THE ASIAN BULLETIN OF GREEN MANAGEMENT AND CIRCULAR ECONOMY
Vol 5, Issue 2(2025)

THE ASIAN BULLETIN OF GREEN MANAGEMENT AND CIRCULAR ECONOMY

ISSN (online): 2959-0035

http://abgmce.com/ 10.62019/abgmce.v5i2.153

ISSN (Print): 2959-0027

Integration of wholesale market prices of rice in district Hyderabad, Sindh

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Chronicle

Article history

Received: june23, 2025
Received in the revised format: July 22, 2025
Accepted: Aug 19, 2025
Available online: Sept 11, 2025

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Abstract

This study investigates the integration of the rice wholesale market in Hyderabad, Sindh, with a focus on pricing structures, market connectivity, and stakeholder dynamics. Utilizing a mixed-method approach, primary data were collected through KoboCollect from 120 respondents, including wholesalers and retailers; while secondary data covered rice production trends in Pakistan from 2010-11 to 2024-25. Statistical analysis revealed a significant upward trend in rice production until 2021-22, followed by a sharp decline due to climatic adversities and natural disasters. Unit root tests confirmed that price series across Hyderabad, Karachi, Jacobabad, and Larkana were non-stationary at levels but became stationary after first differencing, indicating integration of order one [I(1)]. Johansen co-integration results demonstrated that Hyderabad maintains a long-run equilibrium relationship with Karachi and Larkana but not with Jacobabad. Multivariate analysis further confirmed the existence of multiple co-integrating vectors, suggesting broader market cohesion across the four regions. Overall, results indicate strong market linkages, particularly between Hyderabad and Karachi (85% integration), while weaker ties persist with Jacobabad. Price changes were found to be driven by demand-supply dynamics and government policies, with 100% of respondents reporting daily price fluctuations and 99% relying on trader communication for price information. Findings also highlight the dominance of wholesalers (91.6%) generally older, more experienced, and higher-income while the Basmati variety remains the most traded rice type. The study concludes that the Hyderabad rice wholesale market is well-integrated with national markets, though regional disparities exist, and offers insights for improving market performance, addressing volatility, and strengthening farmer-market linkages through infrastructure and policy support.

Keywords Rice wholesale market, Market integration, Price transmission, Multivariate analysis, Demand-supply dynamics, Wholesalers, Hyderabad, Basmati rice.

INTRODUCTION

Rice, the staple food for over half the world's population, is most consumed in Asia, Sub-Saharan Africa, and South America. While widely cultivated, its economical production requires hot days with cool nights, ample water, flat land, and a hard-pan subsoil to reduce water loss (USDA, 2024). Rice varieties vary significantly in panicle length, shape, and weight, which affect the plant's overall productivity. These characteristics contribute to differences in yield and adaptability among different rice cultivars (Augustyn, 2024). India is on number one; according to global leading rice producing countries based on area harvested which are 47.8. million, China is on second number with 29.45 million, Bangladesh have third number with 11.6 million, And Pakistan is on 10th number worldwide leading rice producing countries based on area harvested in hectares that is 3 million (Statista 2024). Pakistan, ranking 9th with 10 million tonnes, plays a key role as a major basmati rice exporter. These figures highlight

the agricultural capacity of leading producers and their importance for regional and global food security (USDA Foreign Agriculture Service, 2024). Agricultural data from 2001-02 to 2022-23 show varying trends across Pakistan's provinces. In Sindh, cultivation rose from 1,139.4 to a 2017-18 peak of 2,046.8 thousand hectares (2,850.5 thousand tonnes) before falling to 1,490.84 hectares and 2,011.8 tonnes in 2022-23. Punjab, the largest contributor, expanded steadily from 3,647.1 hectares and 2,266 tonnes in 2001-02 to a 2021-22 peak of 6,314 hectares and 5,779 tonnes, with a slight decline in 2022-23. KPK remained stable, starting at 150 hectares and 121.7 tonnes, dipping in 2010-11, and reaching 140.04 hectares and 137.27 tonnes by 2022-23. Balochistan fluctuated, peaking at 643.7 tonnes in 2008-09, but declined to 313.71 hectares and 103.16 tonnes in 2022-23. These figures highlight Punjab's dominance, Sindh's recent downturn, KPK's stability, and Balochistan's sharp productivity drop (Ministry of Food and Agriculture, Federal Bureau of Statistics, 2024)

From 2001-02 to 2022-23, rice cultivation in Pakistan was dominated by Punjab, with Sindh as the second-largest contributor. Both provinces showed overall growth in area and production, though with fluctuations—Sindh peaking in 2008–09 and 2013–14, and Punjab reaching its highest output in 2021-22. KPK and Balochistan maintained smaller, relatively stable contributions. Overall, the data underscores Punjab and Sindh's central role in rice cultivation, with KPK and Balochistan playing minor yet consistent parts (Agriculture Statistics of Pakistan, 2023).

Rice remained a promising crop in 2023-24, with its area increasing by 22.2% to 3.6 million ha and production rising 34.8% to 9.9 million tons, compared to 7.3 million tons the previous year (GoP, 2024). Approximately 480 million metric tons of milled rice are produced each year, with China and India accounting for half of the global rice grown and consumed. Rice supplies up to 50% of the daily caloric intake for millions living in poverty across Asia, making it vital for food security. It is also becoming an important staple in Latin America and Africa. Despite its significance, rice remains one of the most heavily protected food commodities in international trade. However, rice is low in vitamins and minerals, and milling causes nutrient losses, placing populations dependent on rice at high risk of vitamin and mineral deficiencies (Muthayya et al., 2014). Pakistan is a leading rice producer, renowned for its Basmati rice, prized for its long grains and aroma.

Pakistan exports rice to countries including China, Kenya, Afghanistan, Saudi Arabia, UAE, and several African nations. This report highlights the current market status and identifies potential new markets to enhance Pakistan's rice trade opportunities and boost its export potential globally (Ilyas et al., 2022).Rice is one of the world's most vital food crops, with international trade crucial in balancing its supply and demand. Examining the structural evolution of the global rice trade through a network perspective is essential to understand the rice supply chain fully and to support efforts in maintaining global food security amid changing trade dynamics and market demands (Chen & Zhao 2023). The growth in rice consumption has either slowed down or become negative in all the continents although additional per capita demand for rice exists in Africa.

The future additional rice demand will mainly come from the population growth in Africa and Asia. Recent production growth, driven mainly by yield increases, has helped meet global rice demand. However, Africa still lags behind other continents in achieving optimal yields. Greater research efforts are needed worldwide to develop high-yielding rice varieties with desired grain quality, with particular focus on Africa. Global rice demand is projected to reach around 584 million tons or less by 2050.

Advances in rice technology are expected to transform rice agriculture by then. Asia may see a reduction of about 5 million hectares in rice cultivation area, while Africa could gain approximately 10 million hectares, reflecting shifting geographic patterns in rice production over the coming decades (Samal et al., 2022).

Rice, consumed by over half the world's population, is vital for global food security, with production projected to reach 567 million tonnes by 2030. Beyond being a major calorie source, rice provides essential vitamins, minerals, and bioactive compounds with antioxidant properties, linked to reduced risks of cardiovascular disease and diabetes (Mohidem et al., 2022).

Figure 1.
Marketing channel of rice from producer to consumers

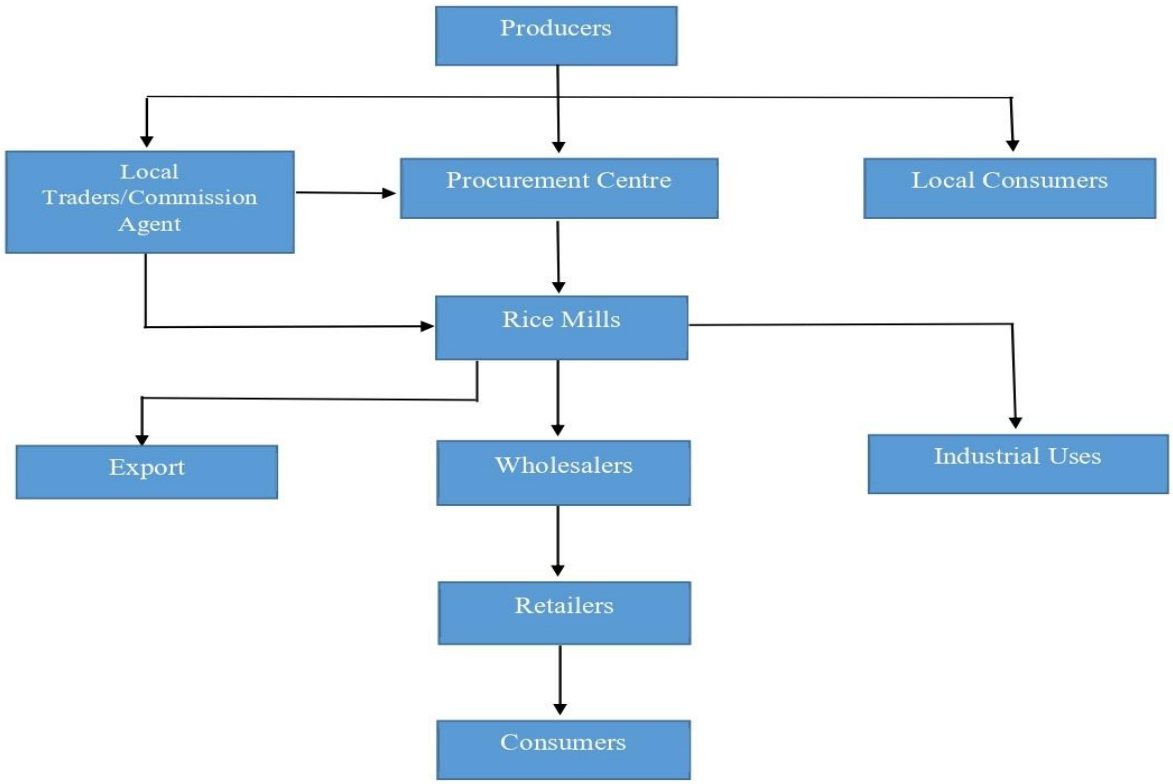


Figure 1 illustrates rice marketing channels in Pakistan, adapted from Badar & Mohy-ud-Din (2011). Farmers may sell directly to local traders, commission agents, procurement centers, or consumers. Traders and procurement centers route rice to mills, where paddy is processed. From mills, rice flows to wholesalers, exporters, or industry, with wholesalers supplying retailers who serve final consumers. This chain underscores the complexity of Pakistan's rice supply system, involving multiple intermediaries and diverse end-use destinations

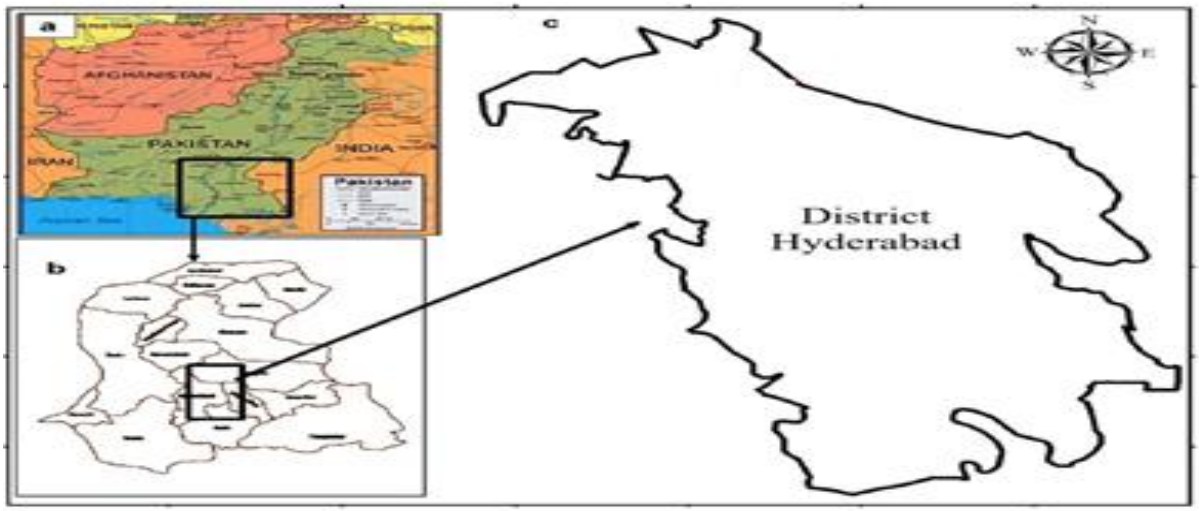
- To examine status of rice production in Pakistan for last fifteen years
- To analyze the spatial price integration of wholesale rice markets in district Hyderabad

MATERIALS AND METHODS

District Hyderabad is purposively selected for the present study as rice is a major agricultural commodity in the area and plays a significant role in the local wholesale market.

Study area and sampling size

District Hyderabad holds a significant position in the local wholesale and retail markets for rice. Due to time and financial constraints, the present study was confined to this district. A purposive sample of 120 rice wholesalers was selected and engaged through structured interviews using a customized questionnaire. Primary data was gathered through personal interviews, conducted in alignment with the objectives of the study.



A key component of the survey process was the development of a well-structured questionnaire tailored to the current research on rice markets. With guidance from the research supervisor, the questionnaire was designed to gather information on status of rice production, m, socioeconomic characteristics, market structure, market integration and price information. Data collection was closely aligned with the study's objectives and incorporated both primary and secondary sources. Secondary data included time-series statistics on area, production, and yield of rice, while primary data focused on price variations, capturing both seasonal and off-season pricing trends to provide a comprehensive understanding of price integration in the wholesale market.

Co-integration technique

To investigate market performance, it was necessary to test the price relationship between the different markets of district Hyderabad for the reliability of prices. The compilation of the monthly wholesale prices of rice was obtained from various markets. To examine a stable relationship between markets the market integration test was run. First we applied Augmented Dickey Fuller test for checking data stationary or non-stationary.

The most similar work in this area was done by Yasir (2015) in the study to investigating the real shocks in the discount rate of Pakistan. The time series data of the discount rate for 65 years, from 1948 to 2013, was collected from the State Bank of Pakistan. Since the data was time series, the Augmented Dickey-Fuller unit root test (ADF) was deployed to determine the presence of stationarity/non-stationarity in the given series of discount rates (Batool et al., 2024).

Market integration test

To examine the price relationship between two markets, the following basic equations is commonly used to test for the existence of market integration:

$$A_{it} = \propto_0 + \propto_1 A_{IJ} + \varepsilon_t$$

Where,

A_I = Price series of rice in i^{th} market

A_j= Price series of rice in j^{th} market

ε = is the residual term assumed to be distributed identically and independently.

$\propto_0$= Represent cost

Dickey-Fuller (1979) test (DF test) can be used to determine the stationary of variable. The test is based on the t-statistic of β_1 given by the following equation.

$$\Delta A_t = \alpha + \beta A_{t-1} + \gamma t + \sum_{k=2}^{n} \delta_k \Delta A_{t-k} + \varepsilon_t$$

Where,

$$\Delta A_t = A_t - A_{t-1}$$

$\Delta A_{t-k} = A_{t-k}$,A_{t-k-1}

k= 2, 3 ….n, $\alpha\beta\gamma and\delta$ are the parameter to be estimated

In the estimation of the equation, the null hypothesis is $H_0: A_t$ is I (1) which is rejected in favour of I(0)], if $\beta_1$is found to be negative and statistically significant. The above test can also be carried out for the first difference of the variables. That is, estimate the following regression equation:

$$A_{it} = a_1 + a_2 A_{jt} + v_{it}$$

Where A_{it} is the price in market *i* at time *t* ,A_{jt} is the price in market j at time t, a_1 and a_2 are the parameters to be estimated and v_{it} are the white noise error terms.

$\Delta v_t = \delta v_{t-1} + \sum_{k=2}^{n} \gamma_k \Delta v_{t-k} + \sigma_t$

Where v_t , v_{t-1}, $v_{t-k-1}$are residuals at time t, t-1, t-k and t-k-1.δ , γ are the parameters to be estimated while σ_t is the residual term.

Role of KoboCollect in collecting and computing data

KoboCollect played a key role in collecting data directly from the field in real time. Its ability to organize numerical responses made it easier to apply statistical functions. By helping calculate measures like averages, KoboCollect supported a clear and reliable understanding of traders' views. Its use ensured a strong analytical approach, clearly showing the strengths and weaknesses of market integration and helping guide targeted efforts to boost farmer participation and productivity.

RESULTS

This study was conducted to investigate the integration of rice wholesale market pricing in Hyderabad, Sindh. The KoboCollect tool was used to gather data from the 120 respondents that took part in the study.

The table 1 illustrates the yearly trends in rice cultivation area (in thousand hectares) across Pakistan's four provinces Sindh, Punjab, Khyber Pakhtunkhwa (KPK), and Balochistan from 2008-09 to 2022-23. Punjab consistently leads in rice cultivation, with its area expanding from 4,887.09 thousand hectares in 2008-09 to a peak of 6,314.01 thousand hectares in 2021-22, before a decline to 5,410 thousand hectares in 2022-

23. Sindh shows notable fluctuations, with a sharp drop in 2010-11 (892.56) followed by a rebound, peaking at 2,046.81 in 2017-18 and then declining again. KPK and Balochistan maintain comparatively smaller and steadier cultivation areas, though Balochistan shows a steep decline after 2010-11. Nationally, the rice cultivation area decreased significantly in 2010-11 to 5,844.89 thousand hectares, followed by a general upward trend reaching a peak of 8,741.2 thousand hectares in 2021-22. However, the area contracted again in 2022-23 to 7,354.59, indicating recent challenges in sustaining high cultivation levels.

Table 1.
Provincial and national trends in rice cultivation area in Pakistan (2008-09 to 2022-23)

Year	Sindh	Punjab	Kpk	Balochistan	Pakistan
2008-09	1812.55	4887.09	151.48	469.76	7320.88
2009-10	1748.8	4772.93	132.95	469.76	7124.44
2010-11	892.56	4365.94	113.92	472.47	5844.89
2011-12	1571.13	4235.96	123.8	422.8	6353.69
2012-13	1262.98	4229.04	120.59	92.67	5705.28
2013-14	1842.2	4469.97	136.65	443.56	6892.38
2014-15	1931.66	4639.98	140.61	430.71	7142.96
2015-16	1778.7	4399.05	159.88	431.95	6769.58
2016-17	1854.56	4291.06	165.56	420.09	6731.27
2017-18	2046.81	4549.05	152.22	419.59	7167.67
2018-19	1705.55	4704.97	153.95	379.31	6943.78
2019-20	1917.33	5014	155.18	427.01	7513.52
2020-21	1751.97	5917	160.41	413.18	8242.56
2021-22	1869.56	6314.01	158.75	398.88	8741.2
2022-23	1490.84	5410	140.04	313.71	7354.59

Source: Source Ministry of Food and Agriculture, Federal Bureau of Statistics (2024)

Table 2 displays the annual rice production (in thousand tonnes) across the provinces of Pakistan, Sindh, Punjab, Khyber Pakhtunkhwa (KPK), and Balochistan from 2008-09 to 2022-23. Overall, Punjab has been the largest contributor to rice production, peaking at 5,779 thousand tonnes in 2021-22, followed by Sindh, which showed significant variability with a high of 2,861.38 in the same year but dropping sharply to 2,011.8 in 2022-23. KPK and Balochistan contributed comparatively smaller quantities, though KPK's production remained relatively stable between 102.4 and 158.53 thousand tonnes, while Balochistan experienced considerable fluctuation, notably declining to just 103.16 thousand tonnes in 2022-23. At the national level, total rice production reached its lowest in 2010-11 at 4,823.3 thousand tonnes due to sharp declines in all provinces, especially Sindh, but then steadily increased, culminating in a peak of 9,322.68 thousand tonnes in 2021-22. However, there was a notable drop in production in 2022-23 to 7,322.23 thousand tonnes, likely due to regional agricultural or environmental challenges.

Table 2.
Provincial and national status of rice production

Year	Sindh	Punjab	KPK	Balochistan	Pakistan
2008-09	2537.1	3643	128.2	643.7	6952
2009-10	2422.3	3713	102.4	645	6882.7
2010-11	1230.3	3384	78.4	130.6	4823.3
2011-12	2260.1	3277	94.7	528.6	6160.4
2012-13	1843.9	3478	93.8	120.2	5535.9
2013-14	2617.3	2481	111.9	587.9	5798.1
2014-15	2652.6	3648	131	571.2	7002.8
2015-16	2572.8	3502.3	153.8	572.7	6801.6
2016-17	2661.6	3475	158.2	554.5	6849.3

2017-18	2850.5	3898	147.5	553.8	7449.8
2018-19	2571.1	3979	153.8	498.1	7202
2019-20	2374.3	4143.72	152.9	535	7205.92
2020-21	2416.07	5301.4	158.53	543.67	8419.67
2021-22	2861.38	5779	157.55	524.75	9322.68
2022-23	2011.8	5070	137.27	103.16	7322.23

Source: Source Ministry of Food and Agriculture, Federal Bureau of Statistics (2024)

Table 3 presents the annual yield of rice (in maunds per acre) for each province of Pakistan—Sindh, Punjab, Khyber Pakhtunkhwa (KPK), and Balochistan, as well as the national average from 2008-09 to 2022-23. Throughout the period, Sindh consistently recorded the highest yields, peaking at 38.26 maunds per acre in 2021-22. Punjab and KPK showed steady improvement in yield over the years, with Punjab increasing from 18.64 in 2008-09 to 23.43 in 2022-23, and KPK from 21.16 to 24.51 in the same timeframe. Balochistan experienced major fluctuations, notably a dramatic drop in 2010-11 to 6.91 maunds per acre and again in 2022-23 to just 8.22. At the national level, the rice yield ranged from a low of 77.96 maunds per acre in 2010-11 to a high of 118.84 in 2021-22. However, a significant decline was observed in 2022-23, with the national average yield dropping to 89.9, largely influenced by the sharp reduction in Balochistan.

Table 3.
Provincial and national status of rice yield (unit 40 kg per acre)

Year	Sindh	Punjab	Kpk	Balochistan	Pakistan
2008-09	34.99	18.64	21.16	34.26	109.05
2009-10	34.63	19.45	19.26	34.33	107.67
2010-11	34.46	19.38	17.21	6.91	77.96
2011-12	35.96	19.34	19.12	31.26	105.68
2012-13	36.5	20.56	19.45	32.43	108.94
2013-14	35.52	13.88	20.47	33.14	103.01
2014-15	34.33	19.66	23.29	33.15	110.43
2015-16	36.16	19.9	24.05	33.15	113.26
2016-17	35.88	20.25	23.89	33	113.02
2017-18	34.82	21.42	24.22	33	113.46
2018-19	37.69	21.14	24.98	32.83	116.64
2019-20	30.96	20.66	24.63	31.32	107.57
2020-21	34.48	22.4	24.71	32.9	114.49
2021-22	38.26	22.88	24.81	32.89	118.84
2022-23	33.74	23.43	24.51	8.22	89.9

Source: Source Ministry of Food and Agriculture, Federal Bureau of Statistics (2024)

Table 4 shows that the role of participants in the rice market based on their market position. The majority of respondents (91.6%) are wholesalers, indicating that the research result mainly involved individuals dealing in bulk quantities of rice at the wholesale level and only 8.3% of respondents are retailers, who sell rice in smaller quantities directly to consumers. These results suggest that the market is dominated by wholesalers, reflecting the focus of market on bulk transactions and business-to-business trade rather than direct consumer sales.

Table 5 shows the age distribution of respondents categorized as wholesalers and retailers. In wholesalers group the oldest respondent is 66 years old, the youngest respondent is 24 years old, the average age of wholesalers is 43.89 years, indicating that group of wholesalers consists of relatively older individuals on average.

Table 4.
Role of participants in the rice market based on their market position

Role in market	
Wholesalers	Retailers
91.6%	8.3%

In retailers group the oldest respondent is 54 years old, the youngest respondent is 28 years old, the average age of retailers is 35.9 years, showing that this group is generally younger compared to wholesalers. Overall, wholesalers tend to be older than retailers, with a broader age range among them.

Table 5.
Age of respondents of wholesalers and retailers

Age of respondents (Wholesalers)		
Max	Min	Average
66	24	43.89091
Age of respondents (Retailers)		
Max	Min	Average
54	28	35.9

Table 6 shows the monthly income distribution of wholesalers and retailers, showing the maximum, minimum, and average income for each group. In wholesalers group, the highest recorded monthly income is 600,000, the lowest recorded monthly income is 70,000, the average monthly income is 386,545.5, in retailers group, the highest recorded monthly income is 150,000, the lowest recorded monthly income is 50,000, and the average monthly income is 109,000, which is notably lower than that of wholesaler. Indicating that wholesalers generally earn a significantly higher income.

Table 6.
Monthly income of wholesalers and retailers

Monthly Income of (wholesaler)		
MAX	Min	Average
600000	70000	386545.5
Monthly Income of (retailer)		
MAX	Min	Average
150000	50000	109000

Table 7 shows the market experience of wholesalers and retailers, showing the maximum, minimum, and average years of experience in the market for each group. The most experienced wholesaler has 25 years of market experience, the least experienced wholesaler has 2 years of experience, and the average experience among wholesalers is 9.11 years, indicating a relatively seasoned group. And the most experienced retailer has 16 years of market experience, the least experienced retailer has 4 years of experience. And the average experience among retailers is 8.9 years, which is slightly lower than that of wholesalers. Indicating that Wholesalers have more market experience as compared to retailers.

Table 7.
Market experience of wholesaler & retailer

Market experience (Wholesaler)		
Max	**Min**	**Average**
25	2	9.109091
Market experience (Retailer)		
Max	Min	Average
16	4	8.9

Table 8 shows the total number of family members for wholesalers and retailers, showing the maximum, minimum, and average family size for each group. In the group of wholesalers, the largest family size recorded is 10 members, the smallest family size recorded is 4 members. The average family size among wholesalers is 5.58 members. The largest family size recorded is 9 members, the smallest family size

recorded is 5 members. The average family size among retailers is 5.9 members, which is slightly higher than that of wholesalers. This indicates that, Wholesalers have a wider range of family sizes (4 to 10 members), while retailers family sizes range from 5 to 9 members. The difference in average family size is minimal, suggesting that both groups have similar household structures.

Table 8.
Total family members of wholesaler & retailer

Total Family Members (Wholesaler)		
Max	**Min**	**Average**
10	4	5.581818
Total Family Members (Retailer)		
Max	Min	Average
9	5	5.9

Table 9 shows the percentage distribution of educational levels among wholesalers and retailers, categorizing them into Primary and Secondary education. 53% of wholesalers have primary education, 46% of wholesalers have secondary education. This suggests that the majority of wholesalers have only primary-level education, with slightly fewer progressing to the secondary level. 50% of retailers have primary education. 50% of retailers have secondary education, this indicates wholesalers have a slightly higher proportion of individuals with only primary education (53%) compared to retailers (50%).

Table 9.
Percentage of level of education

Percentage of level of education (Wholesaler)	
Primary	**Secondary**
53%	46%
Percentage of level of education (Retailers)	
Primary	Secondary
50%	50%

The table 10 presents the types of rice most commonly traded by wholesalers and retailers, showing the percentage of respondents dealing in different rice varieties: Basmati, IRRI, and Others. 100% of wholesalers trade in Basmati rice, making it the most dominant variety in their trade.60% of wholesalers also trade in IRRI rice, indicating that a significant portion of them deal in multiple varieties.20% of wholesalers trade in other rice varieties, showing some level of diversification in their trade. 100% of wholesalers trade in Basmati rice, making it the most dominant variety in their trade. 60% of wholesalers also trade in IRRI rice, indicating that a significant portion of them deal in multiple varieties. 20% of wholesalers trade in other rice varieties, showing some level of diversification in their trade. The table 11 presents the average wholesale price of rice sold last month for wholesalers and retailers, highlighting the maximum, minimum, and average prices as per unit (per kilogram) The highest wholesale price recorded was 250. The lowest wholesale price recorded was 150.The average price of rice sold by wholesalers was 191.27 and The highest retail price recorded was 280, The lowest retail price recorded was 160.

Table 10.
Type of rice wholesaler and retailer mostly trade

Type of rice they mostly trade(wholesaler)		
Basmati	**IRRI**	**Others**
100%	60%	20%
Type of rice they mostly trade(retailer)		

Basmati	IRRI	Others
100%	70%	10%

The table 11 presents the average wholesale price of rice sold last month for wholesalers and retailers, highlighting the maximum, minimum, and average prices as per unit (per kilogram) The highest wholesale price recorded was 250. The lowest wholesale price recorded was 150.The average price of rice sold by wholesalers was 191.27 and The highest retail price recorded was 280, The lowest retail price recorded was 160. The average price of rice sold by retailers was 201, This shows that, Retailers sell rice at higher prices on average (201) compared to wholesalers (191.27).

Table 11.
Frequency of rice trading among wholesalers and retailers

How often do trade rice in the market (Wholesalers)	
Daily	1, 2 days
100%	0%
How often do trade rice in the market (Retailers)	
Daily	1, 2 days
70%	30%

Table 12 shows, Wholesalers primarily sell to Local Retailers, with 100% of respondents identifying them as customers, a large portion also sells to Other Wholesalers (90.83%), suggesting a strong B2B network, Consumers are still a notable group at 76.66%, but less so than businesses. and in retailers the Wholesalers serve a broad mix of customers, primarily local retailers, but also other wholesalers and consumers. Retailers, on the other hand, focus entirely on direct consumers and do not engage in B2B sales.

Table 12.
Primary customers of wholesalers and retailers

Who are primary customers? (Wholesalers)		
Local Retailers	**Other Wholesalers**	**Consumers**
100%	90.83%	76.66%
Who are primary customers? (Retailers)		
Local Retailers	Other Wholesalers	Consumers
0%	0%	100%

Table 13 shows 100% of wholesalers source their rice from traders and 0% source from local farmers or other wholesalers and 100% of retailers source their rice from wholesalers, 0% source from traders or local farmers or others.

Table 13.
Primary sources of rice for wholesalers and retailers

From where do you primarily source your rice?(Wholesalers)		
Traders	**Local Farmers**	**Other Wholesalers**
100%	0%	0%
From where do you primarily source your rice?(Retailers)		
Traders	Local Farmers	Wholesalers
0%	0%	100%

Table 14 shows that 100% of respondents reported that wholesale rice prices change daily and 0% said prices change every 2–3 days or at other intervals.

Table 14.
Percentage of how frequently do wholesale prices of rice changed in the market

Percentage of How frequently do wholesale prices of rice changed in the market?	
Daily	In 2,3 days, other
100%	0%

Table 15 shows that the Demand & Supply and Government Policies are the most critical factors, universally recognized as affecting rice prices. Market dynamics (e.g., shortages, surpluses) play a dominant role. Policies (e.g., subsidies, import/export restrictions) have a strong influence. Seasonal Changes (e.g., harvest cycles, weather) are very important butslightly less universal (95%) and Transportation Costs have a minimal impact (10%), suggesting they are not a primary concern in pricing.

Table 15.
The main factors influencing price changes in wholesale market

The main factors influencing price changes in wholesale market			
Seasonal Changes	**Demand & Supply**	**Government Policies**	**Transportation costs**
100%	100%	95%	10%

Table 16 shows that 99% of respondents use this method of Communication with Traders for the information of price changes, Market Reports 92.5% depend on for Market Reports for price updates, and only 30.83% utilize the approach of Digital Platforms (e.g., apps, websites).

Table 16.
How price information is tracked across market/tracking price changes in external markets

How do you track price changes in other markets?		
Communication with traders	**Market reports**	**Digital platforms (e.g., apps, websites)**
99%	92.5%	30.83%

Table 17 shows the distribution of integrated and non-integrated markets across different trade routes originating from Hyderabad. The Hyderabad-Karachi route is the most integrated, with 85% of the market classified as integrated and only 15% as non-integrated, indicating a strong, cohesive trade link. In contrast, the Hyderabad-Jacobabad route is predominantly non-integrated (79.16%), reflecting a weaker or more fragmented connection. Hyderabad-Shikarpur also leans heavily towards non-integration at 66.6%, while Hyderabad-Larkana shows equal proportions of integrated and non-integrated markets (6.66% each), suggesting minimal market activity or reporting in either category.

Table 17.
Distribution of integrated and non-integrated markets by route

Markets	Integrated	Non integrated
Hyderabad-Karachi	85%	15%
Hyderabad-Shikarpur	8.3%	66.6%
Hyderabad-Larkana	6.66%	6.66%
Hyderabad-Jacobabad	4.16%	79.16%

Table 18 reveals that the primary factor influencing rice pricing in the market is prices in other markets, cited by 78% of respondents. This suggests a strong dependence on external market trends for price determination. In comparison, only 16% rely on local demand and supply, and a mere 5% consider government-set prices, indicating that official price controls and local market conditions play a relatively minor role in pricing decisions.

Table 18.
Determining Rice Prices: Market Factors

How do you determine the price of rice in your market?		
Prices in other markets	**Local demand & Supply**	**Government set prices**
78%	16%	5%

Table 19 indicates a strong perception of market connectivity among respondents. A significant 95% believe that wholesale rice prices in their market are influenced by prices in other cities, highlighting a high level of interdependence across regional markets. Furthermore, 100% of respondents agree that the Hyderabad wholesale rice market is integrated with other markets in Pakistan, reinforcing the view that price movements and market dynamics in Hyderabad are closely linked to broader national trends.

Table 19.
Influence of external markets on local rice prices and integration of rice markets: Hyderabad and beyond

Are wholesale rice prices in your market influenced by prices in other cities?	
Yes	No
95%	5%
Do you believe that the rice wholesale market in Hyderabad is integrated with other markets in Pakistan?	
Yes	No
100%	0%

Table 20 presents the results of the Augmented Dickey-Fuller (ADF) unit root test conducted on the price series data from four markets: Hyderabad, Karachi, Jacobabad, and Larkana. The ADF test was applied at both the level and first-difference forms to determine the stationarity of the time series. At the level form, all four markets exhibit ADF test statistics that are higher (less negative) than the conventional critical values (typically around -3.45 at the 5% level for small samples), indicating that the null hypothesis of a unit root cannot be rejected. This suggests that the price series at level are non-stationary across all markets.

However, at the first-difference form, the ADF test statistics for all markets are significantly lower (more negative) than the critical values, with values ranging from -7.33 to -9.04. These strongly negative test statistics indicate that the null hypothesis of a unit root is rejected at the 1% significance level, confirming that the differenced series are stationary. Thus, the results demonstrate that the price series for all four markets Hyderabad, Karachi, Jacobabad, and Larkana are integrated of order one, i.e., I(1), and become stationary after first differencing. This finding is critical for subsequent econometric analyses, such as co-integration testing or vector error correction modeling (VECM), which require stationary time series.

Table 20.
Augmented Dickey-Fuller (ADF) unit root test results for market price series

Markets	Level	1st difference
Hyderabad	-1.74475	-8.97191
Karachi	-1.40789	-8.90016
Jacobabad	-1.50194	-9.04408
Larkana	-1.894343	-7.32851

Table 21 presents the results of the Johansen co-integration test for selected market price pairs using log-transformed series. The test examines whether a long-run equilibrium relationship exists between the price series of Hyderabad and three other markets: Karachi, Jacobabad, and Larkana. Both the trace statistic and the maximum Eigen value statistic are reported for each market pair, along with the corresponding 5% critical values (in parentheses). Asterisks (**) indicate statistical significance at the 5% level, suggesting the rejection of the null hypothesis in favor of the alternative. Overall, the Johansen co-integration test results indicate that Hyderabad shares a

long-run price relationship with Karachi and Larkana, but not with Jacobabad. This finding has important implications for regional market integration and price transmission analysis.

Table 21.
Johansen Co-integration Test results for market price pairs (log-transformed series)

Market Pairs	Null Hypothesis	Alternate Hypothesis	Trace Statistics	Maximum Eigen value Statistics
Log Hyd-Log Karachi	I=0	I≥1	33.28592(15.494)**	29.453(14.264)**
	I≤1	I≥2	3.832(3.841)	3.832 (3.84)
Log Hyd-Log Jacobabad	I=0	I≥1	9.262517(15.494)	5.711(14.264)
	I≤1	I≥2	3.550 (3.841)	3.55(3.84)
Log Hyd-Log Larkana	I=0	I≥1	24.151(15.494)**	19.245(14.264)**
	I≤1	I≥2	4.906(3.841)**	4.906(3.84)

Table 22 presents the Johansen co-integration test results for the log-transformed multivariate market price series comprising Hyderabad, Karachi, Jacobabad, and Larkana. The table reports both the Trace Statistic and Maximum Eigenvalue Statistic for each hypothesis tested, alongside their respective 5% critical values (in parentheses). Significance at the 95% level is denoted by a double asterisk (**). The Johansen co-integration results suggest that the four market series Hyderabad, Karachi, Jacobabad, and Larkana are co-integrated, with evidence of at least two and possibly three co-integrating vectors. This supports the existence of long-run equilibrium relationships among the regional market prices, indicating a degree of market integration.

Table 22.
Johansen Co-integration Test results for multivariate market price series (log-transformed data)

Market Pairs	Null Hypothesis	Alternate hypothesis	Trace Statistics	Maximum Eigenvalue Statistics
Log Hyderabad	I=0	I≥1	98.813 (47.856)**	65.727 (27.584)**
Log Karachi	I≤1	I≥2	33.086 (29.797)**	20.044 (21.131)
Log Jacobabad	I≤2	I≥3	13.041 (15.494)	7.848 (14.264)
Log Larkana	I≤3	I≥4	5.912 (3.841)**	5.192 (3.841)**

Note: *, ** and *** show the significance at 90%, 95% and 99%., Source: Author's calculations

DISCUSSION

Status of rice production of Pakistan from last fifteen years

The outlines rice production trends in Pakistan from 2010-11 to 2024-25, showing fluctuations influenced by agronomic, climatic, economic, and policy-related factors. According to Wang et al. (2024), Pakistan cultivates rice on over three million hectares annually, earning approximately US$2 billion in foreign exchange. The period generally reflects an upward trend, with notable growth from 4,823.3 thousand metric tons in 2010-11 to 6,160.4 in 2011-12a 27.8% increase, likely due to favorable weather, better agricultural practices, and government support. However, production declined by 10.1% in 2012-13, possibly due to water shortages or reduced cultivation. Between 2013-14 and 2014-15, production rose steadily, reaching 7,002.8 thousand metric tons, supported by high-yield seeds and improved irrigation. From 2015-16 to 2017-18, production remained relatively stable, peaking at 7,449.8 thousand metric tons, suggesting modest improvements despite occasional setbacks. A similar trend

continued through 2018-19 and 2019-20, with production hovering around 7,200 thousand metric tons, reflecting consistent yields and stable cultivation practices. The highest production was recorded in 2020-21 and 2021-22, reaching 8,419.67 and 9,322.68 thousand metric tons, respectively, driven by favorable monsoons, enhanced irrigation, and strong export demand. However, 2022-23 witnessed a sharp 21.5% drop to 7,322.23 thousand metric tons, likely due to floods, drought, pests, and economic difficulties. The figures for 2022-24 and 2024-25, 14.805 and 15.002 thousand metric tons are starkly inconsistent and likely reflect data errors or extreme production disruptions caused by severe climatic conditions and agricultural challenges. These trends emphasize the importance of adaptive and resilient agricultural strategies to address Pakistan's ongoing environmental and systemic vulnerabilities in rice production.

Trends of rice cultivation area in Pakistan

According to Ilyas et al. (2022), rice is among the most widely traded cereal commodities worldwide, with global demand continuing to rise. In the 2021/2022 period, approximately 510.25 million metric tons of rice was consumed across the globe. Similarly from 2008-09 to 2022-23, rice cultivation in Pakistan exhibited fluctuating trends, with the national cultivated area ranging from a low of 5.7 million hectares in 2012-13 to a peak of 8.74 million hectares in 2021-22, followed by a notable decline to 7.35 million hectares in 2022-23. Punjab consistently dominated rice cultivation, contributing the largest share each year, while Sindh showed significant volatility particularly in 2010-11 due to catastrophic floods that halved its cultivated area. Khyber Pakhtunkhwa maintained a relatively stable but minor contribution throughout the period, and Balochistan saw occasional sharp drops, such as in 2012-13, likely due to water shortages or infrastructure challenges. The trends reflect the sector's sensitivity to climatic events, especially floods and droughts, alongside policy and economic factors influencing provincial cultivation patterns.

Provincial and national trends in rice yield in Pakistan

Shah et al. (2021) analyze Rainfall and temperature is essential climate parameters that determine crop yield variability at a regional level. The three most important factors that affect the yield per acre in mounds (1 mound= 40 kg) are DAP and Urea Fertilizer and Disease attack respectively. The provincial and national trends in rice yield in Pakistan from 2008-09 to 2022-23, measured in 40 kg per acre, revealing notable disparities across provinces and over time. Sindh consistently recorded the highest yields among provinces, peaking at 38.26 in 2021-22, though it saw a decline to 33.74 in 2022-23. Punjab showed gradual improvement from 18.64 in 2008-09 to 23.43 in 2022-23, reflecting enhancements in productivity. Khyber Pakhtunkhwa's yield steadily increased from 21.16 to 24.51 over the period, while Balochistan displayed extreme volatility dropping sharply to just 6.91 in 2010-11 and again to 8.22 in 2022-23, likely due to environmental stress or limited agricultural support. Nationally, yields peaked at 118.84 in 2021-22 but declined sharply to 89.9 in 2022-23, indicating a possible impact of widespread climatic disruptions such as flooding, which disproportionately affected southern regions.

Role of participants in the rice market based on their market position

The rice market is dominated by wholesalers, who make up 91.6% of participants, compared to just 8.3% retailers. This disparity highlights a market structure focused on bulk transactions and business-to-business operations. However, Okebiorun and Ige (2024) revealed that respondents overwhelmingly agreed that training, seminars,

workshops, literacy instruction, and entrepreneurship education may liberate and empower. Wholesalers play a central role in the supply chain, sourcing from producers and distributing to retailers or institutional buyers. The limited presence of retailers suggests minimal direct consumer engagement in this context. Such a distribution points to potential market consolidation, where a few major wholesalers may control large volumes of trade, influencing pricing and market flow. This structure emphasizes the strategic role of wholesale networks in the rice value chain and signals the need for targeted policies and regulations to enhance efficiency, competition, and equity in the agricultural marketing system.

Age of respondents of wholesalers and retailers

Luján-Pompa and Hernández-Arce (2025) highlighted that in the state of Chihuahua, household heads between the ages of 15 and 25 had an 18.8% chance of becoming entrepreneurs. Similarly, the age distribution of wholesalers and retailers in the rice market, revealing notable differences between the two groups. Wholesalers have a wider age range (24–66 years) and a higher average age of 43.89 years, indicating a generally older and more experienced group. In contrast, retailers range from 28 to 54 years, with a lower average age of 35.9 years, suggesting they are relatively younger. These findings imply that wholesale roles may require more experience and investment, while retail positions are more accessible to younger individuals. Overall, wholesalers tend to be older, reflecting differing career stages and market roles.

Monthly income of wholesalers and retailers

Monthly income distribution of wholesalers and retailers in the rice market, revealing a clear disparity in earnings between the two groups. Wholesalers report a significantly higher income range, with a maximum monthly income of PKR 600,000, a minimum of PKR 70,000, and an average income of PKR 386,545.5. In contrast, retailers have a comparatively lower income range, with a maximum of PKR 150,000, a minimum of PKR 50,000, and an average of PKR 109,000. These findings suggest that wholesalers, due to the nature of their business operations involving larger transaction volumes and higher capital investment, tend to generate substantially higher revenues than retailers.

Noer and Unteawati (2021) examined the rice marketing system using organizational and market demand approaches. They identified rice millers, collectors, traders, and retailers as key players, with millers taking nearly half the profits. While consumption drops as prices rise, overall rice consumption shows an upward trend. The data further imply that wholesalers may occupy a more financially advantageous position within the rice market hierarchy, reflecting their greater market reach and influence over supply chains. This income disparity underscores the structural differences in scale and profitability between wholesale and retail sectors and highlights the economic benefits associated with operating at the wholesale level in the agricultural commodity trade.

Market experience of wholesaler & retailer

Market experience of wholesalers and retailers, highlighting differences in the length of time each group has been active in the rice trade. Among wholesalers, market experience ranges from 2 to 25 years, with an average of 9.11 years, suggesting a relatively experienced group with substantial exposure to market dynamics. In comparison, retailers have market experience ranging from 4 to 16 years, with an average of 8.9 years. While the difference in average experience is marginal, it

indicates that wholesalers, on average, possess slightly more experience than retailers. Rahman et al. (2021) highlight that millers and wholesalers are key players in the Bangladesh rice value chain. Most millers procure paddy from farmers through commissioned agents or wholesalers, with a small number of fully and semi-automatic millers dominating rice processing and exerting significant control over the market. The study found that the marketing margin was distributed as follows: farmers received 52%, paddy wholesalers 12%, rice wholesalers 4%, millers 8%, and rice retailers 24%. Similarly, this may reflect the nature of wholesale business, which often requires greater expertise, capital, and market understanding. The data suggest that market experience may play a role in shaping business scale and strategy, with more experienced individuals gravitating toward the wholesale sector.

Total family members of wholesaler & retailer

The distribution of family sizes among wholesalers and retailers reveals both similarities and minor differences. Wholesalers have family sizes ranging from 4 to 10 members, averaging 5.58, while retailers range from 5 to 9 members, with an average of 5.9. Despite wholesalers showing a broader range, the slightly higher average among retailers indicates similar household structures. This minimal variation suggests that family size is not a significant differentiating factor between these two groups in the rice market. These findings align with studies such as Hayat et al. (2023), who found that the average household size in Pakistan is approximately 6.7 members, indicating that both wholesalers and retailers operate within typical household structures. Similarly, Ali et al. (2021) emphasizes the role of family labor in agricultural activities in Pakistan, highlighting that household size often reflects cultural norms and labor needs rather than specific market roles. Therefore, the comparable family sizes of wholesalers and retailers likely mirror broader societal influences rather than differences in market function.

Percentage of level of education

Distribution of educational levels among wholesalers and retailers, distinguishing between primary and secondary education. Among wholesalers, 53% have completed only primary education, while 46% have attained secondary education. This indicates that the majority of wholesalers possess only primary-level education, with a smaller proportion progressing to the secondary level. In contrast, retailers are more evenly distributed, with 50% having completed primary education and 50% having completed secondary education.

This suggests that wholesalers have a slightly higher proportion of individuals with only primary education (53%) compared to retailers (50%). According to Luján-Pompa & Hernández-Arce (2025), in the state of Chihuahua, having a secondary education raises the likelihood of being an entrepreneur as the head of the home by 6.38%. The likelihood of having a high school diploma or a professional degree is 4.7% and 4.8%, respectively. These findings highlight a potential gap in educational attainment between the two groups, with wholesalers being more likely to have limited formal education compared to their retail counterparts.

This difference may reflect various factors, including the nature of entry into the wholesale market and the types of skills required for such roles. The more even distribution of educational levels among retailers could suggest that secondary education may be more essential or accessible for those entering retail businesses within the rice market.

Type of rice wholesaler and retailer mostly trade

Acording to Wasan et al. (2022), every region have their own variety of rice cultivated having their own nutritional and health properties. In the article they have discussed about different types of rice varieties such as white rice, black rice, brown rice, basmati rice, jasmine rice, wild rice and golden rice and their differences on the basis of their nutritional content, cholesterol level, fats, vitamins and minerals content, similarly types of rice most commonly traded by wholesalers and retailers, focusing on the primary varieties: Basmati, IRRI, and others. Among wholesalers, 100% trade in Basmati rice, confirming its dominance in their market operations. Additionally, 60% of wholesalers deal in IRRI rice, indicating that a significant portion of them engage with multiple rice varieties to cater to diverse market demands(Yin et al., 2025; Qadiret al.,2024).

A smaller group, 20%, trade in other rice varieties, suggesting some level of diversification within the wholesale sector. On the other hand, retailers also predominantly trade in Basmati rice, with 100% of them handling this variety. However, a larger proportion of retailers, 70%, trade in IRRI rice compared to wholesalers, reflecting a preference or market demand for this variety at the retail level. Only 10% of retailers engage with other rice varieties, which is less than wholesalers, highlighting a more focused approach in their trade offerings. Overall, while both wholesalers and retailers prioritize Basmati rice, wholesalers exhibit more diversity in the types of rice they trade, with a notable portion also dealing in IRRI and other varieties. Retailers, by contrast, show a stronger inclination toward IRRI rice, with fewer diversifying into other varieties.

Frequency of rice trading among wholesalers and retailers

Chen and Zhao (2023) revealed that understanding the global rice-trade supply chain and guaranteeing global food security need a network-based analysis of the structural evolution of the global rice trade. In order to illustrate the temporal and spatial patterns of the global rice trade, analyze its network topologies, and uncover the effects of its evolution on food security, this study uses international rice-trade data from 2000 to 2021 and applies a variety of network analysis techniques. The study concludes the scope of the global rice trade has grown over time, suggesting a comparatively stable rise while intricate networks of commerce have gradually emerged. A comparison of the average wholesale and retail prices for rice sold in the market, along with the maximum and minimum price points for both groups. The highest recorded wholesale price was 250 PKR per kilogram, with the lowest at 150 PKR per kilogram.

The average price for rice sold by wholesalers was 191.27 PKR per kilogram. On the retail side, the highest recorded price was 280 PKR per kilogram, with the lowest at 160 PKR per kilogram, and the average price stood at 201 PKR per kilogram. These figures indicate that retailers, on average, sell rice at higher prices than wholesalers, with an average difference of approximately 9.73 PKR per kilogram. This pricing difference may be attributed to the added cost of selling directly to consumers, including overheads, transportation, and retail markups (Li et al.,2024; Huo et al., 2024).

The variation in prices also highlights the different roles wholesalers and retailers play in the rice supply chain, where wholesalers deal in bulk and offer lower prices, while retailers engage in smaller transactions, thus justifying the higher prices. Moreover, it provides insights into the frequency of rice trading among wholesalers and retailers.

All wholesalers (100%) reported trading rice daily, reflecting the continuous nature of wholesale operations and their role in maintaining the supply of rice to the market. In contrast, 70% of retailers trade rice daily, while 30% engage in rice trading every one to two days. This indicates that retailers tend to have less frequent trading compared to wholesalers, possibly due to lower transaction volumes and the nature of retail operations, where stock turnover might be slower.

Primary customers of wholesalers and retailers

Wholesalers and retailers serve distinct functions in the rice supply chain, with their customer bases reflecting their specialized roles. Wholesalers predominantly sell to local retailers, with 100% of respondents identifying them as primary customers, consistent with the traditional function of wholesalers in aggregating and distributing bulk agricultural products (Amfo et al., 2023). Furthermore, wholesalers maintain extensive Business-to-Business (B2B) networks, as indicated by 90.83% of respondents engaging in transactions with other wholesalers. This suggests an active inter-wholesaler trade, supporting supply consistency across regions (FAO, 2020). Additionally, 76.66% of wholesalers sell directly to consumers, indicating some diversification in their distribution channels, although such sales are secondary to their B2B operations.

In contrast, retailers focus solely on consumer sales, with 100% of respondents identifying individual consumers as their primary customers. There is no reported engagement with other businesses, underscoring the consumer-facing nature of retail in the rice market. This is aligned with findings by Barrett et al. (2018), who describe retailers as the final point of distribution, offering accessibility and convenience to end consumers. The data thus highlights the functional divergence between wholesalers and retailers in the rice trade: wholesalers support upstream distribution through B2B transactions, while retailers provide the last-mile link to consumers.

Primary sources of rice for wholesalers and retailers

Primary sources of rice for wholesalers and retailers, revealing distinct sourcing patterns between the two groups. Wholesalers overwhelmingly rely on traders as their primary source, with 100% of respondents indicating this as their main supplier. Rahman et al. (2021) highlight that Millers and wholesalers play key roles in the rice value chain in Bangladesh. Typically, millers acquire paddy from farmers via intermediaries, such as commissioned agents or wholesalers. In this contrast this suggests that wholesalers are deeply integrated into the wholesale market, sourcing rice from traders who likely supply them in bulk quantities for distribution.

Notably, wholesalers do not source rice from local farmers or other wholesalers, highlighting the central role of traders in their supply chains. Retailers, on the other hand, exclusively source their rice from wholesalers, with 100% of respondents indicating wholesalers as their primary suppliers. Retailers do not source rice directly from traders, local farmers, or other wholesalers, which underscores their dependence on wholesalers for their rice inventory(Abaidullah & Basheer, 2024). This sourcing pattern reflects the retailer's role as the final link in the supply chain, purchasing rice in bulk from wholesalers and selling it in smaller quantities to consumers.

The data thus demonstrates a clear distinction in the sourcing strategies of wholesalers and retailers, with wholesalers having a more diversified supply base through traders, while retailers maintain a direct relationship with wholesalers as their sole suppliers.

Percentage of how frequently wholesale rice prices change in the market

Krisnamurthi and Utami (2022) analyzed that according to the empirical results, these price strategies generally had varying effects on price dynamics, suggesting varying reactions from the various rice types in terms of both magnitude and sign. Frequency of changes in wholesale rice prices in the market, with 100% of respondents reporting that prices change on a daily similarly this study indicates a highly dynamic pricing environment for wholesalers, where fluctuations in prices occur regularly, likely in response to market demand, supply conditions, or external economic factors. Notably, none of the respondents indicated that prices change every 2–3 days or at any other intervals, suggesting that the rice wholesale market operates on a daily pricing cycle. This constant price adjustment reflects the perishable nature of the commodity and the influence of short-term market conditions on pricing.

The main factors influencing price changes in rice wholesale market

According to Rahman (2019), the study's results showed that poor management and syndication among channel participants are the main causes of rice price fluctuations, resulting in a situation where a farmer sells paddy at a reduced price while a customer pays a high price for rice. Additionally, the difference between rice supply and demand is widened by natural disasters and seasonal output. Both Demand & Supply and Government Policies are universally recognized as the most significant determinants, with 100% of respondents identifying these factors as crucial. Market dynamics, including fluctuations in supply and demand, as well as government interventions such as subsidies and trade restrictions, are thus seen as primary forces shaping rice prices.

Seasonal Changes, such as harvest cycles and weather conditions, are also important but slightly less universally acknowledged, with 95% of respondents highlighting their influence on price changes. These seasonal factors contribute to the periodic shifts in rice availability, further impacting price volatility. On the other hand, Transportation Costs were cited by only 10% of respondents, indicating that logistical expenses are considered a minimal factor in determining wholesale rice prices. This suggests that, while transportation is an important aspect of the supply chain, it does not play a major role in the day-to-day price fluctuations experienced in the rice wholesale market.

Tracking across market/tracking price changes in external markets

Methods used by respondents to track price changes in the rice market. The most common approach is communication with traders, with 99% of respondents relying on direct interactions with traders for price updates. This indicates that personal networks and relationships with traders are crucial sources of real-time market information. Additionally, Market Reports are an important tool for 92.5% of respondents, underscoring the continued reliance on traditional market analysis and industry reports to gauge price trends. In contrast, digital platforms such as apps and websites are used by only 30.83% of respondents, suggesting that digital tools are still underutilized in tracking rice price changes, despite their growing popularity in many sectors.

By the systematic literature review Olalekan (2024) revealed that entrepreneurs can interact with clients around the world and transcend regional borders by using digital platforms like social media and e-commerce websites. Ferrari et al. (2022) discovered the necessity of specific efforts focused on enhancing digital infrastructure, in line with current legislative proposals to narrow the digital gap. This data indicates that while

digital platforms have a presence, traditional methods of communication and market reports remain dominant in the rice trade.

Distribution of integrated and non-integrated markets by route

Gluschenko (2021) analyzes all pairs of country's regions, which provides a comprehensive spatial pattern of market integration. The region pairs are classified as belonging to one of four groups: perfectly integrated, conditionally integrated, not integrated but tending towards integration (converging), and neither integrated nor tending towards integration, Similarly this study shows the distribution of integrated and non-integrated markets across different trade routes originating from Hyderabad, highlighting significant variations in market connectivity. The Hyderabad-Karachi route stands out as the most integrated, with 85% of the market classified as integrated and only 15% as non-integrated. This strong integration reflects a well-established and cohesive trade link between the two cities, likely facilitated by robust infrastructure and established trade practices.

In contrast, the Hyderabad-Jacobabad route shows a predominantly non-integrated market, with 79.16% of the trade classified as non-integrated, suggesting a fragmented or less cohesive connection between these regions. Similarly, the Hyderabad-Shikarpur route also leans heavily towards non-integration, with 66.6% of the market categorized as non-integrated, further indicating challenges in establishing a unified market system. The Hyderabad-Larkana route is unique in showing an equal distribution of integrated and non-integrated markets, with both categories accounting for 6.66% each, which may indicate limited market activity or a lack of substantial market integration or reporting in this region. These findings suggest that strong consensus among respondents regarding the interconnectedness of rice markets, particularly in relation to the degree of market integration varies significantly across different trade routes, reflecting the influence of infrastructure, market dynamics, and regional trade practices.

Market factors to determining rice prices

Islam et al. (2021) examine the hazards that Bangladeshi rice producers face from the environment, climate, and market prices. Farmers' attitudes and perceptions of risk have a major impact on the practical strategies they use for farm management. The purpose of this study is to identify the aspects that a farmer influences on the danger related to climatic and environmental problems. Using a cross-sectional dataset on 600 rice farmers from three significant rice-growing regions in Bangladesh, this study measures the risk perceptions of rice farmers, their perceived behavior, and other related underlying determinants. Factors influencing rice pricing in the market, with a significant reliance on external market trends. A dominant 78% of respondents indicate that prices in other markets play the most critical role in determining rice prices in their own markets.

This suggests that rice traders are highly responsive to fluctuations in prices beyond their local context, likely due to the interconnected nature of rice markets and the influence of larger regional or national pricing trends. In contrast, only 16% of respondents consider local demand and supply dynamics, suggesting that domestic market conditions have a relatively smaller influence on pricing decisions. Furthermore, a minimal 5% of respondents rely on government-set prices, pointing to a limited role for official price controls or regulations in shaping the rice market. These

findings underline the dominance of external market forces in determining rice prices, while local and government factors appear to exert less influence.

Influence of external markets on local rice prices and integration of rice markets: Hyderabad and beyond

An overwhelming 95% of respondents affirm that rice prices in their local wholesale markets are influenced by prices in other cities, indicating a high degree of inter-market price transmission and responsiveness to external pricing trends. This reflects the dynamic and integrated nature of rice trading, where shifts in supply and demand, even in distant markets, can impact local pricing strategies. Studies on market integration in South Asian agricultural sectors, including rice, have similarly found strong co-movements in prices across regions, suggesting efficient price transmission mechanisms (Khan, 2022; Alioma et al., 2022).

Moreover, the data show that 100% of respondents believe the Hyderabad rice wholesale market is integrated with other markets across Pakistan. This unanimous agreement reinforces the perception of Hyderabad as a vital node within the broader national rice trade network, where pricing and market behaviors are shaped by developments occurring beyond local boundaries. Such findings emphasize the importance of considering national market dynamics in any analysis of rice pricing and trade behavior within regional hubs like Hyderabad (Khan, 2022).

Augmented Dickey-Fuller (ADF) unit root test results for market price series

The crucial insights into the dynamics of rice price movements across key markets, namely Hyderabad, Karachi, Jacobabad, and Larkana. The application of the Augmented Dickey-Fuller (ADF) unit root test reveals that the price series in their level forms are non-stationary in all four markets, as indicated by test statistics that do not exceed the critical values at conventional significance levels. This outcome implies the presence of a unit root in each series, suggesting that rice prices follow a stochastic trend and are influenced by persistent shocks over time. These findings are consistent with previous empirical studies on agricultural market integration. For instance, recent literature emphasizes that price series in agricultural markets often exhibit non-stationarity at levels but become stationary after differencing, reflecting the influence of macroeconomic shocks and policy interventions (Bano & Scrimgeour, 2021). The integration of rice prices to the order of I(1) also aligns with broader global observations, where market linkages are typically evaluated through co-integration approaches once I(1) properties are confirmed (Kaminski et al., 2020). Furthermore, the stationarity of differenced series across geographically and economically diverse markets such as Karachi and Jacobabad suggests the presence of potential market interactions and transmission of price signals. This could indicate a degree of price co-movement, possibly due to trade flows, transportation infrastructure, or shared exposure to international rice market conditions, particularly from dominant exporters such as Thailand or India. According to Diao et al. (2022), such external influences have become increasingly significant in shaping local food prices in South Asian economies.

Johansen Co-integration Test results for market price pairs (log-transformed series)

The presence of co-integration with Karachi and Larkana, as indicated by statistically significant trace and maximum Eigenvalue statistics at the 5% level, implies that these market pairs move together in the long run despite short-term deviations. This outcome

suggests effective price transmission mechanisms and potential arbitrage activities between these locations, which contribute to spatial market efficiency. Such integration is particularly plausible given the economic prominence of Karachi as a major consumption and distribution center, and Larkana's agricultural significance in Sindh (Raza & Siddiqui, 2023). Conversely, the absence of co-integration between Hyderabad and Jacobabad implies a lack of long-run equilibrium price relationship.

This might stem from infrastructural, institutional, or logistical constraints that inhibit efficient market functioning or delay price adjustments. Such regional disparities are not uncommon in developing economies, where transportation inefficiencies and fragmented supply chains often hinder market integration (Gebre-Mariam & Taffesse, 2021). Additionally, localized production shocks or market-specific policies could create asymmetric price behavior, limiting co-movement even within relatively close geographic regions. From a policy perspective, these findings highlight the need for targeted interventions aimed at reducing transaction costs and improving connectivity between less integrated markets. Investments in rural infrastructure, improved market information systems, and better regulatory coordination can enhance integration, thereby facilitating more stable and equitable rice pricing across the region (Basheer et al., 2024).

Johansen Co-integration Test results for multivariate market price series (log-transformed data)

This finding has important implications for understanding market integration. While some market pairs (e.g., Hyderabad–Jacobabad) do not show bilateral co-integration (Table 21), the multivariate analysis reveals that Jacobabad is part of a broader system of price co-movements. This supports the idea that markets may not be tightly linked in pairs but can still share long-run equilibria within a larger network (Singh & Kumar, 2025). The presence of multiple co-integrating vectors suggests that several long-term relationships influence price dynamics across the four markets, likely due to interconnected trade routes, shared external shocks, and overlapping supply chains. These results align with spatial market integration theory, which holds that prices in geographically distinct markets converge over time under efficient arbitrage and low transaction costs (Abdulai, 2023). The detection of co-integration justifies the use of a Vector Error Correction Model (VECM), enabling the analysis of both long-run relationships and short-run price adjustments.

CONCLUSION

The study provides an in-depth analysis of rice production trends and market dynamics in Pakistan over the last fifteen years, with a particular focus on the wholesale structure of the rice market. From 2010-11 to 2021-22, rice production in Pakistan generally followed an upward trend, reaching its peak at 9,322.68 thousand metric tons in 2021-22. This growth was largely driven by improved agricultural practices, favorable climatic conditions, and governmental support. However, the sudden decline in production during 2022-23 and the anomalous drop in the following two years (2022-24 and 2024-25) reflect serious challenges such as environmental disruptions, climate change, and poor agricultural management, which threaten the sustainability of rice farming in the country. Market analysis reveals that the rice trade in Pakistan is heavily dominated by wholesalers, who account for 91.6% of the market participants. These wholesalers tend to be older, more experienced, and earn significantly higher incomes than their retail counterparts. Retailers, on the other hand, play a smaller role and primarily engage in direct consumer sales. Basmati rice remains

the most traded variety, highlighting a clear consumer preference and market demand, while IRRI and other varieties support trade diversification. Price volatility is a prominent feature of the market, with daily price fluctuations influenced predominantly by demand and supply forces, government policies, and external market conditions. Traders and market reports serve as the primary sources of price information, with minimal use of digital platforms, pointing to a lack of technological integration in market operations. The data also highlights strong inter-market connectivity, especially in major routes like Hyderabad-Karachi, while other routes such as Hyderabad-Jacobabad remain poorly integrated. The influence of prices in other cities and the perceived integration of Hyderabad's rice market with national markets confirm the interdependent nature of rice pricing across regions.

Overall, the findings underscore the need for improved infrastructure, better market integration, and adaptive strategies to cope with climate change, and greater technological adoption to ensure the long-term growth and stability of Pakistan's rice sector. Strengthening policy frameworks and promoting resilience at both production and market levels are critical to safeguarding the future of this vital agricultural commodity.

RECOMMENDATIONS

- Given the sharp production declines in recent years due to climatic stress, it is crucial for policymakers to invest in climate-resilient agricultural practices. This includes promoting drought- and flood-resistant rice varieties, improving water management systems, and training farmers in adaptive cultivation techniques.
- With price changes occurring daily and traders being the primary source of price information, the development and adoption of digital platforms (e.g., mobile apps, SMS alerts, online dashboards) can enhance market transparency. This would empower both wholesalers and retailers with timely access to price updates and improve decision-making.
- As the Hyderabad-Karachi route shows strong integration while others remain fragmented (e.g., Hyderabad-Jacobabad), targeted infrastructure development (better roads, logistics, and communication systems) should be prioritized to enhance integration across all routes. This would help stabilize prices and promote fair competition.
- With the wholesale market dominated by older, more experienced traders, efforts should be made to support youth engagement in the rice trade. Vocational training, access to finance, and mentorship programs could encourage the next generation to enter and innovate within the sector.
- While government price-setting currently plays a minimal role, the implementation of transparent and enforceable price regulation policies could help mitigate excessive price fluctuations, especially during crisis periods. Government interventions such as price stabilization funds or Minimum Support Prices (MSPs) should be explored.
- The data reveals that all wholesalers source rice from traders rather than farmers. Encouraging direct procurement models, such as farmer cooperatives or contract farming—can improve farmer incomes, reduce middlemen costs, and increase traceability in the supply chain.
- With most market participants only having primary or secondary education, targeted educational programs focusing on agribusiness, supply chain management, and digital literacy would enhance operational efficiency and market participation.

- The national decline in 2022-23 indicates vulnerability to climate shocks such as floods and droughts. Strengthening early warning systems, investing in climate-resilient rice varieties, and adopting sustainable water management practices should be national priorities.
- Continuous monitoring of yield trends and real-time advisory services through digital platforms can empower farmers to make better-informed decisions regarding input use, pest control, and crop management.
- Given the vulnerability of rice farming to both climatic and market risks, especially in Sindh and Balochistan, a robust crop insurance system and Minimum Support Price (MSP) mechanism should be introduced to protect farmers and encourage sustained cultivation.

DECLARATIONS

Acknowledgement: We appreciate the generous support from all the contributor of research and their different affiliations.
Funding: No funding body in the public, private, or nonprofit sectors provided a particular grant for this research.
Availability of data and material: In the approach, the data sources for the variables are stated.
Authors' contributions: Each author participated equally to the creation of this work.
Conflicts of Interests: The authors declare no conflict of interest.
Consent to Participate: Yes
Consent for publication and Ethical approval: Because this study does not include human or animal data, ethical approval is not required for publication. All authors have given their consent.

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