriculture & Farmers Welfare, GoI. Also, the data on procurement quantity was collected from price policy for kharif crops (various reports), published by the Commission for Agricultural Costs and Prices (CACP), MoA&FW, GoI (2021c). The per capita income and exchange rate data is sourced from the Handbook of Statistics on the Indian Economy (2024), Reserve Bank of India (RBI). The data on Wholesale Price Index (WPI) of pigeon pea was collected from the website of the office of the economic adviser, department for promotion of industry and internal trade, GoI. The present study used green gram price as an independent variable in the model to determine the influence on pigeon pea price due to its being used as a substitute for pigeon pea. The prices (Rs/quintal.) of green gram in the Latur market were sourced from the AGMARKNET portal, DMI, MoA&FW, Government of India. The data on international prices of pigeon pea at producer level was collected from online portal by FAO (2024). Apart from this the primary data regarding stakeholders' perceptions about factors influencing the prices of pigeon pea was collected during October 2021 to March 2022, from Farmers (560), Traders/Commission agents, Processors, Wholesalers and Retailers (32 from each category), and importers (5) in the Maharashtra state. The details of the sampling procedure adopted for the field survey are presented in Chapter 4.

2.3.1 Data Analysis:

Descriptive statistics measures such as Mean, Median, Standard Deviation (SD), Coefficient of Variations (CV), Range, etc. were used for analysis in the present study to understand the overall variability in price series. The time series analysis was conducted to

know the trend and seasonality in Pigeon pea prices. The seasonal indices for the price of pigeon pea were calculated using the X-13 ARIMA SEATS method (U.S. Census Bureau, 2017). Subsequently, the multivariate linear regression model was used to identify the factors influencing the prices of pigeon pea and quantify the relationship between dependent and independent variables in the study. The annual average model price (Rs/quintal) of pigeon pea prevailing in the Latur Market, Maharashtra, is a dependent variable. The independent variables considered in the model include area, production, yield, export, import, government procured quantity, per capita income, population, exchange rate, WPI, prices of other pulses, international prices and MSP. With the help of regression analysis, the study estimates the coefficients associated with the various factors. It thus assesses how changes in the independent factors affecting pigeon pea will influence it.

The stepwise backward or forward regression method can follow to add or drop the explanatory variables on the basis of the F test to determine the set of the independent variables in the model (Gujarati et al.,2015). The present study used the stepwise backward regression method to select the best-fit model by removing non-significant explanatory variables one variable at a time till we obtained the best-fit model.

Multivariate Regression Model

Annual price of Pigeon pea (Y) = f (Total availability (X1) + Trend (X2) + Price of Green gram (X3)

Thus, the multiple regression model can be expressed as -

$$\ln Y = a + b \ln X_1 + b_1 \ln X_2 + b_2 \ln X_3 + e$$

All variables are expressed in natural logarithms (ln).

Dependent variable (lnY): The annual price of pigeon pea in the Latur Market is expressed in rupees per quintal.

Details of the final explanatory variables are presented below with justification.

Total Availability (lnX₁) – It includes the production plus the import quantity minus the export quantity of pigeon pea. The total availability for domestic consumption is expressed

in million tonnes. The data on opening stocks is unavailable for all the years and, hence, is not included in the total availability.

Trend (Linear) ($\ln X_2$): Which represent the increased demand for pigeon pea. The annual prices of pigeon pea show an increasing trend during the study period (Figure 1), and the compound annual growth rate in prices of pigeon pea is 7.59 percent. The trend in pigeon pea price shows the effect of increased demand and a rise in inflation of agricultural commodities. During the study period, the Wholesale Prices Index (WPI) for agricultural commodities rose at a compound annual growth rate of 6.5 percent. Also, the average per capita income (PCI) has grown at 3.9 percent annually during the study period. The positive growth in PCI indicates the increased demand for commodities. Thus, the increase in demand can influence the price of pigeon pea. Hence, the linear trend is used in the analysis as the independent variable. It reflects the demand for pigeon pea. The values of the trend are expressed as 1,2,3,4, etc., for each year.

Annual Price of Green gram ($\ln X_3$): Green gram and Pigeon pea are used in the Indian diet. While not a perfect substitute for pigeon pea, green gram is often used as an alternative and pulses are substituted to some extent (Oppewal et al., 2017). Hence, the annual price of green gram in the Latur market is taken as an independent variable to quantify the influence on pigeon pea prices. It is expressed in rupees per quintal.

2.4 Results and Discussions:

The results obtained from empirical analysis of prices are presented in this section. Before conducting formal analysis to identify and quantify the influence of each factor, to understand the overall trends in data, basic statistical measures such as Mean, Median, Standard Deviation (SD), coefficient of variations (CV), Range, etc., have been used in the study. The results of descriptive statistics are presented in Table 2.1.

Table 2. 1: Summary of descriptive statistics of key variables

Sr. No,	Particulars	Pigeon pea Prices (Rs/quintal)	Production (in Million Tonnes)	Imports (in Million Tonnes)	Green gram Prices (Rs/quintal)
1	Mean	4567	3.2	0.5	4714
2	Median	4245	2.9	0.5	4798
3	SD	1874	0.8	0.2	1614
4	CV	41%	25%	32%	34%
5	Range	6810	2.6	0.7	5385
6	Minimum	1794	2.3	0.2	2051
7	Maximum	8604	4.9	0.9	7437
8	CAGR	7.6%	3.3%	7.8%	6.6%

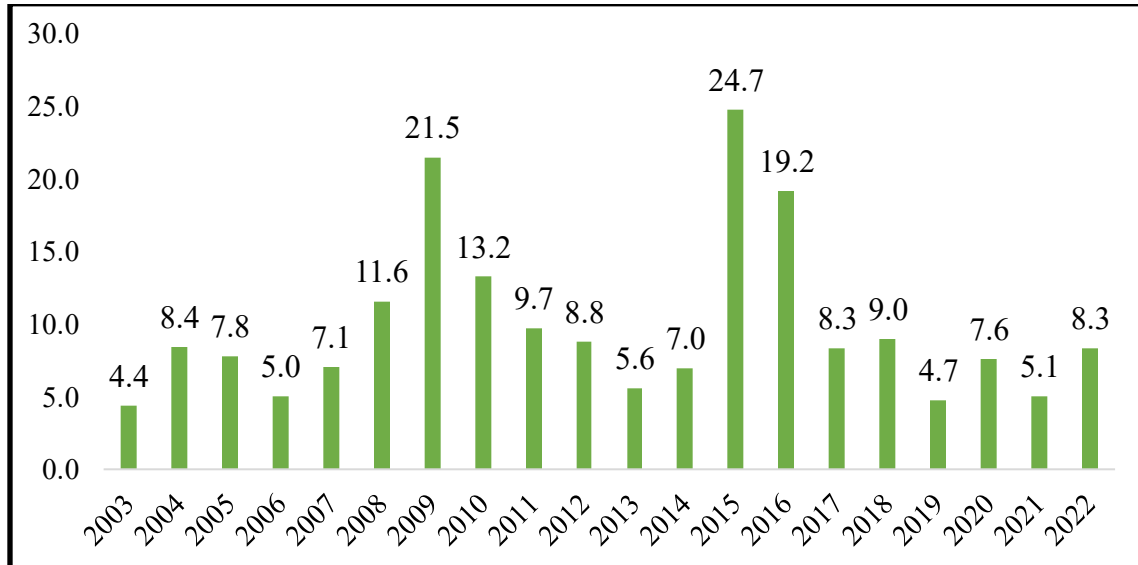
Source: DMI, Agmarknet portal, GoI (2024) and GoI (2023)

Table 2.1 describes the summary statistics of key variables used in the study during 2005 to 2022. It is observed that, the average annual price of pigeon pea in the Latur market was Rs.4567 per quintal, with a compound annual growth rate (CAGR) of 7.6 percent. The standard deviation (SD) was 1844, the coefficient of variation (CV) was 41 percent and the price range was Rs.6810 per quintal, indicating significant price volatility. Similarly, the average production of pigeon pea was 3.2 million tonnes, growing at an annual rate of 3.3 percent, with a CV of 25 percent, indicating moderate fluctuation. Additionally, the average import quantity was 0.5 million tonnes, with CAGR of 7.8 percent, showing continuous growth in pigeon pea imports. The SD value for imports of pigeon pea was 0.2, which indicated minimal fluctuations, while the CV value was 32 percent, representing moderate import variations. However, the CAGR in imports was higher than that of production of pigeon pea, indicating increasing dependency on imports to meet the domestic demand for pigeon pea. Likewise, the average price of green gram in the Latur market was Rs.4567 per quintal, increasing at 6.6% annually, with a CV of 34 percent, indicating significant price fluctuation. Overall, the volatility in pigeon pea prices was higher than green gram. The higher growth in annual imports (7.8%) than the production (3.8 %), indicating an increase in the dependency on imports to fulfill the domestic demand, which suggests the demand and supply gaps. Therefore, the increase in pigeon pea prices suggests the possibility of the influence of demand and supply side factors.

2.1 Volatility in Pigeon pea Prices

The pattern in price volatility indicates the high volatility during the study period.

Figure 2. 2: Coefficient of Variation (CV) of Prices of Pigeon pea (%)



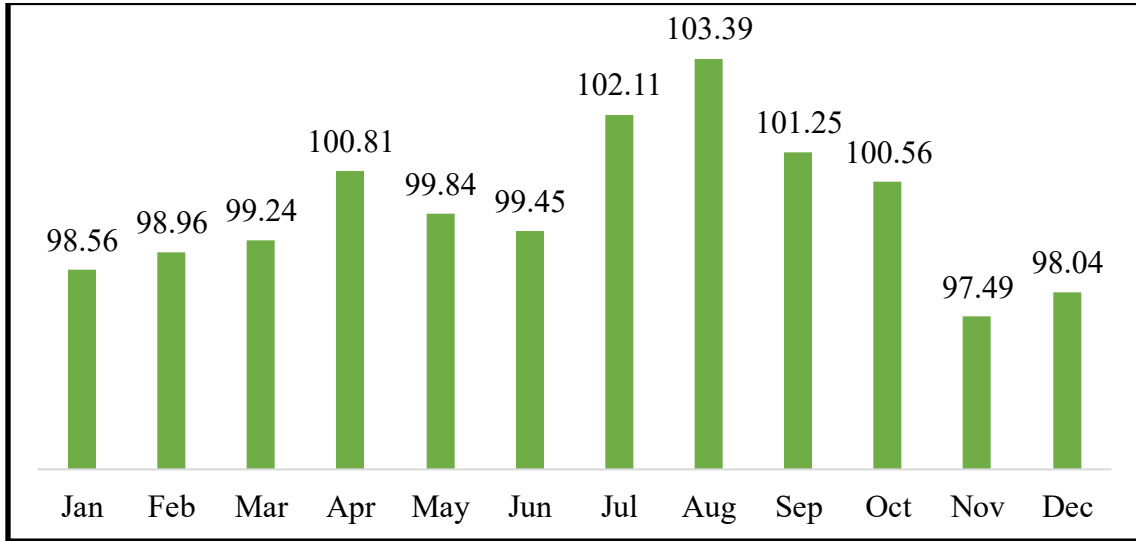
Source: DMI, Agmarknet portal, GoI (2024)

Figure 2.2, represents the volatility in pigeon pea prices over the last two decades. The coefficient of variation (CV) values ranged from 4.4. to 24.7 percent. Significant price fluctuations were observed in prices during 2007 to 2012, with a significant spike observed in 2009, it might be because of the impact of external factors. Similarly, the highest price volatility was observed in 2015, this is because of lower domestic production of pigeon pea. Subsequently, post 2017, the inter year variation in prices appear to have declined. This might be because of government interventions such as an increase in total availability, quantitative restrictions on import and bumper production.

2.4.1 Seasonality in Pigeon pea Prices

Agricultural product prices have varied due to the seasonal nature (Schnepf, 2006). The present study analyzed seasonality in pigeon pea prices from 2003 to 2022. The monthly seasonal indices of pigeon pea are presented in Figure 2.3.

Figure 2. 3: Monthly seasonal indices of pigeon pea prices



Source: DMI, Agmarknet portal, GoI (2024)

Figure 2.3 shows the monthly seasonal indices of pigeon pea prices in the Latur Market, India. It can be observed that the prices of pigeon pea were lower in November by 2.51 percent and highest in August by 3.39 percent. Although, there is considerable inter year variability in pigeon pea prices, but intra year variation appears to be relatively limited. The seasonality observed in pigeon pea prices is lower, if we consider price benefits after storing and relevant costs including losses the net return will be very small, therefore we can say that farmers might not benefit from storing pigeon pea.

2.4.2 Results of Factors Influencing the Prices of Pigeon Pea:

The factors influencing the prices of pigeon pea were analysed using multiple regression analysis. The annual price of pigeon pea prevailing in the Latur market was used as the dependent variable, and these prices are expressed in rupees per quintal. The total availability for domestic consumption (Production + Imports – Exports), Trend, and Annual prices of green gram (Mung Bean) were used as independent variables. However, the present study used the stepwise backward regression method to select the best-fit model. The influence of other factors such as procurement quantity, per capita income, exchange rate, MSP, international prices, and prices of Chickpea, Black Gram, Lentil was analyzed. It was found that the p-values for these factors were non-significant. Consequently, non-significant explanatory variables were dropped one variable at a time till the best-fit model was obtained. The stationarity results of ADF test show that all the

series are non-stationary at the level, and they becomes stationary at the first-order difference with statistically significant. The results of the final best fit model are presented Table 2.2.

Table 2. 2: Results of Factors Influencing on Pigeon Pea Prices

Variables	Coefficient	Std. error	T-Statistics	Prob.
Const	3.40152	1.91715	1.774	0.0978*
Total availability	-0.68460	0.270994	-2.526	0.0242**
Demand (trend)	0.36150	0.145321	2.488	0.0261**
Green gram prices	0.60490	0.244948	2.47	0.0270**
Results of goodness of fit				
Mean dependent var	8.342	SD dependent var		0.43758
Sum squared resid	0.372	S.E. of regression		0.16292
R-squared	0.886	Adjusted R-squared		0.8613
F(3,14)	36.214	P-value(F)		7.53E-07
Log-likelihood	9.382	Akaike criterion		-10.765
Schwarz criterion	-7.203	Hannan-Quinn		-10.274
Rho	0.260	Durbin-Watson		1.40935

Source: DMI, Agmarknet portal, GoI (2024), and Government of India, (2022a)

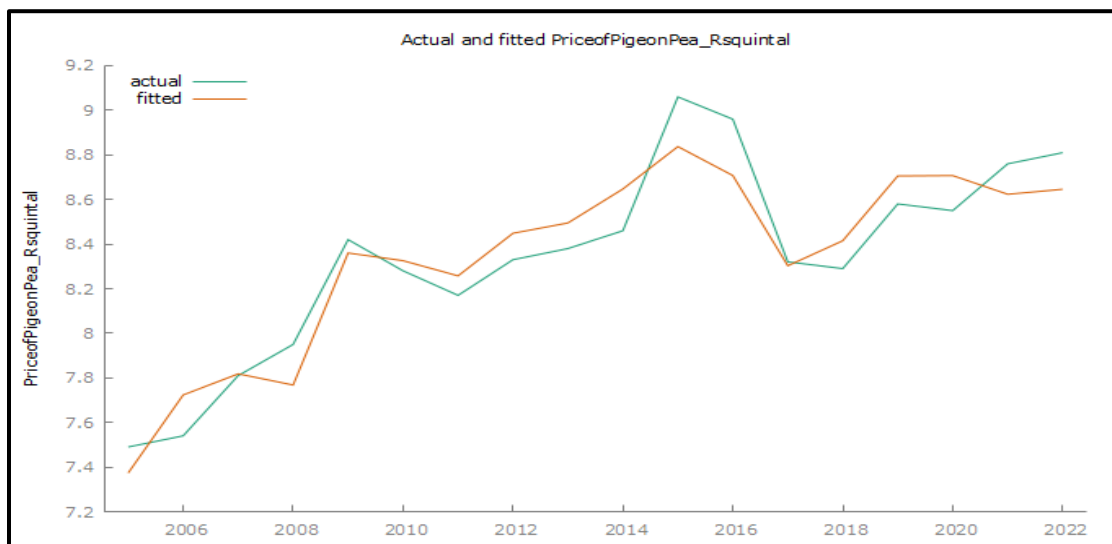
The results of the multiple regression model obtained from using Gretl software are presented in Table 2.2. The model results show that all the variables are statistically significant at a p-value at 0.05 percent level. The coefficient of total availability of pigeon pea for domestic consumption is -0.68 , which is negative and highly significant. It indicates the inverse relationship between the prices and the total availability of pigeon pea. It means that with a one percent increase in total availability of pigeon pea, the prices tend to decrease by -0.68 percent

Similarly, the coefficient of trend variable, which represents demand for pigeon pea is 0.36 , which is positive and significant at a p-value 0.05 percent level. This indicates that one percent change in demand increases the prices of pigeon pea by 0.36 percent. The higher demand tends to increase prices of pigeon pea. The study also observed that the per capita income (PCI) and overall inflation have been increased during the study period. The model results show a positive relationship between the prices of green gram and Pigeon pea. The coefficient value of green gram is 0.60 , which is positive and statistically significant,

suggesting that an increase in the price of green gram also increases the price of pigeon pea. This means a one percent increase in the price of green gram, increases the price of pigeon pea by 0.60 percent. This may be due to both commodities being substitutes for each other in consumption.

Overall, the R-square of the model is 0.89, indicating variation in the price of pigeon pea explained by independent variables such as total availability which includes production, imports and exports, demand of pigeon pea (Trend), and Price of Green gram. The Durbin-Watson statistic is 1.40. which indicates the positive moderate autocorrelation in the residual. However, the LM test for autocorrelation up to order 2 shows that no autocorrelations in residual and p-value is more than 0.05. The model is a good fit and explains the high variation in dependent variables, and the results of independent variables are statistically significant. The graphical presentation of actual and predicted prices is shown in Figure 2.4.

Figure 2. 4: Actual and Fitted Prices of Pigeon pea



Source: DMI, Agmarknet portal, GoI (2024)

Figure 2.4 represents the actual versus fitted prices. The X-axis indicates the time period, and the Y-axis indicates the actual and fitted prices of pigeon pea. The model fits well because actual and fitted lines move parallel and show similar patterns. Line. The model is a good fit for the prices of pigeon pea.

2.4.3 Results of Perceptions of Value Chain Actors About Factors Influencing Prices

The qualitative information regarding perceptions about factors influencing the prices of pigeon pea among value chain stakeholders was collected through field survey and analyzed in the present study. The perceptions reported by the value chain actors based on their knowledge and experience about factors influencing the price of pigeon pea are presented in Table 2.3.

Table 2. 3: Perceptions of value chain actors about factors influencing prices

Sr. No.	Particulars/ Factors	Farmers	Traders/Commission agents	Processors	Wholesalers	Retailers
1	Sample Size	560	32	32	32	32
2	Production	57.5	93.75	96.88		
3	Area under crop	37.03	81.25			
4	Rainfall	51.34	25.00			
5	Color		78.13	62.50	84.38	71.88
6	Last year prices	23.04	45.50			
7	Last year stocks		78.13	75.00		
8	Moisture content	44.10	81.25	84.38	78.13	62.50
9	Variety of produce	34.11		71.88	81.25	59.38
10	Quality of produce	47.86	87.50	87.50		
11	Foreign matters		60.33	63.40		
12	Minimum support price (MSP)	36.61	68.75	62.50		
13	Government policy (Trade)	28.93	81.25	68.75	65.63	68.75
14	Market demand	47.68	78.12			
15	Availability of storage facilities	46.07			93.75	65.63
16	Demand from the processing industry.		90.62			
17	Demand from wholesalers			90.63		
18	Demand from bulk buyers		75.00	65.63		
19	Export demand		65.63	21.88	59.38	37.50
22	Import quantity		68.75	53.13	68.75	46.88
23	Demand from retailers				96.88	
24	Size of tur dal			68.75	90.63	78.13

Sr. No.	Particulars/ Factors	Farmers	Traders/Commission agents	Processors	Wholesalers	Retailers
25	Demand from consumers					96.88
26	Domestic stocks (dal)			71.88	75.00	56.25

Source: Field Survey

a. Perceptions of Farmers

Most of the farmers perceived that production (57.5%), Rainfall (51%), quality of produce (47.9 %), market demand (47.68 %), Availability of storage facilities (46.07%), Minimum Support Price (MSP) (36.6 %), variety of produce (34.1%), government trade policies (28.9%) have influenced the price of pigeon pea (Table 2.3). This indicates that the level of awareness is low.

b. Perceptions of Traders/Commission Agents

The traders/commission agents perceived that the production (93.75 %) is the most important factor influencing the prices of pigeon pea (Table 2.3), followed by demand from processing industries (90.82 percent), quality of produce (87 percent), Area under crop (81.25 percent) and moisture content (81.25 percent).

c. Perceptions of Processors (Dal Millers)

The processor (Dal Miller) is one of the important actors in the pigeon pea value chain. The processors perceived that the production (96.88%) is the most important factor influencing the prices of pigeon pea, followed by demand from wholesalers for 'Pigeon pea Dal'; moisture content, quality of produce, last year's stocks, and variety are the most important factors influencing the price (Table 2.3).

d. Perceptions of Wholesalers and Retailers

The wholesalers perceived that the demand from retailers, the size of pigeon pea dal, availability of storage facilities, the color of produce, and government policies are the important factors influencing the price of pigeon pea dal (Table 2.3). Likewise, the retailers perceived that consumer demand, color, availability of storage facilities, and government policies are the most important factors influencing the price of pigeon pea dal (Table 2.3).

e. Perceptions of Importers

The importer respondent perceived that domestic arrivals, domestic existing stocks, market demand and prices, transportation and logistics facilitates, policies of export countries, government policies, export-import taxes, and duties are important factors influencing the prices of pigeon pea in India. Overall, the study noted that the perceptions of value chain actors about factors influencing the price of pigeon pea differed from respondent to respondent. However, all the respondents perceived that production, demand, imports, quality of produce, and government policies about minimum support price and trade are the most significant factors influencing the market prices of pigeon pea in India. The results indicate that the farmers have less awareness about factors affecting the prices of pigeon pea compared to other value chain actors. Farmers are not fully aware of the factors influencing the prices. The awareness of factors such as MSP, last year stocks, demand from various actors needs to be increased. The dissemination of market information to the farmers will enhance their ability to make informed decisions about the marketing of pigeon pea.

2.5 Conclusion and Policy Implications:

Pigeon Pea (*Cajanus Cajan*) is one of the most important pulses cultivated in India. It is an important part of the Indian diet and the major source of protein for vegetarians. India is a major producer, consumer, and importer of pigeon pea in the world. Despite this, the volatility in pigeon pea prices has become a serious concern in India in recent years; it has affected producers and other stakeholders in the value chain and consumers. Therefore, understanding the factors influencing the price of pigeon pea will be helpful in implementing the price stabilization policy more effectively. Hence, the present study examines factors influencing the prices of pigeon pea in India. The secondary data on dependent and independent variables were used for the empirical analysis from January 2005 to December 2022. The multivariate regression analysis technique is used to determine the influence of factors on the price of pigeon pea. Also, the perceptions of value chain actors regarding factors influencing the prices of pigeon pea have been studied. Results of the multiple regression model shows that the total availability of pigeon pea for

domestic consumption (production+import-export) shows an inverse relationship with pigeon pea prices indicating that a one percent increase in availability decreases prices by -0.68 percent. In comparison, a one percent increase in demand raises prices by 0.36 percent. The prices of green gram positively influence pigeon pea prices. Even one percent increase in green gram prices leads to 0.60 percent increase in pigeon pea prices. Overall, the model explains 88.58 percent price variation due to changes in independent variables. The model is a good fit and explains the high variation in dependent variables, and the results of independent variables are statistically significant. It is observed that total availability of pigeon pea in the domestic market plays an important role in determining the prices of pigeon pea in India. This suggests that the government would focus on increasing the production of pigeon pea and which will help in increasing the availability of pigeon pea for domestic consumption.

Also, the study noted that the perceptions of value chain actors about factors influencing the price of pigeon pea differed from respondent to respondent. However, all the respondents perceived that production, demand, imports, quality of produce, and government policies about minimum support price (MSP) and trade are the most significant factors influencing the market prices of pigeon pea in India. Farmers have relatively less awareness about factors affecting the prices of pigeon pea compared to other value chain actors. Therefore, dissemination of market information to the farmers may enhance their ability to make informed marketing decisions and get better prices.

Lastly, the key implication is that the empirical results of the study will be helpful in modeling and forecasting the price of pigeon pea and policymakers to develop strategies to mitigate the price volatility and sustainability of the production of pigeon pea in the county. However, the results show the influence of independent factors used in the study with statistical significance, but other factors may affect the price of pigeon pea, which the model does not explain. However, the model results show reasonable accuracy, but there is further scope for exploring other macroeconomic and climate factors. Further, data on previous year stocks of pigeon pea were not available for all the year; hence, stocks data were not included in the total availability of pigeon pea for domestic consumption.

CHAPTER 3: MARKET INTEGRATION OF PIGEON PEA

3.1 Introduction

Market integration is crucial to understand the market efficiency, performance of spatially located markets, possible arbitrage chances, efficient price transmission and better price realization (Ravallian, 1986; Rapsomanikis *et al.*, 2003; Reddy, 2012). Market integration occurs when prices of the same commodity in one market reflect a change in another or follow the same pattern over a long period (Goodwin and Schroeder, 1991). This situation indicates the co-movement in prices, price signals and information transmitted smoothly across differently located markets (Reddy, 2012). The report on 'Doubling Farmers Income'(DFI) shows that the effective integration of the marketing system would reduce price dispersion across the country (variation in prices across sellers of the same item), especially due to regional demand inconsistency and greater market integration is essential for farmers to get higher farm-gate prices (GoI, 2017). After trade liberalization, market integration of agricultural commodities raised policymakers' concerns about developing price policies and marketing reforms. Policy liberalisation and the use of information and communication technologies (ICT) have influenced the integration of agricultural commodity market (Goletti and Babu, 1994).

Globally, pigeon pea is cultivated in tropical areas, primarily semi-arid and tropical regions (Sah *et al.*, 2022). It is one of the most important legume crops cultivated in India. It is known as red gram /tur/arhar. It is a rainfed crop mainly grown by the marginal and small farmers during June –July. Mostly, it is cultivated as an intercrop. Even though it is harvested from December onwards, most of the produce is brought to the market from January to March. India is a leading producer, consumer and importer of pigeon pea. It accounted for 79.2 percent of the global production in 2022, followed by Malawi (8.4%), Myanmar (6.76%), Tanzania (3.1%) and Kenya (1.6%) (FAOSTAT, 2022). Its global production has increased at the compound annual growth rate (CAGR) of 2 percent, while in India it increased at 3.1 percent during 2011-2022. In the same period, the area under it rose from 68.62 percent to 77.61 percent. But its share in the global production dropped from 92.7 percent in 1961 to 79.2 percent in 2022 (FAOSTAT, (2022). It is an important

staple food and a rich source of protein (GoI, 2021a). Within India, Maharashtra is its largest producer, accounting for one-third of the total production, followed by Karnataka (28.90%) and Madhya Pradesh (5.98%) (GoI, 2023). Despite India being the world's major producer and consumer of pigeon pea, price volatility in it has recently increased (Bisht and Kumar, 2019; Kulkarni, 2019). Fluctuation in agricultural commodity prices significantly impacts its area under cultivation, production and yield (Blay *et al.*, 2015). Hence, price volatility has emerged as a concern, affecting producers and other stakeholders involved in the value chain. Volatility in prices indicates market inefficiency.

The study of market integration and price transmission across spatially distributed markets is crucial for policymakers to understand whether the price change in one market affects the prices in another. Disproportionate attention is being paid to studying the market integration of cereals while relegating pulses, especially pigeon pea, to insignificance. Therefore, the objectives of the present study are: i) to examine the market integration of pigeon pea in major markets in key producing states in India using the Johansen Cointegration Test (1990); ii) to investigate the short-run speed of adjustment in prices by using Vector Error Correction Model and iii) causality (direction) between prices of pigeon pea in differently located markets by using Granger Causality Test. The present chapter is divided into four sections. In the following section, the study and literature review are discussed. Methodology and data used for the study are explained in the third section. The results and discussion are presented in Section IV. Finally, the conclusions are drawn.

3.2 Literature Review

Market integration is the 'reflation of a change in prices of the same commodity in one market resulting in a change in another market or the prices of commodities follow the same pattern over a long period' (Goodwin and Schroeder (1991). The degree of price transmission between two either vertical or spatial markets is called market integration (Virmani and Surbhi, 2006; Jena, 2016) and the co-movement of prices indicates the degree of market integration (Golettl *et al.*, 1995). Price transmission refers to a price change in one market that reflects the price change in another market (Cramon-Taubadel and Goodwin, 2021). Several studies on price transmission focus on horizontal and vertical price transmission (Reddy, 2012; Poul *et al.*, 2016; Cramon-Taubadel and Goodwin, 2021;

Grace et al., 2013). Vertical price transmission refers to price linkages along a given supply chain, while horizontal price transmission, also called spatial price transmission, refers to price linkages across marketplaces (Esposti, 2012). Spatial price transmission refers to the difference between prices in spatially located markets that should not exceed transaction or spatial arbitrage costs (Esposti, 2012; Cramon-Taubadel and Goodwin, 2021).

Further, market integration is also known as the 'Law of one price' (LOP), an important concept (Virmani and Surbhi, 2006). It states that identical commodities will have the same price in different markets, assuming the commodity markets are perfectly competitive, with no transport cost, no tariffs, and free trade (Steinwender, 2014). Perfect market integration implies a strong form of the Law (Fackler and Goodwin, 2001). However, if the markets are fully integrated, the Law prevails in the long term, and arbitrage opportunities ensure the price difference between markets is minimized to the marginal transaction costs (Boffa and Varela, 2019). The high degree of market integration indicates that the markets are highly competitive and contribute to the smooth transmission of price signals and information across spatially separated markets (Lyu et al., 2023; Goletti et al., 1995).

Market integration is studied by using different methods. According to Goletti et al. (1995), price correlation is a simple method used to measure price co-movement in different markets. In early studies on market integration and price transmission, scholars applied the bivariate correlation method and described co-movement in prices in spatially separated markets (Lele, 1967). Some studies brought out limitations of bivariate models or methods relying on price information only to explain market integration (Gonzalez-Rivera et al., 2001; Fackler and Tastan, 2008; Hnin et al., 2005; Rapsomanikis et al., 2003). This method also suffered from the problem of auto-correlation (Ravallion, 1987). To overcome these issues, Ravallion (1987) developed the Ravallion procedure to study market integration. Samarpitha (2014) used the zero-order correlation matrix to examine the spatial price integration of pigeon pea and found that markets are integrated in terms of prices because of better transportation facilities, access to the market and access to price information. Advanced methods, such as the Engle-Granger Cointegration Test developed by Granger in 1987, are used to understand the existence of a relationship between two variables in a time series. Johansen and Juselius (1990) developed a test to examine the cointegration

between multiple time series called as Johansen Multivariate Cointegration Test. Several studies have used these two approaches to investigate the market integration in agricultural commodity markets (Gonzalez-Rivera and Steven, 2001; Ghosh, 2000; Shekhar, 2012; Reddy, 2012; Paul *et al.*, 2016; Grace *et al.*, 2013; Horo *et al.*, 2019; Wavdhane *et al.*, 2020; Anrdle and Blagrave, 2020; Pavithra *et al.*, 2022; Pandey *et al.*, 2023). Further, the Vector Error Correction Model (VECM) and Granger Causality Test were used to investigate the speed of price adjustment in the short run and the direction of prices transmitted from one market to another market respectively. However, the direction and speed of adjustment in the markets are different both in the short and long runs (Reddy, 2012; Pavithra *et al.*, 2022; Pandey *et al.*, 2023).

Shekhar (2012) used Gonzalo–Granger (G–G) model to examine the agricultural market integration and found that gram markets are well integrated due to no restriction on inter-regional movement and domestic market structure. Also, the pulses markets in India are co-integrated, the speed of adjustments is high, the price changes are temporary and converge to equilibrium within a given period since the direction and intensity in price changes may be affected by linkages between supply and demand in pulses (Paul *et al.*, 2016). Some studies found that the prices of chickpea vary together in integrated markets and have existence of significant cointegration and interdependence between the markets, and both wholesale and retail markets are integrated (Reddy, 2012; Pavithra *et al.*, 2022; Panddy *et al.*, 2023). However, the law of one price does not exist, and the major exogenous consuming and export-import terminal markets play an important role in price formation (Reddy, 2012; Pavithra *et al.*, 2022). However, Grace *et al.* (2013), in their study of gram and arhar, noted that markets are not closely integrated but are interlinked. This may be due to lack of infrastructure, market information, transport and storage facilities. However, recent works by Horo *et al.*, (2019) and Wavdhane *et al.* (2019) argue that pigeon pea markets are cointegrated in the long run and there is improvement in spatial integration also.

Some studies reported co-movement between wholesale and retail prices but found imperfect integration for agricultural commodities (Boffa and Varela, 2019; Gonzalez-Rivera, *et al.*, 2001). Similarly, Anrdle and Blagrave (2020) show that the agricultural

market integration in India has not increased in recent years. This may be because the impact of the government initiatives is little. Pigeon pea markets in India are not tightly integrated, may be due to lack of infrastructure, market information, transport and storage facilities (Grace *et al.*, 2013).

Though different methods were applied to examine the market integration prices of agricultural commodities, cointegration, and error correction models are considered the standard tools for analyzing market integration (Rapsomanikis *et al.*, 2003). Therefore, we used the Johansen Multivariate Cointegration approach, Granger Causality Test and Vector Error Correction model to investigate the market integration of pigeon pea in India.

3.3 Data and Methodology

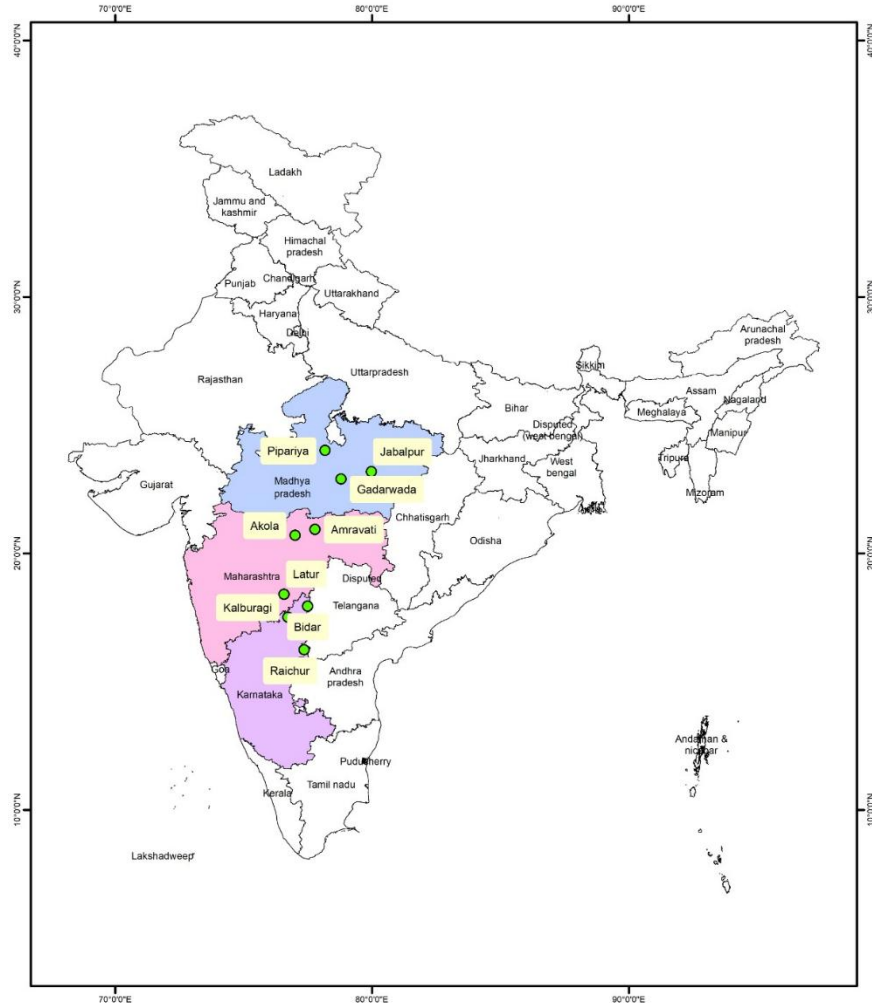
3.3.1 The selection of markets

The study emphasizes spatial market integration of pigeon pea in India. Nine markets were selected on the basis of maximum arrivals and the availability of price data from three major pigeon pea producing states, i.e., Maharashtra, Karnataka and Madhya Pradesh which together account for 63 percent of the total production (GoI, 2023). Three markets from each selected state were selected. Latur, Amravati and Akola markets from Maharashtra; Bidar, Raichur and Kalaburagi (Gulbarga) markets from Karnataka; and Pipariya, Jabalpur and Gadarwara markets from Madhya Pradesh. These markets are the Agricultural Produce Market Committee (APMC) and are regulated/controlled by the state governments (GoI, 2024). The location of the markets selected for the study is presented in Figure 3.1.

3.3.2 The Data

This study is based on secondary data. The monthly average wholesale prices from January 2003 to December 2022 were used to study the selected markets. The data was downloaded from the Agricultural Marketing Information Network (AGMARKNET) portal, Directorate of Marketing and Inspections, Government of India and the websites of mandi boards of respective states.

Figure 3. 1: Geographical Locations of the Markets selected for the Study



3.3.3 Analytical Model

The study applied a multivariate cointegration approach (Johansen Cointegration Test) to examine price integration. The market integration analysis involved five steps. The first step consisted of a time series analysis of prices, including descriptive statistics, trends and correlation to understand price series and variations in prices. In the second step, to check the stationarity, we used Augmented Dicky -Fuller (ADF) test and Phillips-perron (PP) Test. In the third step, Johansen Cointegration Test, the Trace statistics, and Maximum Eigen Value Test results were used to investigate the number of cointegrations. Further, the Vector Error Correction Model (VECM) was applied to examine the speed of adjustment in the short run towards the equilibrium in the long run. Finally, the Engel-Granger

Cointegration test was applied to explore the pair-wise unidirectional and bi-directional causal relationship between the prices of pigeon pea in selected markets in India.

3.3.4 Unit Root Test (Stationarity Test):

A Unit Root Test is a statistical test used to determine whether a time series is stationary or non-stationary (Gujarati et al., 2015). If the time series is non-stationary, it is necessary to transform the non-stationary time series into stationary. Augmented Dickey-Fuller (ADF) Test (Dickey and Fuller, 1979) and Phillips-Perron (PP) Test (1988) are widely used unit root tests to check stationarity. The ADF Test works by regressing the first difference of the time series on its lagged values, as well as on the lagged values of the first difference itself and the test is a nonparametric statistical method. But it allows for serial correlation in the error term without adding lag difference terms. Both ADF and PP Tests are similar (Gujarati et al., 2015). The equation of the ADF Test is as follows:

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum \alpha_l \Delta Y_{t-1} + \varepsilon_t$$

Where: Y_t = Price series

ΔY_t = First difference of Y_t

$\Delta Y_{t-1} = (Y_{t-1} - Y_{t-2})$, $\Delta Y_{t-2} = (Y_{t-2} - Y_{t-3})$, etc.

β_1 = Intercept term, $\beta_2 t$ - Coefficient, ε_t = a pure white noise error term

The null hypothesis of the ADF Test is that $\beta = 0$, which implies that the time series has a unit root and is, therefore, non-stationary. The alternative hypothesis is that $\beta < 0$ implying that the time series does not have a unit root and is, therefore, stationary.

3.3.5 Johansen Cointegration Test:

Cointegration describes the long-run association among the variables (Gujarati et al., 2015). Johansen and Juselius (1990) developed a test to examine the cointegration between multiple time series. This test is used to investigate the existence and number of cointegrating vectors and long-run relationships between the market prices (Johansen, 1988; Johansen and Juselius, 1990). After checking stationarity in time series, Johansen multivariate cointegration method was used to find out the number of cointegration vectors and long-run relationship among variables. Trace Statistics and Maximum Eigenvalue Test results are used to examine the number of cointegration vectors. This method is commonly

used for investigating market integration (Reddy, 2012; Katoch, et al., 2021; Pandey et al., 2023; Paul et al., 2016). The equation of Johansen Cointegration Test can be expressed as follows,

$$\Delta X_t = \Pi X_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \mu + \epsilon_t$$

Where, ΔX_t represent the vector of first differences of market prices, Π denotes the rank matrix of cointegrating vectors, Γ_i represents the matrices of short run parameters for lag i , μ denotes the intercepts, ϵ_t indicates error terms.

Trace Statistic Test:

$$\Lambda_{trace(r)} = -T \sum_{i=r+1}^n \ln(1 - \lambda_i)$$

Where- λ_i = Eigenvalues, T = number of effective observations, r – number of cointegrating vectors,

Here, the null hypothesis (H_0), i.e., the number of cointegration vectors, is $r=r^*$, and the alternative hypothesis (H_1) is r is more than r^* .

Maximum Eigenvalue Test:

$$\Lambda_{max} = -T \cdot \ln(1 - \lambda_{i+1})$$

Where, λ_i = Eigenvalues, T = number of effective observations

Here, the null hypothesis (H_0), i.e., the number of cointegration vectors, is $r=1$ (at most r cointegration), and the alternative hypothesis (H_1) is $r=r+1$.

Vector Error Correction Model (VECM):

If there is at least one or more cointegration relationships among variables, then VECM is applied to examine the short-run and long-run relationship between variables (Usman et al., 2017). This method is commonly used for investigating short-run causality (Katoch et al., 2021; Pandey et al., 2023; Paul et al., 2016). The VECM for nine variables case can be expressed as follows:

$$\Delta P_t = \alpha \beta' P_{t-1} + \Gamma_1 \Delta P_{t-1} + \Gamma_2 \Delta P_{t-2} + \dots + \Gamma_{k-1} \Delta P_{t-k+1} + \epsilon_t$$

Where,

$P_1, P_2 \dots P_9$ denote the price series in different markets, ΔP_t – First Difference, $\alpha\beta' P_t - 1$ – error correction term, ε_t denotes the error terms

3.3.7 Granger Causality Test:

The Granger causality test checks whether one variable is caused by another (Granger, 1969). The existence of a relationship between variables does not prove causality or the direction of influence (Gujarati et. al., 2015). Since cointegration results show the short-run and long-run integration but do not specify the direction of causal relation among prices, the Granger Causality Test was used to investigate the presence of unidirectional and bidirectional causality in the market prices of pigeon pea in the present study. The bivariate Granger Causality Test can be expressed as:

$$\text{Equation 1: } Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \dots + \alpha_i Y_{t-i} + \beta_1 X_{t-1} + \dots + \beta_i X_{t-i} + \mu$$

$$\text{Equation 2: } X_t = \alpha_0 + \alpha_1 X_{t-1} + \dots + \alpha_i X_{t-i} + \beta_1 Y_{t-1} + \dots + \beta_i Y_{t-i} + \mu$$

Whereas, α_0 = intercepts, μ = error term

Null hypothesis: 1. X does not Granger cause Y, and 2: Y does not Granger cause X.

Unidirectional causality exists if reject the null hypothesis, either equation 1 or 2. If the null hypothesis is rejected in both cases, then bidirectional causality is present, and if the null hypothesis is accepted in both cases, which means there is no causality in the price series.

3.4. Results and Discussion

3.4.1 Descriptive statistics

The descriptive statistics of the monthly wholesale prices of pigeon pea for all the markets are presented using a box plot (Figure 3.2).

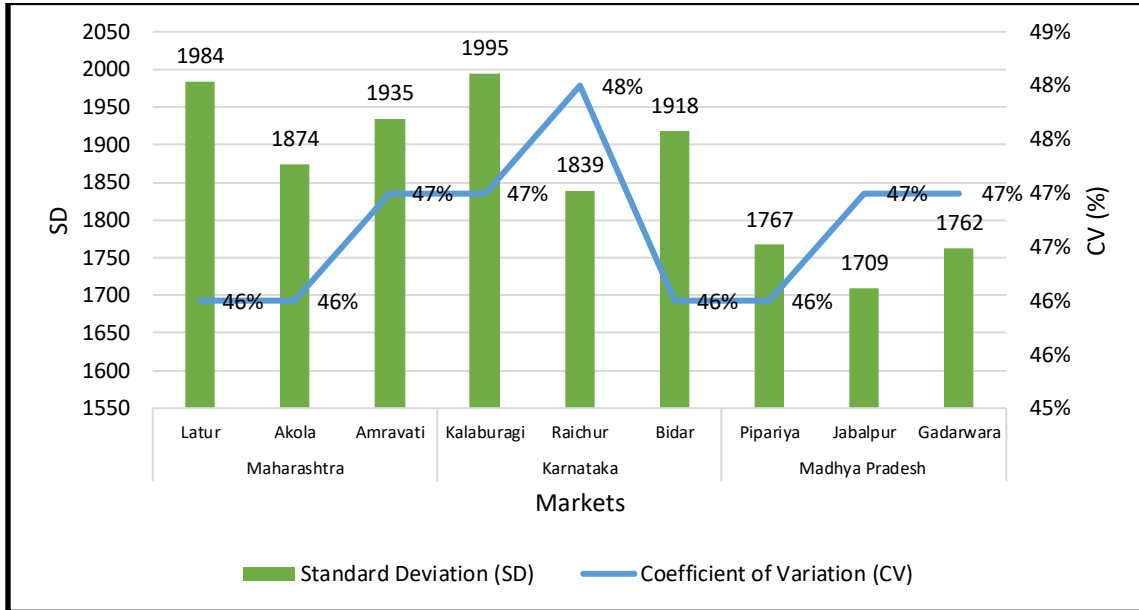
Figure 3. 2: Descriptive statistics of the monthly wholesale prices of pigeon pea



Source: DMI, Agmarknet portal, GoI (2024)

Figure 3.2 depicts the box plot of the descriptive statistics of the monthly price series in the selected market. The line inside the box shows the median value of the price series. Latur market price shows the highest median value (Rs.4152/qrtl), while Jabalpur market (Rs.3517/qrtl) shows the lowest. The monthly price data distribution across the markets seems symmetric because all the boxes are almost of the same length. The maximum outliers observed in Latur market (4), Kalburgi market (3), Bidar market (2), and remaining markets observed one for each. Among all the selected markets, the interquartile range is highest in the case of Raichur (3013) and lowest in the case of Jabalpur market (2457).

Figure 3. 3: Standard deviation and coefficient of variation of monthly prices



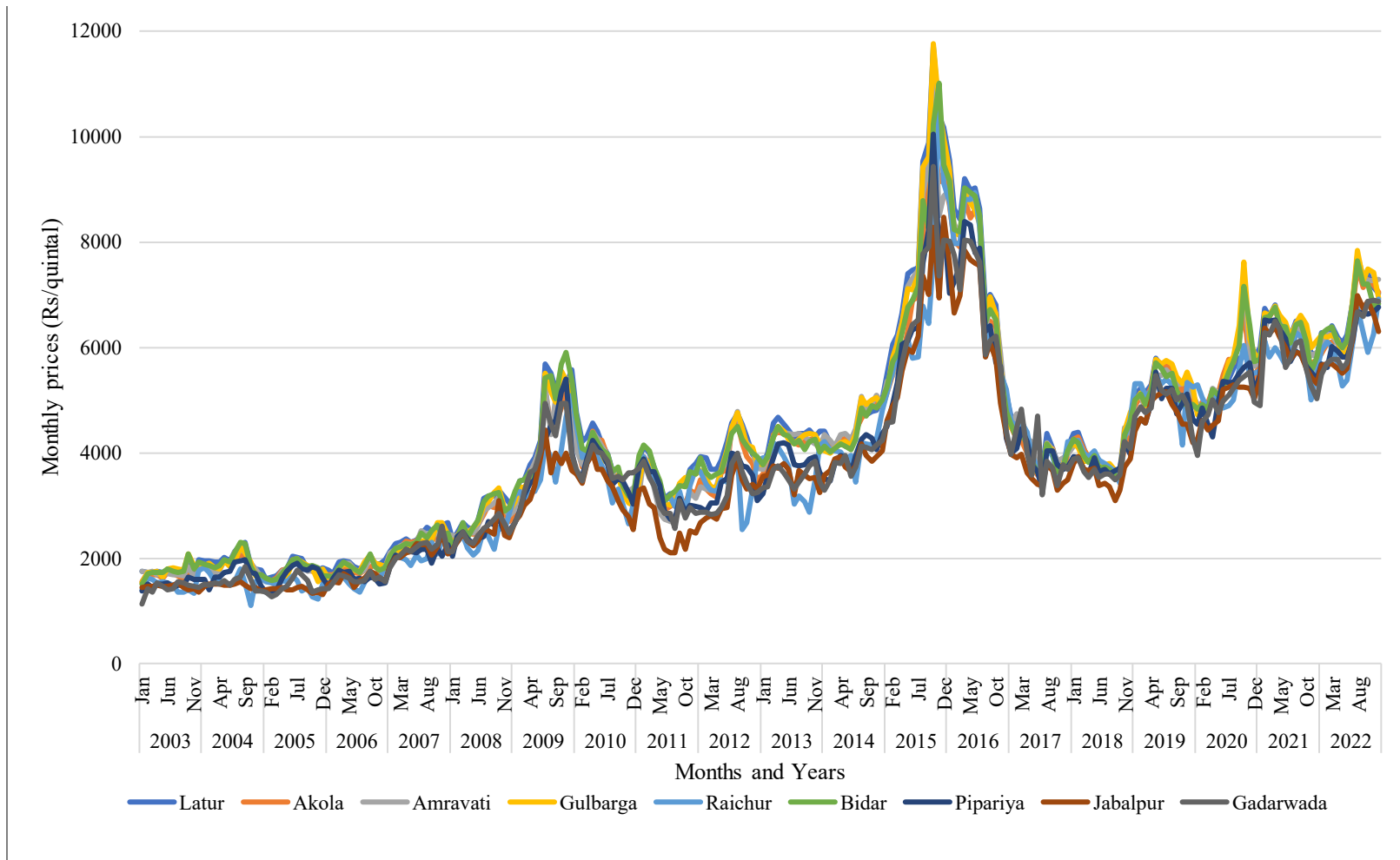
Source: DMI, Agmarknet portal, GoI (2024)

Figure 3.3 depicts that the standard deviation (SD) and coefficient of variation (CV) of monthly prices of pigeon pea. The value of standard deviation (SD) is found higher in Kalaburagi market (1995) and lowest in Jabalpur market (1709). However, SD differs from market to market. The value of CV is ranged between 46 - 48 percent, which shows that volatility in prices differ in markets.

3.4.2 Trends in the prices of Pigeon pea in the selected markets:

The monthly prices of pigeon pea per quintal at selected markets in India from January 2003 to December 2022 are presented in Figures 3.4.

Figure 3. 4: Monthly prices of pigeon pea in selected markets in India (Rs/quintal.)



Source: DMI, Agmarknet portal, GoI (2024) and State Mandi Board

Figure 3.4 depicts the prices of pigeon pea in selected markets. The prices show an increasing trend with wide fluctuations over space and time. They show the co-movement to each other. The highest prices were in October 2015 due to production shocks because many producing states experienced drought situations in consecutive years, resulting in less production. Later, in 2017 production increased and prices declined. Further, the price changes are due to less production and high demand in India. Prices show a continued increase after 2018. The pigeon pea prices exhibit an increasing trend over time with fluctuations (Figure 1). They exhibit co-movement in the same way. However, the highest prices were in October 2015 in all the markets due to production shocks in 2014-15 and 2015-16, experienced by many producing states due to drought situations in consecutive years, resulting in less production. There may be a possibility of cointegration among prices.

3.4.3 Relationship Between Prices of Pigeon pea in Selected Markets

Some studies have used the correlation coefficient technique to measure market integration and concluded that markets are cointegrated (Lele, 1967). The results of correlations among prices are presented in Table 3.1.

Table 3. 1: Summary of correlation matrix of the prices of Pigeon pea

Sr. No.	Markets	Latur	Akola	Amravati	Kalaburagi	Raichur	Bidar	Pipariya	Jabalpur	Gadarwara
1	Latur	1								
2	Akola	0.99	1							
3	Amravati	0.99	0.99	1						
4	Kalaburagi	0.99	0.99	0.99	1					
5	Raichur	0.97	0.97	0.96	0.96	1				
6	Bidar	0.99	0.99	0.99	0.99	0.98	1			
7	Pipariya	0.98	0.99	0.99	0.99	0.96	0.98	1		
8	Jabalpur	0.98	0.98	0.99	0.98	0.97	0.98	0.99	1	
9	Gadarwara	0.98	0.98	0.99	0.98	0.96	0.98	0.99	0.99	1

Source: DMI, Agmarknet portal, GoI (2024), MH: Maharashtra, MP: Madhya Pradesh and KAR: Karnataka.

Table 3.1 shows the existence of a strong correlation between pigeon pea prices in the selected markets under study and the results are statistically significant. The maximum correlation coefficient value is 0.99, and the minimum value is 0.97. However, the

strong association indicates that price changes in one market influence the price movement in another. However, the correlation coefficient values were found to be high, but that is not sufficient to conclude that markets are integrated (Sekhar, 2012). Since correlation coefficients are insufficient to measure market integration, methods such as the Engle-Granger and Johansen Multivariate Cointegration Tests were used to estimate the market integration of spatially distributed markets. Hence, we used the Johansen Multivariate Cointegration Test for analysis.

3.4.4 Results of the Cointegration test

Engle-Granger and Johansen Cointegration Tests are the two cointegration tests used in the earlier studies to test cointegration among variables (Paul *et al.*, 2016; Pandey *et al.*, 2022). Johansen Cointegration Test is used because it allows cointegration testing between multiple time series (Johansen and Juselius, 1990).

3.4.5 Results of Unit Root Test

It is necessary to test stationarity in time series before conducting Johansen Cointegration Test. The unit root test is used to check the stationarity in the price series. To test the null hypothesis, i.e., all the price series are stationary. We used the Augmented Dicky- Fuller (ADF) Test (i.e., $Y_t = bY_{(t-1)}$) and Phillips-Perron (PP) Test.

The results of the ADF Test show that price series in the nine selected markets are non-stationary and become stationary at first order difference (Table 3.2). However, it has been validated using the Phillips-Perron Unit Root Test. The results of both the tests show that all the price series of pigeon pea in selected markets are stationary at the first difference level and the results are significant.

Table 3. 2: Results of Unit Root Test in Price Series

Sr. No.	Name of the state	Name of market	Augmented Dickey-Fuller Test statistic				Phillips-Perron Unit Root Test			
			At level		1st difference		At level		1st difference	
			t-statistic	P-value	t-statistic	P-value	t-statistic	P-value	t-statistic	P-value
1	Maharashtra	Akola	-1.69	0.44	-4.56	0.00	-1.52	0.52	-13.37	0.00
		Amravati	-1.45	0.56	-16.13	0.00	-1.43	0.57	-16.13	0.00
		Latur	-1.85	0.35	-8.88	0.00	-1.64	0.46	-13.47	0.00
2	Karnataka	Kalaburagi	-2.03	0.28	-5.14	0.00	-1.64	0.46	-13.92	0.00
		Bidar	-1.66	0.45	-4.90	0.00	-1.68	0.44	-13.67	0.00
		Raichur	-1.47	0.55	-6.75	0.00	-1.67	0.45	-14.53	0.00
3	Madhya Pradesh	Pipariya	-1.86	0.35	-4.20	0.00	-1.48	0.54	-16.85	0.00
		Jabalpur	-1.33	0.62	-10.42	0.00	-1.40	0.58	-17.73	0.00
		Gadarwara	-1.27	0.64	-17.75	0.00	-1.43	0.57	-17.74	0.00

Source: DMI, Agmarknet portal, GoI (2024)

3.4.5 Results of Johansen Cointegration Test

Johansen (1988) and Johansen and Juselius (1990) have developed a multivariate cointegration method which is a robust procedure for testing long-run relationships between stationary prices and allows the testing of multiple cointegrating vectors. The cointegration vector indicates the extent of the co-movement in prices. An increase in the number of cointegrating vectors implies an increase in the strength and stability of price linkages. The prerequisite of the Johansen Cointegration Test is that all the variables must be stationary. In this study, we found that all variables are non-stationary at level, and after converting into first differences, the series becomes stationary. Since the Johansen Multivariate Cointegration Test is lag length sensitive, we must select the appropriate lag length before conducting the test.

The Vector Autoregressive Model (VAR) was used and lag length was selected based on different information criteria. In the literature, there are different information criteria used to select the optimum lag length such as Akaike Information Criteria (AIC) developed by Akaike (1974), Schwarz Information Criteria (SIC) by Schwarz (1978), Sequential modified LR Test Statistic (LR), Final Prediction Error (FPE) and Hannan - Quian Information Criterion (HQ).

Table 3. 3: Results of lag order selection model

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-13295.4	NA	8.85E+39	114.6848	114.8036	114.7327
1	-12471.2	1584.44	1.26E+37	108.1314	109.2010*	108.5628*
2	-12383.3	162.9638	1.03e+3Y	107.9251	109.9456	108.74
3	-12308	134.352	9.38E+36	107.8278	110.7991	109.0261
4	-12231.9	130.5941	8.52e+36*	107.7233*	111.6454	109.305
5	-12173.6	95.92018	9.09E+36	107.7728	112.6458	109.738
6	-12117.3	88.87191	9.92E+36	107.8389	113.6627	110.1876
7	-12064.8	79.28669	1.13E+37	107.9375	114.7122	110.6697
8	-12000.7	92.21299*	1.18E+37	107.9371	115.6625	111.0527

*Indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level),
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion,
HQ: Hannan-Quinn information criterion

Source: DMI, Agmarknet portal, GoI (2024)

Based on the VAR model for lag order selection, one lag is considered for the analysis based on SIC and HQ criteria (Table 3.3). The study noted that in the present situation, the information speed is growing as modern technologies are developed. Hence, the price information of one marketplace will be reached immediately or within minutes or hours and in a day in another marketplace, and this information may influence the trading behaviour of that day in the market. Further, one trader can be operating at multiple places in trading. Hence, as suggested by SIC and HQ information criteria, we chose to go with minimum lag. Also, the markets selected for the study are within a country and adjoining states. So, there may be no lag in the case of agricultural commodity prices. The study proposes that minimum lag (i.e., one month) is considered while conducting a formal analysis of the Johansen Multivariate Cointegration Test as suggested by SIC and HQ criteria. After examining stationarity in price series and lag length, we applied the Johansen Cointegration Test to investigate cointegration among prices of pigeon pea in selected markets. We assume that all the variables (price series) are stationary at the first difference [I (1)] and based on the VAR model and one lag is used while performing the model.

The Johansen Cointegration Test gives results for two types of statistics. These are Trace statistics and Maximum Eigenvalue statistics. We set the hypothesis for Johansen Cointegration Test as the null hypothesis (Ho) is that all the markets are not integrated and the alternative hypothesis (H1) is that all the markets are co-integrated. The test

results have been interpreted by applying the results of trace statistics and maximum of eigen values. If the value of these Tests is more than the critical value of 0.05 percent, the null hypothesis will be rejected.

Table 3. 4: Results of Johansen Cointegration Test

Hypothesis e d No. of CE(s)	Trace Statistics				Maximum Eigen Value			
	Eigenvalue	Trace Statistic	Critical Value (0.05)	Prob.**	Eigenvalue	Trace Statistic	Critical Value (0.05)	Prob.**
$r=0^*$	0.420	516.37	197.37	0.000	0.420	129.82	58.43	0.000
$r \leq 1^*$	0.360	386.55	159.53	0.000	0.360	106.24	52.36	0.000
$r \leq 2^*$	0.260	280.31	125.62	0.000	0.260	71.77	46.23	0.000
$r \leq 3^*$	0.232	208.55	95.75	0.000	0.232	62.97	40.08	0.000
$r \leq 4^*$	0.209	145.57	69.82	0.000	0.209	55.94	33.88	0.000
$r \leq 5^*$	0.166	89.63	47.86	0.000	0.166	43.21	27.58	0.000
$r \leq 6^*$	0.114	46.42	29.80	0.000	0.114	28.73	21.13	0.004
$r \leq 7^*$	0.065	17.69	15.49	0.023	0.065	15.90	14.26	0.027
$r \leq 8$	0.007	1.78	3.84	0.182	0.007	1.78	3.84	0.182
Note(s): Trace test and Maximum Eigen Value tests indicates 8 cointegrating eqn(s) at the 0.05 level								
*denotes rejection of the hypothesis at the 0.05 level								
** Mac								

Source: DMI, Agmarknet portal, GoI (2024)

The results of trace statistics and maximum eigen value tests indicate that eight pigeon pea markets are integrated (Table 3.4). The Trace and maximum Eigenvalues are greater than the critical values at 0.05 percent level. Hence, we can reject the null hypothesis and accept the alternative hypothesis that the markets are cointegration. A long-run relationship may exist between pigeon pea prices in selected markets. The studies by Horo et al. (2019) and Wavdhane et al. (2019) found similar results. The prices will adjust over time and equilibrium exists in the long run. Hence, we can conclude that pigeon pea markets in India are highly integrated.

The normalized cointegrating equation of Johansen Cointegration Test represents the long-run relationship between variables. The study assumed that the price series of Latur market is a dependent variable and the price series of other markets are independent variables (Table 3.5). Prices in Akola, Amaravati, Kalaburagi, Pipariya, and Gadawara markets have a positive and significant impact on the prices of pigeon pea in Latur market in the long run. It means an increase in prices of pigeon pea in these

markets leads to an increase in prices in Latur market. On the other hand, in the case of Bidar, Raichur and Jabalpur market price series, it has a negative and significant impact on Latur prices in the long run.

3.4.6 Results of Vector Error Correction Model (VECM)

The speed of adjustment among variables is measured through the Vector Error Correction Model (VECM) in the short run. Results of Johansen Cointegration Test show that the prices in spatially located markets are co-integrated and have a long-run relationship. If the long-run associations between variables are found, then the VECM is used to test the short-run relationship between price series. Further, it is applied to know the speed of adjustment among prices and the tendency to reach equilibrium. After performing and confirming the long-run cointegration from Johansen Cointegration Test to know the short-run disequilibrium and the speed of adjustment, the VECM was applied. The Error Correction Terms (ECT) show the speed of adjustment while coefficient values show how the prices quickly return to their equilibrium level (Table 3.5).

The short-run equation of VECM (Table 3.5) shows that the coefficient value is negative (-0.05) but not significant in the case of Latur market. This means that it takes time to return to its original level in the short run. This may be due to it being a price setter or price discovery occurring in it. However, while conducting the field survey and discussion with value chain actors (traders, commission agents and processors) in Latur, it was confirmed that the market is known as the national market for pigeon pea and the price in it gets transmitted in the other markets in the country. Also, the market players in other markets consider this as reference prices. In the case of Akola market, the coefficient value is negative and statistically significant. Prices in Akola recovered by around 47 percent within a month.

Table 3. 5: Results of short-run equation of VECM

Error Correction:	D(LATUR)	D(AKOLA)	D(AMRAVATI)	D(BIDAR)	D(KALABURAGI)	D(RAICHUR)	D(PIPARIYA)
CointEq1	-0.056723	0.359936	0.417800	0.372304	0.420276	0.145625	0.189648
	(0.12800)	(0.11827)	(0.13769)	(0.12094)	(0.13558)	(0.12741)	(0.12703)
	[-0.44316]	[3.04333]	[3.03431]	[3.07834]	[3.09984]	[1.14298]	[1.49290]
CointEq2	-0.015652	-0.472005	0.243971	0.065963	0.202238	-0.200468	0.170524
	(0.19547)	(0.18061)	(0.21027)	(0.18469)	(0.20705)	(0.19457)	(0.19400)
	[-0.08008]	[-2.61335]	[1.16026]	[0.35715]	[0.97678]	[-1.03033]	[0.87901]
CointEq3	0.241852	0.040048	-0.503416	0.238619	0.101362	0.196944	0.261203
	(0.15618)	(0.14431)	(0.16801)	(0.14757)	(0.16543)	(0.15546)	(0.15500)
	[1.54857]	[0.27752]	[-2.99639]	[1.61698]	[0.61271]	[1.26685]	[1.68515]
CointEq4	-0.044220	-0.090581	-0.112004	-0.829517	-0.212918	-0.565203	0.031066
	(0.16367)	(0.15124)	(0.17607)	(0.15465)	(0.17337)	(0.16292)	(0.16244)
	[-0.27017]	[-0.59894]	[-0.63613]	[-5.36371]	[-1.22811]	[-3.46918]	[0.19124]
CointEq5	-0.113279	-0.066252	-0.163320	0.039918	-0.535601	0.364241	-0.252906
	(0.16912)	(0.15627)	(0.18193)	(0.15980)	(0.17914)	(0.16834)	(0.16784)
	[-0.66983]	[-0.42397]	[-0.89772]	[0.24981]	[-2.98991]	[2.16374]	[-1.50680]
CointEq6	-0.063605	-0.024564	-0.060537	-0.062317	-0.128728	-0.283630	0.019387
	(0.06590)	(0.06090)	(0.07090)	(0.06227)	(0.06981)	(0.06560)	(0.06541)
	[-0.96512]	[-0.40338]	[-0.85387]	[-1.00072]	[-1.84400]	[-4.32355]	[0.29641]
CointEq7	0.102437	0.123952	0.051134	0.260822	0.169095	0.416158	-0.638504
	(0.12348)	(0.11410)	(0.13284)	(0.11668)	(0.13080)	(0.12292)	(0.12256)
	[0.82955]	[1.08634]	[0.38494]	[2.23538]	[1.29277]	[3.38570]	[-5.20993]
CointEq8	0.064931	0.270041	0.318589	-0.010070	0.132698	-0.142582	0.161050
	(0.11134)	(0.10288)	(0.11978)	(0.10521)	(0.11794)	(0.11083)	(0.11051)
	[0.58316]	[2.62477]	[2.65986]	[-0.09572]	[1.12513]	[-1.28649]	[1.45740]
C	22.09623	22.97908	23.19247	22.24268	22.58996	23.08368	22.49791
	(23.5039)	(21.7178)	(25.2842)	(22.2086)	(24.8963)	(23.3958)	(23.3270)
	[0.94011]	[1.05808]	[0.91727]	[1.00154]	[0.90736]	[0.98666]	[0.96446]
R-squared	0.038082	0.079519	0.097119	0.233979	0.124651	0.304942	0.135094

Adj. R-squared	0.004624	0.047503	0.065715	0.207335	0.094204	0.280766	0.105011
Sum sq. resides	30367246	25927325	35141699	27112363	34071933	30088499	29911815
S.E. equation	363.3614	335.7492	390.8836	343.3363	384.8881	361.6899	360.6264
F-statistic	1.138208	2.483686	3.092526	8.781632	4.094057	12.61346	4.490624
Log likelihood	-1743.539	-1724.650	-1760.989	-1729.991	-1757.295	-1742.438	-1741.734
Akaike AIC	14.66560	14.50754	14.81163	14.55223	14.78071	14.65638	14.65049
Schwarz SC	14.79652	14.63845	14.94254	14.68314	14.91162	14.78729	14.78140
Mean dependent	22.09623	22.97908	23.19247	22.24268	22.58996	23.08368	22.49791
S.D. dependent	364.2044	344.0195	404.3968	385.6337	404.4077	426.4826	381.1962
Determinant resid covariance (dof adj.)	8.36E+40						
Determinant resid covariance	5.92E+40						
Log likelihood	-14270.98						
Akaike information criterion	120.7027						
Schwarz criterion	122.9282						

Source: DMI, Agmarknet portal, GoI (2024)

In Amravati and Kalaburagi markets, the coefficient values are negative and significant. The prices of pigeon pea in these markets were adjusted to their equilibrium of 50 percent and 53 percent respectively in a month. The highest price recovery was in Bidar (82%) in the short run, while the lowest recovery was in Raichur Market (28%). It is estimated to take around three months to adjust to the equilibrium level. It may be due to the distance between markets. Lastly, a 63 percent recovery was in Pipariya Market. The minimum coefficient values 28 percent (Raichur) to a maximum of 82 percent (Bidar) took place in pigeon pea markets in the short run.

According to the study by Grace et al. (2013), the error correction coefficient values were between 0.11 to 0.28 percent in the short-run in pigeon pea markets in India. The present study shows that an improvement in the speed of adjustment in the prices may be due to recent government policies or technological development. All the markets are well integrated in the long run, an indicator of market development.

3.4.7 Results of Pair-wise Granger Causality Tests

Granger Causality Test is applied to understand the directions of price transmission among selected pigeon pea markets after performing Johansen Cointegration Test and VECM Test. The presence of a bidirectional causal relationship means both markets transmit price information to each other. However, unidirectional price transmission indicates that the price of only one market transmits to the other one but not the other one (Saha et al., 2021).

Table 3.6 shows the results of the Granger Causality Test for pair-wise causality among prices of pigeon pea. All the selected markets are cointegrated with one another and the significant F-statistic and probability values show the rejection of the null hypothesis. The results show that the Latur market price Granger cause to change in Pigeon prices in Akola, Bidar, Kalaburagi, Raichur, Pipariya, Jabalpur, and Gadawara markets. However, in this case, all these markets do not cause a change in Latur market prices. The results indicate the unidirectional price transmission among these markets. Likewise, Akola market price causes change in prices in Amravati, Bidar, Kalaburagi, Raichur, Pipariya and Gadawara markets.

Table 3. 6: Results of Granger Causality Tests - Unidirectional Price Influence

Sr. No.	Null Hypothesis:	F-statistic	Sr. No.	Null Hypothesis:	F-statistic
1	Latur → Akola	7.38249*	14	Amravati → Bidar	45.6356*
2	Latur → Bidar	39.2575*	15	Amravati → Kalaburagi	11.3362*
3	Latur → Kalaburagi	10.1552*	16	Amravati → Raichur	66.1233*
4	Latur → Raichur	52.9510*	17	Amravati → Pipariya	22.9994*
5	Latur → Pipariya	16.3628*	18	Jabalpur → Amravati	9.57926*
6	Latur → Jabalpur	4.77109*	19	Amravati → Gadawara	17.7818*
7	Latur → Gadawara	15.8835*	20	Kalaburagi → Bidar	28.6889*
8	Akola → Amravati	7.43866*	21	BIDAR → RAICHUR	33.5645*
9	Akola → Bidar	31.4565*	22	Kalaburagi → Raichur	56.4333*
10	Akola → Kalaburagi	8.63561*	23	Jabalpur → Kalaburagi	6.80613*
11	Akola → Raichur	54.5666*	24	Kalaburagi → Gadawara	10.0687*
12	Akola → Pipariya	23.9731*	25	Jabalpur → Pipariya	16.5461*
13	Akola → Gadawara	24.5345*	26	Jabalpur → Gadawara	32.1765*

Source: DMI, Agmarknet portal, GoI (2024).

Note: → indicates does not Granger Cause, * denotes the significance at 0.05 % using p-value.

Correspondingly, Amravati market price Granger causes the market prices of Bidar, Kalaburagi, Raichur, Pipariya, Jabalpur and Gadarwara. Furthermore, Kalaburagi market price Granger causes Bidar, Raichur and Gadarwara market price. Similarly, Bidar market price Granger cause to Raichur market price. Also, Jabalpur market price Granger cause Kalaburagi, Pipariya and Gadarwara prices of pigeon pea. Thus, the study shows high cointegration across the selected markets of pigeon pea in India. However, some markets show that bidirectional prices influence each other. Results of bidirectional influence obtained from the Granger Causality Test are presented in Table 3.7.

Table 3. 7: Results Granger Causality Tests - Bidirectional Price Influence

Sr. No.	Null Hypothesis:	F-statistic	Sr. No.	Null Hypothesis:	F-statistic
1	Amravati → Latur	4.09650*	6	Pipariya → Kalaburagi	8.89090*
	Latur → Amravati	7.68789*		Kalaburagi → Pipariya	11.1730*
2	Jabalpur → Akola	5.17202*	7	Pipariya → Raichur	73.5509*
	Akola → Jabalpur	5.87804*		Raichur → Pipariya	6.90508*
3	Pipariya → Bidar	30.3754*	8	Jabalpur → Raichur	37.3264*
	Bidar → Pipariya	11.4072*		Raichur → Jabalpur	8.56718*
4	Jabalpur → Bidar	13.3497*	9	Gadarwara → Raichur	56.5362*
	Bidar → Jabalpur	7.37713*		Raichur → Gadarwara	8.34110*
5	Gadarwara → Bidar	15.5154*	10	Gadarwara → Pipariya	8.11589*
	Bidar → Gadarwara	12.4458*		Pipariya → Gadarwara	10.4867*

Source: DMI, Agmarknet portal, GoI (2024)

Note: → indicate does not Granger cause, * denote the significance at 0.05 % using p-value. The results of pair-wise Granger Causality Tests of bidirectional influence are presented in Table 3.7 indicating that price transmission between market pairs such as Latur - Amravati, Jabalpur - Akola, Pipariya - Bidar, Jabalpur - Bidar, Gadarwara - Bidar, Pipariya - Kalaburagi, Pipariya -Raichur, Jabalpur - Raichur, Gadarwara - Raichur and Gadarwara - Pipariya are bidirectional. In other words, prices in the former market Granger cause price formation in the latter market and vice-versa. In short, pigeon pea markets are closely linked with one another and price signals are transmitted in the markets. It indicates that the markets are co-integrated and that the price change in one market influences the prices in other markets. Similar results are found by Horo (2019) and Wavdhane et al., (2019).

Table 3. 8: Results of Pairwise Granger Causality Tests

Sr. No.	States	Markets	Maharashtra			Karnataka			Madhya Pradesh		
			Latur	Akola	Amravati	Bidar	Kalaburagi	Raichur	Gadarwada	Jabalpur	Pipariya
1	Maharashtra	Latur		→	↔	→	→	→	→	→	→
		Akola	→		→	→	→	→	→	↔	→
		Amravati	↔	→		→	→	→	→	→	→
2	Karnataka	Bidar	→	→	→		→	→	↔	↔	↔
		Kalaburagi	→	→	→	→		→	→	→	↔
		Raichur	→	→	→	→	→		↔	↔	↔
3	Madhya Pradesh	Gadarwada	→	→	→	↔	→	↔		→	↔
		Jabalpur	→	↔	→	↔	→	↔	→		→
		Pipariya	→	→	→	↔	↔	↔	↔	→	
↔ Denotes the bidirectional causality						→ Denotes the Unidirectional causality					

Source: DMI, Agmarknet portal, GoI (2024)

Table 3.8 presents the results of the Granger Causality test for pairwise causality among prices of Pigeon pea. The selected markets under study are cointegrated, and the unidirectional and bidirectional price transmission were observed among these markets. All pairwise Granger causality results were found to be statistically significant.

3.5. Conclusion and Policy Implications

Market cointegration is one of the important indicators of market performance and to understand whether the price signals are transmitted from one market to another in spatially distributed markets. Market integration is essential for farmers to get higher farm-gate prices (GoI, 2017). The absence of spatial market integration has a significant influence on the economic welfare of the society (Rapsomanikis, et al.2001, Barrett and Li, 2000). Hence, it is important to have cointegration across the markets in the long run for price stabilization. India is the largest producer of pigeon pea which is an important crop in food and nutritional security. The present study examines the market integration of pigeon pea in India. Their monthly wholesale prices in nine markets in Maharashtra, Karnataka and Madhya Pradesh were examined in the study.

The study found that its prices exhibit an increasing trend and the correlation between prices is high. The coefficient of variation is between 46 to 48 percent in the markets. The monthly wholesale price series of pigeon pea are found to be unit root at level and stationary at the first difference level. Since variance and coefficient values in price series seem to be uniform and promising markets are well integrated in terms of prices. We used a formal test of market cointegration. Since the markets selected for the study are within a country and adjoining states, the data of monthly maximum lag of one month is to be considered in the formal analysis I (0) lag, i.e., for the first difference data. The Johansen Multivariate Cointegration Test is used in the study to examine market integration.

The study findings show that the trace test and maximum eigen value test indicate eight cointegrating equations at the 0.05 level for selected markets, indicating that markets are highly integrated. The results further show that the speed of adjustment in prices varied from market to market in the short run. The results of VECM for the short-run show that any disequilibrium in prices adjusted 28 to 82 percent within a month and the results are significant. However, Grace et al. (2013) found that the price adjustment speed was 11 to 28 percent. The study shows development in the speed of adjustment in prices of pigeon pea in the country.

The markets are closely linked with one another and prices have bi-directional and unidirectional influence across the selected markets. Results of the pair-wise Granger Causality Test found that Latur market price change in prices of Akola, Bidar, Kalaburagi, Raichur, Pipariya, Jabalpur and Gadawara markets. Most markets under the study found unidirectional price transmission except the market pairs such as Latur - Amravati, Jabalpur - Akola, Pipariya - Bidar, Jabalpur - Bidar, Gadawara - Bidar, Pipariya -Kalaburagi, Pipariya - Raichur, Jabalpur - Raichur, Gadawara - Raichur and Gadawara - Pipariya which indicates the bidirectional price influence on one another. Hence, the study indicates that the markets are cointegrated and a long-run association exists among them. So, the law of one price may exist at a broader level in the case of pigeon pea wholesale prices in India. Also, we applied Bai-Perron Multiple Breakpoint Test to identify the structural breaks in

the time series, and the tests results indicate the presence of breaks in the price series at level and trend in the month of November 2016, for all the markets, excepts Raichur market indicate the break in December 2016. However, the Johansen Cointegration and VECM results continue to support the existence of long-run market integration. The limitation of the present study is that the results rely on only price series data and are limited to nine markets. It will provide important insights to actors involved in the pigeon pea value chain so that they can make better decisions about trading.

The results can be useful to the government/policymakers in framing policy regarding price stabilization. The government can use any of these market prices as a reference to frame the price stabilization policies and disseminate price information to the farmers. Though the markets are integrated, state-wise policy can be uniform. There is no need for separate policies required for each state. Future research may focus on determinants of market integration of pigeon pea.

CHAPTER 4: VALUE CHAIN ANALYSIS OF PIGEON PEA

4.1 Introduction

Pigeon pea (*Cajanus Cajan L.*) is one of the important grain legume crops after chickpea in India. It plays a significant role in nutritional food security (20-22% protein content) and improving soil fertility through nitrogen fixation in the country (Sarkar et al., 2018; Singh et al., 2020; Jorin et al., 2021; Babu et al., 2017). It is also used as food, fodder, feed and fuel (GoI, 2017; Harshitha et al., 2020). It is grown in semi-arid areas and tropical regions worldwide (Sah et al., 2022). Pigeon pea is grown in 19 countries; however, six countries (India, Myanmar, Malawi, Tanzania, Uganda, Kenya and Haiti) produce 98 percent of the total (GoI, 2017). India is the world's major producer, consumer, and importer of pigeon pea. It accounted for 79 percent of global production and 92.65 percent of global import in 2021 (GoI, 2024). The country imported 7.71 lakh tonnes pigeon pea during the financial year 2023-24 (GoI, 2024). In 2021-22, the area under it was 5.05 million hectares with production of 4.34 million tonnes, which was 17 percent of the total production of pulses in the country (GoI, 2023). Maharashtra is the leading pigeon pea-producing state in the country, contributing a 30.76 percent share in the total production, followed by Karnataka (28.68%), Uttar Pradesh (6.89%) and Madhya Pradesh (6.62%) (GoI, 2023).

The area under pigeon pea in Maharashtra increased slowly from 10.74 lakh hectares in 2004-05 to 11.12 lakhs in 2023-24 with year-to-year fluctuation, and the compound annual growth rate (CAGR) in the area under pigeon pea in Maharashtra is 0.17 percent, which shows that the area grew very slowly over the year (Government of Maharashtra (GoM), 2024). Its production varied significantly over the years from 2004-05 to 2023-24. The CAGR of production is 1.54 percent which shows that production increased steadily over the years despite wide fluctuations (GoM), 2024). Marathwada and Vidarbha are the leading regions of pigeon pea production in Maharashtra, both together accounting for more than 60 percent of the total area and production of pigeon pea. It is an important crop for the economic well-being of the small and marginal farmers in the studied area. Variability in the yield, climate change, low market linkages, price fluctuations, lack of technical knowledge and limited government support are significant challenges faced by the farmers.

On the other hand, long and fragmented value chains, inadequate storage facilities, inefficient markets, high post-harvest losses, lack of transport facilities and limited value addition are major value chain issues. Therefore, a comprehensive analysis of the value chain of pigeon pea is required to know the complete mapping of the value chain which will help pigeon pea value chain stakeholders to make marketing and policy decisions. The value chain concept was introduced first in 1985 by Porter and the term 'value chain' used to 'describe a series of value-adding activities including value-creation opportunities through primary and support activities' (Porter, 1985). Porter distinguished two important components of the value chain, i.e., primary activities (inbound logistics, operations, outbound logistics, marketing and sales, and services), and support activities (strategic planning, human resource management, technology development, infrastructure and procurement). The term value chain defines "the full range of activities that are required to bring a product or service from conception through the different phases of production, delivery to final consumers and final disposal after use, which includes all the activities such procurement of raw materials, seed and inputs aggregation, assembly, transformation, transport and other services, and finally consumers" (Kaplinsky and Morris, 2002; Hellin and Meijer, 2006). Value chain analysis is an important tool to investigate the relationship between different players in a given industry (Zamora, 2016). The markets are inefficient due to multi-layers of intermediaries in the value chain of pulses, and marketing costs vary in different marketing channels in India (Shalendra, 2012). The pulses value chain is long and complex, and several actors are involved playing specific roles (Sah et al., 2021). Also, the farmers' share in consumer rupee is 65 percent in the case of pigeon pea which is low as compared with chickpea (75%) and moong (70%) in India (Jose et al., 2024). Access to finance, lack of market intelligence at farmers' level, infrastructure, non-availability of processing units, low market efficiency, long marketing chain, high-profit margin of intermediaries, knowledge of new technology, branding and market access are key issues in value chain (Kumar and Sharma, 2016; Sah et al., 2021).

Therefore, the present study focuses on the complete mapping of the value chain of pigeon pea in Maharashtra. It analyzes the price spread across its value chain and activities carried out at each stage, the intermediaries involved, identify the marketing channels in the studied area and farmers' share in the consumer rupee. The empirical findings would help

the farmers and other value chain actors to make marketing decisions, gain better returns and knowledge about value addition, and prepare policy interventions to improve the performance of the value chain of pigeon pea.

4.2 Literature Review

The literature on value chain analysis of agricultural commodities has been reviewed and presented in this section. A simple value chain refers to the actors which manage a product as it moves through it including input suppliers, farmers, traders, processors, transporters, wholesalers, retailers and final consumers (Hellin and Meijer, 2006). Their involvement in performing value-adding activities has remained important to the value chain definition (Kaplinsky and Morris, 2002). FAO (2013) defines a value chain as a set of “interdependent economic activities” and a “group of vertically linked economic agents”. The Food and Agriculture Organization (FAO, 2014) states that the value chain is a distinct and complex concept required to understand its structure, conduct and performance and it helps to know the advantages and disadvantages of firms and countries specializing in production rather than services and how producers are connected to final markets which may influence their ability to gain from participating in markets (*Ibid.*, 2014). Over time, several frameworks, guidelines and approaches have been designed and formulated by both national and international institutions such as the FAO, UNDP, ILO, World Bank, etc. These guidelines and methodologies are used to enhance the performance of the value chain across firms, commodities as well as different sectors. A value chain typically begins with the production of a primary commodity and ends with the consumption of the final product, including all the economic activities undertaken between phases such as processing, delivery, wholesaling and retailing (FAO 2013; Pavithra et al., 2018,). The concept originated from the supply chain and it explains the value created at each chain stage, integral to satisfying the consumer's needs (Kumar and Sharma, 2016). Thus, as Gilbert (2008) observes, value chain analysis extends traditional supply chain analysis by assigning values to each stage within the chain.

The value chain analysis comprises both qualitative and quantitative approaches. Hellin and Meijer (2006) advocate initiating the analysis with a qualitative approach which is followed by semi-structured interviews, focus group discussions and questionnaires. This

approach will help understand the different value chain actors and their interactions within the value chain. Likewise, value chain mapping technique is widely used in analyzing the value chain of agricultural commodities. A value chain map is the visual representation of the flow of products from farmers to final consumer, actors involved, activities undertaken, role of various actors, value creation and profit earned by actors at each stage (Pavitra et al., 2018; Udhayan et al., 2023, Mohapatra and Ramadas., 2022, Reddy, 2013). Recently Ganguly and Gulati (2022) used mapping techniques to analyze the value chain of pulses in the context of competitiveness, access to finance, inclusiveness, scalability and sustainability.

Several studies have identified the major challenges within India's pulses value chain which includes long marketing channel, presence of multiple actors and intermediaries high marketing costs, low farmers' share in the consumer rupee, low marketing margin, lack of adoption of technologies, lack of market access and inadequate infrastructure (Shalendra, 2012; Kumar and Sharma, 2016; Sah et al., 2022, Ganguly and Gulati, 2023, and Reddy, 2013).

Most studies focus on the value chain analysis of cereals, fruits and vegetables with limited attention given to pulses, especially pigeon pea in terms of assessing the value addition, price spread at each stage and farmers' share in consumer rupees. To address this gap, the present study undertakes a comprehensive analysis of the value chain of pigeon pea. This is the first study that covers all the actors involved in the value chain. It aims to map the flow of pigeon pea from the farmer to the final consumer, actors involved in the value chain, examine the value distributed across the chain, quantifying price spread and examine the farmer's share in consumer rupee.

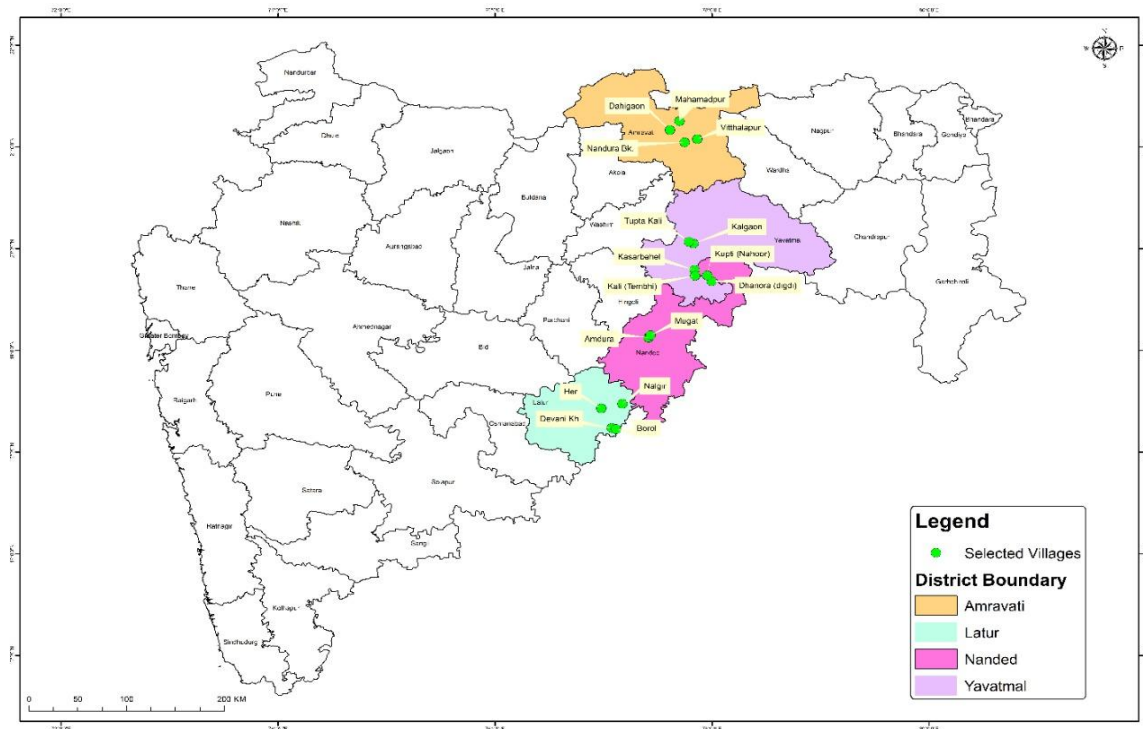
4.3 Data and Methodology

The present study uses both primary and secondary data. The qualitative and quantitative data were collected through field survey and secondary data from various sources to map the value chain. Details of the studied area, sampling procedure and analytical techniques used are presented below.

4.3.1 Study Area

Maharashtra ranks first in both area and production of pigeon pea in India and accounted for 30.84 percent share in pigeon pea production in 2021-22 (GoI, 2023). Hence, we selected Maharashtra for the field work. The field survey was carried out in four major districts of two regions in Maharashtra: Latur and Nanded from Marathwada and Yavatmal and Amravati from Vidarbha. Figure 4.1 shows the districts and villages selected for the study.

Figure 4. 1: Map of districts and villages selected for the study



4.3.2 Sampling

A mixed design of the multi-stage stratified and convenient sampling methods was used to select the location and value chain actors for the study. Marathwada and Vidarbha were selected by applying twin criteria: the highest area under pigeon pea and its production. The top two districts were selected using the same criteria from each selected region. Thus, all four leading districts were chosen. Further, from each selected district, two top talukas/ blocks were short-listed, identifying eight talukas/ blocks. From each selected taluka/ block, two villages were selected totaling sixteen villages. A list of pigeon pea growers was prepared during a field survey of each selected village, and 35 farmers were selected

randomly from each selected village. Thus, a sample of 560 farmers was drawn and data regarding activities performed during marketing channels, price received, marketing and production costs, and storage was collected through semi-structured questionnaires in the study.

Apart from this, the pigeon pea value chain actors such as commission agents/traders, processors, wholesalers and retailers, were selected by using the random sampling method from available lists with APMC offices. A sample of eight commission agents/traders, processors, wholesalers and retailers was drawn from each selected district. Thus, 32 commission agents/traders, 32 processors, 32 wholesalers and 32 retailers were chosen. On the other hand, other value chain actors like two transporters and FPCs were selected from each district, thus eight transporters and farmer producers' companies (FPCs) each were covered under the study. A tabulation of the sample covered is presented in Table 4.1.

4.3.3 Data Collection and Analysis:

Data for the present study is drawn from both primary and secondary sources. The primary data is collected through field survey which was conducted during October 2021-March 2022. The data on marketing, processing, storage, transportation operations, price received, marketing, production cost and challenges faced by pigeon pea farmers, etc., have been collected through interviews using semi-structured questionnaires and has been used for the analysis. Likewise, data on activities performed by value chain actors during trading, processing, storage, transportation, value additions and prices received were collected using checklists from other value chain actors covered in the study. Also, necessary secondary data of area, production and yield of pigeon pea were collected from published sources such as *Agricultural Statistics at Glance*, MoA & FW, Ministry of Food Processing Industries (MoFPI), Government of India, website of Department of Agriculture, Government of Maharashtra.

Value chain mapping: Mapping techniques were used to visualize the flow of product and actors involved in the value chain of pigeon pea. This helps to identify different activities performed by actors and value addition at each value chain stage (Reddy, 2013; Sah *et al.*, 2022).

Subsequently, for measuring price spread at each stage and the farmers' share in consumer rupees, the quantitative analytical method was used. The analysis was carried out by using the following formulas. Also, marketing channel-wise results of price spread and farmers' share in consumer rupee are presented in the study.

Farmers' share in consumer rupees: Farmers' prices are calculated by dividing the price paid by the consumers by a hundred (Acharya and Agarwal, 2016). It is expressed in percentage (%). The formula used for the calculation is expressed as

$$Fs = Pf/Pc*100$$

where,

Fs =Farmers' share in consumer rupees

Pf= Farmers' price (Rs/quintal)

Pc= Price paid by the consumers (Rs/quintal)

Price spread: It is calculated as the consumers' price minus farmers' prices. It is expressed in absolute terms (Acharya and Agarwal, 2016).

$$Ps= Cp -Fp$$

where,

Ps= Price spread

Cp= Consumers' price (Rs/quintal)

Fp= Farmers' price (Rs/quintal)

Table 4. 1: Sample covered in the study

Sr. No	Particulars	Latur Division		Amravati Division		Total	Criteria used
1	Districts	Latur	Nanded	Amravati	Yavatmal	4	The highest area under the pigeon pea crop
2	Taluka	2	2	2	2	8	
3	Villages	4	4	4	4	16	
Value chain stakeholders							
4	Farmers	140	140	140	140	560	35 from each selected village, random selection from a list prepared at the time of the field survey
5	Commission agents	8	8	8	8	32	Eight from the nearest APMC markets in selected districts, random selection from available lists with APMCs
6	Processors	8	8	8	8	32	Eight from each selected district, random selection from a list prepared during field survey
7	Wholesalers	8	8	8	8	32	
8	Retailers	8	8	8	8	32	
9	Transporters	2	2	2	2	8	Eight from each selected district using the convenience method
10	FPCs	2	2	2	2	8	Two from each selected district from the available list and FPC dealing with pigeon pea crop

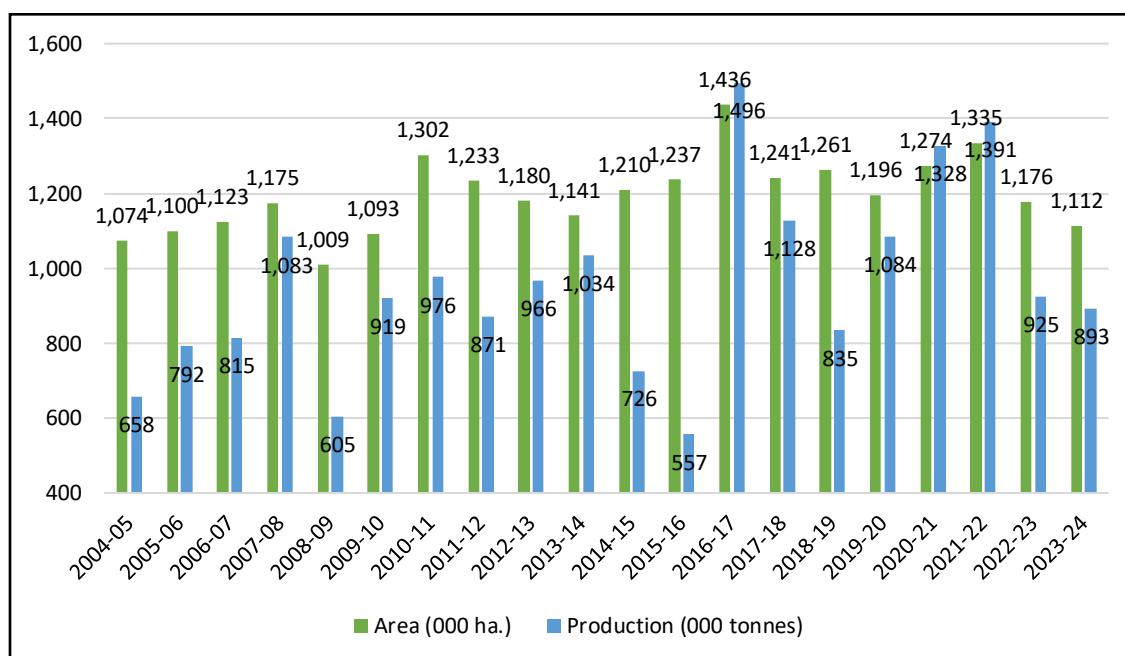
4.4 Results and Discussions:

This section represents the findings of empirical analysis with discussion in the context of research objectives of the study.

4.4.1 Area, Production and Yield of Pigeon pea in Maharashtra

The temporal analysis of the area and production of pigeon pea in Maharashtra from 2004-05 to 2023-24 is presented in Figure 4.2. It shows the wide fluctuation in area and pigeon pea production over the year. Production shows higher fluctuation than the area under pigeon pea. This may be due to the drought situation in some years (2014-15, 2018-19 and 2020).

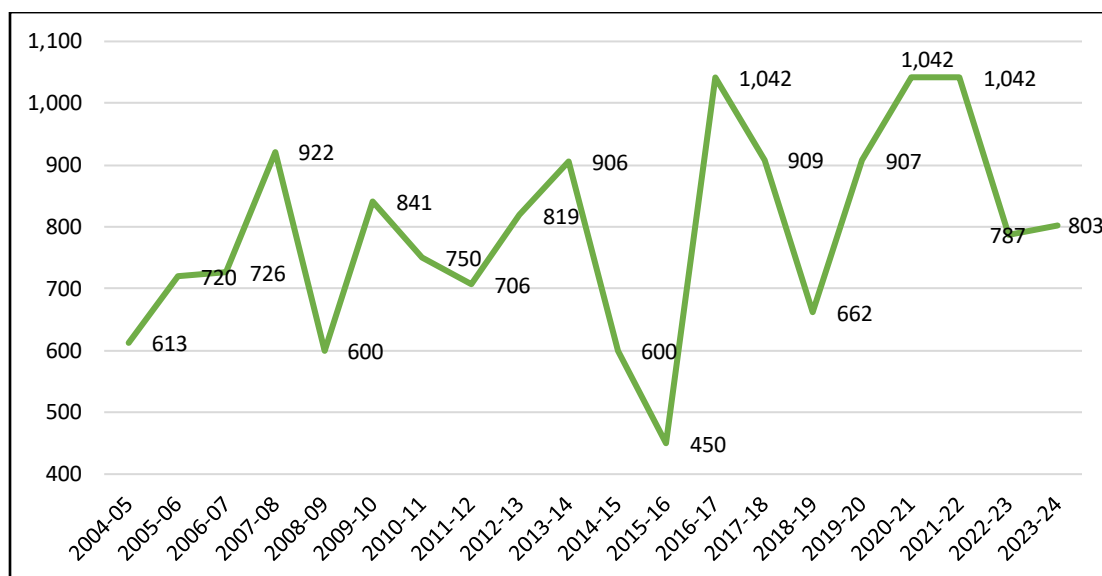
Figure 4. 2: Area and production of pigeon pea in Maharashtra



Source: Government of Maharashtra, Department of Agriculture (2024).

Figure 4.3 represents the year-wise yield of pigeon pea in the studied area. It seems to have wide fluctuations over time. In 2015-16 the yield of pigeon pea was lower due to the drought situation in the studied area.

Figure 4. 3: Yield of pigeon pea in Maharashtra (Kg/ha.)



Source: Government of Maharashtra, Department of Agriculture (2024)

4.4.2 Area, Production and Yield of Pigeon pea In Studied Districts

The average area, production and yield of pigeon pea in studied districts compared with Maharashtra state from 2016-17 to 2020-21 are presented in Table 4.2.

Table 4. 2: Average area, production and yield of pigeon pea in studied area

Sr. No.	Studied Districts	Area (00 ha.)	Production (00 tonnes)	Yield (Kg/ha.)
1	Latur	1098	1761	1604
2	Nanded	781	754	965
3	Amravati	1128	1148	1018
4	Yavatmal	1367	1247	912
Total (4 districts)		4374	4910	1123
5	Maharashtra State	13254	13302	1004
% to total		33.00	36.91	

Source: Government of Maharashtra. Department of Agriculture (2024)

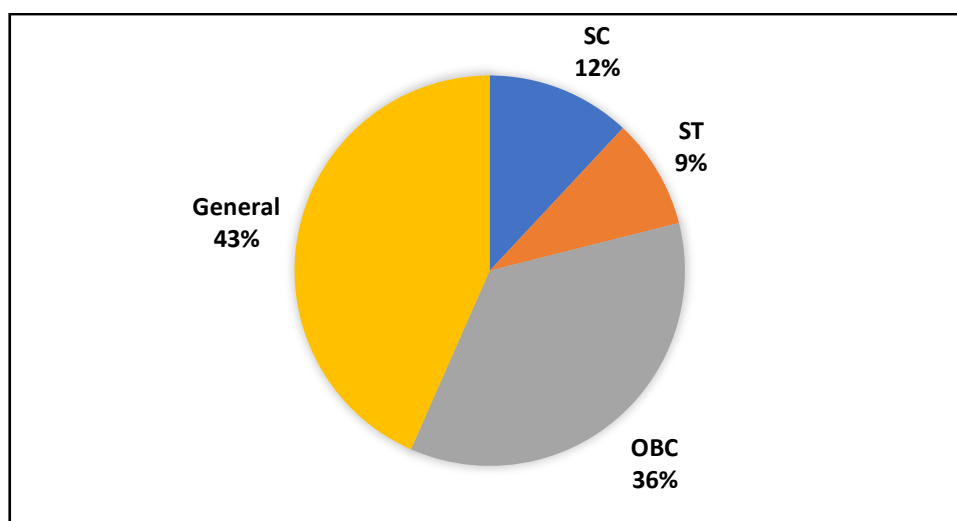
The total average area and production of pigeon pea in Maharashtra were 13,254 hundred hectares and 13,302 hundred tonnes from 2016-17 to 2020-21 respectively. The studied districts together accounted for 33 percent in the area and 36.91 percent in production of pigeon pea in Maharashtra (Table 4.2). The spatial variability is observed

in area, production, and yield. Yavatmal district had the highest area under pigeon pea cultivation. However, in the case of production, Latur district contributed the most to the total production in Maharashtra. The average yield (1123 kg/ha.) of pigeon pea in these four districts is higher than the state average yield (1004 kg/ha.). The highest average yield of pigeon pea was observed in Latur district (1604 kg/ha.) and lowest in Yavatmal district (912 kg/ha.). Despite having the highest area under pigeon pea in Yavatmal district, its yield is lower than that of other districts. The spatial variability observed in yield suggests that there is scope for improvement in the yield.

4.4.3. Socio-Economic Profile of the Sample Farmers

The average age of the farmer respondents was observed to be 47 years and the gender representations shows that 96.8 percent were male and 3.2 percent were female. Regarding the social categories of the farmer respondents, it is observed that 12 percent belong to the scheduled castes (SC), 9 percent to scheduled tribes (ST), 36 percent to other backward classes (OBC) and general 43 percent (Figure 4.4).

Figure 4. 4: Social categories of Sample farmers

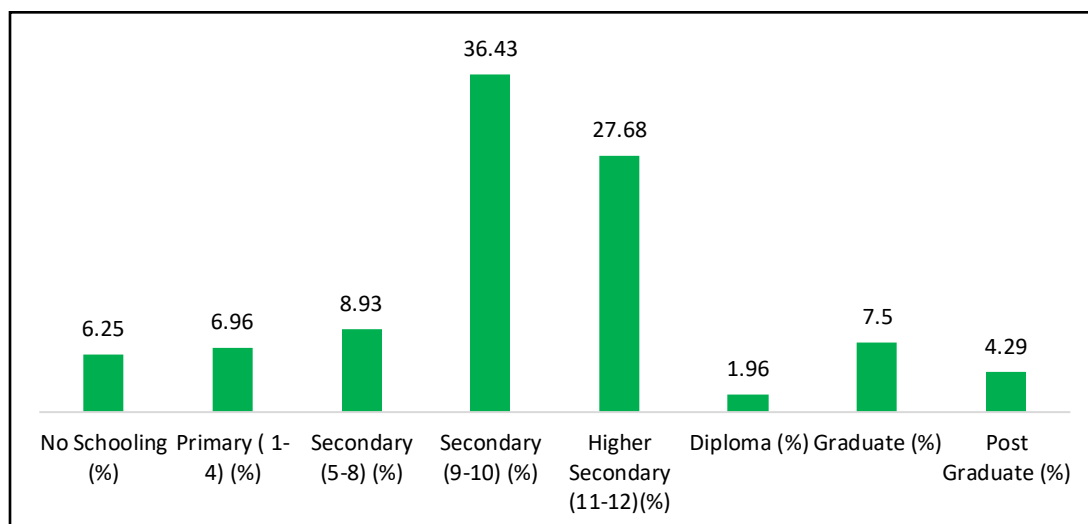


Source: Field survey.

In terms of educational level (Figure 4.5), only 6.25 percent respondents did not attend school, while 6.96 percent completed their primary schooling, 8.93 percent accomplished secondary schooling up to VIII class and 36.43 percent completed IX to X Class. Higher secondary education was completed by 27.68 percent respondents, while diploma and graduate degree education were obtained by 1.96 and 7.50 percent

respectively. Moreover, 4.29 percent respondents pursued post-graduate degrees. This suggests that most of the respondents are literate.

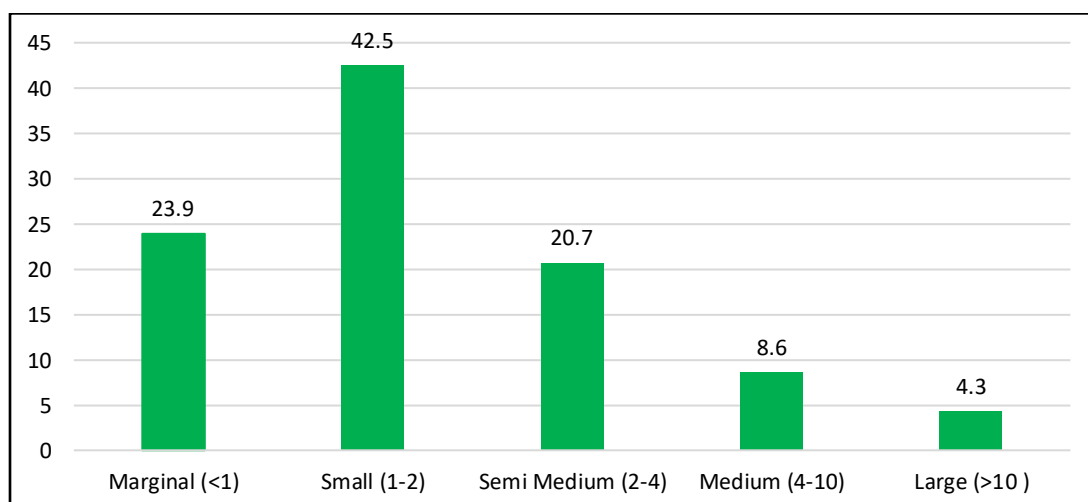
Figure 4. 5: Educational qualifications of sample farmers



Source: Field survey.

The landholding patterns of the farmers (Figure 4.6) show that 40.2 percent of them hold less than one hectare land, 26.8 percent hold 1-2 hectares land, 18.2 percent under semi-medium categories 2-4 hectares land and 11.3 percent under medium categories 4-10 hectares of land. Only 3.6 percent farmers hold more than 10 hectares of land. The average land holding size of farmer respondents is 1.6 hectares. However, *Agriculture Census, 2015*, the average landholding of the farmers in Maharashtra is 1.34 hectares (GoM, 2022).

Figure 4. 6: Land-holding pattern of sample farmers (%)



Source: Field survey.

The study also found that 23.93 percent of the farmer respondents are associated with various institutions, i.e., gram panchayats, self-help groups, farmers' producer organizations, etc. The annual average income of farmer households covered under study was Rs.1,06,000. However, according to the NSSO report (2019), the average monthly income of the agricultural households in Maharashtra was Rs.11,492 and Rs. 10,218 for all-India. If this is translated into annual average income, it becomes Rs. 137,904 in Maharashtra and Rs. 122,616 at all-India level. This shows that the annual average income of the farmers' households is lower as compared with the state as well as all-India.

4.4.4 Cost of Production and Net Returns of Pigeon pea

The average cost of production and net returns of pigeon pea in Maharashtra were calculated and the results are presented in Table 4.3. The average cost of pigeon pea cultivation in the studied area was Rs.18,129 per acre. Out of the total cultivation cost, the operational cost was Rs. 5835 per acre, including human labour (both family and hired), animal labour and machine. The total input cost of pigeon pea was Rs.5734 per acre. Its average yield was 4.79 quintals per acre. The farmer received an average price of Rs.5958 per quintal. Likewise, the average cost of production was Rs.3785 per quintal and the total gross income was Rs.28,539 per acre. However, according to the Commission for Agricultural Costs and Prices (CACP) report, the average cost of production (A2+FL) for pigeon pea was Rs. 3886 per quintal at all-India for 2022-23 (GoI,2021). The net return from producing pigeon pea was Rs.10,409 per acre. The benefit-cost ratio for pigeon pea cultivation was at 1.57, which indicates that the cultivation is profitable. The net return from pigeon pea cultivation is calculated using A2+FL cost concept developed by the CACP. These results align with the earlier study by Mane and Kale (2012) who found a BC ratio of 1.05 for pigeon pea in Maharashtra.

Table 4. 3: Cost of production and net returns of pigeon pea

Sr. No.	Costs	Sub-component	Particulars	Average expenses (Rs/acre)
1	A. Operational costs		Human labour (hired + family)	2521
			Animal labour (hired + owned)	1174
			Machine labour (hired + owned)	2140
			Total operational cost (A)	5835
2	B. Input cost		Seed	963
			Fertilizer	1397
			Manure	1042
			Pesticides (insecticide, fungicide, organic etc.)	2332
			Total input cost (B)	5734
	Working capital (A+B)			11569
	Irrigation charges			286
	Miscellaneous			189
	Fixed cost		Rent value of own land (Rs.)	4850
			Land rev. cesses/taxes	57
			Depreciation of farm bldgs. & implements	833
			Interest on fixed capital (6%)	344
	Total fixed cost (Rs. /acre)			6085
3	Total cost of cultivation (Rs. /acre)			18129
4	Average yield (quintal per acre)			4.79
5	Cost of production: Rs. per quintal			3785
6	Average price received (Rs. /quintal):			5958
7	Total gross income (per acre):			28,539
8	Net return/income (Rs. /acre):			10409
9	Benefit-cost ratio:			1.57

Source: Field survey.

4.4.5. Marketing of Pigeon pea

The marketing of pigeon pea involved various marketing channels from farmers to consumers. The results of where respondents are selling their produce, quantity sold, distance from farm to marketplace, mode of transport used for marketing, activities conducted by farmers before selling the pigeon pea, the price received by the farmers and reasons for selling produce to a particular purchaser, etc., are presented in Table 4.4.

Table 4. 4: Marketing of pigeon pea in the studied area

Sr. No.	Farmers' sale to	Number of farmers	Percent	Quantity sold (Quintal)	% to the total quantity	Reasons for selling produce to the particular purchaser
1	Commission agent/arhtiyas	497	88.8	3360	94.89	Credit, instant payment, trust
2	Farmers' producer companies	14	2.5	94	0.94	Nearest place, getting additional benefits
3	Processor	11	2.0	110	1.09	Timely payment
4	Village traders	18	3.2	142	1.41	Timely payment, credit
5	Government procurement centres	20	3.6	167	1.66	Received minimum support price (MSP)
	Total	560	100.0	3873	100.00	

Source: Field survey.

Note: Reasons for selling to particular purchasers reported other than better price received.

Most respondents (88.8%) sell pigeon pea to commission agents or traders in the APMC markets due to better prices, instant payment, credit facilities and services such as cleaning facilities. Similarly, 3.4 percent farmers sell to village traders, reporting timely payment and financial support. Additionally, 2.5 respondents sell pigeon pea to FPCs because FPCs are situated in the nearest place and also farmers get additional benefits such as cleaning/grading facilities, inputs and price information. Also, 3.6 percent respondents sell to the government procurement agencies (National Agricultural Cooperative Marketing Federation (NAFED)/ Small Farmers Agri Business Consortium (SFAC) /State) as and when the government procures the pigeon pea and when market prices are lower than MSP. Only around 2 percent farmers sell directly to the processors.

Additionally, access to the market is one of the important aspects of getting better prices and net return to the farmers. The average distance from the farm to the market place is 23 km. Most farmers used tractors (52.68%), followed by light motor vehicles (LMV) having capacity of 3 to 5 tonnes (36.07%), while very few used trucks (4.46%) for

transporting pigeon pea to the market. Also, most farmers sell their produce immediately after harvest, if the market prices are higher. However, 97 percent of farmers sell their produce individually, highlighting the scope for farmers' collectivization. In the case of post-harvest practices done at farmers' level, 67 percent of farmers clean their pigeon pea before selling them and the cleaning activities take place at various locations such as on the farm (12.23%), at the APMC market (74.82%), at the FPC facilities (2.15%) and at the storage place (10.79%).

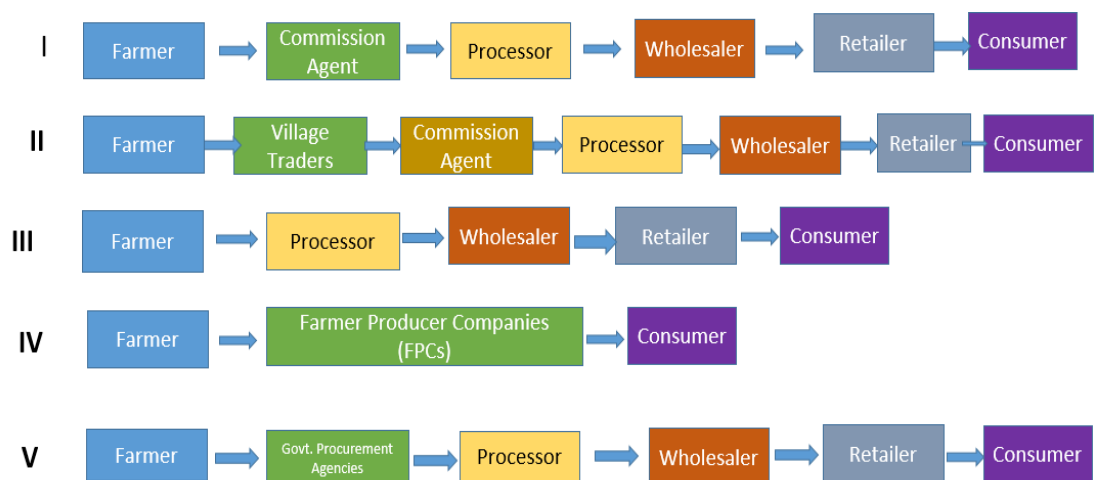
The respondents did not adopt the production of a ratooning of pigeon pea. This might be because of the lack of irrigation facilities required for such practices. Moreover, awareness about the marketing of green pigeon pods remains low with no respondent engaged in this activity. This suggests that promoting green pod marketing could provide farmers with an additional source of income, as there is demand for green pigeon pea pods in the urban market.

4.5.6 Marketing Channel Identified:

Marketing channels represent the routes of products flow from the farmers to the consumer (Kohls and Uhl, 1985). They vary from commodity to commodity. The respondents in the studied area were selling pigeon pea through using five major marketing channels. They are presented in Figure 4.7.

Multiple marketing channels exist with multiple intermediaries. Their multiple intermediaries range from one to five. However, channel IV was the shortest, involving only one intermediary (Figure 4.7).

Figure 4. 7: Marketing channels of pigeon pea



Source: Field survey.

4.5.7 Activities Performed by Actors Involved in The Value Chain

The actors involved perform various activities presented in Table 4.5.

Table 4. 5: Activities performed by value chain actors

Sr. No.	Stakeholders	Activities performed by value chain actors
1	Farmers	Production, harvesting, marketing of produce, packaging, storage, transport to market, loading and unloading.
2	Commission agents	Act as a facilitator between farmers and processors, provide cleaning and trading facilities, weighment, loading and unloading and provide price information.
3	Processors	Cleaning, drying, heating, de-husking, splitting, oil adding, drying, grading, packaging, storage and marketing of 'daal.'
4	Wholesalers	Grading, purchasing large quantities, packaging, branding and storage.
5	Retailers	Packaging, storage (small quantity) and selling dal to consumer.
6	Farmers' Producer Companies (FPCs)	Aggregation, cleaning, packaging, purchasing, processing, direct selling to consumers (dal), price information, participation in government procurement programme.
7	Village traders	Aggregation of produce and selling in the nearest market or processors/bulk buyers/agents.
8	Govt. procurement agencies (centres)	Provide cleaning and grading facilities, aggregation, storage, release and purchase at MSP.
9	Transporters	Transportation of produce from the farm to market and storage place, market to processing place, processing to storage place, at wholesalers' place and retailers' place.
10	Importers	Import of pigeon pea and selling it to agents and dal millers.

Source: Field survey.

4.5.8 Marketing Channels, Price Spread and Farmers' Share in Consumers' Rupees

Table 4.6 depicts the price spread, value addition, net returns, farmers' share in consumer rupees from selling pigeon pea through various marketing channels to the

farmers. The farmers realized a higher net return (Rs.2267 per quintal) while selling through channel III (i.e., farmers – processors – wholesalers – retailers - consumer), followed by channel IV (Rs.2202 per quintal). In contrast, the net return was lower in the case of channel II (Rs.1729 per quintal). This indicates that farmers using channels III and IV tend to get better net returns than those using other channels. However, channel I (i.e., farmer-commission agents/arhtiyas - processors – wholesalers – retailers - consumer) is the most popular with 88.8 percent farmers selling their produce through it.

Channel-wise price spread of pigeon pea varies between 35 to 55 percent. The highest price spread (55%) is in the marketing channel II (farmer - village traders - commission agents – processors – wholesalers - retailers - consumers). This might be because the number of intermediaries involved in this channel are higher than in other channels. Among the existing channels, the lowest price (35%) is in channel IV (farmers – farmers' producer company - consumer). This is because the number of intermediaries is less as compared with other marketing channels. The highest price spread at the processor level ranged from 16 to 34 percent in the marketing channels, which might be because of the higher processing and marketing cost of pigeon pea at the processor level, followed by the retailer level (13%) and wholesaler level (5%). The price spread at the village traders and commission agents' level was around 6 percent.

The presence of multiple actors and a wider price spread in the value chain reduces the farmers' share in the consumer rupees (Narasalagi and Ka, 2018). The present study also found multiple actors' involvement and wider price spread in the value chain. Therefore, the present study analyzes the farmers' shares in the consumer rupees. The farmers' share in the consumer's rupee is higher (74.16%) in the case of sale through marketing channel IV, i.e., the farmers' sale to FPCs. Also, farmers get additional benefits in terms of inputs and cleaning facilities from FPCs, followed by channel number III (70.73%) and channel V (68.92%). However, the lowest farmers' share in consumer rupees was in the case of channel II (farmers – village traders – commission agents – processors – wholesalers – retailers – consumers) due to higher number of intermediaries/actors (7) as compared with other channels. As per the RBI's study (2024), the farmers' share of the consumer rupee in the case of pigeon pea is 65 percent. These results are aligned with RBI's study.

4.6 Conclusion and Policy Implications

The present study focuses on the value chain analysis of pigeon pea in Maharashtra. It includes examination of cost of production, net returns and benefit -cost analysis, identifying the marketing channels, actors involved, activities carried out at each stage in the value chain, price spread at each stage and farmers' share in consumer's rupee in different marketing channels. The results show a high spatial variability in the yield of pigeon pea. Despite this, these districts contributed significantly to the total production of pigeon pea in Maharashtra. This highlights the scope for improvement in the yield. Most farmers (88.8%) sold their produce to commission agents/arthritis in the nearest APMC markets due to better price realization, trust, credit and instant payment, while few farmers sold their produce directly to the processors (2%), village traders (3.2%), Government procurement centres (3.5%) and FPCs (2.4%). A majority of farmers (97%) sell their produce individually, which indicates scope for aggregation of produce. At the same time, 67 percent respondents do cleaning before selling pigeon pea. The benefit-cost ratio of pigeon pea cultivation was 1.57. which is better than chickpea (1.53), as reported by Chavan et al. (2020).

The study found the existence of five major multiple marketing channels. Among them, the farmers using channel IV (farmer - producer company – consumer) realized higher returns because the number of intermediaries between farmers and consumers are minimal. Farmers also received additional benefits in terms of inputs and cleaning facilities from FPCs. However, the marketing channel I (farmer - commission agents – processors – wholesalers – retailers – consumers) was more popular because most farmers (88%). The price spread in the value chain ranged from 35 percent to 55 percent. However, the highest price spread is at the processor level which ranged from 16 to 34 percent in the marketing channels, followed by the retailer level (13%). This led to an increase in price at the consumer's end. Also, the farmers' share in the consumer's rupee varied in marketing channels ranging from 64.68 percent to 74.16 percent. The farmers' share in the consumer's rupee is higher (74.16%) if pigeon pea sold through marketing channel IV, i.e., the FPCs. This suggests that there is scope for processing units to be established at farm gate and the government should focus on strengthening FPCs to provide better returns to the farmers and reduce the cost burden on consumers. Policy interventions such as strengthening and promoting of FPCs would be beneficial for the farmers.

Table 4. 6: Marketing channels, price spread and farmers' share in consumers' rupees

MC no.	Particulars	Value Chain Actors						
		Farmer	Commission agents	Processors	Wholesaler	Retailer	Consumers	
I	Production cost	3785						
	Cost of marketing	110.07						
	Purchase price		5958	6300	7337	7704	8706	
	Selling price	5958	6300	7337	7704	8706		
	Difference between selling and purchase prices		342	1037	367	1002		
	Net returns	2062	342	1037	367	1002		
	Price spread at each stage (%)		5.74	16.46	5	13.01		
	Farmers' share in consumers' rupee (%)	68.44						
II	Particulars	Farmers	Village traders	Commission agents	Processors	Wholesalers	Retailers	Consumers
	Production cost	3785						
	Cost of marketing	117.3						
	Purchase price		5631	5958	6300	7337	7704	8706
	Selling price	5631	5958	6300	7337	7704	8706	
	Difference between selling and purchase prices		327	342	1037	367	1002	
	Net returns	1729	327	342	1037	367	1002	
	Price spread (%)		5.81	5.74	16.46	5	13.01	
	Farmers' share in consumers' rupee (%)	64.68						

MC no.	Value Chain Actors					
	Particulars	Farmers	Processors	Wholesalers	Retailers	Consumers
III	Production cost	3785				
	Cost of marketing	105.7				
	Purchase price		6158	7337	7704	8706
	Selling price	6158	7337	7704	8706	
	Difference between selling and purchase prices		1179	367	1002	
	Net returns	2267	1179	367	1002	
	Price spread (%)		19.15	5	13.01	
	Farmers' share in consumers' rupee (%)	70.73				
IV	Production cost	3785				
	Cost of marketing	97.1				
	Selling price	6100	8225			
	Purchase price		6100		8225	
	Difference between selling and purchase prices		2125			
	Net returns	2218	2125			
	Price spread (%)		34.84			
	Farmer share in consumers' rupee (%)	74.16				

MC no.	Particulars	Value Chain Actors					
		Farmers	Govt. procurement centres	Processors	Wholesalers	Retailers	Consumers
V	Production cost	3785					
	Cost of marketing	113					
	Price received by farmers	6000	6100	7337	7704	8706	
	Purchase price		6000	6100	7337	7704	8706
	Difference between selling and purchase prices		100	1237	367	1002	
	Net returns	2102	100	1237	367	1002	
	Price spread (%)		1.67	20.28	5	13.01	
	Farmers' share in consumers' rupee (%)	68.92					

Source: Field survey. Note: * MC no. - marketing channel number, *cost of marketing includes packaging, unloading, weighment and transport borne by the farmers, *** all figures are in rupees per quintal.

CHAPTER 5: ESTIMATION OF LOSSES IN PIGEON PEA VALUE CHAIN

5.1 Introduction

Pulses play an important role not only in India's agriculture sector but also in social life. While they are an integral part of the Indian diet providing food and nutritional security, they enhance soil health and offer additional income opportunities to small and marginal farmers by way of intercropping (Government of India (GoI), 2018; Varma, 2019). Also, India produces one fourth (25%), consumes marginally higher than one fourth (27%) and imports 14 per cent of the global pulses. (*FAOSTAT, 2022*). India's production of pulses has increased from 22.01 million tonnes in 2001-02 to 31.03 million tonnes in 2021-22 and the per capita net availability of pulses has improved from 10.9 kg per to 19.6 kg per annum in the corresponding period (GoI, 2023).

Pigeon pea (*Cajanus Cajan*) is one of the important legume crops (pulse) cultivated in India, and it has significant importance in terms of being the richest source of protein (containing 22% protein) and nutrition (GoI, 2002; Sah, et al., 2022). Also, it is an important component of the human diet in developing countries and it is considered as a climate resilient and drought tolerant crop (Haji, et al., 2024).

Annually 5.33 million tonnes of pigeon pea are produced in the world (*FAOSTAT, 2022*). India is the largest producer of pigeon pea in the world and it accounts for about 79 percent share in the total world production, followed by Malawi (8%), Myanmar (6%), Tanzania (3%), and Kenya (2%) (*FAOSTAT, 2022*). The production of pigeon pea has increased from 3.33 million tonnes in 2001-02 to 5.05 million tonnes in 2021-22 (GoI, 2023). Despite this India is a major importer of pigeon pea and imports totaled 7.71 lakh tonnes in 2023-24 as compared with 8.9 lakh tonnes in 2022-23, which are around 22.77 percent and 26.88 percent to production respectively (GoI, 2024c).

Food and Agriculture Organization (FAO) defines post-harvest losses as “a measurable quantitative and qualitative loss in a given product” and which can occur in the various stages of the post-harvest system (Lucia and Assennato, 1994). The post-harvest losses are a major policy concern both at national and international levels as they not only adversely affect the food and nutritional security of the people adversely, and economic stability in

India (Gulati et al., 2024). Minimizing the post-harvest losses is an important part of the strategy to fulfil the increasing demand as a result of the growing population (Kumar and Kalita (2017). The value of annual post-harvest losses in major agricultural products at the national level estimated to be approximately INR 92,651 crores and in case of pulses they stood at INR 3877 crores (GoI, 2016). To fulfil increasing demand of population, 39 million tonnes of pulses are needed by 2050 in India (GoI, 2023). To achieve the demand of a growing population and enhance farmers income, there is a huge scope for minimizing post-harvest losses (GoI, 2023). According to Global Hunger Index 2023, India ranks 111 out of 125 countries, which indicates that the country is experiencing severe hunger (Von Grebmer et al., 2023). Hence, minimizing the post-harvest losses is important to ensure food security, enhance profitability, sustainability of agriculture, resilience in the value chain and benefits to the consumers. The United Nations member countries adopted the 2030 agenda for sustainable development goals (SDGs) in 2015. ‘Responsible Consumption and Production’ is identified as the 12th SDG with the aim, “*By 2030, halve per capita global food waste at the retail and consumer level and reduce food losses along production and supply chains, including post-harvest losses*” (Martin, 2023, FAO, 2018, FAO 2023 a,b). The United Nations has evolved two concepts, Food Loss Index and Food Waste Index as sub-indicators to measure and track food losses and waste globally (United Nation Development Program (UN, 2023; UNEP, 2024; FAO, 2018). While the global food losses index (GFLI) measures the food losses that occur from production to retail level in terms of change in percentage losses for selected 10 major commodities including pigeon pea, the food waste index focuses on retail and consumption level (UN, 2023; UNEP, 2024). According to the UN *Sustainable Development Goals Report (2023)*, the global post-harvest losses were estimated at 13.2 percent in the supply chain from farm to consumer in 2021.

Empirical investigations point to the existence of significant post-harvest losses in pigeon pea. The study by Shah (2014) shows that the post-harvest losses are in the region of about 14-18 percent in the pre-harvest, harvest and post-harvest operations of pigeon pea. Some studies estimated about seven percent overall post- harvest losses for pigeon pea (Nanda et al., 2012, Jha et al.,2015; NABCONS, 2022). Kannan *et al.* (2014) assessed the post-harvest losses of pigeon pea for Karnataka (11.71 kg per quintal), Maharashtra (6 kg per

quintal) and Gujarat (3.05 per quintal). Despite the importance of pulses in the livelihood of farmers and food security of India, the high post-harvest losses in pigeon pea remain a neglected policy concern. There are studies on post-harvest losses at farm level, but the losses at marketing, processing, wholesale and retail level are addressed inadequately. Findings of the study will bring the needed focus on this policy concern and help “formulate strategies to reduce the losses” (Jha, et.al., 2015). One of the most important factors behind increasing food inflation in India is product wastes because of inefficient post-harvest practices and wastages that occur at different levels of the value chain (Yigezu, et al., 2021). Reduction in losses will enhance food availability and decrease in food prices volatility which will be beneficial to farmers as well as consumers (Mukherjee, et al., 2022). Overall, the post-harvest losses disturb the supply of products causing volatility in prices.

The present study is an attempt to examine the post-harvest losses of pigeon pea. Its objectives are to analyse the post-harvest losses incurred in the value chain and their causes. The primary data collected through semi-structured questionnaires. The results of the study can be beneficial to the value chain stakeholders for improvement in practices and enhance efficiency and sustainability of the agricultural sector of the country.

This chapter is organized into five sections. The introductory section explains the importance of pigeon pea in Indian agriculture and food basket. The review of available literature is presented in the following section. The description of methodology, including studied area, sample covered and analytical techniques used for the study are offered in the third section. The fourth section covers the results of the study. Conclusions and policy implications are presented in the last section.

5.2 Literature Review

The post-harvest system is made up of harvesting, pre-harvest drying, transport, post-harvest drying, storage, processing and marketing, involving a series of operations (Grolleaud, 2001). These can be fruitfully divided into two groups: technical activities comprising harvesting, field drying, threshing, cleaning, additional drying, storage and processing; and economic activities involving transportation, marketing, quality control,

extension, nutrition, information and communication, administration and management (Grolleaud, 2001).

The late harvest, insufficient drying of grains, improper threshing operations, poor storage and transport conditions result in losses. The direct and indirect causes of post-harvest losses with respect to types of losses which are divided into three parts, i.e., losses in weight, quality and economic (Grolleaud, 2001). The premature harvest, poor maturation, poor threshing, insufficient cleaning and bird attacks are the direct causes of losses and rodent, insect and microorganism attacks, bio chemical change causing loss in quality of product, leakage and waste, moisture content, inadequate storage and transport lead to economic losses (Grolleau, 2001). On other hand, inadequate capital, professionalism, equipment, pesticides, packaging, transport and organization are the indirect causes of post-harvest losses (Lucia and Assennato, 1994). Losses in quality decrease the value of the product in the market and therefore result in loss of money.

According to the FAO (2011), 1.3 million tonnes of food was lost due to losses and waste. The ratio of food loss and waste is higher in the case of fruits and vegetables (44%), followed by roots and tubers (20%), cereals (19%), milk (8%), meat (4%), pulses (3%) and seafood (2%). The food losses occur post-harvest, in-transition and before reaching the consumer and even at the consumers' end and post retail and they are effectively a loss of marketable volume and value, adding an economic burden on the food supply system (FAO, 2011). Some studies reported that high post-harvest losses and cost of storage lead to immediate sale of pigeon pea resulting in low profit margin in comparison with other crops in Tanzania (Mponda et al., 2014). It has geographical dimensions as well. According to the FAO report the total per capita food loss and waste is the highest in North America (296 kg per annum), and lowest in South and South-east Asia (126 kg/annum) (FAO, 2014).

The total post-harvest losses incurred as percentages of production for Bengal gram were 3.74, for green gram 2.38, for lentil 7.14 and for black gram 2.46 in India (GoI, 2002). In case of pigeon pea, they stood at 2.20 percent, the losses incurred at threshing, winnowing and transportation from field to threshing and storage for pigeon pea were 0.62 percent, 0.43 percent, 0.58 percent and 0.35 percent of production respectively (GoI,2002).

However, this study did not estimate losses incurred over the entire value chain of the pulses. Factors that lead to post-harvest losses in pulses are inadequate storage facilities, lack of proper handling techniques during harvesting, unsatisfactory transportation, poor processing practices (especially at the time of drying), pests and diseases, limited market access, inefficient marketing, distribution channels, etc. (Nanda et al., 2012, Jha et al.,2015, Nanda et al., 2012; Mukherjee, et al., 2022, Varma and Deo, 2024, GoI, 2002). Furthermore, the recent conducted studies by Central Institute of Post-harvest Engineering and Technology (CIPHET) of the Indian Council of Agricultural Research (ICAR) (Nanda et al., 2012, Jha et al.,2015), as well as by the Ministry of Food Processing Industries (through by NABCONS, 2022), Government of India, have estimated the total post-harvest losses of various agricultural commodities, including pulses in India. On average the post-harvest losses for pigeon pea were estimated 5.81 percent at the national level (Nanda et al., 2012, Jha et al.,2015; 2015; NABCONS,2022).

Similarly, a study by Vishwakarma et al., (2019), have estimated the post-losses for pigeon pea at 6.36 percent in India. However, these studies employed similar methodology and estimated the post-harvest losses at farm level operations (harvesting, collection, threshing, winnowing, drying, packaging, transportation and storage) and in storage channels at market level, but did not study the losses incurred in trading operations, at processing stage and marketing at wholesaler and retailer level. The study by Varma and Deo (2024) shows that storage and milling are the major areas which contribute maximum in post-harvest losses of pulses and suggest that decentralization of storage and milling facilities will be helpful in reducing them. Additionally, the monetary value of post-harvest losses for pigeon pea has been estimated at Rs. 2067 crore at national level (NABCONS, 2022). The summary of post-harvest losses estimated for pigeon pea in literature is presented Table 5.1.

Table 5. 1: Post-harvest losses in value chain for pigeon pea (%)

Sr. No.	Studies	Operations	ICAR-CIPHET 2012	ICAR-CIPHET 2015	NABCONS 2022	Average losses
1	Farm Level	Harvesting	0.48	1.18	1.1	0.92
		Collection	0.44	0.39	0.28	0.37
		Threshing	0.69	2.13	1.84	1.55
		Winnowing/Cleaning	1.04	0.41	0.33	0.59
		Drying	0.47	0.18	0.2	0.28
		Packaging	0.19	0.22	0.18	0.2
		Storage	1.36	1.02	0.52	0.97
		Transport	0.11	0.19	0.21	0.17
		Total loss in farm level operations	4.78	5.72	4.67	5.06
2	Market Level (Storage channels)	Godown	0.01	0.1	0.12	0.08
		Wholesalers	0.22	0.08	0.1	0.13
		Retailers	0.08	0.16	0.15	0.13
		Processing unit	0.3	0.32	0.35	0.32
		Transport	-	-	0.27	0.27
		Total loss in market level	0.61	0.66	0.99	0.75
Overall total post-harvest losses			5.39	6.38	5.65	5.81

Source: Nanda et.al, ICAR-CIPHET (2012); Jha et.al, ICAR-CIPHET (2015); NABCONS, (2022)

The report by Committee on Doubling the Farmers' Income (2017) focused on mitigating the food loss in the supply chain and marked the post-harvest losses as one of the major hindrances to increasing the farmers' income which, in turn, would improve their living standard. Kannan, et al.; (2013) estimated the post-harvest losses of pigeon pea from harvesting to marketing at 11.15 percent in Karnataka, India. Shah (2014) found that the total post-harvest losses of 6 kg per quintal in Maharashtra, noting losses declined as the landholding size increased and also the study estimated the total production losses of pigeon pea at 14-18 percent incurred during pre-harvest, harvest and post-harvest operations caused by high moisture, unsuitable harvesting time, inappropriate harvesting methods, poor mode of transport and unscientific storage practices. The study suggested

the need for developing techniques that are appropriate for both large and small farmers to minimize post-harvest losses (Shah, 2014). However, both these studies by Kannan, et al., (2013) and Shah, (2014), have not covered the losses incurred in the entire value chain of pigeon pea, such as losses in the processing level, wholesaler and retailer level. Therefore, the present study addresses this gap.

The literature shows that the post-harvest losses which occur during farm operations and storage at marketing channels or up to the marketing stage have been studied. However, the losses incurred in the value chain during processing and transportation (from dal mills to consumers) have not been investigated. The present study is an endeavor to examine post-harvest losses in pigeon pea in Maharashtra and bring back the focus on an economically and socially significant commodity.

5.3 Data and Methodology

5.3.1 Study Area

The study was conducted in Maharashtra as “Maharashtra ranks first in both area and production of pigeon pea in India and accounts for 30.84 percent share in total production of pigeon pea in 2021-22” (GoI, 2023). Data for it is drawn from both primary and secondary sources. The qualitative data regarding post-harvest losses incurred in the value chain of pigeon pea has been collected through semi-structured questionnaires and checklists. Necessary secondary data was collected from published sources such as Agricultural Statistics at Glance, Ministry of Agriculture and Farmers’ Welfare (MoA & FW), Ministry of Food Processing Industries (MoFPI), Government of India.

5.3.2 Sampling

A mixed design of the multi-stage stratified sampling method and convenient sampling method was used to select the location and value chain actors for the study. Marathwada and Vidarbha regions from Maharashtra were selected by applying twin criteria: highest area under pigeon pea and its production. From each selected region, the top two districts were selected using the same criteria. Thus, four leading districts (Latur and Nanded from Marathwada region, and Yavatmal and Amravati from Vidarbha region) were chosen. Further, from each selected district, two top talukas/blocks were short-listed, resulting in identification of eight talukas/blocks. From each selected taluka block, two villages were

selected for the study. A total of sixteen villages were selected based on area under pigeon pea. From each selected village, a list of pigeon pea growers was prepared during field visit and 35 farmers were selected randomly from each selected village. Thus, a sample of 560 farmers drawn and data regarding post-harvest losses and causes collected through semi-structured questionnaires.

Apart from this, the pigeon pea value chain actors such as commission agents/traders, processors, wholesalers and retailers were selected by random sampling from available lists with APMC offices. From each selected district, a sample of eight commission agents/traders, processors, wholesalers and retailers each was drawn. Thus, 32 commission agents/traders, 32 processors, 32 wholesalers and 32 retailers were chosen. On the other hand, other value chain actors like transporters and farmer producer companies (FPCs) involved in the pigeon pea value chain were selected. In all, transporters (08) and FPCs (08) selected from study districts. The data of post-harvest losses incurred during marketing channels was collected from these value chain actors. A tabulation of samples covered in the study is presented in chapter 4.

This study is based on primary data collected through the field survey using questionnaires during October 2021 to March 2022. The field survey was carried out in four major districts in two regions in Maharashtra and the data of post-harvest losses incurred in the value chain of pigeon pea has been collected through personal interviews using semi-structured questionnaires and checklists, and the same has been used from analysis. The data for calculating post-harvest losses incurred during such as harvesting, threshing, winnowing, cleaning, drying, packaging, storage and transportation at farm level operations were collected. Likewise, data on post-harvest losses during marketing operations such losses incurred during trading, processing, storage, handling, loading/unloading and transportation were collected from other value chain actors covered in the study. In addition, secondary data of area under cultivation, production, yield and export-import were collected from published sources such as *Agricultural statistics at glance*, Ministry of Agriculture and Farmers Welfare (MoA & FW), Ministry of Food Processing Industries (MoFPI), Government of India.

5.3.3 Data Analysis:

The total post-harvest loss of produce during each operation carried out at farm level, marketing, storage, processing, wholesale and retail levels were calculated separately. The total post-harvest losses were calculated using the sum of losses incurred at each stage of operation., An appropriate statistical test is used to compare the difference between district-wise post-harvest losses incurred. Besides, the monetary value of the post-harvest losses was calculated by using three-year average prices in the Latur market in Maharashtra and all-India production data for the year 2021-22. Similar method has been used in recent studies (NABCONS, (2022), ICAR-CIPHET (2015).

5.4 Results and Discussions:

This section presents the findings on post-harvest losses at both farm and market level operations, with their causes, preventive knowledge and challenges reported by the respondents

5.4.1 Post-harvest Losses of Pigeon pea at Farm Level Operations

The data of post-harvest losses occurred at farm level operations conducted by pigeon pea growers were collected, this includes harvesting, threshing, winnowing, cleaning, drying, packaging, transportation from field to home or storage place, and storage at farm level. The district-wise results obtained from the field data are presented Table 5.2.

It is observed from Table 5.2, that losses at harvesting and threshing stage are major contributors to total post-harvest losses at farm level in both study regions. This suggests the need for better practices and improved threshing techniques during these operations. The total post-harvest losses at farm level in Vidarbha region (7.51%) were found slightly higher compared to the Marathwada region (7.07%), mainly because of higher losses in the harvesting and drying stages. The post-harvest losses at storage and transportation operations are found relatively low at the farm level operations.

Table 5. 2: Region-wise and district-wise post-harvest losses at farm level (%)

Sr. No.	Farm operations	Marathwada Region			Vidarbha region			Average losses
		Latur	Nanded	Total losses	Amravati	Yavatmal	Total losses	
1	Harvesting	1.43	1.40	1.42	1.82	1.75	1.78	1.60
2	Threshing	1.79	1.98	1.89	1.88	1.91	1.89	1.89
3	Winnowing /cleaning	1.23	1.56	1.40	1.49	1.45	1.47	1.44
4	Drying	1.10	1.23	1.17	1.19	1.29	1.24	1.21
5	Packaging	0.34	0.22	0.28	0.29	0.24	0.26	0.27
6	Storage at producer level	0.81	0.72	0.77	0.69	0.69	0.69	0.73
7	Transportation	0.18	0.15	0.17	0.16	0.18	0.17	0.17
Total losses at farm level (%)		6.88	7.26	7.07	7.52	7.51	7.52	7.30

Source: Field Survey,

The district-wise post-harvest losses at farm level show that out of the four selected districts, the highest losses were observed in Amaravati district (7.52 %), followed by Yavatmal (7.51 %), Nanded (7.26 %) and Latur (6.88 %). However, the recent study by NABCONS (2022) shows overall post-harvest losses of pigeon pea in Maharashtra (6.9%) and that the highest losses were in Yavatmal (7.63%), due to improper harvesting, manual threshing, diseases and pest infestation. The present study results are broadly aligned with the findings of a recent study by NABCONS (2022).

The overall total average losses of 7.30 % at farm level is significant and shows the potential economic losses that could be reduced through encouraging awareness and use of improved practices in harvesting, threshing, cleaning and drying operations.

5.4.2 Farmers Category-wise Post-Harvest Losses at Farm Level

The post-harvest losses are calculated kg per quintal according to the landholding pattern of the farmers to understand variance in accordance with the farm size. Some studies reported that small and marginal farmers experienced higher losses as compared with large farmers and post-harvest losses decreased as land holding size increased (Kannan et.al.,

2013, Shah, 2014). This study calculated the farmers' category-wise post-harvest losses of pigeon pea at farm level and the results are presented Table 5.3.

Table 5. 3: Farmers Category-wise Post-harvest Losses

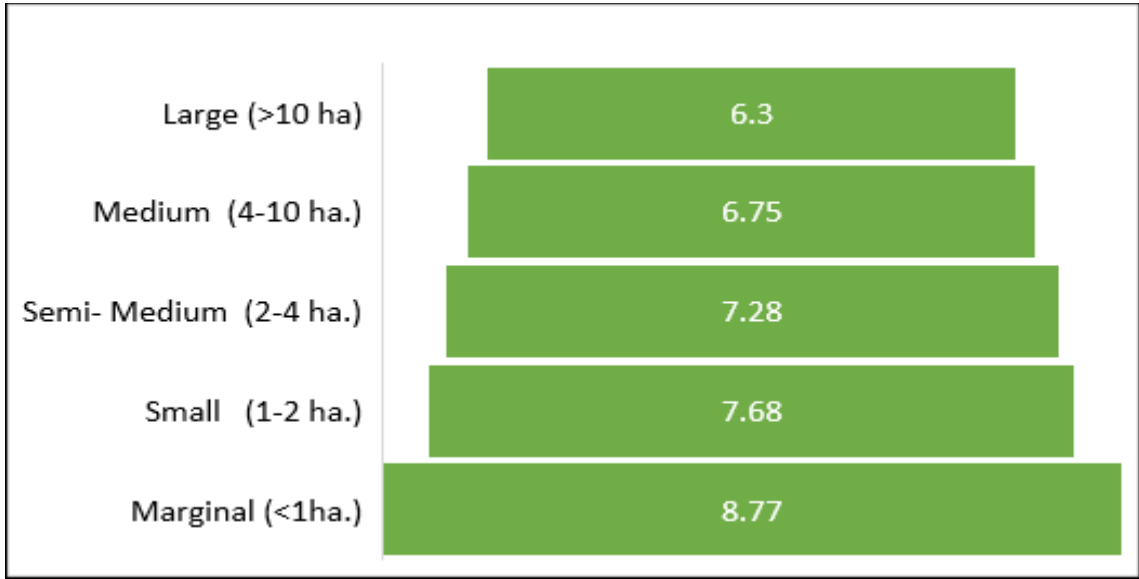
Sr. No.	Farm level activities	Farmers' category					
		Margin al (<1ha.)	Small (1-2 ha.)	Semi-Mediu m (2-4 ha.)	Mediu m (4-10 ha.)	Larg e (>10 ha)	Averag e Losses (%)
1	Harvesting	1.92	1.82	1.62	1.39	1.33	1.62
2	Threshing	2.06	1.91	1.89	1.88	1.71	1.89
3	Winnowing /cleaning	1.56	1.54	1.43	1.32	1.28	1.43
4	Drying	1.37	1.2	1.21	1.19	1.05	1.20
5	Packaging	0.29	0.29	0.27	0.24	0.31	0.28
6	Storage	1.01	0.75	0.71	0.64	0.55	0.73
7	Transportation	0.56	0.17	0.15	0.09	0.07	0.21
Total post-harvest losses (kg/quintal)		8.77	7.68	7.28	6.75	6.30	7.36
Total post-harvest losses (Kg/ha.)		84.9	74.3	70.5	65.3	61.0	71.2

*Note: Total post-harvest losses (kg/ha.) = losses in kg/quintal * Yield per ha.

Source: Field Survey

The post-harvest losses differed in terms of landholding size of the farmers (Table 6, Figure 1). The post-harvest losses of pigeon pea at farm level operations were higher in the case of marginal and small farmers as compared with medium and large farmers. This might be because of lack of access to farm machinery, lack of storage facilities, financial constraints (Kannan, 2014). The losses during harvesting, threshing and winnowing were higher as against other activities for all the categories of farmers. Total post-harvest losses at farm level ranged from 6.30 to 8.77 kg per quintal, which showed a decreasing trend with increasing landholding size (Figure 5.1). However, the post-harvest losses for pigeon pea per hectare were estimated at 71.2 kg per hectare at farm level operations. The study results are in line with earlier work by Kannan et.al.; (2013) and Shah (2014).

Figure 5. 1: Landholding size and post-harvest losses of Pigeon pea (%)



Source: Field Survey

5.4.3 Harvesting Methods Used, Costs and Losses

The proper harvesting method is crucial in reducing the losses. The data on methods used for harvesting, cost incurred and losses are presented in Table 5.4.

Harvesting, threshing and winnowing were performed manually, semi-manually and through harvesting machines (harvesters). The study shows that when all the activities were performed manually, in the resultant losses were 2.52 percent, by semi-manually (cutting manually and threshing and winnowing by machine) they were 3.27 percent and by using combined harvester (cutting, threshing and winnowing by harvester) 3.89 percent (Table 5.5). It is observed that post-harvest losses were higher in the case of using a combined harvester than harvesting the crop manually or semi-manually, but the cost of harvesting per quintal was lower than manually harvesting. Some studies have reported that, the crop variety, machine speed, crop height, the skill of the harvester operator, and low cutting height are the main factors contributing to post-harvest grain losses while using a combine harvester (Wang et al., 2021; Kumar et al., 2021; Sharifuddin & Mustaffha, 2020, Grolleaud, 2001). Overall, the methods used for harvesting, threshing, winnowing, and drying need to be improved.

Table 5. 4: Harvesting methods used and post-harvest losses

Sr. No	Harvesting method	Number of Farmers	Average Number of Labour (per quintal)	Labour charges (Per quintal)	Machine charges (Per quintal)	Total Charges incurred Rs. (Per quintal)	Average Losses (%)	Reason for following this method
A	Manually harvesting (cutting + threshing and winnowing)							
1.1	Manual cutting (harvest)	496	2	416		416	2.01	Traditional method,
1.2	Manual threshing	107	6			80	0.29	Traditional method,
1.3	Manual winnowing	107	1			110	0.22	Traditional method,
Total (A)							2.52	
B	Semi-manual (cutting manually and threshing, winnowing by machine)							
2.1	Manual cutting	496	2	416		416	2.01	Traditional method,
2.2	Threshing and winnowing by machine	389			200	200	1.26	Time saving, labour shortage
Total (B)							3.27	
C	Combine harvester (cutting, threshing and winnowing by harvester)	64			285	485	3.89	Time & labour shortage,

Source: Field survey.

5.4.4 Results of Post-Harvest Losses Incurred in The Value Chain of Pigeon pea

After calculating the district-wise post-harvest losses incurred at farm level, the overall losses in the study area and value chain of pigeon pea has been presented in Table 5.5.

Table 5. 5: Overall post-harvest losses of Pigeon pea

A	Farm level operations	Total losses (%)
1	Harvesting	1.60
2	Threshing	1.89
3	Winnowing/cleaning	1.43
4	Drying	1.20
5	Packaging	0.27
6	Storage	0.73
7	Transport	0.17
Total losses – (A)		7.29
B	Marketing and Processing operations	
8	Commission agent (Traders)	1.2
9	Processor level	2.3
10	Wholesaler level	0.79
11	Retailer level	0.47
Total losses (B)		4.76
Total losses (A+B)		12.05

Source: Field survey.

Table 5.5 describes the overall losses estimated at different stages of the value chain of pigeon pea: farm level operations, marketing and processing activities. While performing harvesting, threshing and winnowing/cleaning activities the losses occurred were at 1.60 percent, 1.89 percent and 1.43 percent respectively. Drying activity contributed 1.20 percent. in total post-harvest losses at farm level operations. Total post-harvest losses of pigeon pea were estimated at 7.29 percent at the farm level. The earlier studies reported that the total post-harvest losses at farm level were 4.67 percent (NABCONS, 2022), 6 percent by Shah (2014), 11.26 kg/quintal by Kannan et. al. (2013), 4.78 and 5.72 percent by ICAR- CIPHET, 2012, 2015 respectively. The post-harvest losses incurred are estimated at 4.76 percent at marketing and processing level, 1.2 percent at commission agents/traders' level, 2.3 percent at processing level and 0.79 percent and 0.47 percent at the wholesalers and retailers' levels respectively.

The overall post-harvest losses of pigeon pea were estimated at 12.05 percent. Up to processing stage they were 8.49 percent, while during pigeon pea dal processing, they were estimated at 2.3 percent and at selling of tur dal they were 1.26 percent. The use of modern

and appropriate post-harvest technologies in the field and knowledge of post-harvest technologies at farm level activities are essential to reduce post-harvest losses.

5.4.5 Monetary Value of Losses of Pigeon pea

From the economic perspective, the loss in quantity of the product expected means loss of money (Lucia and Assennato, 1994). The economic value or monetary value of post-harvest losses of pigeon pea is calculated by using the method given by Jha, et. al, (2015). the production data for the year 2021-22 and three-year (2021 to 2023) average prices of pigeon pea in the Latur market, Maharashtra. The monetary value of post-harvest losses is presented in Table 5.6.

Table 5. 6: Monetary value of post-harvest losses of pigeon pea

Sr. No.	State	Production (MT)_2021-22 (Lakh Tonnes)	Average prices of Pigeon pea in Latur market (Rs/MT) (2021-2023)	Estimated total post-harvest losses in present study (%)	Total post-harvest production loss (Lakh Tonnes)	Monetary Value (Rs in crore.)
1	Maharashtra	16.49	74,200	12.05	2.07	1537.27
2	All India	42.20	74,200	12.05	5.30	3932.84

Source: Field survey, Production: MoA&FW, Prices: DMI, Agmarknet portal, GoI (2024) Agmarknet,

The economic value of post-harvest losses of pigeon pea for Maharashtra and India are estimated at Rs.3932.84 Crore and 1537.27 crores respectively for the period of 2021-22 (Table 5.6). However, India imported 8.34 lakh tonnes of pigeon pea during 2021-22 valued at Rs. 6232.8 crore. The value of post-harvest losses is 63 percent of the import value of pigeon pea. Hence, there is a need for reducing the post-harvest losses.

5.4.6 Reasons for Losses Incurred in The Value Chain of Pigeon pea

The data related to reasons behind losses experienced at different stages of the value chain of pigeon pea has been collected. The reasons reported by the respondents during the field survey are presented in Table 5.7.

Table 5. 7: Reasons for losses incurred in the value chain of Pigeon pea

Sr. No	Value chain actors	Reasons	Frequency	Percentage
1	Farmers (N-560)	Manual harvesting & threshing	442	79
		Use of combine harvester machine	469	83.7
		Lack of availability of storage	179	32
		Packaging method	241	43
2	Traders (N-32)	High moisture content during peak marketing days	28	87
		Loading & unloading (mishandling)	22	69
		Removing foreign matters	26	81
		Packaging	20	64
		Transportation	24	76
3	Processors (N-32)	High moisture	30	93
		Process of removing foreign matters	25	77
		Transportation	28	86
		Broken and powdering	18	56
		Loading & unloading (mishandling)	14	45
		Improper storage	22	70
4	Wholesalers (N-32)	Loading & unloading (mishandling)	25	79
		Transportation	24	76
		Improper storage method	13	40
	Retailers (32)	Rodent and insects	26	81
		Handling and storage	24	74

Source: Field survey.

Table 5.7 depicts the reasons reported by the value chain stakeholders for post-harvest losses. It found that 79 percent farmers reported manual harvesting and threshing, lack of storage facilities (32 percent) and packaging (43 percent) as the important causes of post-harvest losses at farm level. At the marketing channel, high moisture content during peak marketing days (87 percent), loading and unloading process (69 percent), removing foreign matters (81 percent), packaging (64 percent), transportation from trading place to dal mill or storage place (76 percent) were reported by the traders and commission agents as the

reasons. In the processors' view, 93 percent losses occurred due to high moisture content (77 percent), removing foreign matters, (86 percent) transportation (45 percent) and (70 percent) improper storage. At the point of selling pigeon pea dal, wholesalers and retailers reported mishandling as the causes of post-harvest losses. In contrast, the loading and unloading process (79 percent), transportation (76 percent) and improper storage methods (40 percent) are reported by the wholesalers as responsible for losses. Eighty-one percent retailers reported that rodents and insects cause losses in handling and storage (74 percent).

5.4.7 Awareness of Precaution to be Taken During Harvesting by Farmers

During the field visits, data on whether the farmers have taken proper precaution for harvesting the crop; they have taken proper care of the crop and what precautions they have taken during harvesting was collected. The results are presented in Table 5.8.

Table 5. 8: Awareness of precaution to be taken during harvesting Time

Sr. No,	Precaution taken during harvesting time	Frequency	Percentage
1	Taken proper precaution during harvesting to minimize losses	275	49
If yes, what type of precautions taken			
2	Not harvested before the maturity	241	43
3	Used proper equipment to harvest	321	57
4	Not harvested during adverse climate condition	260	46
5	Keeping harvested pigeon pea in dry place	308	55
6	Keeping variety-wise harvested crop separately	274	49

Source: Field survey.

Table 5.8 shows that around half of the respondents have taken proper precaution during harvesting to minimize losses. The type of precautions taken by them were: not harvested before maturity, used proper equipment to harvest, not harvested during adverse climate conditions and keeping variety-wise harvested crops separately. However, the study observed that 40 percent of respondents did not take any proper precautions during harvesting to minimize losses. This suggests that the government should raise awareness among the farmers about modern post-harvest techniques and practices to minimize the losses of pigeon pea.

5.4.8 Post-harvest Challenges Faced by The Respondents

The results of post-harvest challenges faced by the farmers are presented in Figure 5.2. It is observed that 49 percent respondents reported that low prices for produce after harvesting is one of the major challenges they face. Additionally, non-availability of transport facilities on time (48%), distance between farm to market is high (45%), packaging material not available timely (43.6%) and lack of storage facilities (33%) (Figure 5.2).

Figure 5. 2: Post- harvest challenges faced by respondents



Source: Field survey.

5.5 Conclusion and Policy Implications

This chapter presented the empirical findings of the field survey conducted to examine post-harvest losses incurred in the value chain of pigeon pea in Maharashtra. The study results shows that losses at harvesting and threshing stage are major contributors to total post-harvest losses at farm level operations, this suggests a need for improved practices and threshing techniques during these operations. However, the post-harvest losses at storage and transportation operations are found relatively low. Among the study areas, the highest post-harvest losses were observed in Yavatmal district. This aligns with the results of NABCONS (2022), which reported an overall post-harvest losses of 6.9% pigeon pea in Maharashtra, with the highest losses were in Yavatmal district (7.63%), because of improper harvesting, manual threshing, diseases and pest infestation. The average total farm level loss of 7.30 % observed in the current study is significant, showing the potential

economic losses. This suggests the need to reduce the post-harvest losses through encouraging awareness and use of improved practices in harvesting, threshing, cleaning and drying operations.

The survey findings revealed that marginal and small farmers experienced higher post-harvest losses compared to medium and large farmers. This might be because of lack of access to farm machinery, lack of storage facilities, financial constraints (Kannan, 2014). Also, the total post-harvest losses at farm level ranged from 6.30 to 8.77 kg per quintal, which showed a decreasing trend with increasing landholding size. Overall, the study estimated post-harvest losses incurred in the pigeon pea value chain at 12.05 percent with key contributing factors harvesting and threshing methods, lack of storage facilities, pests and diseases contributing to losses.

Additionally, sample respondents reported higher losses when using combine harvesters compared to manual or semi- manual methods, although the cost of harvesting per quintal was lower with mechanized methods. However, some studies reported that factors such as crop variety, machine speed, crop height, operator skill, and low cutting height were identified as the main factors contributors to grain losses when using a combine harvester (Wang et al., 2021; Kumar et al., 2021; Sharifuddin & Mustaffha, 2020, Grolleaud, 2001). Overall, the study concluded that the methods used for harvesting, threshing, winnowing, and drying need to be improved.

The monetary value of post-harvest losses for pigeon pea was substantial. It is more than 60 percent of the value of imported pigeon pea in the county. This suggests that, despite some farmers adopting precautionary measures during farm level operations, there is still scope for improvement in reducing the losses at the value chain. In addition, after harvesting farmers faced various constraints such as low prices, timely unavailability of transportation, distance of the markets and lack of storage facilities. Overall, the study highlights the importance of utilizing modern post-harvest technologies and dissemination of knowledge about good agricultural practices to minimize losses to avoid economic loss of the country as well as value chain actors.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

India is a leading producer, consumer and importer of pigeon pea globally (*FAOSTAT*, 2022). Despite this, volatility in the pigeon pea prices have become a serious problem in recent years, often negatively affecting producers, consumers and other stakeholders in its value chain. To understand the issue of pigeon pea price volatility, the study systematically examined factors influencing their prices, markets integration of significant pigeon pea markets in India, speed of adjustment in prices in the short-run and causality (directions) between prices of pigeon pea in selected markets, mapping of value chain, price spread among marketing channels, farmers share in consumer rupee and post-harvest losses incurred in the value chain. In this chapter conclusions and recommendations are presented.

The data for the present study was collected from both primary and secondary sources. The primary data related to various aspects constituting the pigeon pea price - the cost of production, marketing, methods used for harvesting, perceptions about factors influencing prices, price received and post-harvest losses during marketing, price spread and losses during marketing and processing operations (trading, processing, storage, handling, loading and unloading, and transportation) was collected from 560 farmers and 149 other stakeholders by conducting field surveys using questionnaire and checklists. The necessary secondary data relating to the area, production, yield, export-imports, WPI, prices of pigeon pea, etc., was collected from various published sources. To analyze the data statistical methods and econometric models were used. The multiple regression analysis method was employed to examine the factors influencing pigeon pea prices, while three econometric models were applied to study the market integration and price transmission across the selected markets. The Johansen Multivariate Cointegration approach was used to identify the market integration, whereas the speed of price adjustment in the short run was investigated by the Vector Error Correction Model (VECM). The Granger Causality Test was adopted for analyzing the direction and causality among the markets (see chapter 3). The analysis of pigeon pea marketing channels, price spread and farmers' share in

consumer prices has been done through value chain mapping and finally estimated the post-harvest losses at different stages using primary data.

6.2 Major Findings / Conclusions:

One of the key findings of the study is that the prices of pigeon pea appear to be more volatile compared with the other pulses. The availability of pigeon pea in the domestic market has shown a mixed trend during the last decade, which partly explains fluctuations in the domestic prices. Inter-year variation of pigeon pea prices was higher than the intra-year variation. The seasonal indices indicate lower seasonality in its prices, registering the lowest prices in November by 2.51 percent and the highest in August by 3.39 percent.

Empirical analysis of factors influencing the price of pigeon pea indicate that factors- total availability (production + import-export) of pigeon pea for domestic consumption, demand (trend) and price of substitute commodity (green gram) - have a significant influence on pigeon pea prices. Overall model explains 88.58 percent variation with statistically significant result. The analysis also reveals that the value chain actors hold different perceptions about factors influencing the prices of pigeon pea. However, there is an agreement among all respondents that production, demand, imports, quality of produce and government's trade policies, especially MSP, are the most significant factors influencing its market prices in India.

The results of the Johansen multivariate cointegration test for nine markets revealed the presence of eight cointegrating vectors among the nine selected pigeon pea markets. This indicates a high degree of long run equilibrium relationship, suggesting that these markets are highly integrated, and prices suggest existence of a long-run price relationship among them. Prices are transmitted across the markets because they are closely interlinked. The speed of price adjustment (Error Correction coefficient) was from 0.28 to 0.82 percent in the selected markets in the short run. The present study shows an improvement in the speed of adjustment in the prices of pigeon pea which may be the result of recent government policies or technological interventions. The results of the pair-wise Granger Causality Test confirmed the existence of bidirectional and unidirectional causality across the selected markets. Latur market is the price leader. It has had an influence on the prices in selected

markets. The study confirmed that the price changes in one market changed the prices in another.

The findings of the value chain analysis indicate wide fluctuation in both the area and production of pigeon pea over the year. Production seems to be fluctuating more than the area under pigeon pea. The spatial variability in the yield suggests ample scope for enhancing pigeon pea yield. The average cost of production stood at Rs.3785 per quintal. The benefit-cost ratio for pigeon pea cultivation was 1.57, indicating that pigeon pea cultivation is profitable. These results are in line with the findings of the earlier study by Mane and Kale (2012).

Analysis of marketing practices shows that most farmers (88.8 %) sell their produce to commission agents/arthritis in the nearest APMC markets because of better price realization, credit and instant payment, while few of them sold their produce directly to the processors, village traders, Government procurement centres and FPCs.

Farmers used five marketing channels. Traditional marketing channels (that is, farmers – APMC commission agents– processors – wholesalers – retailers – consumers) were more popular. The price spread in the pigeon pea value chain ranged from 35 percent to 55 percent. The lowest price spread (35%) was in Channel IV (farmer – farmer producers' company (FPC)– consumer), while the highest price spread (55%) was in the marketing Channel II (farmer – village traders – commission agents – processors – wholesalers – retailers – consumers). The highest price addition was at the processor level ranging from 16 to 34 percent in the marketing channels, followed by the retailer level (13%). This led to an increase in the prices at the consumer end. This suggests that there is scope for establishing processing units at the farm gate. Among them, the farmers using channel IV (farmer producers' company (FPC) – consumer) realized higher returns because of the lowest price spread and minimum intermediaries between them. Farmers also get additional benefits in terms of inputs and cleaning facilities from FPCs. The findings show the need for strengthening marketing Channel IV and routing the sales through it.

Farmers' share in the consumer's rupee was higher for pigeon pea sold through marketing Channel IV (72.93%), followed by Channel III (70.74%) and Channel V (68.92%). The lowest farmers' share in consumer rupees was in the case of Channel II (farmer – village traders – commission agents – processors – wholesalers – retailers – consumers). This is because of the existence of more intermediaries (five) as compared with other marketing channels. The results are aligned with an earlier study by the Reserve Bank of India (RBI, 2024).

The post-harvest losses incurred in the value chain of pigeon pea were estimated at 12.05 percent, registering higher losses at farm-level operations (7.29%) compared with the processing and marketing stages (4.76%). The economic value of post-harvest losses for pigeon pea was around 60 percent of imported pigeon pea (2021-22). In addition to this, the post-harvest losses are higher when using a combined harvester compared with harvesting the crop manually or semi-manually. Hence, there is a need to reduce the post-harvest losses at the farm level and the entire value chain. These losses were higher in the case of small and marginal farmers as they used traditional methods of harvesting, threshing and winnowing which confirmed findings reported in the earlier studies (Kannan et al., 2013 and Shah, 2014). Despite some farmers taking precautions during farm-level operations, the post-harvest losses are high and so there is room for improvement in reducing them.

The value chain actors reported that manual harvesting and threshing, lack of storage facilities, use of combined harvesters, pests and diseases contributed to losses. The results indicate potential benefits flowing to the value chain stakeholders by improving practices and enhancing the efficiency and sustainability of the country's agricultural sector.

6.3 Policy Recommendations

- The adoption of a long-term policy strategy based on empirical results of the study to enhance domestic production and reduce post-harvest losses will help mitigate price volatility and sustainability of pigeon pea production.
- The government should focus on disseminating knowledge about good agricultural practices, modern post-harvest technologies and market intelligence to stabilize the prices and minimize post-harvest losses to avoid economic loss.

- The price spread across the value chain is generally higher, except in Channel IV (farmer – farmers’ producer company (FPC) – consumer), indicating a need for the government to prioritize post-harvest management and the strengthening of FPCs.
- The government can frame the uniform price stabilization policy and disseminate price information to the farmers as the pigeon pea markets are integrated.

6.4 Limitations and Scope for Further Studies

The present study covers select markets and the data collected from the more respondents from different states would help strengthen it. The farmers reporting and simultaneously actual measurement would have strengthened the study further. The study does not estimate the actual post-harvest losses incurred in the various operations conducted by value chain actors. There are limitations to generalizing research findings beyond the commodity under study and regions. However, this opens new avenues further in the area of determinants of market integration of pigeon pea, actual measurement of post-harvest losses incurred in the value chain and so on.

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Annexures 1: Questionnaires

1.Schedule for Farmers

Note: The information is to be collected for the agriculture year 2020-21. (Kharif Season)

District		Taluka	
Village		Date	
Questionnaire No.		Coordinates	
Interview Start time		Interview End time	

Basic Information

Sr. no	Details	Unit	Response
1	Name of the Farmers	Name	
2	Mobile number		
3	Age	Year	
4	Gender	1 Male 2 Female	
5	Social Category	1.SC, 2.ST 3 OBC, 4. General	
6	Education qualification		
7	Total Number of Member in Family	Total/Male/Female	
8	Are you/ any member of your household, member of Institutions?	1.FPC, 2.SHG, 3. Grampanchayt, 4. FIG, 5. Water committee, 6. Primary agri. Credit cooperative society other	
9	If Yes, How family many?	Numbers	
10	Total annual income of the family	Rs. In thousand	
10.a	From Agriculture	Rs. In thousand	
10.b	From Allied activities and business	Rs. In thousand	

II. Land holding details

Sr. No	Particulars	Unit	Response
1	Total Land holding	Acre	
A	Own Land	Acre	
B	Leased land	Acre	
2	What are the sources of Irrigation?	1.Well, 2. Borewell, 3. River, 4. Canel, 5. Farm pond 6.Lift Irrigation 6. Other	
3	land under irrigation in last year	Kharif Rabi Summer	

III. A. Cropping pattern (last year)

Season	Main Crop	Intercrop	Area Under Main Crop (in Acre)	Area Under Inter Crop (in Acre)	Area under Irrigation	Production of Main Crop (qtl)	Production of Intercrop (qtl)	Total Production cost (in Rs.)	Quantity Sold (qtl) Main Crop	Quantity Sold (qtl) Inter Crop	Sale of main Crop to-	Sale of Inter crop to-	Price Received (per qtl) Main Crop	Price Received (per qtl) Inter crop
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Kharif	1													
Rabi	2													
Summer														
Annual	1													

Code for Q.12 &13: 1. APMC,2. FPOs,3. Processor, 4. Local Traders, 5. Rural Haat, 6. Govt. Procurement agency, 7. Contract farming 8. E- trading 9. Other

III. B. Area Under Pigeon pea production during last 5 year

Year	Variety sown	Any specific reason for selecting this variety	Area (acre)	Area under irrigation	Quantity of Seed used per acre (kg)	Type of Seed Used 1.certified 2. truthful 3. own/local	Reasons for increase or decrease in Area under Tur cultivation	Total Production (qtl)	Reasons for increase or decrease in production	Total produce Sold (qtl.)	Produce used for self - consumption (qtl)	Produce sold to -	Price Received (per qtl)	Reasons for selling to particular agency	if sold to other than APMC market How is price decided?
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Code for ques.13: 1. APMC,2. FPOs,3. Processor, 4. Local Traders, 5. Rural Haat, 6. Govt. Procurement agency, 7. Contract farming 8. E- trading 9. Other

III.C. Source of Inputs

Sr. No	Inputs	Source	Response
1	Seeds	Input supplier	
2	Fertilizers	Krushhi Seva Kendra	
3	Pesticides	Own Other	

IV. Cost of cultivation of Pigeon Pea

Costs	Sub component	Particulars	Quantity/ Numbers	Rate/.Prices/daily wage	Total Expenses (Rs)
A. Operational Costs	Human Labour cost (Rs)	Hired	Number		
		Family	Number		
		Total	Number		
	Animal Labour cost (Rs.)	Hired	Number		
		Owned	Number		
		Total	Number		
	Machine Labour cost (Rs.)	Hired	Number		
		Owned	Number		
		Total	Number		
Total Operational Cost (Rs.)					
B. Input Cost (in Rs.)	Seed		Kg		
	Fertilizer		Kg		
	Manure		Tonnes		
	Pesticides (Insecticide, Fungicide, Organic etc.)		Unit		
	Total Input Cost		Rs.		
Working Capital (A+B)					
Fixed Cost (Rs.)	Interest on Working Capital in Rs. (12.5%)				
	Irrigation charges (Rs.)				
	Rent Value of own land (Rs.)				
	Land rev. cesses Taxes				
	Depreciation of farm bldgs.& implements				
	Interest on fixed Capital (10%)				
Other costs	Electricity use		KwH		
	Fuel use		Liters		
Total Fixed Cost (Rs)					
		Total Cost (Rs.)			

IV.1 : Are you taking up the production of ratooning tur? 1. Yes 2. No

If Yes, please provide following information

IV.1 Calendar of Operations

Sowing	Month	-----
Harvesting	Days after sowing -	How many days?
Cutting		
Threshing		

Winnowing		
Storage		
First sale		
Second Sale (if stored)		

VII. Harvesting Methods and costs incurred

Harvesting method	Number of Labour	Machine charges	Total Charges incurred Rs.	Reason for following this method	Losses in kg
Manual (cutting + Threshing and Winnowing)					
Manual Cutting					
1.2 Manual Threshing					
1.3 Manual Winnowing					
Semi manually (cutting manually and Threshing and Winnowing by Machine (threshing))					
2.1 cutting manually					
2.2 Threshing and Winnowing by Machine					
Combine harvesting (both cutting and threshing by harvester)					

VIII. Activities performed after harvesting

Sr. no	Activities	Particulars	Response
1	Draying	Days	
2	Labour cost for draying	Labour charges Rs.	
3	Method followed for drying	Sunlight /solar dryer /electricity dryer	
3.1	If solar or electricity dryer	Charges incurred (Rs.)	
4	Losses during drying	Kg.	

IV-b. Packaging and Storage Activities performed by producer

Sr.	Questions	Options/Unit	Response
Packaging			
1	Quantity packaged	Qtl.	
2	Material used for packaging	Gunni bags/Plastic bags/Used fertilizer bags Other	
3	Number bags used	Number	
4	Cost per bag	Rs.	
5	Total packaging cost incurred (bags, labour etc.)	Rs.	
6	Quantity losses during packaging	kg	
Storage Activities by Producers			
1	Do you Store the Pigeonpea?	1.Yes 2. No	
2	If yes, where do you store the Pigeonpea?	1.Own facility/Own house, 2.Govt. Godwon (MSWC) 3.Pvt. Godown 4. Other	
3	How much quantity stored?	Qtl.	

4	What was the transportation costs from drying yard (farms) to storage facilities	Rs.	
5	If Govt. storage facility is used, how much charges were incurred?	Rs./ Per qtl.	
6	If Private storage facility is used, how much charges were incurred?	Rs./ Per qtl.	
4	What are the activities prepared prior to store?	Drying, /Cleaning /Grading /Packaging	
5	How much was storage period?	Months	
6	How much total losses incurred during storage?	Kg	
7	Labour Charges for storage (Weighting, Handling, Loading, Unloading, etc.)	Rs/ qtl	
15	Are you aware about pledge loan scheme?	1.yes, 2. No	
16	If yes, had you taken pledge loan?	1.yes, 2. No	
17	If yes, from whom?	Govt. Bank /Pvt. Bank/Cooperative societies MSWC/APMC /Other (specify)	
18	How much pledge loan was taken?	Rs	
18.a	What was the interest rate applied?	---%	

X.A. Marketing of Pigeonpea

Sr. No	Particulars	Unit/Details	Response
1	Where did you sell produce?	1.Traders (APMC) /Arhatias /Commission Agent 2. FPOs, 3. Processer (Dal millers) 4. Local / village Traders, 5. Rural Haat 6. Govt. Procurement agencies 7. Other (specify)	
2	Quantity sold to particular purchaser	qtl.	
3	What is the mode of transport used from home to market?	1. Bullock cart 2. Tractor- trolley 3. Tempo/Pickup 4. Truck 5. other (specify)	
4	Distance of market from home/storage place?	Km	
5	How much time is required to reach the market?	Hour	
6	How much quantity was transported?	Qtl.	
7	How do you sell your produce?	1.Individual /2. Group 3. Through FPO	
8	When do you sell your produce?	1.Immediately after harvest 2.After getting better prices 3.For meeting the expenses of festivals	
9	How many times you have sold produce to this place? (last 5 years)	Number	

10	What is the reason behind selling produce to the particular purchaser?	-----	
11	What is the price received?	Rs/qtl	
12	Do you follow Cleaning / Grading practices before selling?	1. Yes 2. No	
13	If yes, where?	At drying yard / farm At APMC At storage place	
14	How much charges are incurred for cleaning and grading?	Rs/qtl	
15	How much is the transport cost?	Rs/qtl	
16	What are the loading and unloading charges?	Rs.	
17	What are the losses during the transportation?	Kg	
18	What are the other charges incurred at selling place?		

XI. Marketing of Green Tur Pods

Sr. No	Question	Unit	Response
1	Are you selling green tur pods ?	1. Yes 2. No	
2	If yes, where do you sell?	1. Rural Haat 2. APMC market 3. Direct selling in vegetable market 4. FPOs 3. other (Specify)	

XII. Issues and challenges faced by producer during marketing of Pigeonpea

Sr. no	Issues and challenges	Response
1	Weighing of produce are not done at time	
2	Weighing of produce are not done properly	
3	Kadata ghetal jato	
4	Fair prices are not received	
5	Prices received less than MSP	
6	Payment delay	
7	Other (specify)	

XIII. Processing activities done by producer (if any)

Sr. no	Questions	Options	Response
1	Does the producer involved in processing activity?	1. yes 2. No	
2	Quantity processed	Qtl.	
3	Quantity sold after processing	Qtl.	
4	Quantity retained for self-consumption	Kg.	
5	Processing costs	Rs.	
6	Method used to processing	Manual /Traditional Processed through mini dal mill Through FPOs Other	
7	If manual, how much quantity processed in one day	Kg	

	If manual, labour involved	number	
8	If 2&3, then charges incurred	Rs.	
9	Quantity after processing	Kg. (dal) Kg (Chuni) other material	
10	Losses incurred during processing	Kg.	

X. Post-harvest losses

Losses incurred	Unit	Response (tentative)
During harvesting (Cutting) at farm level	Kg	
During Threshing	kg	
During Winnowing	kg	
Losses incurred during transportation form field to home	Kg	
During transportation from field to storage place	kg	
Losses incurred during transportation from home/farm/storage place to market	kg	
Other	Kg	
Total losses at farmer's level		

XIV Precaution taken during harvesting time

Sr. No	Precaution taken up	Response
1	Have you taken proper precaution during harvesting to minimize losses?	1. Yes 2 No
1.1	If yes, what type?	
A	Not harvested before the maturity	1.yes 2. No
B	Used proper equipment to harvest	1.yes 2. No
C	Not harvested during adverse climate condition	1.yes 2. No
D	Keep harvested Pigeonpea in dry place	1.yes 2. No
E	Keeping variety wise harvesting crop separately	1.yes 2. No
F	Other (Specify)	

XV. Major issues faced during pre-harvesting stage?

Sr. No	Issues Faced	Response
1	Dry spell during growth period	
2	Heavy rainfall prior to harvest	
3	Pest and disease attack	
4	Inputs shortage	
5	Any other	

XVI. Farmers Opinion/Feedback on Government procurement system

Sr.	Question	Unit	Response
1	Have you sold Pigeonpea to Government procurement agencies?	1.Yes 2. No	
2	How much quantity was sold?	qtl	
3	Price Received	Rs/Qtl.	
4	Within how many months did you get the payment?	Months	
5	Payment received?	1.Cash 2. Cheque 3. Account transfer	

6	Charges incurred for selling at procurement center?	Rs	
7	Any other service received from purchaser?	-----	
8	Are you satisfied with the service received at procurement center?	Yes No	
9	Do you feel that MSP is required for Pigeonpea?	Yes No	
	If Yes, Why		
	If no, why?		

XVII. Crop Insurance information

Sr. No	Question	Unit	Response
1	Have you taken up crop insurance for Pigeon pea?	1. Yes 2. No	

XIX. Good Agricultural Practices/ Technologies followed for production of Tur

S.N	Technology	Response	S.N	Technology	Response
1	Use of Climate resilient variety/improved varieties		9	Use of Drip irrigation and fertigation	1 Yes, 2. No
2	Germination test		10	Nipping of apical bud	
3	Seed treatment (Bio-fertilizer and fungicides)		11	Opening of dead furrows	
4	Use of INM practices		12	Spraying techniques with safety measures	
5	Soil amendments		13	Integrated Weed Management	
6	Sowing of Inter-crop with specific spacing		14	Draining of excess water	
7	Follow IPM practices		15	Foliar Spray of Micronutrients	
8	Crop residue management		16	Thinning & Gap filling	

XVIII. Major sources of information on Crop Advisory, Extension, Prices, Crop Insurance, Training

Sr.	Particulars	Received (Y/N)	Source	mode	Frequency	Other
1	Crop Advisory					
2	Weather Advisory					
3	Price Information					
4	Crop Insurance					
5	Extension Services					
6	Training related to marketing					

Code: 1. source: 1. Agri. dept, 2. Agri. University 3. Pvt sources 4. KVK 5. Radio/TV 6. NGOs 7. FPOs

2. mode: 1. SMS, 2. Whats apps 3. Phone Call, 4. Newspaper 5. Magazine, 6. Field visit 7. Apps

3. Frequency: 1. Daily, 2. Weekly 3. Monthly 4. Other

XX. According to you, which of the following factor /s affects the prices of Pigeonpea?

Sr. No.	Factor/s	Multiple Response
1	Fluctuations in production	
2	Quality of produce	
3	Consumer preference	
4	Variety of Pigeonpea	
5	Market Demand	

6	International prices	
7	Storage facilities	
8	Government policy - MSP	
	Government policy - Export –Import	
9	Other (specify)	

XXI Post- harvest constraints faced

Sr. No	Issues faced	Response (1. Yes 2. No)
1	Insufficient storage facilities	
2	Low prices	
3	Transport facilities not available	
4	The market is too far	
5	Packaging material not available timely	
6	Any other (specify)	

XXII Any suggestions regarding production, Harvesting and Marketing of Pigeonpea

2. Schedule for Commission Agents/ Arhtiyas

Basic information

Sr. No	Particulars	
1	District	
2	Taluka	
3	APMC /Market Place	
4	Name of Agents/Arhtiyas	
5	Contact Number	
6	Years in business	
7	Major commodities dealt with	
8	Business in how many locations	

Details of Pigeonpea trading

Sr. No	Particulars	Unit / Options	Response
1	How much total quantity of Pigeonpea purchased during average in last five years?	tonnes	
2	What was the average price given to producers during last year? (Rs/qtl.)	Year	Quantity
		2020-21	Price
3	How do you measures the quality of Pigeonpea before purchase?	Factors	Yes 2. No
		Moistures	
		Foreign materials	
		Colour	
		Grain size	
		Damaged grains/infected grains	
		Variety	
Others (specify)			

3	What kind of services provided to producers other than auction?	Services	Yes No	Response
		Cleaning		
		Grading		
		Unloading		
		Transporting		
		Packaging bags		
		Advance payment		
		Loan		
		Storage facilities		
		other(Specify		
4	What are the charges applied for services provided to farmers? (Rs/qtl)	Cleaning	Rs/qtl.	
		Grading		
		Unloading		
		Transporting		
		Packaging bags		
		Weighing		
		Rate of interest (if loan given to the farmers)		
		Market Fee	Rs/qtl.	
	Storage facilities			
5	Are you providing price information to the producers?	Yes No		
5.1	If yes, how frequently you provide information to the farmers?	Daily Weekly Monthly		
5.2.	If yes, what type of medium is used to provide price information to the producers?	1.SMS, 2. Phone Calling 3.Whats apps 4.other		
6.	What type of activities/process are performed after purchase Pigeonpea?	1. Cleaning 2. Grading 3. Packaging 4. other		
	If grading is done on what basis?	Variety Size Colour As per requirement of purchasers Other		
7.	To whom purchased Pigeonpea is sold?	Purchasers	Percent sold	
		Big traders/Agents Processors Organized retailers (e.g. Big- Bazaar, D-Mart, Reliance, ITC)		

		Other		
8	Are you aware about price volatility?	Yes No		
9	If yes, what are precaution taken up for dealing with price volatility?	-----		
10	Do you have a storage facility?	Yes 2. No		
	If yes, what is the capacity of storage facilities?	Tonnes		
11	How much average quantity was stored during last 3 years after purchase?	Year	Tonnes	Average Number of days stored
		Year 1		
		Year 2		
		Year 3		
10.	If No, which storage facilities availed?	MSWC Godown Pvt. Godown		
11	Average losses incurred during storage period?	Kg/ctl.		
12	Are you trading in commodity market?	1.Yes 2.No		
12.1	If yes, which commodities?			
13	According to you, what are the factors contributing in the determination of Pigeonpea prices?	Factors	Yes /No	
		1. Production		
		2. Area under crop		
		3. Demand form processing industry		
		4. Import quantity		
		5. Export Demand		
		6. MSP		
		7. Produce quality		
		8. Moisture content		
		9. Foreign matters		
		10. Colour		
		11. Demand from bulk buyers		
		12. Last year stocks		
		13. Last year prices		
		14. International Prices		
15. Other Govt. Polices				
14	According to you, why the prices in the different markets are different? -----			
15	What percent of losses are incurred during purchase from farmers to sale?			
16	Do you feel that there is need to be reforms in Agri. marketing?	1. Yes 2. No		
16.1	If yes, please provide suggestions for improvement in agriculture marketing -----			

17	What are the your suggestions for Pigeonpea producers?-----		
18	According to you, what are the reasons for fluctuations of prices of Pigeonpea?-----		
19	What is average value addition at your level in terms of prices of Pigeonpea?	Purchased price (Rs/Qtl.)	
		Selling prices (Rs/Qtl.)	
20	What difficulties you are facing in trading business?		
21	Are you involved in processing?	Yes 2. No	
21.1	If yes, how much quantity processed during last year?		
22	What mechanism used to decide purchase price?		
22	What mechanism used to decide selling price?		

3.Schedule for Processors (Dal Millers)

Basic information

Date of Survey		
Name of processor		
Address	District-----Taluka----- Village-----	
Contact Number		
Year in business	-----years	
Name of the major commodities processed	Name of the commodities	years
	Tur	-----
	Gram	-----
	Urad	-----
	Moong	
Other (if any)		
Family business	1.Yes 2.No	
how many family's member involved?	-----	
Processing system	1. advanced	2. Traditional
Marketing of processed product		

1. Details of Pigeon pea Processing:

S	Particulars		Response	
1	What is the total quantity of Pigeon pea purchased for the processing during last years?	Years	Qty.(Tonnes)	Average procurement price (Rs/ctl.)
		2020-21		
2	From whom do you buy/ purchase the raw Tur?. During last years trend	Sources	Percent procured	
		Bulk Buyer		
		APMC market Arhtiyas/Commission Agents		
		Direct Purchasing from farmers		
	Other			

2.2	If answer is 3 , What kind of services provided to producers last 2-3 years	Services	Tick	Charges if any (Rs/ctl.)	
		1.Cleanning			
		2. Grading			
		3. Unloading			
		4. Transportation			
		5.Packaging			
		6. Advance payment			
		7. Storage facilities			
	6.Other (Specify)				
3	Are you providing price information to the producers? 1.Yes 2. No				
3.1	If yese, what type of medium is used to provide price information to producer?	Medium	Tick if provided	Frequency	Charges if any
		1.SMS, 2. Calling 3.Whats apps 4.other			
5	Do you have Direct Marketing license? 1.Yes 2. No				
6	Which factors considered to determining the procurement prices?	Factors			
		Moisture content			
		Foreign matters			
		Colour			
		Size of the grains			
		Variety			
		Dal Recovery (%)			
		Demand (wholesale)			
	Other				
7	What type of activities done before processing of Pigeon pea? Please specify in detail (including time taken for each step)				
7.1	Days required for each step				
7.2	Losses incurred in each step (kg/ctl.)				
8	How much average time required for Tur processing from day of procurement to ready to sell? (Excluding days post process, storage in W. house			-----days	
8.1	How many average days processed dal is storage in W. House?			-----Days	
9	Capacity of dal mill used? (qtl. Per day)			-----Qtl.	
9.1	Working days of dal mill in a year?			-----Days	
10	How much cost incurred for processing of Tur?			-----Rs/ctl	
11	What type of tur dal do you produce?			Types specify (%)	
				Polished	
				Fatka	
				Unpolished	
				Other	
12	Dal processing: Quantity of main and by product	Products			
		1. Dal (kg)			
		2. Chuni (kg)			

	received from 1 qtl. of Tur.					
		3. Other (kg)				
13	Whom do you sell processed dal? During last year	Buyers	Percent	Location of buyer	Percent of the total sold to particular buyer	Average selling price (Rs/qtl.)
		Wholesalers				
		Own outlet				
		Super markets				
		Export				
14	what precaution taken up for dealing with price volatility?					
15	Details of processed dal storing?	Type of storage facilities Tick if used	Percentage	Number of days after processing	Losses incurred in storage (kg/qtl.)	Cost incurred for storage (Rs/qtl.)
		Own storage				
		Govt. facilities used				
		Pvt facilities used				
		Other				
16	According to you, which factors are influencing Tur prices? (prices received by farmers)	Factors	Tick if important			
		1. Production				
		2. Area under Tur				
		3. Export Demand				
		4. Import				
		5. MSP				
		6. Produce quality				
		7. Moisture content				
		8. foreign matters				
		9. Colour				
		10. Demand form wholesalers				
		11. Demand from bulk buyers				
		12. Previous year stock				
		13. Oil prices				
		14. Govt. policy				
		15. other specify)				
17	According to you, what are factors contributing in the determination of Tur Dal prices? (Wholesale and Retail)	Factors	Tick			
		1. Dal quality				
		2. Moisture content				
		3. Colour and Size				
		4. Demand from bulk buyers				
		5. Demand from Wholesalers				
		6. Govt. policies				
		7. Export demand				
		8. Import quantity				
		7. other				

18	Reasons behind the variations in Tur prices in different APMCs markets in India		
19	Which type of dal having more demand? Why?		
20	Do you export tur dal?	1.yes 2. No	
20.1	If yes, where? And quantity exported?		
21	How much price received for exported tur dal?		
22	Have you import Tur? Yes 2. No		
	If yes, Quantity imported	Quantity imported (Tonnes)	
		purchase price	
		cost Rs/tonnes	
23	Which factors are considered while importing Tur?	Factors	Tick
		Domestic Production	
		Total Supply	
		Area under production of tur current year	
		International Prices	
		Domestic prices	
		Last year stocks	
		Quality	
	Current year demand		
24	How do you measures quality of Tur dal produced?		
25	What are the difficulties you are facing in processing of Tur?		
26	Do you feel that there is need to be reforms in Agri. marketing? 1.yes 2. No		
26.1	If yes, please provide suggestions for improvement in agriculture marketing		
27	Please provide following information (From Tur to Dal)	Purchase price of Tur purchased (Rs/qtl)	
		Selling price of Tur Dal (Rs/qtl.)	
		Total Processing cost (Rs/qtl.)	
28	Materials used to package of Tur Dal	1. Gunni Bags 2.Plastic bags	
28.1	Losses incurred during packing	Kg /qtl	
29	Transportations		
	Average transport Cost (from and to processing unit)	Qtly in Tonnes: ----- Cost (Rs/ Qtl.):-----	
	Average transport Cost (processing unit to sell)	Qtly in Tonnes: ----- Cost (Rs/ Qtl.):-----	
	Losses incurred during transportation	Kg/qtl.-----	
	Type of transportation used		
30	Any suggestions		

Schedule for Wholesaler (Tur Dal)

2. Basic information

Date of Survey	
District name	
Taluka	
Place	
Name of Wholesalers	
Contact Number	
Name of the major products deals with	
How many year do you have in this business	

3. Details of Tur trading

1	What is the total quantity of Tur Dal purchased during last years?	Year	Quantity Purchase (Tonnes)	Average Purchase price (Rs/qtl.)	Quantity sold (Tonnes)	Average selling price of Tur Dal (Rs/qtl.)	losses (kg/qtl.)
		2020-21					
2	If losses incurred , main reasons behind losses -----						
3	From whom do you buy/ purchase the Tur Dal?. During last years	Sources	Percent procured				
		1.Processors					
		2.APMC market Arhtiyas/Commission Agents					
		3.Other					
3	Tur Dal Selling information during last 5 year	Sources	Percent Sale				
		Retailers					
		Having Own selling unit					
		Other					
		Big Retailers					
4	Which factors are influencing price of Tur dal while purchasing and selling?	Factors	Tick				
		1. Moisture Content					
		2. Colour					
		3. Size of Tur Dal					
		4. Variety					
		5. Demand from Retailers					
		6. Export					
		7. Import					
		8. Domestic stock					
		9. Govt. policy					
		10. Availability of storage facilities					
		11. Other					
5	Do you have a storage facility?				1.Yes	2. No	
6	Do you store Tur Dal?				1.Yes	2. No	
6.1	Details of procured Tur dal storing?	Type of storage facilities	Tick if used	Percentage	Number of stored	Losses incurred in storage (kg/qtl.)	Cost incurred for storage (Rs/qtl.)
		1. Own storage					
		2. Govt. facilities used					
		3. Pvt facilities used					
		4. Other					
6.2	Losses incurred during packaging				Kg/qtl.		
12	How is the price determined for selling of Tur Dal?						
13	Do you gets the price information?				1 Yes 2. No		

13.1	If yes, from whom? What form?	Source)	Most reliable source	Why (Please provide reason)	How much cost incurred for getting price information ? If any	
		1.SMS,				
		2. Calling				
		3.Whats apps 4.other				
14	Which type of varieties of tur dal having maximum demand? Why?					
15	Reasons behind the variations in Tur prices in different markets in India		_____			
16	Do you export tur dal?		1.Yes 2.No			
16.	If yes, where?		Name of the country _____			
16.	Last year export quantity		-----tonnes _____			
16.3	Price Received		Rs/ctl. _____			
17	Do you Import tur dal?		1.Yes 2.No			
17.1	If yes, where?		Name of the country _____			
17.2	Last year import quantity		-----tonnes _____			
17.3	Cost incurred		Rs/ctl. _____			
17.4	Which factors considered while importing Tur Dal?		_____			
15	According to you, which factors are influencing the Tur Dal Prices?	Factors	Tick			
		1.Current year production				
		2.Area under				
		3. Export demand				
		4. Import				
		5. Consumer choice				
		6. Produce quality				
		7. Moisture content				
		8. Colour				
		11. demand form retailers				
		12. Demand from bulk buyers				
		13. Previous year stock				
		14 other				
16	What are the difficulties you are facing in this business?					
17	Do you feel that there is need to be reforms in marketing of tur?		1.Yes 2. No			
18	If yes, please provide suggestions for improvement in agriculture marketing					

4.Schedule for interviews of Retailers

Basic information

Date of Survey	
District name	
Taluka	
Place /Address	
Name of Retailers	
Contact Number	
Name of the major products deals with	
How many year do you have in this business	

Details of Tur Dal trading

1	What is the total quantity of Tur Dal purchased during last years?	Year	Quantity Purchase (Tonnes)	Average Purchase price (Rs/ctl.)	Quantity sold (Tonnes)	Average selling price of Tur Dal (Rs/ctl.)	losses (kg/ctl.)
		2020-21					
2	If losses incurred, main reasons behind losses						
3	From whom do you buy/ purchase the Tur Dal?. During last years trend	Sources	Percent procured				
			2020-21				
		1.Wholesalers					
		2.Processors					
	3.Other						
3	Tur Dal Selling information during last year	Sources					
		Consumer					
		Other					
4	Which factors are influencing price of Tur dal while purchasing and selling?	Factors	Tick				
		Moisture Content					
		Colour					
		Size of Tur Dal					
		Variety					
		Demand from consumers					
		Export					
		Import					
		Domestic stock					
		Govt. policy					
	Availability of storage facilities						
	Other						
5	Do you have a storage facility?			1.Yes	2. No		
6	Do you store Tur Dal?			1.Yes	2. No		

6.1	Details of procured Tur dal storing?	Type of storage facilities	Percentage	Number of stored	Losses incurred in storage (kg/ctl.)	Cost incurred for storage (Rs/ctl.)
		Own storage				
		Govt. facilities used				
		Pvt. facilities used				
	Other					
6.2	Losses incurred during packaging			Kg/ctl.		
12	How is the price determined for selling of Tur Dal?					
13	Do you gets the price information?			1 Yes 2. No		
13.1	If yes, from whom? What form?	Source)	Most reliable source	Why (Please provide reason)	How much cost incurred for getting price information? If any	
		1.SMS,				
		2. Calling				
		3.Whats apps 4.other				
14	Which type of varieties of tur dal having maximum demand? Why?					
15	Reasons behind the variations in Tur prices in different markets in India					
15	According to you, which factors are influencing the Tur Dal Prices?	Factors	Tick			
		1.Current year production				
		2.Area under				
		3. Export demand				
		4. Import				
		5. Consumer choice				
		6. Produce quality				
		7. Moisture content				
		8. Colour				
		9. Demand from consumers/ buyers				
		10. Previous year stock				
11. other						
16	What are the difficulties you are facing in this business?					

5. Schedule for Interviews of Exporters and Importers

4. Basic information

Sr. No	Date	
1	District	
2	Taluka	
3	Place	
4	Name	
5	Contact Number	
6	Years in business	
7	Major commodities dealt with and year	
8	Business in how many locations	
9	Average turnover last 5 year	

5. Details of Pigeon pea trading

1	Do you export tur dal?	1.Yes 2. No		
2	If yes, where? And quantity exported?			
3	How much price received for exported tur dal?			
4	Have you import Tur?	1. Yes 2. No		
5	If yes, How much total quantity was imported during last 5 year?	2020-21		
		Quantity imported (Tonnes)		
		Purchase price (Rs/ctl.)		
		Selling Price (Rs/Otl.)		
	cost (Rs/tonnes)			
3	How do you measures the quality of Pigeonpea before purchase/Import?	Factors	Yes / No	
		1. Moistures		
		2. Foreign materials		
		3. Colour		
		4. Grain size		
		5. Damaged grains/infected grains		
		6. Variety		
7. Others (specify)				
7.	To whom purchased Tur dal is sold?	Purchasers	Percent sold	Selling price
		Big traders/Agents Processors Organized retailers (e.g. Big- Bazaar, D-Mart, Reliance, ITC) Other		
8	Are you aware about price volatility?	1. Yes 2. No		
9	If yes, what are precaution taken up for dealing with price volatility?	-----		
10	Do you have a storage facility?	1. Yes 2. No		
	If yes, what is the capacity of storage facilities?	Tonnes		
11	How much average quantity was stored during last 3 years after purchase?	Year	Tonnes	Average Number of days stored
10.	If No, which storage facilities availed?	1. MSWC Godown 2. Pvt. Godown		
11	Average losses incurred during storage period?	Kg/ctl.		
12	Are you trading in commodity market?	1.Yes 2.No		
12.1	If yes, which commodities?			
13	According to you,	Factors	1.Yes 2.No	

	what are the factors contributing in the determination of Pigeonpea prices?	1. Production		
		2. Area under crop		
		3. Demand form processing industry		
		4. Import quantity		
		5. Export Demand		
		6. MSP		
		7. Produce quality		
		8. Moisture content		
		9. Foreign matters		
		10. Colour		
		11. Demand from bulk buyers		
		12. Last year stocks		
		13. Last year prices		
		14. International Prices		
		15. Other Govt. Polices		
14	According to you, why the prices in the different markets are different?-----			
16	Do you feel that there is need to be reforms in Agri. marketing? 1. Yes 2. No			
16.1	If yes, please provide suggestions for improvement in agriculture marketing -----			
17	What are the your suggestions for Pigeonpea producers?---			
18	According to you, what are the reasons for fluctuations of prices of Pigeonpea?----			
19	What is average value addition at your level in terms of prices of Pigeonpea?	Purchased price (Rs/Qtl.)		
		Selling prices (Rs/Qtl.)		
20	What difficulties you are facing in trading business?			
21	Are you involved in processing?	1.Yes 2. No		
22	What mechanism used to decide purchase price?	_____		
22	What mechanism used to decide selling price?	_____		
23	Any Suggestions for Farmers	_____		
24	Any Suggestions for Government	_____		



6.Schedule for interview with FPC

Basic information

Date of Survey			
Name of FPC			
Address	District-----Taluka-----Village-----		
Contact Number (Director)		Email-	
Year in business	-----years		
Name of the major commodities buying and selling	Name of the commodities	years	

	Tur	-----
	Gram	-----
	Urad	-----
	Moong	
	Other (if any)	
Organizational setup	Establishment year –	
Number of Member	Male	Female
Classification of Farmer members	Small	Marginal Medium Large
Social Category wise distribution of members	SC	ST Other
Paid up capital (Rs in lakh)		
Working capital (Rs in lakh)		
Turnover (Rs. In Lakh)	2020-21	2019-20

6. Details of Pigeonpea Processing

Sr. No	Particulars		Response		
1	What is the total quantity of Pigeon pea purchased for the processing during 5 years?		Years	Qty.(Tonnes)	Average procurement price (Rs/ctl.)
			2020-21		
2.2	What kind of services provided to producers last 2-3 years	Services	Tick if provided		Charges if any (Rs/ctl.)
		1.Cleanning			FPC members Non members
		2. Grading			
		3. Unloading			
		4. Transportation			
		5.Packaging			
		6. Advance payment			
		7. Storage facilities			
	6.Other(Specify)				
3	Do you have Direct Marketing license?		1.Yes 2. No		
4	Which factors considered to determining the procurement prices?	Factors	Specifications (minimum threshold level)	Please tick	
		1. Moisture Content			
		Foreign matters			
		Colour			
		Size of the grains			
		Variety			
		Demand (wholesale)			
	Other				
	Do you process Tur?		1. Yes 2.No		
5	If yes, What type of activities done before processing of Pigeon pea? Please specify in detail (including time taken for each step)				

6.1	Days required for each step						
6.2	Losses incurred in each step (kg/ctl.)						
7	How much average time required for Tur processing from day of procurement to ready to sell? (excluding days post process, storage in W. house	-----days					
8	How many average days processed dal is storage in W. House?	-----Days					
9	Capacity of dal mill used? (qtl. Per day)	-----Qtl.					
9.1	Working days of dal mill in a year?	-----Days					
10	How much cost incurred for processing of Tur?	-----Rs/ctl					
11	What type of tur dal do you produce?	Types specify	Percentage				
		Polished					
		Fatka					
		Unpolished					
		Other					
12	Dal processing: Quantity of main and by product received from 1 qtl. of Tur.	Products					
		Dal (kg)					
		Chuni (kg)					
		Other (kg)					
13	Whom do you sell processed dal? During last year	Buyers	Percent	Location of buyer	% to sold	Average selling price (Rs/ctl.)	
		1. Wholesalers					
		2. Own outlet (own brand)					
		3. Super markets					
		4. Export					
		5. Other					
14	what are precaution taken up for dealing with price volatility?						
15	Details of processed dal storing?	Type of storage facilities	Tick if used	Percentage	Number of days after processing	Losses incurred in storage (kg/ctl.)	Cost incurred for storage (Rs/ctl.)
		Own storage					
		Govt. facilities used					
		Pvt facilities used					
		Other					
16	According to you, which	Factors	Tick if important				
		1.Production					

	factors are influencing Tur prices? (prices received by farmers)	2.Area under Tur		
		3. Export demand		
		4. Import		
		5. MSP		
		6. Produce quality		
		7. Moisture content		
		8. foreign matters		
		9. Colour		
		10. Demand form wholesalers		
		11. Demand from bulk buyers		
		12. Previous year stock		
		13. Oil prices		
		14. Govt. policies		
		15. other (specify)		
17	According to you, what are factors contributing in the determination of Tur Dal prices? (Wholesale and Retail)	Factors		Tick
		1. Dal quality		
		2. Moisture content		
		3. Colour and Size		
		4. Demand from bulk buyers		
		5. Demand from Wholesalers		
		6. Govt. policies		
		7. Export demand		
		8. Import quantity		
		7. other		
18	Reasons behind the variations in Tur prices in different APMCs markets in India			
19	Which type of dal having more demand? Why?			
20	Do you export tur dal?			1.yes 2. No
20.	If yes, where? And quantity exported?			
21	How much price received for exported tur dal?			
22	Have you import Tur?			2. Yes 2. No
22.1	If yes, How much total quantity was imported during last 5 year?		2020-21	
		Quantity imported (Tonnes)		
		purchase price (Rs/ctl.)		
		cost (Rs/tonnes)		
23	Which factors are considered while importing Tur?	Factors		Tick
		Domestic Production		
		Total Supply		
		Area under production of tur current year		
		International prices		
		Domestic prices		
		Last year stocks		
		Quality		
		Current year demand		
		Other (specify)		
24	How do you measures quality of Tur dal produced?			
25	What are the difficulties you are facing in processing of Tur?			

26	Do you feel that there is need to be reforms in Agri. marketing? 1.yes 2. No	
26.1	If yes, please provide suggestions for improvement in agriculture marketing	
27	Please provide following information (From Tur to Dal)	1. Purchase price of Tur purchased (Rs/qtl)
		2. Selling price of Tur Dal (Rs/qtl.)
		3. Total Processing cost (Rs/qtl.)
		4. Electricity used
		5. Labour cost
		6. Storage cost
		7. Water used for processing (per tonnes)
		8. Cost of water
		9. Type of Waste water treatment
28	Materials used to package of Tur Dal	Gunny Bags /Plastic bags/Other
28.1	Losses incurred during packing	Kg /qtl
29	Transportations	
	Average transport Cost (from and to processing unit)	Qtly in Tonnes: ----- Cost (Rs/ Qtl.):-----
	Average transport Cost (processing unit to sell)	Qtly in Tonnes: ----- Cost (Rs/ Qtl.):-----
	Losses incurred during transportation	Kg/qtl.-----
	Type of transportation used	
33	Any suggestions	

34. Are you involved in Tur procurement programme of Govt.? 1. Yes 2. No

Year	Quantity procured (in qtl.)	Commission or charges received (Rs.per qtl.)	Cost incurred (Rs. In Qtl.)
2019-20			
2020-21			

35. Please provide your experience regarding participation in govt. Tur procurement programme and suggestions?
