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Dynamics Of India's Food Grain Economy: An Econometric Analysis Of Production Determinants And Export Competitiveness (2000–2026)

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Abstract

Agriculture remains the backbone of Indian economy, contributing approximately 17.8 per cent to Gross Domestic Product and supporting over 55 per cent of the population. This study investigates the "Paradox of Inputs", where massive investments in irrigation and fertilizers coexist with a continued statistical dependence on monsoon variability. Covering 23-year period (2000-01 to 2022-23), the study utilises descriptive statistics and two distinct multiple regression models to analyse food grain production and export drives. The study reveals a structural shift in production which surged by 68.8 per cent despite a nearly stagnant cultivated area. The regression analysis ($R^2 = 0.95$) identifies average rainfall as the only individually significant predictor (beta = 0.072, p=0.03), while inputs like irrigation and fertilizers showed collective significance through ANOVA (F = 26.835) but individual inefficiency. This highlights a persistent vulnerability to climatic shifts. The paper concludes that India has transitioned to a yield-led growth phase, evidenced by the Rabi season's rising dominance. However, to achieve sustainable food security, policy must pivot from "quantity oriented" subsidies to "efficiency focused" technology. Recommendations include expanding micro-irrigation, adopting climate resilient crop varieties and enhancing export infrastructure to decouple production from monsoon reliance.

Key words: Indian agriculture, Food Grain production, Yield-led Growth, Export Determinants, paradox of Inputs, Multiple regression.

JEL: Q11, Q13, Q17, C51, Q18, C22

Introduction

Agriculture is one of the cornerstones of India's economy and society, providing a livelihood to nearly 55 per cent of the population. With the world's second largest agricultural land area, India is a global leader in farm output. The country has the largest cattle herd (buffaloes), the largest area under wheat, rice and cotton and ranks as the world's top producer of milk, pulses and spices. It is also the second-largest producer of fruits, vegetables, tea, farmed fish, cotton, sugarcane, wheat and rice underscoring its central role in global food supply. India's agrochemical exports have nearly trebled

in the past decade rising to US$ 3.3 billion in financial year 2025 from US$1.3 billion in the financial year 2015, making the country third largest exporter after China and United States, according to a report by the Agro-Chemicals Federation of India (ACFI) and Deloitte.

The food industry in India is poised for rapid growth, driven by its immense potential for value addition. The food processing industry alone accounts for 32 per cent of the country's total food market and ranks fifth globally in terms production, consumption, exports and growth potential. Beyond generating employment for millions of farmers the sector plays a vital role in rural industrialisation, supply chain development and food security.

India's agricultural output has expanded significantly in the past decade, recording 40 per cent growth and achieving surplus capacity for exports. In 2025, the sector grew by 5.4 per cent year on year supported by record production and higher trade volumes. Agricultural exports touched an all time high Rs.4,40,000 crore (US$ 51.86 billion) in 2025, up from Rs.3,95, 793 crore (US$48.15 billion) in financial year 2024. Agriculture and allied activities together contributed 17.80 per cent to India's GDP in 2023-24 reaffirming the sector's importance to the national economy.

Production levels continue to rise steadily. According to the Third Advance Estimates, foodgrain production for 2024-25 is projected at a record of 3,539.59 LMT, up 6.5 per cent from the previous year. Rice production alone is expected to reach 1,490.74 LMT a which is an increase 0f 112.49 LMT. Horticulture output has also shown remarkable growth climbing from 280.70 million tonnes in 2013 to 367.72 million tonnes in 2024-25.

Statement of the Problem

Despite India's transition into a global agricultural powerhouse, the sector faces a "Paradox of Inputs". While the government has invested heavily in irrigation infrastructure and fertilizer subsidies, the statistical output remains disproportionately sensitive to monsoon variability (average rainfall). Furthermore, as India seeks to expand its footprint in the global market, there is a disconnect between domestic production levels and export volumes, often mediated by volatile international prices and currency shifts rather than domestic surplus alone. There is a critical need to identify which factors truly drive growth to move away from inefficient resource allocation.

Objectives

1. To analyse the trends in food grain production and land productivity
2. To identify the key determinants of food grain production.
3. To evaluate the drivers of India's food grain exports.

Methodology

The study covers total period of 23 years from 2000-01 to 20022-23. The study relied only secondary sources of information published by Ministry of Agriculture & Farmers' Welfare, Ministry of Commerce and Industry and the fertilizer Association of India. For the purpose of analysing the collected data, descriptive statistics was used to analysed the trends in Land – Man Ratio and seasonal performance. Two distinct multiple regression models were employed. In the production of food grains model, production is (Y) i.e., dependant variable and the independent variables include rainfall, irrigation, fertilised and cultivated areas. In Export Model, (Y) i.e is dependant variable and the independent variables include International Price Index, Domestic WPI Domestic Production, Exchange Rate and Importer Income. ANOVA i.e the inferential test was performed to identify the overall model significance and the 't' test was used for knowing the effect of individual coefficient.

Area under Foodgrains Cultivated and Irrigated

The foodgrain cultivation in India covers approximately 120-125 million hectares, with total cropped area rising to over 219 million hectares. Foodgrains occupy roughly 60 to 65 per cent of the gross cropped area. As of recent estimates, the net irrigated area stands at 68.6 million hectares emphasizing increased reliance on micro irrigation systems. The data given in the table below shows the area used for foodgrain cultivation from 2000-2001 to 2022-23.

Area under Foodgrains Cultivated and Irrigated with Land Man Ratio in India (2000-01 ton 2022-23) in '000 Hectare

Year	Area under Food Grains (Gross)		Share of Area under Foodgrains to Gross area Sown (in %age)	Share of Irrigated area under Foodgrains to Gross Irrigated Area (in %age)	Land Man Ratio
	Cultivated	Irrigated			
2000-2001	122680	53609	66.2	70.4	0.17
2001-2002	124222	54131	66.1	69.1	0.16
2002-2003	115254	50043	66.3	68.5	0.16
2003-2004	124971	53242	65.9	68.2	0.16
2004-2005	122710	54715	64.2	67.5	0.16
2005-2006	123610	56489	64.1	67	0.15
2006-2007	124106	58550	64.5	67.5	0.15
2007-2008	125859	59512	64.5	67.6	0.15
2008-2009	124635	60415	63.8	68	0.15
2009-2010	121467	58107	64.2	68.3	0.15
2010-2011	127479	61385	64.3	68.7	0.14
2011-2012	123485	61651	63.1	67.1	0.14
2012-2013	120487	61968	62	66.8	0.14
2013-2014	125272	65159	62.2	67.7	0.14
2014-2015	122977	65802	62	67.3	0.14
2015-2016	121567	64449	61.4	65.9	0.13
2016-2017	127973	67114	63.6	67.4	0.13
2017-2018	128154	68426	63.8	67.4	0.13
2018-2019	127053	69512	63.2	66.4	0.13
2019-2020	134390	76545	63.6	68.1	0.12
2020-2021	136289	80402	63.1	67.6	0.12

2021-2022	138629	79397	63.3	66.0	0.12
2022-2023	136309	79575	62.1	65.1	0.12

Note: Land Man Ratio = Land under Permanent Crops /Population

Source: Ministry of Agriculture & Farmers' Welfare, Govt. of India (ON3802) & Past Issues & The Fertilizer Association of India (ON4202) & Past Issues

The provided data on the area under foodgrains cultivated and irrigated along with the lan man ratio in Inda from 2000-01 to 2022-23 reveals several significant trends in Indian agriculture. The gross cultivated area under foodgrains has seen an overall increase from 122,680 thousand hectares in 2000-01 to 136,309 thousand hectares in 2022-23. There were notable peaks in 2021-22 (138,629 thousand hectares). There has been a steady and substantial rise in the irrigated area under foodgrains growing from 53,609 thousand hectares in 2000-01 to 79,575 thousand hectares in 2022-23. This indicates a significant expansion of irrigation infrastructure over the two decades.

The share of foodgrains to gross sown area reveals that the percentage has gradually declined from 66.2 per cent in 2000-01 in 2022-23. This suggests a diversification of Indian agriculture towards non foodgrain crops like oilseeds, pulses or commercial crops. The share of irrigated foodgrains to the total irrigated area has also decreased slightly from 70.4 per cent to 65.1 per cent, further confirming that more irrigation is being diverted to other crop categories. The Land Man Ratio (LMR) has consistently declined from 0.17 in 2000-01 and 0.12 in 2022-23. This downward trend highlights the increasing pressure of population on available agricultural land suggesting that less land is available per person over time.

India's Agricultural Production Performance

In the year 2024-25, India recorded an unprecedented foodgrain output of 357.73 million metric tonnes, marking an increase of 25.43 million metric tonnes over the preceding year, reflecting sustained gains in productivity, improved input management and strengthened institutional support to farmers. The increase was primarily driven by higher production of rice, wheat, maize and coarse cereals.

Season-wise Area, Production and Yield of Foodgrains

Year	Kharif			Rabi			Total		
	A	**P**	**Y**	A	P	Y	A	P	Y
2000-01	75.22	102.09	1357	45.83	94.73	2067	121.05	196.81	1626
2001-02	74.23	112.07	1510	48.55	100.78	2076	122.78	212.85	1734
2002-03	68.56	87.22	1272	45.30	87.55	1933	113.86	174.77	1535
2003-04	75.44	117.00	1551	48.01	96.19	2004	123.45	213.19	1727
2004-05	72.26	103.31	1430	47.82	95.05	2004	120.08	198.36	1652
2005-06	72.72	109.87	1511	48.88	98.73	2020	121.60	208.60	1715
2006-07	72.67	110.58	1522	51.04	106.71	2091	123.71	217.28	1756
2007-08	73.58	121.00	1644	50.49	109.77	2174	124.07	230.78	1860
2008-09	71.45	118.18	1654	51.39	116.28	2263	122.85	234.47	1909
2009-10	69.51	104.00	1496	51.83	114.11	2202	121.34	218.11	1798
2010-11	72.42	120.90	1669	54.25	123.60	2278	126.67	244.50	1930
2011-12	72.08	131.27	1821	52.67	128.01	2430	124.75	259.29	2078
2012-13	67.69	128.07	1892	53.09	129.06	2431	120.78	257.13	2129
2013-14	69.05	128.69	1864	55.99	136.35	2435	125.04	265.04	2120

2014-15	68.77	128.06	1862	55.53	123.96	2232	124.30	252.02	2028
2015-16	69.20	125.09	1808	54.01	126.45	2341	123.22	251.54	2041
2016-17	73.20	138.33	1890	56.03	136.78	2441	129.23	275.11	2129
2017-18	72.00	140.47	1951	55.53	144.55	2603	127.52	285.01	2235
2018-19	72.33	141.52	1957	52.45	143.69	2740	124.78	285.21	2286
2019-20	70.86	143.81	2029	56.13	153.69	2738	126.99	297.50	2343
2020-21	72.44	150.58	2079	57.35	160.17	3793	129.80	310.74	2394
2021-22	72.90	155.36	2131	57.27	160.25	2798	130.17	315.62	2425
2022-23	70.70	155.71	2203	55.31	157.84	2854	132.20	329.69	2494
2023-24	70.63	155.80	2205	55.11	160.00	2903	132.10	332.30	2515

Note: A - Area in Million Hectares, P - Production in Million Tonnes, Y - Yield in Kg. /Hectare
Source: Ministry of Agriculture & Farmers' Welfare

The data given in the table reveals that there is a significant transformation in Indian agriculture, characterized by increasing efficiency and a shift in seasonal dominance. The total area under foodgrains has remained relatively stable (fluctuating between 121 and 132 million hectares), the production has risen from196.81 MT in 2000-2001 to an estimated 332.30 MT in 2023-24 representing 68,8 per cent increase. Historically (Kharif i.e monsoon time) production was significantly higher than Rabi (winter). However, the gap has closed. In the early 2000s, Kharif produced around 7 MT more than Rabi; by 2023-24, Rabi production (160 MT) has actually surpassed Kharif (155.8 MT) in certain estimates, showcasing the success of irrigation and winter crop management.

The most striking trend is the consistent rise in yield across both seasons which explains how production increased despite limited land expansion. Rabi crops consistently maintain a higher yield than Kharif crops, largely because winter crops like wheat are less susceptible to the volatility of monsoon rains and benefit from more controlled irrigation. A significant dip is visible across all metrics (Area: 113.86, Production: 174.77). This was one of India's severest drought years impacting the Kharif season most heavily (yield dropped to 1272 kg/ha). Production took a massive leap after 2016-17 crossing 275 MT mark and never looking back. This correlates with improved seed varieties and expanded micro-irrigation schemes. The general observation is that India has moved from a position of "Area Led Growth" to Yield-led growth", meaning we are producing much more food on roughly the same amount of land.

India's Food Grain Production and its determinants

Model Specification

The linear multiple regression model can be expressed as:

$Y_{FGP} = \beta_0 + \beta_1 (IAR) + \beta_2 (ITIA) + \beta_3 (FU) + \beta_4 (TAC) + u$

Y_{FGP} = India's Food Grain Production
β_1 = India's Average Rainfall
β_2 = India's total irrigated area
β_3 = Fertilizers use
β_4 = Total Area Cultivated
u = Error Term

Co-efficient of India's Food Grains and its determinants

Variables	β = Value	Std Error	t – value	Sig.
β_1	0.072	0.026	2.83	0.03
β_2	-1.27	6.92	-0.18	0.86
β_3	0.162	0.12	1.31	0.23
β_4	0.015	0.04	0.29	0.77

The multiple regression analysis results reveal that among the variables assessed, only average rainfall exerts a statistically significant influence on India's food grain production. The coefficient for rainfall ((β_1 = 0.072) is positive and significant at 5% level (p = 0.03), indicating that a rise in rainfall results in a proportional increase in food grain output, assuming other parameters remain constant. Conversely, the total irrigated area (β_2 = -1.27) exhibits a negative coefficient, which contradicts theoretical expectations. It is statistically insignificant (p = 0.86), signifying no substantial influence. Likewise, fertilizer applications (β_3 = 0.162) and total cultivated area (β_4 = 0.015) both display positive coefficients, however, their elevated p-values (0.23 and 0.77, respectively) indicate that these variables are not statistically significant predictors of food grain output in this model. The findings indicate that food grain production in India is predominantly reliant on rainfall, whereas factors such as irrigation, fertilizer application and cultivated area exhibit minimal impact on food grain production.

ANOVA

Description	Sum of Squares	Df	Mean Squares	F- test
Regression	750472.997	5	150094.599	26.835
Residual	33559.140	6	5593.190	
Total	784032.136	11		

The ANOVA results demonstrate that the overall regression model elucidating India's food grain production is statistically significant. The regression sum of squares (750472.997) significantly exceeds the residual sum of squares (33559.140), indicating that a considerable percentage of the variation in food grain output is elucidated by the independent variables incorporated in the model. The computed F – statistics is 26.835, indicates a strong overall fir of the model to the data. The collective influence of the explanatory variables – rainfall, irrigated area, fertilizer application and total cultivated area substantially affect food grain output, despite the individual coefficients except rainfall potentially lacking statistical significance. In summary, although the variables may not individually have significance, they are collectively crucial in elucidating variance in food grain production.

Regression Model Summary

Model	R	R^2	Adjusted R Square	Std. Error of the Estimate
1	0.97	0.95	0.92	74.78

The regression model summary demonstrates an exceptionally robust match in educating India's food grain production. The correlation coefficient (r = 0.97) indicates a substantial positive relationship between the dependant variable and the independent variables in the model. The coefficient of determination (R^2 = 0.95) indicates that almost 95 per cent of the variability in food grain

output is accounted for by the explanatory variables namely rainfall, irrigated area, fertilizer application and total cultivated area. This demonstrates the model's exceptional explanatory capability.

The adjusted R^2 value of 0.92, which considers the number of predictors and sample size is notably high, signifying that the model is not overfitted and has robust explanatory power post adjustment. The standard error of the estimate R^2 value of 0.92 quantifies the average divergence of observed values from anticipated values and its moderately sized value indicates that the model's predictions are reasonably elucidates change in India's foodgrain production.

Policy Suggestions

The regression results indicate a significant and rather unsettling policy reality. India's food grain output remains mostly reliant on rainfall rather than manageable agricultural inputs. This has explicit ramifications for policy. Initially, given the rainfall is the sole statistically significant determinant, policy makers ought to prioritize diminishing reliance on monsoon variability. This entails the expansion of climate resilient agriculture encompassing investments in drought resistant crop varieties enhanced weather forecasting systems and crop insurance programs. Enhancing water conservation methods, including rainwater harvesting and watershed management would contribute to stabilizing production during years of inadequate rainfall.

Secondly, while the irrigated area, fertilizer application and cultivated land are statistically negligible, it would be erroneous to assert that they lack importance. The results indicate inefficiencies in the utilisation of these resources. Irrigation may be ineffectively distributed or infrastructure may be underutilised. These necessities enhanced irrigation management practices including the optimisation of canal systems, the promotion of micro-irrigation (drip and sprinkler systems), and the assurance of equal water access across area.

Third, the triviality of fertilizer application signifies a necessity to transition from quantity-oriented subsidies to efficiency focussed utilisation. Policies ought to promote equitable and scientific fertilizer application, soil health assessment and organic alternatives to enhance productivity rather than merely augmenting input usage.

Fourth, given the limited total cultivated area, developing arable land may not constitute the most effective method. Policy should prioritize enhancing productivity per hectare via technological adoption, mechanization and improved agricultural practices. The robust overall model fit (high R^2 and substantial F-test) indicates that although individual factors may seem minor, they jointly impact production. Consequently, policy must adopt a comprehensive strategy, incorporating rainfall management, irrigation efficiency, input optimisation and technology innovation instead of depending on a singular element. Transition from rain-dependent agriculture to resilient, efficiency oriented and technology enhanced farming methods to guarantee steady and sustainable food grain production in India.

India's Food Grain Export and its determinants

Exports of Agriculture commodities vis-à-vis Total National Exports From 2000-2001 to 2024-2025 (Values are Rs. In Crores)

Year	Agriculture Exports	Total Country's Exports	% of agri. Exports to tot. Country's Exports
2000-2001	28657.37	201356.45	14.23
2001-2002	29728.61	209017.97	14.22
2002-2003	34653.94	255137.28	13.58
2003-2004	37266.52	293366.75	12.70
2004-2005	41602.65	375339.53	11.08
2005-2006	49216.96	456417.86	10.78
2006-2007	62411.42	571779.28	10.92
2007-2008	79039.72	655863.52	12.05
2008-2009	85551.67	840755.06	10.18
2009-2010	89341.50	845533.64	10.57
2010-2011	111018.99	1142921.92	9.71
2011-2012	180528.60	1465959.39	12.31
2012-2013	223618.24	1634318.84	13.68
2013-2014	262778.96	1905011.09	13.79
2014-2015	239681.04	1896445.47	12.64
2015-2016	215396.55	1716378.05	12.55
2016-2017	226651.91	1849433.55	12.26
2017-2018	251563.94	1956514.53	12.86
2018-2019	274571.28	2307726.19	11.90
2019-2020	252976.05	2219854.17	11.40
2020-2021	310811.42	2159043.21	14.40
2021-2022	375662.47	3147021.48	11.94
2022-2023	427767.45	3621549.87	11.81
2023-2024	404900.38	3618952.27	11.19
2024-2025 (Provisional)	440577.33	3701070.09	11.90

Source: Ministry of Agriculture & Farmers Welfare, Govt. of India (ON2729) & Past Issues, Ministry of Commerce and Industry, Govt. of India.

The data for India's agriculture exports (2000-01 to 2024-25 showcases a massive expansion in absolute value, alongside a fluctuating yet critical role in the country's overall trade balance. While total national exports have grown exponentially the agricultural sector has managed to maintain a double-digit share in most years driven by specific domestic and global determinants.

The trajectory of agricultural exports can be divided into three distinct phases. The steady phase was noticed from 2000–2010. During this period, agricultural exports grew from ₹28,657 Cr to ₹89,341 Cr. During this decade, the share of agriculture in total exports began a slow decline (from 14.2% to 10.5%) as India's services and manufacturing sectors started to dominate. The Boom Phase was from 2011–2014. During this period, a dramatic surge occurred here, with exports leaping from ₹111,018 Cr to ₹262,778 Cr in just three years. This was largely due to high global commodity prices and a policy shift allowing significant non-basmati rice exports. The Modern Expansion Path was seen from 2020–2025. Here we can observe that after a stagnant period (2015–2019), exports surged again during and after the pandemic. The provisional figure for 2024-25 stands at an all-time high of ₹440,577 Cr. Despite a massive 1,437% increase in the value of agricultural exports since 2000, its percentage share of total national exports has slightly decreased (from 14.23% in 2000-01 to 11.90% in 2024-25). This is not a sign of agricultural weakness, but rather an indicator of a maturing economy where other sectors (like Engineering goods, Pharmaceuticals, and Electronics) are growing even faster. However, the 14.40% spike in 2020-21 is a notable anomaly, where agriculture acted as a "resilience engine" for the economy while other sectors were halted by COVID-19 lockdowns.

Determinants of India's Foodgrains' Export

Year	Y Export	X1- International Price Index (Annual Avg.)	X2- Domestic Whole Sale Price	X3-Total Domestic production *Units: Million Tonnes*	X4 Exchange Rate	X-5 Income of Major importing Country
2001-02	28657.37	52.5	40.8	212.85	47.69	10,581
2002-03	29728.61	53.1	42.2	174.77	48.40	10,936
2003-04	34653.94	58.0	43.8	213.19	45.95	11,471
2004-05	37266.52	66.1	45.4	198.36	44.93	12,213
2005-06	41602.65	67.4	48.2	208.60	44.27	13,036
2006-07	49216.96	72.6	53.0	217.28	45.25	13,814
2007-08	62411.42	94.2	57.8	230.78	40.26	14,451
2008-09	79039.72	117.5	64.4	234.47	45.99	14,712
2009-10	85551.67	91.7	74.2	218.11	47.44	14,448
2010-11	89341.50	106.7	86.5	244.49	45.56	14,99
2011-12	111018.99	131.9	100.0	259.29	47.92	15,542
2012-13	180528.60	122.8	109.2	257.13	54.41	16,197
2013-14	223618.24	120.1	123.1	265.04	60.50	16,784
2014-15	262778.96	115.0	129.4	252.02	61.14	17,521
2015-16	239681.04	93.0	134.1	251.54	65.44	18,219
2016-17	215396.55	91.9	140.3	275.11	67.07	18,707
2017-18	226651.91	98.0	143.2	285.01	64.45	19,542
2018-19	251563.94	95.9	144.1	285.21	69.92	20,611

2019-20	274571.28	95.1	155.2	297.50	70.88	21,433
2020-21	252976.05	98.1	159.9	310.74	74.20	21,060
2021-22	310811.42	125.7	174.4	315.61	74.51	23,315
2022-23	375662.47	143.7	185.7	329.69	78.60	25,462
2023-24	427767.45	124.0	191.1	332.30	82.80	27,360
2024-25	404900.38	121.2	202.8	357.73	84.10	29,825
2025-26 (E)	440577.33	123.5	208.5	348.65	90.50	31820

X1 - International Food Price Index (2001–2026), Base Period: 2014–2016 = 100
X2 - India's Domestic Wholesale Price Index (WPI): 2001–2026, *Base Year: 2011-12 = 100*
X3 -Total Domestic Production, *Units: Million Tonnes*
X4 - Exchange Rate
X5 - Income of Major importing Country

Model Specification

The linear multiple regression model can be expressed as:

$Y_{FGE} = \beta_0 + \beta_1(Ipi) + \beta_2(Dwsp) + \beta_3(Tdp) + \beta_4(Er) + \beta_5(IMic) + u$

Y = India's Food Grain Export
β1= International Price Index
β_2 = Domestic Whole Sale Price
β3 = Total Domestic Production
β4 = Exchange Rate
β5 = Income of Major Importing Countries
u = Error Term

Co-efficient of India's Food Grains and its Export determinants

Variables	β = Value	Std Error	t – value	Sig.
β_1	856.543	350.221	2.446	0.024
β_2	970.698	528.063	1.838	0.082
β_3	-791.949	381.959	-2.073	0.052
β_4	4465.509	1708.073	2.614	0.017
β_5	6.426	3.105	2.070	0.052

The multiple regression analysis results demonstrate that many economic factors significantly influence India's food grain exports, albeit to differing extents. The International Price Index (β_1 = 856.543, p = 0.024) exerts a positive and statistically significant influence, indicating that elevated global prices promote increased exports from India. Likewise, the Exchange Rate (β_4 = 4465.509, p = 0.017) demonstrates a robust and significant positive effect, indicating that currency depreciation improves export competitiveness. The Domestic Wholesale Price (β_2 = 970.698, p = 0.082) demonstrates a positive albeit weakly significant correlation, suggesting a substantial impact at the 10% significance level. Total Domestic output (β_3 = –791.949, p = 0.052) exhibits a negative and marginally significant effect, indicating that heightened output may not directly result in increased exports, potentially owing to domestic consumption requirements or legislative limitations. Finally, the income of major importing countries (β_5 = 6.426, p = 0.052) exhibits a positive albeit marginally significant influence, suggesting that elevated foreign income levels may modestly enhance demand for Indian food grains. The data indicate that external factors, especially international prices and exchange rates, are more influential in determining India's food grain exports than internal considerations.

ANOVA

Description	Sum of Squares	Df	Mean Squares	F- test
Regression	430453053929.143	5	86090610785.829	237.691
Residual	6881719872.527	19	362195782.765	
Total	437334773801.670	24		

The ANOVA results demonstrate that the regression model is highly significant, evidenced by an F-statistic of 237.691, indicating that the independent factors jointly exert a substantial influence on the dependent variable. The model accounts for a significant amount of the total variation, indicated by a R^2 value of around 0.984, signifying that roughly 98.4% of the variability in the dependent variable is explained by the predictors. The regression sum of squares significantly exceeds the residual sum of squares, suggesting that the model possesses substantial explanatory power and minimal error. These results indicate that the model exhibits a superior fit to the data; however, the elevated R^2 may necessitate additional scrutiny for potential concerns such overfitting or multicollinearity among the predictors.

Regression Model Summary

Model	R	R^2	Adjusted R Square	Std. Error of the Estimate
1	.992	.984	.980	19031.44195

The regression model summary indicates a superior match to the data. The correlation coefficient (R = 0.992) signifies a robust positive association between the predicted and actual values of the dependent variable. The coefficient of determination (R^2 = 0.984) indicates that around 98.4% of the variance in the dependent variable is accounted for by the independent variables in the model. The adjusted R^2 score (0.980), which considers the number of predictors, is nearly identical to R^2, indicating that the model is not overfitted and that the included variables are pertinent. The standard error of the estimate (19031.44) signifies the average divergence of observed values from projected values, and its very low magnitude further substantiates the model's high accuracy. The model exhibits significant explanatory power and dependability.

Policy Decision

The results of the regression analysis indicate that India's food grain export policy should largely concentrate on harmonizing with global market dynamics while ensuring local stability. Given the substantial and significant positive impact of the exchange rate and international price index on exports, authorities ought to strive for a competitive and stable exchange rate while diligently observing global price trends to leverage advantageous export prospects. The inverse correlation between domestic production and exports underscores the necessity for a balanced strategy that guarantees domestic food security while generating a surplus for export through effective stock management and enhanced supply chains. Moreover, stabilizing domestic wholesale pricing and mitigating market distortions can further enhance export development. Considering the beneficial impact of importing nations' income levels, India ought to enhance trade relations and focus on high-income markets to broaden its export base. The policy approach should prioritize export competitiveness, global integration, and effective domestic market management to maintain growth in food grain exports.

Major Findings

In the production model, only average rainfall was statistically significant at 5% level.

Total irrigated area, fertilizer use, and cultivated area showed positive coefficients but failed to reach statistical significance, suggesting diminishing marginal returns or resource misallocation.

India's food grain exports are primarily "Price and Exchange Rate Sensitive." The Exchange Rate and International Price Index are the strongest predictors of export value.

Total Domestic Production showed a marginally significant negative correlation with exports, likely due to prioritized domestic food security and stock-retention policies.

The year 2024-25 marked a historic peak with 357.73 MMT in production and approximately ₹4,40,577 Crores in agricultural exports.

Suggestions

Shift in policy focus from expanding "Gross Area" to enhancing "Weather-Proofing" through drought-resistant seeds and advanced watershed management.

Transition in fertilizer subsidies from bulk-buying to "Soil Health Card" based precision application to improve the statistical significance of inputs on yield.

Since exports are tied to exchange rates, India should hedge against currency volatility by focusing on "High-Income Major Importing Countries" through bilateral trade agreements.

Move beyond canal-based flooding to micro-irrigation (Drip/Sprinkler) to ensure that the "Irrigated Area" variable translates into actual productivity gains.

Conclusion

The study confirms that India's agricultural sector has achieved remarkable scale but remains structurally tethered to natural cycles and global market whims. The high values (for production and for exports) indicate that we have a clear understanding of the variables at play, yet the lack of significance in controllable inputs (fertilizers/land) is a call for reform. To transform India into a "Viksit" (Developed) agricultural economy by 2047, the policy roadmap must prioritize Input Efficiency over Input Quantity and Global Integration over Market Isolation.

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