CHAPTER 2

REVIEW OF LITERATURE:

This chapter examines various empirical studies with reference to the impact of change in fertilizer prices on consumption, production and cropping pattern, in order to shed light on various issues and facts related to fertilizer pricing policies.

2.0 Introduction

The introduction of New Agriculture Strategy in the 1960s accorded a high priority to the use of “critical inputs” i.e. irrigation, fertilizer and HYV for increasing agricultural production with a particular emphasis on the use of chemical fertilizers. Realizing the importance of chemical fertilizers in augmenting agricultural production, the government has come out from time to time with more conducive policies mainly to promote fertilizer use in the cultivation of all crops across all regions, leading to a spectacular increase in the fertilizer consumption from 69,8000 tonnes in 1950-51 to 26,486,4000 tonnes in 2009-10.

If one observes the trends in fertilizer consumption over a period of time, it becomes evident that there was a sharp decrease in consumption levels in the 1970s, when prices shot up in the face of the oil crisis. However, Later, in 1977, a sharp increase was noted in the consumption of fertilizers when the government extended support to the fertilizer sector in the form of subsidies, particularly with a view to making it more affordable to the poor forming community. This
subsequently led to a tangible increase in use of fertilizers in the 1990s. However, the new economic policies re-examined the policy of continuing subsidies to the fertilizer sector, and finally a reduction in fertilizer subsidies in a phased manner was considered, leading to changes in the fertilizer prices in the later year. The changes in fertilizers prices evoked huge criticisms from many sections of the society that it would have an adverse impact on fertilizer consumption, agriculture production, cropping pattern, agriculture income and particularly the poor and marginal farmers. The policy of withdrawing subsidy on fertilizers and the resultant increase in its prices evoked interesting discussions, arguments and inferences. Arguments in favour of an increase in the fertilizer prices was on the contention that it was leading to wasteful consumption causing environmental and others problems, while, arguments against an increase in fertilizer prices were on the ground that the small farmers would be affected thereby their production and yield, and that as soil fertility had got reduced over the years because of sustained cultivation of lands, it was necessary to restore soil fertility by the application of fertilizers and hence necessary to promote its use at affordable prices. Further, the policy of decontrolling P and K has seriously distorted the nutrients use ratios and inclined towards N which is relatively priced less.

While keeping in view the distortions in the fertilizer pricing scenario and the resultant adverse impacts, a brief review of literature would help provide insights into various issues like the role of fertilizers in agricultural development, fertilizer subsidy, balanced use of fertilizers, factors influencing fertilizer consumption, improving fertilizer use efficiency, the role of fertilizers in
determining output levels, farming practices, impact of fertilizers prices etc. An endeavor has been made in this chapter to understand various issues relating to the impact of changes in fertilizer prices on consumption, production and cropping pattern through various empirical studies. The literature has been reviewed issue wise under the following sub heads.

2.1 Importance of technology in Agricultural development

The following studies examine the progress of the agricultural sector in the context of the usage of HYV seeds and fertilizer technology with due importance given to the role of fertilizers in increasing agricultural production.

Madhuri Srivastava (1983) highlights how Indian Agriculture witnessed a tremendous progress following the adoption of the new technology and the success of green revolution which stressed the use of irrigation, HYV seeds, fertilizers, modern inputs and relay cropping techniques. She also brings out the limitations of the green revolution in terms of its uneven spread with only wheat and rice hogging all the attention. Further, the adoption of the new technology was limited to the availability of adequate irrigation facilities; dry areas were neglected with only some states like Punjab, Haryana, U.P, Tamil Nadu, and Andhra Pradesh getting benefited. In addition, she observes that new high yielding seeds were used for only Rabi season crops and that this technology also called for large investments. All these things collectively resulted in regional disparities in terms of development and at the same time, disparities in income also got widened, following the adoption of the new technology by the rich farmers while the poor farmers could not afford it. She views that further
agricultural development can take place if the new technology reaches all classes of farmers, for which the government should provide sufficient irrigation facilities in addition to the consolidation of land holdings so as to reap the benefits of economies of scale associated with the new technology.

**G.S.Bhalla and Gurmail Singh (1997)** examine the growth of agricultural output in India, in terms of yield and area increase as well as changes in the cropping patterns since 1960, particularly from 1980-83 to 1992-95 for 43 crops. They observe that the new seed-fertilizer technology considerably increases agricultural output besides leading to a distinct shift in the cropping pattern away from coarse cereals to oilseeds and other commercial crops. This increase in yield levels and an overall growth in output are found to have been brought about through an increased use of fertilizers and increased investments on major and minor irrigation works. They recommend concrete policy effort to spread green revolution in the north-western region in view of the fact that there exists a considerable scope for increasing productivity. They express themselves in favour of increased public investments in irrigation in the eastern regions how the net irrigated area in West Bengal had increased through private investments in pump sets and tube wells. In states like Bihar and Orissa where agricultural growth has been lagging behind, the implementation of land reforms in a big way might help achieve better growth in the agriculture sector, while, Institutional credit and other capital inputs would encourage private investments. High growth in crop output has to be sustained through continuation of minimum support price; plan outlay to the eastern regions needs to be increased which helps reach the benefits to the
potential farmers, which in turn would reduce rural poverty. They also stress the need for supporting R&D for addressing region specific problems.

Desai, Rustagi and Singh (1996) while examining the issue of persistent non-use of nutrients in semi-arid tropics of India for the period 1975-76 to 1983-1984 deserve that nearly 60 to 70 per cent of the total cultivated land was not applied with any external nutrients by means of chemical fertilizers. Further, another disturbing observation is that nearly one fourth of the cultivated land in this region was not even applied with any farm of nutrient supplement, chemical or organic, for five to nine years. In some areas due to the scarcity of organic manure, many farmers were restoring to the increased use of chemical fertilizers by way of substitution. These findings bring out the abundant scope existing for better farming practices to enhance productivity levels in semi arid tracts of the country.

A study undertaken by Paramajit Kaur and A. J. Singh (1992) examine resource productivity and use efficiency in agriculture across different agro climatic zones of Punjab based on data collected from 210 households selected from 14 villages spread over 6 agro climatic regions of the state. They have followed the Cobb-Douglas Production Function for assessing the resource use efficiency across different agro climatic zones. The dependent variable in the estimated production function happens to be value of agricultural output, while independent variables include cropped area, irrigation, insecticides and fertilizer use. The estimatations indicate that with an optimal use of resources, returns could be increased by 356 percent in the aggregate, implying that incomes can be
augmented by improving the resource use efficiency through an optimal mix of inputs.

**Nirmal Kumar (1992)** focuses on untapped yield potentials in the rain fed areas that could be harnessed to the extent of 200 to 300 per cent. For this, two major agricultural programmes had been envisaged during the 1990’s; they were to extend an economically viable package of inputs specially fertilizer and water in the rain fed areas and better management of fertilizers and associated factors in the irrigated areas. Promoting biogas technology and reviving of idle urban mechanical compost plants, evolving dry land farming technology, and the effective application of the available technological package to rain fed areas were expected to meet 80 per cent of the additional food requirements. Further, there was an emphasis on the advantages of dry land technology in terms of cost effectiveness, reduced risks and ecological benefits.

### 2.2 Factors influencing fertilizers consumption

**Kumar-Desai (1996)** analyzes diffusion and intensity of fertilizer use across farm size, crops and irrigation status. The factors influencing farmers decision in favour of fertilizer consumption confirms the importance of farm size, HYV, irrigation and access to credit. The problems identified include untimely and irregular application of fertilizer and deficiencies in the fertilizer use practices leading to lower fertilizer use efficiency and hence recommends location specific research on fertilizer practices.

**G. Parthasarathy and B.Chinna Rao (1986)** have examined the influence of factors like irrigation, HYVs, changes in the cropping patterns and the area under
cultivation for the Rabi season crops on fertilizer use. The results show that a 10 percent change in irrigation results in a 0.3 percent change in the total fertilizer use with other inputs kept constant; the elasticity of fertilizer use is found very high as reflected by the estimations carried out for pooled observations which include both fertilizer users and non-users; however when estimates are compared by using data only with respect to fertilizer using cultivators; it becomes evident that, non-fertilizer users can harvest better crop yields through fertilizer application. These non fertilizer using cultivators may be marginal and small farmers who are constrained to apply fertilizers due to high cost of fertilizers and non-availability of irrigation. In the case of cropping pattern, the estimates show that a 1 percent change in the cropping pattern in respect of more fertilizer using crops would result in a 6 per cent increase in fertilizer consumption which indicates that farmers’ choice of crops and their varieties are an important factor in determining the usage of chemical fertilizers.

Gunvant M Desai (1991) examines the issues in the growth of fertilizer usage in India focusing on how to sustain the rapid growth in fertilizer consumption with minimum adverse impacts on the environment. He analyzes the factors behind the growth of fertilizer consumption in developing counties and the factors governing the past growth of fertilizer use in India for examining the possible further growth in fertilizer use and its implications for future research and policies. He points out that a sustained growth in fertilizer consumption is the only alternative for meeting the ever increasing food grain requirement of the growing population and the increasing yield levels per hectare is the only way out in this respect since no
other cost effective alternative measures are available. More importantly, he cautions the policy makers against the potentially adverse environmental implications if we just concentrate on pushing through a high rate of chemical fertilizer consumption without addressing the “Flawed Fertilizer Practices”. India’s experience reveals that it was the government’s policies aimed at achieving the national objective of self-sufficiency in food production that exerted greater influence on demand for and supply of fertilizers than factors like irrigation, HYVs, and prices of fertilizers. Indian agriculture has reached a stage that any further increase in fertilizer consumption appears remote is very difficult since major crops dominating fertilizer consumption have reached a plateau and any further increased application can turn out be uneconomical besides adversely affecting yield levels and soil systems. Any further growth in fertilizer consumption, he claims, is dependent on improvements in the technology and economic efficiency of use and broadening of technology based growth in agriculture especially in non-irrigated areas with an emphasis on support systems and that rigorous government policies are quite imperative. The author emphasizes on guiding principles such as, growth in agriculture production as a means to achieving the basic national objective of self sufficiency in food production and elimination of poverty besides employment oriented growth and balanced regional development. The author also recognizes the ever increasing cost of cultivation which is pushing agriculture to uneconomical levels and that it is the need of the hour to move towards Cost-efficient agriculture with a continuous up-gradation of technology and judicious use of modern inputs.
The study by Shah and Shah (1996) aims at understanding the differences in fertilizer usage practices among farmers with a relatively less and uncertain irrigation access and those with an assured access to abundant irrigation in Gujarat. The study reveals that farmers under un-irrigated conditions apply fertilizers at sub-optimal levels both in terms of quantity and composition as compared to those with an assured access to irrigation. The field specific soil tests indicate higher returns on fertilizer application as compared to those based on either blanket recommendations or farmers own practices. The study further observes that farmers with better farming practices follow soil test based recommendations while others substitute higher fertilizer dosages as a substitute for better farm practices.

R. C. Dahiya (1967) In his work, estimates fertilizer consumption for the years 1965-66 to 1970-71 using a trend analysis method based on data for the period 1951-52 to 1963-64. The estimated trend indicated that the likely consumption levels are much less than what was targeted for the 2nd and 3rd Five year plans. Hence, the author insists on sincere and strong efforts on the part of the government to overcome the gaps between targets and trend estimates for the 4th Plan. Factors like prices of agricultural products, availability of Irrigation and prices of fertilizers which determine the demand for the fertilizers were not in favor of increasing fertilizing demand.

C. H. Hanumantha Rao and Ashok Gulati (1994) observed that the ongoing reforms have opened up Indian agriculture to the world market, which is likely to turn the terms of trade in favour of agriculture. To make the most of the prevailing
conditions, they identify certain crucial drivers of agricultural growth like diffusion of technology, irrigation, fertilizer, infrastructure, institutional reforms, agrarian reforms, participation of women, and poverty alleviation programmes, which helps increase an appropriate aggregate supply response in the agrarian production system in addition to accelerating the growth of Indian Agriculture. In the case of fertilizers, the reforms suggested relate to a wider distribution of the fertilizer production system i.e., the domestic production system should be exposed to foreign competition in addition to gradual reduction in fertilizer subsidy. They also suggest that the resultant savings be diverted towards irrigation and soil and water conservation schemes.

**P.V.Sarma (1981)** argues that a steady increase in fertilizer prices without a commensurate increase in the prices of agricultural output results in fall in fertilizer consumption because the consumption of fertilizers depends on the revealing price of fertilizers and the expected prices of crop output. The study further reveals that the quantum of increase in procurement prices is not in proportion to the very high fertilizer prices so as to offset the impact of a rise in fertilizer prices. This might lead to an adverse impact on fertilizer consumption. Hence, the study suggests the use of bio-fertilizer and green manure, the promoting efforts towards growing green manure, and also the promoting biogas units with a view to restoring soil nutrients (without sacrificing the fuel requirements) based on cattle shed waste.
C.R Rao (2002) in his paper titled “stagnation in fertilizer consumption- causes and remedial measures”, traces the stagnation in fertilizer consumption over the last one decade to uncertainties in fertilizer prices, non-remunerative prices of some commercial crops, insufficient credit availability to small and marginal farmers and the failure of rains and stagnation in area under irrigation and HYV in some regions.

2.3 Issues pertaining to subsidies;

The introduction of seed-fertilizer technology (New Agricultural Technology) in the 1960’s accorded high importance and priority to inputs like irrigation, fertilizer and high yielding verities (HYV) for increasing agricultural production. Further, these inputs were made affordable by giving “subsidies” to promote their use. Over the years, the varying magnitudes of subsidies led to huge fiscal stresses. Among the input subsidies, fertilizer subsidy was one which increased from Rs.505 crore in 1980-81 to Rs 96,603 crore in 2008-09. The New Economic Reforms aimed at ending the subsidy regime and putting resources to more efficient uses, so as to ensure fiscal sustainability, resulted in an increase in fertilizer prices leading to serious debates and stiff resistance indicating that it would affect fertilizer use and thereby agricultural production. In order to know whether the rise in prices has had any impact on agricultural production, fertilizer consumption and its likely implications, pertinent studies have been reviewed. The following studies examined the implications of an increase in fertilizer prices from various angles.
2. 3. 1 Studies in favor of subsidy

Gulati and Pradeep K. Sharma (1999) examined issues pertaining to fertilizer pricing and subsidy in the Indian context from an economic perspective to know whether a farmer is net subsidized or not. The study results indicate only 60 percent of fertilizer subsidies going to farmers, while the remaining 40 percent to the fertilizer industry. Indian cultivators would have been better off under free trade conditions rather than under a controlled trade regime. As far as relative crop fertilizer price ratios for wheat, rice and cotton are concerned, the study implies that Indian farmers are net taxed and not net subsidized in view of crop-fertilizer pricing. The fertilizer subsidies shared by well endowed regions and better off farmers tend to deprive other regions of their legitimate share in resources for infrastructure development further, the potential yield of paddy with an optimum dose of NPK for the eastern region works out to 407 percent as against 155 percent in respect of the North region and 152 percent for the southern region (1981-82). Therefore, to optimize social gains, large quantities of fertilizer should be given to regions with an untapped potential which in turn requires intervention on the non-price front such as improving the distribution network. He further argues that irrigation has a more decisive influence on the pattern of fertilizer consumption than price fluctuations.

Mohinder S. Mudahar (1982) develops a methodology for measuring the contribution of fertilizers to growth in productivity of wheat and paddy crops. The results show both area and yield growth being high in the case of wheat when compared to rice over the period 1963-64 to 1973-74. The share of wheat and rice
in the total fertilizer consumption is found very high and the rate of increase appears very rapid and impressive. This high growth rate is attributed to fertilizer subsidies, technological changes, favourable prices and various farmer friendly policies of the government. Over the period 1963-64 to 1973-74 the results show an increased fertilizer application resulting in 37 and 89 per cent growth in the production of wheat and paddy, respectively. For the subsequent ten years i.e. 1973-74 to 1984-85, the contribution of fertilizers to growth in productivity is found high for paddy at 85 per cent as compared to 57 per cent in the case of wheat. Thus, it is clear that fertilizers have played a vital role in expanding the production of both wheat and paddy in India. As land supply is limited, further growth in production is possible only through increased productivity and efficient use of fertilizers.

Vijay Paul Sharma and Hrima Thaker (2009) while examining the trends in subsidies and issues pertaining to the distribution of subsidies between farmer and the fertilizer industry, across regions/states, crops and different farm sizes, find fertilizer subsidies increasing from 0.85 per cent of the GDP in the year 1991 to 1.52 percent in 2008 - 2009. They also disprove the misconception that the fertilizer industry gobbling up a major share of subsidies while observing that subsidies remained largely confined to a few states and t crops like Paddy, Wheat, Sugarcane and Cotton together account for two thirds of the total fertilizer subsidies, with small and marginal farmers deriving a larger share of fertilizer subsidy. While justifying subsidy to fertilizers, this study concludes that a
decrease in subsidies will have an adverse impact on farm production and incomes of small and marginal farmers.

**R.K.Khatkar, C.R.Kaushik and Chamola S.D (1992)** examine the extent and impact of input subsidies on Indian agriculture, using secondary data. The findings show that input subsidies have increased over the years mainly to offset the increasing prices of inputs and also to encourage the use of modern inputs. The study observes a higher subsidy received by agriculturally developed states that account for about 60 percent of the total fertilizer subsidy. The share of fertilizer subsidy to cultivators is found to have declined from 93 percent in the triennium ending 1982-83 to about 55 percent in the triennium ending 1986-87 whereas in respect of the fertilizer industry, it is found to have increased from 7 to 45 per cent over the corresponding periods and a decrease in returns per hectare ranging from 10 percent to 56 percent and cautions against withdrawal of input subsidy. The study suggests the continuation of input subsidies for increasing agricultural output by way of plugging leakages.

**A study by G.Subramaniyan and V.Nirmala (1991)**, to identify factors affecting fertilizer demand at the macro level examines, using static and dynamic models, for fertilizer which helps understand the implications of fertilizer prices and agricultural product prices for fertilizer use and their inter relationship based on time series data from the year 1966-67 to 1985-86. The co-efficient of the relative price indicates that when a relative fertilizer price increases by 10 percent there is a 4.26 percent decrease in fertilizer demand. The co-efficient for area
under irrigation reveals that a 10 percent increase in irrigated area leads to a 14.38 percent increase in fertilizer usage. They posit becomes that as land became scarcer, the consumption of fertilizers per hectare also increases. The dynamic model further finds fertilizer demand decreasing by 13 percent in the short run while by 15 percent in the long run; for a 10 percent increase in fertilizer prices, while comparing the two models, it is found that fertilizer demand is price elastic. And the study recommends two policy options for increasing fertilizer demand i.e., either increasing agricultural commodity prices or reducing fertilizer prices. Although subsidy extended to fertilizers is justified on the ground that it facilitates the availability of fertilizers to the farmers at affordable prices and also helps achieve self-sufficiency in food production particularly in the developing countries; and as the fertilizer subsidy received by the industry being in the nature of intra-economy transfer, there is no drain on the exchequer. The authors also suggest that fertilizer subsidy be pursued and that non-price factors like cropping pattern, irrigation, agricultural research and development, credit etc be emphasized which in turn might increase fertilizer demand besides strongly favouring a decrease in the prices of fertilizers so as to boost fertilizer demand and thereby maintaining the growth in agricultural sector at a desired level. While favoring the policy of fertilizer subsidy, the study further suggests that HYVs be used on a large scale and that additional area be brought under irrigation to boost fertilizer use for which investments on extension services and infrastructure facilities are indispensable particularly in the Indian context. The Study points out
the importance of fertilizer subsidy and also suggests an increased emphasis on other complementary inputs for increasing fertilizer usage.

*Anantha Ram (1992)*, while analyzing the secondary data pertaining to the magnitude of fertilizer subsidy and its distribution over space and time (across 4 zones in India) from 1984-85 to 1988-89 finds the production of rice and wheat which account for a major share of fertilizer consumption increasing by 21 per cent and 22 per cent, respectively, While the amount of subsidy increasing by 68 per cent over the (same period) with subsidy per additional ton of rice and wheat produced amounting to Rs.594.50, constituting one fifth of the total value of rice and wheat. Produced the amount of fertilizer subsidy going-over to the 4 zones is found inequitable as the North and South zones enjoy a higher share than the West and East zones, while economic subsidy derived through fertilizer subsidy amounts to Rs.84.80 per tons of rice and wheat produced in 1988-89. Between 1984-85 and 1988-89 an additional ton of fertilizer application is found to have yielded 4.80 ton of rice and wheat, which in monetary terms amounts to almost Rs.2,907 and Rs. 8,640, respectively. The author views, the government’s decision to increase fertilizer prices as improper. He suggests the reexamining of the pricing of supplies from feed stock agencies to the fertilizer industry, so as to reduce the regional imbalance in fertilizer use and the sharing of fertilizer subsidy equitably, and also the development of the complementary infrastructure facility like irrigation in eastern and western regions.
**Nishi Sinha, (1994)** in her study examines the changes with respect to the consumption of P and K following the decontrol of fertilizer prices by the Government in August 1992. Based on the survey data collected by the Madras Fertilizer Limited for the year 1992 (covering 1,155 farmers small, medium and large) pertaining to major crops in the southern states and union territory of Pondicherry, finds the consumption of P decreasing by 35 per cent in respect of Karnataka and by 31 per cent (irrigated crops) in respect Tamil Nadu, while across rain fed crops, declining by 32 per cent with respect to Andhra Pradesh and by 24 per cent with respect to Karnataka. The overall decrease of P consumption amounts to 27 per cent, excepting Sugarcane (Tamil Nadu) Chillies (Andhra Pradesh) and Rubber (Kerala), while the reduction in consumption of K works out to 59 per cent for TN, 54 per cent for A P, 45 per cent for Kerela and 36 per cent for Karnataka for irrigated crops; for rain fed crops it amounted to 88 per cent for A P, and 33 per cent for Karnataka except Groundnut and Chilies in respect of Andhra Pradesh, while, its use is found high in the case of those crops, which fetch a high market price and less in the case of those crops (Cotton) which fetch a low market price. With respect to the use of NPK, the ratio of N to P and K is found to have increased by 65 per cent for Tamil Nadu, 31 per cent for other states (irrigated crops) while, 17 per cent for Andhra Pradesh, and 26 per cent for Karnataka in respect of rain fed crops due to disparities in the prices of P and K in relation to N.

With respect to the crop wise fertilizer usage pattern, the farmers in Karnataka and Kerala indicate that they tend to reduce the consumption of K by
30 and 36 percent, and P by 15 to 25 percent, for irrigated crops, and by 11 and 41 percent for rain fed crops, respectively. The overall findings indicate a reduction in the consumption of P and K. Observations also reveal that a 1 percent increase in irrigation would lead to a 1.2 percent increase in fertilizer consumption, while a 100 percent increase in irrigated area would lead to a 120 percent increase in fertilizer consumption; however, a corresponding increase in farm produce price will not result in a decline in fertilizer demand. It is also observed that resources invested in irrigation would generally lead to an increase in GDP as compared to investment made on fertilizer subsidy, further, a comprehensive fertilizer policy that protects farmers’ interests and those of the fertilizer industry is felt necessary, by the author.

Y. Ratna Reddy and R.S. Deshpande (1992) examine the input subsidy policy while focusing on the importance of different input subsidies, their performance and regional spread, and their relationship to the pattern of growth and also the impact of withdrawal of fertilizer subsidy at the micro level. The study point out that fertilizer subsidy is not the only one which gobbles up a large share of resources when compared to input subsidies extended to irrigation, electricity and credit. They observe that only a few states have consistently benefited from the policy, and that if a blanket policy of subsidy withdrawal were to be effected all over at the same time, it would be detrimental to achieving the long-term objective of sustained growth. The micro level findings reveal the possibility of a decline in productivity, input intensity and distortion of technological progress if fertilizer subsidy is withdrawn.
**T.R. Satish Chandran** (1993) in his paper titled “Pricing of Feed stocks in India” finds a 99 per cent net increase in fertilizer subsidy getting offset by a steep increase in the cost of indigenous feedstock and inputs besides increased railway freights. He further observes the bulk of the fertilizer subsidy being in the nature of intra-economy transfer and, therefore, not a drain on the exchequer.

2.3.2 **Studies in favour of removal of subsidy**

*Anjan Roy’s* (1992) paper justifies the government’s move regarding the decontrol of fertilizer prices on the following grounds that since price of Urea (N) remains uncontrolled, which small and marginal farmers mainly use, it will not affect the use of N. Considering that decontrolled varieties of fertilizers P& K are mostly used in commercial crops, any increase in prices of fertilizer can be offset by increasing procurement prices. A balanced use of NPK can be restored by introducing some checks, and at least by reducing subsidy would help government free from some fiscal burden.

A partial equilibrium analysis reveals that the removal of fertilizer subsidy leads to a decrease in retention price which will only marginally reduce the incomes of domestic producers, and will not have an adverse impact on employment in the fertilizer industry. A general equilibrium analysis finds importing of food grains a better alternative for increase per capita cereal consumption rather than relying on short term measures such as fertilizer subsidy. It also suggests irrigation as a better alternative; as investment on it leads to an increase in GDP, fertilizer use, production of food grains and welfare of rural and urban poorer classes. Any decrease in retention price would only marginally
reduce the Industry’s profits without affecting retail prices through fertilizer consumption and retail prices still needs to be reviewed to allow for greater competition and efficiency. Subsidiary on fertilizer prices ultimately plays a marginal role in promoting consumption in that whenever there has been a decrease in fertilizer prices, an impressive increase in consumption of fertilizers is also observed. Therefore, efforts should be focused on removing structural bottlenecks in fertilizer use through strengthening of distribution networks, and promotional efforts through extension programmes.

**D.T.Nanjegowda (1992)** observes that the continuation of subsidies to food grains and fertilizers has more disadvantages, as it erodes into government resources besides accentuating inflation and also various forms of subsidy to the agricultural sector has not brought about any expected returns. Thus, extension of subsidies to the agricultural sector should be judged not only from the agricultural productivity point of view but also its effects on the economy as a whole.

**Nita Singh (1992)** study examines the repercussions of fertilizer subsidy policy on incentives for Wheat Cultivation. The study, with respect to Panjab and madha pradesh , measures in terms of profits, compensating changes in output prices and their effects on the cropping pattern. In that a direct impact of an increase in fertilizer prices would get reflected in the quantity of fertilizers demanded, while an indirect impact in terms of changes in yield levels. Using elasticity measurement, the study finds the response of demand to changes in fertilizer prices inelastic even as farmers are very much aware of the advantages of using fertilizers and also that it is no longer determined by fertilizer prices.
Instead, it is largely determined by the availability of irrigation, and HYV seeds, rather than prices of fertilizers. The estimates indicate a 30 percent increase in fertilizer price offset by a 1.5 percent and 3 percent increase in output prices for wheat for MP and Punjab respectively. The study observes that any further hike in fertilizer prices should be compensated by raise in output price for which the government has to do a balancing act between the objective of reducing budgetary deficit on the one hand and the social cost of higher food prices. The study is in favor of compensating the farmers by providing remunerative prices to their output.

V.S. Vyas (2001) lays down a few imperatives for the agriculture sector particularly pertaining to agricultural subsidies, (for one none of the arguments for the continuation of subsidy holds good), agricultural subsidies lending to fiscal imbalance and crowding out public investment in agriculture. The study infers that in a situation wherein the marginal productivity of fertilizers and irrigation are showing a declining trend, an increased use of subsidized inputs will not help in any way increase production efficiency in the agriculture sector. The study calls for a time bound commitment to phase out fertilizer subsidies and also for diverting further investments towards strengthening of rural infrastructure, research and extension programmes. The study also strongly recommends the plugging of leakages in input supplies.

A study focusing on the issue of subsidy in the agricultural sector in terms of the rationale, magnitude and effects on the economy undertaken by Ashok Gulati and Anil Sharma (1995). Shows that Indian farmers remains net taxed
rather than net subsidized, hence subsidies to be abolished and the money invested in rural infrastructure, research and extension activities. The study finds the magnitude of subsidy amounting to 52.56 per cent over the triennium ending 1981-82 and Rs 131.07 crore over the triennium ending 1992-93 with respect to the total expenditure incurred on agriculture. The harmful effects identified include a wrong choice of crops (i.e., crops with more subsidy components) and injudicious use of fertilizers which lead to salinity and water logging besides polluting ground water, which in turn can accentuates regional imbalances, leaving a relatively new technology adoption. The measures suggested include less scope for decontrolling N, reducing subsidies and initiating drastic reforms in output prices.

Ashok Gulati and A.N.Sharma (1992) examine the degree of distortions in subsidies in the agricultural sector across several countries during the 1980s, with respect to the possible implications of subsidy reduction, and trace the origin of distortions in terms of policies followed by major countries; they also measure the degree of distortions on a country and commodity specific basis, and estimate in terms of “Producers subsidy equivalent” and present the position of various countries on subsidy reduction and liberalization. The finding at the macro level reveals Japan emerging as the highest protector of its farm sector followed by the European community. It is shown that India would gain if it lowered its protection to the farm sector. Further highly protected commodities like rice, wheat and cotton can find a significant export market if protection is removed. The study suggests the reallocation of resources from highly protected crops to those crops
not protected; however, the potential for export market is very low, but these crops are very important interview of meeting food requirements at the domestic level, since commodities such as wheat, rice fruits and vegetables have the potential to become major foreign exchange earners. On the whole, agriculture would be greatly benefited and would fetch higher incomes if reforms at the global level are carried out effectively, the very demand pattern in the country would change.

The increasing burden of fertilizer subsidy made Ashok Gulati (1990) to examine the issue whether Indian farmers are subsidized or not, and also examines the relationship between Crop- fertilizer prices. He finds fertilizer subsidy to cultivators amounting to only 48 per cent with the remaining 52 per cent assumed to be going to the fertilizer industry in the form of intra economy transfers within the government agencies such as from ONGC to CIL and state Electricity Boards and as such can not be called as subsidy. With regard to crop fertilizer ratio (In respect of major crops such as wheat, rice and cotton which account for a major share of fertilizer consumption) under a free and controlled trade regime (wheat, rice and cotton), it is found that Indian farmers stand to gain more under a free trade scenario rather than under a controlled trade regime. Under a controlled trade situation, Indian cultivators face unfavorable crop fertilizer price ratios when compared to ratios prevailing in most Asian and Pacific countries. Thus, it is inferred that Indian farmers are net taxed rather than net subsidized despite a large quantum of subsidy extended to fertilizers with no economic relevance.
Ashok Gulati and G.D. Kalra (1992) in their study suggest ways to offset the burden of fertilizer price hike, which simultaneously affects the farmers, the fertilizer industry and consumers. On farmers’ front, an increase in fertilizer prices can be absorbed through an increase in support and procurement prices of main fertilizer consuming crops (i.e. wheat, Rice and cotton). As for the fertilizer industry, a comprehensive exercise involving the computation of domestic resources cost of producing fertilizers on a plant and product specific basis for identifying plants that need to improve efficiency. Needs to be put in place on the consumer front, there is an urgent need to reorient the public distribution system making it more focused towards the poorer sections of the society. They emphasize the improving of an increased investment on irrigation which would help both in terms of increasing food grain output and employment.

Vidya Sagar (1996) observes that an increase in the price of fertilizers is the only available alternative for reducing fertilizer subsides. He supports a dual pricing policy of fertilizers to save the interests of small and marginal farmers.

D.S. Tyagi (1993) in his paper titled “Pricing of Fertilizer,” argues that the benefits of subsidies are being enjoyed by all sections of consumers. He is of the view that a large part of the increased burden on the part of farmers must be shared by all sections of consumers of agricultural produce.

Gunvant M. Desai (1993) in his paper on fertilizer policies raises the question of how to sustain the growth of fertilizer consumption with a minimum adverse impact on fiscal resources and environment. He points out that it can be achieved through a better management of demand for and supply of fertilizers.
Ashok Gulati and G.D. Kalra (1993) look at the issue of fertilizer subsidy by way of focusing on ‘equity and efficiency’. They argue on the basis of empirical evidence that investment in irrigation is a better policy option rather than subsidizing fertilizer. By way of questioning ‘Who benefits from fertilizer subsidy’? Pratap Narayan (1993) observes that the subsidy has benefited neither the industry nor the farmers, excepting the consumers of food grains. M.H. Majumdar (1993) attempts a component based analysis to determine the share of subsidy going to the farm and non-farm sectors and finds the subsidy component of farm and non-farm sectors at the ratio of 2:1.

U.K. Srivastava (1993) reviews research studies relating to “Price Elasticity” of Fertilizer Demand in India. He stresses the need for estimating price elasticity of fertilizer demand at disaggregate levels such as state, crop wise, farm size wise, etc., and suggests that non-price factors must be incorporated into the demand model along with the price factor for obtaining meaningful and reliable estimates. The study reveals mixed reaction with respect to a reduction in fertilizer subsidy: A few studies clearly point out that a fertilizer price hike would likely to have an adverse impact on consumption, agricultural production and farm income, whereas a few other studies point out the leakages in subsidy distribution and suggests measures for plug giving the leakages and making it more efficient. It is also observed that a differential price rise across different nutrients (NPK) would result in a high level application of cheaper fertilizers resulting in distortions in the use of fertilizers which in turn will adversely affect productivity and soil conditions. Some studies have revealed that technological absorption would be
limited if distortions in the protection given to agriculture are not corrected. Some studies favor the discontinuation of fertilizer subsidy on the grounds that fertilizer subsidy has no economic relevance and that it does not benefit the farmer either. It has also been clearly brought out that Indian agriculture remains highly protected thereby not allowing the farming community to reap the benefits of a liberalized economy. They are unanimous in recognizing not only the importance of organic manures as a substitute for chemical fertilizers but also of an enhanced investment on public investment in agriculture particularly on irrigation either thoroughly removing or rationalizing fertilizer subsidy.

Nompoothin and Desai (1996) emphasize the role of supply side factors in promoting fertilizer growth. The study finds the growth rate of fertilizer consumption declining from 27 percent to 10 percent in the 1970’s and to 6 percent in the 1980’s. The decrease is not due to an adverse price environment but due to a virtual stagnation in the potential creation through HYV-irrigation. With respect to the 1980’s, top supply side factors such as the density of distribution network and the availability of credit through co-operatives shows a higher correlation with respect to fertilizer consumption than the demand side factors like irrigation and the availability of HYVs. The study emphasizes the need for location specific adaptive research and better agronomic practices for improving fertilizer use efficiency so as to reap the potential to its maximum extent.

M.S. Bhatia (1983) examines the variations in fertilizer consumption across different states based on data for the year 1977-78 collected from 8430 cultivators spread over 16 states which constitute 97 percent of the total fertilizer
consumption in the country. The study reveals significant variations in the consumption of fertilizers in various states in relation to the all India pattern of fertilizer consumption. The analysis shows food grains alone accounting for 75 to 78 per cent of the total fertilizer consumed while the remaining 22 to 25 per cent by non-food grain and other commercial crops. Results of the study clearly show variations across regions and the scope for enhancing fertilizer consumption in regions where the level of consumption is very low coupled with a very high marginal productivity for fertilizers. This would help increase the overall fertilizer response ratio in the country besides reducing disparities in agricultural productivity across different states.

2. 4 Fertilizers use efficiency

*Bundyopadhya (1992)* examines the efficiency of chemical fertilizers (NPK use) in terms of yield per unit of plant nutrients applied for paddy cultivation in states of Assam, Orissa and West Bengal with two sets of villages, one set of villages were provided with vital production inputs, training, improved production techniques and free soil testing, while the Second set of villages were kept as control villages without providing any such inputs. Surprisingly, contrary to the expected results, there was no significant difference between the two sets of villages in terms of fertilizer use efficiency and output realized; in both the villages, fertilizer use efficiency was found appreciably high. These unexpected results clearly reveal that farmers use their own rational in choosing their production technology, i.e., given the suitability of any technology, farmers would adopt them even without the support of any extension support or subsidized
inputs. This puts the onus on the researchers and policy makers to develop region-specific production technologies.

**M.K. Chaudhary and Dalel Singh (1992)** look into fertilizer usage for rice and wheat crops in the North Eastern region of Haryana which accounts for a major share of the total fertilizer consumption in the state; and per hectare fertilizer application is also very high, in this region, about 150 kg per hectare. Their study reveals that fertilizer use response to rice and wheat has been declining over the years, and the major factors identified include declining fertilizer use efficiency over time and the method of fertilizer application, selection of fertilizer responsive varieties, weed infestation, improper irrigation management. It is also observed that farmers apply only main nutrients ignoring the importance of micro nutrients and that the application of organic manure is almost forgotten.

**K. H. Rao, Jacob George and R.R. Hermon (1992)** in their article make an attempt to study the issue of fertilizer use efficiency for rice crop in Nizamabad district of Andhra Pradesh under divergent conditions. Yield levels are found higher under well irrigation as compared to canal irrigation with the fertilizer use efficiency being highest under irrigated red soils. It clearly brings out the role of irrigation in determining the efficiency of fertilizer use.

**P. Sunandini, Shaik Haffis, C.A. Rama Rao and Y.V.R. Reddy (1992)** in their paper analyze input use efficiency in respect of paddy farms in West Godavari district of Andhra Pradesh, using Cobb-Douglas Production Function. The results reveal that the marginal value of production to factor cost ratio associated with each input factor under the study is higher than unity, indicating the
underutilization of resources by both small and large farms. It clearly brings out the fact that there is a sufficient scope for maximizing gross incomes by increasing the use of inputs, particularly fertilizer in Rabi season.

Frank Notes (1985), emphasize fertilizer use efficiency in order to increase agricultural production. He observes that, given the limitation of further expansion of cultivable area it is inevitable to increase productivity per unit area through intensive use of external plant nutrients, particularly chemical fertilizers. However, an intensive use of costly chemical fertilizers is accompanied by increased cost of cultivation. Hence, optimizing the use of fertilizers would lead to an increase in profit through higher yield. He further observes that there is a need for proper agronomical practices through an appropriate combination of different nutrients depending on soil and climatic conditions. Under an intensive cropping system, a balanced use of all essential nutrients including secondary nutrients assumes greater significance he observes that in this respect, the use of micronutrients, proper soil conservation measures, watershed management etc. need to be encouraged for increasing fertilizer use efficiency.

U.K. Pandey, Veena Manocha and K.C.Goel (1992) examine, based on secondary data, two related aspects, i.e., productivity growth in relation to the pattern of input-output and differences in natural resource endowments in respect of all the districts of Haryana and find that modern inputs along with an appropriate technological combination would lead to a rapid agricultural growth with an emphasis on agricultural research and extension activities. The Results indicate that areas which receive a relatively higher rainfall record a high growth
in output, and that further agricultural productivity can be increased through evolving an appropriate dry land technology.

R.N. Yadav, M.P.Azad and Vipin Kumar (1987) study tries to estimate the extent to which farm income can be maximized through an optimum use of fertilizer and irrigation without resorting to any change in the cropping pattern. Based on Cobb-Douglas production function, the results point out that the marginal value of productivity of fertilizers and irrigation is higher in comparison to other independent variables like human and bullock labour and seeds. And shifting of funds from human labour, bullock labour and seeds towards the use of fertilizers and irrigation, leads to a maximum possible increase in production per unit of area. The estimates also indicate that net income can be increased by three folds through reallocation of available funds to the farm sector along with the optimization techniques of farm resources without effecting changes in the cropping pattern, and additional investments.

V.N.Misra (1971) study based on a survey of 156 cultivators in shahabad district of Bihar coming under IADP programme, attempts a comparative analysis uses Cobb-Douglas production function for measuring the efficiency of resource use through marginal returns on fertilizers. Two sets of data comprising both fertilizer users and non-fertilizer users have been analyzed. A comparison of marginal returns on fertilizer with their costs reveals that there is no significance difference in the efficiency of resources use between users and non-users, and that a further scope exists for increasing net revenue by increasing inputs. A higher marginal productivity of fertilizers suggests that there is still much scope for increasing the
use of fertilizer per unit of land in order to optimize the returns. The study also finds that the sample farmers do not apply fertilizers to an optimum level.

2. 5 Imbalance in nutrients use ratios;

One of the critical issues has been the imbalance and overuse of fertilizers (N-P-K) brought about by distortions in price ratios in favour of N fertiliser. This has already caused widespread soil degradation and reduced productivity, which is becoming more acute with the passage of time (Planning Commission, 2007). Several researchers have examined this issue as presented below.

B.C.Biswas and T.K.Chandhra (1992) look into the productivity issue in India and China while attempting to identify the potential reasons for variations in food production and productivity levels. They observe that china has managed to achieve a higher growth in agricultural production as compared to India through integrated and balanced use of chemical and organic manures containing micro nutrients, efficient soil and water management, use of HYV seeds, efficient training and management programmes for farmers which in turn have ensured very little gaps between knowledge and practice. The authors suggested that to internalize Chinese practices and to increase fertilizer production, revamping and modernization of fertilizer plants is important.

R.H. Khatkar, J.C.Karwasra, K.S. Suhag and B.S. Duhan (1992) observe that oil seeds and pulses respond well to fertilizer use in all states and that there exists a very high response in the case of sugarcane. On the basis of experiments conducted at farmers’ fields and secondary data, they find that there exists a sufficient scope for increasing productivity of agricultural crops in less developed
states and rain fed areas through a balance use of NPK. Through their experiments, researchers have developed an optimum combination of different nutrients for different crops. They opined that the efficiency of fertilizer use could be higher if recommended dosages were applied.

H.K.Bal, Sandeep Kapur and H.S.Bal (1992), argue that the use of fertilizer exerts a profound influence on the structure of Indian Agriculture, particularly on Punjab’s agricultural system. It observed that farmers use more quantities of fertilizers for wheat and paddy than what is actually required. Based on survey undertaken to find variations in actual and recommended doses of fertilizers, using farm level data with a sample size of 300 farmers in the year 1990-91 in Punjab, the study reveals that in the case of wheat, the average use of fertilizer was happens to be less than the departmental recommendation; however, in some areas an overuse of fertilizers is observed. In the case of paddy, a large number of farmers are found to have used excessive doses, resulting in the lowering of farm profits, and polluting of ground water. The study emphasizes on motivating the farmers to adopt better farm practices and modifying the recommendation from time to time and from region to region in order to make an effective utilization of fertilizers, a costly input.

A study undertaken by A. Raja (1992) for examining factors influencing the productivity of HYV Paddy and the extent of inter farm variations in the productivity of paddy in relation to various inputs used per unit of cultivated area, employs ‘Cobb-Douglas Production Function’ by taking Paddy output as a dependent variable and input as an explanatory variable. The results show that
output of paddy declines with an increase in farm size. In the case of labour input, it is a labour intensive activity. The output elasticity of organic manure is found positive, indicating that production can be increased with an increased use of organic manure. In the case of fertilizers, output elasticity is found negative indicating an excessive application of fertilizer and any additional application results in productivity decline beside leading to unavoidable side effects. Thus it is inferred that productivity of paddy can be further increased by readjustments in the use of resource inputs.

**M.Champati and S.C.Patnaik (1986)** make an attempt to examine the extent of adoption of improved agricultural practices in Balasore district in Orissa across 38 villages spread over 6 blocks. The major objective of the study was to examine the differences between recommended practices like the cropping pattern, fertilizer application and the resultant yield levels, with respect to fertilizers, it is found that almost all sample cultivators use less than recommended doses of N throughout. It also observes that during the rainy kharif season nearly 57 per cent of farmers do not apply any fertilizer at all. However, a majority of them use between 25 to 75 per cent of recommended dosage of N. In the case of phosphate, 97 per cent of farmers do not apply phosphate during the rainy season to rice while; only 11 per cent apply phosphate for winter rice crop. In the case of potassium, a higher percentage of sample respondents do not apply any amount of potash during the rainy season (98%), however for winter crop about 29 per cent of farmers are found to have applied potash. In total, it is observed that, none of the respondents is found to have applied recommended doses during any season,
i.e., either they have applied more than recommended or less than recommended doses. The study further points out those quantities of various inputs used and yields received by farmers and the norms fixed by the government in this respect widely differ across farm classes. The yield level are found less than expected because of the unbalanced doses of input used; and it is also found that sample cultivators are not aware of the importance of the timely application of various inputs. The study recommends the strengthening extension services to create awareness among cultivators regarding the recommended package of practices in addition to the timely application of required inputs so as to reap the expected benefits.

**Desai and Rustagi** analyze the impact of agro climatic factors on agricultural growth and productivity in general and fertilizer in particular. The study finds that the growth rate of output is positively associated an efficient use of fertilizers, while suggesting a balanced use of. The study also finds 57 percent of the cultivators in Panjab using nitrogenous fertilizers during the eighties declining to about 37 percent by 1987.

**Gandhi, Desai, Raheja and Prem Narain** estimate fertilizer response functions to understand the overall environment for fertilizer consumption in India and the future growth of fertilizer usage for major food grain crops like wheat and rice. They analyze secondary data pertaining to 51 districts spread over 6 geographical regions for a period of four years. Their analysis of fertilizer response to the use of N & P alone and NPK across different regions reveals that there exist imbalances in fertilizer application for wheat in North India and Rice
in South India. The study recommends of fertilizer consumption in favour of Uttar Pradesh and the central region which account for an additional 6 million tones of wheat production. Similarly, reallocating away from the south along with a balanced use of NPK may increase rice production by 15.4 metric tones resulting in an additional fertilizer consumption of 2.9 million tones.

S.P.Pant (1980) examines the impact of fertilizer price increase on consumption and agricultural output. He analyzes the relationship between fertilizer prices and fertilizer consumption for the period 1966-67 to 1978-79 and finds no significant relationship between fertilizer consumption and their prices. The study further serves that technological progress exerts a greater emphasis on the use of fertilizer rather than the relative price of fertilizers. It also shows that the application of fertilizers remains profitable in spite of fertilizer price rise though the rate of profitability is found declining. With respect to intensity effect, it is observed that price rise affects intensity effect and influence in spread effect was not violent. The demand function of fertilizer depends not only on the relative prices but also structural and institutional variables particularly institutional credit. He views that technological development, assured irrigation, better managerial practices and supply of credit can ensure a continued growth of fertilizer consumption and thereby agricultural production.

J.C Katyal and R.K Rattan (2002), in their paper titled “Integrated plant nutrition system to meet the challenges of nutrient mining threatening sustainable agriculture”, sums up that increasing agricultural productivity would be at the cost of depletion of soil nutrients, which can be made good only through an integrated
nutrient management and supply system, wherein a combined use of man made fertilizers and natural nutrient sources can become an integral feature of soil fertility maintenance for the sustainable development of agriculture.

In the case of fertilizers, one of the critical issues related to subsidies concerns the imbalance and overuse of fertilizers (N-P-K) brought about by distortions in price ratios in favour of N fertilizer. This has already caused widespread soil degradation and reduced productivity, which is becoming more acute with the passage of time (Planning Commission, 2007). Several researchers have examined this issue as presented below.

**Duxbury (2000)** uses a composite index for the imbalance the in use of N-P-K that indicates Punjab and Haryana topping the imbalance list in fertilizer use followed by Bihar, Kerala and Rajasthan. An overuse of synthetic fertilizers (particularly N fertilizers) is the main reason behind the imbalanced use of synthetic fertilizers. Further, Discrepancy and overuse of fertilizers are highly problematic especially because they cause extreme levels of soil degradation and associated losses in yield level. While analyzing the data from several long-term experiments on intensive rice-wheat systems, the study finds that there has been a significant decline or stagnation in yield level especially in respect of rice. For example, rice yields in respect of the highest yielding treatments in eight out of 11 long-term (over eight years) rice-wheat experiments in India and Nepal have declined, while in three cases, wheat yields have declined.

**Bhandari (2002)** also reports multiple such observations of yield fatigue raising concerns about the long-term sustainability of the intensive rice-based cropping
systems. He tracks the decline in rice yields at an average rate of 23 kg/ha each year using data from 33 long-term experiments in South Asia, most of which have been conducted in India. This yield decline is attributed to the loss of organic matter, decrease in nutrient supply, and climate fluctuations. Based on a 14-year study carried out with respect to Punjab, the study notes that rice yields have declined even when the recommended rates of nutrients (N-P-K) are applied. This decline is attributed to the total loss of soil nitrogen and organic matter.

Banga, (2005) reports that in Punjab, the state with the highest use of synthetic fertilizers in India, data on the relationship between food grain production and fertilizer consumption from 1960 to 2003 clearly shows, in spite of a consistent increment in N-P-K fertilizer consumption, food grain yields remaining not only practically stagnant but also declining with increased fertilizer application for the latter period of 1992 to 2003.

According to a review by the Food and Agricultural Organization (FAO) in the 1990s, about half of the cultivable soils in India remain degraded, accounting for the highest percentage in the Asian-Pacific region. Moreover, soil degradation in India continues to be a major problem, especially for food production and food security. Since World War II, soil degradation in Asia has led to a cumulative loss of crop productivity to the extent of 12.8 per cent. Improper management of soil fertility, including overuse and an imbalanced use of synthetic fertilizers, is one of the causes behind soil degradation in general, (and is thus linked to food insecurity worldwide) and India in particular Soil degradation- mainly a decline in soil organic matter both in terms of quality and quantity- is one of the major
reasons linked to stagnation and a decline in yields in the most intensive agriculture areas in India (Dawe 2000; Yadav 2000; Ladha, 2003). The decline in soil organic matter is related to an improper use of synthetic fertilizers and the lack of organic fertilization (e.g. addition of fertilizers rich in organic matter, like compost, manure or green manure), and practices that are now widespread in the most intensive agriculture areas in India (Masto et al., 2008, Singh et al., 2005). An emerging concern in rice-wheat systems is the reduction in soil organic matter and the associated reduction in nutrient supplying capacity.

Nambiar (1993) reports a soil organic matter decline in soil systems not receiving farmyard manure in some long-term experiments (LTEs) in India, besides observing that application of farm yard manure is effective in building up soil organic matter and boosting crop yields. In the present rice-based cropping systems, crop residues are either burnt or removed from the field for stock feed and bedding, roofing and fencing. The traditional practice in many places of the Indo Gangetic Plains of burning rice straw after harvest causes large scale losses of major nutrients and micronutrients.

Another component of soil degradation impacting Indian agriculture productivity relates to a negative nutrient balance, both for macro and micro-nutrients. In general, soil nutrient balances in the region are negative, due to inappropriate fertilizer applications (Ladha et al., 2003). Integrated nutrient management, including the application of organic amendments is a practice for improving the nitrogen status of soils (Dwivedi, 2003, Masto, 2008, Yadav, 2000).
Masto (2008) reports that the common practice of applying mostly nitrogen fertilizers (usually only urea) which gets influenced by the government’s subsidy system on nitrogen, is not only causing nutrient imbalances, but also negatively affecting the physical and biological properties of the soil systems. For example, indicators of good soil fertility like microbial biomass, enzymatic activity and water-holding capacity all have got drastically reduced under the common nitrogen fertilizer practices.

Darilek (2009) finds another common detrimental effect of the excessive use of nitrogen fertilizer on soil health - acidification and the impact it has on living organisms in the soil systems which are crucial to the natural nutrient cycling. Many Indian scientists have called for a revision of the current unsustainable farming practices, that are causing soil degradation besides compromising on the future of the country’s food security (Gupta and Seth, 2007, Mandal et al., 2007, Masto et al., 2008, Prasad, 2006, Ranganathan ., 2008). The role of fertilizer inputs in the agricultural growth is vital, considering the fact that among the soil nutrient deficiencies in India, the most extensive and important ones are those of nitrogen, phosphorus, potassium, zinc and sulphur. Deficiencies of iron, manganese, boron and molybdenum have also been reported from intensively cultivated areas.

Motsara (1982) works out a district-wise fertility index based on a 5 million soil sample analysis for the period 1973-77. It suggests that there is no correlation between the fertility index and fertilizer consumption with regard to all the nutrients i.e. N P K. This may be possibly due to the fact that fertilizer application
is not based on the soil test results. Again the author (2001) has worked out a nutrient index and the available NPK status based on the analysis of 3.65 million soil samples from different States for the period 1998-99.

The concept of ‘Soil Nutrient Index’ was deployed by Parkar (1951) while comparing the fertility levels of different areas. Fertilisers have been used for a century or more in most countries where agriculture is now well developed. But in India, their crucial role in the development of agriculture came to be recognised only in the mid sixties. Indian farmers used 338 thousand tones of NPK in 1960-61, which in 1970-71 about 6.7 times as much was used. The nutrient used in 1980-81, 1990-91 and 1998-99 came to 16.3, 37.1 and 49.5 times more as compared to 1960-61. These increases in the nutrients used for crops were essential for supporting the agricultural revolution which began in India during the mid sixties after the introduction of high yielding varieties (HYV) of wheat and rice and the development of irrigation infrastructure in the first phase.

The Planning Commission to assess the micronutrient deficiency in Indian soils, 252,000 soil samples and 25,600 plant samples from 20 States were analysed under the All India Coordinated Research Project for micronutrients (AICRP) and as per this study, 48 per cent of the samples have been found deficient in zinc, 33 per cent in boron, 13 per cent in molybdenum, 12 per cent in iron and 5 per cent in manganese. Over the last four decades, developments in fertilizer use have been dominated by N, while the share of P₂O₅ is much less than desired and the use of K is practically negligible. Crops raised on impoverished soils with an inadequate and unbalanced use of fertilizers are unable to fetch
expected returns. Although India happens to be the third largest fertilizer user, in
the world, the average rate of nutrient application works out to 96 kg/ha; further,
the consumption is highly concentrated in certain areas with large areas receiving
very little fertilizers. Across 466 districts (sub-units of states), 25 per cent of the
total fertilizer consumption is accounting for by 37 districts, 50 per cent by 102
districts and 75 per cent by 202 districts. The average rate of fertilizer application
is also indicative of a few well-fertilized areas with large areas receiving very
small rates of application: Less than 100 kg of N+P$_2$O$_5$+K$_2$O used by 65 per cent
of districts; between 100-200 kg of N+P$_2$O$_5$+K$_2$O used by 28 per cent of districts;
Greater than 200 kg of N+P$_2$O$_5$+K$_2$O used by 7 per cent of districts.

**Chapter Summary and Conclusion**

The above reading of literature throws up very clear propositions that the new
agricultural technology has made a lasting impression on agricultural production
and particularly chemical fertilizers in terms of determining the growth of the
agricultural sector. And further forecasts the critical role of fertilizers in
agricultural growth though many studies have tried to ascertain the factors
promoting the fertilizer use, but with regard to fertilizer prices are very scanty
and have expressed divergent opinions, however, in majority of cases the studies
covers only major crops and high yielding areas where as studies pertaining to
impact of changes in prices on consumption, agricultural production and,
cropping pattern are meager and studies clearly point out distortions in nutrient
use ratios but studies with regard to the distortions across the crops, irrigational
levels, farm-sizes are not updated, the micro level data with regard to improving
fertilizers use efficiency are not concentrated, while many studies have observed the importance of increasing levels of fertilizer consumption rather than improving fertilizer use efficiency. And calculations of economic loss due to imbalance use of fertilizers at micro level were lacking, hence the present study would try to fill the existing gaps and add to the existing literature.