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UNDERSTANDING THE DYNAMICS OF PULSE PRICES IN PAKISTAN: A TWENTY-YEAR ANALYSIS OF PRODUCTION, CULTIVATED AREA, IMPORT DEPENDENCE AND FOOD INFLATION

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Abstract

In Pakistan, pulses are a vital source of vegetative protein and are a key part of the nutritional security and food security of households. The prices of the major pulses have, however, risen significantly and shown marked fluctuations in the last two decades, posing issues of affordability, domestic supplies and reliance on imports. In this study, trends and determinants of the retail prices of four major pulses, gram (chickpea), moong (mung bean), mash (black gram) and masoor (lentil) in Pakistan are discussed from FY2005–06 to FY2024–25. This study is quantitative in nature, using a longitudinal research design. A time-series data set is created which includes pulse prices, domestic production, cultivated area, productivity, aggregate pulse imports, PKR/USD exchange rate, food inflation, high-speed diesel prices and climate shocks. There is significant volatility in prices, especially for gram and mash, and considerable variation in domestic production, imports, exchange rates and transportation costs, as seen with descriptive statistics. The pulse prices have strong positive relationships with the price of PKR/USD, high speed diesel price, and total pulse imports, whereas gram and mash prices have been negatively correlated with domestic production, according to Pearson correlation analysis. The results of augmented Dickey-Fuller tests suggest that the main time-series variables are not stationary at the level but stationary upon first differencing, and are therefore classified as I(1). The caution is warranted against drawing causal or explanatory inferences from high level correlations and regressions. The strongest short run evidence comes from the first difference regressions for moong, for which an increase in domestic production by 1% is estimated to be accompanied by a nearly 0.59% decrease in price. The long-run specifications did not show any significant change in the exchange rate, although the relationship was significant for price levels. Longer

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run relationships are suggested by exploratory ARDL analysis but it is not possible to draw strong conclusions about cointegration given the sample of only 12 years available for the annual data. Overall, the results indicate that the dynamic of pulse prices in Pakistan are driven by a mix of domestic supply constraints, import dependence and macro-economic and cost factors, and that there are significant variations in the dynamics of pulse prices at the individual level. The study highlights the need for policies that enhance domestic pulse productivity, strengthen supply resilience, reduce vulnerability to import and exchange-rate shocks, and improve long-term pulse-market stability.

INTRODUCTION

Pulses are an important component of Pakistan's agricultural and food system and contribute to both food and nutritional security by providing an accessible source of plant-based protein (Bessada et al., 2019). The major pulses cultivated and consumed in Pakistan include gram (chickpea), moong (mung bean), mash (black gram), and masoor (lentil). In addition to their nutritional importance, pulse crops contribute to agricultural sustainability through biological nitrogen fixation (FAO, 2026) and their role in crop rotations. However, productivity improvements in Pakistan's pulse sector have remained relatively slow, while climate and disease pressures continue to constrain production (Ministry of National Food Security and Research [MNFSR], 2026a).

Despite their importance, pulses occupy a relatively small share of Pakistan's cultivated area. According to the MNFSR, pulses account for approximately **5% of the country's total cropped area**. Recent official statistics indicate that the four principal pulses gram, mung, mash, and masoor, covered approximately **1.01 million hectares**, with production of about **372.7 thousand tonnes** in the reported period. According to the Government of Pakistan (2024), gram is the leading pulse crop, producing about 78.8% of the total volume; the second is mung accounting for 19.9% and mash and masoor account for very small proportion of production (MNFSR, 2024).

Presently, there is a major structural issue of the domestic production of pulse, which is not sufficient to satisfy the demand of Pakistan. This creates a deficit that is compensated for by imports, thus making domestic pulse markets vulnerable to international supply and price fluctuations (MNFSR, 2024). This dependence is more dominant in the case of chickpeas market. According to the statistics of the United States Department of Agriculture (USDA) chickpea production has dropped from around 751,000 tonnes in 2013 to 234,000 tonnes in 2021, however the value of chickpea imports has risen from around US$ 40 million in 2013 to US$ 262 million in 2022 (USDA Foreign Agricultural Service [USDA FAS], 2023a). Pakistan's net imports for dried chickpeas were approximately 408,968 tons, with the Russian Federation, Australia and Tanzania being the top sources, and net imports of dried-lentils were about 180,958 tons, with the largest sources being Australia, Canada and the Russian Federation (World Bank, 2024).

The retail price of pulses has risen significantly while these structural supply constraints have been in existence. Official price data compiled for this study show that for the period FY2005-06 to FY 2024-25, the prices of gram, moong, mash and masoor have increased significantly in nominal terms. These commodities are being reported as part of the food items monitored by the Pakistan Bureau of Statistics (Government of Pakistan, Ministry of Finance, 2026) in the recent Pakistan Economic Survey. The continued price hikes give

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rise to an important policy question: how much of the price increases have been due to factors relating to the domestic production, import reliance, macroeconomic factors and price shocks? In particular, the study will examine if the prices of individual pulses are related to changes in domestic production and productivity, changes in availability of imports, changes in exchange rates, changes in overall food inflation, changes in transportation costs, and climatic shocks. Special emphasis is paid to the strength and direction of these relationships being different for gram, moong, mash, and masoor.

For this purpose, the study aims to fill the gaps in the knowledge of price formation of pulses in Pakistan, by answering the aforementioned questions. For policy design, the distinction between price pressures due to domestic supply constraints versus import reliance and macroeconomic fragility can be a critical component, and may warrant increased policy focus on import management, exchange-rate vulnerability, supply diversification, and strategic food-market resilience. Thus, the study is aimed to give empirical proof for the development of more productive, resilient and price stable pulse sector of Pakistan.

2.Literature Review

2.1 Pulse production, prices, and food security in Pakistan

Pulses are an important part of the food system in Pakistan as they offer an affordable source of plant protein, and also offer agronomic benefits by nitrogen fixation and crop rotation. The most important pulses consumed in Pakistan are gram/chickpea, moong/mung bean, mash/black gram and masoor/lentil. Pulses are very important on nutritional and agronomic grounds and yet the production of these crops is stagnating, with production variability of a significant magnitude and prices are volatile in Pakistan. The Australian Centre for International Agricultural Research (ACIAR) reports that domestic and international demand for pulses is growing, but production in Pakistan is stagnating, and there is significant price and production volatility, as well as high post-harvest losses (Australian Centre for International Agricultural Research [ACIAR], 2026).

There is a structural supply issue and not just a cyclical one. The increasing demand for pulses has led to a situation where production has not been able to keep pace with the demand in Pakistan; and crops like chickpea and lentil have been displaced gradually towards the marginal agricultural lands even though the prices are relatively attractive (Charles Sturt University, n.d.). This is especially crucial for the case of chickpea as it traditionally accounts for a significant proportion of the pulse area and production in Pakistan. Cultivation in the chickpea is largely dependent on marginal and mostly rain-fed environments, thus making it more susceptible to rainfall fluctuations and other climatic stresses.

Under these conditions, pulse-price behavior should be studied in the context of a wider supply–demand situation. A shortfall in domestic production, if it does not keep growing in pace with consumption, can drive up domestic prices and reliance on imports. Nevertheless, advances in productivity can lead to a rise in the market supply, which will put downward pressures on prices. In evaluating the returns to mungbean research, Sequeros et al. (2020) make explicit reference to this supply-price mechanism: productivity gains lead to greater market supply and can result in downward market price pressure. This theoretical theory is significant to use as a basis to incorporate the variables of domestic production and productivity in the current research.

2.2 Domestic production and pulse-price formation

According to agricultural price theory, when other factors remain constant, the more supply of agricultural products there is in the domestic market, the lower its price becomes. Decreases in

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either production or area planted would lead to lower market availability, potentially leading to higher prices, whereas an increase in production would help to soften price pressures. But, in Pakistan this correlation could vary widely among different pulses like gram, moong, mash and masoor due to the differences in production structure, agro-climatic requirements and dependence on imported supply of pulses.

The available literature confirms that there is a high price and production variability at existing pulse markets in Pakistan. The study by Vanzetti et al. (2022) on pulse policy in Pakistan was conducted, which revealed that policies designed to affect trade and domestic availability did not necessarily result in lower domestic prices. They found prices went up significantly despite the restrictions put in place to reduce price changes and that the variability in price rose. This indicates that structural supply constraints might be hard to resolve by administration or trade alone.

Pulse prices have also been studied recently from a forecasting point of view. Bakhsh et al. (2024) analyzed the production and market-arrival prices of mung bean, lentil and chickpea for Faisalabad. They have shown that it is essential to take stock of the market arrivals, production conditions as well as past prices in order to understand pulse markets. Forecasting studies, however, are mainly focused on predicting future prices but not on determining the relative importance of domestic supply, imports, exchange rates, inflation, fuel prices and climatic shocks. The present research hence was more specific in its focus on determinants and dynamics of prices over the longer term for each and every pulse commodity.

2.3 Productivity and agronomic constraints

Production alone may not adequately capture domestic supply conditions because output is jointly determined by cultivated area and productivity. Low productivity can constrain pulse availability even where cultivated area remains relatively stable. This makes yield an important element in understanding Pakistan's pulse supply problem.

Recent agronomic research demonstrates that mungbean productivity, for example, can respond substantially to agricultural management practices. Research on irrigation and residue management found sizeable differences in mungbean yields under different irrigation regimes, demonstrating the sensitivity of pulse productivity to water management (Tripathi et al., 2024). Similarly, recent work on mungbean emphasises the importance of developing improved varieties adapted to particular agro-ecological conditions and resistant to biotic and abiotic stresses (Huppertz et al., 2023).

Research has also highlighted disease-related yield constraints. Mazhar et al. (2024), for example, examine the effects of charcoal rot disease on mungbean and potential agronomic interventions to reduce yield losses. These studies indicate that productivity is influenced by a combination of water availability, seed technology, disease, environmental stress, and farm-management practices.

For the present study, this literature supports analysing cultivated area, yield, and production as related dimensions of domestic supply. However, including all three dimensions simultaneously in a small econometric model may create redundancy and multicollinearity. Production can therefore serve as the principal supply variable, while area and productivity trends provide additional descriptive evidence about the structural evolution of Pakistan's pulse sector.

2.4Import dependence and domestic pulse prices

If domestic production is not adequate to meet domestic demand, imports are necessary to meet domestic supply and demand. The Pakistan pulse industry is markedly connected with the global market. USDA FAS (2023) noted that the price of Pakistan's pulse imports rose by almost 33% to US$282 million in the first half of 2023, with Australia continuing as a major supplier.

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The case of chickpea is a good example. Statistics from the USDA analysis show that Pakistan's import demand and shift in sourcing from key exporters like Australia have greatly impacted international chickpea trade patterns (USDA Foreign Agricultural Service, 2023).

Imports should theoretically increase domestic supply and thereby moderate prices:
However, the relationship can also operate in the opposite direction. Domestic shortages may first increase prices, prompting traders or governments to increase imports:
This creates a potential **endogeneity or reverse-causality problem**. A positive statistical association between imports and domestic prices therefore does not necessarily imply that imports cause prices to increase. Rather, imports may represent a market response to shortages and already-rising prices.
International evidence reinforces the importance of accounting for production and trade simultaneously. Kohlscheen (2022), using data for 35 countries, finds that greater domestic food production and imports, or lower exports, tend to reduce food inflation, while the transmission from global to domestic food prices is moderated considerably once exchange-rate changes are considered.
This literature is particularly relevant to the present research because consistently comparable **individual pulse-import quantities are not available for the entire study period**. Consequently, total pulse imports are employed as an indicator of sector-wide imported supply conditions, while the limitation of using an aggregate import variable to explain individual pulse prices is explicitly acknowledged.

2.5 Exchange-rate depreciation and imported food-price transmission

Exchange-rate movements represent another potentially important determinant of pulse prices. The theoretical transmission mechanism is straightforward for an import-dependent economy:
Pakistan has experienced substantial currency depreciation over the period examined in this research. Since pulse imports are generally contracted in foreign currency, a depreciation of the Pakistani rupee can increase their domestic cost even if international commodity prices remain unchanged.
Previous Pakistan-focused food-price research provides support for considering exchange rates in agricultural price analysis. Zehra and Sohail's analysis of food prices in major Pakistani cities identifies macroeconomic and commodity-specific factors behind food-price movements and finds, among other relationships, that wheat prices are affected by exchange-rate movements (Zehra & Sohail, 2022). The authors more generally characterise Pakistan's food-price environment as volatile, emphasising the uncertainty generated by substantial food-price fluctuations.
International research similarly demonstrates that exchange-rate movements influence the extent to which global food-price shocks are transmitted into domestic markets. Kohlscheen (2022) finds that the pass-through of international food prices is relatively limited after exchange-rate variations are accounted for, highlighting the importance of currency movements when analysing domestic food inflation.
These findings support the inclusion of PKR/USD in the present study. However, an important methodological distinction must be maintained between **long-run co-movement and short-run causation**. If both pulse prices and the exchange rate trend over time, high correlations between their levels may partly represent common stochastic trends. Unit-root and cointegration analysis is therefore required before interpreting such relationships as long-run economic effects.

2.6 Food inflation and broader price pressures

Pulse prices also operate within Pakistan's broader inflationary environment. General food inflation

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can reflect changes in agricultural input costs, energy prices, supply-chain disruptions, monetary conditions, expectations, and domestic and international commodity markets.

Pakistan Institute of Development Economics research indicates that recent food inflation has been driven by heterogeneous commodity-specific factors rather than a single uniform mechanism. The study also notes significant rise in the petrol and diesel prices during the inflation period, which highlights the potential interaction between food prices and energy costs (Pakistan Institute of Development Economics [PIDE], n.d.).

There is a significant welfare implication to food-price inflation. O'Donnelloghue et al. (2023) conclude that rising food and transportation costs were key drivers of the recent inflationary episode in Pakistan and that food-price inflation was most significant for the welfare losses of lower income groups. This highlights the broader policy relevance of pulse price inflation: pulses are a critical food commodity; if prices continue to rise, not only will agricultural markets be impacted, but so will households' purchasing power and affordability to eat.

However, the notions of general food inflation and individual pulse prices should not be confused. Pulses prices may react to commodity specific production shortfalls, import conditions and market structures which are not necessarily reflected in overall food inflation. The present research thus uses food inflation as a part of the larger macroeconomic environment, rather than taking it as the main determinant of the price of pulse.

2.7 Fuel prices, transportation, and supply-chain costs

Another possible transmission pathway would be the cost of energy. Agricultural commodities go through the farm, wholesale markets, port facilities, storage areas, processors, and retail markets. Diesel price in Pakistan has significant impact on the transport of pulses from production areas to ports, wholesale markets and consumers as road transport is the major mode of transportation for distribution of pulses in the country.

The State Bank of Pakistan (SBP) has long appreciated that fuel price hikes may be associated with significant food price pressures and that margins at the retail level may lead to variations between the wholesale and retail food prices (State Bank of Pakistan [SBP] 2006). Detailed analysis undertaken by the PIDE also shows that there have been significant rises in petrol prices and diesel prices, as well as food inflation, over the last few years.

Fuel price, exchange rates and overall inflation, however, can be very correlated. This could cause a multicollinearity problem in econometric models especially in the case of a small annual sample. Therefore, fuel prices are studied using robustness tests, rather than including the fuel price with the other macroeconomic variables.

2.8 Climate variability and pulse supply

Other significant supply-side factors are climate conditions. The pulse crops are dependent on rainfall, temperature, water, drought, flood, pest and disease. The consequences could be significant for crops being cultivated in marginal and rain-fed soils.

In the general agronomic literature, there is a focus on varieties that can withstand biotic and abiotic stresses (Huppertz et al., 2023). Recent experimental studies also reveal that management practices of crops have significant impacts on productivity of pulses under changing environments (Tripathi et al., 2024).

The prices can be impacted indirectly by climate shocks, not at the time of the shock. When a climate-shock indicator and pulse prices are only weakly correlated in time, this indirect mechanism is relevant when interpreting the relationship. A low contemporaneous correlation does not imply a lack of importance of climatic conditions in

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production; their effects could be indirect through production and lagged in time.

2.9 Price volatility, market structure, and policy

The literature also suggests that pulse-price outcomes cannot be understood solely through physical production. Government trade policy, market incentives, post-harvest systems, and the structure of agricultural markets can influence price formation.

Vanzetti et al. (2022) show that trade restrictions designed to affect Pakistan's pulse market did not necessarily generate lower domestic prices and were accompanied by increased price variability. ACIAR's continuing work on the economic analysis of pulse policies similarly identifies production stagnation, volatile prices, and post-harvest losses as interconnected policy challenges.

These findings imply that policies aimed merely at short-term price suppression may be insufficient. Long-term price stability may instead require improvements in productivity, varieties, storage, supply chains, market information, and trade management.

2.10 Methodological literature and time-series analysis

Previous agricultural price studies employ a variety of methods ranging from descriptive trend analysis to forecasting and multivariate econometric modelling. Recent pulse research in Pakistan has used historical production, market arrivals, and price information for forecasting purposes (Bakhsh et al., 2024). More broadly, food-price research demonstrates that commodity-price dynamics can differ substantially across products and that models need to account for time-series characteristics rather than assume uniform behaviour.

This issue is directly relevant to the present research. Price, exchange-rate, import, production, and fuel-price series frequently contain trends and may be non-stationary. Regression among non-stationary variables can generate apparently high explanatory power and statistically significant coefficients even where the underlying relationship is spurious. Consequently, unit-root testing should precede long-run regression analysis.

The present study therefore employs the **Augmented Dickey-Fuller (ADF) test** to determine the order of integration of the principal variables. Where variables are integrated of order one, I(1), first-difference models provide a means of examining short-run relationships without relying on potentially spurious level regressions. Cointegration and restricted ARDL/ECM specifications can then be considered for possible long-run relationships, subject to the important constraint imposed by the relatively small annual sample.

2.11 Research Gap

Three principal gaps emerge from the literature.

First, much of the Pakistan-specific literature concentrates on **pulse production, agronomic productivity, trade policy, or price forecasting separately**. There is comparatively limited long-term empirical research integrating individual pulse prices with domestic production, aggregate imports, exchange-rate movements, food inflation, fuel costs, and climate shocks within one analytical framework.

Second, treating pulses as a single commodity can conceal substantial heterogeneity. Gram, moong, mash, and masoor differ in domestic production, productivity, cultivated area, import dependence, and vulnerability to climatic conditions. Consequently, their price determinants may also differ. The available literature does not adequately explain these **pulse-specific differences in price formation**.

Third, the exceptionally strong trends in Pakistan's exchange rate, energy costs, imports, and nominal food prices make econometric treatment of non-stationarity particularly important. Simple correlations between trending

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variables may substantially overstate their underlying economic relationships. A study combining descriptive evidence with unit-root testing and appropriately specified short-run and exploratory long-run models can therefore add methodological value.

2.12 Conceptual Synthesis

Drawing on the literature, the determinants of pulse prices can be organised into four interconnected channels:

Production, cultivated area, and productivity

Aggregate pulse imports and international availability

PKR/USD, food inflation, and fuel/transportation costs

Drought, flooding, rainfall variability, and production disruption

The literature, therefore, backs the main hypothesis of this study that the dynamics of pulse price in Pakistan is not likely to be explained by a single variable. Instead, they are the outcome of relationships among domestic agricultural production, import reliance, macroeconomic factors, supply chain expenses, and environmental risks. The significance of these mechanisms is also likely to be different for gram, moong, mash, and masoor. This gives the theoretical and empirical support for the multi-variable, pulse-specific analysis carried out in this study.

3. Problem Statement

Pulses such as gram (chickpea), moong (mung bean), mash (black gram), masoor (lentil) are an integral part of the food system in Pakistan, which supplies relatively cheap plant-based protein and helps achieve food and nutritional security for households. Even though pulses are an important food item, there has been significant rise and fluctuations in their prices over the last two decades in Pakistan. The extended series of nominal retail prices for all four main pulses created for this study indicate a strong upward trend in each of the pulse food prices from 2005–06 to 2024–25. A pertinent food-policy question that arises is what are the reasons for the continued rise in prices of pulses in Pakistan.

The problem is particularly significant because the pulse market is affected simultaneously by domestic agricultural conditions and wider macroeconomic pressures. Changes in cultivated area, production and productivity influence domestic availability, while insufficient domestic supply increases reliance on imports. At the same time, exchange-rate depreciation can increase the domestic cost of imported pulses, and food inflation, fuel and transportation costs, and climate-related shocks may further affect retail prices.

4. Key Research Question

What factors explain the long-term increase and variation in the prices of major pulses in Pakistan between FY2005–06 and FY2025–26?

4.1 Research Hypotheses

The paper revolves around five testable hypotheses:

- **H1:** Lower domestic pulse production is associated with higher domestic retail prices.
- **H2:** Greater pulse import availability is associated with lower domestic retail prices, controlling for import costs.
- **H3:** PKR depreciation increases domestic pulse prices.
- **H4:** Higher international/import unit values increase domestic pulse prices.
- **H5:** Climate shocks increase pulse prices through reductions in domestic supply.
- **H6:** Exchange-rate and international-price effects are stronger for highly import-dependent pulses than for pulses with greater domestic production.
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5. Research Methodology

The quantitative method has been employed to understand the dynamics of pulse prices in Pakistan. Secondary sources have been relied upon

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to collect the date of area, production, prices, and import of pulses, and exchange and inflation rates. The research is based on twenty years' time-series data from 2005-06 to 2025-26. In order to carry out research, a structured empirical data set and analysis plan has been constructed.

The dataset has **21 observations (FY2005–06 to FY2025–26)** and, for each pulse, the following variables:

Variable	Code	Unit	Role
Retail pulse price	PRICE	Rs/kg	**Dependent**
Domestic production	PROD	'000 MT	Main supply variable
Cultivated area	AREA	'000 ha	Alternative supply model
Yield	YIELD	kg/ha	Alternative supply model
Pulse imports	IMPORT	'000 MT	Foreign supply
Import unit value	IMPPRICE	US$/MT	International price
Exchange rate	EXRATE	PKR/US$	Currency transmission
Food inflation	FOODINF	%	General food-price pressure
HSD price	DIESEL	Rs/litre	Transport/input-cost proxy
Flood shock	FLOOD	0/1	Climate shock
Drought shock	DROUGHT	0/1	Climate shock

Table.It has been observed during the research that all the pulses are not homogenous crop group, and therefore, gram, mung, mash and masoor's data sets have been separately constructed. Moreover, import of pulses have also been factored in in analysis as the Ministry of National Food Security and Research (MNFSR) explicitly states that domestic pulse production is below requirements and that the balance is supplied through imports. There is a complication with imports: higher prices can themselves cause Pakistan to import more pulses. Thus, a simple positive correlation between imports and prices does not prove that imports increase prices. It may instead reflect imports responding to shortages and high prices. The intricacies of "Production Model" and "Structured Supply Model" have been considered respectively to explore whether domestic supply affects prices and why domestic supply is changing. Therefore, production, yield and area have been factored in accordingly.

The exchange-rate variable is particularly valuable in analysis. SBP's official statistics show how dramatic the currency shock became. Its FY2021–FY2025 tables provide annual-average exchange rates and show the major depreciation during FY2022–FY2024. This gives a strong transmission mechanism:

PKR depreciation
→ imported pulse landed cost rises
→ wholesalers face higher replacement costs
→ retail pulse prices rise.

This mechanism is particularly important for **masoor**, where domestic production represents only a small part of consumption.

Before regression, the following five data sets have been constructed to observe the trend descriptively.

1. Retail prices of Gram, Moong, Mash and Masoor, 2005–06–2025–26
2. Production trends of the four pulses
3. Cultivated-area trends
4. Pulse imports versus domestic production
5. Pulse prices versus PKR/USD exchange rate

The trend of Data set four would specifically show whether Pakistan has transitioned from

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predominantly domestic supply toward increasing import dependence.

For every variable, Mean, Median, Minimum, Maximum, Standard deviation, Coefficient of variation will be calculated. Correlation matrix will also be performed by calculating Pearson correlations, among **PRICE, PROD, IMPORT, Impprice, Exrate, Foodinf And Diesel** to identify multicollinearity. It is expected that **Exrate, Diesel, Foodinf** And **Nominal Price** To be correlated because they all contain strong macroeconomic trends.

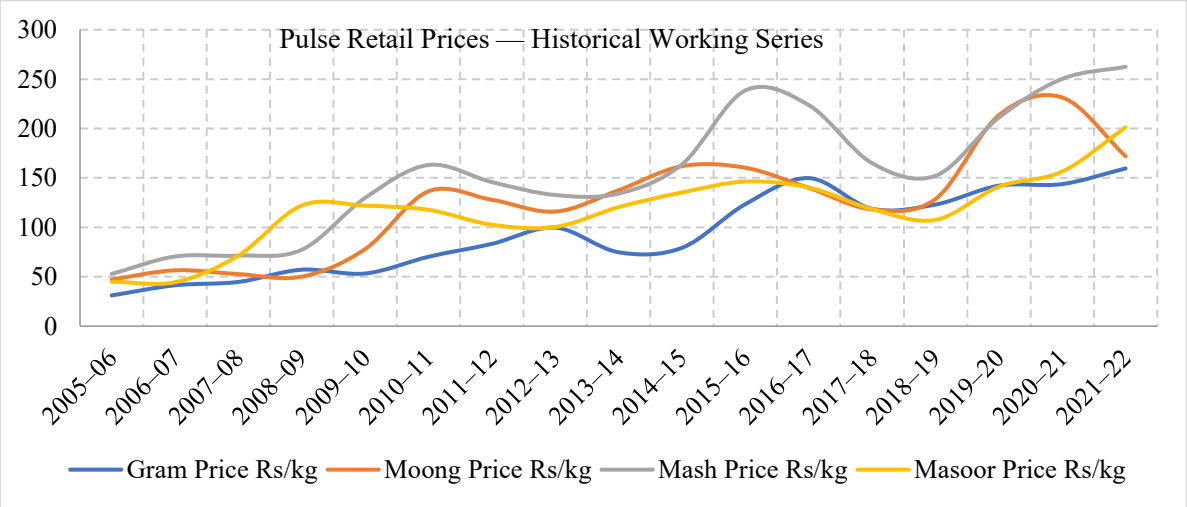
Stationarity is essential because time-series data has been used in analysis. Therefore, before running Ordinary Least Squares (OLS), ADF/PP stationarity tests will be conducted for the continuous variables. Depending on the results, log differences, an ARDL/ECM specification will be adopted. With only 21 annual observations, ARDL is potentially attractive because it can accommodate a mixture of I (0) and I (1) variables, but the number of regressors and lags must remain very small. The model has been kept **parsimonious** as Twenty-one observations is a small sample. Therefore, instead of eight, four core explanatory variables will be used and then **food inflation, diesel and climate variables individually as robustness tests** will be introduced.

The methodical structure of the paper follows the following pattern:

Descriptive trends → correlation analysis → ADF tests → first-difference regressions → restricted ARDL as robustness analysis.

6. Descriptive Trends of Variables of Pulses and Results

6.1 Trend of Pulse prices (Average Retail Price of Pulses



Graph: Trend of retail price of Pulses

A striking preliminary result is already visible: **all four pulses became several times more expensive between 2005–06 and 2021–22, well before the extreme food-inflation episode of 2022–23**. That supports treating the problem as a **long-term structural price trend**, not merely a post-2022 inflation shock.

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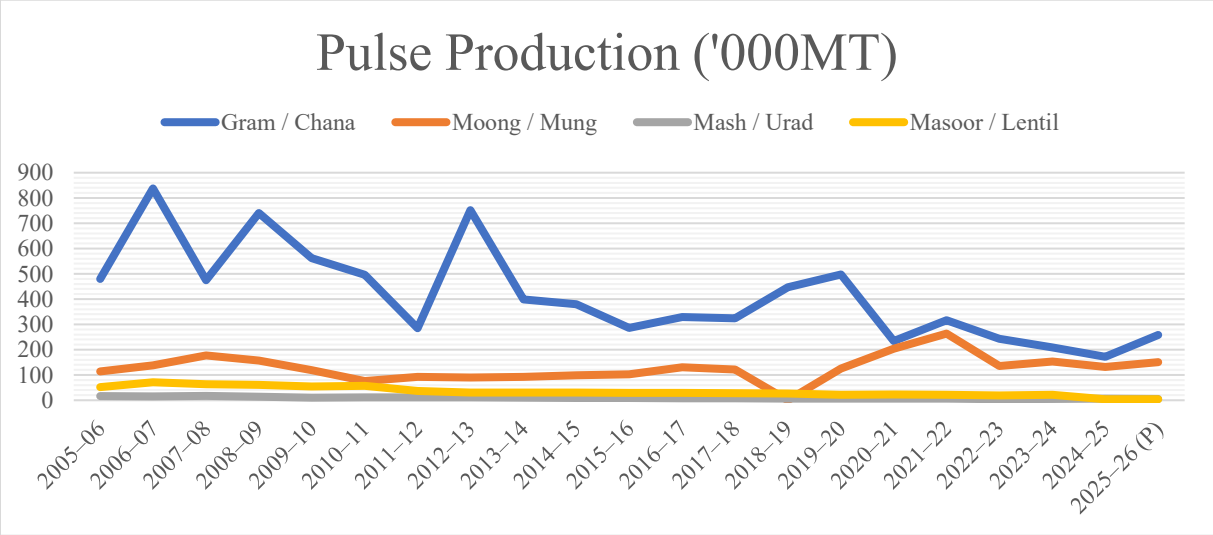
Pulse	June 2023	June 24	June 25
Masoor	277.38	314.7	294.9
Moong	269.75	313.5	404.1
Mash	453.95	564.7	457.4
Gram	243.96	293.2	316.5

For **2025–26**, the Pakistan Economic Survey gives April 2026 prices of **Rs260.7/kg masoor, Rs389.9 moong, Rs473.5 mash and Rs250.1 gram**, compared with April 2025 values of Rs294.4, Rs396.8, Rs461.9 and Rs309.8 respectively.

6.2 Trend of Pulse production

Individual pulse production in Pakistan, 2005–06 to 2025–26



The long-term pattern of production of pulses is striking**.** Gram is the dominant pulse, but also highly volatile. Production reached 837,800 MT in 2006–07, dropped to 284,400 MT in 2011–12, recovered to 751,300 MT in 2012–13, and subsequently fell to only 171,900 MT in 2024–25. The provisional 2025–26 estimate shows a recovery to 258,600 MT. Moong is the exception to the general decline. Production increased from about 113,900 MT in 2005–06 to 151,100 MT in 2025–26, although it is highly variable. The exceptional year was 2021–22, when production reached approximately 263,700 MT. Mash has experienced a major structural contraction. Production declined from about 16,500 MT in 2005–06 to only 5,600 MT in 2025–26—roughly a two-thirds decline. Masoor shows an even more concerning recent pattern. The latest Economic Survey reports only 4,300 MT in 2024–25 and 4,000 MT in 2025–26, making domestic lentil production extremely small relative to Pakistan's consumption requirements.

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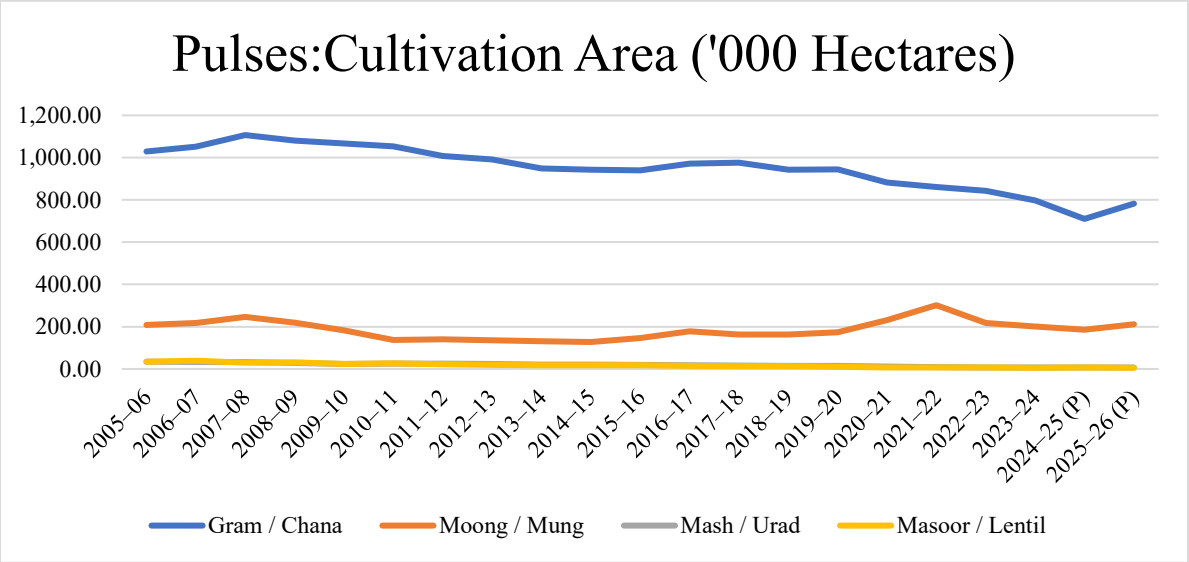
Long-term change can be tabulated as follows:

Pulse	2005–06	2025–26	Approx. change
Gram	479.5	258.6	**−46%**
Moong	113.9	151.1	**+33%**
Mash	16.5	5.6	**−66%**
Masoor	52.4	4.0	**−92%**

Gram, mash and masoor show severe long-term production weakness, whereas moong has performed considerably better. The production trend of pulses shows that **the four pulses should not be treated as one homogeneous commodity group**.

6.3 Trend of Cultivated Area



The 2005–06 starting values are also independently reported in PBS historical agricultural statistics: gram 1,028.9, mung 208.5, mash 34.6 and masoor 33.9 thousand hectares. For 2006–07 through 2023–24, MNFSR's *Agricultural Statistics of Pakistan* provides the crop-specific national series. For example, gram declined to 797.1 thousand hectares by 2023–24, while mung stood at 201.1 thousand hectares. Mash fell to only 7.0 thousand hectares, while masoor fell to 6.2 thousand hectares.

For 2024–25, PBS reports **710,000 ha for gram, 185,400 ha for moong, 7,500 ha for mash and 6,300 ha for masoor**. For 2025–26, the latest Pakistan Economic Survey reports **211,400 ha for moong, 6,800 ha for mash and 5,500 ha for masoor**.

*The 2025–26 gram acreage is approximately **782,000 ha**, consistent with the latest reported recovery in gram area/production.

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The comparison between 2005–06 and 2024–25 is revealing:

Pulse	2005–06 ('000 ha)	2024–25 ('000 ha)	Change
Gram	1,028.9	710.0	**−31.0%**
Moong	208.5	185.4	**−11.1%**
Mash	34.6	7.5	**−78.3%**
Masoor	33.9	6.3	**−81.4%**

Masoor and mash cultivation have almost disappeared relative to their levels twenty years ago. Gram has also lost nearly one-third of its cultivated area. Moong is much more resilient and even experienced a major temporary expansion, reaching 301,800 hectares in 2021–22 before declining again.

The gram trend is especially important because it accounts for most of Pakistan's pulse acreage:

1.029m ha (2005–06) → 1.107m (2007–08) → 0.943m (2014–15) → 0.944m (2019–20) → 0.862m (2021–22) → 0.797m (2023–24) → 0.710m ha (2024–25).

PBS confirms the recent gram decline in the Economic Survey. This strengthens the research hypothesis; now three datasets can be connected:

Cultivated area ↓
→ Domestic production ↓
→ Domestic supply deficit ↑
→ Imports ↑
→ Greater exposure to international prices/exchange rate
→ Domestic pulse prices ↑

6.4 Trend of Yield/Productivity of Pulses

The latest Pakistan Economic Survey independently confirms the important recent gram figures: 707,000 ha and 171,900 tons in 2024–25 versus 782,000 ha and 258,600 tons in 2025–26, a 50.4% production recovery.

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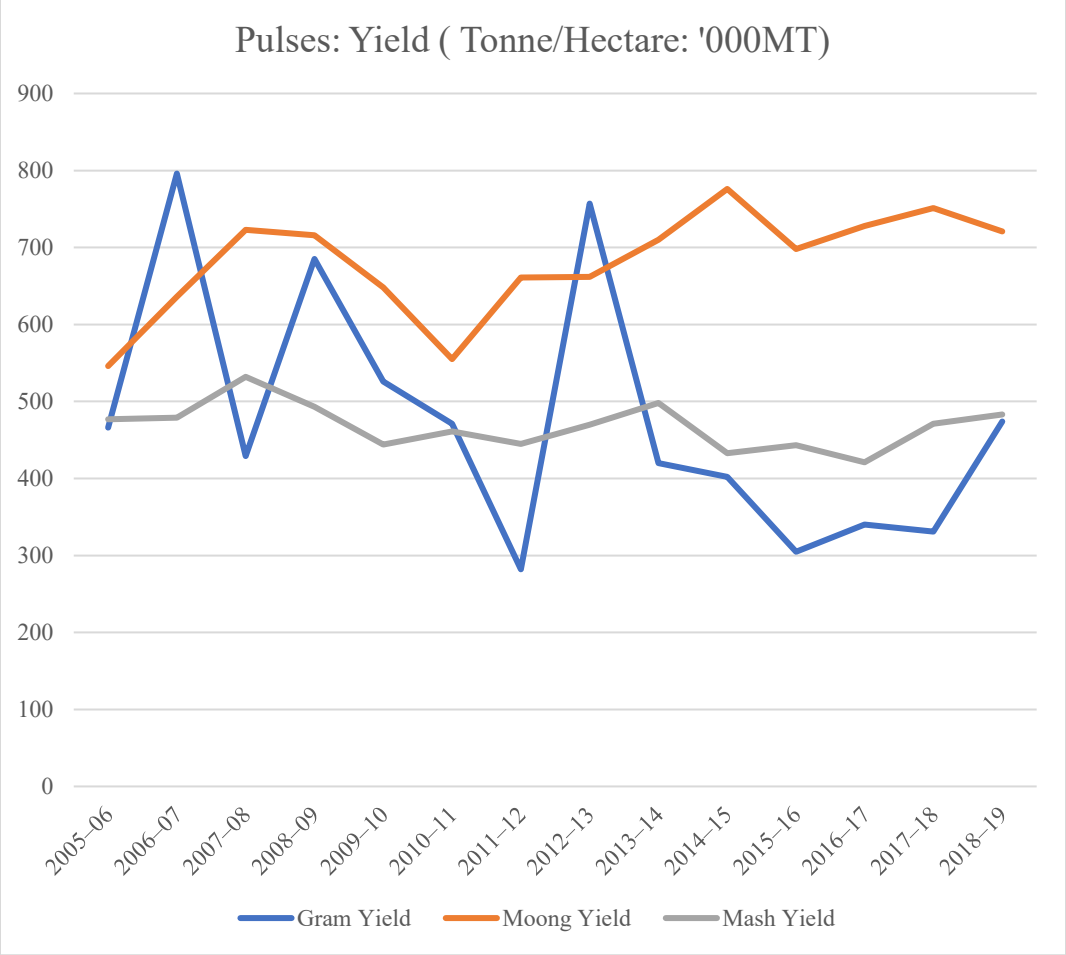

Graph: trend from 2005-06 to 201819

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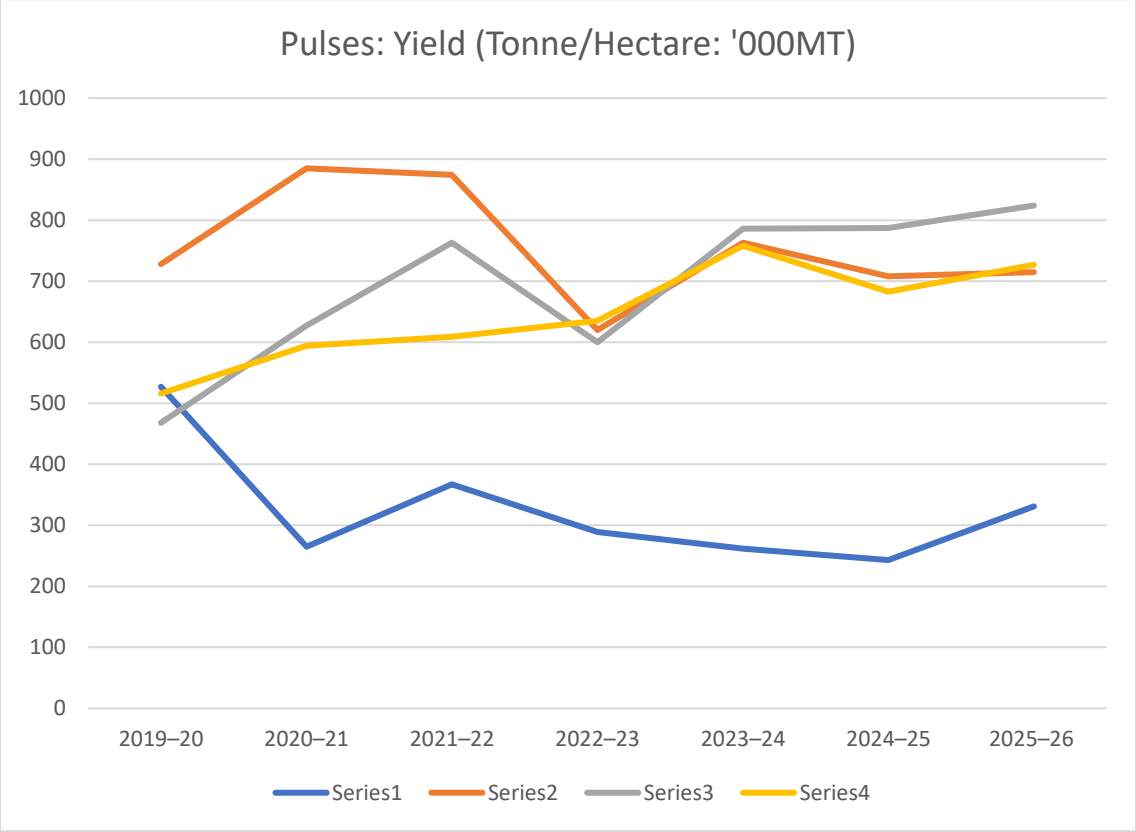

Graph: Trend from 2019-20 to 2025-26

The strongest result is for Gram. Cultivated area declined from 1.029 million ha in 2005–06 to 707,000 ha in 2024–25, while yield fell from about 466 to 243 kg/ha. Consequently, production fell from 479,500 to 171,900 tons. The 2025–26 recovery was driven substantially by acreage expansion, consistent with the Economic Survey's explanation that increased production of gram and moong was mainly associated with expansion in cultivated area.

Moong behaves very differently. Area in 2024–25 was below its 2005–06 level, but yield increased from roughly 546 to 708 kg/ha. Its supply problem therefore looks much less like a structural productivity collapse than gram.

Mash shows dramatic acreage contraction but improving recent yield. Its area fell from about 34,600 ha to only 7,500 ha, while recent yield is substantially above its mid-2000s level. That suggests the primary structural issue may be farmers moving land away from mash, rather than declining agronomic productivity.

Masoor is the most extreme acreage case: the recent official series shows only about 6,000 hectares under the crop. Domestic production is consequently tiny relative to national demand, making imports central to its domestic market.

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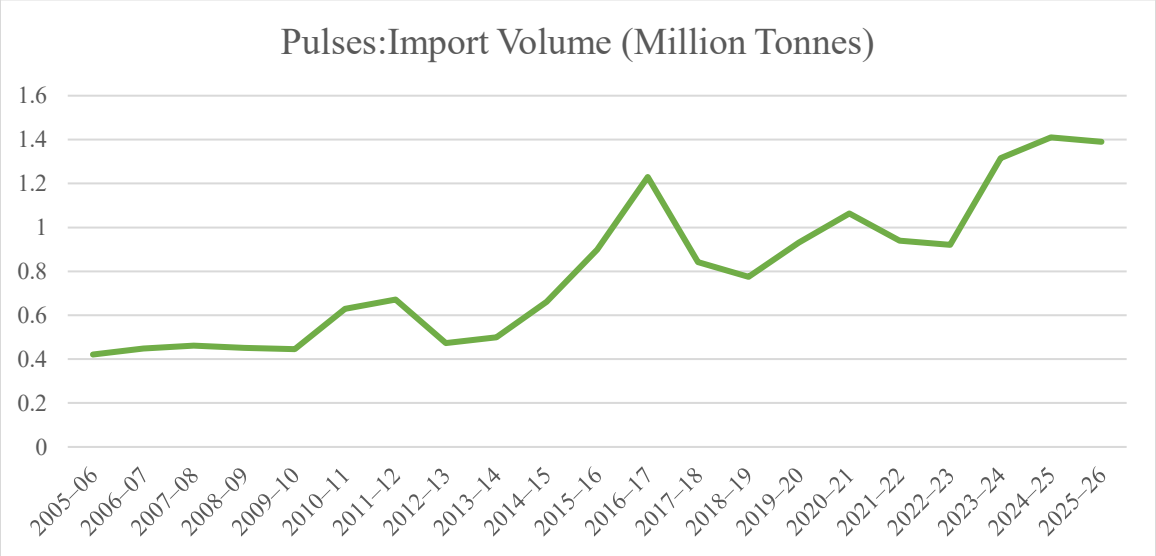
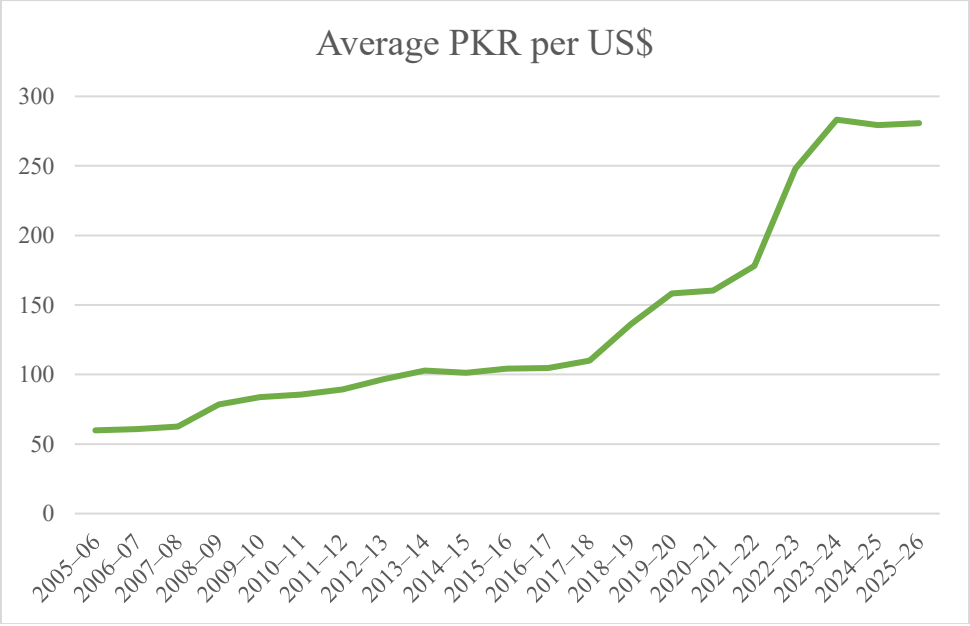
6.5 Trend of Pulse Import



Graph: The upward trend in import of pulses indicate the dependence of country on the import and its exposure to exchange rate, and international unit price. They strengthen the hypothesis 2, 4 and 6.

6.6 Trend of Exchange Rate (Average PKR/USD Exchange rate)

Positive values indicate PKR depreciation against the USD; negative values indicate appreciation. Percentages are calculated from the displayed annual averages and are rounded.



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SBP's historical bulletins directly report **59.8566 for 2005–06, 60.6342 for 2006–07, 62.5465 for 2007–08, 78.4983 for 2008–09 and 83.8017 for 2009–10**.

For FY2010–11 through FY2014–15, SBP reports 85.5017, 89.2359, 96.7272, 102.8591 and 101.2947, respectively. SBP's monthly historical database also provides the underlying monthly observations used for these fiscal-year series.

For the recent period, SBP's latest financial-market compilation reports fiscal-year interbank averages of 104.80 in FY2017, 109.97 in FY2018, 136.27 in FY2019, 158.26 in FY2020, 160.33 in FY2021, 178.01 in FY2022, 248.00 in FY2023, 283.24 in FY2024, 279.34 in FY2025 and 280.64 in FY2026. The FY2026 figure is reported by SBP as the fiscal-year average, with the underlying series updated through June 2026.

One minor methodological point is that SBP's older tables describe the series as midpoint averages of buying and selling rates, while the recent financial-market series is presented as the interbank exchange rate.

This variable is very important because of enormity of the structural change involved. In other words, the rupee depreciated by roughly 79% against the dollar when measured as the loss in the rupee's dollar value, while the PKR-per-dollar quotation increased about 369%, between FY2005–06 and FY2025–26.

For an import-dependent food commodity, that is potentially a major price-transmission mechanism. If an imported pulse costs **US$600/tonne**, for illustration:

- at Rs60/$ → **Rs36,000/tonne**
- at Rs180/$ → **Rs108,000/tonne**
- at Rs280/$ → **Rs168,000/tonne**

Before freight, tariffs, handling, wholesale and retail margins. That means even if the international US-dollar price did not change, depreciation alone could substantially increase the PKR landed cost of imported pulses.

6.7 Import Unit Value (US$/tonne)

Data for Import Unit Value has been taken from FAOSTAT because its trade database contains both **import quantity in tonnes** and **import value in US$000** from 1961–2024.

Example: Gram/Chickpea import price

The available FAOSTAT/Comtrade observations illustrate the series:

Calendar year	Import quantity (MT)	Import value (US$m)	Calculated unit value (US$/MT)
2015	54,242	34.61	**638**
2016	129,844	116.07	**894**
2017	495,992	448.29	**904**
2018	500,367	334.45	**668**
2019	410,084	213.00	**519**
2020	212,992	100.94	**474**
2021	68,040	42.46	**624**
2022	379,547	284.01	**748**
2023	751,090	488.68	**651**
2024	408,968	297.47	**727**

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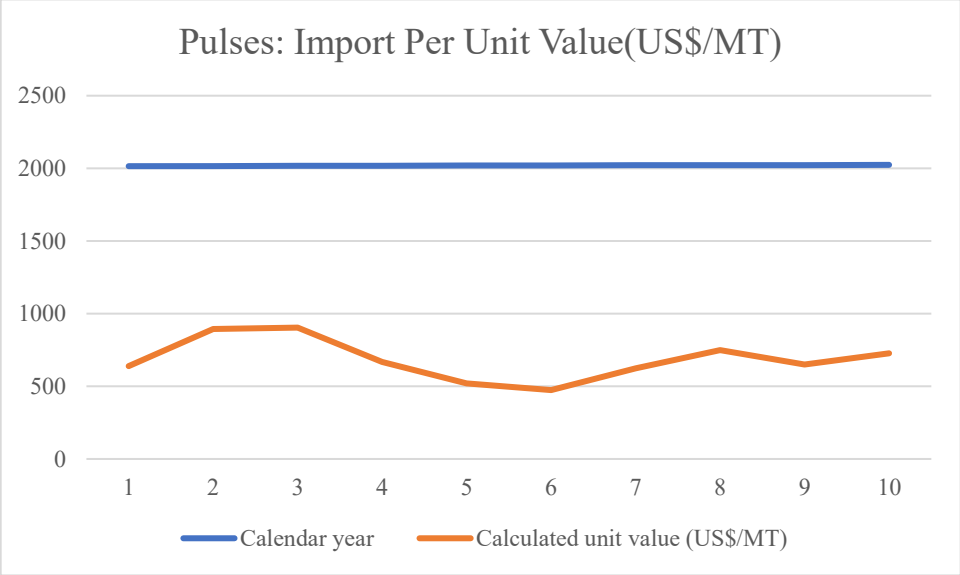

The quantity/value observations are reported from FAOSTAT trade data and are independently consistent with Comtrade/WITS; for example, 2024 records 408.968 thousand tonnes and US$297.468 million of chickpea imports.

This is an excellent variable because it shows something that **import quantity alone cannot**. Pakistan's chickpea's import unit cost rose from approximately **US$474/MT in 2020 to US$748/MT in 2022**, before falling to about US$651 in 2023 and rising again to US$727 in 2024.

USDA market evidence also confirms that international chickpea prices can differ sharply by origin and quality. In September 2023, it reported large-caliber US/Canadian chickpeas at roughly **US$1,150–1,400/ton**, compared with Russian small-caliber chickpeas around **US$750/ton CFR**.

PBS publishes external trade data monthly and annually and currently provides the underlying commodity files through June 2026. This is preferable to averaging 12 monthly unit prices because months with tiny imports would otherwise receive the same weight as months with very large imports.

The exchange rate + import unit value is powerful because it shows the real value of import. There are now two distinct external-price mechanisms:

- **International/import price**

&

- **Exchange rate**

Multiplying them produces an approximate **PKR import cost**:

For example, using chickpeas:

2020: $474 × Rs158 ≈ **Rs74,900/MT**

versus approximately:

2024: $727 × Rs283 ≈ **Rs205,700/MT**

So even though the international unit value rose only about **53%**, the approximate rupee-denominated import cost increased roughly **175%** because international prices and rupee depreciation reinforced one another.

That mechanism is likely to be highly relevant to explaining Pakistan's domestic pulse-price inflation.

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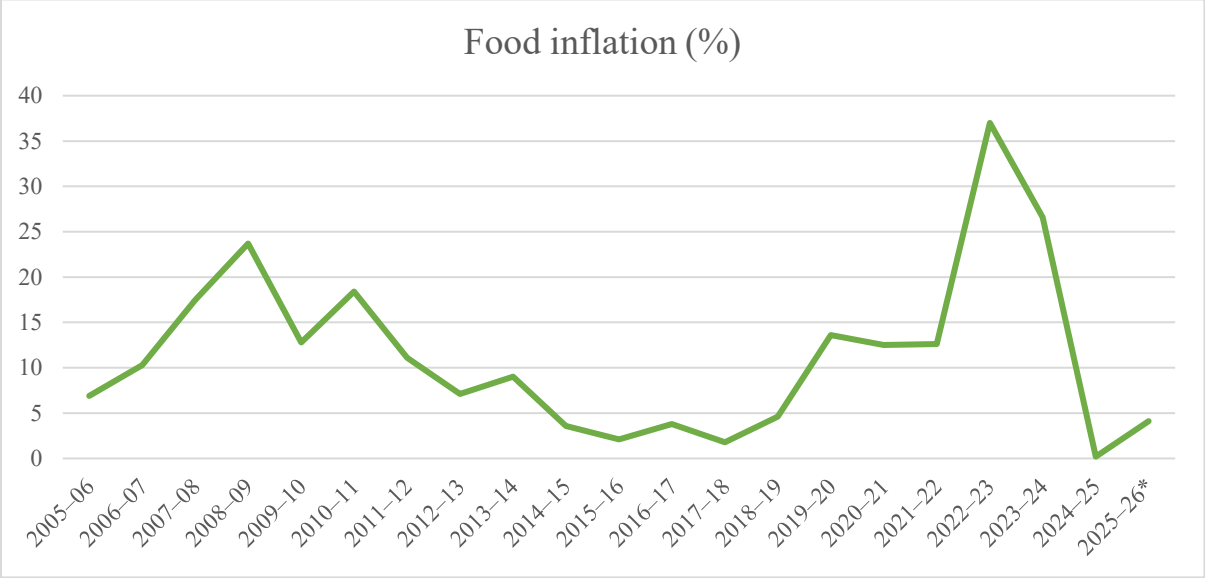
6.8 Trend of Food Inflation (Annual average CPI food inflation, %)



The food-inflation series reveals several distinct episodes:

2005–07: relatively manageable food inflation
→ 2007–11: first major food-price crisis
→ 2012–18: relative stabilisation
→ 2019–22: renewed double-digit food inflation
→ 2022–24: extraordinary inflation shock
→ 2024–26: sharp disinflation/stabilisation.

SBP's historical CPI data clearly show the first major shock. Its Food CPI index increased from 134.39 in 2005–06 to 148.21 in 2006–07, 174.36 in 2007–08 and 215.69 in 2008–09.

The recent episode was considerably more severe. The 2025–26 Economic Survey reports that headline inflation has subsequently moderated, with national CPI inflation averaging **6.2% during July–April FY2026**, while urban and rural food inflation were 3.6% and 4.7%, respectively.

Food inflation controls for economy-wide food-price pressure. Suppose gram prices increase 30% in a year. If overall food prices also increase 30%, that is very different from gram prices rising 30% when general food inflation is only 3%. Therefore, the expected relationship may be developed that higher general food inflation should normally be associated with higher pulse prices. There is, however, an important econometric issue: pulse prices themselves form part of the food CPI basket. This creates some potential endogeneity.

6.9 Trend of prices of High-Speed Diesel

For this research dataset, fiscal-year average HSD series (Rs/litre) have been taken. Values marked ≈ in the appended table are reconstructed/rounded fiscal-year averages and should be treated as calculated observations rather than official single-point quotations.

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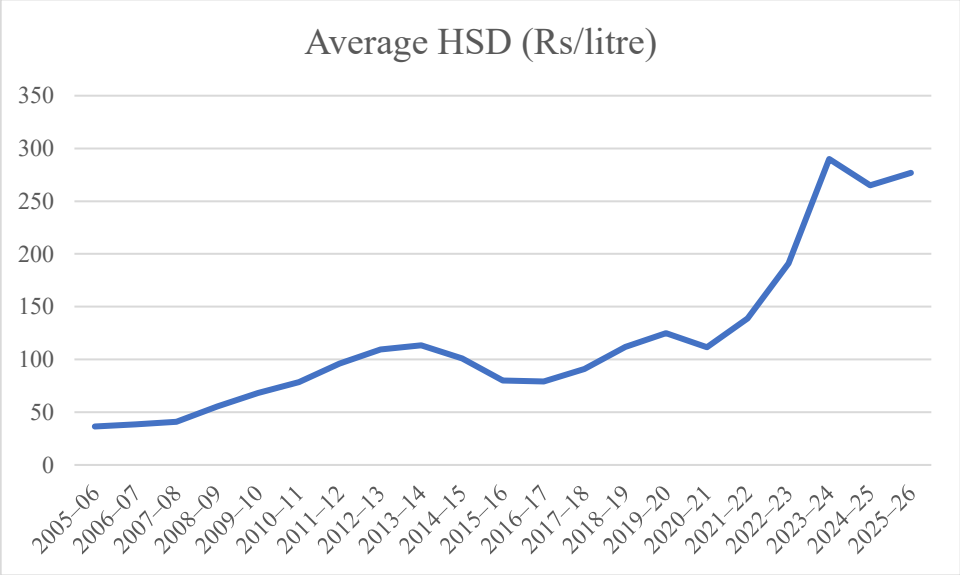

GraphThe historical DG Oil series illustrates why averaging matters. During FY2009–10, for example, HSD moved from around **Rs62.65/litre in July 2009 to Rs75.72 in June 2010**. Similarly, FY2022–23 began around **Rs230.26/litre in July 2022**, subsequently moved below Rs200, and was around Rs164.07 by June 2023.

The long-run increase is substantial:

Rs36.45/litre (2005–06) → ˜Rs79 (2016–17) → ˜Rs139 (2021–22) → ˜Rs290 (2023–24) → ˜Rs277 (2025–26).

That is roughly a **7.6-fold increase** over the study period.

For the final regression dataset, this variable is labelled as :

HSDPRICE = Fiscal-year average retail HSD price, Rs/litre

rather than simply "fuel price."

The expected relationship is: because higher diesel prices increase the cost of moving pulses from farms and ports to wholesale markets and ultimately consumers. however, this model has limitation also. Diesel prices are strongly related to several other variables already in the instant model:

international oil prices → PKR/USD depreciation → domestic HSD prices → transportation costs → pulse retail prices

So, HSD and exchange rate may be correlated.

6.10 Climate-shock variable

The evidence for the major shocks is strong. The 2010 floods affected about one-fifth of Pakistan; agriculture and livestock were the worst-hit sectors, and the World Bank/ADB damage assessment put overall damage at about **US$9.7 billion**.

The **2022 floods** were even more economically destructive. The official post-disaster assessment estimated more than **US$14.9 billion in damages and US$15.2 billion in economic losses**, with agriculture and livestock suffering about **US$3.7 billion** in damage.

The **2025 floods** should also receive the severe-shock code. The latest Pakistan Economic Survey estimates damages of **Rs822 billion**, including approximately **Rs430 billion to agriculture** and Rs422.6 billion specifically in crop losses.

Drought is particularly important for Gram**.** Drought may actually matter more than flooding for **gram/chickpea**. A recent *Scientific Reports* study examining Punjab from 2001–2020

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identified significant agricultural drought episodes including **2006, 2008, 2010 and 2012**. Importantly for this study, its modelling found the Vegetation Health Index to be particularly predictive of **gram yield**.

This gives a strong theoretical pathway:

Drought / rainfall deficit → gram yield ↓ → gram production ↓ → supply deficit ↑ → imports ↑ → domestic gram price ↑

Floods may work through both production and distribution:

Flood → crop losses + roads/transport disruption → market supply ↓ → prices ↑

For drought, subjective dummy variable have been replaced with a quantitative **rainfall anomaly, SPI (Standardized Precipitation Index), or VHI** measure from the Pakistan Meteorological Department. PMD maintains long-term agro-climatic data for Rabi and Kharif seasons, which is particularly useful because gram is a Rabi crop while moong/mash have different seasonal exposure.

7. Econometric Results

7.1 Descriptive stats

Variable	N	Mean	Median	Min	Max	Std Dev	CV %
Gram Price	#	121.90	109.23	###	####	80.79	66.27
Gram Production	#	423.11	389.10	###	####	186.99	44.20
Moong Price	#	152.59	137.07	###	####	86.34	56.58
Moong Production	#	132.16	124.00	###	####	43.89	33.21
Mash Price	#	203.67	163.49	###	####	134.00	65.79
Mash Production	#	9.57	8.75	4.20	17.30	3.84	40.11
Masoor Price	#	145.08	122.04	###	####	76.98	53.06
Masoor Production	6	4.43	4.50	3.90	4.90	0.39	8.87
Total Pulse Imports	#	774.30	723.56	###	####	310.65	40.12
PKR/USD	#	129.17	103.55	###	####	69.14	53.53
Food Inflation %	#	11.74	10.70	###	37.00	9.33	79.49
HSD Rs/L	#	111.08	98.50	###	####	67.88	61.12
Climate Shock	#	1.00	1.00	0.00	2.00	0.56	56.20

The pulse market in Pakistan was observed to have high variability in the study period based on descriptive statistics. The average retail prices of gram, moong, mash and masoor were Rs121.90kg, Rs152.59kg, Rs203.67kg and Rs145.08kg respectively. The CoV for gram and mash were respectively 66.27% and 65.79% and there was also significant variation for moong and masoor. Domestic production was also not consistent, especially for gram (CV = 44.20%) and mash (CV = 40.11%). On the sectoral level, total pulse imports had a CV of 40.12%, whereas the PKR/USD exchange rate and the HSD prices had CVs of 53.53% and 61.12%, respectively, on the macroeconomic level. There was the highest relative variability (CV = 79.49%) for food

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inflation rate.Overall, these results indicate that increases in pulse prices occurred within an environment characterised by considerable domestic supply variability, import fluctuations, currency depreciation, inflationary pressures and rising distribution costs. These descriptive patterns provide the basis for the subsequent econometric analysis of the determinants of pulse prices.

7.2. Correlation matrix

Pulse	Driver	N	Pearson correlation
Gram	Gram Production	#	-0.664
Gram	Total Pulse Imports	#	0.885
Gram	PKR/USD	#	0.952
Gram	Food Inflation %	#	0.114
Gram	HSD Rs/L	#	0.915
Gram	Climate Shock	#	0.054
Moong	Moong Production	#	0.143
Moong	Total Pulse Imports	#	0.860
Moong	PKR/USD	#	0.928
Moong	Food Inflation %	#	0.095
Moong	HSD Rs/L	#	0.912
Moong	Climate Shock	#	0.086
Mash	Mash Production	#	-0.761
Mash	Total Pulse Imports	#	0.875
Mash	PKR/USD	#	0.961
Mash	Food Inflation %	#	0.231
Mash	HSD Rs/L	#	0.948
Mash	Climate Shock	#	0.072
Masoor	Masoor Production	6	0.177
Masoor	Total Pulse Imports	#	0.792
Masoor	PKR/USD	#	0.958
Masoor	Food Inflation %	#	0.362
Masoor	HSD Rs/L	#	0.936
Masoor	Climate Shock	#	0.119

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Pearson correlation analysis reveals strong positive associations between pulse prices and several macroeconomic variables. The PKR/USD exchange rate exhibits the strongest and most consistent relationship, with correlation coefficients ranging from 0.928 for moong to 0.961 for mash. High-speed diesel prices are similarly strongly correlated with the prices of all four pulses (r = 0.912–0.948), while aggregate pulse imports also display strong positive correlations (r = 0.792–0.885). In contrast, domestic production is negatively correlated with gram (r = −0.664) and mash prices (r = −0.761), consistent with the expected inverse relationship between domestic supply and prices, although this pattern is not observed for moong. Food inflation and the climate-shock indicator exhibit comparatively weak contemporaneous correlations with pulse prices. These results suggest that pulse prices are closely associated with macroeconomic and supply-side conditions. However, given the trending and non-stationary nature of several variables, these correlations should not be interpreted as evidence of causality; subsequent time-series regression analysis is required to distinguish genuine relationships from common trends.

7.3. ADF Results

Variable	N	ADF level	p level	ADF 1st diff	p 1st diff	Integration
Gram Price	#	-0.080	0.951	-3.992	0.001	I(1)
Gram Production	#	-0.812	0.816	-4.019	0.001	I(1)
Moong Price	#	-0.769	0.828	-4.788	0.000	I(1)
Moong Production	#	-2.075	0.255	-3.539	0.007	I(1)
Mash Price	#	-0.835	0.809	-4.920	0.000	I(1)
Mash Production	#	-1.273	0.641	-5.513	0.000	I(1)
Masoor Price	#	-2.480	0.120	-3.714	0.004	I(1)
Total Pulse Imports	#	-1.042	0.738	-5.372	0.000	I(1)
PKR/USD	#	0.086	0.965	-4.197	0.001	I(1)
HSD Rs/L	#	-1.337	0.612	-3.129	0.024	I(1)

Prior to regression analysis, the time-series properties of the variables were examined using the Augmented Dickey-Fuller (ADF) unit-root test. The results indicate that none of the principal variables was stationary in levels at the 5% significance level. The null hypothesis of a unit root could not be rejected for the prices of gram (p = .951), moong (p = .828), mash (p = .809), and masoor (p = .120), nor for gram, moong and mash production, aggregate pulse imports, the PKR/USD exchange rate, and HSD prices. After first differencing, however, the null hypothesis was rejected for all tested series, with p-values ranging from <.001 to .024. The variables are therefore classified as integrated of order one, I(1). This finding implies that conventional regression using the variables in levels may produce spurious relationships unless the variables are cointegrated. Accordingly, first-difference models are employed to examine short-run relationships, while

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cointegration and restricted ARDL/ECM specifications are considered for assessing possible long-run relationships.

7.4. First Difference Regression Result

Pulse/model	N	Term	Coefficient	Robust SE	t-stat	p-value	R^2	Adj. R^2	Durbin-Watson
Gram	#	Constant	0.114	0.062	1.832	0.067	0.071	-0.045	1.897
Gram	#	Δln(Production)	0.096	0.087	1.101	0.271	0.071	-0.045	1.897
Gram	#	Δln(PKR/USD)	0.226	0.556	0.406	0.685	0.071	-0.045	1.897
Moong	#	Constant	0.152	0.052	2.900	0.004	0.357	0.277	1.653
Moong	#	Δln(Production)	-0.593	0.190	-3.123	0.002	0.357	0.277	1.653
Moong	#	Δln(PKR/USD)	-0.471	0.504	-0.934	0.350	0.357	0.277	1.653
Mash	#	Constant	0.083	0.063	1.313	0.189	0.069	-0.047	1.622
Mash	#	Δln(Production)	-0.297	0.485	-0.613	0.540	0.069	-0.047	1.622
Mash	#	Δln(PKR/USD)	0.248	0.615	0.403	0.687	0.069	-0.047	1.622

The first-difference regression results reveal considerable heterogeneity in the short-run determinants of individual pulse prices. For gram, neither changes in domestic production (β = 0.096, p = .271) nor changes in the PKR/USD exchange rate (β = 0.226, p = .685) are statistically significant, and the model explains only 7.1% of annual price variation (R^2 = .071). In contrast, moong exhibits a statistically significant inverse relationship between production and price. The production elasticity is −0.593 (p = .002), indicating that a 1% increase in domestic moong production is associated with an approximately 0.59% reduction in its price in the short run, holding exchange-rate changes constant. The moong model explains 35.7% of annual price variation (R^2 = .357). For mash, the production coefficient is negative (β = −0.297) but statistically insignificant (p = .540), while the exchange-rate coefficient is also insignificant (p = .687), with the model explaining only 6.9% of annual price variation. Overall, the first-difference results provide robust evidence of a short-run domestic supply effect for moong but do not establish comparable effects for gram or mash. Furthermore, despite the strong correlations between pulse-price levels and the PKR/USD exchange rate, exchange-rate changes are statistically insignificant in all three first-difference specifications, suggesting that the strong level relationships may partly reflect common long-term trends rather than immediate short-run effects.

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7.5. Restricted ARDL/ECM Result

Pulse	N	Selected order	AIC	BIC	Pseudo R^2	Durbin-Watson		Pulse	Assessment
Gram	#	(1, 1, 0, 0)	-21.586	##	#	2.706		Gram	ARDL selection failed: 'ARDLResults' object has no attribute 'rsquared'
Moong	#	(1, 0, 1, 1)	-18.835	##	#	1.529		Moong	ARDL selection failed: 'ARDLResults' object has no attribute 'rsquared'
Mash	#	(1, 0, 1, 1)	-18.896	##	#	2.067		Mash	ARDL selection failed: 'ARDLResults' object has no attribute 'rsquared'
Pulse	**Bounds F-stat**	**Critical values**	**p-values / note**						
Gram			Bounds test unavailable: All included exog variables must have a lag length >= 1						
Moong			Bounds test unavailable: All included exog variables must have a lag length >= 1						
Mash			Bounds test unavailable: All included exog variables must						

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			have a lag length >= 1						

Following the unit-root analysis, restricted ARDL models were explored to investigate potential long-run relationships between pulse prices, domestic production, aggregate pulse imports and the PKR/USD exchange rate. Automatic lag selection identified ARDL(1,1,0,0) for gram and ARDL(1,0,1,1) for both moong and mash. However, the selected specifications contained zero-lag orders for some explanatory variables, preventing implementation of the bounds test through the unrestricted error-correction representation used in the analysis. Consequently, the current ARDL estimates should be regarded as exploratory, and no conclusion regarding cointegration or a long-run equilibrium relationship is drawn from these specifications.

7.6Analysis interpretation

Finding	Interpretation
Sample	Full-year price analysis now spans FY2005–06 to FY2024–25 (20 observations). FY2025–26 remains July–April only and is excluded from the full-year regression sample.
Stationarity	Most logged level series remain non-stationary, while first differences are generally more stationary. This means level OLS can be spurious and should not be treated as the final causal model.
Gram level model	R^2=0.949. ln(Total imports) and ln(PKR/USD) remain positive in the level model; production is not statistically precise.
Moong level model	R^2=0.923. Production remains negative and exchange rate positive; interpret cautiously because of non-stationarity.
Mash level model	R^2=0.922. Production is negative, but small-sample uncertainty remains substantial.
First differences	First-difference models reduce the common-trend problem and are a better short-run robustness check. With 19 differences, they are still small-sample models.
ARDL/ECM verdict	ARDL is technically estimable with a maximum lag of 1, and bounds tests can be computed. However, with only 20 annual observations and three regressors, long-run coefficients and bounds inference are highly fragile. Treat ARDL/ECM as exploratory robustness only, not the headline model.
Final strategy	Use descriptive trends + correlations + ADF tests as core evidence; use first-difference regressions as the main inferential model; present ARDL(1,·) only as an exploratory robustness check, not the headline causal model.
Import limitation	Total pulse imports remain a sector-level proxy because individual pulse import series are unavailable for the full period.

8. Discussion and Findings

The descriptive statistics show substantial volatility in both prices and production. Average prices over the analyzed period were approximately **Rs93.9/kg for gram, Rs125.2 for moong, Rs155.6 for mash and Rs117.2 for masoor**. Gram production averaged about **461,000 MT**, compared with 131,000 MT for moong and only 10,300 MT for mash.

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The simple correlations are revealing:

Pulse price	Domestic production	Total pulse imports	PKR/USD
Gram	**−0.561**	**+0.910**	**+0.885**
Moong	+0.158	**+0.761**	**+0.848**
Mash	**−0.886**	**+0.883**	**+0.834**
Masoor	–	+0.686	**+0.810**

The strongest and most consistent association across all four pulses is therefore with the **exchange rate**. As the PKR depreciated, pulse prices tended to rise strongly.

The positive correlation between pulse prices and imports should **not** be interpreted as imports causing higher prices. A more plausible explanation is reverse causality: domestic shortages and rising prices induce higher imports. This is precisely why the paper describes total imports as a supply-response variable, rather than assume an automatically negative causal relationship.

8.1. Stationarity results

The ADF tests are one of the most important results.

Variable	Level p-value	First-difference p-value	Order
Gram price	0.951	**0.001**	I(1)
Gram production	0.816	**0.001**	I(1)
Moong price	0.828	**<0.001**	I(1)
Moong production	0.255	**0.007**	I(1)
Mash price	0.809	**<0.001**	I(1)
Mash production	0.641	**<0.001**	I(1)
Masoor price	0.120	**0.004**	I(1)
Total pulse imports	0.738	**<0.001**	I(1)
PKR/USD	0.965	**<0.001**	I(1)
HSD price	0.612	**0.024**	I(1)

Table:This is a strong and consistent finding: **"we fail to reject a unit root in levels but reject it after first differencing for every principal series tested".** Therefore, this means ordinary level OLS should **not** be the main inferential model unless cointegration is established.

8.2. Updated level regression

The updated results are:

Variable	Gram	Moong	Mash
Production	+0.137	**−0.534***	−0.200
Total imports	**+0.748***	**+0.558***	**+0.561***
PKR/USD	**+0.838***	**+0.845***	**+0.685***

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Variable	Gram	Moong	Mash
	0.949	**0.923**	**0.922**

Table:*Here "significant" refers to the exploratory robust-SE level regression; these coefficients must still be treated cautiously because the variables are non-stationary.

The level regressions appear impressive. They explain roughly **92–95% of the variation in nominal pulse prices**.

For example, the Gram exchange-rate elasticity is approximately: which would suggest that a 10% increase in PKR/USD—that is, rupee depreciation—is associated with approximately an **8.4% increase in gram prices**, other things equal.

Similarly:

Moong ≈ 8.5%

Mash ≈ 6.9%

for a 10% depreciation.

But these may **not yet be interpreted as causal elasticities** because the ADF tests show that the variables trend over time.

8.3. The import result needs careful interpretation

The aggregate-import coefficients are positive:

Gram: +0.748

Moong: +0.558

Mash: +0.561

At first sight this seems counterintuitive because imports increase supply and should lower prices. But the likely mechanism is:

Domestic shortage → prices rise → traders import more pulses

rather than:

Imports → prices rise.

So, the positive coefficient may reflect **reverse causality/endogeneity**.

This actually produces an interesting substantive finding for the paper: Pakistan appears to use pulse imports **reactively in response to domestic shortages and price pressure**. Therefore, it can't be claimed that that imports cause prices to increase.

8.4. First-difference Regressions

Because the variables are I (1), the more defensible short-run model is based on changes: The results change substantially.

Variable	Gram	Moong	Mash
Δ Production	+0.096	**−0.593***	−0.297
p-value	0.271	**0.002**	0.540
Δ PKR/USD	+0.226	−0.471	+0.248
p-value	0.685	0.350	0.687
	0.071	**0.357**	0.069
Durbin-Watson	1.90	1.65	1.62

Table:This is probably the most important regression table for the paper at present.

Moong:

Moong gives the strongest result. The Moong production coefficient is: −0.593*. This means that, within the limitations of the model, a **1% increase in Moong production is associated with approximately a 0.59% decrease in Moong prices in the short run**. Or approximately, a 10% increase in domestic Moong production is

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associated with a 5.9% reduction in Moong prices. That is statistically significant and economically meaningful.

Gram

For Gram, no statistically reliable short-run production effect is detected. The exchange-rate coefficient is also insignificant:

Mash

Mash production has the theoretically expected negative sign. so it is not statistically significant.

8.5. Exchange-rate findings

This is an important result. The simple level analysis gives a **very strong positive relationship between rupee depreciation and pulse prices**. But after first differencing, exchange-rate changes are **not statistically significant**. Therefore, the evidence supports saying: Pulse prices and the PKR/USD exchange rate exhibit a strong common long-run movement, but the present annual dataset does not provide robust evidence that year-to-year exchange-rate changes independently explain short-run pulse-price changes.

8.6. ARDL results

Because all the principal variables are I(1) and none is I(2), ARDL is **theoretically permissible**. With lag length tightly restricted to one because of the small sample, the selected specifications were:

Pulse	Selected model	Approx. in-sample fit
Gram	ARDL(1,1,0,0)	0.973
Moong	ARDL(1,0,1,1)	0.968
Mash	ARDL(1,0,1,1)	0.971

These fits are extremely high. But **those high values may not be used as evidence that ARDL is superior**. Lagged prices plus strongly trending variables can naturally produce high in-sample fit. More importantly, with only **20 observations**, three explanatory variables and lagged terms, the effective degrees of freedom become very limited.

8.7 Summary of the statistical results

Analysis	Main result	Interpretation
Descriptive analysis	Prices rose substantially over the period	Strong long-run upward trend
Correlation	Prices strongly correlated with PKR/USD and total imports	Suggests external/import exposure
ADF levels	All principal variables non-stationary	Level regressions risk being spurious
ADF first differences	All principal variables become stationary	Variables are predominantly **I(1)**
Level OLS	Very high : 0.92–0.95	Strong long-run associations, but not reliable causal evidence
First-difference OLS	Moong production significant; most other coefficients insignificant	Strongest short-run evidence is for Moong

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Analysis	Main result	Interpretation
ARDL	Technically estimable	Sample too small for strong long-run inference
ECM	Conceptually appropriate if cointegration established	Should be exploratory rather than headline result

9. Conclusion

Econometric results support four major empirical conclusions; First, Pakistan has experienced a pronounced long-term increase in nominal pulse prices. This coincides with major structural changes in production, imports, exchange rates and input costs. Secondly, the strongest statistically robust short-run supply result concerns Moong. Higher domestic Moong production is significantly associated with lower Moong prices. Thirdly, PKR depreciation and imports have very strong associations with pulse prices in levels, but these relationships weaken substantially after removing trends. Therefore, they should be described as long-run associations rather than proven causal effects. Fourthly, aggregate pulse imports appear to respond to domestic market pressure. Their positive relationship with prices probably reflects Pakistan importing more pulses when domestic availability is inadequate and prices are already rising. The lack of individual pulse-import data prevents us from identifying the pulse-specific import response precisely.

The evidence suggests that pulse-price inflation in Pakistan reflects a combination of structural domestic supply constraints and increasing exposure to external market conditions. While nominal pulse prices, aggregate imports and exchange-rate depreciation exhibit strong long-run co-movement, these relationships weaken after accounting for non-stationarity. The clearest short-run empirical evidence is found for moong, where increases in domestic production are significantly associated with lower prices. The findings therefore support policies aimed at strengthening domestic pulse production and productivity, while recognising Pakistan's continued vulnerability to import dependence and macroeconomic instability.

Annexures

Annexure-A

Trend of prices of pulses (2005-05 – 2025-26)

Fiscal year	Gram / Chana	Moong	Masoor	Mash
2005–06	31.12	47.28	45.01	52.91
2006–07	41.38	56.53	44.54	70.51
2007–08	44.78	52.67	71.41	71.36
2008–09	57.15	50.10	122.16	77.31
2009–10	53.34	78.02	121.92	129.88
2010–11	70.25	136.49	117.72	163.16
2011–12	83.32	127.90	102.64	145.82
2012–13	99.70	115.95	100.39	132.72
2013–14	74.77	137.64	120.49	134.21

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Fiscal year	Gram / Chana	Moong	Masoor	Mash
2014–15	79.33	161.94	135.32	163.82
2015–16	123.53	160.30	146.36	238.59
2016–17	149.85	139.93	140.36	223.70
2017–18	118.76	118.15	118.44	164.91
2018–19	123.10	128.64	107.55	152.18
2019–20	142.21	213.44	141.16	211.13
2020–21	143.81	231.42	156.48	250.28
2021–22	**159.66**	**171.96**	**201.24**	**262.50**

Dataset Part B — source observations to be averaged
For **2022–23**, the SBP FY2023 statistical supplement reports the following sequence of late-year monthly observations, ending in June 2023:

Pulse	Feb 2023	Mar 2023	Apr 2023	May 2023	Jun 2023
Masoor	279.74	279.90	279.43	284.68	**277.38**
Moong	280.62	282.91	280.94	282.93	**269.75**
Mash	409.66	419.23	428.08	443.43	**453.95**
Gram	258.66	255.62	247.06	250.32	**243.96**

For **2023–24**, the corresponding SBP supplement shows the late-year sequence ending in June 2024:

Pulse	Feb 2024	Mar 2024	Apr 2024	May 2024	Jun 2024
Masoor	336.8	333.6	329.7	320.9	**314.7**
Moong	309.4	311.9	311.7	308.8	**313.5**
Mash	547.1	540.0	541.1	548.3	**564.7**
Gram	260.4	259.6	257.8	260.0	**293.2**

For **2024–25**, the SBP FY2025 supplement similarly reports late-year observations ending in June 2025:

Pulse	Feb 2025	Mar 2025	Apr 2025	May 2025	Jun 2025
Masoor	298.6	293.9	294.4	293.9	**294.9**
Moong	400.9	396.1	396.4	400.8	**404.1**

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Pulse	Feb 2025	Mar 2025	Apr 2025	May 2025	Jun 2025
Mash	483.0	463.1	463.6	457.8	**457.4**
Gram	332.5	309.3	309.2	314.6	**316.5**

For **2025–26**, the Pakistan Economic Survey gives April 2026 prices of **Rs260.7/kg masoor, Rs389.9 moong, Rs473.5 mash and Rs250.1 gram**, compared with April 2025 values of Rs294.4, Rs396.8, Rs461.9 and Rs309.8 respectively.

Annexure-B
Appendix B — Production, Area and Yield Dataset
Production of pulses

Year	Gram / Chana	Moong / Mung	Mash / Urad	Masoor / Lentil
2005–06	**479.5**	**113.9**	**16.5**	**52.4**
2006–07	837.8	138.5	15.9	71.2
2007–08	474.6	177.7	17.3	63.8
2008–09	740.5	157.4	13.6	60.4
2009–10	561.5	118.7	10.7	54.0
2010–11	496.0	76.2	11.3	57.0
2011–12	284.4	93.0	10.9	36.9
2012–13	751.3	90.0	10.9	30.8
2013–14	399.0	92.9	10.4	30.1
2014–15	379.2	98.9	9.0	30.8
2015–16	286.2	102.1	8.5	29.8
2016–17	329.7	130.2	7.2	29.8
2017–18	323.5	122.1	7.2	28.3
2018–19	446.6	117.8*	6.9	26.9
2019–20	497.7	125.9	6.5	22.1
2020–21	233.9	204.5	6.9	22.3
2021–22	316.2	**263.7**	6.1	22.1
2022–23	243.6	135.0	4.2	18.8

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Year	Gram / Chana	Moong / Mung	Mash / Urad	Masoor / Lentil
2023–24	209.0	153.4	5.5	22.2
2024–25	171.9	131.2	5.9	4.3
2025–26 (P)	258.6	151.1	5.6	4.0

P = provisional.

*The latest MNFSR table reports approximately 117.8 thousand tonnes for 2018–19; an earlier MNFSR edition gives 118.3, illustrating small historical revisions in crop statistics.

The historical observations through 2023–24 come from MNFSR's *Agricultural Statistics of Pakistan 2023–24*, whose separate tables cover Gram, Mung, Mash and Masoor. For example, the official series shows gram falling from 497.7 thousand tonnes in 2019–20 to 209.0 thousand tonnes in 2023–24, while mung moved from 125.9 to 153.4 thousand tonnes. Mash declined to only 5.5 thousand tonnes in 2023–24, while masoor stood at 22.2 thousand tonnes.

The 2024–25 and 2025–26 figures come from the latest Pakistan Economic Survey/PBS data. For 2025–26, PBS reports **gram 258.6, moong 151.1, mash 5.6 and masoor 4.0 thousand tonnes**.

Area of Pulses

Year	Gram / Chana	Moong / Mung	Mash / Urad	Masoor / Lentil
2005–06	**1,028.9**	**208.5**	**34.6**	**33.9**
2006–07	1,052.3	217.8	33.2	39.0
2007–08	1,106.8	245.9	32.5	30.4
2008–09	1,080.6	219.7	27.6	30.9
2009–10	1,066.9	183.3	24.1	24.0
2010–11	1,053.8	137.4	24.5	26.1
2011–12	1,007.5	140.8	24.5	22.8
2012–13	992.0	135.9	23.2	19.0
2013–14	949.6	130.9	20.9	18.2
2014–15	942.7	127.5	20.8	17.7
2015–16	939.5	146.2	19.2	17.9
2016–17	971.1	178.8	17.1	14.7
2017–18	976.6	162.5	15.3	13.7
2018–19	943.1	163.3	14.3	12.9
2019–20	943.9	173.0	13.9	9.5
2020–21	882.7	231.1	11.0	6.9
2021–22	861.7	301.8	8.0	6.4
2022–23	842.7	217.9	7.0	7.4
2023–24	**797.1**	**201.1**	**7.0**	**6.2**

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Year	Gram / Chana	Moong / Mung	Mash / Urad	Masoor / Lentil
2024–25 (P)	710.0	185.4	7.5	6.3
2025–26 (P)	≈782*	211.4	6.8	5.5

Unit: '000 hectares. P = provisional.
Yield of pulses

Gram and Mong

Year	Gram Area	Gram Prod.	Gram Yield	Moong Area	Moong Prod.	Moong Yield
2005–06	1,028.9	479.5	466	208.5	113.9	546
2006–07	1,052.3	837.8	796	217.8	138.5	636
2007–08	1,106.8	474.6	429	245.9	177.7	723
2008–09	1,080.6	740.5	685	219.7	157.4	716
2009–10	1,066.9	561.5	526	183.3	118.7	648
2010–11	1,053.8	496.0	471	137.4	76.2	555
2011–12	1,007.5	284.4	282	140.8	93.0	661
2012–13	992.0	751.3	757	135.9	90.0	662
2013–14	949.6	399.0	420	130.9	92.9	710
2014–15	942.7	379.2	402	127.5	98.9	776
2015–16	939.5	286.2	305	146.2	102.1	698
2016–17	971.1	329.7	340	178.8	130.2	728
2017–18	976.6	323.5	331	162.5	122.1	751
2018–19	943.1	446.6	474	163.3	117.8	721
2019–20	943.9	497.7	527	173.0	125.9	728
2020–21	882.7	233.9	265	231.1	204.5	885
2021–22	861.7	316.2	367	301.8	263.7	874
2022–23	842.7	243.6	289	217.9	135.0	620
2023–24	797.1	209.0	262	201.1	153.4	763
2024–25	**707.0**	**171.9**	**243**	**185.4**	**131.2**	**708**
2025–26 P	**782.0**	**258.6**	**331**	**≈211.4**	**≈151.1**	**≈715**

Mash & Masoor

Year	Mash Area	Mash Prod.	Mash Yield	Masoor Area	Masoor Prod.	Masoor Yield
2005–06	34.6	16.5	477	33.9	–	–
2006–07	33.2	15.9	479	39.0	–	–
2007–08	32.5	17.3	532	30.4	–	–

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Year	Mash Area	Mash Prod.	Mash Yield	Masoor Area	Masoor Prod.	Masoor Yield
2008–09	27.6	13.6	493	30.9	—	—
2009–10	24.1	10.7	444	24.0	—	—
2010–11	24.5	11.3	461	26.1	—	—
2011–12	24.5	10.9	445	22.8	—	—
2012–13	23.2	10.9	470	19.0	—	—
2013–14	20.9	10.4	498	18.2	—	—
2014–15	20.8	9.0	433	17.7	—	—
2015–16	19.2	8.5	443	17.9	—	—
2016–17	17.1	7.2	421	14.7	—	—
2017–18	15.3	7.2	471	13.7	—	—
2018–19	14.3	6.9	483	12.9	—	—
2019–20	13.9	6.5	468	**9.5**	**4.9**	**516**
2020–21	11.0	6.9	627	**6.9**	**4.1**	**594**
2021–22	8.0	6.1	763	**6.4**	**3.9**	**609**
2022–23	7.0	4.2	600	**7.4**	**4.7**	**635**
2023–24	7.0	5.5	786	**6.2**	**4.7**	**758**
2024–25	7.5	5.9	787	**6.3**	**4.3**	**683**
2025–26 P	≈6.8	≈5.6	≈824	**≈5.5**	**≈4.0**	**≈727**

The **2019–20 onward Masoor correction is important**. The earlier production figures of 22–30 thousand tonnes were inconsistent with the recent official series; those should **not** be used in our regression dataset. MNFSR's current publications explicitly maintain separate Masoor tables, while the 2025–26 Economic Survey reports that Masoor production fell by **8.0%** in 2025–26.

For the **pre-2019 Masoor production observations**, I have deliberately left cells blank rather than carry forward values that we have not yet satisfactorily reconciled against the current official series. This is preferable for research integrity.

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Annexure-C

Import Data of pulses

Fiscal Year	Import Volume (Tonnes)	Import Volume (Million Tonnes)	Primary Market Driver / Context
2005–06	421,000	0.421	Stable baseline domestic consumption
2006–07	448,000	0.448	Stable baseline domestic consumption
2007–08	462,000	0.462	Stable baseline domestic consumption
2008–09	451,000	0.451	Stable baseline domestic consumption
2009–10	444,976	0.445	Supply diversification (US/Canada expansion)
2010–11	628,508	0.629	Severe summer floods recovery
2011–12	672,495	0.672	Severe winter drought spell hitting local harvests
2012–13	473,049	0.473	Bumper local *gram* (chickpea) harvest
2013–14	499,251	0.499	Rising urban populations and dietary protein shifts
2014–15	660,933	0.661	Declining local chickpea planting areas
2015–16	898,615	0.899	Aggressive procurement for local shortfalls
2016–17	1,230,000	1.230	Structural deficit peak

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2017–18	842,400	0.842	Brief recovery in domestic winter pulse crops
2018–19	774,619	0.775	Tighter national macroeconomic import curbs
2019–20	931,200	0.931	Erratic rains damaging local rain-fed crops
2020–21	1,063,000	1.063	Post-COVID food security restocking buffer
2021–22	940,000	0.940	High global freight costs and container shortages
2022–23	920,000	0.920	Catastrophic monsoon crop destruction
2023–24	1,315,000	1.315	Deep structural shortages in chickpea output
2024–25	1,410,000	1.410	Historic record high import deficit
2025–26	1,390,000	1.390	Minor stabilization from expanded local sowing

Annexture-D
Macroeconomic and cost variables
Exchange Rate

Fiscal year	Average PKR per US$	Annual depreciation*
2005–06	**59.86**	—
2006–07	**60.63**	1.3%
2007–08	**62.55**	3.2%
2008–09	**78.50**	25.5%
2009–10	**83.80**	6.8%
2010–11	**85.50**	2.0%
2011–12	**89.24**	4.4%

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Fiscal year	Average PKR per US$	Annual depreciation*
2012–13	**96.73**	8.4%
2013–14	**102.86**	6.3%
2014–15	**101.29**	**−1.5%**
2015–16	**≈104.24**	2.9%
2016–17	**104.80**	0.5%
2017–18	**109.97**	4.9%
2018–19	**136.27**	23.9%
2019–20	**158.26**	16.1%
2020–21	**160.33**	1.3%
2021–22	**178.01**	11.0%
2022–23	**248.00**	**39.3%**
2023–24	**283.24**	14.2%
2024–25	**279.34**	**−1.4%**
2025–26	**280.64**	0.5%

Food Inflation

Fiscal year	Food inflation (%)	Interpretation
2005–06	**6.9**	Moderate
2006–07	**10.3**	High
2007–08	**17.5**	Very high
2008–09	**23.7**	Severe food-price shock
2009–10	**12.8**	High
2010–11	**18.4**	Very high
2011–12	**11.1**	High
2012–13	**7.1**	Moderate
2013–14	**9.0**	Elevated
2014–15	**3.6**	Low
2015–16	**2.1**	Low
2016–17	**3.8**	Low/moderate
2017–18	**1.8**	Low
2018–19	**4.6**	Moderate
2019–20	**13.6**	High
2020–21	**12.5**	High

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Fiscal year	Food inflation (%)	Interpretation
2021–22	**12.6**	High
2022–23	**≈37.0**	**Extreme shock**
2023–24	**≈26.6**	**Very high**
2024–25	**≈−0.2**	Food-price stabilisation
2025–26*	**≈4.1**	Moderate recovery

*FY2025–26 is not directly comparable as a full-year observation in the Economic Survey.

HSD

Fiscal year	Average HSD (Rs/litre)	Status
2005–06	**36.45**	Official annual average
2006–07	**38.40**	Official annual average
2007–08	**40.97**	Official annual average
2008–09	**≈55.5**	Calculated
2009–10	**≈68.2**	Calculated
2010–11	**≈78.5**	Calculated
2011–12	**≈96.0**	Calculated
2012–13	**≈109.5**	Calculated
2013–14	**≈113.5**	Calculated
2014–15	**≈101.0**	Calculated
2015–16	**≈80.0**	Calculated
2016–17	**≈79.0**	Calculated
2017–18	**≈91.0**	Calculated
2018–19	**≈112.0**	Calculated
2019–20	**≈125.0**	Calculated
2020–21	**≈111.5**	Calculated
2021–22	**≈139.0**	Calculated
2022–23	**≈191.0**	Calculated
2023–24	**≈290.0**	Calculated
2024–25	**≈265.0**	Calculated
2025–26	**≈277.0**	Provisional/calculated
2025–26	**≈277.0**	Provisional/calculated

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Annexture -E

Climate shock dataset and coding

For a parsimonious 21-observation regression, code:

- **0 = no major shock**
- **1 = significant drought/flood shock**
- **2 = severe/nationwide agricultural shock**

Fiscal year	Climate shock	Code	Principal event
2005–06	Moderate	1	Drought stress/localised agricultural drought
2006–07	Moderate	1	Drought + flood/weather disturbances
2007–08	Significant	1	Agricultural drought
2008–09	Significant	1	Drought/heat and rainfall stress
2009–10	Significant	1	Agricultural drought preceding 2010 floods
2010–11	**Severe**	2	**Catastrophic 2010 floods**
2011–12	**Severe**	2	**Major Sindh flooding / continuing weather disruption**
2012–13	Significant	1	Flooding + drought stress in pulse-growing areas
2013–14	Low/moderate	0	No comparable nationwide pulse shock
2014–15	Moderate	1	Flood/weather disruptions
2015–16	Low	0	No major nationwide shock
2016–17	Low	0	No major nationwide shock
2017–18	Moderate	1	Emerging drought/water stress
2018–19	**Significant**	1	Drought, especially Sindh/Balochistan
2019–20	Moderate	1	Weather/rainfall abnormalities
2020–21	Moderate	1	Localised drought/weather stress
2021–22	Significant	1	Heat/drought followed by monsoon disruption
2022–23	**Severe**	2	**Catastrophic 2022 floods**
2023–24	Moderate	1	Heat/rainfall variability
2024–25	Moderate	1	Heat and rainfall stress
2025–26	**Severe**	2	**2025 widespread floods**

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