

Agriculture Input Policies in India: Retrospect and Prospects

ABSTRACT

The overall objective of the study is to understand the awareness of mandatory production and distribution of Neem Coated Urea (NCU), trends in chemical fertilizer consumption (NKP) and their relation to food grain production across different periods of time and policies. An effort has also been made to understand the association between fertilizer consumption and productivity with respect to fertilizer-intensive crops. Finally, it was attempted to identify the important determinants of fertilizer consumption. The compound annual growth rate (CAGR) was calculated for analysing the trends in fertilizer consumption and food grain production in India. Further, the growth rates per hectare consumption of fertilizers vis-à-vis the growth rates of yield of fertilizer-intensive crops are calculated. Multiple regression model is applied to identify factor influencing fertilizer consumption. The study has uncovered that the general development pace of chemical fertilizer consumption in India for the period-I, was 5.58%, has diminished to 3.24% per annum for the period-II. By 2030, the fertilizer demand is projected to be around 57 million tons and is expected to grow at a faster rate, thereafter. Study focused on NCU policy of the government. The awareness level is 70 to 100% in Karnataka, Bihar, Assam, Punjab Maharashtra and Madhya Pradesh. At aggregate level, 85% of farmers noticed the difference between (NCU) and (NU) by reflecting the mandatory production and distribution of Neem Coated Urea (NCU) policy is in the right direction, considering the benefits realized by the Indian farming community.

Keywords: Agriculture Input Policy, Neem Coated Urea policy, National Agriculture Policy, multiple regression Model, demand forecasting.

1. INTRODUCTION

“During the mid-1960s, a consecutive two-year drought resulted in a large negative growth of agricultural sector, particularly in terms of food grain production and as a result, the country faced a serious shortage of food grains leading to starvation of underprivileged” [30].

“Considering the contribution of the agricultural sector to GDP (about 50%), its poor performance adversely affected the Indian economy as a whole, and even the political regime itself. As a result, the country was forced to import as many as 10 million tons of food grains (mainly wheat and rice), from abroad for two successive years. This serious economic crisis forced the Government of India to revisit its agricultural policy and accordingly, as a corrective measure, the government called for attention to technological innovations and even decided to import new agricultural technologies” [30]. “Moreover, it was an opportune twist of fate for India that the mid 1960s was a phase when new seed- fertilizer technology dissemination started in the tropical developing world. In particular, it was fortunately found that wheat High Yield Varieties (HYVs) developed by CIMMYT in Mexico were found to be suitable to Indian climatic conditions, particularly North Indian states such as Punjab, Haryana, Uttar Pradesh and Madhya Pradesh. As a result, the Government of India was able to achieve food self-sufficiency within a short span of time, and today India is the highest food grain producer (308.65 million tons during 2020-21) in the world though with a few ups and downs during drought years” [31,32]. “In this context, chemical fertilizer coped with irrigation has played a significant role in agricultural production, particularly NPK fertilizers. The application of chemical fertilizers has considerably improved the quantity and quality in terms of plant parameters such as, increasing grain yield, leaf area, plant growth, photosynthesis and ultimately, main product and by-product yields. Thereby, chemical fertilizers have increased food availability, income and food security of the growing population of the nation today, but the impact of their long run application is a much-debated issue among environmentalists” [31, 32].

Fertilizer consumption per hectare of arable land and land under perennial crops in India was 145 kg during 2017, which is equal to 126 kg per hectare of Gross Cropped Area (GCA), as compared to 434 kg in China, 162 kg in Brazil, and 360 kg in Egypt, a clear indication of scope for fertilizer application. There are about 159 fertilizer production plants operating in the country comprising 30 urea, 19 DAP/NP/NPK complex, 99 Single Super Phosphate (SSP), 10 Ammonium Sulphate, and one Ammonium Chloride plants.

The demand for agricultural commodities in India is perpetually expanding due to an ever-increasing population [31, 32]. Considering the numerous obstacles facing agricultural sector, the role of fertilizers in increasing foodgrain production assumes critical significance, especially from the viewpoint of ensuring the food security of the country’s population [1]. However, fertilizer consumption in terms of requirement shows a decrease during the Post-

National Agriculture Policy, with a growth rate of 3.24%. In any case, the consumption trend seems to be reacting to the policy interventions made by the government from time to time. Agriculture has consistently been the main player in the development process of the Indian economy. For instance, during 2017-18, the agricultural sector contributed 15.87% of the GDP, 12.07% of the exports, with more than half of the population is being dependent on agriculture [31, 2]. This role has seen a change from the conventional strategy followed for crop production to the modernization of agricultural production.

It is a fact that the expansion of area under cultivation is preposterous, but on the contrary, the arable land has been declining [3]. However, the demand for agricultural commodities is ever increasing due to increased population pressure. There are also several other impediments to increasing production viz., scarcity of water, declining soil productivity, non-availability of modern technology and fundamental characteristic of agriculture being exposed to the vagaries of nature [33]. Some authors argue that fertilizer was as important as speed in the Green Revolution [4], contributing as much as 50 per cent of the yield growth in Asia [5]. As indicated by [6] these situations, achieving the desired levels of agricultural production in the short to medium duration would require more concerted efforts towards bridging yield gaps with the existing available technologies.

Fertilizers help meet the requirements of food, fibre, fuel, and feed for our growing population and livestock as well. Considering that plant nutrients are becoming increasingly deficient in soil (7) due to intensive agricultural practices, the use of fertilizers is vital to restore nutrients in the soil systems (8). The foodgrain production in India during 2002-03 was 174.78 mt with a fertilizer consumption of 16.09 Mt, which increased to 283.37 Mt in 2017-18 (a record increase by 38% corresponding to the previous year) with a fertilizer consumption of 47.20 Mt (9). “While fertilizer consumption, both in absolute terms and per hectare basis has increased manifold over the years, its growth in the last few years has not been satisfactory” (10). It is also been established that increased fertilizer use efficiency leads to economy in the use of fertilizers, reduction in the cost of per unit production, increase in agricultural productivity, besides maintaining environmental quality and encouraging efficient use of other inputs such as irrigation and high yielding varieties (HYVs) in the context of developing countries.

The Government of India has taken steps from time to time as part of encouraging the application and production of fertilizers in the country. The policy initiatives of the

government aim at proper distribution of fertilizers, fertilizer subsidies, and promoting investment in fertilizer industry. These initiatives date back to the establishment of Central Fertilizer Pool in 1944 through to the present Nutrient Based Subsidy (NBS) policy for P and K Fertilizers for 2015-16, with a number of policies implemented as and when required. All such efforts of the government, the introduction of modern technology in the 60s and various other factors have contributed significantly to an increased consumption of fertilizers in India. Over time, a shift paradigm purchasing fertilizer inputs for crop production has been observed. Among these modern inputs, the current status of fertilizer use can be attributed to all categories of farmers. However, there exist huge crop-wise variations in the application of fertilizers too.

Many factors influence the demand for and consumption of fertilizers in crop production. The factors which contribute to the growth of fertilizer application include spread of intensive cultivation practices, increased use of HYVs, effect of fertilizer demonstration programs, improved profitability of growing crops due to better minimum support prices (MSP) by the government, and overall improvement in the infrastructural support, including the supply of fertilizers [11], [12]. However, most of these studies pertain to the pre-reforms period. Factors affecting fertilizer consumption in India also include institutional support. Which has implications for all the stakeholders- farmers, industries, distributors and the government.

With this background, this research study is an attempt to analyse the relationship between chemical fertilizer consumption and foodgrain production, growth determinants of fertilizer consumption and fertilizer demand forecast for 2030 in order to achieve sustainable foodgrain production and study the awareness of farmers on neem coated urea policy decisions taken by the Government of India for promoting agriculture. The specific objectives are as follows:

1. To analyse the long-run relationship between fertilizer consumption and foodgrain production in India.
2. To understand the trends in fertilizer consumption over time and policies.
3. To identify the relationship between fertilizer consumption and its determinants.
4. To study the awareness of farmers on neem coated urea
5. To forecast the chemical fertilizer demand by 2030.

2. MATERIAL AND METHODS

The study has absolutely depended upon primary data obtained from farm-households of selected states and secondary data from various sources. In order to explore the awareness of neem coated urea (NCU) adoption on crop production and productivity across selected states of India, the study adopted a very relevant and detailed primary survey-based approach on the adoption of NCU. The state and the crops selected for the study was based on the major crops (in terms of area) in each state. The study covered six very important cropping systems: Paddy, Tur, Sugarcane, Maize, Soybean and Jute. The states included are Assam, Bihar, Karnataka, Maharashtra, Madhya Pradesh and Punjab. To make the coverage exhaustive, roughly 1200 sample farmers were surveyed. The reference period of the study was Kharif season for the agriculture year 2015. Irrigated and rainfed crops which accounted for the highest urea consumption in each of the selected states were considered for the study. For each crop, two districts were selected based on the area under the selected crop and their urea usage within the state. From each district, two taluks/tehsils were selected based on the same criterion. Within the selected taluks, two clusters comprising three to four villages per cluster were selected for conducting the survey. Secondary information gathered for a period of 32 years (1986-87 to 2017-18). Further, the investigation timeframe has been separated into two periods viz., Period-I, Pre-NAP (1986-87 to 1999-2000) and Period-II, Post-NAP (2000-01 to 2017-18) for examining the urea fertilizer utilization. Additionally, study focused on consumption of neem coated urea after mandatory policy implementation in India.

Analytical Tools:

The compound annual growth rate (CAGR) was calculated for analysing the trends in fertilizer consumption and food grain production in India. Further, the study attempted to analyse the growth rates per hectare consumption of fertilizers vis-à-vis the growth rates of yield of fertilizer-intensive crops. An exponential growth model of following form was used for the analysis.

Compound annual Growth Rate (CAGR)

$$Y = ab^t + e \dots\dots\dots(1)$$

Where, Y= Dependent variable for which the growth rate is estimated (Fertilizer consumption and food grain production, production of fertilizer intensive crops).

a= Intercept

b= Regression coefficient

t= Time variable (1986-87 to 1999-2000 and 2000-01 to 2017-18)

e= Error term

The compound growth rate was obtained from the logarithmic form of equation (1) as below

$$\ln Y = \ln a + t \ln b \dots \dots \dots (2)$$

The per cent compound growth rate (g) was derived using the relationship

$$g = (\text{Antilnb}-1)*100 \dots \dots \dots (3)$$

2.2. Multiple Regression Models

It is used to analyse the factors affecting fertilizer consumption in the country in the specified period. The pragmatic models for fertilizer consumption are specified as follows:

$$Y_{it} = \beta_0 + \beta_1 \text{AHYV}_t + \beta_2 \text{GAI}_t + \beta_3 \text{CI}_t + \beta_4 \text{PCF}_t + \beta_5 \text{MSP}_t + \beta_6 \text{CA}_t + \beta_7 \text{ARF}_t + \beta_8 \text{DFP}_t + U_t \dots \dots \dots (4)$$

Where,

Y_{it} is fertilizer consumption; where 'i' denotes three nutrients N, P and K and total (N+P+K) fertilizer consumption in thousand tons'' denotes year. The following independent variables were hypothesized to influence the consumption positively (+), negatively (-), or either negatively or positively (+/-):

AHYV= Area under high yielding varieties

GAI = Gross area under irrigation

CI = Cropping intensity

PCF=Price of chemical fertilizers

MSP = Minimum support price

CA= Credit availability

ARF= Annual rainfall

DFP= Domestic fertiliser production

2.3. Fertilizer Demand Forecasting:

The distinctive useful models were utilized for determining the fertilizer demand, for example, simple linear regression, quadratic, logarithmic, exponential, Inverse, logistic, and so forth. Total consumption is regressed on time in various functional models and compared with other different models R^2 values and coefficients. Finally, the total consumption was regressed on time in a logarithmic model provided well-fitted for estimating the demand for fertilizer. Be that as it may, data fitted well with the logarithmic model and the forecast values appeared to follow the past fertilizer consumption trend. The GCA was additionally discovered, using a similar logic. With the assistance of total fertilizer demand forecast and the forecast of GCA, per hectare consumption in kg was determined for examining India's situation on the world fertilizer use intensity-wise.

The mathematical form of model is as follows:

Logarithmic Regression $Y_t = \beta_0 + X \beta_1 \ln(t) + \epsilon \dots \dots \dots (5)$

X: Independent variable, i.e., Time

Y_t = Dependent variable i.e., total Fertilizer consumption

β_0 = Intercept

β_1 = Coefficient

ϵ = Error

3. RESULTS AND DISCUSSION

Farming is the most important sector of the Indian economy with over 70 per cent of the rural families being dependent on farming as a source of income and livelihood. The Indian farming sector contributes about 18 per cent to the total GDP and provides employment opportunities to 60 per cent of the country's workforce. The food grain production has increased from 51 million tons (Mt) during 1950-51 to 283 million tons (Mt) during 2017-18, the highest ever since independence. This considerable increase in the foodgrain production could be attributed mainly to the preface of the green revolution, mechanization, irrigation and modernization of agriculture, encouragement to innovative agriculture research and market-led extension in the agriculture sector. However, this was accompanied by a substantial increase in the application of chemical fertilizers after the introduction of the green revolution in the 60s that subsequently lead to an unsustainable agriculture. The Green Revolution was a technology package continuing a technical

component of improved high yielding varieties of two staple portions of cereal (rice and wheat), irrigation and use of fertilizers, pesticides, and better management practices. The high yielding varieties demanding increased usage of fertilizers were supported by the subsidy policy on fertilizers. In the early 1990s, India introduced the New Economic Policy (NEP) which opened up the economy to privatization and globalization. In a globalized economy, the agricultural sector became more commercial with production being oriented to the export market. This also led to an increase in the consumption of fertilizers.

3.1. Trends in Fertilizer Consumption Vis-À-Vis Food Grain Production during Pre & Post-National Agricultural policy In India

The availability of quality seeds, access to irrigation facility, supply of micro and macronutrients through application fertilizer are some of the major factors that during influence the growth and yield levels of food crops. Chemical fertilizers supply the required nutrients to the soil systems that get affected adversely by the process of crop production and cultivation practices. Synthetic chemicals have several drawbacks including soil degradation, water pollution, and human safety. Currently, the urgent need to counterbalance negative environmental impact has opened the way for the use of natural and renewable products that may help to restore soil structure [13],[14] identified that an imbalanced usage of chemical fertilizer was one of the major reasons for stagnation in agricultural production, loss of soil health and environmental problems. The trends in fertilizer consumption vis-a-vis total foodgrain production in the country are presented in **Table 1**. It reveals the trends in chemical fertilizer consumption and foodgrain production in India during the Pre- & Post-National Agricultural Policy (NAP), 2000.

The findings of the study clearly reflect that the growth rate of chemical fertilizer consumption has decreased Post-NAP, while it has recorded a CAGR of 5.58 per cent per annum between 1986-87 and 1999-2000 and the results are significant at one per cent level. This increase in fertilizer consumption could be attributed to rapid expansion of irrigation, spread of HYV seeds, introduction of Retention Price Scheme, distribution of fertilizers to farmers at affordable prices, expansion of dealers' network, improvement in fertilizer availability and unchanged farm-gate fertilizer prices. These findings also conform to the study findings of [29] who found that agriculture remains a highly regulated sector in India, with various government agencies having supervisory powers. Regulatory controls are imposed by both central and state governments. Schemes for supporting agriculture are

provided at central and state levels through subsidies for fertilizer. For the period from 2000-01 to 2017-18, the growth rate of total fertilizer consumption shows fluctuations with an annual growth rate of 3.24 per cent, which is also statistically significant at five per cent level. It is interesting to note that the trends in fertilizer consumption in India over time reflect changes in policies implemented by the Government of India from time to time. On the other hand, foodgrain production also has registered a marginal decrease in the growth rate from 3.24 per cent to 2.22 per cent per annum during the same period and the growth rate is statistically significant at various levels. It is pertinent to note that the growth rate of foodgrain production has always been lower than the growth rate of fertilizer consumption, as reflected by the results [15] pointed out the importance of agriculture for food, feed, and fibre and thus holds a key position in the economy of developing countries.

The government has continuously taken up steps towards easing distribution and improving capacity utilization of fertilizer manufacturing units at affordable prices. One more reason behind the increase in fertilizer consumption is that virtually there was no change in farm-gate fertilizer prices over the period (1981-1991)[16]. Subsidies were provided as part of promoting fertilizer usage among small and marginal farmers with no access to fertilizers.

Table 1: Trends in Fertilizer Consumption Vis-À-Vis Foodgrain Production in India (19986-87 to 2017-18)

Fertilizer consumption	Food grain production	Fertilizer consumption	Food grain production
Period-I (1986-87 to 1999-00)		Period-II (2000-01 to 2017-18)	
Pre-NAP		Post-NAP	
5.85***	3.00***	3.24**	2.22***

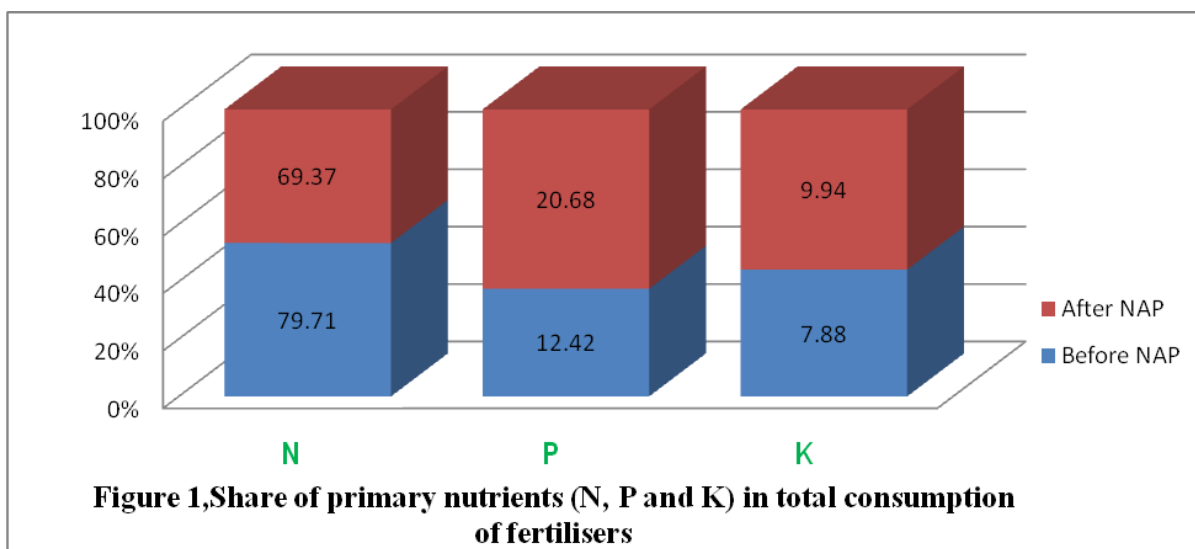
Note: ***, ** indicate 1 and 5 per cent levels of significance

3.2. Share of N, P and K in the Total Consumption of Fertilisers

Sixteen plant food nutrients are essential for proper crop growth. Each and every plant nutrient is equally important to the growth and development of plants, yet each element is required in different quantities. These differences have led to the grouping of these essential elements into three categories: primary (macro) nutrients, secondary nutrients and micronutrients. Primary (macro) nutrients are nitrogen (N), phosphorus (P) and potassium (K). They are the most frequently required nutrients for crop growth and are supplied in

larger quantities to plants as fertilizer. The secondary nutrients include calcium, magnesium, and sulphur. For most crops, these three are needed in lesser amounts than primary nutrients. The micronutrients such as boron, chlorine, copper, iron, manganese, molybdenum and zinc are used in small amounts, but they are as important to plant growth development and higher yield levels as major nutrients. However, the major focus of the Indian fertilizer sector policy has been on primary (macro) nutrients. The changing pattern of three primary nutrients is presented in **Figure 1**. Nitrogenous fertilizers account for nearly two-thirds of the total nutrient consumption in the country. The share of N which was 79.71 per cent during the Pre-NAP (1986-87 to 1999-2000) declined to 69.37 per cent in the Post-NAP (2000-01 to 2017-18). In the case of P fertilizers, the share has increased from 12.42 per cent in period-I to 20.68 per cent in period-II. Likewise, the share of K has increased from 7.88 per cent in period-I to 9.94 per cent in period-II. Nevertheless, urea has continued to be under price control. Following the policy of economic reforms, all types of fertilizers, excepting urea, were freed from all types of pricing mechanisms, movement, and distribution control in the early 1990s. This resulted in an increase in the price of P and K fertilizers with a resultant reduction in the consumption of P and K and an imbalance NPK ratio that leads to a large leaking of N fertilizer to the environment resulting in abysmally low nitrogen use efficiencies and environmental adversity [17].

An increase in the share of Nitrogen and a fall in the share of P and K fertilizer during the Pre-NAP were mainly due to a slow growth in the consumption of P and K chemical fertilizer as compared to N fertilizer through the imposition of decontrol of P and K fertilizer and a marginal increase in prices vis-a-vis N fertilizer, which remained almost stable during the period-I (Pre-NAP). Concerned with the problem of an increased imbalance in the use of primary nutrients, the government introduced a concession scheme for the sale of decontrolled P and K fertilizers to farmers, but still, the prices of these fertilizers were higher than nitrogenous fertilizers. In the late-1990s and early-2000s, the government hiked the concession rates for P and K fertilizers, which led to an increase in their consumption and a higher share in the total fertilizer use during 2017-18.



Source: Authors' estimation using data from Fertiliser Association of India (2018)

3.3. Consumption Growth Rate of Major Fertilizer in India

Table-2 depicts the growth rates of major fertilizer consumption in India. The growth rate of Nitrogen (N) fertilizer consumption was at a maximum of 5.51 per cent per annum during the period -I (Pre-NAP 1986-87 to 1990-2000). The higher growth of N fertilizer consumption was due to the introduction of high yielding varieties of wheat and rice in the mid-1960s. Hence, fertilizer imports increased significantly. During period-II (Post-NAP) (2000-01 to 2017-18) the fertilizer consumption growth rate fell to 2.91 per cent. However, the growth rate of N fertilizer consumption further declined in the consequent year (2015) due to the introduction of Neem Coated Urea (NCU) (**Refer Table 3**). These findings also conform to the study findings of who found that the review analyzes the literature on government agriculture policy used to influence agriculture production [19].

The fertilizer consumption in India has generally exceeded the domestic production in respect of both nitrogenous and phosphatic fertilizers, except for a few years. The entire requirement of potassic fertilizers was met through imports in the absence of commercially viable sources of potash. The level of P imports, which was very low in the fifties, increased significantly during the sixties and seventies. With the introduction of high yielding varieties of wheat and rice in the mid-1960s, fertilizer imports increased significantly. Phosphorus fertilizer consumption growth rate which was 2.39 per cent per annum during the period-I (Pre-NAP 1986-87 to 1999-2000) increased to 6.24 per cent per annum in period-II, i.e., Post-NAP (2000-01 to 2017-18). It is interesting to note that the growth of phosphorus

fertilizer consumption increased twice during Post-NAP, which might be due to the implementation of nutrient-based subsidy schemes by the government. Similarly, the potash fertilizer consumption growth rate, which was 3.91 per cent per annum during the period-I, declined to 1.69 per cent per annum during period-II. The share of (N+P+K) consumption declined from 57 per cent in the 1960s to 43 per cent in the 1970s, further to about 24.8 per cent in the 1980s, 21.3 percent in the 1990s before increasing to 26.2 per cent in 2000s. Almost a similar trend was observed in the case of nitrogenous and phosphatic fertilizers [18, 34].

Table 2: Consumption Growth Rate of Major Fertilizer in India

Sl. No	Major fertilizer	Period-I (1986-87 to 1999-00) Pre-NAP	Period-II (2000-01 to 2017-18) Post-NAP
1.	N	5.51***	2.91***
2.	P	2.39***	6.24***
3.	K	3.91 ***	1.69NS

Note: ***, ** indicate 1 and 5 per cent levels of significance

3.4. Impact of Neem-Coated Urea on Total Fertilizer Consumption

In view of the importance of agriculture in meeting the increasing foodgrain requirements of the growing population of the country, fertilizer as an input in agricultural production, assumes a greater significance in terms of ensuring a sufficient foodgrain production. However, prolonged overuse of fertilizers in general and, urea in particular has affected soil quality, resulting thereby in a gradual reduction in the yield levels across the country. Urea is one of the most prominent fertilizers, which alone accounts for 57 per cent of the total fertilizer consumption in the country. In this connection, the researchers came up with the development of Neem-Coated Urea (NCU), which helps increase Nitrogen Use Efficiency (NUE) in crops. Recognizing the potential benefits associated with NCU relative to NU, the Ministry of Agriculture and Farmers Welfare (MoA & FW), Government of India, included NCU in the Fertilizer Control Order (FCO) since July 2004 and subsequently made the production and distribution of NCU mandatory from 25th May 2015 [18], [19].

The impact of NCU on the growth of nitrogen consumption for two different periods viz., pre & post implementation of NCU at the all-India level is illustrated in Table 3. The table shows that the growth rate of nitrogen consumption, which was 4.08 per cent during the

Pre-NCU period, decreased to 2.91 per cent in Post-NCU period. It is interesting to note that, the growth rate of urea consumption further declined in the consequent years due to the superior quality of NCU as compared to normal urea, as indicated by extensive laboratory and field experiments conducted by various scientists worldwide.

On other hand, the government policies, since independence, have been directed towards regulating the sale, prices and distribution of fertilizers with the objective of encouraging investment in the fertilizer industry and ensuring the availability of fertilizers at affordable prices through payment of subsidies as an incentive, as part of the larger goal of maximizing agricultural production in the country. With the initiation of economic reforms, the government began decontrolling the prices and distribution of fertilizers, excepting urea. This resulted in an increased consumption of N fertilizers and reduced use of P and K fertilizers. The New Pricing Scheme, implemented in 2003, was a concession scheme for urea, which further increased the distortions in the N+P+K consumption pattern. In 2010, to promote a balanced use of fertilizers, a Nutrient Based Subsidy scheme was announced, according to which, the government would fix subsidy on an annual basis, based on the weights of different macro/ micronutrients in fertilizers. However, since the scheme did not cover urea, no self-sufficiency in urea production could be achieved, as reflected in a steady rise in its consumption since 2003-04. This led to a widening gap between production and consumption, forcing the government to increase its urea imports. In order to make urea available at affordable prices to farmers, the government implemented Investment Policy for urea in 2012. With the revised energy consumption norms, to make urea production energy-efficient and to rationalize the subsidy burden and also to increase its production, the Government made mandatory the production (100%) of Neem Coated Urea (NCU) domestically and the coating of imported urea with neem since May 2015.

Table 3 clearly shows that the government policy reduced significantly the growth of nitrogen consumption i.e., to the extent of 2.91 per cent. Hence, the impact of Neem Coated Urea on the growth of nitrogen consumption declined at the rate of 1.17 per cent per annum due to the fact that NCU use is characterized by a slow release of nitrogen, with a resultant reduced consumption, as compared to Normal Urea (NU). These findings also conform to the study findings of [25], [26] who found that by adopting the organic farming also reduce the fertilizer consumption and also protect the environment by reflecting a greater socio-economic impact on a nation. More importantly, as NCU cannot be used for industrial

purposes, an illegal diversion of subsidized urea to non-agricultural uses could be curbed. In fact, this policy is expected to help the government save money to the tune of Rs.6500 crore given away in the form of subsidies, annually

Table 3: Impact of Neem-Coated Urea on the Growth of Nitrogen Consumption

(Values in %)

Sl. No	Pre-NCU period (2000-01 to 2011-15)	Post-NCU Period (2000-01 to 2017-18)	Impact of NCU
1	4.08***	2.91***	1.17

Note: ***, ** indicates 1 and 5 per cent levels of significance

3.5. Farmers Awareness on Neem Coated Urea Application

The details of awareness on neem coated urea with regard to farmers of paddy, tur, maize, sugarcane, soybean and jute crops in the study states are presented in **Table 4**. It may be noticed from the table that, the awareness level is 100 per cent, 83 per cent and almost 70 per cent each among maize-farmers in Bihar, jute-farmers in Assam, and sugarcane and soybean-farmers in Maharashtra and Madhya Pradesh, respectively. With regard to paddy, the awareness level is 90 per cent at aggregate level. Among the selected states, the awareness level is highest in the case of Bihar (99.50%) followed by Punjab (98.50%), Madhya Pradesh (94.50%) Assam (89%) and least in the case of Karnataka (67%). Although farmers are aware of neem coated urea, a majority of them might be ignorant about the potential benefits of neem coated urea usage relative to normal urea. Hence, special efforts are needed on the part of all States with regard to all crops in general, and tur and soybean crops in particular, especially its more so in the case of Maharashtra and Madhya Pradesh, where about 30 per cent of the farmers are not aware of neem coated urea.

Table 4. Farmers Awareness on Neem Coated Urea Application (Percentage)

Sl.No	Crops	Punjab	Karnataka	Madhya Pradesh	Assam	Bihar	Maharashtra	Overall
1	Paddy	98.50	67.00	94.50	89.00	99.50	-	90.10
2	Tur	-	12.00	-	-	-	42.00	27.00

3	Maize	-	-	-	-	100.00	-	100.00
4	Sugarcane	-	-	-	-	-	69.50	69.50
5	Soybean	-	-	69.28	-	-	-	69.28
6	Jute	-	-	-	82.50	-	-	82.50

Sources: Field Survey data

3.6. Distinguish Characteristics of Neem Coated Urea (NCU)

The factors which help paddy, tur, sugarcane, maize soybean and jute farmers differentiate between neem coated urea and normal urea (NCU) is presented in **Table 5**. It may be noticed from the table that more than 85 per cent of farmers was able to differentiate between neem coated urea (NCU) and normal urea (NU) at aggregate level. It is evident from the table more than 80 per cent of paddy-farmers are able to identify the difference between NCU and NU, whereas, in the case of tur-farmers, relatively less (52%) of farmers are able to notice the difference between NCU and NU. Interestingly, almost all sugarcane-farmers are able to identify the difference between NCU and NU. It is imperative that the colour, leaf figure on the bag and price difference (higher price) are the major factors that help farmers differentiate between NCU and NU. It is noticed that more than one factor have helped them differentiate between NU and NCU in almost all the States. Across the sample States, a majority of the paddy-farmers reported to have identified NCU based on the leaf figure on the bag. However, the proportion of farmer groups having noticed the difference based on the leaf figure on the bag is highest among soybean farmers (56.30%) followed by paddy farmers (47.38%), maize farmers (40.62%) and tur farmers (33.05%). Similarly, as per about 66.28 per cent of jute farmers and 29 per cent of paddy-farmers, it's the NCU colour that helps them differentiate between NCU and NU. Apart from this, a majority of the farmers also have reported that more than one factors help them differentiate between NCU and NU. Price-difference is the other important factor which helps tur-farmers distinguish NCU from NU (43%). Correspondingly, sugarcane-farmers are able to notice the difference between NCU and NU on the basis of more than one factors (85%). Interestingly, none of the sugarcane farmers have stated leaf figure on the bag as the factor that helps them differentiate between NCU versus NU. Does not vanish easily has been also expressed by 22 per cent of sugarcane farmers and rest of the factors by a few farmers from all crops.

Table 5: Distinguish Characteristics of Neem Coated Urea perceived by farmers

Sl.No	Factors	Paddy	Tur	Maize	Sugarcane	Soybean	Jute	Overall
	% of farmers being able to notice the difference between NCU and NU	79.98	52.08	94.67	99.73	92.36	93.21	85.34
Distinguish Characteristics								
1	Colour difference	28.88	-		8.55	20.46	66.28	31.04
2	Price difference	14.58	43.25	13.75	4.91	23.23	8.86	18.09
3	Leaf figure on the bag	47.38	33.05	40.62	-	56.30	27.81	41.03
4	More than one factors	9.27	57.54	45.63	85.21	-	-	49.41
5	Any other Specify) Does not vanish easily	4.63	3.40	-	22.40	-	-	18.09
6	Others (Blank/ No response)	28.88	35.71	-	8.55	-	-	24.38

Sources: Field Survey data

3.7. Trends in Major Foodgrain Production during Pre- & Post-NAP In India:

For Indian agricultural sector to nourish a more than billion populace, it is absolutely essential to increase crop productivity with the help of modern inputs, especially fertilizer. It is well known that a majority of farmers in India are small and marginal, unable to access capital inputs, like innovative technology, machines, tractors nor can they adopt digital agriculture. They face resource constraints while doing so and the land size is not suitable too. They are left with the use of consumable modern inputs to increase their agricultural productivity. Out of these consumable inputs, fertilizer is one of the inputs they can depend on for increasing productivity.

The growth rates of major fertilizer-intensive foodgrain crops for two different periods viz., pre & post implementation of NAP at the all-India level are illustrated in **Table 6**. The table shows the production growth rates of major foodgrain crops viz., paddy, wheat, coarse cereals, cotton, sugar cane, and raw Jute & mesta cultivated in India. During the period of pre-implementation of NAP, the production growth rates of these fertilizer-intensive crops were 2.73, 3.83, 0.69, 4.31, 3.53, and 2.46 per cent per annum, respectively for paddy, wheat, coarse cereals, cotton, sugar cane, and raw jute & mesta. Among these fertilizer-intensive crops, the highest and impressive compound annual growth rate was seen in the case of cotton (4.31%) while the lowest growth rate was observed in respect of coarse cereals (0.69%) and these growth rates were statistically significant at various levels. The reason for such high growth rates for cotton, wheat, sugarcane, paddy, and raw jute and Mesta crops was mainly due to an increase in N, P, K fertilizer application, accompanied by an increase in the area under irrigation and introduction of high yielding varieties. On the other hand, a reduction observed in the growth of coarse cereal crops was mainly due to the scarcity of water (a majority of these crops are mostly grown under rainfed conditions). During the II period, post-implementation of NAP (2000-01 to 2017-18), the growth rates of paddy, wheat, coarse cereals, cotton, sugar cane, and raw jute & mesta increased marginally at 1.83, 2.49, 2.28, 8.69, 1.77, and -0.10 per cent per annum, respectively. It is very interesting to note that the compound growth rate of cotton crop more than doubled i.e., from 4.31 per cent per annum in period-I (Pre-NAP, 1986-87 to 1999-2000) to 8.69 per cent in Period-II (Post-NAP, 2000-01 to 2017-18), which was mainly due to the intervention of new BT cotton seeds, improvement in production technologies, application of more fertilizer, improved management practices spread across the country. Tables 2, 3, and 4 clearly indicate a positive impact of NAP in terms of fertilizer consumption on the growth of fertilizer-intensive crops and output with the outputs being much more impressive during the Post-NAP period, as compared to Pre-NAP.

Table 6: Production Growth Rates of Major Fertilizer-Intensive Crops (1986-87 to 2017-18)

Sl. No	Major crops	Period-I (1986-87 to 1999-00) Pre-NAP	Period-II (2000-01 to 2017-18) Post-NAP
1.	Paddy	2.73***	1.83**
2.	Wheat	3.83 **	2.49***

3.	Coarse Cereals	0.69 NS	2.28***
4.	Cotton	4.31***	8.69**
5.	Sugar cane	3.53**	1.74***
6.	Raw Jute & Mesta	2.46***	-0.10Ns

Note: ***, ** indicate 1 and 5 per cent levels of statistical significance

3.8. Relationship between Yields of Fertilizer-Intensive Crops and Fertilizer Consumption

To understand the relationship between per hectare fertilizer consumption and yields of fertilizer-intensive crops, a correlation analysis was employed. The total fertilizer consumption may not indicate fully the intensity of use, as there exist huge variations in the fertilizer use across states and regions and hence, a per hectare consumption analysis. **Table 7** illustrates the relationship between fertilizer consumption and yields of selected fertilizer intensive crops based on a correlation analysis. The results of a correlation analysis indicate a high positive correlation between all the fertilizer-intensive crops and total fertilizer consumption for the period from 1986-87 to 2017-18, reflecting a high degree of correlation between fertilizer consumption kg/ha and yields of the selected fertilizer consumption crops.

Table 7: Correlation between Fertilizer Consumption and Yields of Major Crops

Sl. No.	Variables	Fertilizer Consumption	Paddy	Wheat	Coarse Cereals	Cotton	Sugar cane	Raw Jute & Mesta
1.	Fertilizer Consumption	1						
2.	paddy	0.9205						
3.	Wheat	0.9234						
4.	Coarse Cereals	0.9128						
5.	Cotton	0.8629						
6.	Sugar cane	0.6317						
7.	Raw Jute & Mesta	0.7114						

Source: Authors' Calculations.

3.9. Determinants of Chemical Fertilizer Consumption in India

The demand for fertilizer is often called a derived demand because it is determined, to a great extent, by the final demand for enhancing soil fertility, soil health, demand for the crop cultivated, price received for the same crop, GCA, area under irrigation, availability of credit to cultivators and ultimately increasing crop yield and surplus production. In general, the demand for fertilizer depends on several factors such as (a) price of crop outputs; (b) fertilizer price; (c) prices of other inputs that substitute for complement fertilizer; (d) coefficients of production function that describe the technical transformation of inputs into outputs, i.e., fertilizer response production function [20], [21] and [22]. Although prices may be important in determining fertilizer consumption, they are possibly less important than other non-price factors such as the introduction of new technology, high yielding crop varieties, expanded area under irrigation, availability of credit, changing cropping pattern, etc., in leading to a shift in the derived demand for fertilizers over time. Specifying a forecast-model is always a challenge, especially the model type and relevant variables.

The determinants of chemical fertilizer consumption in India are analysed and presented in **Table 8**. Various price and non-price factors determine the consumption of chemical fertilizers. Based on the available literature pertaining to the consumption of chemical fertilizers, several causative factors that contribute to an increase in fertilizer consumption were considered for the study. Totally, nine determinants were included for identifying the influence of the determinants on chemical fertilizer consumption. Among these, area under high yielding varieties, gross area under irrigation, cropping intensity, fertilizer price, minimum support price, credit availability, annual rainfall, and domestic fertilizer production play an important role in determining the demand for fertilizers in the country.

A multiple linear regression function was employed for understanding the relationship between these determinants and the total fertilizer consumption in India. The overall adequacy of the model was tested through 'F' ratio and R^2 value, which appeared to be fairly good. The chosen levels of significance were one and five per cent. The Durbin Watson test was employed to test for autocorrelation with respect to the residuals of regression analysis. Durbin-Watson statistic ranges between 0 and 4 indicating that the value of 2 reflects that there is no autocorrelation detected in the samples. The results reveal that there is no autocorrelation in the samples, as reflected by D-W test value (1.538).

The regression results for the total chemical fertilizer consumption reflected a high R^2 value (0.981) which indicates that the explanatory variables in the chosen model explain over 98 per cent variation in the chemical fertilizer consumption. The chosen model best fits the fertilizer demand estimation. The selected model was significant at one per cent level. The identified independent variables used in the model were statistically significant with theoretically expected signs. The area under high yielding varieties, gross area under irrigation, cropping intensity, minimum support price, credit availability, annual rainfall, and domestic fertilizer production, were found positively influencing the chemical fertilizer consumption over time. Interestingly, the price of chemical fertilizer was found negatively influencing the fertilizer consumption/ fertilizer demand. Consequently, the price of chemical fertilizer was identified as the most important determinant of fertilizer consumption in the country, while the price of output as the least, as compared to the input price. The broadcasting method excessive use fertilizers are strongly significant, at 1%. It was found that younger farmers have a significant effect at 10% on the excessive use of fertilizers. Policy formulation on optimum use of fertilizer by introducing different placement methods is the need of the hour [23].

Further, the non-price factors played an important role in the total fertilizer consumption, as the extent of contribution by non-price factors to the total chemical fertilizer consumption was high due to the adoption of non-price factors. Hence, the non-price factors were the more important determinants of fertilizer consumption. Among the non-price factors or institutional factors, the increasing area under irrigation was the most important determinant influencing chemical fertilizer consumption, followed by land-use pattern or cropping intensity and increasing area under high yielding varieties. The next variable influencing the consumption of chemical fertilizers were minimum support price, credit availability, annual rainfall, and domestic fertilizer production, which shows a higher magnitude of fertilizer consumption, however, they have their own limitations too. Not all farmers are able to benefit themselves from the minimum support price. Moreover, in the case of credit, non- institutional sources/ private moneylenders still have their presence in the agricultural credit system.

The contribution of irrigation to chemical fertilizer consumption is quite substantial, as reflected by the regression coefficient. The findings of the study clearly show that increased area under irrigation, frequency of land use or cropping intensity and adoption of

high yielding varieties have accelerated the chemical fertilizer consumption in India. As per policy decision concerned, fertilizer-pricing policy instruments enhance prices of chemical fertilizers, thereby leading to a decrease in fertilizer consumption, while output prices have a positive impact on chemical fertilizer use, but are less powerful than input prices. As a result, it is essential to prioritize input price policy mechanisms in excess of higher output prices, as high output prices reimburse a small percentage of cultivators, while low input prices help enhance fertilizer use among a large number of small and marginal farmers.

The domestic production of fertilizers has increased over the years. In the case of N and P, the country is near to achieving self-sufficiency. However, the addition of new capacity and an efficient use of existing capacity are still lagging behind. If we compare the growth rates, imports have shown a higher growth. This has many implications for the country being completely dependent on imports for K fertilizers. Thus, policies have to be adopted to create an encouraging environment for domestic industries, while the existing industries have to increase their efficiency. The increasing requirement should be met with increased domestic production, instead of increasing imports. International prices of fertilizers are also increasing, adding to the fiscal burden of the government. A conducive policy structure for domestic production is a must. Subsidies play a huge role in determining fertilizer consumption. They form a major part of the total subsidy expenditure of the government. Sometimes, it is claimed that the structure of fertilizer subsidies leads to an imbalanced use of fertilizers. Indian soils are now deficient in many micronutrients as well. Thus, managing subsidies such that it will lessen the burden and promote a balanced use of all fertilizers, which is the need of the hour.

Table 8: Results of Regression Model for Determinants of Chemical Fertilizer Consumption

Sl. No	Particulars	Coefficients	Standard error	t-values
1.	Intercept	-44715.236	7871.697	-5.681
2.	Area under high yielding varieties	42.708***	32.743	1.304
3.	Gross area under irrigation	328.891***	89.875	3.659
4.	Cropping intensity	320.494**	73.427	4.365
5.	Price of chemical fertilizers	-454.001***	119.703	-3.793
6.	Minimum support price	4.076**	2.417	1.687

7.	Credit availability	0.022**	0.010	2.138
8.	Annual rainfall	3.197***	0.979	3.265
9.	Domestic fertiliser production	1.849**	0.667	2.771
10.	Adj. R Square	0.981		
11.	F	921.3182***		
12.	D-W statistics	1.538		

Note: ***, ** statistically significant at one and 5% levels of significance.

3.10. Chemical Fertilizer Demand Forecasting

Except a few years, the demand for chemical fertilizers in India has generally exceeded their domestic production, particularly nitrogenous and phosphatic chemical fertilizers. The total demand for potassic fertilizers is met through imports, as the country lacks economically viable sources of potash production, even as about two-thirds of the domestic demand for nitrogen fertilizer is being met through imports as well. With the preface of technological factors viz., high yielding variety, irrigation, and mechanization in the production of wheat, paddy and sugarcane in the 60s, the chemical fertilizer imports increased considerably. During the 90s, the production of chemical fertilizers declined drastically due to low/no addition to the domestic capacity. With a rise in demand for fertilizers during the last two decades, imports have increased significantly. India has imported about 8.54 Mt of NPK fertilizer in 2017-18, as against 1.93 Mt in 2002-03. Therefore, the current consumption pattern of fertilizers in India is repeatedly said to have a further scope for an efficient and balanced use with an increased intensity to improve agricultural productivity and profitability.

In this background, the current article focused on the projection of demand by 2030 for total fertilizers viz., urea, DAP, SSP, MOP and complex fertilizers, based on their percentage shares in N+P+K demand. Several functional forms were tried for forecasting the fertilizer demand. Finally, a logarithmic model was selected based on the highest R_2 value and significance of coefficients. Based on the logarithmic model technique, the projected demand for fertilizer for the next 11 years, i.e. till 2030 and the results are presented in **Table 9**.

The projected demand reveals that the total chemical fertilizer demand for 2025 will be around 46735 thousand tons, which will reach to a level of 57316 thousand tons by 2030.

The result also demonstrates that the coming years will witness a persistent increase in the demand for fertilizers. Consequently, the domestic production of fertilizer will have to be promoted to meet the increasing requirement rather than importing these chemical fertilizers, as they lead to a huge financial burden on the government. In addition, the authors also worked out likely fertilizer consumption per hectare with the help of forecasted GCA and presented in the same table.

The forecast also suggests that by 2025, the per hectare fertilizer consumption will exceed the level of 238 kg, twice the current usage of fertilizer. Likewise, the year 2030 will witness a fertilizer consumption of around 277 kg/ hectare. However, this will be still below the level of the intensity of usage in other countries. According to the World Bank data, per hectare fertilizer consumption in Bangladesh for the year 2017 amounted to 209 Kg which is higher compared to India though Bangladesh's arable land is less than that of India and likewise of China, Colombia and Malaysia. The fertilizer consumption of these countries was 364.4, 648.8 and 1726.6 kg/ha, respectively and much higher than for India for the same year. It is interesting to note that these countries are able to achieve higher crop yields with higher levels of fertilizer application. This clearly shows that the fertilizer application for 2017-18 for middle-income countries amounts to 135.12 kg/ha and for high middle-income countries (146.14kg/ha). Therefore, fertilizer application intensity in India more or less matches with that of most of the countries, however, still there is a fair scope for scaling up the same for India. Thus, the findings of this article clearly show that we need a concerted policy response towards the encouragement of domestic chemical fertilizer production and capacity utilization, reduced dependence on imports of chemical fertilizers, efficient management of subsidy for the sector, promoting a balanced use of chemical fertilizers with the help of awareness programs and improvement in agricultural education, and efforts towards reducing the huge variations in the use of fertilizers across regions.

Table 9: The Projected Fertilizer Consumption for the Years 2017 to 2030

Year	Total chemical fertilizer demand (000 tons)	Gross cropped area (000 ha)	kg/ha
2020	38107	200522	190.04
2021	39695	201142	197.35
2022	41348	201761	204.94
2023	43071	202380	212.82

2024	44866	203000	221.01
2025	46735	203619	229.52
2026	48682	204239	238.36
2027	50710	204858	247.54
2028	52823	205477	257.08
2029	55024	206097	266.98
2030	57316	206716	277.27

Source: Authors calculations.

3.11. Discussion of Results and Conclusions

The declining cultivable land resources due to urbanization, industrialization coupled with the burden of increasing population have led to a shrinkage of cultivable lands. It is also expected that Indian cultivable land might drop to below the present level of about 140 million ha, if the use of cultivable land for commercial/non-agricultural purposes is not restricted in the near future. Therefore, the only possible way of improving food production is to increase crop productivity with the help of modern technologies. One of the important available technologies is the soil testing and adoption of recommended doses of fertilizers for increasing crop productivity with an emphasis on protecting the environment. Hence, the role of chemical fertilizers in increasing agricultural production in India has been well recognized. Chemical fertilizer consumption in India has been mounting over the years and today India is one of the largest producers and consumers of chemical fertilizers in the globe, but the level of fertilizer consumption in India is still lower as compared to many other countries. The Government of India has been consistently pursuing policies conducive to increased availability and consumption of fertilizers in the country. These results also conform to the study findings of who suggested “a policy instrument should encourage long-term solutions to enhance agricultural productivity through regenerative production system and preserve the environmental resource base” [24]. Excepting potassium (K), the country has achieved near self-sufficiency in the production of N and P fertilizers through domestic industry and as a result, a significant decrease is observed in the import of N and P during the last 10 years, while most of the K requirement is met through import only. It is observed that the growth rates of chemical fertilizer consumption and food grains production have decreased between 1986-87 to 1999-2000, and 2000-01 to 2017-18 in India. Interestingly, the growth rate of total fertilizer consumption, which was 5.58 per cent during 1986-87 to 1999-2000, has

decreased to 3.24 per cent between 2000-01 to 2017-18, whereas, the growth rate of food grain production was 3.00 per cent between 1986-87 and 1999-2000 has decreased to 2.22 per cent between 2000-01 to 2017-18. For the entire study period, it is noticed that paddy, wheat, coarse cereals, cotton, and sugarcane have proved to be the fertilizer-intensive crops, accounting for a major portion of fertilizer consumption. It is noteworthy to mention here that cotton crop, followed by coarse cereals have shown highest growth rates during the Post-NAP period, as compared to the Pre-NAP period, perhaps mainly due to the technological improvements witnessed in the cotton production and favourable policies towards coarse cereals. A nutrient-wise status of fertilizer consumption indicates that nitrogenous fertilizers alone account for nearly two-thirds of the total nutrient consumption in the country. The share of N, which was 79.71 per cent during Pre-NAP (1986-87 to 1999-2000) has declined to 69.37 per cent in the Post-NAP (2000-01 to 2017-18). In the case of P fertilizers, the share has increased from 12.42 per cent in period-I to 20.68 per cent in period-II. Likewise, the share of K has increased from 7.88 per cent in period-I to 9.94 per cent in period-II. Further, the mandatory production and distribution of NCU during 2015 has further slowed down the consumption of N in particular and total fertilizer in general.

It is noticed that, the awareness level is cent per cent, 83 per cent and almost 70 per cent each among maize-farmers in Bihar, jute-farmers in Assam, and sugarcane and soybean-farmers in Maharashtra and Madhya Pradesh, respectively. With regard to paddy, the awareness level is 90 per cent at aggregate level. Among the selected states, the awareness level is highest in the case of Bihar (99.50%) followed by Punjab (98.50%), Madhya Pradesh (94.50%) Assam (89%) and least in the case of Karnataka (67%). Further, more than 85 per cent of farmers were able to distinguish neem coated urea (NCU) and normal urea (NU) at aggregate level. It is evident that more than 80 per cent of paddy-farmers are able to identify the difference between NCU and NU, whereas, in the case of tur-farmers, relatively fewer (52%) farmers are able to notice the difference between NCU and NU. These findings also conform to the study findings of [27],[28] and [29] who found that an main determinants of fertilizer application were non-price or institutional factors viz., area under high yielding varieties, gross area under irrigation, cropping intensity, minimum support price, credit availability as the most important factors in influencing the demand for fertilizer. Similarly, price policy instruments, affordable fertilizer prices and higher output prices are found to be the more powerful elements in influencing fertilizer consumption amongst farmers. A high product-price support policy has benefited large farmers (with more net marketable surplus), while

low input prices have benefited all categories of farmers. These findings also conform to the study findings of [25],[26] who found that pandemic wreaked a substantial physical, social, economic and emotional havoc on all the stakeholders of Indian agricultural system. Seizing the crisis as an opportunity, the state announced a raft measures and long pending reforms; protesting farmers are demanding the government repeal the three laws. The projected demand results indicate that the total chemical fertilizer demand will reach around 46735 thousand tons by the next six-year (2025) and further to 57316 thousand tons by 2030. The results also point to a continuous rise in the fertilizer demand in the coming years. Hence, the domestic production of fertilizers needs to be promoted to meet the increasing requirement instead of imports as this can be a huge financial burden to the government.

Future Scope of the study: The application of NCU minimizes loss due to leaching; prevents its misuse as well as puts the fertiliser in a slow release mode thereby nourishing the saplings for a longer period; avoids the repeated use of fertilizer and economize the quantity of urea required by crops (enhancing Nitrogen-Use Efficiency); increases the shelf-life of the product; reduces caking during storage and improve the availability of nitrogen to crops; results in a better crop yield and efficient pest control management; reduces the leaching of nitrates into the groundwater aquifers and thereby help reduce its pollution and so on. Further, there was a notion that NCU had stopped diversion of urea into non-agricultural/ industrial purposes. Keeping this in view, the Government of India included neem-coated urea, a slow release fertilizer, in the Fertilizer (Control) Order, 1985 besides making it mandatory for all the indigenous producers to produce cent percent of their total subsidized urea in the form of NCU from 2015. Further, it has since taken various steps to promote NCU use with a view to improving the soil health status and also realising a higher yield per hectare.

Limitation: The study was undertaken on a short notice post the policy implementation of a 100% production of NCU (since, May 2015) and hence, it is difficult to assess the impact of NCU on crop production, productivity and farmers income within a limited period. However, the reference period of the study is Kharif 2015.

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