

RESEARCH PAPER

Temporal Analysis of Nutrient-wise Fertilizer Production, Consumption and Import in India

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ABSTARCT

The study analyzed time series secondary data of nutrient-wise production, consumption and import of fertilizers in India. The overall period taken for the study was from 1961-62 to 2021-22 which was further divided into six sub-periods: sub-period-I (1961-70), sub-period-II (1971-80), sub-period-III (1981-90), sub-period-IV (1991-2000), sub-period-V (2001-10) and sub-period-VI (2011-21). The compound growth rates (CGRs) of production, consumption and imports were estimated for all the sub-periods and for the overall period. The overall production trend was found significantly positive for nitrogen and phosphorus (~7%), despite a continuous decline in the consecutive decades which signifies a plant-level production saturation. The overall consumption trend exhibited a positive picture for nitrogen, phosphorus and potassium (6-7%) but consumption instability is reported highest in the potassium fertilizers. The overall import was found significant for nitrogen, phosphorus and potassium but the decadal trends have been quite erratic with the highest overall growth reported in phosphorus (11.11%).

HIGHLIGHTS

- ❶ The overall production trend is significantly positive and stable although increasing in absolute terms, the relative growth is declining.
- ❷ There has been significantly continuous growth in consumption till 2010 accompanied by a fall during 2011-21, certainly due to the NBS scheme and international price volatility.
- ❸ There is an increasing trend in imports of all fertilizers with potassium import although volatile (~40%), exhibiting the most stable trend relatively.

Keywords: Fertilizer, Instability, Production, Consumption, Import, CGR

Fertilizer is an important input for crop production. With India being the most populous country, considering its growing food requirements and limited land availability, the focus should be on increasing crop productivity. Optimal fertilizer application is one of the solutions to enhance agricultural production. The government has been consistently making efforts to promote the use of fertilizers among farmers since independence. However, the efforts did not lead to an appreciable growth in fertilizer production and consumption till the early 1960s (Tewatia and Chanda, 2017). The advent of the green revolution in 1967-68 led to an increase in the use of chemical fertilizers which

supplemented the high-yielding crop varieties (Mala, 2013, McArthur and McCord, 2017). This fertilizer consumption trend was further supported by the favorable fertilizer-subsidy policies of India. The contribution of fertilizer in increasing crop productivity and ensuring food security is well well-established since the green revolution (Mala, 2013; McArthur and McCord, 2017; Bora 2022; Majumder, 2024).

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On the domestic front, India is the world's second-largest producer of fertilizers with its production continuously increasing over the years. Yet the total production is insufficient to meet the total fertilizer demand in the country. Nearly 30 per cent of the total requirement of fertilizers is met through imports (Anonymous, 2022a). The imports are not a major issue unless the cost of imports is more than the supply price of production at domestic front. In case of imports become expensive than domestic levels, it would create the need to increase domestic production to reduce import dependence. This could be achieved by expanding production in the already existing plants and investments in new fertilizer plants and for this to happen the pricing system for fertilizers need to be improved. India is also the second largest consumer of global chemical fertilizers after China. However, the average intensity of fertilizer application in India is much lower than many countries in the world but it is quite distorted, with large inter-regional, inter-state and inter-district disparities. Consumption of total nutrients per ha of arable land and land under permanent crops in the world was 129.2 kg in 2020 and in India 192.9 kg. The Indian fertilizer market was at 28.56 billion USD in 2022 and is predicted to grow with a CAGR of 6.25 per cent to reach 41.08 billion USD in 2028 (Anonymous, 2022b).

To develop effective policies to enhance the growth of the fertilizer sector, it is crucial to thoroughly understand the dynamics of demand and supply within the sector. This creates the need to study the production, consumption and import growth pattern of NPK in India. The objective of the paper is to study the growth and instability in the production, consumption and import of fertilizers nutrient-wise in the country.

Methodology and Data Analysis

The study analyzed time series data of nutrient-wise production, consumption and imports of fertilizer in India, compiled from various volumes of fertilizer statistics of India from FAI (Fertilizer Association of India). The period taken for the study is from 1961-62 to 2021-22, divided into six sub-periods: sub-period-I (1961-70), sub-period-II (1971-80), sub-period-III (1981-90), sub-period-IV (1991-2000), sub-period-V (2001-10) and sub-period-VI (2011-21).

Compound annual growth rate: It was analyzed using Compound growth rate (CGR) exponential function which was transformed into a linear form by taking the log function (Kalidas *et al.* 2020).

$$Y = A (1 + r)^t$$

Where:

Y = Time series data of fertilizer production, consumption and import for which growth rate is calculated.

A = Constant coefficient.

r = Rate of annual increment or annual growth rate.

t = Time element.

Using the compound formula, the log-linear or the exponential regression model was obtained by taking logarithms to base 'e'.

$$\ln Y = \ln A + t \ln (1 + r)$$

The final equation for estimating the growth rate was given by:

$$CGR (r) = [Antilog (\log b) - 1] * 100$$

Where,

r = Compound growth rate

b = Regression coefficient.

The values were also tested for significance using the student 't' test.

Instability analysis: The instability in the production, consumption and import of fertilizer was measured by the Cuddy Della Valle Index (%) (Cuddy and Della Valle, 1978) using the following formula:

$$Instability\ index = CV (1 - R^2)$$

Where,

CV = Co-efficient of variation [$CV = (\text{Standard Deviation (SD)} / \text{MEAN}) \times 100$]

R^2 = Adjusted coefficient of determination from a time-trend regression

RESULTS AND DISCUSSION

Production of fertilizers

The nutrient-wise production trend of fertilizers (Nitrogen and Phosphorus) shows an increasing trend since 1961 as shown in Fig. 1. Nitrogen occupies the major share in production which is nearly three times the phosphorus production. Due to lack of production facilities for potassium, its entire demand is fulfilled through imports.

Growth in production

Table 1 presents the compound annual growth rates of total production of Nitrogen (N) and Phosphorus (P_2O_5) over the past six decades in the country. Production-wise both Nitrogen and Phosphorus have exhibited a robust growth rate of about 7 per cent during this period, with the highest growth rate recorded between 1961 and 1970, approximately 21 and 15 percent, respectively. This impressive growth can be attributed to the Green Revolution that took place in the mid-1960s (Mala 2013; Tewatia and Chanda, 2017).

Table 1: Compound annual growth rate of production of N and P_2O_5

CAGR (%) Total Production		
Period	N (Nitrogen)	P_2O_5 (Phosphorus)
Sub-period-I (1961-70)	20.73**	14.58**
Sub-period-II (1971-80)	11.56**	14.49**
Sub-period-III (1981-90)	10.28**	10.01**
Sub-period-IV (1991-00)	5.51**	5.86**
Sub-period-V (2001-10)	1.30**	1.15
Sub-period-VI (2011-21)	1.38**	1.91**
Overall Period (1961-2021)	7.26**	7.04**

Note: * significant at 5% ** significant at 1%

Source: Fertilizer Association of India.

Government policies such as the liberalization of fertilizer marketing up to 50% of production in 1966, and the introduction of fixed subsidies per tonne on P_2O_5 in 1976 to counter the high international prices resulting from the oil crisis, contributed to this growth. The launch of retention price subsidy scheme in the late 70s also sharply enhanced the domestic production capacity and fertilizer

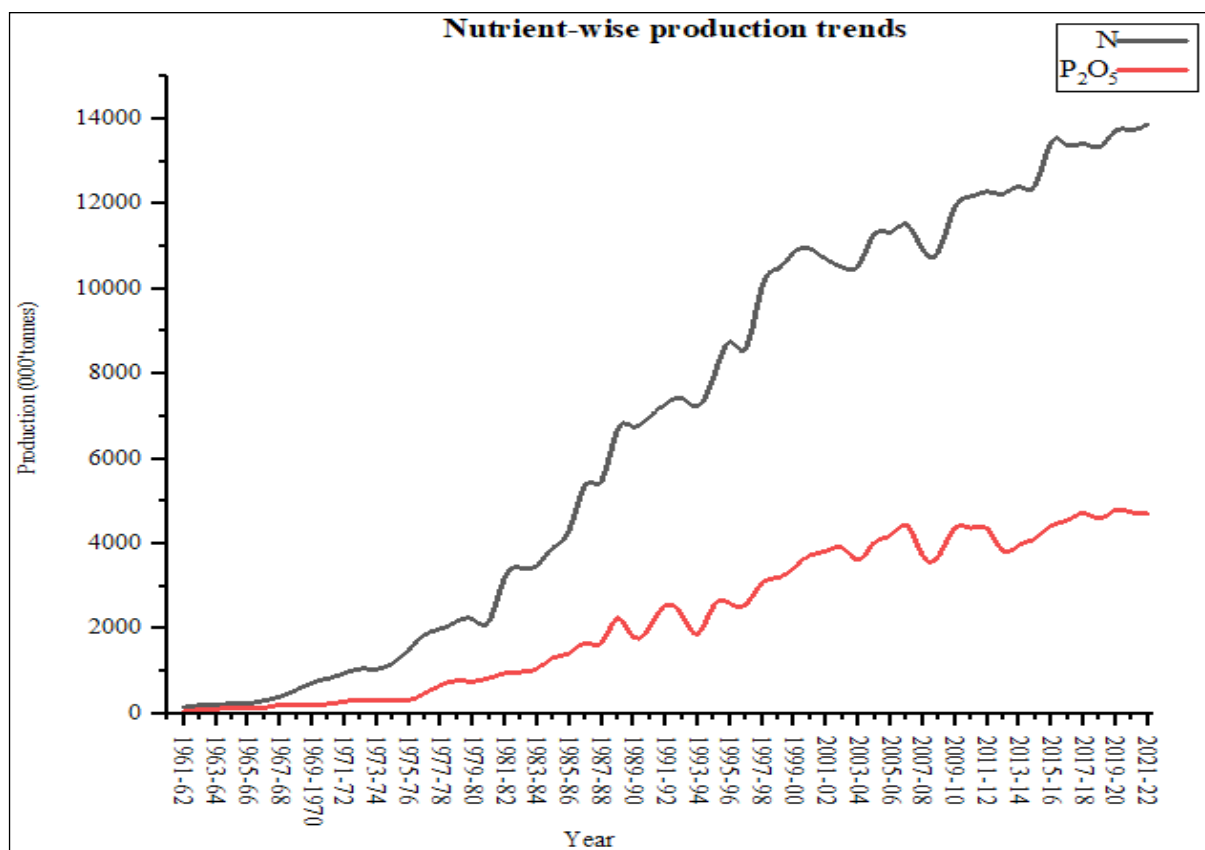


Fig. 1: Production trend of Nitrogen and Phosphorus in India

output between the mid-1970s and the early 1990s. However, the growth rate slowed after 1991 due to the absence of new production facilities and the reliance on imports to meet domestic demand following LPG reforms. This was followed by the decontrol of phosphatic and potassic fertilizers which further reduced the growth in demand and domestic production. The availability of raw materials has been a major constraint in increasing fertilizer production in India. However, there has been a slight increase in growth rate in the last decade, possibly due to policies such as Nutrient Based Subsidy (NBS) in 2010 and Neem-coated urea in 2015.

Instability in production

Table 2 represents the production instability of Nitrogen and Phosphorus from 1961-2021, measured using the Cuddy Della Valle Index (Fig. 4). The instability in production of N is consistently low (12.62%) for all the periods except 1961-70, signifying a stable overall production trend. Whereas overall instability is moderate for the phosphorus (15.50%) with most of the sub-periods exhibiting low instability, again a fairly stable trend in phosphorus production.

Table 2: Instability index for the production of N and P_2O_5

Instability Index (%) (Production)		
Period	N (Nitrogen)	P_2O_5 (Phosphorus)
Sub-period-I (1961-70)	22.96	9.84
Sub-period-II (1971-80)	8.45	15.84
Sub-period-III (1981-90)	6.61	10.50
Sub-period-IV (1991-00)	4.34	9.81
Sub-period-V (2001-10)	3.26	6.76
Sub-period-VI (2011-21)	1.85	4.25
Overall Period (1961-2021)	12.62	15.50

Consumption of fertilizers

The nutrient-wise consumption trend indicates that over the period there is a consistent increase in fertilizer consumption as shown in Fig. 2. Nitrogen occupies the major share in nutrient-wise fertilizer consumption, favored by various government policies.

Growth in consumption

Table 3 outlines the decade-wise per cent change in total consumption of Nitrogen, Phosphorus and Potassium in India since 1961. The overall

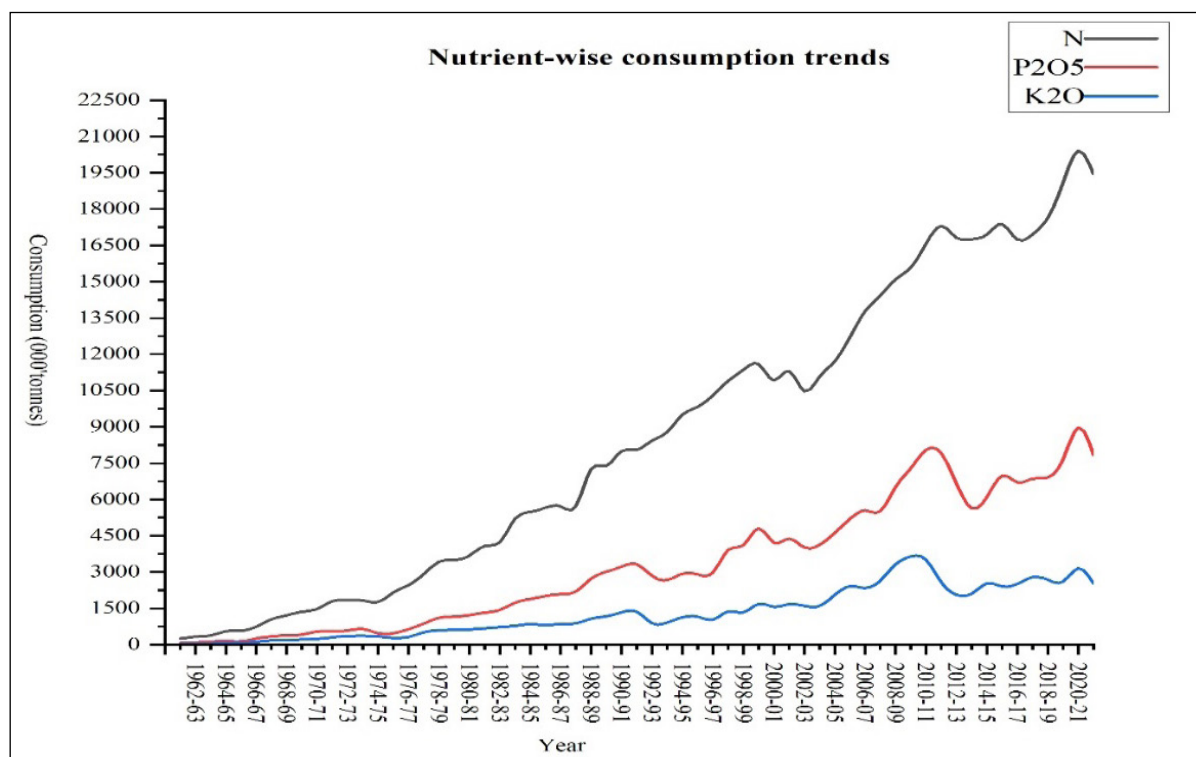


Fig. 2: Consumption trend of Nitrogen, Phosphorus and Potassium in India

consumption growth is significant with a rate of 6.14 per cent for Nitrogen, 7.18 per cent for Phosphorus and 6.49 per cent for Potassium.

Table 3: Compound annual growth rate of consumption of N, P₂O₅ and K₂O

Period	CAGR (%) Total Consumption		
	N (Nitrogen)	P ₂ O ₅ (Phosphorus)	K ₂ O (Potassium)
Sub-period-I (1961-70)	22.72**	27.45**	27.89**
Sub-period-II (1971-80)	9.99**	10.56**	9.06**
Sub-period-III (1981-90)	7.38**	10.16**	7.02**
Sub-period-IV (1991-00)	4.16**	5.52**	5.07*
Sub-period-V (2001-10)	5.26**	7.87**	10.71**
Sub-period-VI (2011-21)	1.65**	2.11	2.32*
Overall Period (1961-2021)	6.41**	7.18**	6.49**

Note: * significant at 5% ** significant at 1%

Source: Fertilizer Association of India.

The substantial increase in the consumption growth rate for these three nutrients was most pronounced during 1961-70. It coincided with the introduction of fertilizer-responsive high-yielding varieties (HYVs) as part of the green revolution. Fertilizers but it gained momentum for the next decade due to the introduction of concession scheme. The consumption growth has been significant for all the periods for all nutrients except Phosphorus in 2011-2021. There has been significant continuous growth in consumption till the 2010s except for Phosphorus (2011-21), but the increase in the consumption growth is less as compared to the previous decades. The fall in growth during the last sub-period (2011-21) is certainly due to the NBS scheme (2010), a sharp increase in the prices of fertilizers and abnormal weather conditions. Various studies have reported similar findings (Tewatia and Chanda, 2017; Shukla *et al.* 2022).

Instability in consumption

Table 4 illustrates the instability in the nutrient-wise consumption growth of fertilizers for a period of sixty years (Fig. 5). The findings indicate that N

consumption remained quite stable over the years whereas moderate instability was observed for both phosphorus (~21%) and potassium (~27%). This instability is particularly attributed to the decontrol of P and K fertilizers and international fertilizer price volatility.

Table 4: Instability index for the consumption of N, P₂O₅ and K₂O

Period	Instability Index (%) (Consumption)		
	N (Nitrogen)	P ₂ O ₅ (Phosphorus)	K ₂ O (Potassium)
Sub-period-I (1961-70)	10.55	16.73	12.99
Sub-period-II (1971-80)	9.54	19.57	17.06
Sub-period-III (1981-90)	6.09	6.37	8.41
Sub-period-IV (1991-00)	3.56	12.71	15.39
Sub-period-V (2001-10)	3.61	7.86	8.70
Sub-period-VI (2011-21)	4.47	11.07	9.14
Overall Period (1961-2021)	10.88	20.51	27.40

Import of fertilizers

Fertilizer production from domestic sources has been increasing over the years. Good progress has been recorded in the production of nitrogen and phosphorus-based fertilizer but it is insufficient to fulfill the whole demand for fertilizers in the country. About 30 per cent of the total requirement of fertilizer materials is met through imports. The whole potash requirement is met through imports due to the non-availability of raw materials. During 2022-23, a gap of nitrogen (N) was 4.47 million MT and phosphate (P₂O₅) 2.91 million MT and the entire requirement of potash (K₂O) was fulfilled through imports only (Anonymous, 2022a). The nutrient-wise fertilizer import has been represented in Fig. 3.

Growth in Imports

Table 5 depicts the decadal growth rate of imports of Nitrogen, Phosphorus and Potassium since 1961. Overall there has been significant growth in the imports of these nutrients for the entire period with Nitrogen, Phosphorus and Potassium

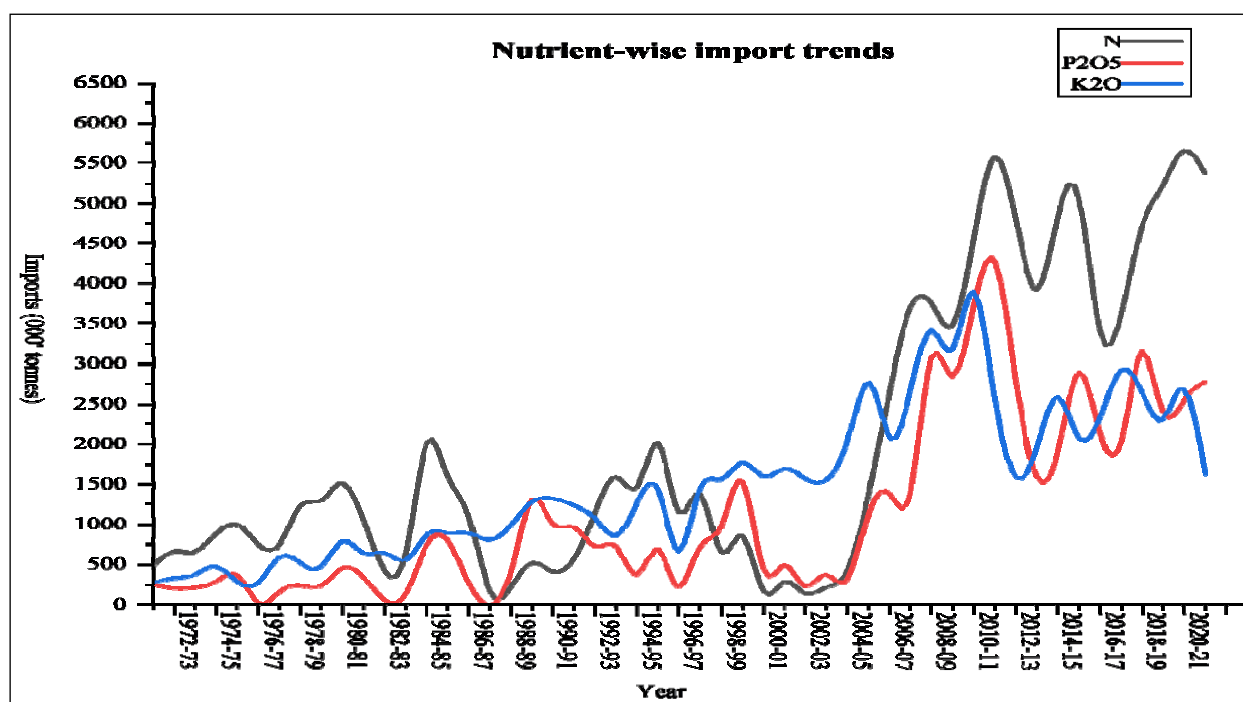


Fig. 3: Imports trend of Nitrogen, Phosphorus and Potassium in India

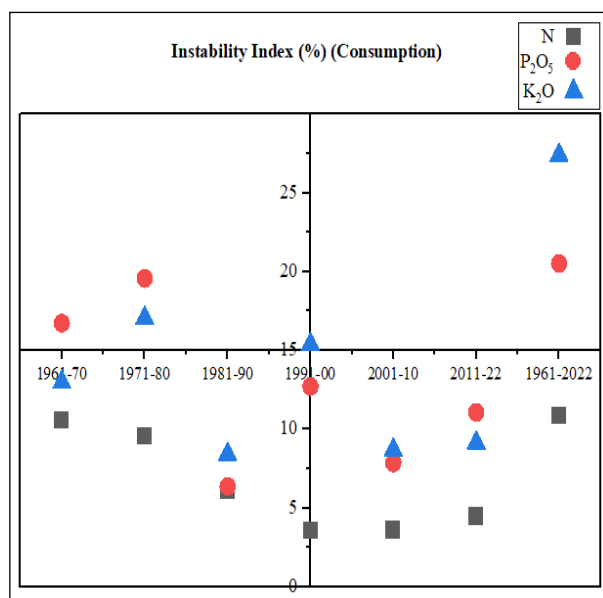


Fig. 4: Instability index for the production

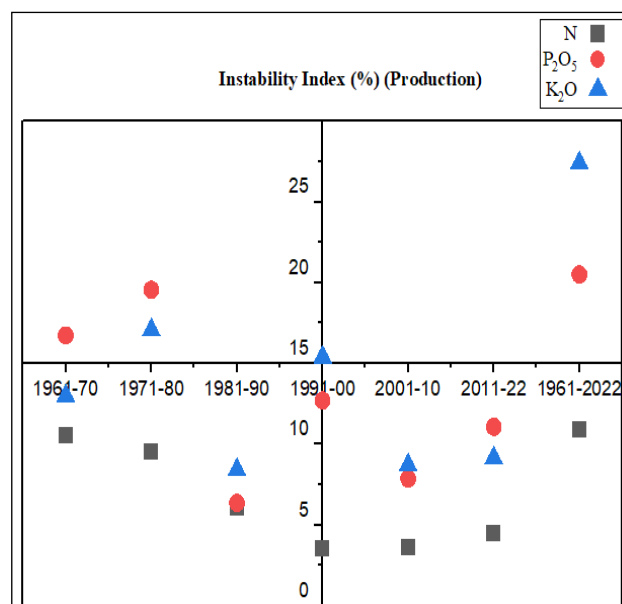


Fig. 5: Instability index for the consumption

exhibiting 6.21%, 11.11% and 7.73%, respectively. However, the trend of import growth has been quite erratic with some sub-periods exhibiting negative growth rates, although not significant. This can be attributed to international market import price rises and consequent domestic production-pricing policies for fertilizer during those sub-periods. The only sub-period where a significant import growth rate has been observed is the immediate post-

liberalization period (2001-10) with Nitrogen, Phosphorus and Potassium imports exhibiting growth rates of ~53%, ~36% and ~11%, respectively. For the period 1971-80, post-green revolution, the import growth was significant for nitrogen (11%) and potassium (~9%). Only Potassium import growth has been significant for 3 sub-periods as the total consumption requirement is met only by imports. For the period 2011-21, the import growth

has been insignificant which could be attributed to government policies like the NPS (new pricing scheme) policy for urea, New Urea Policy, neem coated urea, Potash Derived from Molasses (PDM) for maximizing indigenous production, promoting energy efficiency in production and reduction in import dependence.

Table 5: Compound annual growth rate of imports of N, P₂O₅ and K₂O

Period	CAGR (%) Total Imports		
	N (Nitrogen)	P ₂ O ₅ (Phosphorus)	K ₂ O (Potassium)
Sub-period-I (1961-70)	-17.89	48.59	-10.52
Sub-period-II (1971-80)	11.08**	1.64	9.37*
Sub-period-III (1981-90)	-11.51	9.75	8.82**
Sub-period-IV (1991-00)	-10.56	0.24	5.15
Sub-period-V (2001-10)	52.46**	36.34**	10.78**
Sub-period-VI (2011-21)	0.87	-0.54	0.69
Overall Period (1961-2021)	6.21**	11.11**	7.73**

Note: * significant at 5% ** significant at 1%

Source: Fertilizer Association of India.

Instability in Imports

Table 6 depicts the variability in the import growth of nitrogen, phosphorus and potassium for the period under study (Fig. 6).

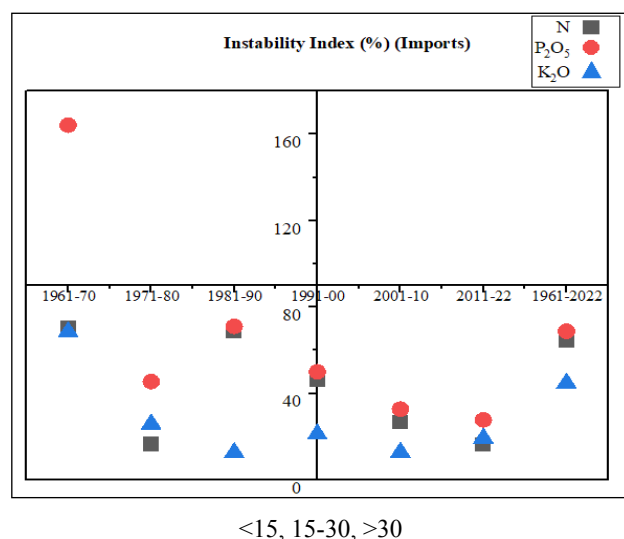


Fig. 6: Instability index for the imports

Across all nutrient categories, there was notable instability, ranging from 16% to 164% throughout the study duration. The instability across all three categories showed an uncertain trend with some periods with high volatility accompanied by periods of moderate volatility, especially post-liberalization. Examining specific nutrients, the highest instability was seen in phosphorus imports throughout the entire period, with highest during the 1961-70 (164%) which highlights its volatile nature. This volatility is attributed to an immediate increase in its demand following the green revolution. For potassium, the imports have been quite stable compared to nitrogen and phosphorus which could be attributed to the fact that all of its requirement is fulfilled by imports.

Table 6: Instability index for the imports of N, P₂O₅ and K₂O

Period	Instability Index (%) (Imports)		
	N (Nitrogen)	P ₂ O ₅ (Phosphorus)	K ₂ O (Potassium)
Sub-period-I (1961-70)	70.23	164.22	68.52
Sub-period-II (1971-80)	16.43	45.41	25.84
Sub-period-III (1981-90)	68.83	71.00	12.56
Sub-period-IV (1991-00)	45.99	49.96	21.16
Sub-period-V (2001-10)	26.58	32.72	12.73
Sub-period-VI (2011-21)	16.06	27.70	19.18
Overall Period (1961-2021)	64.32	68.75	44.71

CONCLUSION

Considering the growing requirements of the rising population, the increasing stable trend of fertilizer production is a positive sign for future needs. For the consumption, a growing trend for N, P and K is a good sign but the continuous skewness towards nitrogen over the years still requires major attention. Undoubtedly the overall growth rate of imports has been significant for the entire period but the declining growth rate of imports in the last decade is a testament to various favourable government policies, aimed at reducing dependence on imports. However, the instability in the imports is a matter

of concern as it is mainly contributed by the international price volatility. So, there are challenges but these are also the potential opportunities that can be pursued for better prospects.

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