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Improving the Effectiveness, Efficiency and Sustainability of Fertilizer Use in South Asia

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ABBREVIATIONS

| | |
|-----------|--|
| AIC, AICL | : Agricultural Inputs Corporation Limited |
| BADC | : Bangladesh Agricultural Development Corporation |
| BARC | : Bangladesh Agricultural Research Council |
| CFQCTI | : Central Fertilizer Quality Control Testing Institute (India) |
| DAP | : Di-ammonium Phosphate |
| DAE | : Department of Agricultural Extension |
| DC | : District Commissioner |
| FAO | : Food and Agriculture Organization |
| FAOSTAT | : Food and Agriculture Organization Corporate Statistical Database |
| FUE | : Fertilizer Use Efficiency |
| FMS | : Fertilizer Monitoring System |
| GDN | : Global Development Network |
| GOI | : Government of India |
| HYV | : High Yielding Variety |
| IFDC | : International Fertilizer Development Corporation |
| IPCC | : Intergovernmental Panel on Climate Change |
| LCC | : Leaf Colour Chart |
| MOP | : Muriate of Potash |
| MRP | : Maximum Retail Price |
| NBS | : Nutrient Based Subsidy |
| N | : Nitrogen |
| NGO | : Non Government Organization |
| NPKS | : Nitrogen, Phosphorus, Potash, Sulfur |
| NI | : Nitrification Inhibitor |
| SRDI | : Soil Resource Development Institute (Bangladesh) |
| SSP | : Single Super Phosphate |
| TSP | : Triple Super Phosphate |
| UNO | : Upazila Nirbahi Officer (Bangladesh) |
| VCR | : Value Cost Ratio |
| WDI | : World Development Index |

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ABSTRACT

This study aims to identify the major constraints that reduce the effectiveness, efficiency, and sustainability of fertilizer use in South Asia. These factors cover threefold issue at different stages of fertilizer use: economic factors, physical and technological factors, and institutional factors. Over the last few decades, declining yield response is increasingly emerging as an important concern in South Asian agriculture. The current pattern of fertilizer use with heavy reliance on nitrogenous fertilizer coupled with poor nutrition management, lack of complementary inputs, declining soil fertility, and weak marketing and distribution systems have emerged as major impediments to improving the effectiveness in fertilizer use in the region. Due to lack of efficiency and effectiveness in fertilizer use, the sustainability of fertilizer use has also come under question. The high imbalance in fertilizer application is an important element of nutrition mismanagement. Irrigation water and better seeds are the other complementary inputs needed for efficient use of fertilizer. The rise of individualistic groundwater based irrigation has made South Asia's large scale surface irrigation schemes to under-perform. Despite the potential benefits from drip and sprinkler irrigation methods, the rate of adoption of drip and fertigation in South Asia is low and slow. Inadequate extension services, underuse of domestic capacity, limited access to credit, and inefficient fertilizer distribution system are several institutional factors that constrain the optimal use of fertilizer. The scope of improving the efficiency and effectiveness of using existing inputs (especially fertilizer) is relatively large in South Asian agriculture due to many factors including inappropriate policies that bring inefficiencies in the production systems by distorting prices and promoting less productive mix of inputs. This shows that one of the important pathways that matters most in South Asia for poverty reduction and food security is to enhance the efficiency and effectiveness of fertilizer use in agriculture and increase productivity from technological advances. The gains from improved fertilizer use is likely to be large as there has been a considerable expansion of fertilizer use in all South Asian countries resulting from wide adoption of the Green Revolution technology.

The role of agriculture in the countries of South Asia varies depending upon the extent to which they rely on the sector as a source of growth and contributor to poverty reduction. Such reliance has traditionally been high in almost all South Asian countries. South Asia witnessed rapid growth in food grains (mainly wheat and rice) productivity, especially during the 1970s and 1980s, made possible by the 'Green Revolution' technology which significantly contributed to improving food security and expanding employment opportunities. This also saved millions of lives and led to notable decline in poverty across the countries of South Asia despite high growth in population. Over the last fifty years, the population in South Asia has nearly tripled from 561 million in 1960 to 1.60 billion in 2010 which is likely to increase further to 2.32 billion by 2050 (UN 2009, WDI 2010).

Rising population, along with increasing income, has been fuelling a growing demand for food in the region. During 1961-2009, cereal production in South Asia has more than doubled which was achieved mostly through raising productivity by using modern inputs like high yielding variety (HYV) seeds, fertilizer, and irrigation. Despite the progress, the recent decades have seen stagnation and decline in agricultural productivity throughout much of South Asia along with rising food prices and deeper concerns about feeding a rapidly growing population. In the last several years, a renewed focus has therefore been given to agriculture by the policy makers in South Asia and to understand the urgency of supporting agricultural development in the region.

Overall one can conceive of three options for expanding agricultural (food) production in South Asia: first, raising efficiency with which farm inputs and technologies are being used at present; second, using more productive inputs while technologies do not change; and third, adopting improved technologies that raise outputs while input application rates may remain the same. Among the three options, the first two can help the smallholder farmers to reap immediate benefits of higher farm outputs and enhance their incomes and living conditions. On the other hand, option three is particularly important for raising the welfare of the consumers including a large segment of the poor households (resulting from lower real food prices) in both rural and urban areas who are net buyers of food in South Asia¹.

The scope of improving efficiency and effectiveness of using existing inputs (especially fertilizer) is relatively large in South Asian agriculture due to many factors including inappropriate policies that bring inefficiencies in the production systems by distorting prices and promoting less productive mix of inputs². This shows that one of the important pathways that matters most in South Asia for poverty reduction and food security is to enhance the efficiency and effectiveness of fertilizer use in agriculture and increased productivity from technological advances. The gains from improved fertilizer use is likely to be large as there has been a considerable expansion of fertilizer use in all South Asian countries resulting from wide adoption of the Green Revolution technology.

¹ One reason for this is that income and price elasticities of demand for food tend to be low. The broad capacity of productivity growth in agriculture to benefit even the poor consumers who are not involved in farming gives agriculture a strong fighting power against poverty relative to other sectors.

² The decomposition analysis of total factor productivity growth typically finds sizable efficiency gains in countries like China and Vietnam resulting from policy and institutional change. See EIU 2008. The South Asian countries may also derive similar benefits.

1.1 Cereal Production in South Asia

Over the last two decades, the growth rate in cereal production has been showing a declining trend which has emerged as a major area of concern for the South Asian policy makers (Table 1.1). The slowdown, along with the degradation of natural resources and changing climatic conditions, have increased concerns regarding food security in South Asia³. Long run estimates suggest that if urgent actions are not taken to reverse the trend, more than 17 percent of total population in South Asia may face food insecurity by 2050 (Titumir and Basak 2011).

Table 1.1
Growth of Cereal Production in South Asia ▼

| Regions | 1961-75 | 1976-90 | 1991-05 |
|----------------------|---------|---------|---------|
| Production | 2.3 | 3.0 | 1.8 |
| Crop Area | 0.4 | 0.1 | 0 |
| Production Intensity | 0.2 | 0.3 | 0 |
| Yeild | 1.7 | 2.6 | 1.8 |

Source: FAOSTAT

Recent experience shows that the successful food grains production strategy based on HYVs of seed, fertilizer, irrigation and other modern inputs of the earlier decades is unlikely to sustain agricultural growth in the longer term in South Asia. For ensuring a sustainable base, South Asia needs a high-value agricultural revolution for which, along with new technologies, wider avenues for revitalizing agriculture are needed through diversification and value addition. This requires supportive policies to encourage farmers to move out from traditional cropping patterns to accommodate new and more profitable crops, invest more in productivity-enhancing areas (e.g. technology, market support services, rural infrastructure), and ensure sustainable productivity growth through removing policy distortions that cause nutrient imbalances, over-extraction of groundwater, water-logging and salinity in potential irrigated areas. The agricultural technology and innovation systems need re-direction and strengthening along with a renewed focus on domestic trade, agro-processing, and land and credit markets that encourage increasing private investments in the farm sector.

³ The South Asian region is highly sensitive to the consequences of climate change and is known to be the most disaster prone region in the world. The fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC) listed serious consequences of climate change for the South Asian region. The melting of the Himalayan glaciers will lead to increased flooding and affect water resources within the next two to three decades. A rise in temperature will negatively impact rice and wheat yields in the tropical parts of South Asia where these crops are already being grown close to their temperature tolerance threshold.

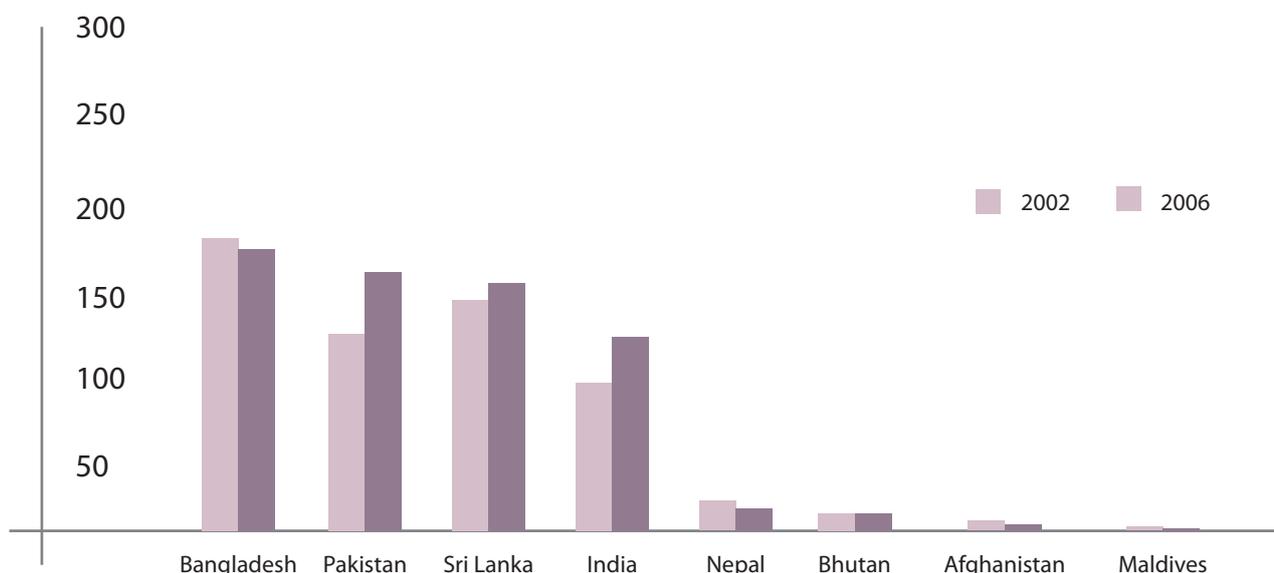
As an integral component of the Green Revolution technology, fertilizer has played a key role in increasing crop yield in South Asia (see, for example, Tomich et.al. 1995, Bumb 1995, Hopper 1993, FAO 1998, 2011). Fertilizer consumption in the region has grown rapidly at 4.0 percent per year over the last decade and the region currently accounts for more than 20 percent of the total global fertilizer consumption.

Although South Asia is an important global consumer of fertilizer, the intensity of its use is still low compared with other regions. An analysis of fertilizer use intensity in the region reveals that, on average, the application rates in South Asia are low. Moreover, the intensity of fertilizer use varies significantly among the South Asian countries with a low of 20.1 kg/ha in Nepal to 180.2 kg/ha in Bangladesh (Figure 1.1).

It has also been observed that the yield response to fertilizer is declining in South Asia. The amount of food grains produced per kilogram of NPK fertilizer has declined from 14.3 kg in 1971-80 to 11.7 kg during 1981-90 and further to 10.9 kg in 1991-98 (Katyal and Reddy 2005). The efficiency of fertilizer use is relatively low in South Asia so that improving efficiency, rather than raising the levels of application, is crucial to raising yields in South Asian countries (Liefert 1995).

The current pattern of fertilizer use with heavy reliance on nitrogenous fertilizer coupled with poor nutrition management, lack of complementary inputs, declining soil fertility, and weak marketing and distribution systems have emerged as major constraints to improving the effectiveness of fertilizer use in the region. The low effectiveness of fertilizers has also led to a reduction in the agronomic efficiency of fertilizer use⁴. Due to low efficiency and effectiveness, the sustainability of fertilizer use has also come under questions. Fertilizer nutrients applied but not taken up by the crops contribute to environmental ills ranging from nitrate leaching to greenhouse gas emissions (Bumb and Baanante 1996, Raun and Johnson 1999).

Figure 1.1
Fertilizer Use Intensity in South Asian Countries ▼



Source: World Research Institute (WRI), Earttrends Searchable Database Results.

Note: Fertiliser use intensity is the amount of fertiliser (nutrients) consumed by agriculture per hectare of temporary & permanent cropland. In the case of Bhutan, the fertiliser intensity of 2002 corresponds to 2005

⁴ Over the last five decades, nutrient use has increased by a phenomenal 1573 percent in India while total food grain production increased by 145 percent contributed by an area increase of 3.5 percent and average yield increase of 125 percent. This shows that the input use efficiency is declining at a fast pace, posing a threat to food insecurity which rapidly engulfs the poor and underprivileged population. See Katyal and Reddy 2005.

Considering the central role that agriculture plays especially in the rural economies of the South Asian countries, promoting efficient and effective use of fertilizer has emerged as an important target of policies and programs in recent decades (see, for example, Hossain and Singh 2000, Gisselquist and Van der Meer 2001, Crawford, Jayne, and Kelly 2006, Minot and Benson 2009, Morris, Ronchi, and Rohrbach 2009). The privatization and liberalization of the fertilizer sector over the years have significantly improved the availability of fertilizer in South Asia but it has not necessarily succeeded in eliminating supply bottlenecks and ensuring fair prices of fertilizers at the farm level. The current distribution systems are still not adequate to supply fertilizers on time or provide fertilizers in remote areas. Furthermore, the fertilizer subsidy policies are putting heavy pressure on the government budgets and have not guaranteed the flow of proportionate benefits to the farmers. The policies have also led to serious distortions in fertilizer consumption toward nitrogenous nutrients reducing efficiency and effectiveness of fertilizer use which have been compounded by low and unbalanced use of fertilizer creating deficiency in organic matters and seriously threatening the sustainability of fertilizer use in South Asia.

1.2 About the Report

This study analyzes the current status of fertilizer use in South Asia in order to identify the major constraints that reduce the effectiveness and efficiency, and hence sustainability of fertilizer use in South Asia⁵. The report draws mainly from existing studies relating to various dimensions of fertilizer use in the case study countries⁶. It is, however, important to recognize that not all findings of the report may be subjected to generalization for all South Asian countries or even for all areas in the same country due to agro-climatic and other differences among different regions. Nevertheless, these conclusions certainly can act as pointers to broad aspects for improving efficiency, effectiveness, and sustainability of fertilizer use that are relevant to countries not only in South Asia but also for countries having similar agro-climatic characteristics in other regions.

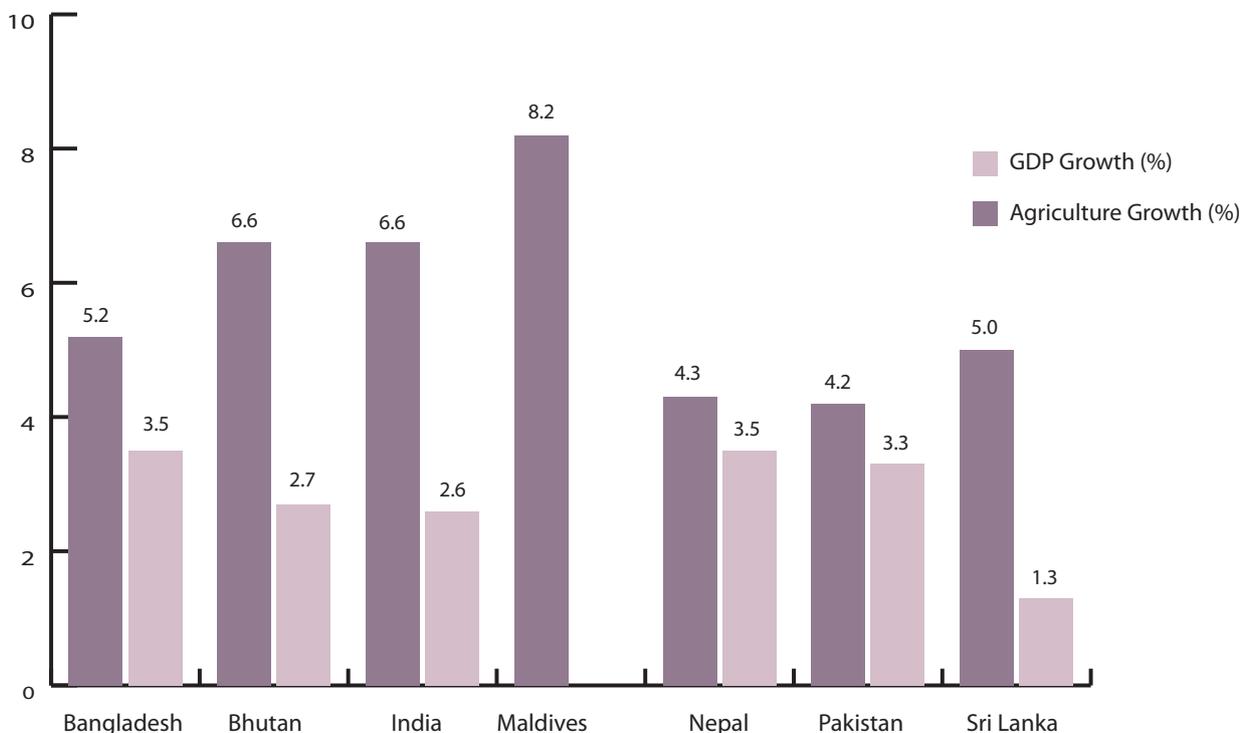
⁵ Efficiency is defined as the output to input ratio and focuses on getting the maximum output with minimum resources. Effectiveness, on the other hand, measures if the actual output meets the desired output. Since efficiency is all about focusing on the process, importance is given to the 'means' of doing things whereas effectiveness focuses on achieving the 'end' goal. Efficiency is concerned with the present state or the 'status quo'. Thinking about the future and adding or eliminating any resources might disturb the current state of efficiency. Effectiveness, on the other hand, believes in meeting the end goal and therefore takes into consideration any variables that may change in the future.

⁶ The study was sponsored by the Global Development Network (GDN). Three countries—Bangladesh, India, and Nepal—were selected to conduct case studies considering their importance in fertilizer consumption and representative potential for South Asia. The details of country level issues are available in separate case study reports for the three countries—Bangladesh, India, and Nepal.

Agriculture in South Asia is the home of small farmers for whom agricultural activities are the main source of livelihood. With a cultivable area of about 200 million hectares, there operate around 125 million holdings having an average size of 1.6 hectares. Of these, more than 80 percent are extremely small holdings with an average size of less than 0.6 hectare. In Bangladesh, for example, 96 percent of the holdings have an average size of only 0.3 hectare. Agriculture, however, engages about half of the work force and contributes nearly a quarter to the region's GDP. With rapid transformation and urbanization in all South Asian countries, the industries and services linked to agriculture in value chain often account for more than 30 percent of GDP (World Bank 2008).

Another important feature of agriculture in South Asia is its low growth relative to growth in GDP (Figure 2.1). Although the land area of South Asia is about 444 million hectares (3.4 percent of the total land area in the world), its total cropped area is 205 million hectares which is 13.6 percent of the world's total cropped area. Overall, at least 94 percent of suitable land is already farmed in South Asia and many of these existing farm-lands and pastures are facing land degradation that threatens their productivity. With nearly no further scope for expansion of arable land on the one hand and the increasing food demand for the rapidly growing population on the other, the most productive/intensive use of the available land has become imperative for South Asia.

Figure 2.1
Growth of GDP and Agriculture in South Asia ▼



Source: World Development Indicators, 2008

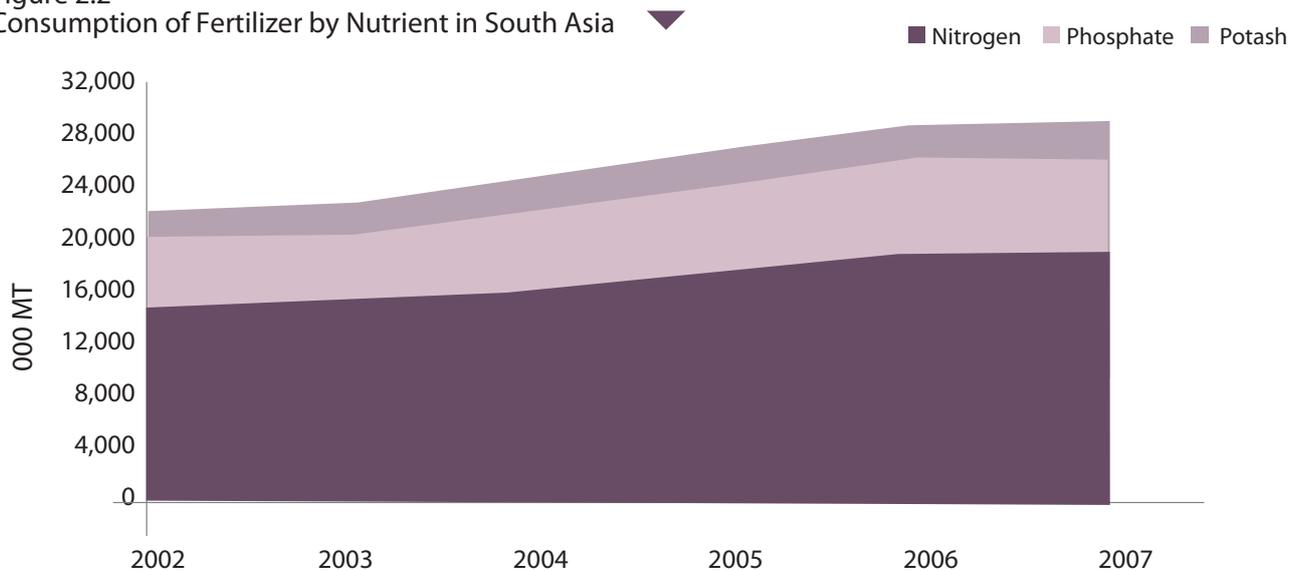
2.1 Fertilizer Use in South Asian Agriculture

Fertilizer has emerged as one of the key inputs in increasing productivity in South Asian agriculture. Overall, the consumption of fertilizer in South Asia has shown a persistent upward trend in (Figure 2.2). During 2002–2007, total consumption increased at an average annual rate of 5.7 percent reaching more than 29 million metric ton of nutrients in 2007. The amount represents 16.5 percent of the total global consumption in 2007. The region is not only one of the major consumers but also an important producer of fertilizer in the world. However, South Asia consumes around one-and-a-half times the amount of fertilizer that it produces.

Like other regions, the use of Nitrogen is predominant in South Asia accounting for nearly 65 percent followed by Phosphate (24 percent) and Potash (11 percent). It is often argued that continuous higher application of Nitrogen (N) in relation to Phosphate (P) and Potash (K) has adverse effects on soil fertility, crop productivity and sustainability of agriculture in the long-run. For best results, the ideal ratio of 4:2:1 of NPK is recommended (National Academy of Agricultural Sciences 1996). In South Asia, fertilizer use has been forecasted to grow annually at a high rate of 2.8 percent over the medium term with corresponding increases for N at 2.2 percent, P at 3.5 percent and K at 4.2 percent. The need for rebalancing fertilizer application points to stronger growth for P and K than for N. As noted earlier, the intensity of fertilizer use is still low in South Asia compared with other regions. The average application rate in South Asia was 86 kg/ha in 2006 compared with 118 kg/ha in Latin America and 179 kg/ha in developing countries in general.

Figure 2.2

Consumption of Fertilizer by Nutrient in South Asia



Source: FAOSTAT online database

2.2 Fertilizer Use by Regions, Crops and Nutrients

In Bangladesh, average rice yield was 1.05 metric tons per hectare in 1971-72 which increased to 2.52 metric tons in 2005-06 mainly due to the spread of water-seed-fertilizer technology. As a result, the application of fertilizer increased significantly during the period. In 1975-76, fertilizer application was 0.36 kg per hectare of agricultural land which rose to 298 kg per hectare in 2007 (Basak 2011). The return from fertilizer use is reported to be high in laboratory experiments (Karim et al. 1994, Saha et al. 2007). It is observed that 'plant height, panicle production, and grain and straw yields significantly increased because of the application of different combinations of inorganic and organic fertilizer' (Saha et al. 2007).

In India, fertilizer consumption increased from 65.6 thousand tons to 26,400 thousand tons while food grain production increased from 51.9 million tons to 218.2 million tons during the 1950–51 to 2009–10 period, implying a low fertilizer use efficiency. It has been reported that the nitrogen use efficiency in rice is only 30-35 percent with an overall efficiency level of 50 percent. Phosphatic fertilizers are the costliest per unit (Rs/kg) on nutrient basis but their use efficiency is only 20-25 percent. The efficiency of potash use is around 80 percent (Awasthi 1999).

The fertilizer use efficiency is not only low in Indian agriculture but has also been declining over the years. A simple regression analysis between food grain production and fertilizer consumption during 1960-61 to 1999-00 shows that the partial factor productivity of fertilizers has been declining continuously. The data available from some centres under the Project Directorate of the Cropping Systems Research (PDCSR), Modipuram indicate a notable reduction in crop response to fertilizer application, especially when balanced fertilization is not practiced. The data from the trials on the farmers' fields conducted by the PDCSR during 1999-2003 show that the average response of cereals to fertilizer was 8-9 kg grain/kg of fertilizer. The efficiency of N is only 30-40 percent in rice and 50-60 percent in other cereals, while the efficiency of P is 15-20 percent in most crops. The efficiency of K is 60-80 percent, while that of S is 8-12 percent. As regards the micronutrients, the efficiency of most of them is below 5 percent (National Academy of Agricultural Sciences 2006).

The crop response ratio of fertilizers (kg of grain per kg NPK) has also been declining over the years. The kg of food grains produced per kg of NPK fertilizers reduced from 15 kg during 1974-79 to 6 kg during recent years. Another study finds that the response ratio (based on partial factor productivity) for fertilizers NPK has declined from 50 kg of food grain/kg of nutrient in 1970-71 to 10 kg/kg of nutrients in recent years (Aulakh and Bnebi 2008).

The findings from long-term fertilizer experiments clearly show that high productivity of an N-based system is not sustainable and becomes counter-productive. The continuous use of N alone can never produce sustained, high yields without addition of adequate P, K and other deficient plant nutrients. This is evident from relatively higher P and K fertilizer use efficiencies and relatively lower N use efficiency in India during the 1980s and 1990s as compared with the 1970s. The yield response to different nutrients in case of rice indicates that the yield response to N has reduced from 2,905 kg/ha in 1977-78 to 2,640 kg/ha in recent years while the yield increased from 500 to 925 kg/ha for P and from 50 to 231 kg/ha for K during the same period (Tiwari 2001). It supports the argument that all three major nutrients N, P and K are essential to achieve sustained yields of crops.

In Nepal, the total fertilizer consumption was 73,810 tons (in nutrient terms) in 1993-94. The results from Nepal show a good response to N, and moderate response to P and low response to K application for most food crops except potato which has a good response to K application (FAO Fertilizer Project Report 1990). However, Nepal lacks recent research on crop yields covering different agro-ecological regions and soil types.

Regional Variation

India is divided into 20 agro-ecological zones and the soils are classified into eight major groups. In India, there are large variations in fertilizer use across the states. Among the major states, Punjab stands first in fertilizer consumption with 213 kg per hectare of gross cropped area followed by Andhra Pradesh with 208 kg/ha, 193 kg/ha in Tamil Nadu and Haryana with 187 kg/ha. The states like Kerala, Madhya Pradesh, Chattisgar, Maharashtra, Rajasthan, Goa, Uttaranjal, Himachal Pradesh, Jammu and Kashmir, Jharkhand, Orissa and north-eastern states have witnessed fertilizer use level below the national average of 119 kg/ha. The states which use more than the national average are Punjab, Andhra Pradesh, Tamil Nadu, Haryana, Karnataka, Gujarat, Uttar Pradesh, Bihar and West Bengal.

As there are considerable differences in area under irrigation across the regions, the consumption of chemical fertilizers across regions also show similar patterns. The fertilizer consumption per hectare varies from 1.74 kg in Nagaland (north-eastern region) to 168.21 kg in Punjab (northern region). Most of the states in southern and northern regions consume fertilizers at levels above the national average. Both the area irrigated and fertilizer consumption are high in the southern and northern regions. The state wise application of N, P and K per hectare of gross cropped area shows that there are larger variations in the use of different fertilizers across states. Punjab ranks the top in use of N and second in P but the use of K is much lower than the national average. Haryana ranks second in per hectare use of N and P, but the use of K in this state is very low. Tamil Nadu stands first in the use of K followed by West Bengal. It is interesting to note that per hectare application of K in southern states is higher than the use of K in other states except West Bengal. The lowest use of all three plant nutrients (N, P and K) is observed in the north east region. The information thus confirms that there are imbalances in the use of fertilizers in the country as well as across different states. As there is significant variation in the status of soil fertility in various parts of the country, the imbalances at the micro level can be better understood and addressed by developing location specific norms for balanced use of fertilizer (Chand and Pandey 2008). Moreover, the imbalances in fertilizer use are also attributed to prices and subsidies available to the farmers in addition to farm and household specific characteristics.

Among the three major ecological regions (terai plains, hills, and mountains) having distinct geological, soil, climatic and hydrological characteristics in Nepal, fertilizer consumption differs widely. In 1993-94, the share of the mountain region was only 4 percent in total fertilizer consumption. The shares of the hill areas and the terai were 35 percent and 61 percent respectively.

Irrigated and Rain-Fed Production Systems

As the review notes, much of the past progress in boosting agricultural productivity has taken place in more favourable irrigated areas in South Asia. However, the prospects of further irrigation developments are limited. In addition, the emerging evidence indicates that crop productivity growth in irrigated areas has slowed or stagnated due to multiple factors. As sources of growth in irrigated areas decline, rain-fed agriculture must increase to fill the gap. Because of population increase and competing demands for land for other sectors of the economy in the South Asian region, most of the increase in food production will have to take place from increase in productivity per unit of land rather than increase under agriculture.

There are significant differences in fertilizer use between irrigated and rain-fed crops with the former

accounting for the lion's share of the total fertilizer application (for evidence from India, see Table 2.2). Overall, fertilizer application has rapidly increased in case of the irrigated crop production system. Although comparable data are not readily available to reveal the exact quantitative magnitudes, available evidence shows that the overall response rate to fertilizer has been showing declining trends in South Asia. There are, however, different implications for the response rates of crops to fertilizer application between the irrigated and rain-fed production systems. For the rain-fed cropping system, the response rate is low as the farmers apply very little fertilizer and other yield-augmenting inputs in view of the high uncertainty of crop yield associated with lack of timely and adequate rainfall and other risks. Two factors underlie the low response rate of non-irrigated crops: first, low rate of fertilizer application and second, uncertainties in availability of critical inputs especially water. On the other hand, response rates in the case of irrigated crops face different constraints. Most irrigated crops (especially rice and wheat) are experiencing declining response trends due to several factors including application of unbalanced doses of fertilizer, micronutrient deficiencies, lack of proper management, declining soil fertility, and similar deficiencies. Thus the observed declining trends in response rates are primarily due to declines in response rates on irrigated crops especially for rice.

The importance of rain-fed agriculture in South Asia is significant where about 60 percent of the farmed land is rain-fed (FAOSTAT 2005). In the region, there has been a major shift toward the cultivation of crops like wheat and maize from drought-tolerant, low-yielding crops such as sorghum and millet. For predominantly rain-fed systems in South Asia, yield of maize has nearly tripled and that of wheat more than doubled since the 1960s. Despite these improvements, average yield in South Asia remains lower than the yield in other regions. For example, rain-fed maize yield is around 2 tons/ha in South Asia compared with 3 tons/ha in Latin America and 1 ton/ha in Sub Saharan Africa⁷. The historic regional difference in the development of yield, moreover, shows that there exist significant potential for raising yields in rain-fed agriculture in South Asia. Within the rain-fed, the dry sub-humid and semi-arid regions have experienced the lowest yields and the weakest yield improvements per unit of land. Here, yields oscillate between 0.5 and 2 tons/ha, with an average of 1-1.5 tons/ha in South Asia for rain-fed agriculture (Rockstrom and Falkenmark 2000, Wani et al. 2003).

The yield gap analysis for major rain-fed crops in semi-arid regions in South Asia reveals large yield gaps, with farmers' yields being a factor of two to four times lower than achievable yields for major rain-fed crops. In the region, the nutrient depletion of agricultural soils is so high that current agricultural land use is not sustainable and nutrient depletion is 7 This can be compared with maize yields in the USA or Southern Europe which normally amount to 7-10 tons/ha. Most maize in these regions are, however, irrigated. Mujeri, Shahana, Chowdhury & Haider: Improving the Effectiveness, Efficiency and Sustainability of Fertilizer Use in South Asia¹¹ one of the chief biophysical factors limiting small-scale production. One recent characterization of 4,000 farmers' fields in different states across India reveals a widespread (80-100 percent fields) deficiency of zinc, boron and sulfur in addition to known deficiencies of macronutrients such as nitrogen and phosphorus (Sahrawat et al. 2007). Such multinutrient deficiencies are largely due to diversion of organic manures to irrigated, high value crops and more reliance on chemical fertilizers supplying macronutrients in pure form over a long period. Other important forms of chemical degradation are the depletion of trace metals such as zinc and iron, causing productivity declines and affecting human nutrition, acidification and salinization.

⁷ This can be compared with maize yields in the USA or Southern Europe which normally amount to 7-10 tons/ha. Most maize in these regions are, however, irrigated.

Since traditional varieties predominate the dry-land/rain-fed conditions, they respond rather poorly to more intensive management and inputs. When fertilizer is applied, traditional varieties usually respond with excessive vegetative growth and often lodge near harvest time. Weeds normally appear as one of the most severe biotic constraints. On the other hand, losses attributed to pests and diseases are less severe than in irrigated systems.

The issues related to crop production under dry-land/rain-fed conditions cover, not only the fertilizer response rates of crops, but also a wide range of related aspects including appropriate varieties, crop management, and weed control. Within a system framework, improvements must focus on increased tolerance for the predominant abiotic and biotic stresses such as late season drought, submergence, and blast. Collaborative actions including research are needed to understand tolerance mechanisms and identify and incorporate the genes responsible. Improvements in nutrient management by better matching soil nutrient supply with crop nutrient demand as water conditions fluctuate will contribute to increased fertilizer and water use efficiency. Efforts are also needed to understand the ecology of principal weeds and appropriate managerial interventions. The important issue is to understand the basis of nutrient-water interactions, especially the dynamics of nutrient release, capture, and use efficiency in fluctuating water environments, which will permit the development of 'smart' fertilizers to better match the soil nutrient supply and crop demand. Improved P extraction efficiency will allow plants to obtain the greatest benefit from applied fertilizer and encourage farmers to use more P and gradually improve the soil reserves.

While there is no doubt about the role of fertilizer in raising crop productivity, there are concerns about its declining efficiency (e.g. units of additional unit yield per unit of fertilizer nutrient). Moreover, inefficient use of fertilizer produces adverse effects on the environment since the lost nutrients either pollute the hydrosphere or the biosphere.

Variation over Crops

The use of fertilizer varies significantly over different crops with around 60 percent of all fertilizers applied to cereals (mostly rice and wheat) in South Asia (Table 2.1). In Bangladesh, the share of rice in total fertilizer consumption is as high as 75 percent. In the case of India, paddy and wheat are the two major crops that account for nearly 53 percent of total fertilizer consumption (Table 2.2). Similarly paddy, maize, and wheat (three main crops) are the major users of fertilizers in Nepal.

Table 2.1
Fertilizer Use by Crops in South Asia ▼

| Crop | South Asia (1000 Tons N+P ₂ O ₂ +K ₂ O) | Percent (%) |
|------------------------------|---|--------------|
| Cereals | | |
| Malze | 448 | 2.1 |
| Millet | 285.6 | 1.4 |
| Rice | 6584.4 | 31.6 |
| Sorghum | 487.1 | 2.3 |
| Wheat | 4730.2 | 22.7 |
| Roots & Tubers | | |
| Cassava yam | 15.6 | 0.1 |
| Potato | 0 | 0 |
| Pulses | 138.4 | 0.7 |
| Oil Corps | | |
| Coconut | 14.9 | 0.1 |
| Groundnut | 529.4 | 2.5 |
| Oil-Palm | 0 | 0 |
| Rapeseed | 571.1 | 2.7 |
| Soybean | 0 | 0 |
| Fruit Crops | 173.3 | 0.8 |
| Beverages & Sugar | | |
| Sugar Cane | 1292.4 | 6.2 |
| Cocoa | 0 | 0 |
| Coffee | 0 | 0 |
| Tea | N/A | N/A |
| Fibres | | |
| Cotton | 1623.5 | 7.8 |
| Jute | 122.4 | 0.6 |
| Vegetables | N/A | N/A |
| Rubber | 5.9 | 0 |
| Tobacco | 1.3 | 0 |
| Others | 3840* | 18.4 |
| Total | 20863.5 | 100.0 |

* Including Food Crops, Tea, Vegetables, Forage.
Source: FAO 2002

Fertilizer Consumption by Nutrient

At the global level, consumption of different nutrients has increased from about 116 million tons in 1980-81 to around 169 million tons during 2007-08 showing an average growth rate of over 1 percent per year. The growth in N consumption is the highest (1.62 percent) followed by P fertilizers (0.48 percent) and K fertilizers (0.11 percent). Of the total nutrients consumption of 156.03 million tons during 2008, N consumption has been 98.65 million tons (63.2 per cent) followed by P (22 percent) and K (14.8 percent).

Table 2.2

Fertilizer Use on Important Crops in India, 2003-04 ▼

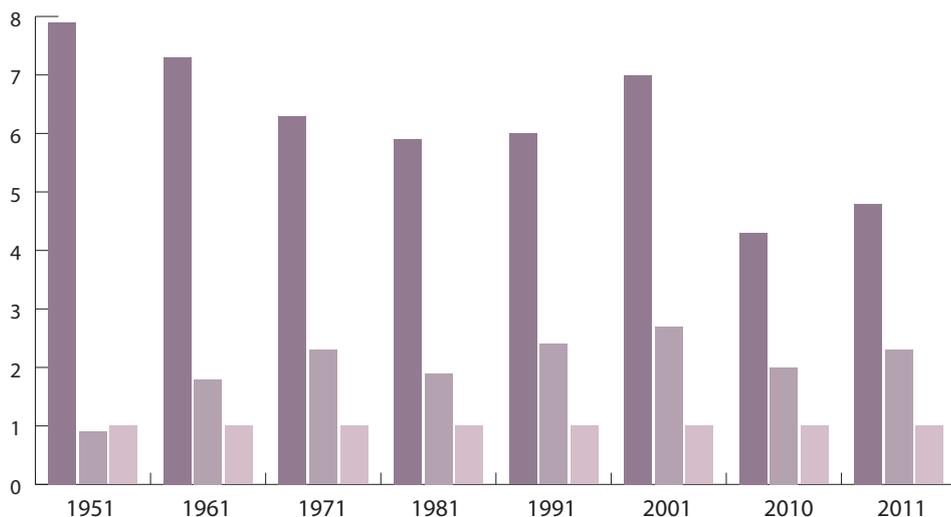
| Crop | Gross Cropped Area (million Ha) | Share in fertilizer consumption (%) | Fertilizer Consumption | | | |
|--------------------|---------------------------------|-------------------------------------|------------------------|-------------------------------|------------------|-------|
| | | | N | P ₂ O ₅ | K ₂ O | Total |
| Paddy | 44.7 | 31.8 | 81.7 | 24.3 | 13.1 | 119.1 |
| Irrigated | 24.0 | 22.2 | 103.4 | 32.8 | 18.8 | 155.0 |
| Rainfed | 20.7 | 9.6 | 56.6 | 14.5 | 6.5 | 77.6 |
| Wheat | 25.7 | 21.0 | 99.6 | 30.2 | 6.9 | 136.7 |
| Irrigated | 22.8 | 19.7 | 105.6 | 32.1 | 7.3 | 144.9 |
| Rainfed | 2.9 | 1.3 | 55.7 | 15.9 | 4.3 | 75.9 |
| Sorghum | 9.9 | 2.9 | 29.2 | 14.2 | 4.1 | 47.5 |
| Irrigated | 0.8 | 0.5 | 58.5 | 29.1 | 10.7 | 98.3 |
| Rainfed | 9.1 | 2.4 | 26.9 | 13.0 | 3.6 | 43.6 |
| Pearl Millet | 9.8 | 1.7 | 21.9 | 5.5 | 0.8 | 28.2 |
| Irrigated | 0.8 | 0.4 | 62.2 | 13.9 | 3.4 | 79.5 |
| Rainfed | 9.0 | 1.3 | 18.4 | 4.8 | 0.6 | 23.8 |
| Maize | 6.6 | 2.3 | 41.7 | 14.7 | 3.8 | 60.2 |
| Irrigated | 1.5 | 0.8 | 59.6 | 27.7 | 4.8 | 92.1 |
| Rainfed | 5.1 | 1.5 | 36.6 | 11.0 | 3.6 | 51.1 |
| Pigeon Pea | 3.6 | 0.8 | 20.9 | 13.3 | 2.0 | 36.2 |
| Irrigated | 0.2 | 0.1 | 36.9 | 20.9 | 2.2 | 60.0 |
| Rainfed | 3.5 | 0.7 | 19.6 | 12.6 | 2.0 | 34.2 |
| Rapeseed & Mustard | 6.0 | 3.4 | 69.1 | 25.0 | 2.9 | 97.0 |
| Irrigated | 3.8 | 2.6 | 81.7 | 30.4 | 4.3 | 116.5 |
| Rainfed | 2.2 | 0.8 | 45.9 | 15.0 | 0.4 | 61.3 |
| Groundnut | 6.6 | 2.9 | 24.4 | 39.3 | 12.9 | 76.6 |
| Irrigated | 1.2 | 0.8 | 35.3 | 53.8 | 28.9 | 118.0 |
| Rainfed | 5.4 | 2.1 | 21.9 | 36.0 | 9.2 | 67.2 |
| Sugarcane | 4.3 | 5.4 | 124.8 | 44.0 | 38.3 | 207.1 |
| Irrigated | 4.2 | 5.3 | 126.4 | 45.0 | 40.6 | 212.0 |
| Rainfed | 0.1 | 0.1 | 106.0 | 32.0 | 12.4 | 150.4 |
| Cotton | 8.5 | 6.0 | 89.5 | 22.6 | 4.8 | 116.8 |
| Irrigated | 2.9 | 2.7 | 115.7 | 30.9 | 7.0 | 153.5 |
| Rainfed | 5.6 | 3.3 | 75.8 | 18.2 | 3.6 | 97.7 |

| Crop | Gross Cropped Area (million Ha) | Share in fertilizer consumption (%) | Fertilizer Consumption | | | |
|-------------|---------------------------------|-------------------------------------|------------------------|-------------------------------|------------------|-------|
| | | | N | P ₂ O ₅ | K ₂ O | Total |
| Jute | 0.8 | 0.2 | 38.0 | 11.5 | 5.0 | 54.4 |
| Irrigated | 0.3 | 0.1 | 55.0 | 22.4 | 10.2 | 88.6 |
| Rainfed | 0.5 | 0.1 | 28.9 | 6.0 | 2.3 | 37.1 |
| Other Crops | 60.4 | 21.6 | 34.5 | 18.5 | 7.1 | 60.1 |
| Irrigated | 12.6 | 13.3 | 113.5 | 46.8 | 16.5 | 176.7 |
| Rainfed | 47.8 | 8.3 | 13.6 | 11.0 | 4.7 | 29.3 |
| All Crops | 187.0 | 100.0 | 59.2 | 22.1 | 8.5 | 89.8 |
| Irrigated | 75.1 | 68.5 | 103.2 | 35.3 | 14.5 | 153.1 |
| Rainfed | 111.9 | 31.5 | 29.7 | 13.1 | 4.5 | 47.3 |

Source: Kumar 2011

In South Asia, fertilizer consumption in terms of different nutrients indicates a similar heavy reliance on nitrogenous fertilizer. In 1981, 64 percent of the total fertilizer used in Bangladesh was accounted for by urea and in 2010, the share increased to 89 percent. In the Indian context, the balanced dose of fertilizer contains 58 percent of N, 28 percent P, and 14 percent K (Chand and Pandey 2008). In contrast, the share of N fertilizer has been around 65 percent of total fertilizer consumption whereas the share of P is around 25 percent and K around 10 percent. Although there still exist imbalances in the fertilizer use ratio in India, consistent improvements are observed over the years (Figure 2.3). For instance, the NPK use ratio was 7.9:0.9:1 in 1951 which became 4.3:2:1 in 2010 which is closer to ideal recommended dose. Similarly in Nepal, the majority of farmers are inclined to use only nitrogenous fertilizers – mainly urea. Such disproportionate use of N, P and K fertilizers occur chiefly due to relatively low price of urea and ignorance about the need and importance of balanced use of fertilizers among the farmers. The excessive use of nitrogenous fertilizers and unbalanced supply of crop nutrients have increased the acidity and deteriorated the physical condition of the soil. Excessive use of nitrogenous fertilizer increases the emission of nitrous oxide, which is one of the major gases responsible for global warming and the resultant adverse effect of climate change deteriorate the quality of underground water in many parts of South Asia.

Figure 2.3
Trend in NPK Use Ratio in India ▼



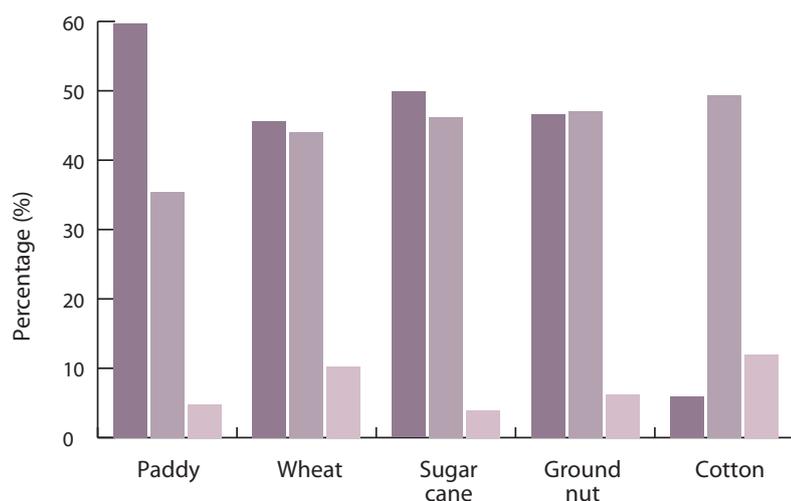
| | 1951 | 1961 | 1971 | 1981 | 1991 | 2001 | 2010 | 2011 |
|---|------|------|------|------|------|------|------|------|
| N | 7.9 | 7.3 | 6.3 | 5.9 | 6 | 7 | 4.3 | 4.8 |
| P | 0.9 | 1.8 | 2.3 | 1.9 | 2.4 | 2.7 | 2 | 2.3 |
| K | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

Source: Kumar 2011

Fertilizer Use by Farm Size

In South Asia, fertilizer use also varies by farm size. In India, small and marginal farmers typically consume 60 percent of total fertilizers used in producing paddy whereas the medium farmers consume 35 percent and large farmers consume 5 percent. Similarly, in other crops such as wheat, sugarcane, groundnut and cotton, the small and marginal farmers consume large quantities of fertilizers compared with other categories of farmers (Figure 2.4). Thus in all crops, fertilizer consumption decreases as farm size increases showing an inverse relationship between farm size and fertilizer consumption irrespective of crops.

Figure 2.4
Fertilizer Consumption by Farm Size in India ▼



| | Paddy | Wheat | Sugar cane | Groundnut | Cotton |
|--------------------|-------|-------|------------|-----------|--------|
| Small and marginal | 59.73 | 45.64 | 49.88 | 46.68 | 38.68 |
| Medium | 35.47 | 44.08 | 46.20 | 47.06 | 49.34 |
| Large | 4.80 | 10.28 | 3.92 | 6.26 | 11.99 |

Source: Fertilizer Statistics 2009-10

In Bangladesh, on the other hand, fertilizer use does not differ much by land size (Abdullah 1987, Asaduzzaman and Islam 2008). This indicates that irrespective of relative distribution of benefits of fertilizer subsidy between the large and small farmers, the poor and marginal farmers are not using lower levels of fertilizers in their farms as compared with the large farmers (Table 2.3).

Table 2.3
Land Ownership and Fertilizer Use in Bangladesh ▼

| Land Ownership status | Urea | | TSP | | MOP | | DAP | | Total | |
|-----------------------|------|------|------|------|------|------|-----|------|-------|-----|
| | N | % | N% | N | % | N | N | % | N | % |
| Landless | 580 | 36.7 | 513 | 32.5 | 459 | 29.1 | 27 | 1.7 | 1,579 | 100 |
| Marginal | 35.1 | 487 | 32.0 | 447 | 29.4 | 53 | 3.5 | 1521 | 534 | 100 |
| Small | 282 | 35.2 | 250 | 31.2 | 234 | 29.2 | 35 | 4.4 | 801 | 100 |
| Medium | 362 | 35.3 | 322 | 31.4 | 306 | 29.9 | 35 | 3.4 | 1025 | 100 |
| Large | 69 | 35.0 | 62 | 31.5 | 57 | 28.9 | 9.0 | 4.6 | 197 | 100 |

Note: Landless: Land ownership up to 0.04 acre; Marginal: between 0.05 and 0.49 acre; Small: between 0.50 and 2.49 acre; Medium: between 2.50 and 7.49 acre; Large: 7.50 acres and above.

Source: Barkat et al 2010

Table 2.3 shows the distribution of fertilizer use across farmers by land-ownership groups. It is quite apparent that the use of urea, TSP and MOP is very similar among all categories of land-holdings and nearly one-third each of total fertilizer users in each category. In the case of DAP use, there is a discernible pattern showing that larger land-holdings use more DAP compared with smaller land-owners. It might be related to pricing and availability issues that affect the small land-owners than the large land-owners.

2.3 Demand-Supply Gap of Fertilizer in South Asia

In recent years, a rising demand-supply gap has been observed across most South Asian countries. A recent study indicates that the total demand for fertilizer nutrients would be 41.7 million tons in India by 2020. Of the total demand, the demand for N would be 23 million tons (55 percent), 11.5 million tons for P (28 percent) and 7.1 million tons for K (17 percent). The regional analysis indicates that the demand for fertilizers would be more in the north and west zones followed by the south zone.

The supply of fertilizers is met both by domestic production and imports in South Asia. The fertilizer consumption in India generally exceeds domestic production for both N and P fertilizers in most of the years. The entire requirement of K fertilizers is met through imports as India does not have commercially viable sources of potash. India mainly imports urea, DAP and muriate of potash (MOP). The N production in India has witnessed an annual compound growth rate of 2.7 percent during the period 1991-92 to 2009-10 and P has witnessed a growth of 3.8 percent. With the current growth rate, the production of N would be 16.24 million tons by 2020 and that of P would be around 7.84 million tons. This indicates that there will be a potential gap of 6.8 million tons of N, 3.7 million tons of P and 7.1 million tons of K. Thus, by the year 2020, there would be a potential demand supply gap of 17.5 million tons for all fertilizers. Hence, expansion in the production capacity for increasing the production of N and P is important for India. However, the entire demand for K has to be met by increasing imports of potash fertilizers.

Bangladesh also cannot meet its demand for fertilizer from domestic production alone. In fact, its capacity to meet demand from domestic production has steadily declined since 2002-03 when 28 percent of all fertilizers were imported. The share of import has gone up to 56 percent in 2008-09. For example, Bangladesh imported only 8 percent of urea from the world market in 2002-03. In 2008-09, it imported almost half of the urea needed. In the case of MOP, it is entirely imported. Although Bangladesh has two DAP plants, they hardly contribute to meeting the rapidly rising local demand. Total amount of fertilizer supplied to the farmers also falls short of what is demanded in Bangladesh (Table 2.4). Moreover, the deficit varies over different regions of the country. In a field study, for instance, it has been reported that the total requirement of urea, TSP and MOP was 4,650, 583, and 588 metric tons in Hatiya but the supply was reported to be 85 percent, 18 percent and 21 percent respectively (Alam et al. 2009).

Table 2.4
Demand for and Use of Fertilizer by Type in Hatiya, Bangladesh (MT) ▼

| Name of Fertilizer | 2004-05 | | | 2005-06 | | | 2006-07 | | |
|--------------------|----------------|--------------|---------------------|----------------|--------------|---------------------|----------------|--------------|---------------------|
| | Require - ment | Actual Use | % of Req. fulfilled | Require - ment | Use | % of Req. fulfilled | Require - ment | Use | % of Req. fulfilled |
| Urea | 26.00 | 25.23 | 97.04 | 28.00 | 24.61 | 87.89 | 28.75 | 25.15 | 87.48 |
| TSP | 5.00 | 4.20 | 84.00 | 4.50 | 4.36 | 96.89 | 4.50 | 3.40 | 75.56 |
| SSP | 1.25 | 1.41 | 112.80 | 1.25 | 1.45 | 116.00 | 1.25 | 1.22 | 97.60 |
| DAP | 3.00 | 1.71 | 57.00 | 1.75 | 1.30 | 74.29 | 2.50 | 1.15 | 46.00 |
| MOP | 4.50 | 2.60 | 57.78 | 3.00 | 2.91 | 97.00 | 3.00 | 2.30 | 76.67 |
| NPKS | 1.00 | 0.90 | 90.00 | 1.50 | 1.10 | 73.33 | 1.75 | 1.25 | 71.43 |
| Gypsum | 1.50 | 1.36 | 90.67 | 1.50 | 1.05 | 70.00 | 1.50 | 0.72 | 48.00 |
| Zinc | 0.25 | 0.08 | 32.00 | 0.25 | 0.08 | 32.00 | 0.30 | 0.26 | 86.67 |
| Total | 42.50 | 37.49 | 88.21 | 41.75 | 36.76 | 88.05 | 43.55 | 35.45 | 81.40 |

Source: Alam et al 2009

An estimation of total nutrient removal by various crops in Nepal indicates that at the present level of crop production, approximately 600,000 metric tons of plant nutrients (N, P₂O₅ and K₂O) per annum are being removed by the major crops in the country. Considering the present level of fertilizer supply and application of about 500,000 metric tons per year (formal and informal imports combined) and that fertilizer contains 50 percent nutrients on average, the gross contribution of nutrients through chemical fertilizers would be around 250,000 metric tons per annum. Assuming agronomic use efficiency of the applied fertilizer nutrients to be 40 percent, the actual contribution of nutrients through fertilizers to the gross total nutrient removal will be about 100,000 metric tons per year, i.e. 17 percent of the total nutrients removal. This shows an annual gap of some 500,000 metric tons (83 percent), which is extremely high.

It may, however, be noted that the nutrient supply gap is at least partly filled through the use of other sources of crop nutrients such as organic manures, soil content, symbiotic and non-symbiotic natural fixation of plant nutrients to the soil. Moreover, reliable estimations relating to fertilizer use efficiency and informal import of fertilizers are lacking in Nepal. Overall, it is perceived that most of the soils in Nepal are being heavily mined through continuous crop production and for lack of sufficient nutrient replenishment and soil conservation measures and practices, which in the long run will adversely affect soil health and nutrient reserves leading to yield reduction and desertification (Pandey 2010).

In most South Asian countries, the need for realistic assessment of demand for fertilizers is apparent. The overestimation of demand leads to high inventory carrying costs, deterioration in the quality of fertilizers due to prolonged storage, and liquidity problems. On the other hand, underestimations of the demand result in situations of fertilizer scarcity, and rise in fertilizer prices paid by farmers, thus leading to lower agricultural production due to inadequate quantities of fertilizers applied to the crops. The above brings out the need to adopt appropriate methodologies for fertilizer demand assessment in South Asia for which various approaches/methodologies for demand-forecasting system in developing countries are available (FAO/RAPA 2009). It is important to recognize that reliable fertilizer demand assessment is the first step towards planning for their adequate and timely availability. Whereas a short-term demand assessment meets the immediate fertilizer requirements, medium- and long-term demand assessments become essential as tools for planning for the future.

Recognizing the importance of fertilizer in agriculture and its potential to bringing about desired technological transformation, the governments in South Asian countries have pursued active policies with respect to rapid adoption and promote productive use of fertilizer in respective countries.

3.1 Fertilizer Policy in Bangladesh

Over the years, the Government of Bangladesh (GOB) has adopted a number of policies related to price, marketing, and distribution of fertilizers. These policies, however, have undergone significant changes over the last four decades.

In the 1950s, when fertilizer was first introduced in Bangladesh, it was heavily subsidized. The agriculture input management system was government dominated and the procurement and distribution of fertilizers were under the control of the government agency, the Bangladesh Agriculture Development Corporation (BADC). Similarly, all donor-supplied fertilizers were channelled through BADC. The prices were also government-controlled.

The BADC acted both as a monopsonist as well as a monopolist. It acted as a monopsonist by obtaining fertilizer from the global market and also from local producers, while it acted as a monopolist because it was the sole supplier of fertilizer to the farmers in the country. There was no involvement of the private sector in the imports of fertilizers but private sector participation was allowed in distribution as dealers were appointed by BADC for selling fertilizers to the farmers. These dealers collected fertilizers from BADC warehouses and sales centres located at the Thana level and were allowed to sell fertilizers only in areas designated by the Thana Committee⁸.

The system of fertilizer distribution under BADC did not work well because of a host of factors. The appointment of dealers involved a time consuming selection procedure, supply of fertilizers was erratic and uncertain, BADC had limited transportation and storage capacities, and low commissions received by the fertilizer dealers had a serious impact on dealer incentives. The system was maintained till early 1970s as fertilizer intensive modern varieties continued to dominate rice production in Bangladesh.

In the 1970s, the government continued to maintain monopoly over procurement and distribution through BADC, but reduced subsidies on fertilizer drastically. For example, subsidy on urea came down from 52 percent in 1975-76 to 4 percent in 1982-83 (Osmani 1985). In 1977 and early 1978, the government, with the assistance of USAID, took up a project to improve the fertilizer distribution system. The project's goal was to increase agricultural production through improved use of fertilizer by focusing on technology transfer and increased private sector participation. The dealers were given more responsibility along with better financial facilities.

⁸ Bangladesh is divided into seven divisions. Each division is divided into districts, districts into thanas or upazilas which in turn is divided into unions which is further divided into villages.

Also under the new system, more primary distribution points were opened. This change reduced the transportation and storage costs. Furthermore, many restrictions were withdrawn over the dealers so that they could sell the fertilizers on a competitive basis in the 'free' market. This system, known as the New Marketing System (NMS), continued up to 1987. The New Marketing System is considered a major success in some important respects.

- Studies reveal that the NMS had (i) privatized fertilizer distribution at the retail level and increased farmer's access to fertilizer sources; (ii) lowered/deregulated retail prices; (iii) consolidated government warehousing; and (iv) produced a minimal effect on the government's distribution costs. However, distribution constraints continued to exist and farmers' demand for fertilizers during the peak period could not be met. Lifting procedure of the dealers was also considered as complicated and time consuming. It sometimes required 3-5 days to lift fertilizer by a dealer (Barkat et al. 2010).
- From 1987, another USAID funded project implemented by the International Fertilizer Development Centre (IFDC) through the Bangladesh Ministry of Agriculture aimed at creating a competitive fertilizer market. Under the new project, the government allowed fertiliser dealers and wholesalers to lift from the port/fertilizer factory⁹. With the introduction of this system, the price of fertilizers was reduced under command areas of the dealers and farmers were able to get fertilizers at lower prices.
- From 1990-91, the government allowed the private companies/dealers to import all kinds of fertilizers from abroad and subsidies on some fertilizers were partially removed. Implicit subsidy on urea, however, remained.
- The privatization of the fertilizer market in Bangladesh was completed in 1994. Since then, all fertilizer imports are handled by the private sector. Prices are liberalized. All in-country distribution, from import arrival to final sales to the farmers, is handled by private sector firms. Increased private participation in fertilizer imports and marketing resulted in significant economies at various levels in the fertilizer sub-sector. Farm level prices, in real terms, declined by Taka 50 (approximately US\$1.00) per bag during the project life. Fertilizer use increased at an average rate of 8.5 percent per annum; and reached a total of 2.3 million metric tons of fertilizer nutrients in 1994. Bangladesh also achieved rice self-sufficiency in 1993-94.
- An association of Bangladesh dealers, Bangladesh Fertilizer Association (BFA), was created in 1993 and by 1994 its 450 strong membership had begun to perform human capacity building, policy advocacy, and MIS functions for members.
- Several fertilizer crises after privatization, however, led the government to bring back some interventionist measures afterwards¹⁰. In early 1995, a judicial commission was formed and the government, in consultation with the BFA, started to appoint district level dealers through public advertisements and district-based selection committees.

⁹ Earlier, all fertilisers were distributed from Primary Distribution Points (PDPs) and BADC had the control on the primary distribution as the factory directly handed over the products to BADC.

¹⁰ In the boro season (the major rice producing season in Bangladesh) of 1995, farmers faced a shortage of fertiliser supply in different areas of the country during the peak period. In a village of Magura district, farmers were demanding fertilisers in an aggressive procession and the police opened fire on them. Nine farmers died in the incident. In many respects, the crisis was artificial and the rent-seeking dealers and wholesalers hoarded fertilisers during the peak season with a motive of earning abnormal profits. The government at this point decided to bring the domestic urea market back under its direct control to mitigate the crisis by reintroducing controls over urea marketing and distribution.

- Recently, the government made drastic changes in the dealership system for fertilizer distribution. Under the Dealership Policy 2008, it was made mandatory to appoint at least one dealer in each union by cancelling the previous upazila-based system. But the policy was weak in implementation and this was followed by the Dealership Policy 2009 in which abolition of sales representatives of dealers, restriction of dealership within the district, introduction of retail sale and arrangement of ID cards are some features.

The management and use of fertilizer have been the focus of fertilizer policy of Bangladesh during the past few years. Considering the importance of application of fertilizer for stable and expanding agricultural production, various efforts have been made to design an efficient, undistorted and non-discriminatory fertilizer distribution system in Bangladesh.

3.2 Fertilizer Policy in India

In India, fertilizer industry has been subjected to various government controls primarily due to its important role in increasing agriculture production in the country. The Government of India established the "Central Fertilizer Pool (CFP)" in 1944 mainly to achieve equitable distribution of fertilizer throughout the country at fair prices. The pool fertilizers were then distributed in various parts of the country mainly through agricultural cooperatives and outlets of the state department of agriculture. Realising the importance of fertilizers in the agriculture sector, fertilizer has been considered as an essential commodity through enactment of Fertilizer Control Order (FCO) in March 1957 under the Essential Commodities Act (ECA) 1955. Under these measures, the production, distribution, movement and prices of fertilizer were regulated by the Government of India.

The high powered Sivaraman Committee Report on fertilizer which came out in 1966 made important recommendations regarding production, promotion, distribution and consumption of fertilizer in the country. The Committee also highlighted the constraints in the distribution of fertilizer through the governmental distribution network and recommended that manufacturers be given freedom to distribute 50 percent of their output anywhere in India. By 1969, the fertilizer industry was given complete freedom of marketing their entire production through any distribution channel of their choice.

In the early 1970s, global shortage led to a severe shortage of fertilizers in the country. The price of fertilizer in the international market increased steeply. As India was heavily dependent on imports, the government started distribution of fertilizers under Essential Commodities Act of 1955. Moreover, the freedom granted in 1969 was abrogated altogether in the year 1972. All the manufacturers were directed to distribute fertilizer as per state wise ECA allocation under a supply plan decided in zonal conferences for kharif and rabi seasons. Subsequently, Fertilizer (Movement Control) Order 1973 was promulgated which brought fertilizer distribution and its inter-state movement under government control.

Based on the recommendation of the high powered Marathe Committee in 1976, the government introduced the retention pricing scheme (RPS) for all nitrogenous fertilizers in November 1977 while phosphate and potash fertilizers were covered in March 1979. Under the RPS, a fair ex-factory price was worked out for each unit based on prescribed efficiency norms in relation to capacity utilisation and consumption of raw materials and utilities popularly known as 'Retention Price' which included 12 percent post tax return on net worth. In addition to the retention price, the government also provided equated freight under which reasonable cost of transportation of fertilizer (rail/road) from factory to the block level headquarters was covered. The RPS produced several impacts in the fertilizer industry and the economy.

- While the Retention Price Scheme did achieve its objective of increasing investment in the fertilizer industry and thereby created new capacities and enhanced fertilizer production along with increased use of fertilizer and increased food grain production, the scheme attracted criticism for being cost plus in nature and not providing sufficient incentives to encourage efficiency. In order to reduce the budgetary pressure, based on the recommendations of Joint Parliamentary Committee (JPC), the government decontrolled pricing for phosphate and potash fertilizers in August 1992. After decontrol, prices of P and K fertilizers increased significantly and the government had to introduce ad hoc Concession Scheme during the 1992-93 rabi season in order to make fertilizers available at affordable prices to the farmers. At present, it is only the urea fertilizer which continues to be governed by ECA provisions.
- In order to address the problems of increasing subsidy burden on the exchequer, the government constituted various Committees to review both urea and complex fertilizer pricing policy. Based on the recommendations, the government announced changes in the urea pricing policy in June 2002. This included re-assessment of plant capacities, revision in the consumption norms, phased withdrawal of vintage allowance, and increase in capacity utilization norms. However, the changes adversely affected the profitability of many urea producing units as these were made retrospectively.
- The Government of India constituted an 'Expert Group on Phosphatic Fertilizer Policy' to review the phosphatic fertilizer environment, examine international and Indian phosphate fertilizer scenario and suggest alternative to existing methodology of phosphatic fertilizer pricing and costing. It suggested that the subsidy on DAP should form the basis for deriving subsidy on complex fertilizers. Further, a formula proposed by the Expert Group was adopted for working out the price of phosphoric acid for computation of quarterly escalation/de-escalation claims in the concession rates of DAP/NPK fertilizers in place of negotiated prices of phosphoric acid. The formula, however, was adopted only for the year 2006-07.
- The government established the Fertilizer Monitoring System (FMS) in January 2007 to monitor movement of fertilizers up to the district level and to ensure availability of fertilizers in the interior parts of the country.
- In order to maintain adequate stock for urea in the field warehouses, the government also introduced the buffer stocking scheme since the 2007 kharif season. The Scheme is being operated through the Lead Fertilizer Suppliers (LFS). The LFS holds urea under the buffer stock in their warehouses at designated locations approved by the government. The Scheme helps the State Governments to tide over sudden spurts in demand/shortage in any part of the country. However, the LFSs maintaining the buffer warehouses have not yet been paid on time in spite of submission of requisite data to the government.

- To achieve balanced use of fertilizers, the government formulated guidelines for production and use of 'Customised Fertilizers' which are crop specific, climate specific, and soil specific. All subsidized fertilizers can be used for manufacturing of customized fertilizers. As of now, 24 grades of customized fertilizer have been notified.
- A policy for encouraging production and availability of 'Fortified and Coated Fertilizers' was introduced in 2008. The process of fortification involves enriching a regular fertilizer product with micronutrients like zinc or boron.
- The manufacturers/producers were allowed to sell Fortified/Coated Fertilizers, except for zincated urea and boronated SSP at a price above the MRP of the fertilizer covered under subsidy.
- The government announced the continuation of Concession Scheme on Decontrolled Phosphate and Potassic (P and K) fertilizers in July 2008 and it was implemented in April 2008.
- The price of urea, DAP and MOP as well as the prices of phosphoric acid and ammonia started increasing in the beginning of 2008 in the international market. There had been unprecedented rise in the international prices of fertilizers, raw material and intermediates during April-September 2008. Moreover, the availability of the finished fertilizers and raw materials became inadequate in the international market. With a view to making fertilizer available to the farmers in 2008-09 rabi season, the government directed the manufacturers to tie up imports as well as finished goods. It was assured that the concession will be paid to the manufacturers/importers on the basis of receipt of material in the districts. However, the prices of DAP and raw materials started to fall during October-December 2008 in the international market and consequently, the concession payable to the manufacturers/importers also came down from Rs. 51,560 per ton during October 2008 to Rs.25,680 per ton during December 2008. However, since the government paid concession on P&K fertilizer on the basis of sales till November 2008, this badly affected the profitability of the manufacturers/importers. The worst affected were those manufacturers/importers who imported substantial quantities from the international market when the price was at its peak.
- The government introduced nutrient based pricing of subsidized fertilizers in June 2008. Prior to this, the price of nutrients in complex fertilizers were higher than the price of the same nutrient in other fertilizers like urea, DAP, MOP and SSP. Under the nutrient based pricing policy, the maximum retail price (MRP) of all the complexes was revised based on the unit price of N, P, K and S derived from MRPs of urea, DAP, MOP and SSP respectively. Sulphur was also recognised to be the fourth most important soil nutrient after nitrogen, phosphorous and potash and its deficiency was seen as the prime reason for reduced effectiveness of primary nutrients. The implementation of nutrient based pricing policy resulted in significant reduction in the MRPs of all complexes since unit price of N, P, K, and S remained the same in all fertilizers. This also encouraged the farmers to use fertilizer as per the nutrient requirement without being lured by the low priced fertilizers.

- With a view to ensuring easy availability of fertilizers in all parts of the country at the right time and in adequate quantities at uniform prices, the government announced the policy on uniform freight subsidy for fertilizers covered under subsidy in July 2008 which was implemented retrospectively since April 2008. Prior to this, fertilizer companies received a fixed amount as freight from the plant/port to the sale point irrespective of distance for complex and potassic fertilizers. Under the uniform freight policy, rail freight expenditure was paid on actual basis and road freight paid on normative average district lead (average of the actual leads of block headquarters from the nearest rail rake point) and normative per kilometre rates for the state. In case of road despatches, directly from plant/port to the consuming areas involving movement across the state border, a simple average of per kilometre rate of both the despatching state and the receiving state was taken for computation of the road freight. The lead was based on the notified lead for the receiving district. Freight subsidy was paid after the actual receipt of fertilizers at the designated district as per the movement plan. The government also started reimbursement of road transportation costs for those manufacturing units, not having railways siding facilities up to the nearest rake-point based on the actual lead and the per ton per kilometre rate prevalent for the state where the unit was located.
- Other policies announced during the period of NPS III were (i) policy for sales of surplus ammonia from Urea Units and (ii) policy for new investment in the urea sector including policies on revamp of existing units, expansion of existing units, revival of closed units, Green Field Projects, and Joint Ventures abroad.
- Considering unprecedented increase in the subsidy bill in fertilizers shall get additional subsidy. The new policy also provides incentive to fortify the fertilizers with micronutrients to mitigate their deficiency in the soils. The subsidies on N, P, K and S have been fixed keeping in view the prevailing international market prices, medium-term expectations, reasonable returns for producers, and small inevitable price increases.
- The major principles of fertilizer policy since 1977 include: (i) ensuring availability of fertilizers to farmers at every corner of the country and at affordable prices; (ii) enable balanced fertilizer application (phosphorus decontrol in 1992 disturbed the balance); (iii) ensure viability of domestic industry and promote investments in the sector; and (iv) provide incentives for technological developments, efficiency and competitiveness.

3.3 Fertilizer Policy in Nepal

In Nepal, The fertilizer sector development and policy interventions in the fertilizer sector can be broadly divided into three phases¹¹.

Phase I (till 1973)

Fertilizers were introduced in Nepal in early 1950s with some private traders importing small quantity of ammonium sulphate from India. Following this, the National Trading Limited started to import ammonium sulphate from Russia till the mid 1960s. The level of fertilizer use in the country was very low during this period.

In 1966, under the Ministry of Agriculture, which is now renamed as the Ministry of Agriculture and Cooperatives (MOAC), systematic efforts for fertilizer import and distribution began with the establishment of the Agricultural Inputs Corporation (AIC). The AIC, as a public sector enterprise, held the responsibility of procuring fertilizers and distributing them to the farmers in the country. Initially, it imported fertilizers from India only, but later on AIC started to import fertilizers from the international market. Following the operation of the AIC, the demand for and use of fertilizers in the country began to increase.

From the beginning till 1972, the cost-plus basis of pricing was adopted in distributing the fertilizers. On that basis, the prices of fertilizers in the hills were fixed higher than that in the terai, obviously for the reason of higher costs incurred in transporting fertilizers to the distant hills. However, later on, to commensurate with the rising international market prices of fertilizers, the policy was slightly changed to adopt a uniform-pricing system, wherein the hills farmers would obtain fertilizers at a rate below the actual cost while the terai farmers would pay more than the actual price so as to offset the costs of transportation.

Phase II (Subsidy Regime 1974 -1997)

With the increase in fertilizer prices in the international market, the government introduced a system of price subsidy and subsidy for some selected districts in high-hills and mid-hills in 1974. The subsidy policy was adopted to serve two main purposes: encourage farmers to use fertilizers by providing them with fertilizers at relatively low prices, and discourage the outflow of fertilizers from Nepal to India by keeping the fertilizer prices 15-20 percent higher than they were in India.

With the increase in the demand for fertilizers within the country and the persistent rise in fertilizer prices in the international market, the government had to bear a huge financial burden on account of the subsidy provision. Since fertilizer is considered as a politically sensitive commodity in Nepal, the government was reluctant to make price adjustments in order to reduce the burden on the exchequer. This led to the AIC's loss reaching Rs. 850 million as the consecutive governments were unable to allocate adequate budgets to meet the subsidy requirement. The AIC was unable to import fertilizers as per the demand resulting in severe shortages of supply.

¹¹ For further discussion on Nepal fertilizer policy and its salient features, see Agrifood 2003, Karki and K.C. 2006, Manandhar 2007, and Pullabhotla et al. 2011. This section draws heavily from Shrestha 2010.

In the late 1960s, Nepal began to receive fertilizers under grant aid from friendly countries such as Germany, Canada, Japan and Finland. While some of these countries stopped fertilizer supply after 1991-92, others reduced the quantities. The supplied quantities used to be substantial in the early years but have become only small fractions of the total import in recent years. The latest such fertilizer support came under 2 KR Grant Aid from the Government of Japan in 2006 in which the country received 5,412 metric ton of urea.

Phase III (Deregulation of Fertilizer Trade 1998 - 2008)

The AIC, as a public sector enterprise, enjoyed monopoly in fertilizer trade for a long time before the government decided to deregulate the fertilizer trade in 1997-98. Fertilizer procurement and distribution were completely under the control of AIC, while the government regulated the prices of fertilizers. With increasing demands for fertilizers and the rise in their prices, the government failed to make adequate subsidy allocations. As a result, import and supply of fertilizers declined, adversely affecting agriculture production in the country.

Under the economic reform programs, the government started deregulating the fertilizer trade in November 1997 with the complete removal of subsidy on diammonium phosphate (DAP) and muriate of potash (MOP), and a phase-wise removal of subsidy on urea. The subsidy was fully removed from November 1999. The fertilizer deregulation package involved three parts: removal of AIC's monopoly in fertilizer trade by allowing the private sector to import and distribute fertilizers with equal treatment for both parties; a time-bound phase-out of the fertilizer subsidy; and decontrolling of fertilizer prices.

In pursuance of the fertilizer deregulation policy, the MOAC issued a working policy to involve the private sector in the fertilizer trade. This policy paved the way for private traders to stand at equal footing with the AIC. To institutionalize the deregulation policy and to regulate the business under the policy, the government promulgated the Fertilizer Control Order 1999 following the mandate of the Essential Commodity (Control) Act 1996.

After the government adopted the fertilizer deregulation policy in 1997, fertilizer supply from formal sources (AICL and private importers) improved only till 1998-99. The reasons behind this were the retention of partial subsidy in urea import before November 1999, and the prevalence of a relatively favourable price structure in the international market.

However, fertilizer supply dropped after the fiscal year 1999-00 onwards as both the AICL and the private importers could not import required amounts of fertilizers because of large price fluctuations in the international market. Moreover, it became difficult for both AICL and private sector to sell fertilizers in the domestic market as subsidized and cheap Indian fertilizers as well as adulterated and sub-standard fertilizers became easily available in the market. Farmers were attracted to buy these fertilizers at much lower prices than those the AICL and the authorized private importers charged. Besides, the overall supply situation in remote areas could not improve owing to high costs of transportation. Thus, while the supply situation did not improve as expected, poor fertilizer quality and related problems surfaced widely.

The above situation led to a review and revision of the deregulation policy in order to overcome the emerging complexities (Shrestha 2010). As a consequence, with the view of supporting small and marginal farmers the government reinstated the fertilizer price subsidy provision in 2009, though for a limited quantity of fertilizers (100,000 metric ton per year). At present, while the AICL has continued to import fertilizers, the private sector businesses have stopped it because they do not receive any subsidy (Pandey 2010).

4

EFFICIENCY, EFFECTIVENESS AND SUSTAINABILITY OF FERTILIZER USE

In South Asia, the main challenge is to maintain steady growth in crop yields in the face of diminishing marginal returns to agricultural inputs. Farmers can improve their net returns from agriculture with lower cost inputs and enhanced efficiency of input use. In the region, the low nutrient absorption rate of 30 to 40 percent by crops for N, P and K fertilizers are inefficient and must be improved. For example, by improving N use efficiency by 15 to 20 percent, the projected food production increase for 2030 can be obtained with 20 million tons less fertilizer compared with the current average N recovery rate of 35 percent (Daberkow et al. 2000).

There exists enough evidence that fertilizers are not as effective as they should have been in South Asia for many reasons, such as the quality of fertilizers, use of wrong fertilizers, sub-optimal use levels, absence of complementary inputs such as improved seed varieties and adequate water, bad cultural practices, and similar factors. In the case of rice, the N losses are more than half of the quantity applied. This is not only an environmental hazard but also a substantial economic loss. Reducing nutrient losses is a critical step toward improving soil fertility and agricultural productivity for the poor farmers. It makes sense from every perspective--agronomic, economic and environmental. Thus improving the efficiency of fertilizer use is of paramount importance and needs particular attention in South Asia.

Improved management practices, product and crop attributes all lead to increased nutrient use efficiency. The integrated use of mineral fertilizers and recycled waste products not only reduces the amount of needed fertilizer but also improves nutrient and water use efficiency. The key is to synchronize the nutrient delivery from soils, biological nitrogen fixation, organic materials and mineral fertilizers with crop requirements (Singh 2005). In order to address the key concerns such as food security, profitability in agriculture, and environmental quality, improving the efficiency, effectiveness and sustainability of fertilizer use is the fundamental challenge for the region.

4.1 Factors Affecting Fertilizer Use Efficiency, Effectiveness and Sustainability

Improving the quality of fertilizer use in South Asia is critical from all perspectives such as agronomic, social and environmental. The factors that affect these multiple dimensions of fertilizer cover a wide range of issues at different stages of fertilizer use. These can usefully be classified into three groups: physical and technological, economic factors and institutional factors (Raju 1989):

Economic Factors

- Fertilizer prices
- Output prices
- Other input prices

Physical and Technological Factors

- Soil quality
- Fertilizer-use management
- Availability of other inputs
- Climate
- Extent of micro nutrient deficiency
- Unbalanced use of various fertilizer nutrients

Institutional Factors

- Inadequate credit availability for farmers and dealers
- Insufficient extension activities
- Inadequate infrastructure (roads, transportation)
- Inadequate distribution facilities
- Inefficient domestic production
- Non-availability of quality fertilizers

The above factors do have influence on fertilizer use pattern in each country in South Asia although their relative importance varies across the countries as well as among different farmer groups, regions, seasons, and other location specific characteristics of individual countries.

4.1.1 Economic Factors

The price of fertilizers is one of the important factors which determine the over-use and unbalanced use of different nutrients. Thus, it is essential to examine the relative changes in the prices of different nutrients and changes in prices of fertilizer with respect to prices of output.

Many researchers have studied the role of price and non-price factors in fertilizer consumption and the results have not been similar. One group of studies shows that price of fertilizer plays a crucial role in determining the consumption of fertilizers, while others highlight the importance of non-price factors such as irrigation, area under HYVs, per capita sown area, weather conditions, cropping intensity, retail outlets, rainfall, and similar factors.

According to one estimate (Subramanian and Nirmala 1991), the price elasticity of fertilizer use is in the range of -0.31 to -0.55 in India. Another estimate shows that in the short run it is -0.28 and, in the long run, it is -2.80 (Dholakia and Majumdar 1995). This indicates that the absolute price of fertilizer plays an important and direct role as a determinant of demand for fertilizers¹².

¹² This may have two implications: (i) the effect of an increase in fertilizer price would reduce the use of fertilizers and the trend cannot be reversed by restoring the relative profitability of fertilizers through the increase in output prices; and (ii) for the marginal and small farmers marketed surpluses are far too smaller proportions of their output. Thus high prices would lead to a sharp reduction in their consumption and in turn food grain production (http://knol.google.com/k/fertilizer-pricing_policy#).

Micro level studies reveal that increase in fertilizer prices prompts farmers to offset the effect of price hike in fertilizers by shifting to larger area under less fertilizer intensive crops such as pulses and mustard. Increase in fertilizer prices do not have significant effect on consumption of fertilizers but the farmers stride to shift the cropping pattern from fertilizer intensive crops like wheat to less fertilizer intensive crops (Sinha, et al. 2005).

In general, the demand for fertilizers is price sensitive, particularly in developing countries where farmers have poor financial affordability. When prices of fertilizers rise sharply in relation to the prices of farm produce, the level of fertilizer consumption tends to fall as well. However, in countries where fertilizer prices are partly or fully subsidized, the demand for fertilizers remains relatively less affected. The marketing cost incurred in transfer of fertilizers from the point of production to point of consumption is critical as it determines the price of fertilizers and fertilizer demand.

Transportation Cost

Transportation cost is a major component in the marketing cost of fertilizers followed by packing and storage. Lack of proper infrastructure facilities is mainly responsible for increase in marketing costs of fertilizers. For instance, the landed cost of the imported fertilizer in Nepal is itself very high because the country is landlocked (Table 4.1).

Table 4.1
Fertilizer Marketing Costs at Current Rates in Nepal ▼

| | Cost (US \$/mt material) | |
|---|--------------------------|-------|
| | Urea | DAP |
| Ex-factory price bagged/Import price CIF bagged | 329.4 | 389.2 |
| Transportation | 48.7 | 48.7 |
| Handling | 18.9 | 31.1 |
| Transportation and handling costs (2+3) | 67.6 | 79.8 |
| Total cost (1+2+3) | 397.0 | 469.0 |

Sources: AICL and AIMS/MoAC compiled in Misra 2010 and Pandey 2010.

The analysis of fertilizer prices in South Asia shows that a large component of fertilizer prices is the marketing cost and over the years its share in price has increased. The steep increase in marketing costs of fertilizers is mainly due to increase in fuel prices, cost of manual laborers, cost of packing and packaging materials, and services like transport, handling and storage. Several studies show that the transportation costs assume major component in the marketing cost of fertilizers followed by packing and storage (Meane and Wedder-shoven 1984, Ramarao 1988, Food and Agriculture Organization 2005, Singh et al. 2011). Table 4.2 compares the results from several empirical studies from India showing that the transportation cost of fertilizer on average is more than 30 percent of marketing cost. In certain areas of Bangladesh, transportation cost makes up more than 70 percent of the total marketing costs for dealers (Alam et. al. 2009).

There is hardly any study in Bangladesh that deals specifically with the issue of transportation costs of fertilizers. Alam et al (2009) find it to be 76 percent of total marketing costs for the dealers in Subarnachar and 82 percent for the dealers in Hatiya¹³. The corresponding proportions for the sub-dealers are reported to be 64 percent and 59 percent respectively.

Table 4.2
Marketing Costs of Fertilizer in India ▼

| Particulars | Meane and Weddershoven (1984) | Ramarao (1988) | Food and Agriculture Organization (2005) | Singh et al. (2011) |
|------------------------------------|-------------------------------|----------------|--|---------------------|
| Transportation | 37.3 | 46.0 | 55.0 | 86.0# |
| Packaging Materials | | 25.0 | | |
| Bagging | 20.2 | | | |
| Storage/Warehousing | 7.3 | 13.0 | 10.0* | |
| Handling Charges | 5.2 | | | |
| Physical Losses | 5.0 | | | 1.0@ |
| Capital Costs | 5.3 | | | |
| Administration | | 11.0 | 10.0 | |
| Dealers margin/Distribution margin | 5.2 | | 18.0 | |
| Financial Charges | | 5.0 | | |
| Selling Cost | | | 3.0 | 10.0 |
| Advertising and promotion | | | | 3.0 |
| Other costs | 15.5 | | 4.0** | |

* Storage & Handling Charges; ** Inventory Carrying Cost

Logistics Cost like freight, handling, warehousing, Inventory Management

@ Losses including transit shortages & standardization losses

Source: Kumar 2011

Thus the empirical evidence from all three case study countries indicate that transport cost is relatively high. The marketing cost of fertilizers has been continuously increasing over the years mainly due to increase in fuel prices, cost of manual labour, cost of packing and packaging materials, and services like transport, handling and storage.

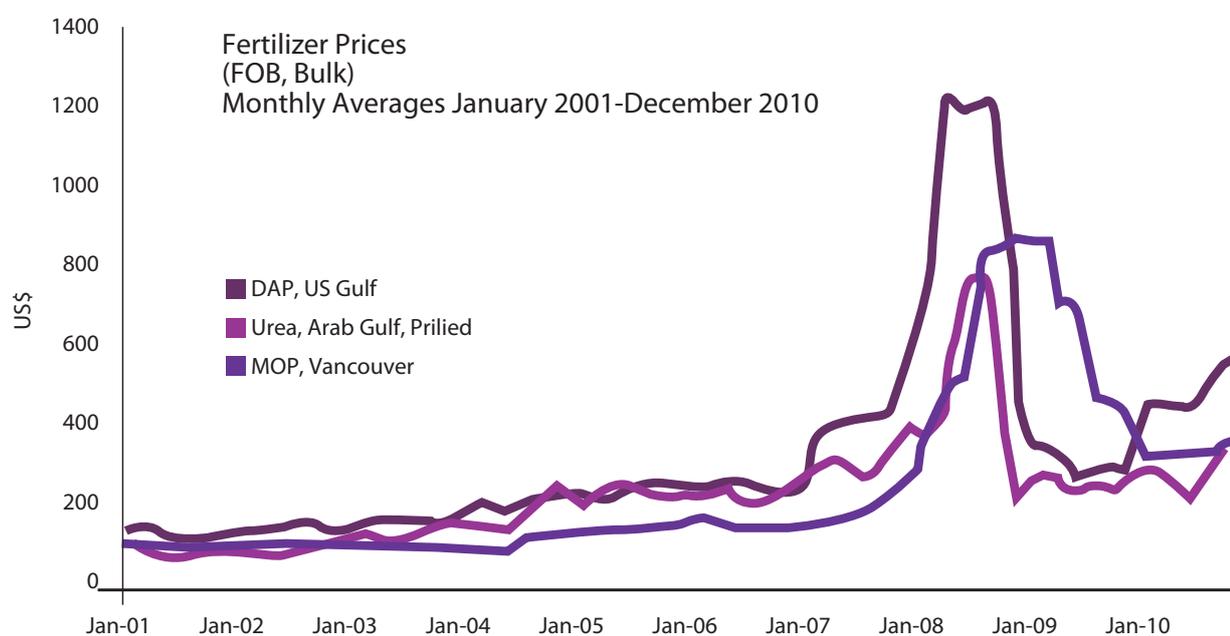
Recent Trend in Fertilizer Prices

Overall, fertilizer prices have shown an upward trend in recent years. Internationally the prices of TSP, DAP and MOP increased abruptly at the end of 2003 and beginning of 2004. Then, in 2007 and 2008, the prices of all fertilizers again went up sharply in international markets because of high energy costs and a shrinking supply of raw materials for fertilizer production (Figure 4.1). After a crash in 2008, the prices have gone back to an upward trend.

¹³ Subarnachar and Hatiya are two upazilas in the district of Noakhali.

Potash prices are the exception, exhibiting a drastic increase in 2008 without a subsequent crash¹⁴. According to Gregory and Bumb (2006), fertilizer prices are subject to large fluctuations over time, because in this industry, prices are easier to adjust than quantities. However, it is unclear whether the observed price variations result from demand-and-supply adjustments, from market power exertion in this highly concentrated industry, or from a combination of both factors. Current high price volatility is a significant disincentive for investing in inputs as the return on investment is highly uncertain. The uncertainty is increased by high variations in currency exchange rates. However, in South Asia due to government subsidies the fertilizer prices are somewhat more stable than in other regions. The rise in fertilizer price in the international market, along with high marketing costs due to poor infrastructure and inefficient distribution system, deprive many small and marginal farmers in the region from desired levels of fertilizer use. The impact of fertilizer prices on fertilizer use also depends on output prices received by the farmers.

Figure 4.1
Global Fertilizer Prices, 2001-2010 ▼



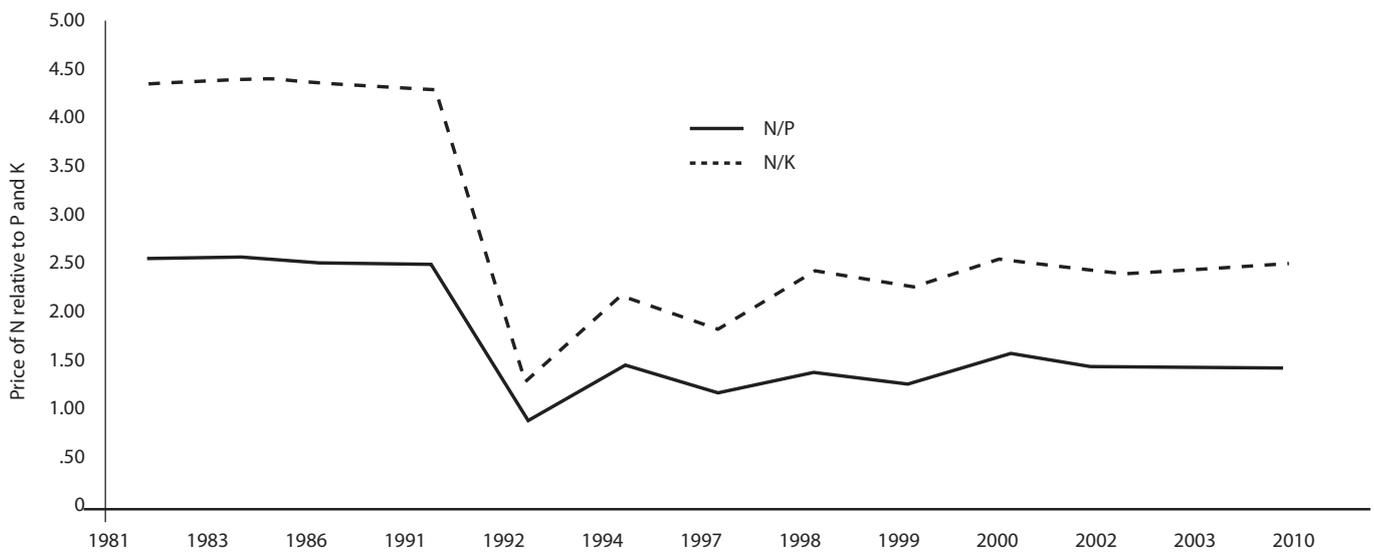
1) Derived from Green Markets. 2) Derived from FMB Weekly

World fertilizer prices doubled in 2007 and reached all-time highs in April 2008. But prices began dropping dramatically in October and November 2008, FOB = free on board (average price, with buyer paying freights and insurance, to destination port) DAP=Diammonium Phosphate. MOP= Muriate of Potash

Source: IFDC

¹⁴ Potash prices have witnessed maximum surge as the supply is concentrated in Canada, Russia and Belarus whereas nitrogen and phosphate supply is more diversified and spread over across the globe.

Figure 4.2
Price of Urea relative to P and K in India ▼



Source: Kumar 2011

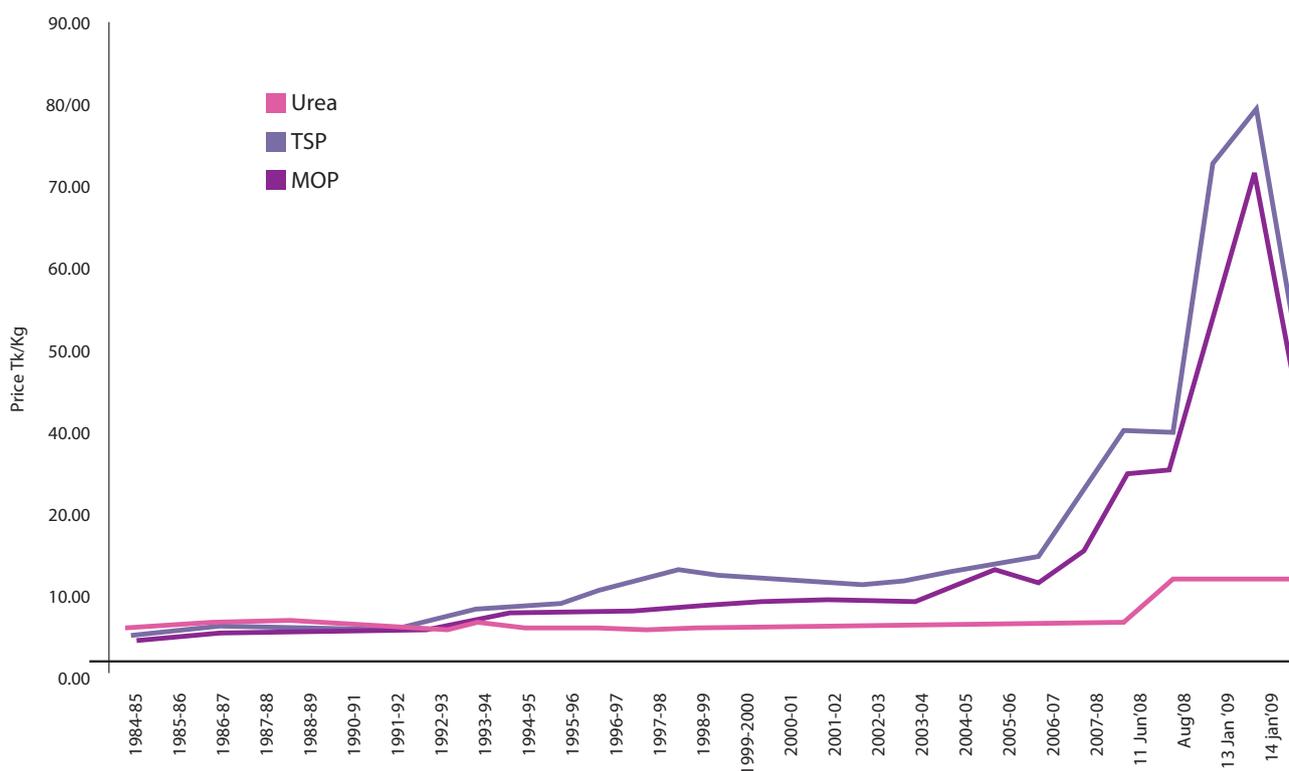
Price of Different Nutrients

The prices of major fertilizers such as Urea, Single Super Phosphate (SSP) and Muriate of Potash (MOP) have been rising steadily in India since 1981. The price of urea witnessed a significant increase after 1992. During the period of statutory control (1981 to 1991) in India, there was not much fluctuation in prices of all fertilizers. After the decontrol of fertilizer prices in August 1992, there was persistent increase in prices of all fertilizers. The increase was more prominent in SSP and MOP.

During the period of 1980-81 to 1990-91, prices of all the three types of fertilizers changed almost in a similar manner. This can be seen from the ratio of N to P and N to K (Figure 4.2). The distortion in relative prices of N, P and K during 1990-91 made the price of nitrogen lower than that of K. Significant change was seen after 1992, the prices of P and K increased at a lower rate than that of N but prices of N relative to P and K were far lower than those prevailed during the 1980s. Thus, the year 1991 made a distinct change in fertilizer prices in favour of N. This is an important factor in shifting the balance of fertilizer use in favour of N and against P and K. The relative prices of N, P and K are important in affecting substitution among the three types of fertilizer (Chand and Pandey 2008).

Figure 4.3 shows the historical trend in the price of fertilizers in Bangladesh. As can be seen, the price of urea remained more or less unchanged until 2008. From 2008, the price of urea has been increasing and since 2009 the price of non-urea fertilizers has been declining. Thus the recent trend is that the price of urea in relation to the prices of non-urea fertilizers has been increasing. Such difference in prices between fertilizers promotes unbalanced use of chemical fertilizers which then accelerates the deterioration of soil fertility.

Figure 4.3
Trends in Fertilizer Prices in Bangladesh ▼



Source: Toufique 2011

Price of Output

The rise in food grain prices improves the farmers' incomes and motivates them to invest more in agriculture. On the other hand, it adversely affects the rural landless and urban poor, compelling them to expend more on food items at the cost of meeting other basic necessities such as family health, education and other livelihood expenses. The relationship between fertilizer and food grain prices is critical in determining economic efficiency of fertilizer, hence the level of fertilizer adoption and use by the farmers. Since the prices of fertilizer nutrients and crop outputs have increased at different pace across South Asia, it is hard to make general comment on economic efficiency for the entire region. However, country specific value-cost ratio (VCR) provides some indications of relative profitability¹⁵. The analysis from Nepal reveals that with the current open market price of fertilizers and the output price for food grains, the use of nitrogenous fertilizers is highly profitable for all major crops viz. wheat, rice and maize. The use of phosphates is quite profitable for wheat and maize but not so much for rice. The use of potash fertilizers, on the other hand, is not so remunerative because of the high nutrient price and lower crop response (Table 4.3). Although no specific studies are available it is widely believed that similar trend exists in other South Asian countries such as Bangladesh and India.

¹⁵ The value-cost ratio (VCR) is the ratio between the value of additional crop yield and the cost of fertilizer which is used as a measure to quantify the economics of fertilizer use.

At present, the agronomic efficiency seems reasonable for farmers to use fertilizer but it varies from nutrient to nutrient and across countries in South Asia. But with rising fertilizer prices coupled with low yield response, it is likely that the efficiency will decline in future.

Table 4.3
Economics of Nutrient Application in Nepal ▼

| Nitrogen through Urea | | | | |
|---|------------------|---------------------------------------|---------------------------------------|------|
| Wheat Price (NRs/kg) | N Price (NRs/kg) | Yield Increase (kg grain/kg nutrient) | Value of Grain (kg grain/kg nutrient) | VCR |
| 28.02 | 52.17 | 10 | 280.2 | 5.37 |
| P ₂ O ₅ through DAP | | | | |
| Wheat Price (NRs/kg) | N Price (NRs/kg) | Yield Increase (kg grain/kg nutrient) | Value of Grain (kg grain/kg nutrient) | VCR |
| 28.02 | 39.06 | 5 | 140.1 | 3.59 |
| K ₂₀ through MOP | | | | |
| Wheat Price (NRs/kg) | N Price (NRs/kg) | Yield Increase (kg grain/kg nutrient) | Value of Grain (kg grain/kg nutrient) | VCR |
| 28.02 | 23.17 | 5 | 140.1 | 1.21 |
| Nitrogen through Urea | | | | |
| Wheat Price (NRs/kg) | N Price (NRs/kg) | Yield Increase (kg grain/kg nutrient) | Value of Grain (kg grain/kg nutrient) | VCR |
| 30.99 | 52.17 | 10 | 309.9 | 5.94 |
| P ₂ O ₅ through DAP | | | | |
| Wheat Price (NRs/kg) | N Price (NRs/kg) | Yield Increase (kg grain/kg nutrient) | Value of Grain (kg grain/kg nutrient) | VCR |
| 30.99 | 39.06 | 2 | 61.98 | 1.59 |
| K ₂₀ through MOP | | | | |
| Wheat Price (NRs/kg) | N Price (NRs/kg) | Yield Increase (kg grain/kg nutrient) | Value of Grain (kg grain/kg nutrient) | VCR |
| 30.99 | 23.17 | 1 | 30.99 | 1.34 |

Note: VCR-Value-Cost Ratio
Source: Misra 2010, Pandaey 2010

4.1.2 Physical and Technological Factors

Soil Quality

According to available statistics, it is estimated that the farmers in Bangladesh use 215 kg of nutrients per hectare per year from chemical fertilizers while the estimated removal is around 280-350 kg per hectare. From organic and natural sources, about 50-70 kg nutrients are added to the soil system every year. Average fertilizer productivity, as measured by the amount of product obtained per kilogram of fertilizer nutrient, varies considerably reflecting factors such as differences in agro-ecological resources (soil, terrain and climate). Although farming practices based on soil test/analysis and subsequent fertilizer application recommendations can lead to improved efficiency, inadequacy of soil-testing facilities is a limiting factor for application of proper doses of fertilizers in all South Asian countries.

Climate

Another non-price factor is the climate and the season. Rainfall pattern (amount and distribution over time) is also a fundamental factor that greatly influences the fertilizer consumption level, particularly in the rain-fed arid areas. Even when all other factors are favourable, the failure of seasonal rainfalls (e.g. monsoon rains) adversely affects the demand for fertilizers.

The frequent failures of rainfall increase the risk for farmers in using fertilizers. Thus they will be reluctant to use fertilizers even if they have resources at their disposal for purchasing fertilizers, as use of fertilizers in the absence of timely and sufficient rains will lead to low soil moisture, damage to crop and soil eventually causing crop failures of varied magnitude.

With regard to fertilizer demand, the case for irrigated areas is different from rain-fed ones. Fertilizer use is significantly higher in irrigated areas compared with rain-fed areas, because in the former the availability of funds is relatively better and assured irrigation makes it possible for farmers to use fertilizers when they want as fertilizers are available in these areas relatively easily and in time.

Fertilizer Use Management

Nutrient mismanagement is widespread in South Asia. The high imbalance in fertilizer application is the first indicator of nutrition mismanagement. There is generally an over application of N compared with P and K that contradicts with the tenets of balanced fertilization and thereby, influences soil fertility, crop yields and quality and the sustainability of agriculture in the long run. In India, the main consumer of all three macronutrients, the share of application of N fertilizers in total is around 65 percent whereas the share of P is around 25 percent and that of K is 10 percent as against the recommended ratio of 4:2:1 for N, P and K respectively (58 percent of N, 28 percent of P and 14 percent of K). Similarly, in Nepal the majority of farmers are found inclined to use only nitrogenous fertilizers – mainly urea (Shrestha 2010). These imbalances in fertilizer use are attributed to several factors including high prices of P and K compared with N, low in-country production base of P and K fertilizers, excessive promotion of urea by local producers, and policies such as subsidy, decontrol of fertilizers favouring increased use of fertilizers particularly N.

Many soils are severely depleted of some nutrients and organic matters because of intensive farming and the non-return of organic residues; crop residues are widely used as fuel and fodder and usually not returned to the soil. The widespread deficiency of phosphorus, sulphur, and organic matter severely affects crop production. For example, the information collected by the Soil Resource Development Institute (SRDI) indicates that a large area of Bangladesh is severely deficient in phosphorus, potassium and sulphur and 53 percent of the country's arable land is severely deficient in organic matter. Such deficiency can lead to low crop quality and imperfect plant morphological structure along with lower efficiency of major macronutrients, such as N, P and K and thereby reduced crop yield (Ghaffari 2010, Cakmak 2002, 2008, Malakouti 2007, Malakouti et al. 2008). Therefore, in order to gain optimal productivity it is important to know both soil type and plant requirement and then to apply fertilizers. At present soil-testing facilities are limited and farmers are still not aware of the plant requirement and are facing difficulty in getting the appropriate nutrients in the right amount and time. Often the delay in fertilizer supply leads to untimely application of fertilizer. Inadequate warehousing capacity, delay in subsidy payment to fertilizer, poor infrastructure are some of the major bottlenecks in the timely availability of fertilizers during the peak seasons.

Slow-and controlled-release fertilizers, and fertilizers stabilized with urease and nitrification inhibitors hold a lot of potential for use in the South Asian countries¹⁶. However, their higher costs mean that, at present, their use is more unlikely in developing countries than that of traditional fertilizers. So, the greatest medium-term gain could be derived from improving the way in which currently available fertilizers are used.

The form of inorganic fertilizers also plays a key role in achieving efficiency. The nutrient use efficiencies viz., agronomic efficiency, apparent recovery and partial factor productivity are more significantly enhanced by the application of tablet forms of NPK sources than other slow release forms as well as standard fertilizer materials (Jagadeeswaran et al. 2005). The common practice of surface broadcasting N fertilizers can entail large N losses, particularly ammonia volatilization, from the system and reduce NUE (Mohanty et al.1999; Randall et al. 1985).

In India, for upland crops results are overwhelming in favour of drilling and placing P below the soil surface and into the root zone (Abrol 1998). Under irrigated conditions, wheat yield increases of 400-700 kg/ha are common when P is placed or drilled compared with surface broadcasting (Tandon 1987).

Leaf colour charts (LCC) have been extensively used in Asia (Balasubramanian et al. 1998). A group of 107 farmers comparing the LCC method with their own N management practices report that the LCC reduces requirements from an average of 154 to 122 kg per ha, a net savings of 32 kg/ha or 25 percent of applied N. This savings in N occurs without any loss of rice yield. Studies conducted in India (Shukla et al. 2005), Bangladesh (Alam et al. 2004), and Nepal (Regmi and Ladha 2005) show that LCC- based N use for different rice cultivars produce larger yields than those obtained with farmers' practices. In several places in India, similar benefits have been observed using LCCs. In wheat, applying 30 kg N/ha each time with an LCC score of 4 and a total application of 120 kg N/ha produces more grain yield, N uptake, and N-use efficiency than using similar amounts (120 kg N/ ha) in three fixed-time splits. Net returns of cropping systems are greater in LCC-based N management than in fixed-time recommended N application for rice and wheat (Shukla et al. 2004).

¹⁶ Urease inhibitors slow the hydrolysis of urea, a reaction which produces ammonia and ammonium-nitrogen. If urea hydrolysis occurs in plant residue or on the soil surface, nitrogen losses by ammonia volatilization occur. These compounds may be effective particularly in high residue systems. Nitrification inhibitors (NI) slow soil conversion of ammonium-nitrogen held by clay and organic matter to leachable nitrate-nitrogen. These compounds are especially useful on coarse textured soils where leaching is likely and on fine textured soils where excess water can cause denitrification losses of nitrate-nitrogen. The use of a nitrification inhibitor can be helpful with both pre-plant and side-dressed nitrogen applications. The use of a nitrogen inhibitor can improve nitrogen use efficiency and provide crop benefits by extending ammonium-nitrogen availability and uptake.

Other Inputs

Similarly, the role of irrigation is important in making fertilizer application effective and efficient, but irrigation facilities too are still very poor in most areas of South Asia. Fertilizer productivity is closely related to soil moisture availability and, hence, to irrigation.

Fertilizer has the strongest relationship with water (95 percent), followed by seed (83 percent) and electricity (72 percent). This means that water is essential to harvest the benefits of fertilizer and electricity is also directly related to pumping of groundwater (Table 4.4).

Table 4.4
Correlation between Agricultural Inputs in India ▼

| | Seed | Water | Fertilizer | Electricity |
|-------------|------|-------|------------|-------------|
| Seed | 1 | 0.73 | 0.83 | 0.49 |
| Water | 0.73 | 1 | 0.95 | 0.68 |
| Fertilizer | 0.83 | 0.95 | 1 | 0.72 |
| Electricity | 0.49 | 0.68 | 0.72 | 1 |

Source: Kumar 2011

Irrigated crops require higher levels of fertilization for optimal productivity, and there is often synergy between irrigation and fertilizers. However, over-irrigation results in leaching of nitrate to the groundwater and reduces the efficiency of N fertilizers. Therefore, irrigation water management is essential for deriving profitable yields and protecting water quality.

Nutrition Mismanagement

Furthermore, due to lack of proper extension services the farmers are usually not aware of the best methods of applying fertilizer. It exists due to several reasons, including inadequate knowledge of farmers, lack of appropriate nutrients supply, lack of credit and proper management. Recently some improved fertilizer application techniques are gaining popularity among South Asian farmers. For instance, some farmers are moving away from the common practice of surface broadcasting N fertilizers which entails large N losses to deep placement of fertilizers, particularly urea, and that has resulted in improved yields and lower N and P losses from flooded rice fields (Kapoor et al. 2008, Bowen et al. 2005, Mohanty et al. 1999, Randall et al. 1985). Deep placement of urea eliminates nitrogen losses due to volatilization, nitrification and floodwater run-off, allowing farmers to realize a 30 percent increase in yields (Box 4.1).

There is a need for creating awareness among farmers about soil health and providing advice on nutrient needs based on soil tests in order to upgrade the biological potential of nutrient-depleted soils through increased application of organic residues, manure and compost along with balanced use of mineral fertilizers. This can be achieved by strengthening the extension services related to fertilizer and/or integrated nutrient management, and other agricultural inputs to farmers in various forms like training and field demonstration.

**BOX
4.1**

Urea Deep Placement in Bangladesh

Urea is an important and widely used fertilizer especially for rice in Bangladesh. But research shows that only 15 to 35 percent of the total nitrogen applied is actually used by the crop. The normal practice of applying broadcasted urea results in upward disappearance of a large part as greenhouse gas along with downward disappearance as pollutant in groundwater or washed away in run-off.

In order to improve the efficiency of fertilizer use, the farmers have adopted urea deep placement (UDP), inserting granules at regular intervals 8-10cm down into the soil. The deep placed urea becomes a 'food store' for the plants, ready to be absorbed when needed, and bringing an increase in yields of at least 25 percent above a conventionally fertilized crop. The technique also reduces fertilizer costs.

Since 2007, around 6,000 extension workers and 2 million farmers have been trained in UDP. According to the International Fertilizer Development Corporation (IFDC), per farm income among those trained has increased by an average of US\$ 116 per year, and the country has saved an estimated US\$ 21 million through more efficient fertilizer use. Ushrani Goswami, a widow who lost more than half her family's tiny land after her husband's death, as trained in 2008 under an UDP expansion project implemented by the Bangladesh Department of Agricultural Extension with assistance from IFDC. In her first season, she harvested an extra 600 kg of rice from her half hectare plot despite using 70 kg less urea. In the next season, she repeated the success inspiring many others in her village to adopt the technique.

No doubt, UDP is both time-consuming and laborious compared with broadcasting because the farmers have to insert fertilizer briquettes by hand. But unlike broadcasting, applying the fertilizer needs to be done only once in a season and farmers also remarked that with UDP their crops need less weeding.

Lack of Complementary Inputs

The N recovery efficiency for fields managed by farmers ranges from 20 percent to 30 percent under rain-fed conditions and 30 percent to 40 percent under irrigated conditions. The effects of irrigation and HYVs are also strong on the consumption of nitrogen (N), as 1 percent increase in area under irrigation and a similar increase in area under HYVs result in 0.66 percent and 0.64 percent increase in the consumption of N respectively.

However, Asia's large scale surface irrigation schemes continue to under-perform, even though total area under irrigation is on the rise, due to the rise of individualistic groundwater based irrigation fuelled by cheap pumps and often supported by government subsidies in the form of cheap electricity.

In order to address the synergetic relationship between fertilizer and irrigation, the concept of fertigation has been introduced. Many studies have found that micro irrigation particularly drip irrigation and fertigation results in a significant impact on resource saving, reduction in cost of cultivation, and enhancement of crops yields and farm profitability. In spite of the potential benefits from drip and sprinkler irrigation methods, studies show that the rate of adoption of drip and fertigation in South Asia is low and slow. Lack of technical support, particularly maintenance of micro irrigation systems, inadequate and lack of information about the operation and maintenance are the main reasons. Capacity building on micro irrigation technologies, including maintenance will help to solve the problems. The government departments and the private firms dealing in micro irrigation systems may be encouraged to deeply involve in the service provisional capacity building process (Patel et al., 2006, Singh et. al, 2007, Espinso et al., 1999, Akib et al. 2011).

4.1.3 Institutional Factors

Inadequate Extension Services

The optimal use of fertilizer can be achieved via several ways. They span from better nutrient management both in terms of time and quantity, balanced use of nutrients, and precision agriculture to development and use of smart fertilizers. However, irrespective of which strategy is chosen, it is essential that the fertilizer industry transfers the knowledge to the farmer's field.

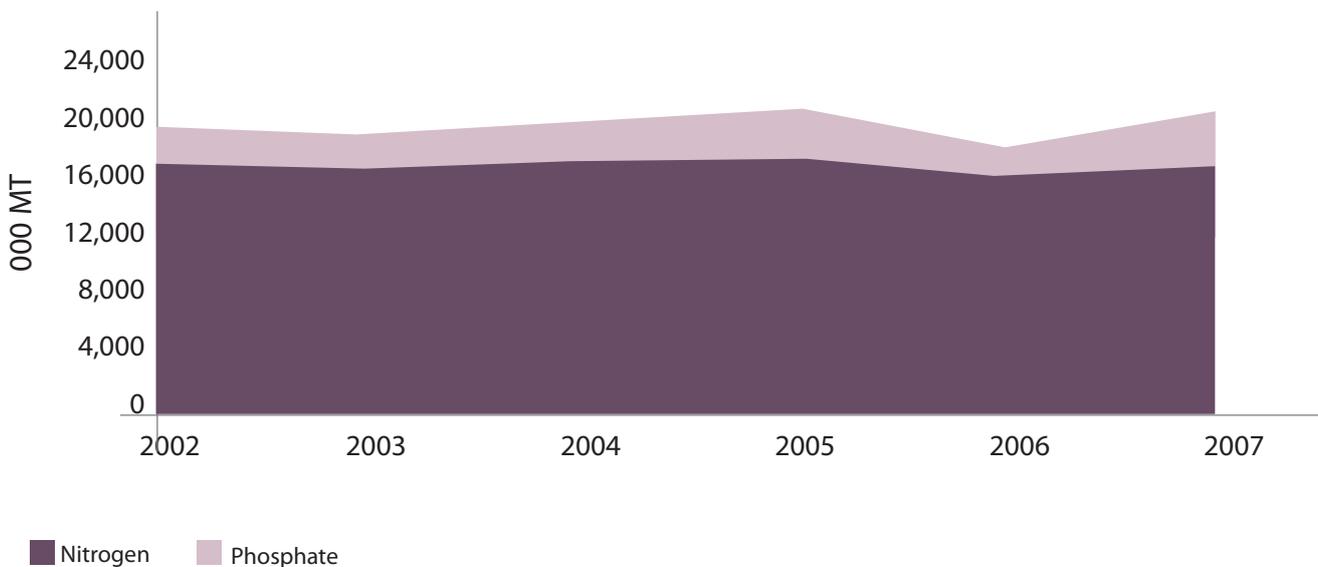
Currently, there is a scarcity of extension workers in the South Asian countries. In addition, the workers lack professional capacity having inadequate linkages with the knowledge-generating systems and they are observed to spend most of their time in activities related to the distribution and administration of fertilizers. This leaves little time for extension and field activities to promote scientific and integrated use of chemical, organic and bio-nutrient resources.

Agricultural extension should be seen primarily as a government responsibility. Other stakeholders such as the fertilizer industry and NGOs may also undertake such activities in accordance with their own mandate and to meet institutional objectives. For instance, village-level fertilizer retailers can play a useful role by providing the farmers with information about products suitable for their crops, correct dosage, efficient application, and handling and mixing of fertilizers in suitable proportions to make mixtures tailored to their needs.

Underuse of Domestic Capacity

The South Asian region is not only one of the major consumers but also an important producer of fertilizer in the world. During 2002–2007, fertilizer production in the region increased at an annual rate of 1.3 percent, totalling almost 20 million metric tons of nutrients in 2007 (11.4 percent of world production). The region produces mostly nitrogen and phosphate. Of the 114 million metric tons of nutrients produced during 2002–2007, nitrogen accounted for 78 percent and phosphate for 22 percent (Figure 4.4).

Figure 4.4
Fertilizer Production in South Asia ▼



Source: FAOSTAT online database

The production in the region is driven by India, which accounts for almost 71 percent of South Asia's production capacity for all fertilizer products, including urea, ammonia, complex fertilizers (NPK), and DAP/MOP. There also exist high concentrations of the fertilizer industry across countries and as well as within main producing countries (Hernandez and Torero 2011). For instance, in India, Bangladesh and Pakistan the top four firms in each country account for more than 56 percent of the country's production capacity. The regional-level concentration depicts the need of countries like Nepal, with zero fertilizer production, to rely completely on import whereas the country-level concentration reflects the heavy dependence on a small number of producers with minimal competition. Also the production plants often fail to operate at full capacity due to many constraints.

With increasing fertilizer prices and rising demand for fertilizers, it is important that South Asian countries having the natural resource base for producing fertilizers provide the required incentive to encourage more investments in the fertilizer industry and take appropriate measures to improve the capacity utilization of the existing plants.

Limited Access to Credit

Fertilizers are high-volume, low-profit-margin products with a seasonal demand. The dealers need inexpensive credit if adequate stocks of the types of fertilizer required by the farmers are to be made available at the time they are required. The farmers, especially the small farmers, need credit to finance the purchase of fertilizers for the period between the application of fertilizer and the harvesting and sale of the agricultural products. An inadequate availability of credit at an affordable cost is frequently mentioned as a major constraint on fertilizer use.

Credit is required by fertilizer distributors to enable them to hold sufficient stocks to meet seasonal demand. In general, suppliers give credit to dealers for payment within a specified interest-free period. But with the expansion of fertilizer trade, the dealers' financial needs are increasing rapidly which require support through adequate credit from formal financial institutions.

Fertilizer Distribution System

The timely availability of adequate and appropriate quantities of fertilizers to the farmers is constrained by inefficient distribution systems in South Asian countries. There usually persists a shortage of retail outlets especially in the interior areas of most countries requiring the farmers to travel long distances to purchase fertilizers. Often the outlets also fail to deliver fertilizer to farmers on time and in right quantity. The dealer network lacks competition and the margin for fertilizer distributors built into the price structure to cover actual costs of transport, storage, administration and overheads is often considered inadequate by the dealers. Another issue is the frequent emergence of fertilizer shortages mainly due to inadequate estimation methods used to determine fertilizer requirements in the countries.

Even if fertilizer is available on time at reasonable price, the farmers have to worry about its quality. The application of adulterated fertilizers reduces crop yields significantly because of their low nutrient contents (Kale and Bhandari 2011). The poor quality of fertilizer may result through several channels. The Central Fertilizer Quality Control Testing Institute (CFQCTI) in India reports that around 70 percent of the problems in quality is due to adulteration or misbranding, another 20 percent is due to deliberate manufacturing of low quality fertilizers, and the remaining 10 percent is due to the difference of the content of the bags and black marketing (CFQCTI 2005). In Bangladesh, the analysis of 3,780 samples of different fertilizers by the Soil Resource Development Institute (SRDI) in 2009 shows that 40 percent of those is adulterated. Katalyst (2009) reports similar results for Bangladesh where an alarming 52 percent of the samples are found sub-standard (Table 4.5). The countries have enacted Fertilizer Quality Control Acts and posted fertilizer inspectors at sub-national levels. But there is a lack of both logistical support and trained staff for effective monitoring. They also have no judicial power to implement the provisions of the quality control acts.

Table 4.5
Substandard/Adulterated Fertilizer Sales in Bangladesh ▼

| Name of Fertilizer | No. of samples analyzed | No. of sub-standard /adulterated samples | |
|--------------------|-------------------------|--|-----------|
| | | No. of samples | Percent |
| Urea | 216 | 10 | 5 |
| Ammonium Sulphate | 6 | 6 | 100 |
| TSP | 628 | 323 | 55 |
| SSP | 64 | 40 | 62 |
| DAP | 183 | 57 | 31 |
| SOP | 74 | 38 | 51 |
| MOP | 668 | 175 | 26 |
| ZnSo ₄ | 1044 | 742 | 71 |
| Chelated Zinc | 35 | 15 | 43 |
| FMP | 2 | 0 | 0 |
| NPKS | 706 | 602 | 85 |
| Boron | 306 | 147 | 48 |
| Organic Fertilizer | 199 | 121 | 61 |
| MgSo ₄ | 500 | 96 | 19 |
| Gypsum | 213 | 93 | 44 |
| Other Fertilizers | 199 | 161 | 81 |
| Dolomite | 10 | 2 | 20 |
| Total | 5053 | 2628 | 52 |

Source: Katalyst, 2009

The governments in South Asian countries, like most other countries in the world, intervene in agriculture keeping multiple objectives in view such as self-sufficiency in basic staples, employment creation, supporting small-scale producers for adopting modern technologies and inputs, reducing price instability, and improving the income of farm households. These interventions take various forms such as import and export policies, and domestic policies like price support programs, direct payments, and input subsidies to influence the cost and availability of farm inputs like fertilizers. Of all domestic support instruments, input subsidies and product price support are the most common in South Asia. As a consequence, interest in input subsidies particularly those on fertilizer has been one of the main agendas in policy discourse in most South Asian countries.

Fertilizer subsidy first came into existence in South Asia in the 1960s. Over the years, it has been adopted widely across the countries in the region. The initial objective behind providing fertilizer subsidy was to promote fertilizer use among the farmers. However, the present rationale for fertilizer subsidy rests more on making fertilizers affordable for small and marginal farmers, support higher production of food grains, and thereby ensure food security. One analysis by Chand and Pandey (2008) shows that in India if subsidy on fertilizer is removed completely then the price of fertilizer will increase by 69 percent and this would cause close to 9 percent reduction in food grain production.

Also, fertilizer subsidies present an alluring appeal to the politicians as a way of gaining and maintaining political support. It is well established that fertilizer subsidy does increase the use of fertilizers. However, it is also responsible for reducing the efficiency and effectiveness of fertilizer use and jeopardizing its sustainability. Despite playing a strong catalytic role in raising crop yields and boosting agricultural production in the past, fertilizer subsidy in the South Asian countries is widely considered as an inefficient allocation of public investments and a major drain on agricultural resources under the present realities of agriculture in these countries. The empirical evidence in general indicates that the subsidy-heavy agriculture in South Asia represents inefficient allocations of public resources from the point of view stimulating growth and reducing poverty. The rapidly rising cost of subsidies has been identified as one of the principal factor behind persistence of under-investment in agriculture in these countries.

5.1 Fertilizer Subsidies in South Asia

The history of fertilizer subsidy policy in the South Asian countries follows a very similar path. Till the early 1990s, these countries administered heavy subsidy on fertilizer followed by a decline in fertilizer subsidy during the period of fertilizer deregulation but, in recent times, they all have reintroduced fertilizer subsidy in order to tackle the issue of food security.

In Bangladesh, fertilizer subsidy first came into being in the 1960s to encourage the use of chemical fertilizers. The subsidy to the agricultural sector rose rapidly over the years and is now more than 0.7 percent of GDP (Table 5.1). The amount represents around percent of total public expenditure on agriculture by the government every year.

Underuse of Domestic Capacity

The South Asian region is not only one of the major consumers but also an important producer of fertilizer in the world. During 2002–2007, fertilizer production in the region increased at an annual rate of 1.3 percent, totalling almost 20 million metric tons of nutrients in 2007 (11.4 percent of world production). The region produces mostly nitrogen and phosphate. Of the 114 million metric tons of nutrients produced during 2002–2007, nitrogen accounted for 78 percent and phosphate for 22 percent (Figure 4.4).

Table 5.1
Fertilizer Subsidy in Bangladesh ▼

| Year | Total amount (in billion Tk. at current prices) | Total amount (in billion Tk. at constant prices) |
|---------|---|--|
| 2001-02 | 1.0 | 1.0 |
| 2002-03 | 2.0 | 1.9 |
| 2003-04 | 3.0 | 2.7 |
| 2004-05 | 6.0 | 5.1 |
| 2005-06 | 12.0 | 9.5 |
| 2006-07 | 15.4 | 11.4 |
| 2007-08 | 22.5 | 15.1 |
| 2008-09 | 57.9 | 36.5 |
| 2009-10 | 49.5 | 29.1 |

Source: MOF 2011

In India, the government budget support for fertilizer at constant 1993 prices rose by more than 30 times from Rs. 2.6 billion in 1976 to Rs. 80 billion in 2000 (see Fan, Thorat and Rao 2004). As a share of GDP, the increase has been from 0.07 percent to 0.61 percent over the period. As a matter of fact, the fertilizer support budget as a share of agricultural GDP has become more than five times larger than the public spending on agricultural R&D. One study shows that paddy and wheat farmers are the main beneficiaries of fertilizer subsidy followed by cotton and sugarcane farmers (Singh 2004)¹⁷. Moreover, it is seen that not all government budget support for fertilizer goes to the farmers with a large share ending up with the domestic fertilizer industry. According to one estimate, the farmers' share of the fertilizer subsidy is about 50 percent (Gulati and Narayanan 2003).

In Nepal, prior to 1997-98, fertilizer subsidy was used extensively to encourage the use of fertilizers. Financing the subsidies required higher taxes and increased external borrowings. Although those subsidies increased the use of fertilizers, the costs were also very high. Subsidized fertilizers played a significant role in raising agricultural production during the initial years but their contribution seems to have declined in the present times as their use has reached higher levels. The Government of Nepal initiated the deregulation of the fertilizer trade in November 1997, along with complete elimination of fertilizer subsidy on DAP and MOP and a phase-wise removal of subsidy on urea. The subsidy removal process was completed by November 1999.

¹⁷ The study reports that paddy farmers consume 35 percent, wheat farmers 19.3 percent, cotton growers 5.8 percent and sugarcane growers 5.5 percent of total fertilizers. Fertilizer use per hectare is also higher for paddy (79.7 kg) and wheat (85.32 kg) followed by 28.8 kg for coarse cereals and 42 kg for other crops. cing policy#).

In March 2009, the government started to distribute fertilizers at a concessionary rate for small and marginal farmers on a limited scale. The current provision of subsidy is limited to a fixed quantity of 100,000 metric tons of fertilizers per year with an estimated outlay of NRs.1.5 billion. The farmers with landholding size of up to 0.75 ha in the hills and mountains and up to 4 ha in the terai are eligible for the subsidy. There is also a provision for meeting the transport cost for 26 remote districts through a special program.

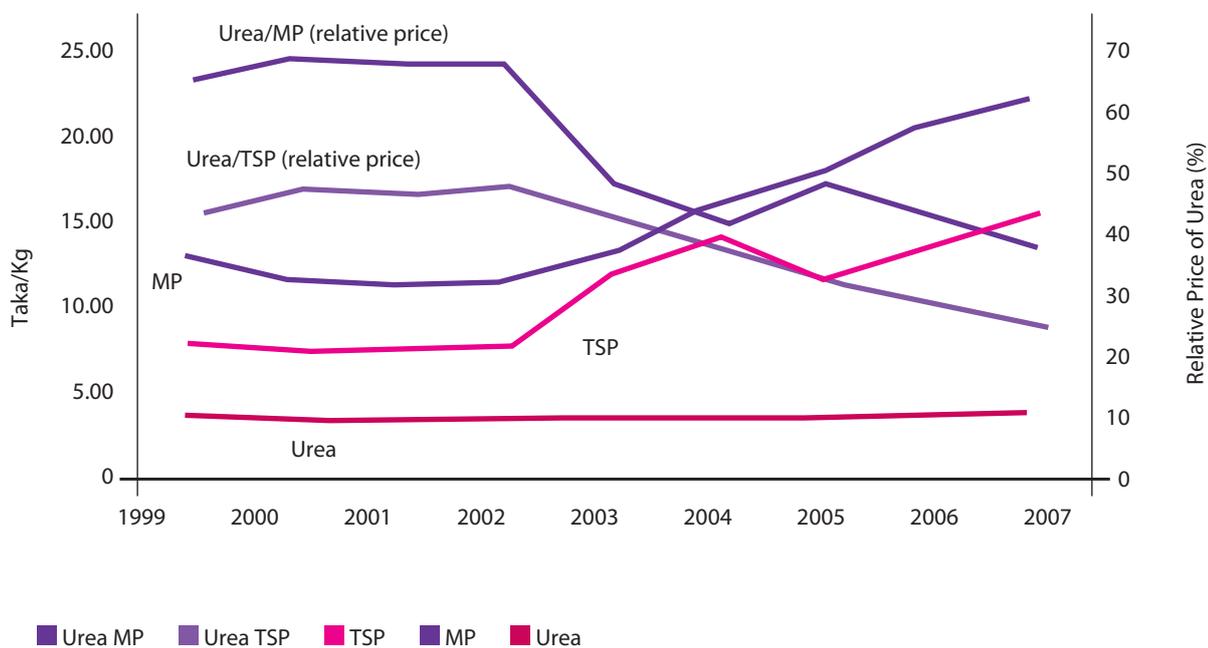
5.2 Impact of Subsidy Policy on Fertilizer Use

The fertilizer subsidy system in operation in South Asian countries affects the efficiency, effectiveness and sustainability of fertilizer use through several channels.

Encourage Unbalanced Use

It is evident that unbalanced use of fertilizers is a common and serious concern in South Asia. The relatively high subsidies given to urea, compared with TSP, MOP and DAP has led to unbalanced fertiliser use which depresses yields and adversely affects soil fertility¹⁸. Figures 5.1 and 5.2 show how relative fertilizer prices have changed in Bangladesh since 1999 resulting in rapid increase in the use of urea. Hossain and Haq (2010) report that the total subsidy on urea was Tk. 42,000 million and non-urea fertilizers was Tk. 6,000 million in 2009-10 in Bangladesh indicating that 87 percent of total subsidy was given to urea alone.

Figure 5.1
Price Movement of Different Fertilizers in Bangladesh ▼



Source: Toufique 2011

¹⁸ The relatively larger use of urea is also because of its immediate impact on enhancing the lush green foliage in crop plants which appeals to the farmers to use it more.

Similar imbalances are also observed in India, Nepal and other South Asian countries. Moreover, the farmers and the policy makers are becoming increasingly aware of the negative implications of unbalanced fertilizer use. The Government of India (GOI) has introduced nutrient based pricing of subsidized fertilizers in 2008. Under the nutrient based pricing policy, the prices of all complex fertilizers have been revised based on the unit price of N, P, K and S derived from the prices of urea, DAP, MOP and SSP respectively. Sulphur is also recognised as the fourth most important soil nutrient after nitrogen, phosphorous and potash and its deficiency is seen as a prime reason for reduced effectiveness of the primary nutrients. The implementation of nutrient based pricing has significantly reduced the prices of all complexes since unit prices of N, P, K, and S now remain the same in all fertilizers. This encourages the farmers to use fertilizer as per the nutrient requirement without being lured by low priced fertilizers.

Figure 5.2
Per Hectare Use of Different Fertilizers in Bangladesh ▼



Source: Asaduzzaman 2009

Inefficient Subsidy Payment Systems

In general, the method of subsidy payment is unnecessarily complicated and highly bureaucratic in the South Asian countries. In India where fertilizer subsidy is routed through the fertilizer industry, there are procedural delays by the government in payment of subsidy and difficulties in the arrangement of working capital by the industry (Chander 2008). In Bangladesh, it passes through different committees such as information cell, storage enquiry sub-committee, price fixation sub-committee, price fixation and monitoring committee and steering committee in order to fix the price (Box 5.1). Each committee works at its own pace which delays the subsidy payments.

Lapses in Effectively Reaching the Target Group(s)

One of the most contentious issues surrounding fertilizer subsidy is how much of what is paid out actually finds its way to the farmers and how much is drawn by the fertilizer companies and other participants in the distribution process. There has always been a debate about the issue of real beneficiaries of these subsidies (Sharma and Thaker 2009). Some evidence from India shows that fertilizer subsidy is distributed equitably across farm size categories. The small and marginal farmers have a larger share in fertilizer subsidy in comparison with their share in cultivated area. The inter-state disparity in fertilizer subsidy distribution is, however, high. Rice, wheat, sugarcane and cotton farmers account for about two-thirds of the total fertilizer subsidy.

BOX 5.1

Subsidy Payment System in Bangladesh

The subsidy payment system in Bangladesh works in several layers as described below.

First Step: Whenever the vessel carrying fertilizer of an importer reaches the outrage of Chittagong port, he/she submits all documents to the cell at the office of the Additional Director, DAE. This cell examines all the documents and then sends samples to the designated laboratories for testing. After testing, the cell sends the report to the Ministry of Agriculture. At the Ministry's directives, the storage enquiry sub-committee inspects the godown where the fertilizer of the importer would be stored. After inspection, the sub-committee sends report to the price fixation sub-committee which then examines all documents of the importer and fixes price of the fertilizer according to the guidelines and forwards the report to the price fixation and monitoring committee. Price fixation and monitoring committee examines the recommendations of storage enquiry sub-committee and price fixation sub-committee, reviews the international prices and carrying and freight costs, considers other miscellaneous costs and fixes the price of imported fertilizer by adding US\$ 29.84 to each ton. The committee prepares recommendation report, after deducting 25 percent of the total price and submits it to the steering committee for approval. In the report, conditions are imposed in such a way that the importer will get back his deducted money (25 percent) after selling the fertilizer within four months of getting the clearance from the Ministry. After approval of the steering committee, the sale order is issued to the importer with carbon copy to the respective Deputy Commissioner (DC) so that the latter knows how much fertilizer is coming to the district. If the storage godown is not in Chittagong and located at Nayaranganj, Naopara (Jessore) or Baghabari (Sirajganj), then an additional US\$ 1.50 is added per ton of fertilizer.

Second Step: After getting the clearance, fertilizer dealers can lift fertilizer from the four assigned godowns to their own godowns with three receipts. Out of the three receipts, the dealer keeps one with him, another goes to the DC's office and the third remains with the Upazila Nirbahi Officer (UNO) who ensures the arrival of fertilizer in the dealer's godown after physical verification. The UNO's signed copy is then forwarded to Deputy Commissioner who is the chairman of the district fertilizer

and seed monitoring committee for signing. The committee adds transport as well as other miscellaneous costs to the fertilizer price and then fixes the price at which the dealers will sell to the farmers. The sale of the fertilizer among the farmers is monitored by the committee.

Third Step: The Deputy Commissioner, after signing the copy, sends it to the importer with a carbon copy to the Ministry of Agriculture. The Ministry verifies and crosschecks the DC's and importer's copies and forwards it to the Ministry of Finance for approval. After getting approval from the Ministry of Finance, the Ministry of Agriculture makes the payment of deducted 25 percent to the importer.

The government has made some changes in the above system recently. The demand order issued in favour of the dealers against the receipt of the importers may now be regarded as a document towards getting the 25 percent deducted amount. This may save time for the importers to get subsidy bill soon but the process is still very inefficient and time consuming.

Source: Kaliffuddin 2008.

Several studies from Bangladesh show that the average price paid by large farmers is lowest and the price paid for urea fertilizer starts to decline as farm size increases (Asaduzzaman and Islam 2008b). Osmani (1985) cites a joint IFDC/BARC farm-level survey to show that the small farmers do pay higher price than the medium and large farmers but the difference is not large enough to suggest that the small farmers do not enjoy the benefit of subsidy at all.

One drawback of the above studies, however, is that they only consider the full price of fertilizer. Apart from the nominal price (administered or otherwise), there are other costs of obtaining fertilizers. These include, for example, transaction costs of obtaining fertilizers. The farmer has to go to the dealer on specified days; they may have to wait for long. When these costs are accounted for, it may well turn out that the poor pays more for a unit of fertilizer as compared with the rich farmers. Asaduzzaman and Islam (2008) mention that "those who had somehow managed to get the fertilizer used various means to do so. The most important among the multiple responses were getting a favourable reference from the chairmen/members of the Union Parishad (in 34 percent of cases) which has been used to influence the dealers to purchase fertilizer. Almost equally important was purchase at high prices followed by use of references of extension officers (24 percent cases)." Thus there are non-price factors that play a role in having access to fertilizers.

In India, an inverse relationship between farm size and average subsidy per hectare is observed. Per hectare subsidy on marginal farms is more than double compared with the large farms. The average subsidy is the highest (Rs. 916/ha) on marginal farms and the lowest on large farms (Rs. 406/ha). The share of marginal farmers in total fertilizer subsidy in 2001-02 was the highest (28 percent), followed by small farms (23 percent) and the lowest on large farms (6 percent). The results show that fertilizer subsidy is distributed more equitably among different farm sizes compared with crop-wise and state-wise distribution of fertilizer subsidy. It may be concluded from the above that there is a fair degree of inter-farm equity in distribution of fertilizer consumption in India (Sharma and Thaker 2009).

Some studies show that almost half of the fertilizer subsidy goes to the fertilizer industry rather than to the farmers. The marginal returns of government spending are lower than for other sectors like agricultural research and development, rural roads, rural education or irrigation. It is reported that the returns to investment on fertilizer subsidy are low at only 0.53 compared with other sectors such as agricultural R&D (6.9), rural roads (3.2), rural education (1.5) and irrigation (1.4).

Unlike cash transfer, direct transfer of fertilizer subsidy is not considered to be a viable policy alternative in India and other South Asian countries. It would be difficult to ensure that direct transfer of subsidy to millions of farmers would actually be used by farmers for buying fertilizer without any leakages. If the subsidy is not used for fertilizer, it might adversely affect agricultural production. Moreover, the new nutrient-based pricing policy instead of earlier product pricing regime for fertilizers is likely to be a positive step as it would ensure balanced application of nutrients and growth of the fertilizer industry (Sharma and Thaker 2009).

Supporting output prices, on the other hand, is an alternative mechanism which reduces the real fertilizer price. The price support policy stimulates further fertilizer use by making farming more profitable and reducing the risk of a decline in the product price. However, the policy adversely affects the consumers who are faced with a consequent hike in the prices of agricultural commodities enjoying government support. The conflict between these policies exists. Barker and Hayami (1976), while examining the impact of fertilizer subsidy and rice price support programs, conclude that fertilizer subsidy is a more preferred means to achieving developmental objectives. However, the merits of fertilizer subsidy should be considered in the broader context of developmental objectives such as the risk of returns, adoption of new technologies, and macro economic feasibility of instituting a subsidy regime. Desai (1986a) stresses that non-price factors such as cropping pattern, crop varieties and irrigation, agricultural research and extension, credit, fertilizer supply and distribution system need to be given importance which could increase fertilizer use in crop production.

5.3 Fertilizer Subsidy in South Asia: How Effective Is It?

Fertilizer subsidy, being the largest input subsidy program in South Asian agriculture, has the most significant impact economically, socially as well as ecologically. Empirical analysis shows that fertilizer subsidies in India provided the least return in the 1980s and were only ahead of irrigation subsidies in the 1990s. While additional investment in sectors like rural infrastructure, education, and agricultural research has the most potential to raise agricultural productivity and reduce rural poverty, large agricultural input subsidies have constrained the allocations of adequate public resources to these more productive activities in South Asian countries (see Fan, Gulati and Thorat 2007).

Over the years, significant amount of subsidy has been disbursed by all South Asian countries and, with rising fertilizer prices, the burden of fertilizer subsidy is rising rapidly. Many researchers criticize fertilizer subsidy mainly because of its huge cost and uneven distribution across different farmer groups. There exists a general view that fertilizer subsidies are concentrated geographically, focus on fewer crops and few producers and, in many cases, do not reach the targeted group(s). Some researchers assert to the extent that these subsidies are causing adverse impact on production. They argue that indiscriminate and over use of fertilizers create adverse impact on agricultural production and cause negative externalities such as surface/ground

water pollution. At the same time, many researchers and policy makers feel that withdrawal of fertilizer subsidies will lead to reduction in food production and thereby create serious concerns regarding food security. A study conducted by Chand and Pandey (2008) made an attempt to understand the relationship between fertilizer subsidy and food security in India. The study suggests that if subsidy on fertilizer is removed completely then price of fertilizer would increase by 69 percent and this would cause close to 9 percent reduction in food grains production and consequently create adverse impact on food security.

In the Indian context, it has been argued that compared with subsidies on power, irrigation and credit, fertilizer subsidy has the worst overall impact on agriculture. The impact of fertilizer subsidy constrains the flow of benefits of the other three subsidies. In particular, farmers over-feeding their lands with cheap urea resulting from its subsidized price experienced declining crop yields, land degradation, and higher water intensity. Nitrogen, unbalanced with phosphorus and potassium, causes the land to degrade fast (requiring higher doses of urea application every year) along with more use of water in the cultivation cycle.

In South Asia, fertilizer subsidy (including irrigation, credit and other input subsidies) has no doubt helped the farmers, especially the smallholders, to adopt the new technologies during the initial years. One recent study notes that agricultural research, education, and rural infrastructure are the three most effective public spending items for promoting agricultural growth and poverty reduction in India (Fan, Gulati and Thorat 2007). The study also finds that input subsidies (fertilizer, electricity, credit and irrigation) yield very low marginal returns in both agricultural growth and poverty reduction despite their large impacts in earlier decades.

In many respects, the history and impact of fertilizer subsidy in South Asia is a glaring example of how a positive policy instrument (to induce technological change) can outlive its productive life, become counter-productive to productivity growth, and emerge as a drag on agriculture and the overall economy. The devastating social and ecological impacts of unbalanced fertilizer use resulting mostly from over-use of subsidized urea have also emerged as a major issue of concern in these countries.

The long-term sustainability of any system requires the explicit consideration of the trade-offs between benefits and losses. However, almost always there are ways of minimizing losses while retaining benefits. The use of fertilizers is no exception (Isherwood 2000). Fertilizer, despite being very effective in driving crop yield improvements, has been found to have negative impacts on the environment.

South Asia, being a region with growing fertilizer consumption and rising fertilizer intensity, has experienced significant deterioration in its soil fertility status through organic matter depletion, nutrient deficiencies followed by degradation of the soil's physical and chemical properties as well as soil acidity. The degradation of the soil has also slowed productivity growth and, in some cases, reduced productivity. Long-term yield trials data at multiple sites across South Asia indicate stagnating or declining yield trends when input use is held constant (Ladha et al. 2003). Fertilizers are also responsible for other environmental concerns, including the eutrophication of surface water, contamination of ground water, accumulation of dangerous or toxic chemicals and emission of greenhouse gases.

The degradation of the soil fertility and other environmental concerns are widespread in South Asia mainly due to the inadequate knowledge of the farmers and the distortionary nature of subsidy policies. Most farmers use chemical fertilizers indiscriminately without adequate information on actual soil/plant requirements. And the existing subsidy regime contributes to this problem by further promoting unbalanced use of nutrients. Furthermore, the current fertilizer distribution systems in the region are plagued with problems that not only limit the transfer of appropriate knowledge to the farmers but also give access of low quality fertilizers to the farmers.

6.1 Negative Environmental Implications

There are several environmental concerns that need to be taken into consideration when using fertilizer. Nitrogen fertilizer stimulates soil microbes, which feast on organic matter. Over time, the impact of this enhanced microbial appetite outweighs the benefits of more crop residues¹⁹. As the organic matter dissipates the soil's storage ability, organic nitrogen declines and thereby reduces soil fertility. In Bangladesh, due to high cropping intensity, the soil has been degraded so much that currently the organic matter content in the soil is very low at around 1-2 percent, whereas it should be maintained at least at 3 percent (Islam 2006). Nitrogen fertilizers also acidify soils and that may reduce nutrient availability. In Nepal, soil acidification has been on the rise and it is reported that 80 percent of the soil samples analyzed by the Department of Agriculture show acidic features..

¹⁹ Increased biomass resulting from fertilizer use can increase soil organic matter. Increased fertilizer use will increase crop residues, and a larger portion of them can be left on the soil to increase its organic matter, protect soils from erosion, and improve soil structure.

The negative impact of excess fertilizer application is not limited to the soil. High content of nitrogen and phosphorus in lake water stimulates the growth of algae in lakes. The algal growth then depletes the oxygen in the water which is essential for fish. Other aquatic plants (weeds) are stimulated and they produce heavy mats near the shoreline, interfering with the recreational use of the lakes. Nitrate²⁰ contamination poses a significant health hazard²¹. High levels of nitrate exposure may increase the risk of contracting cancers although the extent of the risk is unclear. Also, significant portion of the unabsorbed nitrogen fertilizer volatilizes in the form of a major greenhouse gas, having 298 times more global warming potential than carbon dioxide.

The interactions between fertilizers and the environment, however, are not always negative. Fertilizers increase crop yields and therefore, help to preserve millions of hectares of land that can remain in forests, native ranges, and wildlife preserves. Fertilizers allow for quick canopy cover and the development of massive root systems and more above ground crop residue. They also play a positive role in carbon dioxide assimilation by improving the fixation of carbon dioxide by crops, hence contributing to carbon sequestration. Proper fertilization also results in higher crop quality in terms of mineral, protein and vitamin contents, and contributes to the maintenance and improvement of soil fertility.

6.2 Factors Creating Negative Environmental Impacts

The degradation of the soil fertility and other environmental concerns are widespread in South Asia mainly due to the high use of nitrogenous fertilizers, inadequate knowledge of farmers, and availability of low quality fertilizers.

High Use of Nitrogenous Fertilizers

In South Asia there is a relatively strong consumption of nitrogenous fertilizers. This strong bias towards nitrogenous fertilizer use is mainly due to low prices of nitrogenous fertilizers caused by the subsidy policy systems. The existing subsidy regime in South Asia seems to have significantly contributed to the unbalanced use of nutrients in the region. The policies skew fertilizer use heavily in favour of nitrogenous fertilizers. Historically, the price of nitrogenous fertilizers has been significantly lower than all other types of fertilizers in all South Asian countries. The excessive use of nitrogenous fertilizers causes severe environmental consequences and threatens the sustainability of fertilizer use and the entire agricultural system. Table 6.1 summarizes some of the environmental consequences and their causative mechanisms.

²⁰ Manure from intensive livestock operations is also a potent nitrate source.

²¹ In young infants, exposure to high levels of nitrates can result in a disorder whereby the red blood cells cannot function properly, leading to insufficient oxygen or "blue-baby syndrome," which can be fatal.

Table 6.1
Environmental Consequences of Excessive N Use ▼

| Environmental Consequence | Causative Mechanism |
|------------------------------------|--|
| Groundwater Contamination | Nitrate leaching from soil |
| | Erosion, surface runoff, and seepage of N |
| Eutrophication | from agricultural fields |
| Acid rain and ammonia redeposition | Ammonia volatilization |
| Global Warming | Nitrous oxide emissions from soil |
| Stratospheric Ozone depletion | Nitrous oxide and nitric oxide emissions from soil |

Source: Pathak et al. 2003

In general, fertilizer use is highly unbalanced in South Asia to the detriment of potassium despite the fact that plants absorb K in equal quantity as N. Soil potassium mining due to negative potassium balances is prevalent in the region. FAO statistics show that the NK ratio in Sri Lanka deteriorated rapidly from a balanced ratio of N:K = 1:0.65 during the 1970s to N:K = 1:0.28. The NK ratio in India and Bangladesh varies between N:K = 1:0.10 to 1:0.15, whereas Pakistan has a depressing imbalance in fertilizer use of N:K = 1:0.01.

It may be emphasized here that K is responsible for plant's metabolism, translocation of other nutrients, and many more tasks essential for crop development. Adequate K is also needed to increase the efficiency of N²². This increasing deficit in K balance cannot be closed with more use of organic manure, because of its restricted availability as soil amendment. Thus, it is of great importance that the current subsidy policies are restructured in the region to correct the bias in favour of nitrogen.

In addition to being distortionary, the subsidy policies do not encourage the production and use of micronutrients, customized fertilizers, or more efficient forms of existing fertilizers. So, there is also a need to incorporate appropriate measures regarding use of these nutrients into the existing policy framework.

Inadequate Knowledge of Farmers

Most of the adverse environmental effects of fertilizer use result from inadequate knowledge among farmers regarding fertilizer application. Farmers are usually not aware of the need of the crops and the current status of their soils. This gives rise to nutrient mining. Crops remove significantly different nutrients available in the soil. Most farmers use fertilizers indiscriminately without adequate information on actual soil/plant requirements and they often fail to synchronize fertilizer application and crop uptake. The high fertilizer application by farmers for over-optimistic yield expectations often leads to considerable leaching of nitrate. One analysis of the nutrient dose in high yield value crops in Bangladesh shows that there are significant gaps between the recommended dose and the actual dose of fertilizer; and the gaps are greater for TSP and MOP than for

²² It helps absorbed nitrate-N to rapidly incorporate into amino acids, the basic constituents of protein.

urea (Table 6.2). Moreover, the delay between fertilizer application and crop uptake increases the chance for environmental losses through leaching, volatilization, and denitrification. Furthermore, the loss of nitrate is further increased due to other limiting factors such as deficiencies of secondary or micronutrients.

The inadequate knowledge of the farmers is mainly due to the lack of proper support service in the agriculture system. The current agriculture extension services are poorly staffed and equipped to manage the complexity of the problems arising from issues relating to fertilizers, crops, and climatic and soil diversities. Also, in countries like Bangladesh, it is seen that extension officers are sometimes more involved in fertilizer distribution rather than providing support service to the farmers. Therefore, the need for South Asia is particularly for strengthening/developing quality-conscious and efficient soil/fertilizer analysis facilities and training skills for imparting knowledge/services to farmers through competent field-level extension staff (Pandey 2010).

Table 6.2
Use Gap of Fertilizer in Bangladesh ▼

| Rice HYV | Recommended dose (kg/ha) | | | Actual dose (kg/ha) | | | Use gap (%) | | |
|----------|--------------------------|-----|-----|---------------------|-----|-----|-------------|------|------|
| | Urea | TSP | MOP | Urea | TSP | MOP | Urea | TSP | MOP |
| T. aus | 141 | 101 | 69 | 135 | 28 | 17 | 4.3 | 72.3 | 75.4 |
| T. aman | 166 | 101 | 69 | 135 | 30 | 24 | 18.7 | 70.3 | 65.2 |
| Boro | 269 | 131 | 121 | 192 | 47 | 37 | 28.6 | 64.1 | 69.4 |

Source: Basak 2011

Low Quality Fertilizers

Marketing of spurious fertilizers are growing rapidly in the region. A recent study by Soil Research Development Institute (SRDI) in Bangladesh reports that the quality of non-urea fertilizers is often below standard, with more than 80 percent adulteration for mixed fertilizers (NPKS), above 50 percent adulteration for privately imported SSP and TSP, and 25-30 percent adulteration for MOP and DAP. Low quality fertilizers are penetrating the market through various channels. In India and Nepal, the availability of low quality fertilizers is also rising fast. Such mismanaged use of low quality fertilizers is raising severe health concerns and also significantly deteriorating the soil quality and thereby, reducing farmer’s productivity (Kale and Bhandari 2011).

Prospects of Using Organic Fertilizer

It is often argued that one of the ways to reduce the adverse environmental impacts of fertilizer is through increasing the use of organic fertilizer. The use of organic fertilizer brings about improvements in the structure and texture of the soil, enhances its water-holding capacity, supplies micro elements required by crop plants, improves the physical properties of the soil by reducing the use of chemical fertilizers, and promotes better waste management. Saha et al. (2006) report that the application of different combinations of inorganic and organic fertilizer including grey manure causes plant height, panicle production, and grain and straw yields to increase significantly. However, organic fertilizers cannot exclusively help attain the production sustainability of soil and crops under high-intensive cropping systems (Singh and Yadhav 1992).

Like inorganic fertilizers, organic fertilizers also pose a potential risk to the environment. Only proper planning and management will minimize the risk. Traditional chemical fertilizers provide nutrients in forms that are highly water soluble so they quickly move into the soil and be predictably available to the plant. Organic fertilizers typically need to undergo some type of microbially mediated reaction and be converted to the same chemical forms to be available to the plant. Ultimately the plant takes up the nutrients in the chemical form whether they are applied as an organic or chemical fertilizer. Losses occur from both sources with mismanagement. Mismanagement typically takes two forms, poor timing of application and applying too much fertilizer. Organic fertilizers typically fair better with a poorly timed application. There typically is less nutrient loss from poorly timed organic fertilizer applications because the organic form of the nutrient is typically less mobile and less prone to losses. The extra time needed to convert the organic form to the chemical form will slow losses from poorly timed applications. However, it is more difficult to predict the availability of organic nutrients so farmers are more prone to over-apply organic fertilizers potentially leading to greater losses. Another potential difference between chemical fertilizers and manure is uniformity. Quality control of commercial fertilizers is regulated ensuring fertilizers meet strict standards for uniformity and concentration. Some forms of manure are quite variable leading some farmers to apply more to ensure all areas receive sufficient nutrients. This can lead to over-application in some areas of the field potentially leading to greater losses. One advantage of manure is the organic matter content. Organic matter improves soil quality including water infiltration thus reducing runoff from manured sites during precipitation events.

Of late, organic farming is gaining popularity among many farmers across Nepal – in the highlands, lowlands and around the Kathmandu valley. Cases of farmers producing organic fertilizers out of cow's urine and various domestic decomposable wastes and agricultural residues and making pesticides from a combination of animal urine and various plants are seen in farms and reported in the media. A recent Greenpeace India report, "Of Soils, Subsidies and Survival," based on social audits conducted in five Indian States, reveals that 96 percent out of the 1,000 farmers surveyed are of the opinion that the use of chemical fertilizers leads to soil degradation but they continue to use them as there is no other option. Ninety-four percent of the surveyed farmers believe that only organic fertilizers can maintain soil health. However, only one percent of the farmers receive any kind of support for production and use of organic fertilizers. Ninety-eight percent of the surveyed farmers are ready to use organic fertilizers if they are subsidized and made easily available.

Another study reports that if 20-30 percent of the total fertilizer subsidy is given to organic fertilizers then it could easily increase the production of organic fertilizer three times from the present level of production which could cover a significant portion of future fertilizer demand within 2050. In Nepal, in order to distribute organic fertilizers to farmers on grant, the Ministry of Agriculture and Cooperatives, has for the first time issued a Manual. The Ministry has also allocated NRs. 100 million for maintaining soil fertility and to promote organic fertilizer as a supplement to chemical fertilizers. The grant will be disbursed following the Organic Fertilizer Grant Manual (Directive) 2008. The manual maintains that there is a need to offer grant on organic fertilizers as there is no production of (chemical) fertilizer in Nepal and the imported fertilizers too are not regularly available. The grant will be disbursed through the AICL, but the quantity of organic fertilizer and the amount of grant to be offered to a farmer have not been fixed. However, the standard of the organic fertilizer to be purchased by the AICL and then distributed to farmers has been determined. The quality standards of the types and qualities of elements including N, P, K, moisture and the organic carbon the fertilizer should contain have also been indicated.

In order to address the issue of food security, South Asia with very high density of population, is destined to stay dependent on fertilizer use to increase food production. However, the negative impacts of fertilizer on the environment pose a threat to the sustainability of the agriculture system. So, it is now imperative to ensure balanced and efficient use of organic and inorganic fertilizers through improved soil management practices and policy making so that the primary nutrients, secondary nutrients, and various micronutrients are available in the soil in correct amounts for proper nutrient intake by crop plants and that there is minimal negative effects on the environment (Singh 2002).

The long-term sustainability of any system requires complicated trade-offs between benefits and losses. However, almost always there are ways of minimizing losses while retaining benefits. The use of fertilizers is no exception (Isherwood 2000). In order to minimize the negative impacts of fertilizer use in South Asia, farmers need to be imparted with knowledge and education on appropriate fertilizer products, dosage, and time and method of application and also support services in the form of field demonstrations and better soil testing facilities. Moreover, policy reforms are needed not only to eliminate the bias of subsidy policy toward nitrogenous fertilizers but also to divert some subsidy toward the use of organic fertilizers, efficient forms of fertilizers, and higher application of secondary and micronutrients.

Fertilizer Distribution System

Lack of efficient fertilizer distribution system increases the negative impact on the environment in two ways. First, farmers often experience delays in receiving their fertilizers and this prevents them from applying fertilizers during crop intake. Second, poor quality fertilizers easily enter the distribution channel and affect the farmer's productivity (Kale and Bhandari 2011). In India, the Central Fertilizer Quality Control Testing Institute claims that around 70 percent of the problems in quality control is due to adulteration or misbranding, another 20 percent of the problems is due to deliberate manufacturing of low quality fertilizers and the remaining 10 percent is due to the difference of the content of the bags and black marketing (Central Fertilizer Quality Control Testing Institute 2005 cited by Kale and Bhandari 2011).

The study brings out the existence of wide scope of increasing the efficiency and effectiveness of fertilizer use in South Asia by adopting right policies. This is also critical to ensuring the sustainability of fertilizer use in the region which is an important pre-requisite for promoting food and nutrition security for the vast majority of the South Asian population. For employment creation and poverty reduction, sustained agricultural growth based on productivity enhancing interventions is the pillar on which further expansion of economic activities in other sectors can be achieved. In the process, fertilizer is the key input for raising farm productivity which requires policies that would ensure more efficient and effective fertilizer use in a sustainable manner in combination with water, better seeds, and other yield augmenting inputs.

The study brings out several areas where more focused policies are required to bring desired changes in crop productivity through balanced and proper use of fertilizer and other complementary inputs. While the details of the country-specific recommendations for the three case study countries (Bangladesh, India and Nepal) are given at Annex 1, this section highlights the recommendations that are more general in nature having wider applicability across most countries in South Asia and other regions.

- Expand fertilizer production capacity

Since fertilizer use in all countries is likely to increase further to meet the rapidly rising crop demand and enhance food security, the countries of South Asia need to work together to increase fertilizer production in the region. The countries can undertake joint ventures for setting up fertilizer production plants using, for instance, natural gas from Bangladesh, technology and financial capital from India, and hydropower from Nepal. Since the three countries have comparative and competitive advantages in these three major production inputs for fertilizer manufacturing, such trilateral collaboration can bring significant mutual benefits. The governments of the countries having low access to fertilizers can explore practical possibilities of making equity investments in fertilizer factories in countries with high fertilizer production potential. This would ensure assured supply of fertilizers for the countries in South Asia along with possibilities of exports if surplus is available. For reducing transportation costs, the production plants could be built at locations close to major consumption or input supply centres across the countries based on sound feasibility studies and adoption of logical site selection criteria. Such capacity expansion should also be supported by better storage, handling and transport facilities.

- Promote location, soil and crop specific fertilizer use

Appropriate mechanisms should be developed in each country to determine location and crop specific fertilizer requirements based on soil types and agro-ecological zones considering the nutrient supplying capacity of soils. The gathered information and season and crop specific recommendations should be disseminated to the farmers via the extension agents in an effective manner so that the farmers become aware of the advantages and adopt the recommended doses.

- Enhance effectiveness of the extension services

The existing extension service system needs to be well equipped and adequately staffed to cover the large number of small farmers. The extension agents should receive regular training so that they are equipped to transfer appropriate location and crop specific knowledge to the farmers. A vibrant network of the extension system with research institutes, agricultural universities, scientific associations, non-government organizations, fertilizer producing and trading companies can greatly enhance the knowledge base of the extension workers.

- Encourage farmers to adopt more efficient fertilizer application techniques

Fertilizer use efficiency can be significantly increased and associated costs can be reduced by using new techniques such as deep urea placement and the use of leaf charts. The use of smart fertilizers with better application method will further enhance fertilizer effectiveness. The concept of fertigation should be promoted by using 100 percent water soluble fertilizers to enhance both the efficiency of water and nutrients. In spite of the potential benefits from drip and sprinkler irrigation methods, these have not been widely adopted. Lack of technical support, particularly maintenance of micro irrigation systems, inadequate and lack of information about the operation and maintenance are the main reasons. Capacity building on micro irrigation technologies, including maintenance will help to solve the problems. The government departments, and the private firms dealing in micro irrigation systems may be encouraged to get involved in the service provision capacity building process. Extension system should be strengthened to educate farmers about the modern agricultural practices.

- Emphasize synergy in fertilizer policy

The synergetic relationship among key agricultural inputs needs to be adequately recognized while framing relevant policies. This is necessary since wider use of one input (fertilizer) requires the complementary expansion of other inputs (irrigation) in order to get desired outcomes.

- Enhance efficiency in the fertilizer distribution system

Fertilizer prices in the international market depict rising and widely fluctuating trends on which the South Asian countries do not have much control. Individual countries, however, can significantly reduce the marketing costs of fertilizer through making the distribution system more efficient and improving infrastructure facilities. Financial/administrative/technical anomalies and mismanagements such as deliberate delays, indifferences and corruptive mechanisms should be reduced/improve. For instance, in subsidy policy the complicated payment system increases delays in fertilizer use which affects farmers' optimal use of fertilizers.

- Expand credit facilities

In the small and marginal farmer dominated agriculture in South Asia, the availability of credit is an important factor which constrains fertilizer demand and its optimal use at the farm level. The provision of credit in right quantities and at the right time through local and specialized banks and microfinance institutions is necessary for promoting balanced use of fertilizer.

- Redesign fertilizer subsidy policy

The existing fertilizer subsidy policies in most South Asian countries are not sustainable and do not promote the desired objectives efficiently. The policies have led to the adoption of unbalanced fertilizer use by the farmers leading to high economic and social losses. Along with substantial reduction of subsidies and diverting resources to more productive investments in agriculture, nutrient based subsidies as practiced in India could be adopted by other countries in the region. Moreover, steps should be taken to create a national database of farmers that will allow better targeting of fertilizer subsidies.

- Ensure availability of quality fertilizer

Adulterated fertilizers have penetrated the markets of South Asia creating severe production, environment, and health consequences. In order to restrict adulteration, quality testing and ensuring mechanisms at different levels need to be strengthened along with taking necessary actions against persons involved in fertilizer adulteration. Strong monitoring is needed at storage and distribution points to check adulteration of fertilizers.

- Protect adverse environmental consequences

Environmental standards based on scientific criteria and depending on the level of agrochemical use and their pollutant concentrations should be established and measures need to be adopted for ensuring these standards. It is imperative for the South Asian countries to ensure balanced and efficient use of organic and inorganic fertilizers so that the primary nutrients, secondary nutrients, and various micronutrients are available in the soil in correct amounts for proper nutrient intake by crop plants generating minimal negative effects on the environment.

- Promote regional cooperation in fertilizer sector

There are great variations in resource endowment among South Asian countries. In such a scenario, the countries should design their fertilizer subsidy and other policies taking into account the design of similar policies in neighbouring countries. This will reduce significant variation in fertilizer prices across countries and discourage supply through informal channels. Such harmonization of fertilizer policies in the South Asian region will promote more efficient and effective fertilizer use across all countries.

- Rationalize public expenditures in agriculture

The fertilizer subsidy in South Asia is a glaring example of how a positive policy instrument (to induce technological change) can outlive its productive life, become counter-productive to productivity growth, and emerge as a drag on agriculture and the overall economy. Empirical analysis shows that fertilizer subsidies provided the least return in the 1980s and were only ahead of irrigation subsidies in the 1990s. While additional investment in sectors like rural infrastructure, education, and agricultural research has the most potential to raise agricultural productivity and reduce rural poverty, large agricultural input subsidies have constrained the allocations of adequate public resources to these more productive activities in South Asian countries. It is time that the governments take measures to reduce subsidies to rational levels and enhance targeting efficiency to serve limited objectives.

Over the past few decades, the countries of South Asia have achieved spectacular increase in food grain production mainly through using fertilizers, irrigation, and high yielding variety seeds. Among the modern inputs, chemical fertilizers have played a critical role in increasing yield of many crops particularly cereals. The governments in South Asian countries have emphasized on making fertilizers available to the farmers at affordable prices. But the issues related to effectiveness, efficiency, and sustainability of fertilizer use seem to have remained inadequately addressed in these countries.

Besides, there is indiscriminate use of unbalanced doses of fertilizers creating both economic losses and adverse ecological consequences. Growing international and domestic demand for organic farm produce shows clear signs of great potential and prospects of organic fertilizer production and use in the countries of the region. Given the limited and shrinking availability of arable land and the increasing demand for food for the rising population in South Asia, it is imperative to make the most productive use of the existing crop-lands, for which intensive agriculture with adequate and appropriate use of fertilizers should be the first priority to maintain soil fertility and productivity. The governments in South Asia must take measures on a priority basis to reverse the present rapidly rising trend in government expenditure on fertilizer subsidies in order to divert public resources to more productive government investments in the agriculture sector.

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Country-Specific Recommendations

A. Bangladesh

- More incentives need to be provided for raising domestic production of fertilizers.
- Steps should be taken to maintain a fertilizer buffer stock at regional, district and upazila levels. Particular emphasis should be given to the peak boro season. Buffer stock of fertilizer should be maintained by BADC and BCIC to meet up the demand in the peak season and thereby maintain price stability in the market.
- Total fertilizer demand or requirement at the farm level appears to be considerably higher than the corresponding official estimate. This creates shortages in the market at critical times leading to price hikes and losses to the farmers. The causes of such shortages need to be identified along with adoption of corrective measures. The process of estimating fertilizer requirements should also be reviewed.
- Forward planning for import of fertilizers should be adopted in order to ensure availability in time.
- For reducing transportation cost and minimizing shipment time, fertilizers should be supplied to the dealers from the nearest buffer stocks instead of fertilizer factories.
- It is observed that fertilizers which are supposed to be sold through the dealers appointed by the government are available in the open market indicating leakages from the delivery system for rent seeking purposes. Remedial measures are needed for checking such leakages.
- For ensuring market efficiency and effectiveness, the government should follow a fair selection process of dealers so that individuals having fertilizer trading experience and adequate storage facilities are given dealership.
- The existing number of fertilizer dealers at the upazila level is not adequate to handle the fertilizer distribution activities in an efficient manner. Therefore, the number of dealers per upazila should be increased so that at least one dealer per union is in place.
- Monitoring of fertilizer distribution system requires further strengthening.
- Fertilizers should be made available at the dealers' level at least 15 days before the start of the sowing season of each crop.
- The involvement of agriculture extension workers needs to be adjusted in other activities appropriately so that they can give the required attention to dissemination of technology information.
- Different varieties of MOP are available in the market at different prices. If the variety with low content is used, the dose has to be higher. But most farmers are not aware of these differences and hence got lower yields. In the process, the farmers are also deceived through paying higher prices for low grade MOP. Measures are needed so that imported fertilizers are of distinct quality and standard so that farmers are not deceived both in quality and prices.
- The regulatory power of the Upazila Agriculture Officers for restricting adulteration and fertilizer prices should be reviewed and strengthened.
- To restrict adulteration, samples of all kind of fertilizers should be collected randomly from different markets and should be tested in different government laboratories for taking necessary action against the individuals who are involved in fertilizer adulteration.

- Strong monitoring is needed at storage and distribution points to check adulteration of fertilizers.
- The Soil Research Development Institute (SRDI) laboratories under the Ministry of Agriculture can be involved in analyzing fertilizer samples at random from the market periodically and report to the National Fertilizer Committee (NFC).
- Extension activities for promoting balanced and efficient fertilizer use should be expanded and streamlined.
- The prices of different varieties of fertilizers should be determined in such a manner that it would generate incentives amongst the farmers for more balanced use of them.
- There should be more subsidies on organic fertilizer for providing incentives to the farmers to increase its use.
- The subsidy should be fixed by taking into consideration neighbour's fertilizer prices to reduce smuggling of fertilizer across borders.
- Subsidy on fertilizers needs continuation to make crop production more attractive and profitable. The government organizations like BCIC and BADC should be involved in the importation of TSP and MOP and subsidy should be provided to these organizations.
- The small and medium farmers should be particularly targeted. They should be identified and given direct cash subsidy. The large farmers are able to pay for the fertilizers and subsidy policy should focus on promoting balanced use of fertilizers.
- Nutrient based subsidy should be designed.
- Implement measures to reduce the rent captured by the dealers as this is in effect results in diversion of subsidy from the farmers to the dealers.
- Bangladesh should introduce environmental standards based on scientific criteria and depending on the level of agrochemical use and their pollutant concentrations.
- The government needs to adopt media activities aiming to raise public awareness and motivate the farmers to use balanced doses of fertiliser and organic matter.
- The government should facilitate the availability of quality fertilizer at farmers' level. The production, importation, marketing, distribution and use of any kinds of fertilizer that are harmful or detrimental to plant, soil, flora and fauna should be banned.

B. India

In India, although the government interventions helped in meeting the objective of capacity expansion of fertilizer industry leading to achieving self-sufficiency in food grains production, it did not encourage improving efficiency in the sector. In order to meet the rapidly rising demand, there is a need to increase fertilizer supplies through domestic production and imports and creation of adequate and efficient distribution network.

Increasing domestic production

- There is stagnation in productive capacity of various fertilizers in the country. The total demand for NPK is projected to rise to 41.7 million tons during 2020 and the projected domestic production would be far below the demand leading to a potential demand and supply gap of 17.5 million tons. To meet the increasing demand in future, policies should encourage domestic productive capacity of fertilizers as the international prices are highly volatile.

- Fresh investments are needed in the fertilizer sector. This would facilitate timely availability of fertilizer to the farmers and will reduce dependence on fertilizer imports. For increasing domestic production, the critical issue is the scarcity of raw materials. Natural gas which is the main feed stock for production of indigenous fertilizers is available only in limited quantities. Thus there is a need to ensure adequate supplies of feedstock to the fertilizer industry which would pave way for achieving increased domestic production of nitrogenous fertilizers. Similarly, the limited availability of phosphoric acid and rock phosphate, is a constraint in increasing production of phosphatic fertilizers. This may be given adequate emphasis in future to increase the availability of the feedstock for P production. This could be achieved either increasing imports of feedstock or establishing tie-up with foreign collaborators in the form of joint venture.

Fertilizer pricing

- Being a critical input in agricultural production, the fertilizer consumption is affected by both price and non-price factors. The influences of these factors are felt differently by the farmers of various sizes of land holdings. Thus the policy focus should be tilted towards development of irrigation facilities, developing alternative cropping pattern, increasing fertilizer use under non-irrigated conditions, and spreading the area under HYVs. Availability of credit is another important factor which determines the fertilizer demand at the farm level. Hence, easy availability of credit would facilitate rapid growth in fertilizer use.
- Price factors such own price of fertilizers and output prices are crucial in determining fertilizer use. However, compared with the non-price factors, price factors are less dominant. While fixing prices of fertilizers, output prices should also be considered.

Fertilizer subsidy

- The price support policy stimulates fertilizer use by making it more profitable and reducing the risk of a decline in the product price. However, the policy adversely affects the consumers who are faced with price hike of agricultural commodities enjoying government support. The conflict between the policies exists. The merits of fertilizer subsidy should be considered in the broader context of developmental objectives such as the risk of returns, adoption of new technologies, and macro economic feasibility of a subsidy.
- Though there is inequity in terms of fertilizer use across states, regions, and crops, equity exists across farm size groups. As Indian agriculture is dominated by marginal and small farmers, continuing public support for some time, say for another decade is warranted. However, the prices of fertilizers may be fixed by considering the prices of agricultural output particularly the major fertilizer consuming crops like rice, wheat, sugarcane, cotton and groundnut.

Unbalanced use of fertilizers

- Unbalanced use of fertilizers is a common and serious concern in India. Though the policies, such as subsidy, decontrol of fertilizers, favoured increased use of fertilizers particularly N compared with P and K led to imbalance in use. In order to achieve balanced use of nutrients, the Nutrient Based Subsidy (NBS) has been introduced. However, more systematic studies are needed in order to bring out the real impact of NBS in the country. There is a need for creating more awareness among farmers about soil health, soil testing and providing advice on nutrient needs based on soil test.
- Most of the policies relating to fertilizers cover major nutrients like N, P, K and S. The micro nutrients have not been covered adequately as a result of which the soils have been heavily depleted. It has also resulted in declining productivity of crops. Thus, it is essential to evolve a policy to make available all needed nutrients in a given area as per soil tests in sufficient quantities and at prices which would act as an incentive to use them. It may be necessary to subsidize some of these nutrients.
- The concept of fertigation should be promoted by using 100 percent water soluble fertilizers to enhance both the efficiency of water and nutrients. In spite of the potential benefits from drip and sprinkler irrigation methods, these have not been widely adopted. Lack of technical support, particularly maintenance of micro irrigation systems, inadequate and lack of information about the operation and maintenance are the main reasons. Capacity building on micro irrigation technologies, including maintenance will help to solve the problems. The government departments, and the private firms dealing in micro irrigation systems may be encouraged to get involved in the service provisional capacity building process. Extension system should be strengthened to educate farmers about the modern agricultural practices.
- The handling of increasing quantities of fertilizers will need concomitant expansion of storage and handling facilities and transport. The development of market infrastructure will also need more attention.

C. Nepal

- The government needs to review the current import policy of fertilizers from India so that the farmers are not forced to pay exorbitantly high prices charged by traders and can overcome the untimely and uncertain supply of fertilizers through AICL. The farmers should also be provided with the skills to identify whether or not the fertilizers they are buying from Indian traders are of the right quality.
- The huge underutilized and unused resources (manpower, assets, structures such as warehouses, and even funds) that AICL, cooperatives and the private sector traders possess should be mobilized for instituting effective fertilizer production and distribution systems.
- Financial/administrative/technical anomalies and mismanagements such as deliberate delays, indifferences and corruptive mechanisms need attention for ensuring easy and fair access to fertilizer by the farmers.
- Incentives such as reasonable distribution margins (spreads) and other mechanisms should be put in place for private traders and cooperatives so that their participation can be further enhanced in fertilizer sales to inject greater competition and better serve the farmers' needs.
- The government and traders' associations (e.g. chamber of commerce) may form partnerships and financial consortia of large traders for ensuring regular and timely import of adequate quantity of fertilizers.

- The marketing system needs proper adjustments to make it capable of efficiently delivering the right products (of dependable quality) to the farmers at the right time and at reasonable prices.
- The government should take steps to ensure the creation of a much wider, competent and fair retail infrastructure in order that fertilizers are available for purchase and use as an essential commodity by farmers at all locations in the country.
- Fertilizers should be made available in smaller packs (e.g., 25 kg bags) to facilitate their transportation by local farmers to remote locations. The bags must be strong enough to prevent pilferage and transit losses. Additional costs from their handling, re-bagging /packaging could perhaps be compensated from their better utility and preference by the farmers.
- Extensive plantations in denuded areas such as public wastelands and deforested areas should be carried out for multifarious benefits such as humus formation, water resources retention and enhancement in the production and use of organic fertilizers, thus contributing substantially to improved effectiveness, efficiency and sustainability of fertilizer use and increasing agricultural productivity.
- Soil/land conservation and management programmes should be launched massively and more effectively.
- Improvements in the agricultural sector should be brought about by adopting holistic/ecosystem based approaches so that inputs such as fertilizers are most efficiently used for sustained increase in agricultural productivity, environmental health and human wellbeing.
- Substantial increment in allocations to agricultural sector is needed in the national budget. This is necessary for improving the agriculture related activities, for instance, infrastructure building in rural and remote areas for improved supply of fertilizers and other inputs and sale of surplus outputs.
- Regulatory and legal mechanisms relating to the negative impacts or externalities emanating from indiscriminate use of fertilizers should be put in place and made fully effectual.
- Nepal should look into the practical possibilities of making equity investments in the fertilizer manufacturing factories in Bangladesh and India, and of importing fertilizers from China, especially for the northern mountainous and hilly parts of the country for which it has been too time-consuming, difficult and costly to supply fertilizers arriving from India.
- India and Nepal could negotiate for free flow of fertilizers so that problems such as tax evasions, higher transaction costs and unfair practices such as smuggling and adulteration of fertilizers could be avoided for mutual benefits.
- Diplomatic discussions and negotiations between India and Nepal for making subsidized fertilizers from India available for sale to Nepal with the subsidy treated as aid to Nepal should be seriously undertaken.
- As far as possible for all countries, the SAFTA should be used to make fertilizers as a freely traded commodity within South Asia and harmonise agricultural policies of the countries in the region.
- Bangladesh, India and Nepal should seriously work out and implement a scheme in which fertilizer production is undertaken jointly so as to meet the region's requirements and overcome fertilizer supply related delays and dilemmas.
- According to MoAC, fertilizer shortage did not occur in the past as a result of unofficial import of subsidized fertilizers from India. However, such inflow has now declined creating sporadic shortages. Nepal needs to arrange for formal import of the required quantities of fertilizer so that the farmers are not forced to rely on unofficial (illegal) import of fertilizers. Some estimates put the requirements to the tune of 500,000 metric tons per year.

- For the purpose, subsidy should be increased; capacity of AICL enhanced; and subsidy should be provided to the private sector as well.
- Organic fertilizer manufacturing industries should be encouraged to produce more of such fertilizer. Currently 50 percent of the cost of machinery and tools used for organic fertilizer production is paid by the government as grant. The soil management department of the MoAC offers technical help to such enterprises.
- Similarly, if any entrepreneur produces organic produce and gets it certified as organically grown product, the government could encourage the entrepreneur by reimbursing the entrepreneur the amount expended in the certification process. Besides, the process for offering subsidy for the distribution of domestically produced organic fertilizer through the AICL should be installed. The government's commitment to promoting the use of organic fertilizers should be actively pursued

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