RAP PUBLICATION 2011/09

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
REGIONAL OFFICE FOR ASIA AND THE PACIFIC
Bangkok, 2011

ISBN 978-92-5-106914-1

For copies write to: Yuji Niino
FAO Regional Office for Asia and the Pacific
Maliwan Mansion, 39 Phra Atit Road
Bangkok 10200
THAILAND
Tel: (+66) 2 697 4000
Fax: (+66) 2 697 4445
E-mail: Yuji.Niino@fao.org

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Foreword

According to FAO's latest estimates, global food production needs to increase by 70 percent by 2050 to feed an additional 2.3 billion people. Projections indicate that about 80 percent of the gains in production will need to come from increased yield growth and cropping intensity on existing farmlands. Nutrient-depletion of soils is a key constraint to boosting the productivity of small and marginal farmers in Asia and the Pacific, who are among the most food-insecure. Efficient fertilizer use is vital to reversing this trend. Most soil fertility depletion is caused when disposable household income is too low for farmers to advance from low-input/low-output farming, resulting in nutrient mining.

Serious efforts are required at national and regional levels to develop appropriate policies, technologies and capacities to address this challenge. Policies must ensure that soil fertility is not depleted in low-input systems while also helping to curb overuse of fertilizers that, in some cases, leads to serious damage to ecosystems. It is also vital to address impediments to increased fertilizer use through improved management of fertilizer supply and demand. Both public and private sector stakeholders need to be involved in order to increase farmer access to appropriate fertilizer and credit.

This issue assumed urgency with the food price crisis in late 2007 which caused a setback in progress towards the Millennium Development Goal of halving the proportion of hungry people by 2015. As part of FAO's organizational mandate to develop a knowledge base in support of food security and rural livelihoods, the Regional Office for Asia and the Pacific commissioned national studies on fertiliser use in South Asia, which has the largest incidence of food insecurity in the region. The studies aim to provide insight into the soil fertility and fertilizer sector in Bangladesh, Nepal, Pakistan and Sri Lanka with a view to identifying gaps in prevailing strategies and policies, and make recommendations for improvement.

Further, a set of guidelines containing norms for making fertilizer demand projections were prepared to assist policy-makers in effective and efficient management of fertilizer supply and use.

It is hoped that the comprehensive information contained in the case studies and the lessons derived therein, along with the guidelines, will prove valuable to national and regional policy-makers in ensuring timely availability and proper use of fertilizers to enhance productivity and incomes of small and marginal farmers who form the backbone of the region's agriculture sector.

Hiroyuki Konuma
Assistant Director-General and
Regional Representative for Asia and the Pacific
Food and Agriculture Organization of the United Nations

Acknowledgements

This work is based on the country assessments of Bangladesh, Nepal, Pakistan and Sri Lanka conducted by Dr. Rabindra N. Roy, Dr. Ram V. Misra and Mr. Tapan K. Chada with the support of Dr. A.T.M. Farid, Dr. Surya P. Pandey, Dr. Nisar Ahmad, and Dr. Dharmakeerthi B. Wickramasinghe.

Abbreviations and acronyms

ABC	A. Baur & Company (Sri Lanka)
ADC	Agricultural Development Corporation (Pakistan)
AEZ	Agro-ecological Zone
AIC	Agriculture Inputs Corporation (Nepal)
AICL	Agriculture Inputs Company Limited (Nepal)
AISMS	Agriculture Inputs Supply and Monitoring Section (Nepal)
AP	Ammonium Phosphate
APP	Agriculture Perspective Plan (Nepal)
AS	Ammonium Sulphate
ASC	Agrarian Service Centre (Sri Lanka)
B	Boron
BADC	Bangladesh Agricultural Development Corporation
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
BCIC	Bangladesh Chemical Industries Corporation
BFA	Bangladesh Fertilizer Association
BGA	Blue-green algae
BINA	Bangladesh Institute of Nuclear Agriculture
BMR	Balancing, Modernization and Revamping
BRRI	Bangladesh Rice Research Institute
CAGR	Compound Annual Growth Rate
CAN	Calcium Ammonium Nitrate
CCF	Colombo Commercial Fertilizers Company (Sri Lanka)
CDR	Central Development Region (Nepal)
CFC	Ceylon Fertilizer Company (Sri Lanka)
CRI	Coconut Research Institute (Sri Lanka)
DADO	District Agriculture Development Office/Officer (Nepal)
DAE	Department of Agricultural Extension (Bangladesh)
DAM	Department of Agricultural Marketing (Bangladesh)
DAP	Diammonium Phosphate
DC	Deputy Commissioner (Bangladesh)
DCL	Dawood Corporation Limited (Pakistan)
DEA	Department of Export Agriculture (Sri Lanka)
DGA	Director General of Agriculture (Sri Lanka)
DOA	Department of Agriculture
DZ	Dry Zone
ECPL	Engro Chemical Pakistan Limited
EDR	Eastern Development Region (Nepal)
ERP	Eppanwala Rock Phosphate
ETC	Extension and Training Centre (Sri Lanka)
FCRDI	Field Crops Research and Development Institute (Sri Lanka)
Fe	Iron
FFBL	Fauji Fertilizer Bin Qasim Limited (Pakistan)
FFC	Fauji Fertilizer Corporation (Pakistan)
FID	Fertilizer Import Department (Pakistan)
FJFC	FFC Jordan Fertilizer Company Limited (Pakistan)

FRC	Fertilizer Review Committee (Pakistan)
FWDR	Far Western Development Region (Nepal)
FY	Financial Year
GDP	Gross Domestic Product
GOP	Government of Pakistan
GST	General Sales Tax (Pakistan)
HCRDI	Horticultural Crops Research and Development Institute (Sri Lanka)
HYV	High-yielding variety
ICT	Information and Communication Technology
IPNS	Integrated Plant Nutrition System
IPP	Import Parity Price
IRP	Imported Rock Phosphate
IZ	Intermediate Zone
K	Potash (K_2O)
KAFCO	Karnaphuli Fertilizer Company (Bangladesh)
LC	Low Country
LCC	Leaf Colour Chart
LCDZ	Low Country Dry Zone
LCIZ	Low Country Intermediate Zone
LCWZ	Low Country Wet Zone
LIFDC	Low-Income Food-Deficit Country
LPL	Lanka Phosphate Limited (Sri Lanka)
MAP	Mono-Ammonium Phosphate
MC	Mid Country
MCIZ	Mid Country Intermediate Zone
MCWZ	Mid Country Wet Zone
MDG	Millennium Development Goal
MINFA	Ministry of Food and Agriculture (Pakistan)
MMBTU	Million Metric British Thermal Units
MMCFD	Million cubic feet per day
MOAC	Ministry of Agriculture and Cooperatives (Nepal)
MOADAS	Ministry of Agriculture Development and Agrarian Services (Sri Lanka)
MOP	Muriate of Potash
MT	Metric tonne
MWDR	Midwestern Development Region (Nepal)
N	Nitrogen
NAP	National Agricultural Plan (Bangladesh)
NARC	Nepal Agricultural Research Council
NARS	National Agricultural Research System
NFC	National Fertilizer Corporation (Pakistan)
NFDC	National Fertilizer Development Centre (Pakistan)
NFML	National Fertilizer Marketing Limited (Pakistan)
NFS	National Fertilizer Secretariat (Sri Lanka)
NGO	Non-governmental organization
NIBGE	National Institute of Biotechnology and Genetic Engineering (Pakistan)
NLC	National Logistical Cell (Pakistan)
NP	Nitrophosphate
NPK	Nitrogen, Phosphate and Potash
NRMC	Natural Resources Management Centre (Sri Lanka)
OFC	Other Food Crops
P	Phosphate (P_2O_5)

PAPR	Partially Acidulated Phosphate Rock
PARC	Pakistan Agricultural Research Council
PDOA	Provincial Department of Agriculture (Sri Lanka)
PIDC	Pakistan Industrial Development Corporation
PMEU	Project Monitoring and Evaluation Unit (Sri Lanka)
R&D	Research and Development
RP	Rock Phosphate
RRDI	Rice Research and Development Institute (Sri Lanka)
RRI	Rubber Research Institute (Sri Lanka)
Rs	Rupees
SA	Sulphate of Ammonia
SAAO	Sub-Assistant Agricultural Officer (Bangladesh)
SEPC	Socio Economics and Planning Centre (Sri Lanka)
SOP	Sulphate of Potash
SPMDC	Seed and Planting Material Development Centre (Sri Lanka)
SRDI	Soil Resource Development Institute (Bangladesh)
SSMP	Sustainable Soil Management Programme
SSP	Single Superphosphate
TCP	Trading Corporation of Pakistan
Tk	Taka (Bangladesh)
TRI	Tea Research Institute (Sri Lanka)
TSHDA	Tea Small Holding Development Authority (Sri Lanka)
TSP	Triple Superphosphate
UC	Up Country
UCIZ	Up Country Intermediate Zone
UCWZ	Up Country Wet Zone
USG	Urea Super Granules
VCR	Value-Cost Ratio
WAP	Weeks after planting
WAS	Weeks after sowing
WDR	Western Development Region (Nepal)
WZ	Wet Zone
Zn	Zinc
ZS	Zinc Sulphate

Background and regional context

Food price crisis highlights need for improved smallholder production in Asia

In 2008, food prices reached their highest level in real terms in thirty years, worsening the food security situation of the rural poor, in particular small and marginal farmers who comprise the majority of hungry people in Asia and the Pacific. In the closing months of 2010, international food prices rose again to high levels on weather- and natural disaster-linked supply concerns. The FAO Food Price Index was at a record high of 215 in December 2010, above its last peak of 213 points in June 2008. Prices of nearly all agricultural food commodities increased sharply. While a sharp rise in food prices raises concerns about food security, it also provides a window of opportunity for farmers to boost production in response to the strong market signalled by higher food prices. Particular attention has to be given to ensuring that poor smallholder farmers are able to boost their production to take advantage of new market opportunities.

Sustainable fertilizer use and soil fertility management key to higher productivity

FAO estimates that global food production must increase by 70 percent by 2050 to feed an additional 2.3 billion people by then and raise average daily dietary consumption to 3 130 kcal per person. Eighty percent of the increase in production in developing countries will have to come from improved crop yields and higher cropping intensity. Fertilizer use is a vital input for enhanced agricultural production. Studies show that mineral fertilizer use accounts for 50 percent of the increase in food production with an estimated 162 million tonnes of fertilizer nutrients applied to farms worldwide annually. Ensuring timely access to adequate mineral fertilizer is key to agricultural development, food security, poverty reduction and nutritional security, especially in the low-income food-deficit countries (LIFDCs) in Asia and the Pacific.

Asia presently accounts for 58.6 percent of global fertilizer use with demand growing at 2.1 percent annually. However, fertilizer use in most food-insecure countries is low, particularly in South Asia which is projected to face a fertilizer availability deficit of about 4.3, 7.4, and 5.1 million tonnes for nitrogen, phosphate (as P_2O_5 from phosphoric acid) and potash (as K_2O), respectively by 2014.

Inadequate plant nutrition combined with continual mining of soil nutrients and unscientific use of fertilizers is limiting productivity in many Asia-Pacific developing countries. For example, in Bangladesh, research data indicates that cultivation of two crops of high yielding varieties of rice, producing more than 10 tonnes/ha annually, removes about 350 kg/ha of soil nutrients. It is estimated that more than 2 million tonnes of nutrients are removed from the soil per year in Bangladesh, seriously threatening sustainable agricultural production in the country.

The challenges to sustainable soil fertility management in the region include (i) declining trends in soil fertility and mining of soil nutrients; (ii) decline in soil organic matter levels, and; (iii) overuse and inefficient utilization of mineral fertilizers in certain locations and the resulting deterioration of environmental quality.

Policy requirements

Appropriate policies, technologies and capacities are needed to ensure timely and adequate availability of fertilizer to farmers. Policies must ensure that soil fertility is not depleted in low-input systems and at the same time they should help curb over use of fertilizers in various situations.

Reliable supply and demand assessments are essential for effective policy formulation and implementation. Overestimates can lead to expensive inventory build-ups at factories, ports and field warehouses with subsequent deterioration in fertilizer quality while underestimates can result in shortages and price hikes.

An important factor to bear in mind is that fertilizer demand is linked to the cropping season and fertilizer must be procured and stored in advance to ensure timeliness of supply.

FAO support to boosting smallholder productivity in the region

As part of the FAO global response to soaring food prices launched under its Initiative on Soaring Food Prices (ISFP), the FAO Regional Office for Asia and the Pacific commissioned studies to gain insight into soil fertility and fertilizer use in four South Asian countries – Bangladesh, Nepal, Pakistan and Sri Lanka. The aim was to identify gaps in prevailing strategies and policies and propose measures for improvement. Four case studies were produced based on field trips to:

- review the current status of fertilizer production, distribution, and extension mechanisms in the selected countries;
- identify gaps and propose suitable medium- and longer-term recommendations in formulating effective national fertilizer management policies; and
- formulate regional/national trust fund project documents on fertilizer and soil nutrient management policy.

The overall objective was to assist in formulating national fertilizer and soil fertility management policies and strategies in order to strengthen national and regional capacities to implement productive safety nets to boost smallholder food production in the context of high food prices.

The outputs included an assessment of existing national fertilizer management practices and policies and recommendations on sustainable soil fertility management and fertilizer use strategies, guidelines and policy frameworks as well as proposals on suitable models for assessment of effective fertilizer demands in the short and medium term.

Further, included in this publication are guidelines on assessment/forecasting of fertilizer demand which were formulated to assist agricultural policy-makers in the region (i) make realistic estimates of fertilizer demand and supply and assess/forecast domestic fertilizer production/import as well as import of raw materials for domestic production; (ii) monitor the fertilizer supply-demand balance to avoid excessive inventories; and (iii) make better investment decisions in new domestic fertilizer production capacity.

Bangladesh

by

R.N. Roy & A.T.M. Farid

1. Background

Bangladesh is the largest deltaic floodplain in the world with a total area of 147 570 sq km. It has 8.3 million ha of arable land with an average cropping intensity of about 185 percent, supporting about 149 million people. Agriculture has played a pivotal role in the economy since the country's inception, despite significant contributions from the garment industry and remittances from abroad. The agricultural sector contributes about 22 percent to the country's Gross Domestic Product (GDP). About 69 percent of this comes from the main driver of sectoral growth, the crop and horticulture sector. About 84 percent of the total population live in rural areas and are directly or indirectly engaged in a wide range of agricultural activities. About 87 percent of rural households are landless, marginal and small; 63 percent are employed in agriculture (about 53 percent in crop agriculture) and about 33 percent in non-farm activities with backward and forward linkages with agriculture.

The major challenges facing Bangladesh agriculture are:

- raising productivity and profitability;
- reducing instability;
- increasing resource-use efficiency;
- ensuring equity;
- improving product quality; and
- meeting demands for the diversification and commercialization of agriculture.

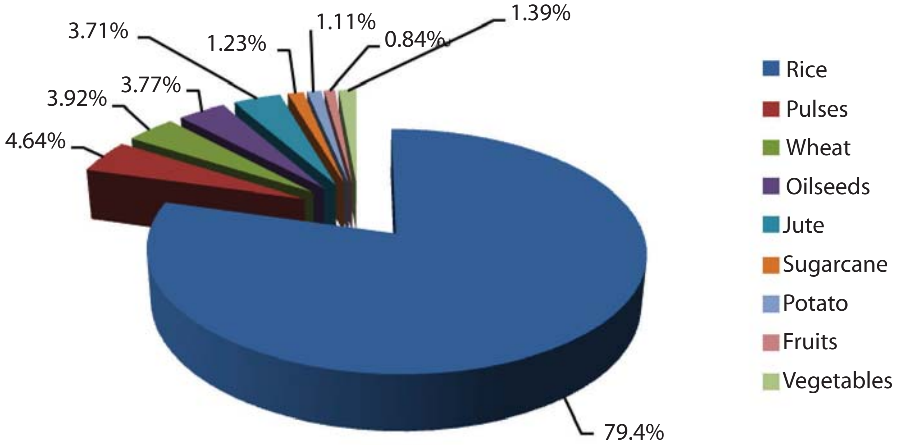
The major weaknesses identified by the National Agriculture Plan are:

- comparative weakness of the agricultural marketing system;
- high post-harvest losses;
- farmers' inadequate capital for agricultural activities;
- limited access to institutional agricultural credit;
- inadequate and ineffective farmers' organizations;
- low input use (water, fertilizer, pesticides) efficiency;
- inadequate technology to meet export market requirements;
- insufficient technologies to cope with an unfavourable environment;
- insignificant private sector investment in Research and Development;
- inadequate numbers of trained scientists and infrastructural facilities for advanced agricultural science;
- low level of agricultural diversification;
- weak quality control mechanism for agricultural inputs;
- minimal coordination between public, private and university research;
- almost non-existent use of information and communication technology (ICT) in the extension system;
- inadequate opportunities for farmers' and entrepreneurs' training; and
- persistently inadequate production and supply of quality inputs (e.g. fertilizer, seed).

The majority of the country's soils, its most important natural resource, are alluvial. Hill and terrace soils represent only 20 percent of the total and 8 to 10 percent of the cultivable land. It is estimated that agricultural land is declining by 1 percent per year (about 220 ha/day) and land quality is deteriorating owing to degradation of soil fertility (e.g. through nutrient mining and imbalance), soil erosion and soil salinity. Water resources are also shrinking. In order to produce more food for an increasing population (about two million per year) and raw materials for agro-industries, the only option left is to expand the use of yield-contributing inputs combined with efficient scientific management practices.

At present, rice covers about 79.4 percent of cultivated land. Area coverage by other crops is: pulses (4.64 percent) wheat (3.92 percent), oilseeds (3.77 percent), jute (3.71 percent), sugarcane (1.23 percent), potato (1.11 percent), fruits (0.84 percent) and vegetables (1.39 percent). This production system dominated by a single crop (i.e. rice) is neither scientific nor acceptable from the economic point of view. It is therefore necessary to increase the cultivation and production of other crops. However, considering the increasing demand for food grains and with a view to ensuring food security (forecast for 2012), production of rice will continue to have priority in the food grain production programmes. In order to increase rice production, support is needed in the form of timely adjustment in fertilizer and diesel prices, increased availability of fertilizers, agricultural input cards and enhanced finance from banks, including collateral-free credit to sharecroppers. Such programmes are at various phases of implementation.

Figure 1: Land area coverage by crop



Food security situation

Although Bangladesh has achieved remarkable progress in domestic food production (Table 1), poverty and widespread malnutrition are still endemic. About two-fifths of the 149 million people are calorie-poor, consuming less than 2 122 kcal per capita per day, while one-fifth of the population are hard core poor who consume less than 1 805 kcal per capita per day, according to estimates by the Bangladesh Bureau of Statistics (BBS) in 2007.

Table 1: Foodgrain demand, supply and balance

Year	Demand ('000 t)	Supply ('000 t)		Availability ('000 t)	Balance ('000 t)
		Net Production[1]	Import		
1997/98	20 696	18 599	1 933	20 532	-164
1998/99	21 027	19 631	5 486	25 117	4 090
1999/00	21 358	22 416	2 104	24 520	3 162
2000/01	21 689	24 083	1 554	25 637	3 948
2001/02	22 020	23 315	1 799	25 114	3 094
2002/03	22 351	24 025	3 221	27 246	4 895
2003/04	24 549	24 699	2 798	27 497	2 948
2004/05	24 945	23 520	3 373	26 893	1 948
2005/06	25 309	24 539	2 562	27 101	1 792
2006/07	25 686	25 250	2 421	27 671	1 985
2007/08	28 422	26 798	3 212	30 010	1 588

Source: *BBS (HIES), DAE and Food*

[1] *Gross production less 10 percent for seed, feed and wastage; rice is calculated on the basis of milled rice.*

Food insecurity remains a major concern and the situation worsens with year to year shortfalls in food grain production caused by climatic variations and natural disaster such as floods, tidal surge and pest attacks. Variations in food intake also exist between regions of the country, between adults and children and between men and women at the household level.

The National Food Policy is to give priority to food production, stock maintenance, distribution and all activities related to food access, to ensure food security at national, household and individual levels. Article 15(a) of Bangladesh's Constitution targets poverty reduction. This complies with the 1996 World Food Summit Declaration and the Millennium Development Goals (MDGs).

The price of food (see Table 2) is one of the determinants of varying per capita calorie intake. Between 1997–98 and 2007–08 the price of coarse rice increased from Tk 11.50 to 25.00/kg. This was eventually responsible for the low calorie intake of marginal and landless farmers who represent the dominant group (87 percent). Other determining factors are per capita income, local availability of a food item, price of food on the international market and domestic production of rice.

Table 2: Foodgrain prices

Year	Price of major foodgrains, Tk/kg (Wholesale)		
	Wheat	Rice (Coarse)	Maize
1997/98	8.71	11.50	
1998/99	9.17	13.77	
1999/00	8.64	12.23	
2000/01	8.70	11.48	
2001/02	8.67	12.02	
2002/03	8.87	13.25	
2003/04	10.17	13.07	
2004/05	12.49	14.74	
2005/06	13.90	15.80	
2006/07	17.07	16.95	14.10
2007/08	25.00	25.00	12.55
2008/09	24.00	23.00	13.23

Source: *Department of Agricultural Marketing (DAM), 2009*

Availability of food at national and household levels depends on domestic production and public and private imports plus food aid and distribution. In the face of the rapidly increasing cost of food imports due to tightening global food marketing and a gradual reduction in food aid, Bangladesh aims to augment domestic food production and build a comfortable and secure food reserve for her people. To this end the government puts great emphasis on increasing domestic production of food commodities. However, domestic production has never run smoothly. It fluctuates due to natural calamities such as the cyclones *Sidr* and *Aila*, and flood and drought. Also the localized problem of *Monga* (the yearly cyclical phenomenon of poverty and hunger) persists. However, despite all these negative factors, total foodgrain (rice and wheat) production increased over time from 20.7 million tonnes in 1997–98 to 29.8 million tonnes in 2007–08 (Table 3). The average productivity of the major cereal, rice, has increased from 1.84 tonnes/ha in 1997–98 to 2.73 tonnes/ha in 2007–08.

The major thrust of Government policies is on yield-contributing factors like fertilizer, seed and irrigation. Of these, fertilizers are the dominant factor in ensuring domestic foodgrain production.

Table 3: Gross area and production of major cereals ('000 ha/'000 tonnes)

Fiscal Year	Milled Rice			Wheat			Total Foodgrains		
	Area	Production	% Growth	Area	Production	% Growth	Area	Production	% Growth
1997/98	10 266.80	18 862	–	804.86	1 803	–	11 071.66	20 655	–
1998/99	10 119.84	19 905	5.5	882.60	1 908	5.8	11 002.44	21 813	5.6
1999/00	10 712.96	23.067	15.9	832.79	1 840	-3.6	11 545.75	24 907	14.2
2000/01	10 802.02	25 085	8.8	772.87	1 673	-9.1	11 574.87	26 758	7.4
2001/02	10 665.59	24 299	-3.1	742.11	1 606	-4.0	11 407.70	25 905	-3.2
2002/03	10 775.30	25 188	3.7	706.88	1 507	-6.2	11 482.18	26 695	3.1
2003/04	10 828.74	26.190	4.0	642.11	1 253	-16.9	11 470.85	27 443	2.8
2004/05	10 372.87	25 157	-3.9	558.70	976	-22.1	10 931.57	26 133	-4.8
2005/06	10 533.60	26 530	5.5	479.35	735	-24.7	11 012.95	27 265	4.3
2006/07	10 583.81	27 318	3.0	400.00	737	0.3	10 983.81	28.055	2.9
2007/08	10 574.14	28 931	5.9	387.00	844	14.5	10 961.14	29 775	6.1

Source: *BBS, 2009*

Role of sustainable soil fertility and fertilizer management policies

Agricultural production must attain continuous growth in order to maintain the level of food supplies or further improve it. The role of fertilizers and other agricultural inputs in enhancing agricultural production is crucial in view of the limitations on bringing more land under cultivation.

A large area of the country is severely deficient in phosphorus, potassium and sulphur and 53 percent of arable land is severely deficient in organic matter. This is an alarming situation. The important task is to follow sound fertilizer use and soil fertility management practice 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.

Problems of nitrate toxicity in drinking water and eutrophication of ponds and lakes are increasingly being observed. There has also been a build-up of nitrous oxides in the atmosphere because of the unscientific use of fertilizers.

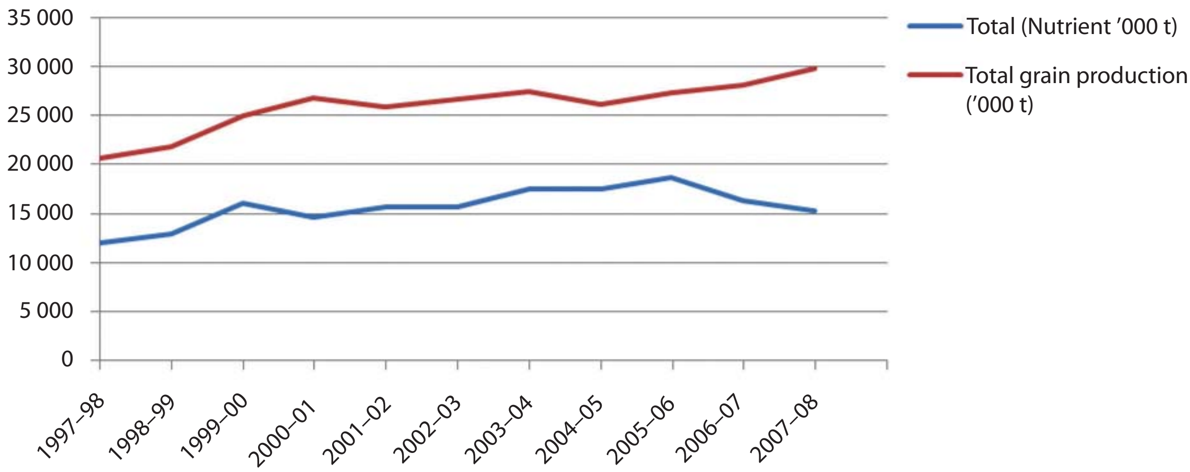
Fertilizer use in agriculture

Fertilizer is one of the key inputs for increasing crop yields and its contribution to crop production is about 50 percent. The supply of this key input to farmers' doorsteps to sustain crop productivity has recently been a critical issue. Urgent demands for fertilizers are heard throughout the country at the beginning of every crop season.

The use of mineral fertilizers in then subsistence and food-deficit former East Pakistan (now Bangladesh) agriculture began in 1951 with the import of 2 698 tonnes of ammonium sulphate. Consumption increased steadily with time after the introduction of modern varieties to feed teeming millions and reached a peak of about 1.7 million tonnes NPK in 2007–08. A reasonably positive relation is observed between nutrient consumption and rice production (Figure 2).

Fertilizer production, import, distribution and marketing were with the government until 1991, when privatization took place. However, total production and import of urea plus production of small quantities of TSP and DAP remain under government control through BCIC and are distributed through BCIC-appointed dealers. Import and marketing of the remaining TSP, DAP and other fertilizers (MOP, SOP, gypsum, magnesium sulphate and micronutrients) are mostly controlled by the private sector, leaving a portion of TSP and MOP to BADC. Small quantities of NPKS granulated fertilizers are being produced

Figure 2: Rice production as affected by fertilizer use



Source: *BBS data, 2009*

by various companies in an effort to achieve balanced mixes. The fertilizer is heavily subsidized so that farmers can afford it. Demand is usually calculated by the Department of Agricultural Extension on the basis of crop area and application level. There is huge gap between demand and supply of domestically produced fertilizer. Timely supply of both locally produced and imported fertilizers at the farmgate are occasionally handicapped by various results in shortages and problems for the farmers.

The fertility and productivity of the country's most important natural resource, soil, must be maintained at optimum level. This is necessary to face the challenges of growing more food in a country where food security is crucial for poverty-stricken people, where about two million people are added to the total population every year and where natural resources including agricultural land are shrinking.

The present study aims to investigate the soil fertility and fertilizer sector of Bangladesh with a view to identifying gaps in prevailing strategies and policies, and propose measures for improvement.

2. Soil fertility and fertilizer management strategies and policies – a review

2.1 Soil fertility and soil health

The arable land of Bangladesh is under intense pressure from increasing population, land degradation, intensive agricultural practices and a wide range of environmental threats. There are 46 important economic crops grown in the country. Land use is mainly decided by land type. High and medium high lands constitute about 65 percent of the country's area, where the cropping intensity is as high as 300 to 400 percent.

According to the Soil Resource Development Institute (SRDI) in Bangladesh, an area of about 8.44 million ha is deficient (very low/medium) in phosphorous and about 7.14 million ha deficient in sulphur. A soil fertility monitoring database, using data generated at 40 different sites throughout the country over the last 17 years by SRDI, shows that phosphorous availability has decreased by between 35 to 65 percent. Phosphorous does not occur as abundantly in soils as N and K. Although the total concentration of P in the soil varies between 0.02 and 0.10 percent, it has no relationship with the availability of P. An FAO-financed project on Zn and Sulphur deficiency in Bangladesh indicated that most soils are deficient in sulphur. S may be considered the second nutrient element limiting rice yields.

Unfortunately, many soils are severely depleted of some nutrients and organic matter because of intensive farming and the non-return of organic residues. The depletion status varies over different agro-ecological regions. However, a widespread deficiency of phosphorus, sulphur and organic matter is severely limiting

Table 4: Extent of major plant nutrient deficiencies in Bangladesh

Plant Nutrient	Deficient Area (ha)
Phosphorus	1 845 424
Potassium	398 083
Sulphur	1 062 864

Source: *BRRI and BARI research reports*

crop production. It is alarming that about 1.8 million, 0.4 million and 1 million hectares of land are severely deficient in phosphorus, potassium and sulphur, respectively (Table 4). It indicates extreme poor health of the soil resource. If this problem is not addressed the soil will be unable to nourish agricultural production to feed the country's growing population.

Another important component is organic matter content which is critically low in about 53 percent of the country's arable land (<1% organic matter). The main causes of this depletion are intensive land use, unbalanced use of mineral fertilizers, little or no use of organic manure/waste and removal of stubble/ residues from the field at harvest.

Research data indicate that cultivation of two crops of high-yielding variety (HYV) rice, producing more than 10 tonnes annually removes about 350 kg of nutrient per hectare from the soil. The input-output balance sheet of nutrients in Bangladesh depicts a large net annual removal of nutrients (mining) from the soil, exceeding more than two million tonnes of nutrients per year from arable land (Karim *et al*., 1994). This is a serious threat to the sustainability of agricultural productivity. Another conspicuous problem is the salinity which is engulfing more and more areas. Low-lying coastal areas are seriously affected while inland salinity has been developing in areas provided with major irrigation schemes.

2.2 Soil fertility, crop response and fertilizer recommendations

Bangladesh has a high cropping intensity of more than 180 percent (BBS, 2006) with modern varieties of crops. In intensive cropping areas the arable soils are being mined which poses a serious threat to sustainable production. Yields of many crops are either stagnating or declining.

Table 5: Contribution of fertilizer to crop production

Crops	Grain/1 kg Fertilizer
Boro Rice	26
T-Aman	11
Wheat	18
Potato	43
Maize	41

Source: *BRRI and BARI research reports*

Fertilizer is a key input and has contributed significantly (>50%) to the increase in agricultural production. Recent analysis of research findings indicates that 1 kg of fertilizer produces 26 kg of HYV Boro rice, 43 kg of potato or 41 kg of maize (Table 5).

Fertilizer recommendations were first compiled in 1985 in the form of a guide that is updated every five years (last done in 2005). Recommendations are made on the basis of a number of parameters for all crops, both individually and on a cropping pattern basis, under irrigated and rainfed conditions, taking soil fertility level and soil test values into consideration. Yield targets, whether high or medium, are also considered when making recommendations. Farmers are not used to applying fertilizers on a cropping pattern basis, ignoring the benefit of long-term soil sustainability. Fertilizer recommendations for major crops (Table 6) and a few cropping patterns (Table 7) are given as examples. Recommendations are made on the basis of field research at the Bangladesh Agricultural Research Institute (BARI) and the Bangladesh Rice Research Institute (BRRI), verified through on-farm trials. There is no recommendation for the application of organic manure, though there is a separate chapter on "Soil organic matter management" in the Fertilizer Recommendation Guide-2005. With the introduction of new high yielding varieties and changes in soil nutrient status, there is a real need to update the guide.

Table 6: General fertilizer recommendations

Crop	Yield (t/ha)	Plant Nutrients dosage (kg/ha)						
		On variable fertility status			National			
		N	P_2O_5	K_2O	N	P_2O_5	K_2O	FYM (t/ha)
Wheat	4.5	80–120	46–69	72–108	100	58	90	–
Rice (Hybrid)	7.5	113–168	48–68	80–118	140	58	99	–
Maize	8.0	130–195	82–124	90–130	160	100	110	–
Potato	30	90–135	48–69	109–162	112	58	136	–
Sugarcane	100	110–165	85–124	144–216	138	105	180	–

Source: *Fertilizer Recommendation Guide, 2005*

Table 7: Fertilizer recommendations for cropping systems

Cropping pattern		Yield goal	Fertilizer recommendation (kg/ha)							
			N	P_2O_5	K_20	S	Mg	Zn	B	Mo
1.	Boro	6.0±0.6	100	32.06	55.20	8	–	1.0	–	–
	Fallow	–	–	–	–	–	–	–	–	–
	T-Aman	4.0±0.4	56	9.16	27.60	7	–	1.0	–	–
2.	Wheat	3.5±0.3	90	45.80	45.60	5	–	1.2	1.0	–
	GM	–	–	–	–	–	–	–	–	–
	T-Aman	4.0±0.4	45	11.45	21.60	8	–	1.0	–	–
3.	Potato	25.0±2.5	80	45.80	57.60	10	2	1.5	–	–
	Fallow	–	–	–	–	–	–	–	–	–
	T-Aman	3.0±0.3	38	11.45	15.60	8	–	1.0	1.0	–
4.	Wheat	3.5±0.35	90	36.64	45.60	4	–	–	1.0	–
	T-Aus	3.2±0.3	54	9.16	18.00	5	–	1.0	–	–
	Mungbean	1.0±0.1	15	41.22	16.80	5	–	–	–	–

Source: *Fertilizer Recommendation Guide, 2005*

In 2008 SRDI analysed about 18 245 soil samples at their regional and mobile soil testing laboratories (Table 8). The results of these analyses are used in formulating fertilizer recommendations and updating soil fertility maps.

2.3 Fertilizer use

Although growth in fertilizer use and crop productivity/production has been quite remarkable, there is a lack of consistency when political changes impact on policy. About 60 percent of N (mainly urea) is used on Boro rice. Urea is cheap and has an immediate greening effect on crops, so the farmers tend to use it in the first instance, sometimes to excess.

The comparatively lower use of P and K is leading to nutrient mining and imbalance. The preferred ratio of use for N, P_2O_5 and K_2O is 4:2:1, whereas the actual ratio in 2007–08 was 7.8:1.3:1. In 2008–09 this deteriorated to 23.7:1.6:1. However, that year was unusual as the prices of P and K fertilizers on the international market were very high. Of more interest is the N:P_2O_5 ratio which was about 5.9:1 in 2007–08 rather than the preferred ratio of 2:1.

Secondary and micronutrient deficiencies are also fast increasing. Guidance is available from the national agricultural research system (NARS) although soil fertility maps and site-specific recommendations based on cropping systems and the agro-ecological zone need to be updated. However, the right technologies are not transferred to the farmers by the extension staff who are preoccupied with fertilizer marketing, distribution and control.

Table 8: Soil testing laboratories – location, capacity and capacity utilization

Location of laboratories (SRDI)	Capacity per annum	Analysed in 2008	Capacity utilization (%)
	('000 samples)		
Central Laboratory, Dhaka	2.9	2.635	92
Regional Laboratory, Dhaka	2.5	2.432	97
Regional Laboratory, Comilla	3.8	3.659	96
Regional Laboratory, Rajshahi	2.1	1.726	82
Regional Laboratory, Khulna	2.0	1.324	66
Regional Laboratory, Jamalpur	0.5	0.359	72
Regional Laboratory, Mymensingh	0.5	0.4	80
Regional Laboratory, Kushtia	0.5	0.15	30
Regional Laboratory, Faridpur	0.5	0.2	40
Regional Laboratory, Barisal	0.5	0.417	83
Regional Laboratory, Bogra	0.5	0.508	102
Regional Laboratory, Sylhet	0.5	0.05	10
Regional Laboratory, Noakhali	0.5	0.827	165
Regional Laboratory, Chittagong	0.5	0.508	102
Regional Laboratory, Dinajpur	0.5	2.165	433
Regional Laboratory, Jhenaidaha	0.5	0.278	56
Total	18.8	15.045	80
Mobile Laboratory	3.2	3.2	100
Grand Total	22.0	18.245	83

Source: *Fertilizer Recommendation Guide, 2005*

The main NPK fertilizers used in Bangladesh are urea, TSP, DAP and MOP (see Table 9).

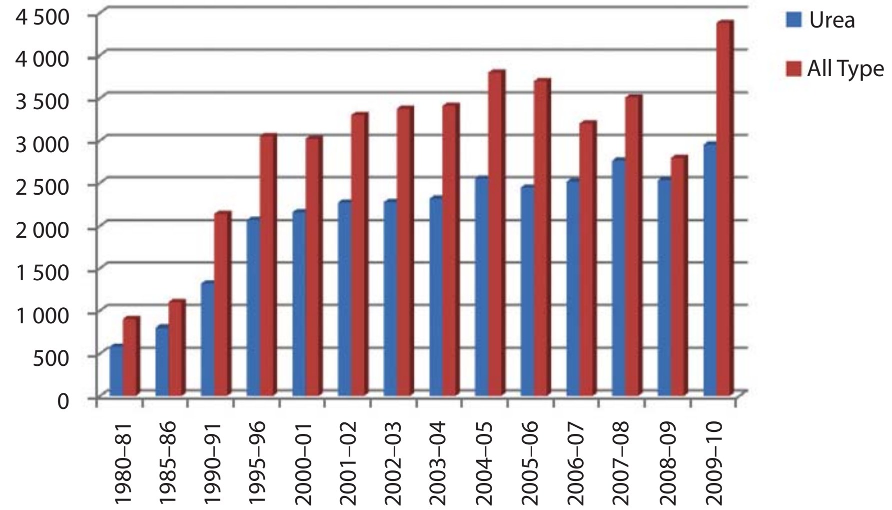
Table 9: Fertilizer consumption ('000 000 tonnes)

Year	Urea	TSP	DAP	MOP	Total Fert.	N	P_2O_5	K_2O	Total NPK
2006–07	25.15	3.40	1.15	2.30	32.00	11.78	2.09	1.38	15.25
2007–08	27.63	3.82	0.89	2.74	35.08	12.87	2.17	1.64	16.68
2008–09	25.33	1.61	0.18	0.82	27.94	11.68	0.82	0.49	13.00
2009–10*	29.51	6.70	2.63	4.97	43.81	14.05	4.29	2.98	21.32

Source: *Fertilizer Recommendation Guide, 2005*
* *Estimated demand during the financial year*

Growth of fertilizer use from 1980–81 to 2009–10 is presented in Figure 3. Consumption of nutrients (NPK) remained around 1.5 million metric tonnes from 2006 to 2008. As a result of the very high international price of fertilizers during 2008–09, consumption dropped to about 1.3 million tonnes. The estimated demand of 2.1 million tonnes for 2009–10 appears to be on the high side.

Figure 3: Growth of fertilizer use in Bangladesh ('000 tonnes)



Source: *BBS & Bangladesh Economic Review 2006*

2.4 Fertilizer availability and demand-supply situation

The Ministry of Agriculture, using figures obtained by the Department of Agricultural Extension through its field surveys, fixes both the monthly and annual requirement for fertilizers.

In 2002–03 there was a low estimate of fertilizer demand and lower projections were made for several years (Karim, 2009). The gap between estimated and actual demand for 2007–08 is shown in Table 10. From field observations, a review of the growth of fertilizer consumption in South Asia and the increase in cropping intensity with hybrid and high value crops, Karim considered it reasonable to increase the 2007–08 target by 25 percent. Based on field surveys, he estimated the actual demand for urea, TSP and MOP to be 3 520 000, 590 000 and 500 000 tonnes, respectively.

Table 10: Fertilizer demand and supply 2007–08 ('000 000 tonnes)

Types of Fertilizer	Government estimate.	Estimate of actual demand*	Gap	Actual consumption
Urea	28.18	35.2	7.0	27.63
TSP	4.75	5.9	1.2	3.82
MOP	4.0	5.0	1.0	2.74
DAP	2.5	3.2	0.7	0.89

Source: *Karim, 2009*

** Based on 25 percent increase of annual allocation supported with field level projections (Karim, 2009).*

The above table indicates a wide gap between demand and supply. About 60 percent of the total annual requirement for fertilizers is used during the HYV Boro season (Jan–Mar), the allocation for which falls short of actual requirements. The real problem is that not only is the total demand for the year underestimated but the peak Boro season demand is not correctly assessed either.

Besides estimating demand, the Ministry also makes a total exercise on production, import and price fixation. Table 11 shows the proposed scenario for 2009–10. It is quite evident that there will be a shortfall of 1 451 000 tonnes of urea which the government will meet through imports and local purchase from KAFCO[1]. Private companies will import 200 000 tonnes of TSP and 105 000 of DAP. BADC[2] will import

[1] Karnaphuli Fertilizer Company (Bangladesh)

[2] Bangladesh Agricultural Development Corporation

Table 11: Proposed fertilizer demand, production, import and prices 2009–10

Fert. type	Demand ('000 000 tonnes)	Production ('000 000 tonnes)	Import ('000 000 tonnes)	Local price (Tk/tonne)		C&F price (US$/tonne)
				Factory/BADC/ Pvt. Importer	Buffer	
Urea	29.51	15.00	14.51	10 000.00	10 700.00	500
TSP	6.70	0.50	1.00 (BADC); 2.00 (Pvt. Sec)	20 000.00	–	270–300
MOP	4.97	–	1.00 (BADC); 2.00 (Pvt. Sec)	23 000.00	–	485–500
DAP	2.63	1.00	1.05 (Pvt. Sec)	28 000.00	–	375
NPKS	1.50	1.50	–	26 979.00 (8:20:14:5); 28 386.00 (12:15:20:6)	–	
Gypsum	1.50	0.60 from TSP factory	0.90 (Pvt. Sec)			
$ZnSO_4$	0.50	0.10	0.40			
$MgSO_4$	0.20	–	0.20			
Total	**47.51**	**18.70**	**23.05**			

Source: *Karim, 2009*

100 000 tonnes of TSP. Private companies will import 200 000 tonnes and BADC 100 000 tonnes of MOP to meet potash requirements. Most of the secondary and micronutrient fertilizers are either made in-country or imported by private companies.

It can be seen that even in 2009–10, demand estimate far exceeds the production and import figures. It may be concluded that neither the estimate of demand nor actual consumption reflects potential demand. The major problem lies with the availability of adequate quantities of fertilizer. The factors responsible are probably: i) delayed decision on P and K subsidy in 2007–08; ii) uncoordinated/inadequate imports; iii) price distortion on the international market and iv) absence of an appropriate mechanism for estimating short-, medium- and long-term demand.

2.5 Fertilizer production

The government-owned Bangladesh Chemical Industries Corporation (BCIC) was established in July 1976 by a presidential order. The corporation manages eight fertilizer factories, six of which produce urea, and one each producing TSP and DAP. Their installed capacities are shown in Table 12.

Table 12: Installed capacities of fertilizer factories

Enterprise Name	Product	Installed capacity/ tonnes per year	Year Established
1. Chittagong Urea Fertilizer Factory Ltd.	Urea	561 000	1987
2. Jamuna Fertilizer Company Ltd.	Urea	561 000	1989
3. Zia Fertilizer Company Ltd.	Urea	528 000	1981
4. Urea Fertilizer Factory Ltd.	Urea	470 000	1970
5. Polash Urea Fertilizer Factory Ltd.	Urea	95 000	1985
6. Natural Gas Fertilizer Factory Ltd.	Urea	106 000	1961
7. TSP Complex Ltd.	TSP	100 000	1976
8. DAP Fertilizer Co. Ltd.	DAP	528 000	2006

Source: *MOA, 2010*

In addition to this, BCIC holds an equity share of 43.51 percent in KAFCO, a 100 percent export-oriented international joint venture company. The KAFCO complex produces 680 000 tonnes of high-grade granular urea and 150 000 tonnes of anhydrous ammonia.

Between 1997–98 and 2009 the highest urea production recorded was around 2.2 million tonnes in 2004–05. Since then production has slowly decreased (Table 13). In 2008–09, BCIC produced 1.4 million tonnes urea, 50 000 tonnes TSP and 100 000 tonnes DAP. It also produced 100 000 tonnes of SSP. Production of SSP was stopped in 2009. During 2009–10, BCIC aims to produce 1.5 million tonnes urea, 50 000 tonnes TSP and 100 000 tonnes DAP against a forecast demand of 2.95 million, 670 000 and 263 000 tonnes of urea, TSP and DAP, respectively. The balance of about 1.45 million tonnes of urea, 620 000 of TSP and 163 000 of DAP will have to be imported.

Table 13: Domestic fertilizer production 1994–95 to 2009–10

Year	Production (tonnes)			
	Urea	TSP	SSP	DAP
1994–95	1 976 000	76 000	81 600	
1995–96	2 134 000	27 500	79 500	
1996–97	1 638 000	31 700	100 150	
1997–98	1 883 000	49 700	100 500	
1998–99	1 607 000	58 600	122 000	
1999–00	1 704 000	65 000	127 000	
2000–01	1 883 000	68 000	120 000	
2001–02	1 546 000	68 000	120 000	
2002–03	2 057 000	65 600	136 400	
2003–04	2 164 000	65 000	135 500	
2004–05	2 200 000	65 000	134 000	
2005–06	1 700 000	60 000	100 000	
2006–07	1 700 000	60 000	100 000	100 000
2007–08	1 400 000	50 000	100 000	100 000
2008–09	1 400 000	50 000	100 000	100 000
2009–2010 (Proposed)	1 500 000	50 000	Nil	100 000

Source: *MOA (Ministry of Agriculture), 2010*

There are more than 50 small zinc sulphate factories in the country, mostly concentrated around Jessore in the south-west. These factories can produce 10 000 to 12 000 tonnes of granular monohydrate and crystalline heptahydrate zinc sulphate. Some companies also produce small amounts of boric acids. About 60 000 tonnes of phosphogypsum (source of sulphur) are produced as a by-product from the TSP factory. Additional requirements of gypsum are imported. All MOP is imported.

The government has recommended six crop-specific grades of mixed or blended fertilizers for balanced application of nutrient elements. These are:

1. NPKS (8–20–14–5) for HYV Rice
2. NPKS (10–24–17–6) for HYV Rice
3. NPKS (10–15–10–4) for Sugarcane
4. NPKS (14–22–15–6) for Sugarcane
5. NPKS (12–16–22–6.5) for Wheat and other Rabi crops
6. NPKS (12–15–20–6) for Wheat and other Rabi crops

At present there are as many as ten companies producing NPKS mixed fertilizers, several of them producing only rice grades. Companies such as Akhter Agro and Fertilizer Industries Ltd., Sabir Fertilizer and Chemical Complex, South Bengal Fertilizer Mills Ltd., Jamuna Agro Chemicals, Aftab Fertilizers, Northern Agro Service Ltd. and NAFFCO produce and market about 150 000 tonnes of mixed fertilizers to farmers.

Natural gas is the only locally available raw material that can be used to produce urea. However, available data indicate that there is not enough gas to allow for the expansion of factories. Some expert opinion is of the view that this scarce resource should be diverted to factories rather than used domestically. An alternative might be to import gas from neighbouring countries. If more gas were available to fuel new factories it would create new job opportunities as well as ensuring food production and food security through assured availability of fertilizers.

2.6 Fertilizer imports

In 2009-10, the Bangladesh Chemical Industries Corporation (BCIC) will import 1 001 000 tonnes of urea, and obtain another 450 000 tonnes from KAFCO. BADC is entrusted with importing 200 000 tonnes of TSP, the remaining 420 000 tonnes being imported by the private sector which will also import 163 000 tonnes of DAP. All MOP will be imported.

Since 1991, TSP, DAP, MOP and zinc fertilizers were imported by the private sector which, jointly with the government, decided national requirements, local production and import targets. The private sector also maintained a buffer stock. This worked smoothly for more than a decade. In fiscal year 2004–05 the government introduced a subsidy for TSP, DAP and MOP which came into effect in January 2005. The workings of the subsidy are complex and there is an occasional lack of coordination. This has sometimes hampered the efficiency of the private sector.

Reviewing the import situation in January 2007, it was found that only 96 900 tonnes of TSP and 166 000 tonnes of MOP had been imported by the private sector. Then, over a six-month period from mid-January to mid-June only 13 000 tonnes of TSP and no MOP was imported, leading to a dearth of phosphorus and potassium during the peak demand period of the Rabi season. The 83 000 tonnes of TSP imported in 2006–07 by the private sector could not be sold because of delays in deciding the subsidy. Although the government did finally provide the subsidy plus interest the damage had been done. The farmers reported that BADC sold a small quantity of TSP at a higher price than usual. Field observations revealed that many Rabi crops and important economic crops such as potato, sugarcane etc. showed symptoms of deficiency resulting in loss of production.

In December 2005 the government suddenly took BADC back to importing fertilizer, asking them to import 130 000 tonnes of TSP and 96 000 tonnes of MOP. BADC did this and sold them to the farmers at a much higher price than the private sector.

Two more urea fertilizer factories, each with a 0.5 million-tonne capacity, should be established, one in the north of the country, the other in the south-west, to minimize the shortfall of urea. DAP plants should be made fully functional as soon as possible to reduce imports.

Port handling facilities

Chittagong, in the east of the country, is the main handling port for imported fertilizer. The other port is Mongla in the south-west. Fully developing this latter port to handle fertilizer would lead to a reduction in logistical costs and reduce the time taken to obtain supplies.

With regard to landing and discharging operations, container vessels have been given top priority in Bangladeshi ports since 1980. They are thus able to berth ahead of most general cargo ships, greatly reducing demurrage charges.

Despite the fact that containers are often left for long periods of time in stacking areas and warehouses are regularly congested with cargo, container and cargo storage in the port areas is rent free for four days. Adequate mechanical off-loading equipment and facilities are needed to handle expected rates of delivery efficiently. Handling methods resulting in damage to bags, e.g. using hooks must be eliminated. Storage facilities must be clean and dry and there must be sufficient space to keep different products separate and permit their easy removal from store.

The quality and weight of the bagged fertilizers should conform to the desired specifications, and control measures are needed to see that this is done. The bagging operation at the port should be efficient enough to move the fertilizer at the desired pace.

In order to check the quality of imported fertilizers, samples are taken from the consignments at Chittagong and sent for analysis. Until such time as the results of analysis are received, the consignment has necessarily to be kept in a warehouse thereby incurring charges. Quick clearance of consignments once the analytical results have been received should be ensured.

2.7 Fertilizer transportation and warehousing

Most fertilizer is transported by road. This is economical for short distances since it is generally quick and losses in transit are low. Transportation by rail is limited, although for long distances it is cheaper than road. Water transportation offers a low energy/low cost option but is used only to a limited extent.

Inadequate warehousing capacity, especially in the northern and eastern areas of the country, is one of the major bottlenecks in the timely availability of fertilizers during the peak seasons. The fertilizer companies make an effort to keep transit and warehousing losses to a minimum and maintain quality standards. Around 10 percent of national fertilizer requirements are presently kept as buffer stocks.

2.8 Fertilizer marketing and distribution

Fertilizer distribution system

Fertilizer marketing, promotion and distribution in Bangladesh started in the late 1950s. At this time the Department of Agriculture was solely responsible for import, storage, distribution and retail sale among the farmers. For various reasons, the distribution system was unsatisfactory. This was reflected in the Report of the Food and Agriculture Commission published in 1960. The report suggested establishing an autonomous organization responsible for proper distribution and marketing of fertilizer and other agricultural inputs on a commercial basis. The Bangladesh Agricultural Development Corporation (BADC) was thus created in 1961, and became responsible for distributing and marketing fertilizers and other inputs. They also had to maintain sufficient stocks in their godowns. BADC's fertilizer distribution programme began in 1963 when they appointed Union-level dealers to make fertilizers easily available to the farmers. The dealers collected fertilizers from the BADC godowns in various Thanas and sold them on a commission basis to the farmers at prices fixed by the government.

This distribution system did not work well because of BADC's gross irregularities in appointing dealers, and the subsequent difficulties encountered by the dealers themselves. These consisted of unnecessary bottlenecks in obtaining clearance from the *Thana* committees and police and restriction of sales to areas delineated by the Thana committees. During the fertilizer crisis of 1974 the number of dealers was reduced to three, though it rose later to 15. In 1975, the dealership system was reformed to allow the sale of fertilizers at village markets. Under the previous system the dealers were allowed to lift fertilizers only from assigned Thana godowns; now they were allowed to take them from any Thana godown convenient to them.

In order to make the fertilizer distribution system more effective a New Marketing System (NMS) known as the Fertilizer Distribution Improvement (FDI-I) project was launched with the assistance of the United States Agency for International Development (USAID) in December 1978. This system brought about qualitative changes in fertilizer distribution. The dealers were given more responsibility and further financial inducements. Under the FDI-I project 101 primary distribution points were opened which reduced transportation and storage costs. The wholesalers and retailers were given the responsibility of distributing the fertilizers to the farmers. All restrictions were withdrawn, allowing them to sell the fertilizers on a competitive basis on the free market. The government's role in these reforms was to monitor prices.

The last reform under FDI-I was to withdraw price control over sales to farmers. This system was first introduced in Chittagong Division then gradually implemented throughout the country in 1982–83. This reform brought about a substantial improvement in the fertilizer distribution system with no increase in prices.

This system continued up to 1987 when FDI-II was initiated. Under FDI-II private dealers were able to buy fertilizers from four transport discount points at reduced rates. This was BADC's first step towards privatizing distribution. It led to a reduction in fertilizer prices in the dealers' command areas. However, in 1989 the system failed. There was a severe shortage of fertilizer at the farmers' level that year despite there being sufficient stocks in the godown. Following this, the government carried out some reforms. For the first time dealers were allowed to collect urea from the Ghorasal Urea Fertilizer Factory, then gradually from other factories at prices fixed by BADC. They were also allowed to import urea.

All the above measures helped lower prices for the farmers and led to a substantial improvement in the distribution system. From 1990 onwards the private sector as well as BADC was allowed to import all types of fertilizers. However, the government eventually obliged BADC to withdraw from fertilizer dealings because of their high prices and fierce competition from the private companies.

With the passage of time, privatization of the fertilizer distribution system proved successful and in 1993–94 sales rose to 2 218 000 tonnes. Unfortunately, there was a severe shortage of urea during the 1995 boro season. The main reasons were:

- After the FDI-II project was wound up at the end of 1994 there was no information about urea supplies.
- BCIC continued to export urea fertilizer without any consideration for the supply and demand situation in the country.

The shortages led to unrest among the farmers who demonstrated in the streets, desperate to obtain fertilizer for their boro crops which were suffering badly.

Following this incident, the government held talks with the Bangladesh Fertilizer Association and decided to appoint new dealers in 1995. With the appointment of the latter the distribution of urea entered into a new era. The present dealers are authorized to take TSP and SSP from the BCIC factories and collect buffer stocks for distribution among the farmers in their command areas.

Urea production and imports are government-controlled, and urea is distributed to the farmers through BCIC-appointed dealers. Private importers bring in TSP, DAP and MOP from the USA, Tunisia, Australia, Jordan, Morocco, CIS countries and China according to the annual needs of the country.

2.9 Economics of fertilizer use

In 2007–08 a survey of fertilizer requirements was conducted in Bogra and Dinajpur districts. The total area of cultivated land was found to be 990.39 thousand ha planted to 53 different crops. The crop species were all categorized into12 different subgroups. The five major crops – rice, wheat, maize, potato and vegetables – covered about 889.97 (89.86 percent) thousand ha of land. The total fertilizer requirement was estimated to be 532 metric tonnes while the actual quantity available at farm level amounted to 246 tonnes, a shortfall of 264 (50 percent).

Based on average fertilizer doses for the five major crops, the total requirement was 758 kg/ha while farmers applied 379 kg/ha, 50 percent short of the recommended application. Because they were using one kg less nutrient per ha, the farmers incurred losses of 45 kg, 35 kg, 6 kg and 2 kg of vegetables, potato, maize, wheat and rice crops, respectively. This resulted in a monetary loss of Taka 6.68 billion. The farmers strongly argued the case for fertilizers being available on the open market as before rather than through the existing coupon system.

2.10 Fertilizer pricing and subsidy

Internationally the prices of TSP, DAP and MOP increased abruptly at the end of 2003 and beginning of 2004, seriously affecting the balanced use of fertilizer. To remedy the situation the Bangladesh Fertilizer Association approached the government about introducing a subsidy for these three fertilizers. The government reacted favourably and provided a 25 percent subsidy. During 2004–05 and 2005–06 the subsidy amounted to Tk 2.6 and 3.7 billion, respectively for the phosphate and potash fertilizers. Helping farmers to obtain fertilizers at reasonable prices significantly increased crop production. Then, in 2007 and 2008, the prices of all fertilizers again went up very sharply in international markets because of high energy costs and a shrinking supply of raw materials for fertilizer production. Again the government provided subsidies to keep market prices down. A clear understanding of the benefits of subsidy can be seen in the comparative prices of TSP, DAP and MOP given in Table 14 and market prices of all fertilizers in Table 15.

Table 14: Comparative prices (Tk/50 kg) of TSP, DAP and MOP, 2004–10

Fertilizer	2004–05		2005–06		2006–07	
	Without subsidy	With subsidy	Without subsidy	With subsidy	Without subsidy	With subsidy
TSP	673–803	504–602	800–936	600–702	870	650
DAP	958–991	719–743	1 112–1 238	872–928	1 340	1 000
MOP	678–689	506–517	796–847	597–635	800	600

Fertilizer	2007–08		2008–09		*2008–09	
	Without subsidy	With subsidy	Without subsidy	With subsidy	Without subsidy	With subsidy
TSP	1 560	1 325	4 700	3 500	4 700	1 900
DAP	2 106	1 790	5 000	4 250	5 000	2 150
MOP	1 618	1 375	3 765	3 200	3 765	1 650

Fertilizer	2009–10		**2009–10	
	Without subsidy	With subsidy	Without subsidy	With subsidy
TSP	4 700	1 900	4 700	1 000
DAP	5 000	2 150	5 000	1 400
MOP	3 765	1 650	3 765	1 150

Source: *Annual Research Report, Agricultural Economics Division, BARI, Gazipur, 2008–09*
* Government announced approximately 55–60 percent more subsidy on 14 January, 2009.
** Government announced approximately 78–80 percent more subsidy on 2 November, 2009.

Table 15: Comparative prices of fertilizers 2007–08 to 2009–10

Fertilizer	Market Price of Fertilizer		
	2007–08 (Tk/tonne)	2008–09 (Tk/tonne)	2009–10 (Tk/tonne)
Urea	6 000	12 000	12 000
TSP	30 000	65 000	22 000
DAP	36 000	99 000	30 000
MOP	28 000	43 000	25 000
AS-Imported	20 000	22 000	22 000
AS-BCIC		35 000	35 000
$MgSO_4$	30 000	40 000	40 000
$ZnSO_4$ (Hepta)	35 000	70 000	70 000
$ZnSO_4$ (Mono)	55 000	95 000	95 000
Boric acid	60 000	100 000	100 000
Chelated Zn	–	450 000	450 000
Sulphur-90	40 000	70 000	70 000

Source: *Annual Research Report, Agricultural Economics Division, BARI, Gazipur, 2008–09*

The timely supply of both locally produced and imported fertilizers at farmgate is handicapped by various constraints resulting in shortages. The prices of urea and other imported fertilizers should be fixed at a par with those in neighbouring countries to prevent smuggling. The farmers should be provided with subsidies not only for fertilizers, but also for other agricultural inputs such as seeds and pesticides.

Method of paying subsidies

The method for paying subsidies is complicated and bureaucratic, involving a variety of different committees, e.g. the information cell, storage enquiry subcommittee, price fixing subcommittee, price fixing and monitoring committee and finally the steering committee under which the prices are eventually decided.

First step:

- When a vessel carrying imported fertilizer reaches to the outrage of Chittagong port, the importer submits the relevant documents to the cell at the office of the Additional Director, Department of Agricultural Extension (DAE) for examination.
- Samples are taken from the consignment and sent to the designated laboratories for testing.
- The test results are forwarded to the Ministry of Agriculture.
- At the Ministry's directive the storage enquiry subcommittee inspects the godown where the fertilizer is stored.
- This subcommittee sends a report to the price fixing subcommittee.
- The price-fixing subcommittee again examines the importer's documents and fixes the price of the fertilizer according to the guidelines.
- This subcommittee then forwards a report to the price fixing and monitoring committee.
- The price fixing and monitoring committee examines the recommendations of the storage enquiry and price fixing subcommittees, reviews the international prices and carrying and freight costs, considers other miscellaneous costs and then fixes the price of the imported fertilizer by adding US$29.84 to each tonne.

- After deducting 25 percent from the total price the committee submits its recommendations to the steering committee for approval. The recommendations are framed in such a way that the importer will retrieve his 25 percent after selling the fertilizer within four months of receiving clearance from the Ministry.
- After the approval of the steering committee, a 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 being brought to his district. If the storage godown is located outside of Chittagong, at Narayanganj, Naopara (Jessore) or Baghabari (Sirajganj), then an additional US$1.50 is added per tonne of fertilizer.

Second step:

- After obtaining clearance, the dealer can take fertilizer from one of the four assigned godowns to his own godown on production of a receipt which is supplied in triplicate. The dealer keeps one, another goes to the DC's office and the third is signed by the Upazila Nirbahi Officer. It is this officer who physically verifies the arrival of the fertilizer at the dealer's godown.
- This latter copy is then forwarded for signature to the Deputy Commissioner who is the chairman of the district fertilizer and seed monitoring committee. The committee adds transport and other miscellaneous costs to the fertilizers then fixes the price at which the dealer will sell to the farmers. These sales are monitored by the committee.

Third step:

- The Deputy Commissioner, after signing his copy of the receipt, sends it to the importer.
- A carbon copy goes to the Ministry of Agriculture.
- The Ministry verifies and crosschecks the DC's and importer's copies then seeks approval from the Ministry of Finance.
- On receipt of approval from the Ministry of Finance, the Ministry of Agriculture pays the deducted 25 percent to the importer.

Changes in subsidy payment procedure

The government has recently made some changes to the complicated process of obtaining subsidies described above. A demand order issued in favour of the dealers against a receipt from the importers serves as a suitable document to obtain the 25 percent deducted amount.

2.11 Credit

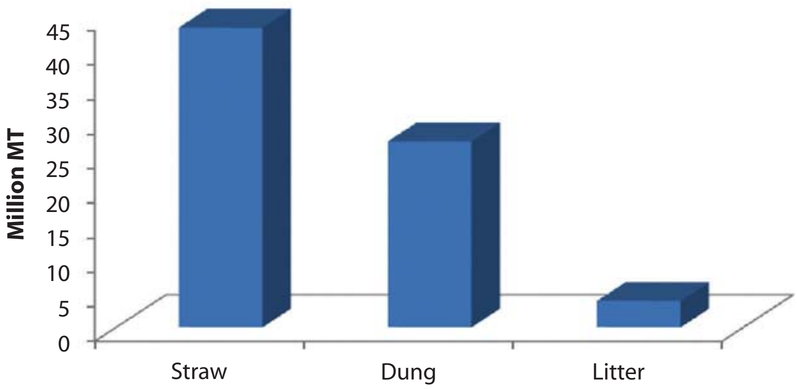
Government agencies do not give credit as such for fertilizers but subsidies are available. Credit facilities are offered by various non-governmental organizations (NGOs) for fertilizer, seed and agricultural equipment and for establishing agro-processing factories including small and medium enterprises (SMEs). There are hundreds of NGOs providing credit to small, marginal and landless people in both rural and urban areas. This is very popularly known as microcredit and is one of the success stories of modern economic and social development in Bangladesh. As of December 2002, microcredit institutions (MCIs) had disbursed more than Taka 500 billion, 60 percent of which was disbursed by only four organizations (i.e. Grameen Bank, BRAC, ASA and Proshika). But microcredit has its limitations: very high rates of interest of more than 30 percent, the mode of realization of money and no excess of extreme poor are to be reformed.

The government currently provides farmers with credit to meet irrigation costs. Marginal and small farmers (Category I) with a maximum one hectare of land are entitled Tk 800, while farmers with over one hectare are entitled to Tk 1 000. This help is much appreciated but the procedure for obtaining the money is tough for illiterate farmers. Sub Assistant Agriculture Officers (SAAOs) have been deployed to help poor, illiterate farmers. Unfortunately this has resulted in the SAAO being diverted from their main duty of providing production services to farmers.

2.12 Other nutrient resources

Rice straw is a valuable source of carbon, potassium, silicon and also a source of organic manure. It is also very cheap. However, the straw is primarily used as fodder and fuel. An estimate of national availability of straw, dung and litter is presented in Figure 4. The use of animal wastes/manure is also very limited, dung being used primarily as fuel. Farmers should be educated in how to conserve such organic waste and prepare their own manure. Despite the use of green manure in rice cultivation having been well demonstrated and validated by research organizations (Farid *et al*. 1994), is not widespread either. Recommendations are made for using poultry manure, cowdung, rice straw and green manure based on field trials and validated through on-farm trials at BARI and BRRI. The results are available in recognized journals. For example it has been shown in a 12-years study how rice straw could be properly utilized for soil health improvement without interfering with cropping time, particularly in an intensively rice cropped area (Farid, 1998b). In other studies the utilization of poultry manure and cowdung combined with mineral fertilizers showed sustainability of yield and fertility (Farid *et al*., 1998a). Compost and vermicompost have been commercially explored and accepted by entrepreneurs in Bangladesh, as reported by a study group sponsored by Katalyst (2009). Farmers are not generally aware of the benefits of organic matter and they are not all able to purchase organic fertilizer. However, some farmers are accustomed to using organic fertilizer for their fruit and vegetable gardens. Although a lot of research has been done by NARS and significant technologies have been developed, there has been no breakthrough in the commercialization of rhizobium, *azospirillum*, BGA or Azolla. BINA produces more than a tonne of rhizobium inoculum yearly on requisition and sells it for Tk 75 000 per tonne.

Figure 4: Yearly generation of agricultural waste (straw, dung and litter)



Source: *Author estimate using data from DLS and BBS*

A significant number of entrepreneurs is presently engaged in manufacturing and marketing compost and vermicompost in Bangladesh. Prices are given in Table 16. The compost retails at Tk 20 per kg, whereas the wholesale rate is Tk 16 per kg. Vermicompost costs the same.

However, vermi-compost is not always and everywhere available because of low production and a restricted licensing system.

Studies conducted in relation to plant nutrition management have shown that in many cropping systems an integrated nutrient supply and management system, through judicious use of organic and chemical fertilizers, would lead to sustainable crop production, as well as overall soil improvement. The Integrated Plant Nutrition System (IPNS) has been accepted as a policy measure by the Department of Agriculture (DOA). However, adoption at the field level is low.

Table 16: Prices of organic and biofertilizer

Items	Prices	
	Bangladesh (Tk/tonne)	US$/tonne*
Compost	16 000.00	228.57
Vermicompost	20 000.00	285.71
Rhizobium	75 000.00	1 071.43

Source: *Katalyst, 2009*
** US$1 = Bangladesh Taka 70*

2.13 Fertilizer quality control

The Fertilizer Management Act, in force since 1995, follows on from previous legislation dating from the pre-independence period, particularly since 1956. This Act controls fertilizer production, imports and prices at farmers' level. It also sets product specifications, takes care of nutrient availability through fertilizer and sets controls against adulteration and pollution by contaminants that may be present in fertilizers. The Act has been amended from time to time, most recently in 2009.

The Ministry of Agriculture is responsible for fertilizer quality control and is empowered to take any action necessary in this regard. Some of the measures it has taken are:

- making it obligatory for importers to furnish quality certificates prior to shipment;
- providing fertilizer sampling and analysis at point of import;
- establishing sampling and analysis at the production and blending sites; and
- carrying out random checks, sampling and analysis at various stages of marketing and distribution.

Standard specifications for various fertilizer products have been laid down. However, field level monitoring is inadequate due to lack of infrastructure, funds and manpower. Existing analytical facilities are given in Table 17.

Table 17: Fertilizer quality control facilities

Laboratory location		Capacity (Samples/annum)	Samples analysed (2007/08)
1	Central Laboratory Dhaka	500	1 210
2	Regional Laboratory Dhaka	600	764
3	Regional Laboratory Comilla	400	391
4	Regional Laboratory Rajshahi	700	1 020
5	Regional Laboratory Khulna	600	950
6	Fertilizer Quality Control Laboratory, Rangpur	500	628
7	Fertilizer Quality Control Laboratory, Chittagong	100	90
	Total	3 400	5 053

Source: *Katalyst, 2009*

Table 18 provides the number of fertilizer samples that were found substandard in 2008, an alarming 52 percent.

Table 18: No. of substandard/adulterated fertilizer samples (2008)

Name of fertilizer	No. of samples Analysed	No. of sub-standard/adulterated samples	
		Number 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
$ZnSO_4$	1 044	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	**5 053**	**2 628**	**52**

Source: *Katalyst, 2009*

2.14 Research and knowledge base

There are several institutions devoted to research on major crops. They need to continue their existing research focus on fertilizer use efficiency. Biofertilizers also need to be explored further.

The soil testing service needs to be rejuvenated. Recommendations based on soil testing for recently evolved varieties, especially maize and short duration rice have yet to be evolved through on-farm research.

Although there is a substantial extension force, its main function at present is the distribution of fertilizers and administration of subsidies. This leaves little time for extension and field activities to promote the scientific and integrated use of mineral, organic and bio-nutrient resources.

2.15 Environmental aspects

Fertilizer use has not reached such a level as to cause environmental pollution, particularly soil and water pollution. Scientists generally agree that:

- The quantity of fertilizer used per hectare in Bangladesh is still low compared to other countries.
- Seasonal rainfall is capable of flushing fertilizer residues away.
- Almost three-quarters of the country's land mass becomes inundated which helps reclamation of the soil.
- Cropping intensity is so high (200 percent) that the fertilizer used is insufficient even for the growing crops and nutrient replenishment.

However, some contamination by heavy metals such as cadmium, nickel, chromium, lead and arsenic may occur through the use of phosphate fertilizers. Arsenic contamination through irrigation of ground water has been reported which, on review, was found not to have reached a critical level.

Some recent reports of pesticide contamination were not borne out when vegetables and crops were tested for contamination.

Fertilizer contaminants may be present in organic, rock phosphate and phosphate fertilizers. In the interests of a safe environment contaminant control measures should be put in place. In fact to prevent pollution Bangladesh has a national standardization committee and set standards of possible polluting chemical elements in practice which with some modifications may well serve the purpose.

The maximum permissible levels of heavy metals in chemical and organic fertilizers are presented in the following tables.

Table 19: Maximum permissible levels of heavy metals in chemical fertilizer

Arsenic (As)	50 ppm
Chromium (Cr)	500 ppm
Cadmium (Cd)	10 ppm
Lead (Pb)	100 ppm
Mercury (Hg)	5 ppm
Nickel (Ni)	50 ppm

Source: *Fertilizer (Management) Act, 2008, MOA*

Table 20: Maximum permissible levels of heavy metals in organic fertilizer

Zinc (Zn)	0.1%
Copper (Cu)	0.05%
Arsenic (As)	20 ppm
Chromium (Cr)	50 ppm
Cadmium (Cd)	5 ppm
Lead (Pb)	30 ppm
Mercury (Hg)	0.1 ppm

Source: *Fertilizer (Management) Act, 2008, MOA*

2.16 Coordination and monitoring

Because fertilizer makes such an important contribution to high crop yields it is essential that it is properly managed. Its availability, use, price and quality are all important and require high-level management. To this end a committee should be set up by the government, composed of the following members:

(1) Additional Secretary, MOA (inputs), Convener

(2) Chairman, BCIC, Member

(3) Director (Field Service), DAE, Member

(4) Chairman, Bangladesh Fertilizer Association (BFA), Member

(5) One socio-economist with expertise in fertilizer demand projections, Member

(6) One senior agronomist with wide experience in crop production planning and management, Member; and

(7) Member-Director (NARM – BARC), Member Secretary.

The committee would consider but not necessarily be limited to the following issues (Z. Karim, 2008):

(i) review of domestic fertilizer production capacity and its potential;

(ii) growth of agriculture and fertilizer use over at least the last five years in Bangladesh and other countries in the region;

(iii) extent of changes in land use in Bangladesh and intensification of high value crops;

(iv) review of analytical data on soil nutrient content for different agro-ecological regions;

(v) review of the responses of major economic crops to fertilizer nutrients;

(vi) global scenario of fertilizer production, price, and marketing; and

(vii) the need for fertilizer use to grow eight percent annually.

The Ministry of Agriculture has set up two fertilizer monitoring committees, one to monitor the quality and quantity of imported fertilizers, the other to monitor organic fertilizers produced in-country. Despite the existence of these two committees, adulterated domestically produced fertilizer and substandard imported fertilizer are reportedly available in the market. Another serious problem reportedly faced by the country is the acute scarcity of fertilizer during the peak demand period (January–March). Such scarcity and the accompanying soaring prices constitute a serious problem for the farmers.

This situation shows the government in a bad light, arising as it most probably does from inadequate supervision and monitoring by the committees and a lack of coordination among the responsible persons, channels and agencies, both public and private.

3. Policy gaps and framework for a sustainable soil fertility and fertilizer management policy and strategy

To sustain a high-yield agricultural production programme, support for efficient soil fertility management and fertilizer use is absolutely essential. About 50 to 60 percent of the increase in cereal production in Bangladesh is attributable to fertilizer use. An occasional external review of existing national soil fertility and fertilizer management practices and policies is essential to identify gaps and propose recommendations for improvement.

The key areas requiring government support could be listed as:

- Measures for improving individual property rights for farmers. The tenure system must encourage farm improvement, e.g. through building up the long-term fertility of the soil;
- Implementing measures that will improve the terms of trade for agriculture, keeping output and input prices at a reasonable level so as to make crop production profitable;
- Development of an improved infrastructure, such as roads to facilitate not only the timely transportation and distribution of fertilizers but also of crop produce to the market;
- Development of irrigation resources to enhance crop productivity through higher crop response to the inputs applied, and exercising control on overuse so as not only to save water but also to avoid the problem of salinization;
- Encouraging and extending prudent banking services to rural areas and provision of adequate farmer credit through the financial agencies;
- Overall planning and provision of a suitable framework to promote the growth of a healthy and efficient fertilizer sector and private sector involvement;
- Providing institutional support for a realistic demand assessment and forecasting mechanism;
- Exploring the economic and technical feasibility, including exploration of indigenous raw materials, of attaining self sufficiency in fertilizer production;
- Making adequate provision for the requisite foreign exchange for importing fertilizers;
- Development of adequate ports and efficient port handling facilities;
- Development of an adequate and varied fertilizer transportation system;
- Development of an adequate and well distributed warehousing and retail network;
- Promotion of appropriate fertilizer distribution channels based on their strengths and weaknesses and relevance to the marketing situation and economic considerations;

- Interest charges, import duties and local taxes constitute a major part of the total marketing cost. Efforts to reduce overall marketing costs may provide benefits to the national economy, which outweigh the treasury's reduced income;
- Providing and enforcing an effective legal framework to protect the quality of inputs and thereby the interests of the farmers;
- Devising and formulating strategies which would lead to a self-sustaining agricultural production programme with little reliance on outside financial assistance like subsidies;
- Where subsidies are inevitable, they should be administered and monitored in such a way that they serve the national interest and objectives;
- Periodic review of governmental controls and regulations to prevent them from obstructing the development of the fertilizer sector and improve marketing efficiency;
- Providing institutional support for adequate soil and fertilizer testing facilities;
- Providing the necessary institutional and technological support for efficient soil fertility management and promoting efficient fertilizer use and an Integrated Plant Nutrition System (IPNS);
- Facilitating R&D activities relating to improvements in fertilizer use efficiency, including product development and resource-conserving eco-friendly agriculture;
- Devising a mechanism for regular monitoring of soil health;
- Establishing an effective technology transfer mechanism and maintaining its efficiency through regular capacity building programmes.

Keeping the above in view, and following on from the national workshop on Farm Level Fertilizer Management held on 19 February 2009, the present study was initiated by the FAO Regional Office for Asia and Pacific. Based on a quick review of the limited information and database available plus an analysis of prevailing policies and programmes, a policy framework for a sustainable soil fertility and fertilizer management is proposed.

3.1 Soil fertility and soil health

The arable land of Bangladesh is under intense pressure and faces multiple threats: of increasing population per unit of arable land; land degradation; intensive agricultural practices; and a wide range of environmental weaknesses. It grows 46 important economic crops throughout the year with an average cropping intensity of about 197 percent. Use is mainly decided by land type. High and medium-high lands constitute about 65 percent of the country's area, where the cropping intensity ranges from 300 to 400 percent.

The input-output balance sheet of nutrients in Bangladesh depicts a large net annual removal of nutrients from the soil, more than two million tonnes of nutrients per year. Soils are severely depleted of nutrients and organic matter because of intensive farming and non-return of organic residues. It is alarming that about 1.8 million, 0.4 million and 1 million ha of the land are severely deficient in phosphorus, potassium and sulphur, respectively. The organic matter content of 53% of arable lands is critically low (<1% of the organic matter).

In view of the above, the following are suggested:

- Achieving production targets through an undue increase in fertilizer use, without taking in to account soil health, would be harmful to agricultural sustainability and could in the long run cause irreversible, serious damage.
- While credible organic fertilizer manufacturing and sale should be encouraged, the mushrooming number of products not included in the Fertilizer Management Act should be banned.

- To promote the return of organic matter to the land while taking into account its multipurpose non-agricultural use by farmers, the following measures could be taken:
  - Promote biogas plants through provision of suitable incentives. To make household biogas projects successful, an increase would be needed in the number of cattle per household (a minimum of four or five head of cattle are required for a functional biogas unit).
  - Promote conservation agriculture/resource-conserving technologies/minimum tillage in suitable areas. Promoting the power tiller operated seeders would be a step forward as in addition to other advantages, it incorporates the rice stubble into the soil (minimizing the likelihood of the stubble being removed from the fields).
  - Encourage the growth of short duration fodder crops, thus sparing the straw for making compost.
  - Provide easier access to cooking gas in the village so that animal manure, crop residues and waste and cereal stubble left after harvest can be saved from burning.
  - Promote household production of quality compost by the farmers.
  - Encourage farmers to grow short duration legumes (grain and green manure crops) within the cropping system through technical advice, provision of seeds and suitable inoculants, price incentives for grains plus incentives for incorporating vegetative matter into the soil.
- Arrest soil mining through the balanced use of fertilizers and promote Integrated Nutrient Management based on cropping/farming systems. Essential to achieve this would be: focused research on identifying potential micro-organisms for legumes and cereals; their quality production by NARS laboratories in the beginning, followed by production by interested entrepreneurs; distribution, quality control and farmers' education.
- Urgent coordinated action needs to be taken to arrest emerging salinity problems in the southern districts. This would involve soil management including amelioration, suitable varietal identification/breeding and appropriate fertilizer use.

3.2 Fertilizer use

Although the growth in fertilizer use and crop production has been quite remarkable, it is uneven, due to policy changes under different political regimes. The majority (about 60 percent) of N, mainly urea, is used on the Boro crop. Urea is the cheapest fertilizer and its application has an immediate greening effect on the crops. The farmers therefore tend to use it in the first instance, sometimes to excess.

The comparatively low use of P and K is leading to nutrient mining and imbalance. The preferred use ratio for N, P_2O_5 and K_2O is 4:2:1, contrasting with an actual ratio in 2007–08 of 7.8:1.3:1. In 2008–09 the ratio further deteriorated to 23.7:1.6:1. That was an unusual year, however, as the price of P and K fertilizers on the international market was very high. Of more interest is the N: P_2O_5 ratio which was about 5.9:1 in 2007–08 against a preferred ratio of 2:1. Secondary and micronutrient deficiencies are also fast increasing. Guidance from NARS is available (although there is a need for updated soil fertility maps and site-specific recommendations based on cropping systems and AEZ) but the right technologies are not being transferred to the farmers by the extension staffs who are preoccupied with fertilizer marketing, distribution and control.

Consequently, fertilizer use efficiency, especially nitrogen, is very low (reported to be about 27 percent). A concerted effort to rectify this situation through the following policy changes is urgently called for:

- Increasing the use of urea super granules (USG) – *guti* urea – would be a step forward. The deep placement of the granules offers better control of application rates than spraying. It also increases efficiency by about 30 percent, thus saving in urea, which in turn saves on subsidies and reduces environmental pollution. However, the labour required for its application and the drudgery involved stand in the way of its wider use. An all out effort to come up with a suitable applicator is urgently needed.

- Promoting the extensive use of properly calibrated leaf colour chart (LCC) for top dressing with N is desirable. Making the charts available to the farmers and training them in their proper use would be required.
- To ensure balanced application, more DAP and NPK/NPKS complex fertilizers should be promoted by making them available in the market at an attractive parity price. This could be achieved by increasing subsidy to P and K while decreasing it to urea. Although mixed fertilizers ensure balanced application, they also add to farm gate costs and are vulnerable to adulteration. They should be slowly phased out as DAP and the complexes find market. If consumption figures and demand forecasts were reported in terms of N, P_2O_5 and K_2O in addition to the current practice of reporting in material terms only it would raise awareness of balanced use.
- To achieve a balance between soil productivity, crop production and nutrient use, NARS should conduct long-term trials in important AEZs and provide the resultant technical and policy advice to MOA through BARC (Bangladesh Agriculture Research Council).

3.3 Fertilizer availability and demand assessment

- To provide food security, adequate and timely availability of fertilizers to the farmers must be ensured through effective policy support. Demand assessment is important in this respect. Medium- and long-term demand assessments are helpful for perspective planning, while short-term assessments estimate the immediate requirement.
- A realistic assessment of demand is necessary. Overestimates result in high inventory overheads and deterioration in fertilizer quality because of prolonged storage, besides reducing liquidity. Underestimates lead to shortages, rises in the farmers' costs and lower agricultural production.
- An effective mechanism for short-term assessments of demand exists at union level in Bangladesh. Extension officers calculate fertilizer requirements on the basis of area under different crops and the average doses of fertilizer recommended for them. Demand figures based on the work of field level officers are aggregated and forwarded to the centre. After discussion, refinement, assessment of the demand/supply position and decisions on imports and the fertilizer is finally allocated to the District/Upazilla/Union, and its use monitored. It is worth noting that demand estimates have always been higher than actual use. It is not clear whether there is a lack of precision in demand estimate or the required quantities were not supplied.
- Sometimes, annual projections grossly underestimate the requirement of urea for some districts and overestimate it for others. The latter problem may arise because formerly cultivated areas in a particular district have been converted to other use, requiring very little fertilizer. In a situation like this, a prompt decision is required to reallocate the fertilizer to areas of high demand.
- Medium term (five-year) demand estimates for the country are presently unavailable. However, a Guideline on various approaches/methodologies used for such forecasting has recently been prepared by FAO, RAP (2010) and may provide a suitable methodology for Bangladesh. FAO should be able to provide assistance in this regard, including training for national staff. The medium-term demand estimate should be done on a rolling plan basis with an annual review/adjustment by experts representing different disciplines and taking into account current and expected developments.
- The government should consider maintaining a buffer stock of about 30 percent of annual requirements, with a provision for rolling the stock to avoid long-term storage and deterioration in quality. This would avoid sudden shortages from unforeseen reasons such as international price hikes, inadequate imports or failure in domestic production.

3.4 Fertilizer production and import

- In 2009–10 the Bangladesh Chemical Industries Corporation (BCIC) is expected to produce 1.5 million tonnes of urea, 50 000 tonnes of TSP and 100 000 tonnes of DAP. The estimated demand is for 2.95 million, 670 000 and 263 000 tonnes, respectively. The balance (to be adjusted after taking the inventory into account) of about 1.45 million tonnes of urea, 620 000 tonnes of TSP and 163 000 tonnes of DAP will have to be imported. The urea will be imported by BCIC except for 450 000 tonnes purchased from KAFCO; BADC will import 200 000 tonnes of TSP, while the balance of TSP and all the DAP will be imported by the private sector. The entire 497 000 tonnes of MOP required will have to be imported, 150 000 tonnes by BADC and the balance by the private sector.
- There are six factories with an installed production capacity of 2.32 million tonnes of urea. However, their highest production, 2.2 million tonnes, was achieved in 2004–05. Production has now fallen to 1.5 million tonnes. The current production of DAP is only 100 000 tonnes against an installed capacity of 528 000 tonnes, and TSP production is 50 000 tonnes against an installed capacity of 100 000 tonnes. It is clear that many of the factories are rather old and in need of modernization.

To meet the growing requirement for fertilizers, serious consideration should be given to undertaking the following:

- a review of under-performing units, with modernization or removal of bottlenecks, as required;
- review of BCIC's human resources as it looks as though there are shortages of senior-level professional staff and skilled labour;
- assuring adequate gas supply to the factories for uninterrupted production;
- installing two more factories, with the most advanced technologies, in the north and west of the country, each with the capacity to produce 500 000 tonnes of urea. It is heartening to note that some negotiations are underway with China in this regard. In the meantime, the most advanced technologies should be adopted;
- exploring joint venture opportunities, especially for producing phosphoric acid and finished DAP and TSP products;
- creating facilities for production of one or two of the most popular NPK/NPKS complex fertilizer grades;
- large-scale production by BCIC of *guti* urea, provided the applicator issue is resolved;
- turning under-performing plants over to the private sector.

The development of indigenous fertilizer production is constrained by a lack of suitable raw materials, the only available resource being limited supplies of natural gas. The government should ensure that comprehensive surveys are carried out to identify new sources of gas and rock phosphate and sulphur through extraction from petroleum, etc. These should be regularly reviewed in the light of new technical developments.

3.5 Transport and warehousing

- The system is working well and apparently there is no shortage of storage facilities. However, if a buffer stock is to be maintained and provision made for the mid-term demand assessment, additional storage facilities would be required.
- Fertilizer is already transported via inland waterways, but efforts should be made to move a higher volume this way. The possibility of using rail transport needs to be explored. In order to develop

an effective, economic and feasible transportation model for fertilizer, a national level logistical exercise, taking all the major modes of transportation modes into account, should be carried out. Such an effort would help contain transport cost and eventually reduce farmgate prices.

3.6 Fertilizer marketing, distribution and monitoring

- Various mechanisms – full government control, liberalization of the market and a mixture of both – have been tried with varying success. At present full government control (mainly because of the subsidy component) is working successfully. However it may not be sustainable in the long term owing to the heavy burden it places on the limited capacities of the government, unhealthy or distorted private sector development, and the diversion of the extension service from its core advisory services to the farmers.
- Although there is a Fertilizer Management Act, quality control has been ineffective. The government should take the key role of monitoring fertilizer distribution rather than being directly involved in the process (unless temporary direct control is warranted because of an unforeseen situation). Rigorous monitoring, with full powers to punish defaulters, would ensure that quality products are delivered to the farmers. Establishment of a central quality control laboratory under the proposed National Fertilizer Commission would be needed.
- During the peak season, it would be a good idea to earmarking barges in the ports to offload imported fertilizer quickly.
- It is unfortunate that no strong private organization has developed in Bangladesh to analyse fertilizer demand and supply properly, and provide analytical information on fertilizer management and marketing. The Bangladesh Fertilizer Association (BFA) is the only agency doing some rudimentary work. It is strongly recommended that the professional capacity of BFA is strengthened in order to provide the field-level information required for quick decision-making by the government. BFA should have the following mandatory functions:

  – fostering a strong network of dealers and the distributors;
  – conducting regular training programmes for farmers, dealers and other stakeholders on important topics relating to changes in the fertilizer management system;
  – have a forecasting and advisory role to the government, enabling it to make quick decisions;
  – occasionally support study on emerging issues such as subsidy, distribution, demand/supply, price analysis, etc.
  – The government should review the urea fertilizer distribution system and consider what roles could be played by BADC and the private sector.

3.7 Fertilizer subsidy

- Subsidy plays an important role in maintaining price parity with neighbouring countries, and assisting resource-poor farmers to increase food production to attain self-sufficiency.
- A critical evaluation of the Value/Cost ratio and profitability of fertilizer use is warranted. This would help to decide on the levels of subsidy required to keep crop production profitable and use of inputs affordable for small and marginal farmers.
- There may be a need to develop a better methodology for ensuring subsidy is well managed and malpractice avoided.
- Subsidy should be targeted towards encouraging the balanced use of nutrients, i.e. gradually increasing the price of urea and using the savings generated to reduce the price of P and K fertilizers.

- The current procedure for obtaining reimbursement of the fertilizer subsidy is fairly complicated and time-consuming. It needs to be made quicker and simpler.
- If the subsidy is phased out, small and marginal farmers should be empowered by forming farmers' groups. Such groups could be provided with the capital required to purchase inputs through a revolving fund mechanism. This would also address the problem of obtaining credit at a reasonable interest rate.

3.8 Fertilizer sector management

- Fertilizer is a crucial input for attaining Bangladesh's food security goal. Various ministries (Agriculture, Industries, Finance and Environment) are involved in its production, importation, distribution, promotion and use. An integrated approach is called for in planning and monitoring various aspects of this sector. However, current experience shows that it is extremely difficult to obtain a full range of information on the sector in one place. To accord due importance to this pivotal sector, the creation of a high-powered independent, permanent body, which could be named the National Fertilizer Commission, under the MoA (Ministry of Agriculture) is recommended. The head of the commission should be a technocrat with in-depth knowledge of the soil fertility and fertilizer sector.
- The Commissioner should be the Member Secretary of the National Fertilizer Coordination Committee.
- The main objective of the commission should be to advise the government on fertilizer and soil fertility management policies. Some of the salient areas on which the Commission should focus are:
  - short-, medium- and long-term fertilizer demand assessments;
  - import procedures, tendering and handling at port;
  - keeping track of international fertilizer markets and prices;
  - coordinating import and foreign exchange requests for imports;
  - monitoring national fertilizer production;
  - registering importers, manufacturers and dealers;
  - market development;
  - undertaking studies on fertilizer demand, supply and price trends, marketing costs and margins, and logistics;
  - quality control regulations and enforcement;
  - studies relating to the impact of fertilizer use on productivity, and identifying problems faced by farmers;
  - measures to promote Integrated Plant Nutrition Systems (IPNS) to improve crop response and the efficiency of fertilizer use in order to maximize returns and farm income, and maintain sustainable soil health and productivity;
  - compilation and analysis of statistics on various aspects of fertilizers and soil fertility management.

References

BARI. 2008–09. *Annual Research Report*. Gazipur, Bangladesh, Agricultural Economics Division, BARI

BBS. 2006. *Bangladesh Economic Review*. Bangladesh Bureau of Statistics, (HIES), DAE and Food

Bangladesh Bureau of Statistics, 2009 *Bangladesh Economic Review*

Bangladesh Bureau of Statistics, 2006 *Bangladesh Economic Review*

Bangladesh Bureau of Statistics, 2007 *Bangladesh Economic Review*

Department of Agricultural Marketing (DAM), 2009 Annual Report

Farid, A.T.M., M.A. Mazid Miah & Z. Karim. 1998b. Innovative residue management in a typical rice soil of Bangladesh. *Thai J. Agril. Sci*. 31(3): 360–368

Farid, A.T.M., M. Rahman, K.H. Talukder, M. Shahidullah & M.S. Islam. 1998a. Efficiency of poultry manure and cowdung alone and in combination with mineral fertilizers on the yield of cabbage. *Bangladesh J. Agril. Res*. 23(1): 157–165

Farid, A.T.M., J.U. Ahmed, M.N. Anwar & M.S. Islam. 1994. Integrated fertilizer management in rice-wheat cropping system. *Bangladesh J. Agril. Res*. 19(1): 60–65

Fertilizer (Management) Act, 2008, MOA

Karim, Z. 2008. *Current farm level situation and agricultural productivity in Bangladesh*

Karim, Z. 2009. *Climate change impacts on Bangladesh agriculture and food security*. Dhaka, Ministry of Agriculture (MOA)

Fertilizer Recommendation Guide. 2005

Nepal

by

R.V. Misra

1. Background

Nepal is located between latitudes 26°22' N to 30°27' N and longitudes 80°4' E to 88°12' E in the Himalaya range. It borders China in the north and India in the east, west and south. Nepal is a landlocked country covering an area of 147 181 sq km.

Agriculture remains Nepal's principal economic activity, employing around 66 percent of the population, although only about 17 percent of Nepal's total land area is suitable for agriculture. The agriculture sector alone contributes 38.81 percent to the national GDP. Nepal's population of 28 million is growing at 2 percent per year, and the ratio of population to arable land is one of the highest in the world.

Diverse climatic belts, ranging from humid subtropical in the plains to alpine in the north, are encountered. Annual rainfall varies from about 250 mm in rain-shadow areas such as the Mustang valley to over 5 200 mm in Pokhara. Over 80 percent of the annual rainfall occurs from June to September. In summer, the maximum temperature in the Terai is more than 40°C while it is about 28°C in the Hills. Western Nepal receives less rainfall than the eastern side and the monsoon rains tend to start later and retreat earlier. Some winter rains are also received in the western part of the country.

The country is subdivided into three major ecological regions. Twenty-three percent is occupied by the *Terai* plains in the southern belt, 42 percent by the hills in the middle belt and the remaining 35 percent by mountains in the northern belt. These regions have distinct geological, soil, climatic and hydrological characteristics. As a result, land use patterns within these zones are distinctly different (FAO/GIEWS, 2007).

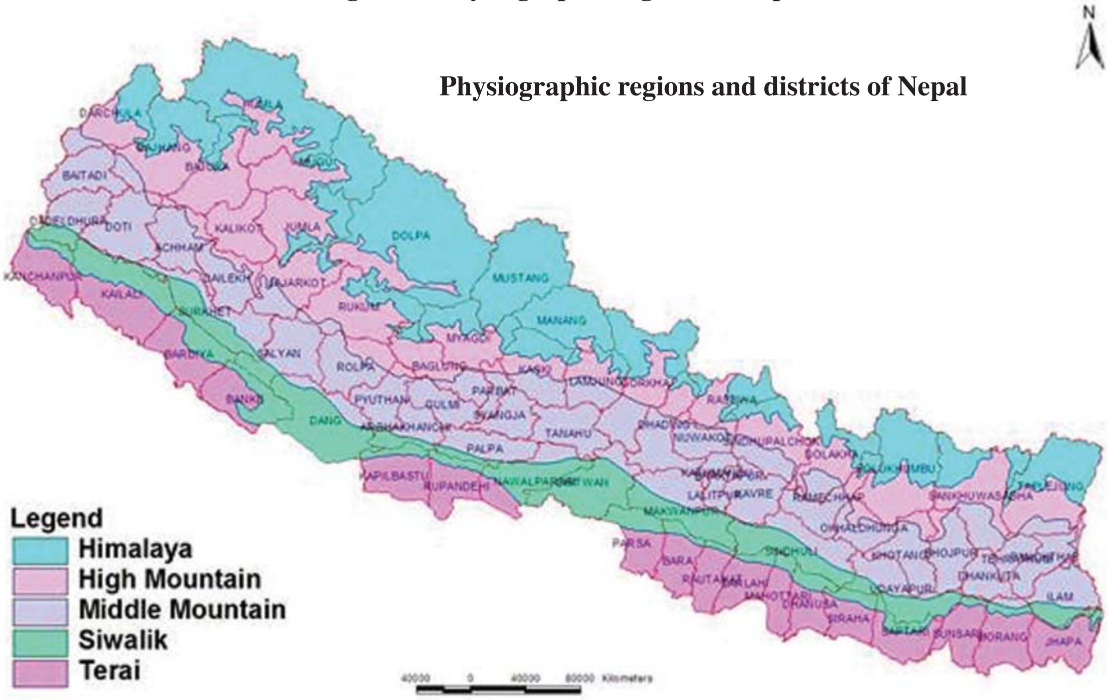
The Terai consists of flat and fertile alluvial land with a tropical and subtropical climate that extends from the Indo-Gangetic plains. This region represents 17 percent of the total land area of Nepal, but accounts for about 46 percent of the gross cultivated area. The Outer Terai ends at the first range of foothills called the Siwaliks. Since most of the Terai can be irrigated and crops can be cultivated all year round, it has greater potential for productivity growth than the other regions. Water resources, fertility and flat terrain permit the cultivation of a variety of crops such as paddy, wheat, maize, legumes, sugarcane, jute and vegetables.

The hill region is located between the mountain and Terai regions and includes the middle mountain ranges and Siwalik Hills. The hill region is located between an altitude of 700 and 4 000 m, with steeply sloped lands and many small valleys. Only 10 percent of the land area is cultivated. The climatic conditions in this region vary from subtropical to temperate. The region has the largest share of the land area at 68 percent. Terraced farms grow a variety of crops including rice, wheat, maize, fruits and vegetables. Rice – wheat/barley and maize – millet/legumes are the main cropping patterns. The region has good cultivation potential for fruits and vegetables.

The mountains lie in the north and include the Himalaya and the high mountainous areas of the country. The region consists of large number of snow-covered areas and is mostly steep, rugged and cold. Because of its geography and cold climatic conditions it is sparsely populated. It has a 15 percent share of land area, only 2 percent of which is suitable for cultivation. Livestock rearing is the main occupation. Subsistence cultivation is practised. Vegetables are cultivated as cash crops in a few areas.

Administratively Nepal is divided into 75 districts (Figure 1).

Figure 1: Physiographic regions of Nepal



Food security situation

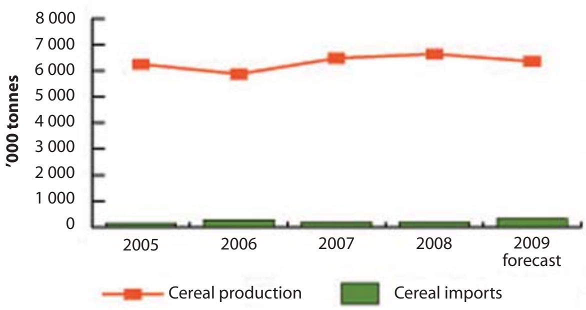
Farm income is still a dominant source for the rural population, especially households living in the Mountains and households in lower income groups. Nepal is a food-deficit country despite agriculture being the primary contributor to economic growth. Population growth has led to fragmented land holdings and depletion of forest products upon which much of the rural population depends for its livelihood.

Increasing food, fuel and input prices in 2008 worsened the country's already precarious food security situation, while a severe winter drought in 2009 led to a significant shortfall of wheat and barley production (FAO/GIEWS, 2009). Following the steep wheat crop losses, the current food security situation in many part of the country has deteriorated sharply in comparison with last year (see Figure 2).

Figure 2: Cereal production and imports – Nepal

Cereal production	2004–2008 average	2008	2008 forecast	change 2009/ 2008
	'000 tonnes			percent
Rice (milled)	2 772	2 986	2 772	-7.2%
Maize	1 770	1 932	1 931	-0.1%
Wheat	1 418	1 409	1 344	-4.6%
Other	317	323	316	-2.2%
Total Cereals	6 278	6 650	6 363	-4.3%

Source: *FAO/GIEWS Country Cereal Balance Sheets*



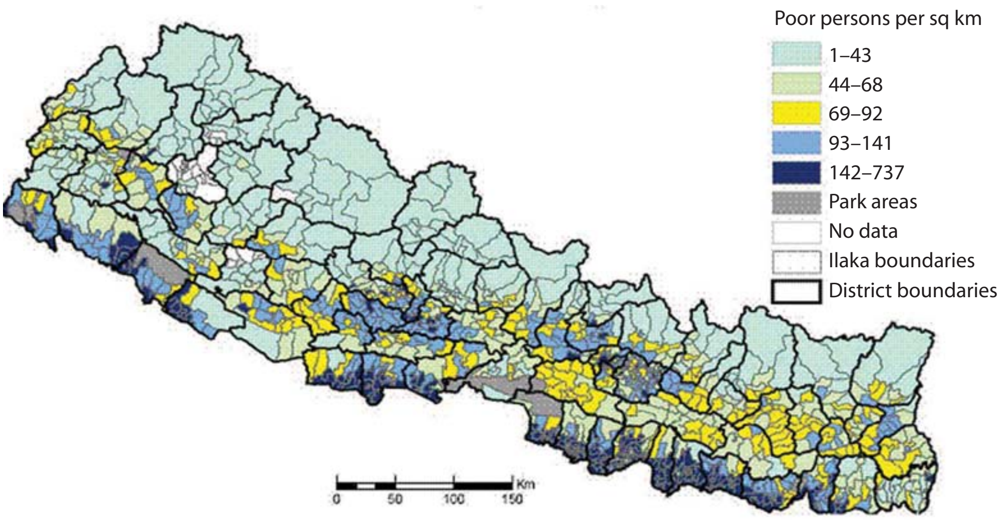
The average net per capita daily availability of aggregate food items is 1 377 g, the composition of which supplies 3 053 kcal energy, 111 g protein and 56 g fat. It also shows that cereals alone contribute 68 percent of the total calorie, 47 percent of total protein and 19 percent of total fat supply. Cereals together with potato and pulses supply more than 78 percent of the calories and 56 percent protein of the Nepalese diet.

The livestock and fishery sector (milk, meat, eggs and fish) contribute 37 percent of total fat but only 7 percent of total calories and 10 percent of total protein supplies. The contribution of fruits, vegetables and other items is small. However, their roles in terms of vitamins and mineral supplies cannot be undermined.

Analysis of the food production and requirement statistics shows that the mid- and far-western hill and mountain regions of the country are food deficit even in a normal production year, while the *Terai* region is a net food-surplus area.

Eight million Nepalese live in poverty and 40 percent of the population is undernourished (see Figure 3). Child malnutrition rates rank among the highest in the world, with nearly one out of two children suffering stunted growth. Thirty-seven percent of the rural population is living below the poverty line. The proportion of population below the poverty line is much higher in the mountains (42.5 percent) among three ecological zones (36.6 percent in hills and 29.5 percent in Terai) and in the far-west (45.6 percent) and mid-west (46.5 percent) among the five development regions.

Figure 3: Poverty density – Nepal



Source: *Special Report, FAO/WFP Food Security Assessment Mission to Nepal, 25 July 2007*

Agriculture in Nepal

Agriculture is one of the major contributors to the national economy. As well as food and income, it provides employment for two-thirds of the population. Growth in agriculture is, therefore, crucial. The sector's current share of national GDP is declining, although there is considerable scope for increasing productivity. About 80 percent of the total population resides in rural areas and pursues agricultural activities.

Among cereals, rice is the most important crop contributing to half of total cereal production (see Table 1.1). Over 70 percent of rice is grown in the Terai. Rice production has stagnated over the past several years. Average yield is in the order of 2.8 tonnes/ha (see Figure 4). Late monsoon rains led to a reduction in 2009 rice cultivation.

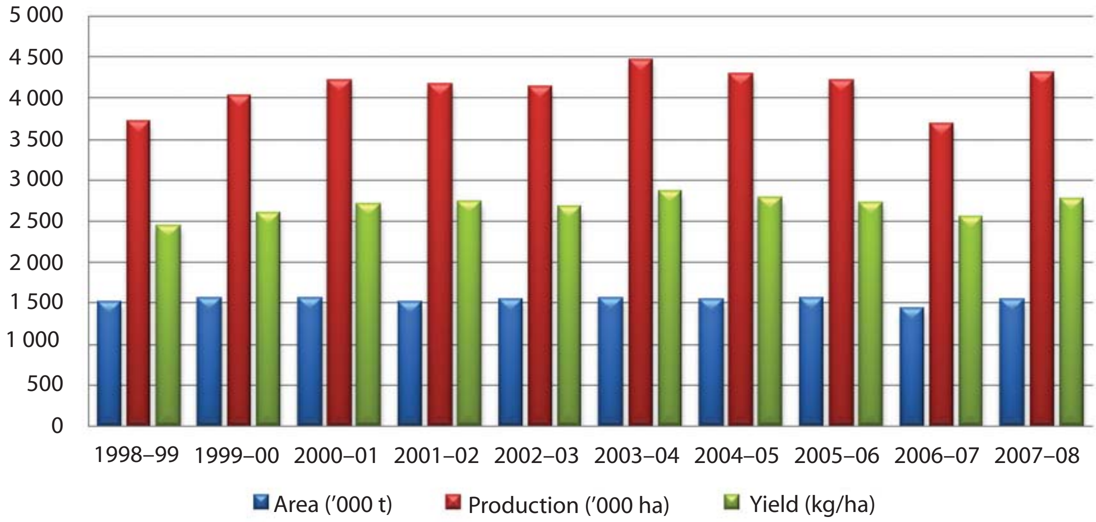
Maize is the second most important cereal, contributing 25 percent of total cereal production. Maize covers nearly 80 percent of the hill area. It is mostly grown under rainfed conditions and on marginal land with little use of fertilizers. Maize is commonly grown with millet. Other important maize-based cropping systems involve soybeans, legumes, radish, potatoes and upland rice. Most of the yield increase is due to

Table 1.1: Foodgrain production trends – Nepal

Year	Area ('000 ha)	Production ('000 tonnes)	Yield (kg/ha)
1994–95	2 990.2	5 426.1	1 815
1995–96	3 241.5	6 246.6	1 927
1996–97	3 267.3	6 425.6	1 967
1997–98	3 243.5	6 360.8	1 961
1998–99	3 253.1	6 465.3	1 987
1999–00	3 321.7	6 985.3	2 103
2000–01	3 313.7	7 171.8	2 164
2001–02	3 295.9	7 246.9	2 199
2002–03	3 336.5	7 360.4	2 206
2003–04	3 344.4	7 747.1	2 316
2004–05	3 352.7	7 767.5	2 317
2005–06	3 360.3	7 656.5	2 279
2006–07	3 304.3	7 329.0	2 218
2007–08	3 417.5	8 069.1	2 361

Source: *FAO, 2009*

Figure 4: Area, production and yield of rice – Nepal



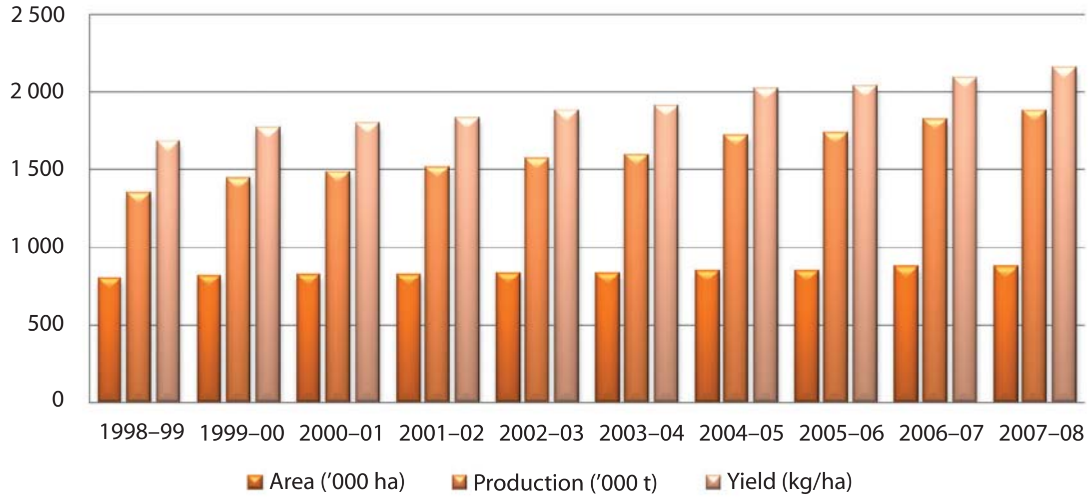
Source: *FAO, 2009*

adoption of hybrid varieties. Yield levels remain relatively low at 2.2 tonnes/ha (see Figure 5). Maize production for 2009 was expected to be about 1.4 million tonnes.

Wheat is the third most important cereal. Over 60 percent of wheat is produced in the Terai. The growth of wheat production has been slow. Average yields remain at 2.2 tonnes/ha (see Figure 6). Wheat production from the main winter crop in 2009 was estimated at 1.34 million tonnes, a decrease of about 14.5 percent from the preceding because of a severe drought. The districts with the most reduction in harvest were those in far- and mid-western hills and mountains, where wheat is the first or second most important crop and losses were estimated at 50 percent or higher.

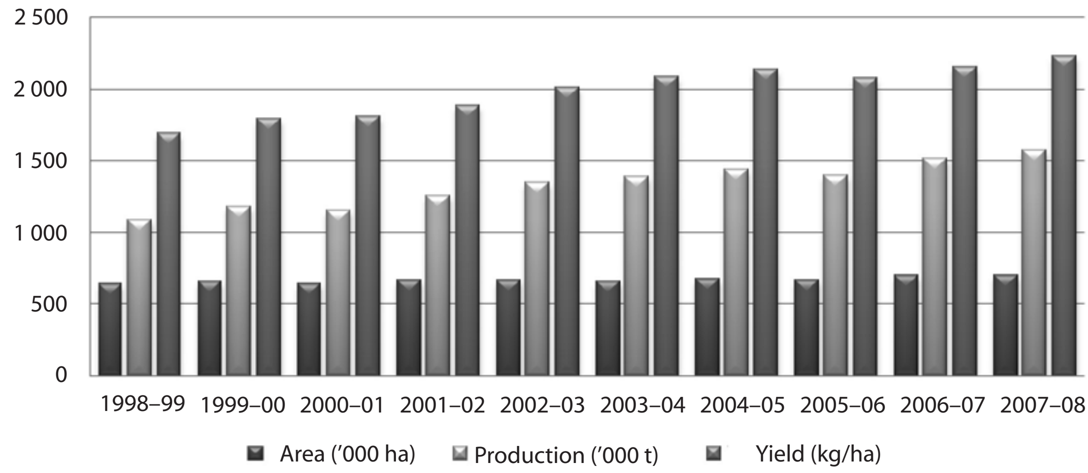
In recent years, the coverage by HYV wheat, rice and maize has increased. However, irrigation coverage has remained stagnant. There is a highly positive correlation between irrigation coverage, cropping intensity, use of HYV and fertilizer use. The synergetic effect of these factors has contributed towards increased crop yields for the major crops.

Figure 5: Area, production and yield of maize – Nepal



Source: *FAO, 2009*

Figure 6: Area, production and yield of wheat – Nepal



Source: *FAO, 2009*

Millet is a minor cereal. It is usually planted with minimal inputs, and is mostly grown on marginal lands. Production growth has virtually stagnated in the past several years. Barley is another marginal cereal crop. Most barley production takes place in the mountains. The 2009 barley harvest was estimated at 23 000 tonnes, 17.3 percent below the preceding year.

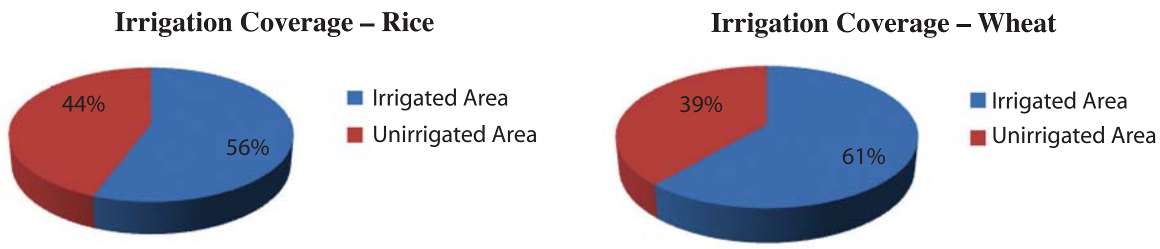
Pulses are mostly grown under rainfed conditions. Lentil is an important pulse crop in the western part of the country. Soybean accounts for about 7 percent of the area and 7 percent of the production of legumes, with the hills accounting for 80 percent of area and production. The growth rate of production of pulses and oilseeds in recent years has been very low.

Oilseed crops such as rapeseed, mustard, *toria*, groundnut, sesame and sunflower have good potential particularly in western region. Oilseed yields have been very low, at about 740 kg/ha.

There is a wide yield gap between farmers' fields and research stations and attainable yields. Nutrient mining, soil erosion and increasing cropping intensities without adequate fertilizer are major reasons for lower crop yields.

Irrigation is recognized, next to fertilizer, as an important factor in contributing to increased crop production. However, irrigation coverage has stagnated at around 24 percent of the total cropped area for the past several years. Irrigation coverage for the major crops – rice and wheat is 56 and 61 percent, respectively (see Figure 7).

Figure 7: Irrigation coverage of rice and wheat



Source: *FAO, 2009*

The choice of crops and cropping intensity is dependent to a large extent on the availability of irrigation water. In the irrigated areas of the Terai, as many as three rice crops can be grown in a year. In the hills, with irrigation support, two crops of rice can be cultivated. The lands/terraces located on the lower hill slopes in the vicinity of rivers are usually irrigated. In these areas, rice is the major crop in summer followed by wheat in winter. On the rainfed upland tracts, maize is the major crop.

Analysis of production trends for various crops (see Tables 1.1 and 1.2) indicates a good increase in the production of wheat, maize and potato, while the production of rice, pulses, oilseeds and others has remained more or less stagnant.

Table 1.2: Production of major crops ('000 tonnes)

Year	Crops						
	Wheat	Rice	Maize	Pulses	Oilseeds	Sugarcane	Potato
2000–01	1 157.9	4 216.5	1 484.1	243.2	132.3	2 211.8	1 313.7
2001–02	1 258.0	4 164.7	1 510.8	250.4	134.9	2 247.9	1 472.8
2002–03	1 344.2	4 132.5	1 569.1	256.9	124.9	2 343.0	1 531.3
2003–04	1 387.2	4 455.7	1 590.1	265.4	132.9	2 305.3	1 643.4
2004–05	1 442.4	4 289.8	1 716.0	271.3	141.9	2 376.1	1 738.8
2005–06	1 394.1	4 209.3	1 734.4	267.5	139.3	2 462.6	1 974.8
2006–07	1 515.1	3 680.8	1 819.9	274.4	135.7	2 599.8	1 943.2
2007–08	1 572.1	4 299.2	1 878.6	269.8	134.2	2 485.4	2 054.8

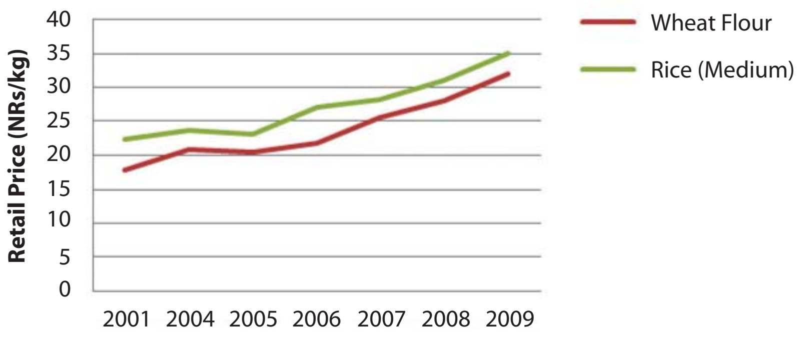
Source: *Ministry of Agriculture and Cooperatives*

Impact of soaring food prices

The recent past has witnessed considerable increase in foodgrain prices. Figure 8 gives the retail prices of foodgrains for the past few years. Prices of wheat flour have increased by more than 80 percent during this period and of rice, by 57 percent.

The rise in foodgrain prices however improves farmers' incomes and motivates them to invest more in agriculture; it adversely affects rural landless and urban poor, compelling them to expend more on food items at the cost of family health, education and other livelihood expenses.

Figure 8: Wheat and rice prices in recent years



Source: *FAO/GIEWS, 2009*

Soaring food and commodity costs saw the vulnerability of the poor to food insecurity skyrocket in 2008. The number of people in need of food assistance increased by 1.4 million to 2.7 million over the course of a year and there was a sharp rise in the incidence of poverty. This severely affected farmers' ability to afford livelihood inputs or to buy produce to supplement food needs. International food prices have fallen from their 2008 peaks, but are higher than they were in 2006 and likely to remain volatile.

Food staple prices have declined, but remain high in comparison to the pre-2008 food-crises levels. The retail price of rice in Kathmandu was 34 rupees/kg in August 2009, 15 percent below the peak in August 2008, but still 28 percent higher than in August 2007. The retail price of wheat flour in Kathmandu was reported to be 27 rupees/kg in August 2009, 23 percent below that in August 2008, but 12.5 percent above that in August 2007 (FAO/GIEWS, 2009).

Food prices remain extremely high in the drought-affected remote Hill regions in the winter. In the districts most affected by a reduced food production in 2008 and 2009, households are expected to have insufficient purchasing power to procure food or to have inadequate access to food, because of the relatively high transportation costs and poorly integrated markets.

Efforts now need to focus on building farmers' resilience to future shocks and improving food security over the long term. Smallholder farmers, many of whom are unable to afford quality seeds and fertilizers, need to be assisted through effective policies and strategies to help them attain higher crop yields to feed their families and improve their incomes.

Uncertainties in crop production and lack of safety nets

Agriculture in Nepal is vulnerable to several types of natural disasters, including droughts, floods, hailstorms, landslides and windstorms. Droughts, floods, hailstorms and landslides are by far the most serious recurring natural disasters and cause significant losses annually.

The middle hills are mainly prone to landslides and hailstorms while the Terai region is prone to floods and fire. Windstorms and heavy snowfall also affect many areas of the country on a regular basis, causing damage to standing crops.

In 2008, severe flooding in the eastern and western regions affected more than 250 000 people. On 18 August, the Koshi River burst its eastern embankment, inundating large areas. Heavy rains in September spread flood damage to the mid- and far-western regions.[3]

There are at present no systems and infrastructure facilities to provide adequate safety nets for such situations.

[3] FAO/GIEWS, 2009

Smallholders and food production

The agricultural sector in Nepal consists mostly of marginal and subsistence farmers. Table 1.3 presents the distribution of land holding categories in sizes, number and extent. The size of holdings and their extent determines the ease and scope for application of modern agricultural inputs and technologies including fertilizer, irrigation and mechanization. In Nepal, around 8 percent of total holdings categorized as large (2 ha and above) cover 31 percent of total cultivated land area. The remaining 92 percent of land holdings are either subsistence-level (45 percent), ranging between >0.5 and <2.0 ha, or marginal (47 percent), having less than 0.5 ha land (see Table 1.3).

Table 1.3: Holdings – number and extent

Size of holdings	Area		Holdings Number	
	('000 ha)	percent	('000)	percent
Total holdings (2001/02)	2 654.0	100.0	3 364.1	100.0
Marginal holdings (<0.5 ha)	390.9	14.7	1 578.9	46.9
Subsistence farmer holdings (>0.5 – <2.0 ha)	1 434.0	54.0	1 504.3	44.7
Large holdings (2 ha & above)	830.2	31.3	254.2	7.6

Source: *CBS Pocket Book, Nepal 2006*

While farmers with large holdings are better able to access modern technology and inputs, subsistence and marginal farmers need more support to gain access to fertilizers, other inputs and modern technology for increasing crop productivity. The fixed-term contract discourages tenant farmers from long-term investment to improve land productivity.

Fertilizer and soil fertility management and food production

The Agriculture Perspective Plan (APP 1995–2015) of Nepal considers availability of fertilizers key to the success of the agricultural production programme. Soil fertility is an important factor in Nepalese agriculture. However, most agricultural soils in Nepal have a poor plant nutrient status.

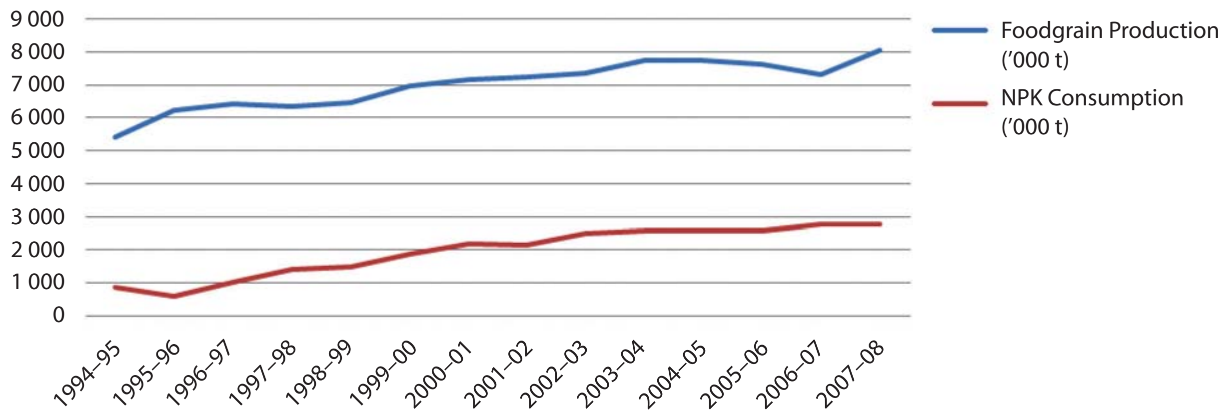
The Terai is the major agricultural zone for food crop production. Due to intensive cropping the zone is showing signs of nutrient depletion with soil micronutrient deficiencies being increasingly observed. Use of organic manures is on the decline especially in the Terai because of an increased inclination towards mechanized farming. The hill and mountain soils are prone to erosion and therefore poor in soil fertility. Besides, the hills and mountains receive only a small fraction of the fertilizers available for Nepalese agriculture. As a result, crop productivity is lower in these regions.

Informal imports of fertilizers through the porous Indo-Nepalese border form a substantial part of total consumption. However, there is a lack of reliable statistics concerning these imports so only rough estimates of consumption can be provided. A positive relationship between estimated fertilizer consumption and foodgrain production is shown in Figure 9.

Role of sustainable fertilizer and soil fertility management strategies in crop production and increasing food security

To maintain the same level of per capita agricultural production, or to improve it, total agricultural production must increase. Limitations relating to suitable additional land that can be brought under cultivation in Nepal increase the critical role of soil fertility management and efficient fertilizer use in attaining agricultural production targets.

Figure 9: Fertilizer nutrient consumption and foodgrain production



Source: *FAO, 2005*

Sustainability of soil resources may be endangered if not managed properly, leading to economic adversity for farmers through lowered productivity and adverse impact on the environment. The decline in the soil resource base may be caused by depletion of nutrients or soil erosion as well as by acidity, salinity, alkalinity, water-logging, nutrient toxicities and decline of vegetative cover.

In many cases the soil resource base in Nepal has been adversely affected by depletion of organic matter, decline in plant nutrient status, occurrence of micronutrient deficiencies, soil acidity, soil erosion and loss of vegetative cover. Sometimes improper use of fertilizers has also led to ecological problems such as nitrates in water resources. It is apparent that sound fertilizer use and soil fertility management is crucial for providing stability to crop production and building food security in Nepal.

2. Fertilizer and soil fertility management policies – a review

Fertilizer use and soil fertility management are the core support elements of a high-yield agricultural production programme. Assessment of existing national fertilizer management practices and policies and appropriate recommendations relating to sustainable soil fertility management and fertilizer use strategies and policy is a pre-requisite in the present context of providing sustainability to the system.

2.1 Agriculture Perspective Plan

The Agriculture Perspective Plan, 1995 (APP) of the Government of Nepal provides the guidelines and underlying principles for policy formulation for the agriculture sector. The APP recognizes that area expansion has ceased to be a predominant means of increasing agricultural production in Nepal and that the fertilizer has become the leading source of increased agricultural output. Fertilizer is expected to contribute between 64 to 75 percent of the total growth target envisaged by APP which visualizes an increase in fertilizer usage from 31 kg/ha in the base year 1995 to 131 kg/ha by 2017.

The APP observes that economic conditions are such that there is a large pent up demand for fertilizer and the supply is inadequate to meet the present demand. The large growing subsidies for fertilizer prior to 1997–98 were difficult to sustain. However, if the price were to rise by the full amount of subsidy, it would be far higher than the relevant border price with India, and the pent up demand might disappear.

Since an immediate response to the APP depends heavily on increased fertilizer use, fertilizer distribution, pricing, and technology policies have become critical issues. The less weight given to subsidies, the more emphasis must be put on stepping up research, increasing profitability, providing timely and convenient supplies, and educating farmers on the profitability of fertilizer. In the long run, as the total volume of fertilizer use increases, both efficiency and environmental considerations will demand greater attention to optimal fertilizer use from both research and extension (APP, 1995).

2.2 Tenth Plan

The Tenth Plan (2001/02–2006/07) estimated the normal economic growth rate to be an annual average of 4.3 percent with 2.8 percent in the agricultural sector. However, during the plan period the average annual growth rate remained at 3.4 percent (2.67 percent for agriculture). The contribution of agriculture to gross domestic product was 37.4 percent in the base year of the plan, and declined to 33.1 percent in its final year. The country's annual population growth rate is a high 2.25 percent. If this growth rate continues, Nepal's current population will double in the next 31 years.

The food problem is complicated because of difficulties in transportation and a non-competitive market, especially in remote hilly areas. Major problems include:

- the inability to use investment and physical facilities effectively:
- lack of intensive cropping;
- inadequate supply and inadequate use of basic agricultural inputs like chemical fertilizers, improved seeds, irrigation and credit;
- the weakness of market mechanisms;
- high production risks;
- ineffectiveness of the agricultural extension services; and
- lack of agricultural research in required sectors.

There is a food deficit in remote areas. There has been a decrease in food security due to lack of access to means and resources.

2.3 Three-year interim plan

The Approach Paper for the Three-Year Interim Plan from 2007–08 to 2009–10, accords high priority to agriculture. It adopts the Agricultural Perspective Plan as the base for agricultural development, and emphasizes using modern and appropriate technology to increase agricultural production. The average annual growth rate of the agriculture sector is projected to be 3.6 percent. The average annual rate of inflation will be restricted to 5.6 percent during the plan period.

The approach recognizes that low productivity and fluctuation in productivity have been major hurdles in the agriculture sector. The major challenge is to commercialize traditional agriculture up to the level of the industrial sector. For this purpose, infrastructure will be developed for scientific land reform and management to revolutionize the agriculture sector. A policy framework conducive to increasing the production and productivity of crops, horticulture, floriculture, animal husbandry and fisheries will be put in place.

During the plan period, the agriculture sector will be oriented towards commercialization, cooperatives will be promoted and emphasis will be put on irrigation, agricultural roads, agricultural loans, research and technology dissemination, rural electrification and development of market structures for increasing productivity.

The plan seeks to improve the access of rural people to financial services by developing a network of bank and financial institutions, cooperatives and microcredit institutions. By operating the microcredit programmes through non-governmental organizations (NGOs) and the private sector, mechanisms will be developed for income growth of small and marginal farmers, entrepreneurs and poor families in rural areas.

2.4 Emergence of fertilizer policy interventions

Fertilizer use was initiated in the early 1950s with private traders importing small quantities of ammonium sulphate (AS) from India. Small quantities of AS were also imported from Russia. From its establishment in 1966, the Agriculture Input Corporation (AIC) was responsible for procurement and distribution of chemical fertilizers in the country. Until 1972, the price of fertilizers was fixed on a cost plus basis. Later on the policy was altered to make for a uniform price system.

With the rise in international market price, the government decided to introduce price subsidy and a transport subsidy in selected high hill and mid-hill districts in 1973–74. With the growing demand for fertilizers and rise in international fertilizer prices, the subsidy allocation placed a huge financial burden on the government. Eventually the government was unable to allocate adequate budget to meet the subsidy. AIC incurred huge losses and was unable to import enough fertilizers to meet demand, leading to short supplies.

The government initiated deregulation of the fertilizer trade in November 1997 with the complete elimination of subsidy on DAP and MOP and a phased removal of subsidy on urea. Subsidy had been completely removed by November 1999.

Deregulation involved the following:

1. removal of AIC's monopoly of the fertilizer trade;
2. entry to the trade of the private sector and handling of imports and distribution through this sector;
3. time-bound phasing out of fertilizer subsidies; and
4. decontrol of fertilizer prices.

To monitor quality control, the government promulgated the Fertilizer Control Order 1999 under the Essential Commodities (Control) Act, 1996.

In line with the deregulation policy, the National Fertilizer Policy (2002) was formulated.

2.4.1 National Fertilizer Policy (2002)

The National Fertilizer Policy (2002) was formulated in the context of the involvement of the private sector in the fertilizer trade since November 1997, and in line with the liberal, open and market-oriented economic policy of the government. The aim was to support agricultural production by ensuring the supplies of good quality fertilizer (production, import and distribution).

The fertilizer policy is a sub-component of the government's broad agricultural policy as set out in the Agriculture Perspectives Plan.

2.4.1.1 Underlying principles

The Fertilizer Policy is based upon the following principles:

- Participation of the private sector is indispensable to improve the availability of fertilizers and promote increased demand for fertilizers among farmers.
- All actors (public, cooperatives and the private sector) should have equal opportunities in the fertilizer trade.
- In the context of the emerging trend of globalization, fast development and dissemination of information technologies and market-oriented economic systems, government should reorient its role away from direct involvement in the trade toward towards regulation and facilitation.

- Agricultural extension and agricultural research should take joint responsibility and work with each other to promote appropriate fertilizer use.
- An integrated plant nutrients system should be adopted in order to prevent the degradation of soil fertility and minimize the other likely negative impacts of chemical fertilizer use on environment and to promote appropriate and balanced use of fertilizers.
- The necessary infrastructure, management and favourable environment should be created for the appropriate and balanced use of chemical fertilizer.

2.4.1.2 Objectives

The principal aim of this policy is to enhance agricultural productivity through improvement in soil fertility, and thereby contribute to the national goal of poverty alleviation. Specifically, this policy has the following objectives:

- provision of conditions (policy and infrastructure management) for enhancing fertilizer consumption; and
- promotion of an integrated plant nutrients management system for the efficient and balanced use of fertilizers.

2.4.1.3 Strategies

The National Fertilizer Policy (2002) envisages adoption of the following measures to achieve the above-mentioned objectives:

2.4.1.3.1 Ensuring availability of fertilizers

2.4.1.3.1.1 Making fertilizer imports reliable, competitive and transparent

Since Nepal does not produce any fertilizers at present and therefore all its demands have to be met by imports, the following measures will be undertaken to make the current fertilizer import system reliable, competitive and transparent:

- Fertilizer off-take level, demand and supply will be estimated and made public six months ahead of the major crop growing season, to enable timely imports.
- Equal opportunity will be provided to all fertilizer importers (public, cooperatives and private sector organizations involved in fertilizer importation).
- Importers will be required to make wholesale prices of imported fertilizers public.
- The system for monitoring the price, quality and availability of fertilizer will be strengthened to make it regular and effective.
- World market prices of fertilizers will be monitored regularly and made public.
- Any person or organization importing fertilizers from the international market will be registered at the Ministry of Agriculture and Cooperatives.

2.4.1.3.1.2 Pricing policy and subsidy

- Market competition will set the selling prices of fertilizers.
- Government will not provide price subsidies on chemical fertilizers but it may provide fertilizers at concessionary rates in targeted geographic areas. Such concessions may be applied to remote and high Hill districts lacking motorable transport services, or to targeted groups such as small and marginal farmers lacking adequate purchasing power, through the special agriculture production programme.

2.4.1.3.1.3 Provision of buffer stocks

- About 20 percent of the estimated annual fertilizer consumption will be held as buffer stock.
- Storage, management and distribution of buffer stock fertilizer will be made transparent and competitive.
- Grant-aid fertilizer made available to the Government will be used as buffer stock (managed in the form of buffer stock fertilizers) and mobilized accordingly.

2.4.1.3.1.4 Domestic Production

- Since it would not be appropriate to depend always on imports for the supply of fertilizer, the establishment of a fertilizer plant will be encouraged in the country.
- Importers importing fertilizers as raw material for the production of mixed or blended fertilizers will be given equal facilities as available to other importers of fertilizers.

2.4.1.3.1.5 Investment in other countries

- The cooperative and private sectors will be encouraged to invest in the fertilizer plants of neighbouring countries.
- The cooperative and private sectors will be encouraged to invest in fertilizer plants outside the country and to obtain a proportionate share of the produce.

2.4.1.3.2 Making the fertilizer distribution system transparent, competitive and effective

2.4.1.3.2.1 Distribution system

- Statistics on fertilizer demand and supply by development regions will be regularly updated and made public.
- A fertilizer use study will be carried out at regular intervals to facilitate and make the fertilizer distribution system efficient and to promote an integrated plant nutrients management system for the balanced use of chemical fertilizers.
- Fertilizer distributors and dealers will be encouraged to establish distribution networks to the district levels.
- Retail sale prices of fertilizers will be monitored regularly.
- Fertilizer dealers' capacities for fertilizer storage, their knowledge of fertilizer use and agricultural production, the marketing system and fertilizer quality management will be enhanced.
- Regular interaction programmes will be held at different levels among fertilizer importers, dealers and farmers.

2.4.1.3.2.2 Provision of fertilizer at concessionary rates for targeted areas and groups

- The Government may provide fertilizers at concessionary rates in the districts of Hill and Mountain regions whose district headquarters are not yet linked with a permanent motorable road. The concessionary rates will be equivalent to the cost of transporting fertilizer to these districts.
- All types of solid fertilizers containing nitrogen, phosphorus and potassium would be eligible for the fertilizer transport cost concessions.
- Opportunities will be provided for the cooperative and private sectors to take part in the distribution of fertilizers provided under concessionary rates.
- Concessions on the local market prices of fertilizers may be provided to small and marginal farmers by integrating such concessions into the special agriculture production programmes.

2.4.1.3.2.3 Quality of fertilizer

- Dealers and consumers will be encouraged to procure fertilizers only from authorized sources.
- The Fertilizer Act and its regulations shall be formulated and enforced for the effective implementation of the policy.
- Laboratories shall be established and strengthened in order to improve fertilizer analysis.

2.4.1.3.2.4 Management of integrated plant nutrients system

The following activities should be carried out to prevent the degradation of soil fertility, minimize any other likely negative impact of chemical fertilizers on the environment, and to promote the appropriate and balanced use of fertilizers:

- Farmers shall be encouraged to use balanced chemical fertilizers on the basis of required nutrients established by soil testing.
- Organic fertilizers and microbial fertilizers shall be encouraged in the integrated plant nutrition system (IPNS).
- Regular interactions among farmers, researchers, agricultural extension workers, NGOs, cooperatives and the private sector shall be organized for the dissemination and evaluation of an IPNS.

2.5 Impact of fertilizer deregulation

After the promulgation of the national fertilizer policy in 1997, fertilizer supplies from formal sources (AICL and private importers) improved up to 1998–99. A decline in supplies started after 1999–2000. Retention of partial subsidy on urea till November 1999 sustained the supplies to a fair extent.

In the following period, AICL and the private importers could not import the required volumes owing to price fluctuations in the overseas market. Besides, they had an uneven competition with the subsidized cheap and often adulterated/sub-standard fertilizers easily available through the informal trade across the long and porous Indian-Nepal border.

Fertilizer quality became a major concern. Due to an excessive rise in price, small and marginal farmers lost access to quality fertilizers. The high price also affected the profitability of fertilizer use and competitiveness of the farmers to sell their produce. Overall, the supply situation in Hill and remote areas remained precarious because of high transportation costs.

2.6 National fertilizer policy revisited (2009)

The issues outlined above led the government to revisit the deregulation policy. The government, *vide* its notification of 25 March 2009, reintroduced the fertilizer subsidy on a limited scale, targeting small and marginal farmers. Salient features of the scheme are as follows:

- annual imports of 100 000 tonnes fertilizers under the scheme;
- sale price fixed between 20 and 25 percent higher than that of India for five import points – Biratnagar, Birgunj, Bhairahawa, Nepalgunj, and Dhangadi;
- AICL as the sole agency to import fertilizers to be distributed at subsidized rate;
- reimbursement to AICL of the difference between actual cost price of importing fertilizers and the sale price at import points;

- farmers' price to be fixed on the basis of sale price at the import points plus transportation cost up to the delivery point;
- eligibility for the subsidy to be limited to farmers with land holdings of 0.75 ha or less in the hills, and 4 ha or less in the Terai;
- subsidized fertilizers to be provided for the technically required amounts for three crops a year;
- subsidized fertilizers to be sold through the offices of AICL and cooperative institutions;
- A fertilizer supply and distribution and management committee headed by the chief district officer of the respective district to look after the various aspects of distributing subsidized fertilizers at the district level.

Under a special programme, there is a provision for a subsidy for transport of fertilizers for 26 districts in the mountain and hill areas.

In the following paragraphs is a sector-wise account of the present state of the fertilizers and soil fertility management programme in Nepal.

2.7 Fertilizer and soil fertility management programme – current status

2.7.1 Fertilizer production

Nepal does not have a chemical fertilizer production facility at present. Given the total lack of natural resources for production of chemical fertilizers in the country, there seems little point in setting up a production unit. The requirement of fertilizer materials being smaller in quantum, setting up even a moderate-sized unit may not be economically feasible. Setting up larger plants based on internal demand considerations as well as exports may involve heavy investment besides proving to be non-competitive.

An alternative option would be to explore joint venture possibilities, preferably with neighbouring countries such as India and Bangladesh, but possibly other countries, and import a proportionate share for internal consumption. The National Fertilizer Policy (2002) provides for this option and mentions that interested parties, either the private sector or cooperatives, will be encouraged to invest in fertilizer plants outside the country.

Geological explorations carried out in the past indicate the possible existence of low grade phosphate rock (PR) deposits in Baitadi District in western Nepal (FAO: GCPF/NEP/030/NET, 1990). The deposits have not so far been exploited because of the lack of transport infrastructure.

2.7.2 Fertilizer imports

Nepal depends solely on imports for meeting its fertilizer requirements. The demand is met from various sources, i.e. formal imports through the public (AICL) and private sectors and through informal inflow along the 1 600 km-long Indo-Nepal open border. The latter informal supplies constitute between 65 to 70 percent of the total imports (Joshi, 1998; Goletti, 2001). In recent years, the contribution of informal imports is possibly substantially higher than earlier estimates.

There are no reliable statistics available for the informal imports of fertilizers. For this study, estimates based on previous studies and methodologies (Goletti, 2001; Thapa, 2006) have been adopted and extrapolated to derive the quantity of fertilizer nutrients that might have been informally imported (see Table 2.1).

A number of straight and compound/complex fertilizer products were imported in earlier years. However, the current import of fertilizer materials is limited to high analysis fertilizers such as urea, DAP and MOP (see Table 2.2). This is logical in view of the high transport and packaging costs involved in transporting fertilizers into remote hilly and mountainous areas.

Table 2.1: Import of fertilizers

Year	(in terms of nutrients) Formal Imports ('000 tonnes)				Change over 1999/00 (%)	Estimated Informal Imports ('000 tonnes)	Total Imports ('000 tonnes)
	N	P_2O_5	K_2O	Total			
1999/00	55.6	25.8	0.0	81.4		120.5	201.9
2000/01	61.4	24.7	3.1	89.2	15.1	146.6	235.8
2001/02	53.1	21.8	2.6	77.5	0.0	145.9	223.4
2002/03	37.3	18.2	0.0	55.5	-28.3	164.6	220.1
2003/04	59.7	22.4	0.7	82.8	7.0	183.1	265.9
2004/05	20.9	22.1	0.1	43.1	-44.3	201.8	244.9
2005/06	29.0	16.9	0.2	46.1	-40.4	220.4	266.5
2006/07	22.3	14.2	0.0	36.5	-52.8	238.9	275.4
2007/08	9.5	5.3	0.0	14.8	-80.9	257.4	272.2
2008/09	31.9	18.2	6.0	56.1	-27.6	275.9	332.0

Source: *AISMS, MOAC database*

Table 2.2: Product-wise imports (formal)

Products	Quantity ('000 tonnes)			
	2006	2007	2008	2009
Urea	42.3	28.7	7.1	54
Ammonium sulphate	6.5	2.4	9.9	–
SSP	2.4	1.9	0	
MOP	0	0	0	10
DAP	25.6	13.3	0.7	39.5
Ammonium phosphate sulphate (20–20–0)	21.5	39.0	24.8	–
Total	**98.3**	**85.3**	**42.5**	**103.5**

Source: *AISMS-MOAC database*

2.7.3 Fertilizer transportation, warehousing and buffer stocking

Road transportation is the only way of transporting fertilizer materials within Nepal. Transportation complexities arise on account of the hilly and mountainous terrain of the country. Costs are on average as high as US$20/tonne. For difficult-to-reach areas, the cost is exorbitant. Between 60 and 75 percent of the total marketing cost is accounted by transport alone. In certain parts the lack of roads makes it difficult to reach the fertilizers. In remote areas they have to be transported in small quantities by pack animals like mules.

Because of a lack of transportation and fertilizer retail outlets, farmers have to travel long distances especially in the hill and mountain areas. The lack of roads also considerably affects the transportation of crop produce to the agricultural markets.

The seasonal demand for fertilizers makes it imperative that fertilizer stocks are held in primary or secondary storage points for subsequent distribution. Prior to deregulation, AICL was the sole import agency for fertilizers. AIC also had a substantial warehousing infrastructure. Even now AICL has a warehousing capacity of 66 000 tonnes. This remains grossly underutilized due to AICL's decreasing in importing fertilizers following deregulation.

Prior to deregulation cooperatives were also actively involved in fertilizer distribution. They hold about 59 000 tonnes of fertilizer warehousing space. However, like AICL, this capacity remains grossly underutilized.

Fertilizer stocks procured under Kennedy round II (KR II) were previously treated as buffer stocks. Currently no buffer stocks are maintained.

2.7.4 Other nutrient resources

Organic fertilizers

There is a long tradition of using organic fertilizers to support Nepalese agricultural production programmes. In some areas, where chemical fertilizer cannot reach, organic fertilizers are the sole source of plant nutrients. Such areas are also considered as potential areas for organic farming.

In the Terai, the production and use of organic fertilizer has decreased because of the diminishing cattle population resulting from increasing dependence on farm mechanization. Organic manure is used to a fair extent (see Table 2.3) in the hill and mountain areas. The sustainable soil management programme (SSMP) initiated by the Swiss development agency, HELVETAS, claims having had good success with improved use of organic sources for sustainable agricultural production. However, the impact of the programme on long-term soil fertility management needs to be further evaluated along with its applicability in other agro-ecological regions.

Table 2.3: General recommendations for organic manure use (tonnes/ha)

Wheat	6–10
Rice	6–10
Maize	6–10
Potato	30
Sugarcane	10
Vegetables	10–20

Source: *FAO, 2005*

Vermi-compost

There has been considerable emphasis on the production and use of vermi-compost using a more efficient species of earthworms. It is made by a number of private producers. However, the market price in certain areas is too high (US$200/tonne). There are quality control problems as well.

Biofertilizers and green manures

Although there is a good scope for biofertilizers, their adoption at farmers' level is negligible. Use of rhizobium, especially for legumes, has shown substantial improvement in yields. The application of blue-green algae (BGA) and Azolla technology for rice is still under research investigation.

Although the research results reveal good response to green manuring for rice, the field level adoption by farmers is limited on account of lack of irrigation facilities, seed supply and concerns relating to losing a crop.

2.7.5 Soil fertility, crop response and fertilizer recommendations

Table 2.4 gives the location, capacity and capacity utilization of the soil testing laboratories under the Department of Agriculture (DOA) for 2008. Considering Nepal's agro-ecological diversity and the area under cultivation, the present capacity may be considered inadequate. Most of the laboratories are concentrated in the Terai and valleys while other regions also need such facilities. The soil testing laboratories suffer from lack of funds, equipment and trained personnel.

Table 2.4: Soil testing laboratories and capacity utilization

Location	Capacity per annum	Samples analysed	Capacity utilization (%)
Soil Management Directorate, Kathmandu	1 000	475	47.5
Regional Soil Test Lab, Jhumka, EDR	500	350	70
Regional Soil Test Lab, Hetauda, CDR	500	350	70
Regional Soil Test Lab, Pokhara, WDR	500	400	80
Regional Soil Test Lab, Khajura, MWDR	800	775	96.8
Regional Soil Test Lab, Kanchanpur, FWDR	500	500	100
Soil Test Lab, Jhapa, EDR	200	150	75

Source: *DOA, 2008*

The existing fertilizer recommendations (see Table 2.5) are based on soil testing carried out a long way back. They need to be revisited in the light of changing crop varieties and soil physio-chemical conditions.

Table 2.5: Fertilizer recommendations for improved crop varieties

Crop	Plant Nutrient Dosage (kg/ha)								
	Eastern Region			Central Region			Western Region		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Wheat	117	50	45	88	45	43	90	49	42
Rice	108	52	36	99	45	35	102	46	34
Maize	105	57	32	89	50	36	86	52	33
Potato	88	45	90	80	38	78	68	35	68

Source: *FAO Nepal Fertilizer Programme (FRIP) Report, 1990*

A quality control programme is an important and integral part of the soil testing system in order to monitor the accuracy of the analytical facilities. However, at present there is no such system.

Soil fertility maps have been developed for 26 of the 75 districts by the directorate of soil management in the Department of Agriculture. This directorate is also responsible for the transfer of soil-related technologies and information to the farmers through the District Agriculture Development Office/Officer (DADO).

In general, most food crops have a good response to nitrogen, moderate response to phosphate and low response to potash. However, potato has a good response to potash.

Straight fertilizer recommendations are gradually giving way to recommendations for IPNS in accordance with the provisions of the National Fertilizer Policy (2002). However, adoption of IPNS recommendations at the field level is low. Several factors such as diminishing sources of organics as in the Terai, non-availability of forest litter, lack of farmers' awareness of new concepts and technology, unavailability and high prices of fertilizers contribute to non-adoption.

2.7.6 Soil health management

Depletion of soil organic matter

Soil organic matter content is one of the key parameters influencing soil fertility and productivity. Instances of organic matter depletion have been reported, especially in the Terai region, on account of intensive cropping and lower application of manures resulting from diminishing organic resources.

Depletion of plant nutrients

Besides the depletion of soil organic matter, the major factors contributing to decline in soil fertility are intensive cropping, inadequately supported with proper fertilization; loss of plant nutrients due to inappropriate fertilization practices; and lack of soil conservation measures.

Secondary and micronutrient deficiencies

Intensively cropped areas like the Terai are revealing increased signs of secondary and micronutrient deficiencies particularly of sulphur, zinc, boron and molybdenum.

Nutrient balance

The nutrient removal depends on the crop yields. A tentative exercise at the national level reveals a negative balance of nutrients with the present levels of nutrient application.

Soil conservation

Soil erosion is a potential threat especially for hilly and mountainous regions and requires constant attention. There is a need for regular refresher programmes for extension personnel and awareness programmes for farmers with regard to soil conservation measures to be adopted at the field level to check and control soil erosion.

Problem soils

Soil acidity is a conspicuous problem. Eighty percent of the soil samples analysed by the Department of Agriculture reveal acidic reaction requiring the application of lime. Adequate provision of lime is thus imperative. However, agricultural lime is not available despite there being ample deposits in various parts of the country.

Biodiversity

At present no studies have been carried out to study and monitor the effect of current agricultural practices on soil biota.

Conservation agriculture

Although there is ample scope for conservation agriculture, the practice has yet to be recommended and adopted at the field level.

2.7.7 Demand assessment

Non-availability of reliable statistics relating to actual supply and consumption is a major obstacle in assessing demand. Projections have been made taking into account gross estimation of supplies through formal and informal imports, using growth rate and trend line projections. Obviously, there is a need to evolve a reliable system for data collection and establish a suitable methodology for demand estimation.

At present, the APP projections (see Table 2.6) are taken as a guide for fertilizer requirements, although they may be off the mark from the actual demand/consumption point of view.

Table 2.6: APP fertilizer demand projections

Year	Plant nutrients ('000 tonnes)				Fertilizers ('000 tonnes)			
	N	P_2O_5	K_2O	Total	Urea	DAP	MOP	Total
2002	82.0	35.0	4.8	121.8	148.5	76.1	8.0	232.6
2003	90.0	37.0	5.4	132.4	164.2	80.4	9.0	253.6
2004	100.0	45.0	6.0	151.0	179.1	97.8	10.0	286.9
2005	110.0	52.0	6.8	168.8	194.9	113.0	11.3	319.3
2006	125.0	63.0	8.0	196.0	218.1	136.9	13.3	368.4
2007	146.0	75.7	9.6	231.4	253.1	164.6	15.9	433.7
2008	169.4	87.8	11.1	268.4	293.5	190.9	18.5	503.0
2009	**196.5**	**101.9**	**12.9**	**311.3**	**340.5**	**221.5**	**21.5**	**583.5**
2010	227.9	118.2	14.9	361.1	394.9	256.9	24.9	676.9
2011	264.4	137.1	17.4	418.9	458.2	298.1	28.9	785.2

Source: *AISMS-MOAC database, APP, 1995*

2.7.8 Fertilizer distribution

Currently, AICL distributes fertilizers through its 41 points of sale located across the country. This also involves more than 1 200 private trained private retailers and cooperatives. It also retails fertilizers directly to farmers in areas near its 41 sales points. However, AICL is unable to utilize its distribution infrastructure to the full extent because of its reduced role after deregulation.

Cooperatives have a wider distribution infrastructure. However, because of various limitations relating primarily to financial and professional capabilities, their involvement in fertilizer distribution is limited.

The private sector was at first active in the trade after deregulation, but now has little interest in fertilizer imports and distribution. This is because of uncertainties regarding international fertilizer prices and the recently introduced targeted fertilizer concessions introduced by the government. Further, the private trade is more inclined to sell fertilizers in easily accessible areas and has little interest in areas lacking infrastructure such as hilly and mountainous areas.

There is dearth of retail points in interior rural areas, forcing the farmers to travel long distances to buy fertilizers.

2.7.9 Credit

Credit is an essential element for access to fertilizers especially for small and marginal farmers. Although there are several financial institutions in the public sector, their role in providing credit to farmers as soft loans is limited. However, it is said that some private-sector financial institutions such as Lakshmi Bank, are planning to make credit available to farmers at lower interest rates. It will be interesting to watch how committed such banks prove to be.

2.7.10 Marketing costs and distribution margin

While the landed cost of imported fertilizer at the entry point is itself very high because the country is landlocked, the inland marketing costs add substantially to the total marketing costs because of widespread hilly and mountainous terrain and inadequate transportation infrastructure. Transportation and handling charges are the major components of the total cost (see Table 2.7).

Table 2.7: Fertilizer marketing costs at current rates

Cost Component	Cost (US$/tonne material)		Cost (NRs/tonne material)	
	Urea	DAP	Urea	DAP
a. Ex-factory price bagged/Import price CIF bagged	329.4	389.2	25 693.2	30 357.6
b. Transportation	48.7	48.7	3 799.0	3 799.0
c. Handling	18.9	31.1	1 478.0	2 422.3
d. Transportation and handling costs (a+b)	67.6	79.8	5 277.0	6 221.3
Total (a+b+c)	397.0	469.0	30 970.2	36 578.9

Source: *AICL & AIMS-MOAC database*

The level at which the dealers' margin for materials imported through formal channels is currently fixed is unlikely to motivate the dealers, including the cooperatives, to engage in the fertilizer business.

2.7.11 Fertilizer pricing and subsidy

The fertilizer policy introduced in 2002 provides a liberalized market for fertilizer. Currently there is no price control by the government; the price is fixed by free market forces.

The Government of Nepal has recently introduced a scheme whereby 100 000 tonnes of fertilizers per annum will be supplied through AICL at a concessionary price to farmers with less than 0.75 ha in the hill and mountain areas, and up to 4 ha in the Terai region.

The price of fertilizers procured under the import parity price (IPP) scheme would be fixed between 20 to 25 percent higher than the price prevailing on the Indian side of the border. The Government of Nepal has allocated NRs1.5 billion (US$20 million) for the current year to cover this price differential.

2.7.12 Economics of fertilizer use

The economics of fertilizer nutrient use for wheat and rice as evident through value-cost ratios (VCR) calculated at current input/output prices is given in tables 2.8 and 2.9, respectively.

In the case of wheat, VCRs are quite favourable for the use of N and P. For rice, VCR is quite favourable for N, while for P and K application it is not favourable. VCR for the use of K is quite low, which is possibly one of the reasons for low K use by the farmers.

Table 2.8: Economics of fertilizer nutrient use for wheat

Nitrogen through urea				
Wheat Price (NRs/kg)	*N Price (NRs/kg)*	*Crop Response (kg grain/kg nutrient)*	*Value of Grain (NRs/kg nutrient)*	*Value: Cost Ratio*
28.02	52.17	10	280.2	5.37
P_2O_5 through DAP				
Wheat Price (NRs/kg)	*P_2O_5 Price (NRs/kg)*	*Crop Response (kg grain/kg nutrient)*	*Value of Grain (NRs/kg nutrient)*	*Value: Cost Ratio*
28.02	39.06	5	140.1	3.59
K_2O through MOP				
Wheat Price (NRs/kg)	*K_2O Price (NRs/kg)*	*Crop Response (kg grain/kg nutrient)*	*Value of Grain (NRs/kg nutrient)*	*Value: Cost Ratio*
28.02	23.17	5	140.1	1.21

Table 2.9: Economics of fertilizer nutrient use for rice

Nitrogen through urea				
Rice Price (NRs/kg)	*N Price (NRs/kg)*	*Crop Response (kg grain/kg nutrient)*	*Value of Grain (NRs/kg nutrient)*	*Value: Cost Ratio*
30.99	52.17	10	309.9	5.94
P_2O_5 through DAP				
Rice Price (NRs/kg)	*P_2O_5 Price (NRs/kg)*	*Crop Response (kg grain/kg nutrient)*	*Value of Grain (NRs/kg nutrient)*	*Value: Cost Ratio*
30.99	39.06	2	61.98	1.59
K_2O through MOP				
Rice Price (NRs/kg)	*K_2O Price (NRs/kg)*	*Crop Response (kg grain/kg nutrient)*	*Value of Grain (NRs/kg nutrient)*	*Value: Cost Ratio*
30.99	23.17	1	30.99	1.34

2.7.13 Fertilizer use by crops

No reliable data are available with regard to fertilizer use by the farmers.

Fertilizer supplies are received through formal and informal channels but mostly informally, sometimes more than 80 percent in certain years. The statistics concerning formal imports are maintained by the government, whereas data relating to informal imports are difficult to estimate and are mostly unreliable. However, data relating to formal and informal import estimations projected on the basis of previous surveys and studies are presented in Table 2.10.

The data in Table 2.10 reveal that the fertilizer use has declined (based on the formal data only). However, the combined (formal and informal) figures show that the per hectare use of fertilizer nutrient has in fact increased and reached a level of 108 kg in 2009. The formal fertilizer consumption data does not represent the complete picture because of substantial imports coming through informal sources.

Micronutrient carriers like zinc sulphate and borax are in use on a limited scale. Use of lime is prevalent for soil amendment but it is not adequately available.

Table 2.10: Nutrient consumption growth pattern

Year	Consumption (formal) ('000 tonnes)				Consumption (informal) ('000 tonnes)	Total Consumption ('000 tonnes) (formal+ informal)	Total NPK use (kg/ha)
	N	P_2O_5	K_2O	Total	Total	Total	
2000–01	54.5	20.5	0.0	75.0	147	222.0	76.1
2001–02	47.0	24.5	0.8	72.3	146	218.3	72.1
2002–03	59.5	27.3	2.2	89.0	165	254.0	71.0
2003–04	51.6	24.7	1.6	77.9	183	260.9	85.8
2004–05	36.5	22.4	1.8	60.7	202	262.7	79.0
2005–06	21.9	20.1	0.6	42.7	220	262.7	86.0
2006–07	25.6	16.1	0.0	41.7	239	280.7	88.8
2007–08	11.9	11.0	0.0	22.9	257	279.9	87.8
2008–09	31.9	18.2	6.0	56.1	276	332.1	108.1

In general, the Terai region is the major fertilizer consumer. The use of fertilizers in the hills and mountains is of a lower order. Large farmers can afford to use higher doses of fertilizer, while the poorer small and marginal farmers cannot.

Wheat is the major consumer for fertilizer followed by rice and maize. In the case of vegetables and commercial crops the farmers use high doses of fertilizer. Fertilizer use in irrigated areas is higher than in rainfed tracts. About 60 percent of the total fertilizers are used for summer crops like rice, maize, and vegetables. The remaining 40 percent is used for winter crops, mainly wheat and vegetables.

2.7.14 Fertilizer quality control

The government introduced a fertilizer control order in 1999 in order to monitor the quality of fertilizers and to keep check on possible malpractices. Each district has a Fertilizer Inspector. However, the inspectors lack both logistical support and staff for effective monitoring. They also have no judicial power to implement the provisions of the control order. Another problem is that they lack of training in fertilizer quality control.

Table 2.11: Fertilizer consumption and foodgrain production

Year	Nutrient consumption('000 tonnes)			Foodgrain production ('000 tonnes)
	Formal	Informal*	Total	
2000–01	75.0	146.6	221.6	7 171.8
2001–02	72.3	145.9	218.2	7 246.9
2002–03	89.0	164.6	253.6	7 360.4
2003–04	77.9	183.1	261.0	7 747.1
2004–05	60.7	201.8	262.5	7 767.5
2005–06	42.7	220.4	263.1	7 656.5
2006–07	41.8	238.9	280.6	7 329.0
2007–08	22.9	257.4	280.3	8 069.1
2008–09	56.1	275.9	332.0	–

The fertilizer samples collected are sent to government soil testing laboratories for analysis. Despite a significant number of samples being found substandard/adulterated, convictions are rare. Quality control problems surface more in the Indo-Nepal border areas especially in relation to informal imports. Fertilizer mixtures formulated in-country also suffer quality control problems.

2.7.15 Research and knowledge base

The Nepal Agricultural Research Council (NARC) is the apex body responsible for agricultural research. NARC implements its research activities through its nationwide network of institutes. However, at present NARC is very much constrained due to lack of funds and human resources. Soil fertility and fertilizer related researches are coordinated by the soil science divisions and verified in farmers' fields through the outreach research divisions.

A good deal of information has been generated on fertilizer use and soil fertility management issues in collaboration with various national and international organizations. A number of long-term soil fertility experiments are also being run on various cropping systems and in various agro-ecological regions. These could be reviewed and revisited with a view to updating them to meet current requirements. From the farmers' perspective, adaptive research for increasing resource use efficiency, including that of fertilizers, is a priority for maximizing profitability and minimizing environmental hazards.

The Department of Agriculture (DOA) under the Ministry of Agriculture and Cooperatives is responsible for technology transfer to farmers and agricultural development. DOA carries out its development activities through its nationwide network. DOA visualizes promoting programmes on organic agriculture for remote Hill and Mountain areas with high value horticultural crops and herbs. The directorate of soil management under the DOA is responsible for disseminating knowledge relating to soil and fertilizer management issues. It operates through its regional soil testing laboratories in collaboration with DADOs in each district.

The directorate of soil management, however, is poorly staffed and equipped to manoeuvre the complexities arising from soil fertility problems accompanied by crop and agro-climatic diversity. It needs support particularly for developing quality-conscious, efficient soil/fertilizer analytical facilities and training skills for imparting knowledge to farmers.

2.7.16 Environmental aspects

There is no regulatory framework at present to monitor the environmental issues arising from overuse of fertilizers.

2.7.17 Coordination and monitoring

Following deregulation, the government established a fertilizer unit (FU) in the Ministry of Agriculture and Cooperatives to: (1) support and facilitate the fertilizer sector though an appropriate policy environment and information management system; (2) provide regulatory support for a free market and safeguard against market failures; (3) provide effective monitoring of the fertilizer market; and (4) manage the buffer stocks to counter unexpected disruption in fertilizer supplies.

The unit has now been upgraded and renamed the 'agriculture inputs supply monitoring section' (AISMS). However, it is poorly staffed. Since it is a key institution for policy formulation, information management and monitoring and coordinating the various agencies involved in fertilizer supply and marketing, it needs strengthening by competent and qualified personnel in order to implement government policies effectively.

3. Policy gaps and suggested framework for a sustainable fertilizer and soil fertility management policy

Fertilizer use and soil fertility management are the core support elements of a high-yield agricultural production programme. About one-third of the increase in cereal production worldwide is attributed to fertilizer use. Assessment of existing national fertilizer management practices and policies and appropriate recommendations relating to sustainable soil fertility management and fertilizer use strategies and policy are imperative in the present context of providing sustainability to the system.

Based on a review and analysis of prevailing policies and programmes as provided in Chapter 2, availability of resources, factors and constraints involved and their inter-relationships and the possible effects of interventions, a policy framework for a sustainable fertilizer and soil fertility management programme is provided herewith. A segment-wise account of the policy gaps and policy measures deemed necessary from the point of view of sustainability is given in the following text.

3.1 Fertilizer availability and demand assessment

Fertilizer is an essential input for agricultural production. An adequate and timely supply of fertilizer for farmers must be ensured through strong policy support measures in order to provide food security to the population in a developing country like Nepal. The APP (1995) and the National Fertilizer Policy (2002) of Nepal take due cognizance of this factor.

Demand assessment is the first step towards planning adequate and timely availability. While a short-term demand assessment meets the immediate requirement, medium- and long-term demand assessments are essential tools for perspective planning.

There is a need for realistic assessment of demand for fertilizers. Overestimation leads to high inventory carrying cost, deterioration in the quality of fertilizers because of long periods of storage and liquidity problems. Underestimation of demand results in scarcity, a rise in the farmers' price and finally to lower agricultural production due to inadequate quantities applied to the crops.

At present there is no effective mechanism for assessment of fertilizer demand. Reliable statistics relating to supplies and consumption do not exist. While the figures for formal imports and supplies are available, during recent years they have been negligible until the planned import of 100 000 tonnes of fertilizers for 2009–10. It is estimated that a considerable portion of fertilizer demand is met through informal trade across the Indo-Nepal border, for which reliable estimates are not available. A survey conducted as far back as 2001–02 estimated that between 65 to 70 percent of total consumption is met through informal trade. Since then, however, there have been no studies on the subject. For the year 2008–09, major requirements were met only through informal imports, as formal imports were non-existent.

In view of the changing situation, there is a need for more frequent such studies in order to arrive at a correct assessment. Present estimations of demand by AISMU are largely based on the past projections of the APP (1995) consumption trend before deregulation (prior to 1997–98) and the agriculture performance review survey, 2001–02. There is substantial scope for error in these because of outdated parameters.

The district agriculture development offices (DADOs) also submit their annual demands. However, these demands are not generally based on any scientific methodologies which take into account the actual determinants, and tend to be over estimations for obvious reasons.

A suitable methodology needs to be adopted for demand assessment. Various approaches/methodologies used for such demand forecasting in developing countries are available through a recently conducted study by FAO, RAP (2009). Looking to the needs and resources available, a suitable methodology could be chosen for such forecasts. The agricultural input supply monitoring section (AISMS) of MOAC, the main national coordinating agency, could undertake the task and be provided with adequate professionals to carry it out.

The National Fertilizer Policy (2002) envisages updating the statistics on fertilizer demand and supply by development regions, and conducting regular fertilizer use studies. These and other elements that would make the statistics more reliable need to be looked into.

3.2 Ownership and management of fertilizer sector

Management difficulties are likely to be inherent in state-owned entities. The lack of strong motivation usually leads to operational inflexibility. The organizations cannot usually be induced to adapt readily to changing market environments, and overheads are generally high.

As a progressive measure, the National Fertilizer Policy (2002) provides equal opportunities to all sectors of the fertilizer trade viz. the public, cooperatives and private sector. With deregulation, the Agriculture Inputs Corporation, the main government import and distribution institution, has been converted into a company known as Agriculture Inputs Company Limited (AICL). With AIC's trade monopoly diluted, there are better opportunities for the private sector to enter the fertilizer business.

3.3 Fertilizer production

Because there are no suitable raw materials, the scope for developing indigenous fertilizer production capabilities is limited. However, there are reports of some low grade phosphate rock deposits in Western Nepal. Production of partially acidulated phosphate rock (PAPR) from these deposits may provide a useful P resource for Nepal agriculture, especially for long duration, horticultural and plantation crops. There is a need for comprehensive exploration surveys in this regard and an examination of the economic feasibility of such production. Previously, access and transportation were recognized as the main bottlenecks. However, with recent improvements in infrastructure, these have to some extent been resolved.

Soil acidity is predominant in Nepal. Agricultural lime is used as a soil amendment to correct it. A number of lime deposits are available in the country. However, many of the lime units have recently stopped production, leading to availability problems. There is a need to amend this situation in the interest of soil health and productivity.

In order to augment supplies, a possible option is investment in fertilizer plants in neighbouring countries. The National Fertilizer Policy (2002) has a provision for such investment by the cooperatives and private sector. This option needs to be vigorously pursued in order to provide a long-term solution to fertilizer supply constraints.

3.4 Fertilizer imports

In the absence of indigenous raw materials imports are the only means of meeting fertilizer requirements.

Imports are expensive in terms of foreign exchange, an acute problem when international fertilizer prices are high. There is no effective way of isolating the country from the inevitable fluctuations on the international fertilizer market. However, government policy can help to minimize any consequent problems.

The timely provision of foreign exchange will help importers to buy at the most opportune moment. Realistic market pricing is also necessary. Policies conducive to timely issuing of the foreign exchange required for fertilizer imports facilitate smooth and economic procurement. A large reliance on imports has implications for domestic fertilizer prices which tend to be affected by international market prices. Situations like that in 2008, when the international prices shot up, led to little imports by AICL. For the last two years, there have been no formal imports by the private sector on account of high fertilizer prices on the international market. Further reluctance to import by the fertilizer trade is on account of a recently introduced scheme for concessionary supply of fertilizers to targeted groups, as it affects their competitiveness in the market.

The flow of material in the domestic market is also dependent on the smooth running of the purchasing and supply chain, from foreign supplier to the importer's main warehouse. Any unexpected delay can cause a local shortage, followed by a lower harvest and lower food security. In view of the above safety nets need to be built into the system.

Informal imports channelled across the Indo-Nepalese border constitute the major chunk of fertilizer supplies in the country. Till a few years back, it was thought that the informal imports were in the order of 65 to 70 percent of total imports. However, in recent years the informal imports are estimated to be much more than that. Formal imports in 2008 were almost negligible and most of the requirement was met through informal imports.

Although the prices of informal imports are lower because of the subsidy prevailing on the other side of the border, they are disadvantaged by legal bottlenecks besides the problems of spurious/adulterated fertilizer supplies. There is a need for an agreement between the governments of Nepal and India to legalize the trade.

3.5 Minimization of import costs

Although the crop price is the most important factor affecting the demand for fertilizers, the price paid for fertilizers is also significant. Governments have a major part to play in ensuring that farmers receive fertilizers at the lowest possible cost commensurate with a reliable and timely supply.

In a country like Nepal, where fertilizers are imported, the most significant factor is the cost delivered to the border point. The fertilizer fob price, the cost of shipping, discharging, bagging and loading on trucks at the port of delivery are important components. There is usually scope for reducing costs and government policy can be of help in various ways:

- Maintaining a stable exchange rate will stabilize import costs.
- An adequate supply of foreign exchange will make it possible to import at the right time to meet demand.
- Fertilizer imports should be kept free from import taxes and duties.
- Port and agency charges should be kept under constant scrutiny and compared with charges in other similar ports.

Internal transport, warehousing and handling charges are important cost components. Costs increase due to high taxes, duties levied by the government itself. In order to keep the costs low, the government has exempted fertilizers from import duties.

3.6 Ports and handling facilities

Imports are presently through Kolkata/Haldia port in India and brought by rail or road to the India-Nepal border point at Birgunj. In order to avoid delays due to excessive congestion at Kolkata, using an alternative Indian port such as Vishakhapatnam needs to be explored. This port, although it is farther from the Nepal border point than Kolkata, may have the advantage of quicker berthing, thereby avoiding waiting charges.

At present Birgunj has a handling and warehousing capacity for about 10 000 tonnes of fertilizer material. This needs to be expanded to meet growing requirements. In the long term- other border points such as Biratnagar, Bhairahawa, Nepalgunj and Dhangadi need to be developed adequately.

There is always scope for improving mechanical offloading equipment, and facilities must be such that they can deal smoothly and efficiently with the expected rates of delivery.

Handling methods resulting in damage to bags, such as using hooks, must be eliminated. Storage facilities must be clean and dry and there must be sufficient space to keep the different products separate and permit easy removal from store.

3.7 Fertilizer transportation and warehousing

The first criterion of effectiveness in fertilizer distribution is that the product be available at the right place, at the right time and in the right quantity. To a large extent this depends on the existence of suitable transport modes and storage facilities. Economical ways to tackle transport and storage problems may be found through good management and effective planning.

Transportation

Inland fertilizer transportation takes place by road. Road transportation is economical for short distances since it is generally quicker, there is less handling, losses in transit are lower and it offers better opportunities for return loads and competitive pricing. To obtain the maximum benefits from road transport, fuel costs can be reduced by proper route planning and by ensuring return loads. Partly laden trucks and long detours to deliver only small quantities need to be avoided since they lead to unnecessary costs.

Warehousing

The seasonal demand for fertilizers makes it imperative that fertilizer stocks are held in primary or secondary storage points for subsequent distribution. AICL has a large warehousing capacity of 68 000 tonnes. Prior to deregulation, when AIC had the monopoly of imprts, the capacity was fully utilized. However, since deregulation the capacity has been grossly underutilized. The cooperatives are also said to have a large storage capacity, in this case 59 000 tonnes, most of it unused.

Planning at national level in regard to economic transport routes and location and extent of storage capacity, with economic and fertilizer movement considerations in mind would go a long way to cutting marketing costs and ensuring timely availability of the fertilizers to the farmers. Such an exercise would have to be done in coordination with and full participation of all the stakeholders in the fertilizer sector.

Buffer stocks

An importing country like Nepal is vulnerable to price and supply fluctuations in the world market and to supply shortfalls arising from higher than expected demand. Some buffer stocks are therefore advisable. The National Fertilizer Policy (2002) has a provision for maintaining 20 percent of the national demand as buffer stocks. However, there are currently no buffer stocks to meet emergent needs.

3.8 Marketing fertilizer products

Fertilizer marketing policies should ensure that appropriate products are made available to the farmers. Marketing of high analysis fertilizers would mean lower transport and handling costs. Among the various fertilizer products imported, urea (46:0:0), DAP (18:46:0) and MOP (0:0:60) hold the major share.

Micronutrient carriers like zinc sulphate, and borax are available along with some multi-micronutrient mixtures and liquid biofertilizers. Marketing of multi-nutrient mixtures have to be approached with caution, since it may lead to applying micronutrients to soil which is not actually deficient in those particular nutrients. In the long term this could lead to toxicity.

Also on the market are liquid biofertilizers with no labelling as to their formulae. Authentic evaluation reports verifying their claim to be beneficial are few and far between. The Nepal Agricultural Research Council (NARC) needs to evaluate such products, and their registration with AISM should follow only after satisfactory evaluation. The manufacturers should also label the containers with details of the products' composition.

Also on the market are soil amendments such as lime.

Fertilizer mixtures are available from specialized mixing units. However, as well as being more expensive, the mixtures suffer from quality control problems. A better option is to apprise the farmers how to make their own mixtures by combining straight fertilizers in the desired proportions.

3.9 Fertilizer marketing and distribution

The function of marketing is to achieve efficient distribution. Properly carried out, it ensures that the right products are available to the farmer at the right time and at the optimum price, consistent with the provision of a reliable supply. Marketing also seeks to increase sales of fertilizers to benefit both merchants and farmers.

The overall goal of marketing policies should be to enhance effectiveness by providing farmers with appropriate products on time, and to improve efficiency by lowering or eliminating unnecessary marketing and distribution costs. This can be achieved by careful monitoring and strict control of marketing operations.

Providing an element of choice or extending the existing level of choice to the farmer is probably the single most important factor in improving the performance of the market. At the wholesale/retail level, policy should be directed to initiating or promoting a more competitive market situation. Besides the competition it would provide for lower costs. The National Fertilizer Policy (2002) provides equal opportunities for to the public, private and cooperative sectors to compete fairly in marketing.

Many farmers feel more inclined to buy fertilizers if a retail outlet is within easy walking distance. Policies should be directed to provide even distribution of the fertilizer retail infrastructure. In the rural interior there are very few retail outlets and farmers have to cover long distances to procure fertilizers. The fertilizers are available in 50-kg bags. Since they have to be carried up to the hilly regions, stronger bags are needed to prevent pilferage and transit losses.

Provision of smaller packs (for e.g. 25 kg) may be helpful in facilitating small farmers' access to fertilizers. However, re packaging would involve additional handling, and therefore higher costs.

Policy should take into consideration that marketing systems will only be effective if an adequate margin is built into the price structure to cover actual costs of transport, storage, administration and overheads as well as the mark-up to return a reasonable profit and to compensate for the risks that any business venture faces. At present, AICL provides a distribution margin of US$3.3 per tonne, which may be inadequate to motivate either the cooperatives or the private sector to take up the fertilizer business.

3.10 Capacity building in the fertilizer marketing system

An adequately trained workforce is a prerequisite for implementing fertilizer marketing policies. Capacity-building programmes for the various cadres of the marketing system are necessary. Such programmes are needed at the following levels:

- Senior managers: The programme should focus on how each marketing function can be performed effectively and integrated so as to provide an efficient marketing system.
- Fertilizer distributors and dealers: The programme should emphasize efficient operation of a fertilizer retailing business and appropriate knowledge of fertilizer use, to enable the participants to assist the farmers in making correct decisions about fertilizer purchase and application.
- Field-level staff need to be trained in skills relating to upkeep of sales points, store-keeping, loading and offloading of fertilizers, avoiding damage to the bags and minimization of losses during transport, handling and storage.

Capacity building is best conducted with the help of professionals. While most organizations are keen on capacity-building, policies should emphasize that such programmes are conducted regularly at all levels by the stakeholders to enhance human resource capabilities efficiently, with the full support of experts on the various subjects.

3.11 Fertilizer credit

Access to credit is important for the farmer because of the long period that elapses between the purchase of inputs, such as fertilizer, and the sale of crops. The usual sources are banks, local traders or the cooperatives. From the policy angle, while providing credit is necessary, loan repayments are equally important. Otherwise there is a risk that the financial institutions may fail.

The agricultural development and rural microfinancing banks are the main source of credit. However, there is no provision of soft loans for agricultural inputs. Prevailing high rates of interest serve little purpose. There is a need for further development of savings and credit cooperatives which also provide loans. Apparently some private banks also intend to extend agricultural loans at low rates of interest.

Many of the banks have shifted their branches from rural to urban areas because insurgency has adversely affected farmers' access to credit institutions.

Credit is also 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. The dealers' financial needs will increase in line with the increase in volume of sales. To meet these needs, they have recourse to commercial or government banks and other institutional lending agencies. In the event of domestic fertilizer price rise, additional credit may be granted.

3.12 Profitability of fertilizer use

Fertilizer use has to be profitable for it to be used by the farmers. A value-cost ratio (VCR) analysis reveals that with the current open market price for fertilizers and the output price for the foodgrains, use of nitrogenous fertilizers is highly profitable for all the major crops viz. wheat, rice and maize. Use of phosphates is quite profitable for wheat and maize but not so much for rice. Use of potash fertilizers is not so remunerative because of the high nutrient price and lower crop response. An increase in output price is seen as a better option than provision of subsidies for enhancing the profitability of fertilizer use. However, the output price has to be kept at a reasonable and affordable level.

3.13 Pricing and subsidies

Prior to 1997–98, fertilizer subsidies were used extensively to encourage the use of fertilizer. Financing the subsidies required higher taxes and increased external borrowing. Although these subsidies increased the use of fertilizer, the cost was very high. While they played a significant role during the introduction of fertilizers, their relevance in the present context of higher fertilizer use has diminished to a certain extent.

The government initiated deregulation of the fertilizer trade in November 1997 with the complete elimination of subsidy on DAP and MOP and phased removal of subsidy on urea. The subsidy removal was complete by November 1999.

However, beginning on 25 March 2009, fertilizers have been made available at a concessionary rate on a limited scale, targeting small and marginal farmers. The current provision of subsidy is limited to a fixed quantum of 100 000 tonnes of fertilizer material per annum with an estimated outlay of NRs1.5 billion. Farmers with land holdings of <0.75 ha in the Hills and Mountains and <4 ha in the Tarai are eligible for the subsidy. A provision for meeting transport costs for 26 districts through a special programme also exists. The scheme is in line with the existing provisions of the National Fertilizer Policy (2002).

In Nepal, farm holdings are small. The upper limit of 4 ha for the small farmers is considered to be on the high side and needs to be re-examined.

Also, there is a need for strict monitoring of the system to ensure that the subsidy reaches only the targeted groups and that there are no unwanted leakages. Identifying eligible beneficiaries is difficult on account of the fact that farmers usually possess as many land ownership certificates as the number of plots they own.

Urea is comparatively cheaper than other fertilizers and no further promotion is required to promote its use. Accordingly, there is scope for gradually bringing down the concessions on urea. This would also lead to economies and savings for the state exchequer.

3.14 Quality control

The AISMS has been entrusted with the responsibility for fertilizer quality control. The government promulgated a fertilizer control order (1999) under the Essential Commodities (Control) Act, 1996. Standard specifications and tolerance limits for various fertilizer products have been laid down.

The quality control set up consists of a single fertilizer inspector for each district. Fertilizer samples are sent for analysis to the soil testing laboratories which need further strengthening in terms of analytical facilities and trained personnel.

Quality control concerns have been on the increase especially for material entering the country through informal channels. However, the fertilizer quality programme has not been very effective. Despite a good number of fertilizer samples having been found sub-standard/adulterated no penal action has materialized.

Fertilizer Inspectors lack logistical and manpower support. Provision of semi-judicial powers would enhance their performance. Capacity-building programmes for the inspectors, focusing on legislative as well as technical aspects of their role is important.

3.15 Efficient fertilizer use and R&D

Fertilizer recommendations based on research studies carried out about 15 years back are in vogue. However, these recommendations need to be revised in view of changed management practices and the introduction of several new varieties. The soil testing service needs to be provided with more funds and a trained workforce.

With more and more exploitation of land for agricultural production, use of high yielding varieties and use of high analysis fertilizers, micronutrient deficiencies are cropping up. There is a need to develop and strengthen micronutrient analytical capacities.

Agricultural research is a prime government responsibility and the government should give high priority to funding research institutions especially the Nepal Agricultural Research Council (NARC). The NARC's present research programme suffers from a dearth of funds and a lack of qualified personnel. In view of high fertilizer costs, more emphasis should be given to research aimed at improving fertilizer use efficiency.

In order to overcome the complexities arising out of the interaction of numerous factors in the soil-plant system, advantage could be taken of the advances made in the field of Information Technology. Models of various soil-plant systems could be developed to serve as powerful tools in resource management. Development of simulation models could be helpful in understanding the role of various variables in fertilizer use efficiency and optimization of resource utilization. An effective fertilizer policy must take into consideration the above-mentioned aspects and make suitable provision to deal with the issues.

3.16 Development and use of supplementary nutrient resources and integrated plant nutrition system

The present government policy lays emphasis on increased production and use of organic manure. Farmyard manure (FYM) and compost are intensively used for certain crops such as vegetables. Soil productivity and environmental concerns have revived global interest in organic recycling practices such as composting. An overview of on-farm composting methodologies, with special emphasis on rapid composting processes, has been provided by Misra and Roy (2003). The overview is intended to promote the wide-scale adoption of composting with the ultimate objectives of improving soil productivity in developing countries and protecting the environment from degradation. Some of these methodologies can be adopted for local situations. The scope for using rice straw to make organic manure is limited since it is also used as fodder for livestock.

Use of biofertilizers is limited. Rhizobium inoculants are currently used for soybean and forage legumes. More in-lab research and field studies are needed to explore the feasibility of blue-green algae and Azolla use at the field level.

In order to support soil fertility management effectively, it is prudent to adopt environmentally-friendly plant nutrition management technologies such as IPNS. The National Fertilizer Policy (2002) recognizes the importance of IPNS and advocates its field-level implementation.

However, adoption of IPNS by the farmers is low. Special emphasis should be given to participatory on-farm research on IPNS for developing location-specific IPN recommendations in relation to specific cropping systems. There is a need for intensive extension efforts to provide the technology, management skills and motivation. Farmers' Field Schools (FFS) could also impart IPNS skills to the farmers and such training should be included in the FFS curricula.

In view of the problems relating to fertilizer supply in the remote and hilly areas and the growing remunerative potential of organic produce in the international market, there is a proposal to promote organic agriculture in 36 hilly and mountainous districts of the country. Helvetas, an NGO, has demonstrated the applicability of sustainable soil fertility management practices in certain selected parts of the Hill region based on organic nutrient resources. The results need to be examined for applicability to other agro-climatic zones and also from the angle of maintaining the long-term fertility of the soils in intensive cropping systems.

3.17 Soil health management

Information relating to current soil fertility levels and soil health for the various agro-ecological zones has yet to be mapped fully because of inadequacies within the soil testing programme. In the interest of a sustainable soil fertility management, there is a definite need to evolve a system to provide for regular assessments and monitoring of soil health.

Soil fertility maps for 26 districts are available. Major nutrient deficiencies are widespread. Secondary and micronutrient deficiencies have also been cropping up. In the Tarai, the organic matter content of the soils reveals a declining trend, emphasizing the need for better adoption of organic recycling practices. Formation of subsoil hard pans in Tarai soils has also been reported. Soil acidity problems are widely encountered and are on the rise.

Benchmark studies need to be planned for each of the agro-ecosystems to assess and monitor the health of the soil system at regular intervals and to establish the changes occurring as a result of current agricultural practices especially input use. Nutrient-balance assessments are valuable tools for delineating the consequences of farming on soil fertility. Various approaches and methods for different situations have been used (Roy, *et al*., 2003). Suitable approaches can be used for various agro-ecological situations in Nepal.

Attention to the assessment and monitoring of the following aspects is considered important:

- changes brought about in soil fertility status with regard to major, secondary and micronutrients;
- alterations in soil organic matter content and physio-chemical soil properties;
- build up of nutrient toxicities, if any;
- development of problems relating to acidity; and
- soil biodiversity especially relating to micro-flora.

3.18 Preventing/mitigating adverse effects of fertilizer over-usage on environment

Fertilizer use has allowed farmers continuously to achieve high yields on the same land for many years. However, in the current situation, some farmers seem inclined to apply overdoses especially for commercial crops. Further, it is often the case that failing to adopt or partly adopt an improved cropping package leads to lower nutrient uptake with consequent nutrient loss and environmental pollution.

Nutrients applied in excess, especially nitrogen, and not taken up by the crop, are likely to be lost to the environment. Efficient fertilization is synonymous with the minimization of nutrient loss to the environment. Correct fertilization must be accompanied by other appropriate agricultural practices. Soil nitrogen balance assessment (SNBA) serves as an effective tool for estimating the magnitude of nitrogen loss/gain of the agro-ecosystems and appraising their sustainability. Quantitative information relating to nitrogen escape into the environment through such exercises can be used to identify causative factors. This helps to enhance fertilizer use efficiency and formulate programmes aimed at plugging N leakages. An overview of nitrogen balance approaches and methodologies has been presented by Roy and Misra (2005).

Erosion control measures can effectively check phosphorus pollution. Minimum tillage and soil conservation measures are very effective in protecting surface water from the effects of phosphates transported with eroded soil.

In order to control the overuse of fertilizers, promote the efficient use of fertilizers and to check the adverse effects of fertilizer use, the policies need to give consideration to the following aspects:

- strengthening of soil testing facilities for major and micronutrients and promoting the adoption of site-specific soil test based fertilizer use recommendations;
- promotion of improved agronomic and efficient fertilizer use practices;
- enhanced support for R&D on fertilizer use efficiency;
- adoption of IPNS at the farmers' level;
- adoption of soil conservation measures;
- establishment of a monitoring system for natural resource pollution; and
- enactment of regulations to prevent environmental pollution.

3.19 Expansion of knowledge base for promoting efficient use of fertilizers

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. A high degree of priority needs to be given to the extension sector.

Extension workers must make use of demonstrations, farmers' meetings, crop seminars/festivals, field days, group discussions and audio-visuals to disseminate technology pertaining to efficient fertilizer use and IPNS and help farmers adopt the same. Regular farm visits by extension personnel must be ensured.

Farmers' participation in extension activities is extremely important. Lead farmers should be involved to a good extent in extension activities and their help should be obtained for the effective spread of information and implementation of the field programmes.

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.

The extension field force must be capable of understanding the scientific findings evolved through research and of translating them into language the farmers can understand. They should also provide the farmers with recommendations based on the same. Their other function is to provide feedback to researchers on the problems faced by the farmers in adopting the technology.

The extension field force, at present under DADO, should have regular training and briefings in order to keep them abreast of the latest technological developments.

3.20 Effective coordination and monitoring of various aspects of fertilizer use sustainability and soil fertility management

Effective planning, development and implementation of a national fertilizer and soil fertility management programme involving various activities such as fertilizer procurement, production, demand forecasting, logistics, marketing and distribution, quality control, efficient use and soil fertility management calls for efficient coordination. Effective coordination provides much needed sustainability to the system.

Several institutions are involved in implementing the programme, and efficient performance of their functions needs to be ensured through provision of information and expert guidance. An apex institution capable of performing such coordination is therefore important.

Monitoring is also important. To be effective, the monitoring institution should be delegated with adequate authority.

Some of the salient areas on which a coordinating and monitoring unit should focus on include the following:

- advice to the government on fertilizer and soil fertility management policies;
- fertilizer demand assessment for the short, medium and long term;
- import procedures, tendering and handling at port;
- keeping a track of international fertilizer market and fertilizer prices;
- coordination of foreign exchange requests for imports;
- national fertilizer production;
- registration of importers, manufacturers and dealers;
- market development;
- undertaking studies on fertilizer demand, supply and price trends, marketing costs and margins and logistics,
- quality control of fertilizers;
- studies relating to the impact of fertilizer use on productivity, and identifying problems faced by farmers;
- compilation and analysis of statistics on various aspects of fertilizers and soil fertility management; and
- measures to promote IPNS to improve crop response and fertilizer use efficiency in order to maximize returns and farm income.

The AISMS has been assigned responsibility for coordination and monitoring.

To do so effectively, AISMS needs further strengthening in terms of personnel, capacity-building, logistics, IT and infrastructural support, which will have to be provided by the government.

While keeping the foregoing recommendations in mind, the main policy spheres requiring government support are:

- formulation and implementation of strategies leading to a self-sustaining agricultural production programme with little dependence on outside financial assistance;
- measures for improving the terms of trade for agriculture and profitability of input use;
- improving individual property rights to induce farmers to take more interest in building up long term soil fertility;
- exercising a check on inflation by reducing expenditure and tightening monetary policy since inflation seriously hampers the procurement of imported fertilizer and consequently its availability.
- measures for improved infrastructure such as roads to facilitate transportation of both fertilizers and crop produce;
- development of irrigation resources to enhance crop response to agricultural inputs;
- policy measures for promoting the growth of a healthy and efficient fertilizer sector, with enhanced private sector involvement, accompanied by regular review of government controls in order to make them better able to achieve their objective.
- participation and investment in joint sector projects in neighbouring countries;
- exploration of sites where deposits of phosphate rock may be found and using the PR to produce finished products like PAPR;
- strengthening the mechanism for realistic demand assessment and forecasting;
- timely provision of adequate foreign exchange for fertilizer imports and adoption of policy measures aimed at minimizing import costs;
- development of an effective and economic model for transporting and warehousing fertilizers;
- development of an adequate and well distributed retail network;
- monitoring, administration and rationalization of fertilizer prices and subsidies to ensure that they serve the national interest and objectives;
- ensuring adequate provision of agricultural credit for the farmers;
- promotion of fertilizer distribution channels that are appropriate to prevailing marketing and economic conditions;
- measures for keeping overall marketing costs as low as possible;
- enforcing effective legal sanctions to ensure the availability of good quality fertilizers to the farmers and institutional support for fertilizer testing and quality control;
- providing the required institutional, technological and R&D support for soil fertility management, promotion of efficient fertilizer use, IPNS, soil testing and conservation agriculture;
- devising a mechanism for monitoring soil health and adoption of measures to check unscientific/ overuse of fertilizers;
- strengthening the technology transfer mechanism and maintaining its efficiency through regular capacity-building programmes; and
- strengthening the national coordination and monitoring body to oversee the various aspects of sustainable fertilizer use and soil fertility management.

References

APP. 1995. *Agriculture Perspective Plan (1995–2015)*. Kathmandu, NPC, Government of Nepal.

CBS. 2006. *Statistical Year Book of Nepal*. Kathmandu, Central Bureau of Statistics, Government of Nepal.

CBS. 2007. *Statistical Year Book of Nepal*. Kathmandu, Central Bureau of Statistics, Government of Nepal.

FAO/GIEWS. 2007 *Special Report, FAO/WFP Food Security Assessment Mission to Nepal, 25 July 2007,* GIEWS Country Briefs – Nepal, 7 October 2009. Rome, FAO/GIEWS.

FAO. 1990. *Increased crop production and farmers' income in the hills through the use of fertilizer and related Inputs*, Technical report for Government of Nepal. FAO Fertilizer Programme: GCPF/NEP/030/NET, FAO

Goletti, Francesco. 2001. The Impact of fertilizer subsidy removal in Nepal. *Discussion Paper No. 1. Agricultural Sector Performance Review*, ADB TA3536-NEP.

Misra, R.V., Roy, R.N. & Hiraoka, H. 2003. *On-farm composting methods*. Land and water discussion paper 2, Rome, FAO.

MOAC. (1995–2008). *Statistical information on Nepalese agriculture (time series information) for various years*. Kathmandu, Ministry of Agriculture and Cooperatives, Government of Nepal.

Roy, R.N., Misra, R.V., Lesschen, J.P. & Smaling, E.M. 2003. Assessment of soil nutrient balance – approaches and methodologies. *Fertilizer and plant nutrition bulletin*, (14). Rome, FAO.

Roy, R.N. & Misra, R.V. 2005. Soil nitrogen balance assessment and its application for sustainable agriculture and environment. *Sci China C Life Sci*. (48) Special Issue 843–855, Science in China Press.

Thapa, Y.B. 2006. *Constraints and approach for improving fertilizer supply for meeting domestic demand*. Prepared for Economic Policy Network GON/MOF and ADB Nepal Resident Mission.

Pakistan

by

Nisar Ahmad

1. Background

Agriculture is considered the main engine of national economic growth and poverty reduction in Pakistan. It is indeed the largest income- and employment-generating sector of Pakistan's economy, contributing around 22 percent to gross domestic product (GDP) and providing employment to 44.7 percent of the active population. The livelihood of more than 67 percent of the country's rural population is directly or indirectly linked with agriculture. Whatever happens to agriculture is bound to affect the livelihood and consequently food security of poor rural people. The irony is that despite significant progress in terms of production particularly in major cereals, Pakistan is still a food importing country. The incidence of poverty is still high at 33 percent. The incidence of food poverty is higher in rural areas (35 percent) than in urban areas (26 percent). The country is struggling to maintain daily per capita dietary intake at 2 400 kcal. About half of the caloric needs are met only through cereals with livestock products contributing between 7 to 16 percent to the daily rural diet. The dietary intake progressed from 1 754 calories per person per day in 1961 to 2 300 kcal/person/day by the end of the 1970s, but stagnated without substantial improvement in the 1980s and 1990s. The major factors for this include inadequate food supply due to high annual population growth of 2.85 percent since 1947. In addition, the small and declining size of landholdings, 32 percent being less than 1 ha and another 24 percent of less than 2 ha each, is a constraint to productivity and agricultural income. Wheat is the main staple food crop of the country and any shortfall in production affects both household food security and the national economy.

Surging international food prices during 2007–08 also affected Pakistan because of the following factors:

- increased food production costs as high oil prices pushed up fertilizer and fuel prices;
- speculation in commodity markets pushing up short-term demand;
- food price differentials with neighbouring countries that provide a strong incentive for informal trade; and
- subnational trade restrictions that led to regional imbalances in food availability.

All these developments have the potential to drive a growing section of the population below the poverty line and make them food insecure.

The Government of Pakistan constituted a task force on food security in May 2008. Its terms of reference were to review the status of the food supply and devise an action plan to promote food security. The task force considered all the dimensions of food security i.e. adequacy of food supply; access to food; and equity of food distribution and presented a strategy and policy documents, framing the needs and priorities for food security. These include an efficient, competitive and sustainable agriculture with the ability to contribute to the economic development of Pakistan. This is to be achieved through sustainable and efficient use of natural resources (land and water) and proper application of physical inputs such as increased use of quality seed, balanced fertilizer application (organic and inorganic) and integrated pest management.

Fertilizers have played a vital role in increasing crop productivity and food security in Pakistan since the mid-1960s with the advent of high-yielding varieties. The total nutrient consumption per ha from the mid-1960s to 2007–08 increased from 7 kg/ha to 161 kg/ha at a growth rate of over 5 percent per annum. During the same period, wheat productivity increased from 812 kg/ha to 2 600 kg/ha at a growth rate of about 2 percent per annum. The current average national wheat yield is scarcely 65 percent of its economic yield potential of 4 000 kg/ha obtained by a large number of progressive farmers with balanced use of fertilizers. The yield gap of rice and maize, the other two important food crops, is 45 and 58 percent, respectively. The growth in fertilizer consumption since the mid-1960s has remained skewed in favour of nitrogen because of the availability of cheap domestically produced urea and a lack of promotion of balanced and integrated fertilization. Thus, it is imperative that sustainable fertilizer and soil fertility management policies and strategies are adopted at the farm level to bridge the yield gap, provide stability to crop production and ensure food security. This report reviews and analyses the fertilizer and soil fertility management policy and strategies, identifies gaps and proposes an action plan.

2. Fertilizer and soil fertility management policies – a review

2.1 Fertilizer production

Local fertilizer production dates back to 1958, when small-scale ammonium sulphate (AS) and single super-phosphate (SSP), plants were set up by the public-sector Pakistan Industrial Development Corporation (PIDC). With the introduction of high-yielding varieties (HYVs), the demand for chemical fertilizers picked up significantly which motivated private-sector companies to undertake fertilizer manufacturing. In 1968, Exxon commissioned a new urea plant, followed by Dawood Hercules in 1971. These new plants brought state-of-the-art technology to the country.

The government's nationalization of fertilizer marketing and distribution in 1973 brought to an end, private sector investment in new fertilizer plants. The Government of Pakistan (GOP), therefore, formed the National Fertilizer Corporation (NFC), the successor organization of PIDC, with responsibility for managing PIDC fertilizer plants, marketing their production and setting up new fertilizer plants. NFC set up two urea plants – Pak Saudi at Mirpur Methalo, Sindh Province and Pak China at Haripur, NWFP in 1980. NFC also expanded urea and calcium ammonium nitrate (CAN) capacities and added new capacity of nitrophosphate (NP) in the Pak Arab fertilizer plant at Multan. However, because of financial constraints, NFC couldn't set up new fertilizer plants to keep pace with the rapidly growing demand for fertilizers. This led to permission being given for the private-sector Fauji Fertilizer Company Limited (FFC) to set up a large-scale urea plant at Goth Machhi which was commissioned in June 1982.

During the period 1973–85, the fertilizer business remained regulated. Manufacturers were allowed fixed marketing incidentals that were revised from time to time. The GOP either subsidized their production or levied a developmental surcharge on them. If the cost of production plus marketing incidentals exceeded the government fixed retail price, then the differential was given to the manufacturer as subsidy. However, if the retail price exceeded the cost of production plus marketing incidentals, then GOP received the differential as a developmental surcharge. The manufacturers were, however, allowed a fixed annual return of about 20 percent on the equity.

The regulated regime was marked by a high fertilizer subsidy burden on the national exchequer. Because manufacturers were assured of fixed returns on equity, there was little incentive for them to operate efficiently. In fact, low-cost manufacturers were subjected to a development surcharge while high-cost manufacturers received a government subsidy. Thus was efficiency penalised. However, in May 1986 GOP deregulated straight nitrogenous fertilizer prices and abolished fixed marketing incidentals and the subsidy/developmental surcharge mechanism. This not only significantly reduced the subsidy burden of GOP but also provided a great incentive to urea manufacturers to increase efficiency, reduce costs and enhance production to secure a higher return on equity. Both FFC and Engro Chemical Pakistan Limited (ECPL) – formerly Exxon Chemicals Pakistan Limited – planned new large-scale urea plants to meet domestic demand. FFC's plant came on stream in March 1993 while the ECPL plant started production in August 1995. In continuation of this policy, GOP deregulated phosphatic fertilizer prices, eliminating subsidy in 1993 and allowed the private sector to import fertilizers. In 1995, when potash fertilizers were also deregulated, the deregulation programme was complete.

The period following deregulation witnessed encouraging developments in fertilizer production. Capacities were expanded through the balancing, modernization and revamping (BMR) programme and public-sector fertilizer plants were privatized. FFC and ECPL added diamminium phosphate (DAP) and nitrogen phosphate and potash (NPK) to their production line. The public-sector NFC Pak Saudi urea plant with a capacity of 575 thousand tonnes/year, was purchased by FFC in May 2002. The Pak China urea plant with a capacity of 96 000 tonnes per year was purchased by the Shaun Group. Pak Arab, with production capacities of 100 000, 459 000 and 304 000 tonnes of urea, CAN and NP, respectively, was purchased by Fatima Fertilizer Company Limited. Lately NFC's new urea plant at Daud Khel with a production capacity of 350 000 tonnes per year, and the SSP plant at Haripur with a capacity of 90 000 tonnes per year were also privatized and purchased by the Azgard Group. With this fertilizer production became completely privatized. Table 1 presents the plants' installed capacity for nutrient fertilizers and actual production in the country during FY 2008–09.

Table 1: Fertilizer production (2008–09)

A	Stage	Capacity (Nutrients '000 tonnes)				Production (Nutrients)	Capacity Utilization
i.	*Factories under production*	N	P_2O_5	K_2O	Total	'000 tonnes	%
ii.	Dawood Hercules	205	–	–	205	235	115
iii.	Engro Chemical Pak Ltd.	391	–	–	391	427	109
iv.	Pak American (AZGARD), Daud Khel	159	–	–	159	176	111
v.	FFC (Rahimyar Khan)	612	–	–	612	771	126
vi.	FFC (M. Methalo)	265	–	–	265	324	122
vii.	FFC (Bin Qasim)	365	331	–	696	625	90
viii.	Pak Arab (Fatima Group), Multan	224	81	–	305	284	93
ix.	NFC/(AZGARD)	–	29	–	29	32	110
B	ECPL NP/NPK	20	33	10	63	55	87
x.	*Factories under implementation*						
xi.	Engro Chemical Pak Ltd.*	598	–	–	598		
	Pak Arab (Fatima Group)**	428	80	–	508		

Source: *NFDC database, 2009*
* *Starting July 2010*
** *Urea production starting March 2010; other products one year later*

The installed capacity of the plants and their actual production in FY 2008–09 is given in Annex 1. The performance of all urea plants was above capacity, showing excellent output and efficiency. Production of various fertilizers for selected years since 1985–86 is presented in Table 2.

Table 2: Fertilizer production since 1985–86 ('000 tonnes)

Year	Urea	CAN	AS	NP	SSP	DAP	NPK	Total
1985–86	1 834	394	102	323	106	–	–	2 759
1991–92	2 030	319	95	321	164	–	–	2 929
1995–96	3 258	383	84	337	104	–	–	4 166
2000–01	3 983	374	–	285	160	321	2	5 125
2004–05	4 611	330	–	339	164	408	139	5 991
2008–09	4 921	349	0	338	178	534	57	6 377
CAGR	*4.6*	–	–	–	–	–	–	*3.9*

Source: *NFDC database, 2009*

Table 2 shows that urea production increased significantly, whereas CAN and NP production remained static and the AS facility was closed down in 1997. SSP production showed an increase because of a number of small producers using local rock phosphate to make SSP containing 14 percent P_2O_5. Fauji Fertilizer Bin Qasim (FFBQ) at Karachi expanded DAP production capacity to 720 thousand tonnes.

New capacities

To bridge the gap between domestic production and consumption, the government announced a fertilizer policy in 2001, with the main objective of encouraging new investments in the fertilizer sector. The main feature of the policy was to ensure the availability of gas at rates close to those of Middle East producers for a period of ten years and allow duty-free import of phosphoric acid and rock phosphate. Pursuant to this policy ECPL's new urea plant, with a capacity of 1 300 000 tonnes/year, was expected to start commercial production by July 2010. The plant will cost US$1.05 billion. It is the largest private sector investment by a national corporate body in the form of the world's largest single train ammonia-urea plant. It is supported both by a consortium of national banks and international financing agencies. The Fatima Fertilizer Company's new plants, with annual production capacities of 500 000 tonnes of urea, 350 000 tonnes of NP, 200 000 tonnes of NPK and 450 000 tonnes of CAN, were in an advanced stage. Commercial urea production was expected to start by March 2010, but other products could take another year. The two plants would give the country surplus urea after July 2010.

Raw material

Each fertilizer plant has an allocation of the main raw material for urea production, natural gas. The plants consume around 200 000 million cubic feet per day (MMCFD), which accounts for about 20 percent of gas consumption in the country. Local deposits of rock phosphate contain low levels of P_2O_5 and are therefore used in only 14 percent of SSP production, by small producers. Phosphoric acid for DAP is imported from Morocco under a joint venture between FFBQ and OCP. The local rock phosphate deposits have the potential to replace imported rock if developed properly.

2.2 Fertilizer imports/exports

Despite a wide base of fertilizer production, the country has remained a net importer of fertilizer, the volume of imports changing slightly in terms of quantity and products. Imports of fertilizer nutrients have ranged from 579 thousand tonnes to a maximum of 1.3 million tonnes since 2000–01 (see Table 3). The share of total nutrient availability has remained within a range of 17 to 20 percent except for 2006 when it was 29.39 percent.

Table 3: Fertilizer imports since 2000–01

Year	Imports ('000 tonnes)				Percent change over base year	Share in total availability %*
	N	P_2O_5	K_2O	Total		
2001	194	369	16	579	–	17.25
2002	178	429	18	625	7.94	19.13
2003	216	542	8	766	22.56	22.56
2004	204	553	6	763	-0.39	20.97
2005	310	458	17	785	2.88	20.04
2006	603	640	25	1 268	61.53	29.39
2007	308	476	12	796	-37.22	19.72
2008	287	566	24	877	10.18	21.72

Source: *NFDC database, 2009*

* *Total availability consists of opening balance plus domestic production plus imports*

In product terms the major recent imports were of DAP followed by urea. The other imported products are mono-ammonium phosphate (MAP), triple superphosphate (TSP) and sulphate of potash (SOP). Imports for selected years since 1985–86 are shown in Table 4.

Table 4: Fertilizer imports in selected years ('000 tonnes)

Year	Urea	DAP	NP	TSP	MAP	SOP	MOP	NPKS	AS	Total
1985–86	0	323	4	0		57	0	58		442
1990–91	541	499	83	0		98	0	27		1 248
1995–96	389	598	0	230		37	0	100		1 354
2000–01	86	773	47	0		0	22	15	15	943
2001–02	0	919	26	0		20	11	5	32	981
2002–03	0	1 124	30	9	28	16	0	0	17	1 224
2003–04	0	1 046	31	52	79	0	10	0	0	1 218
2004–05	307	811	36	53	100	6	23	0	15	1 351
2005–06	825	1 171	–	88	116	46	3	–	–	2 249
2006–07	281	935	–	–	68	7	14	–	–	1 305
2007–08	181	1 072	–	51	94	35	11	–	–	1 444

Source: *NFDC database, 2009*

Fertilizer import policy

Fertilizer imports remained regulated by the public sector. The fertilizer import department (FID) attached to the Ministry of Food and Agriculture (MINFA) was the main agency responsible for imports. In line with the policy prevailing until 1992, imports were distributed between the public and private sectors in a ratio of 40:60. Imported fertilizer was further allocated to each province and the provincial quotas divided among distributors on the basis of their market share. The private sector was hesitant to enter the import business mainly because of the subsidies, trade barriers and concessions in favour of FID.

In a major policy decision in 1993 the government granted the private sector the same import and distribution concessions as FID. The private sector entered the fertilizer import business in 1994–95.

Following the government's decision to allow private sector imports, new companies entered the fertilizer import and marketing business. In 1999–2000, about 25 companies were importing and marketing fertilizer. However, through lack of experience many of them suffered heavy losses resulting from non-recovery of credit extended to dealers. The number of companies importing DAP fell from 20 in 2000–01, to nine in 2003–04. However, as of 2009–10, about five new parties had joined the field. The rest of the imports in the private sector were by local fertilizer manufacturers. All of the urea was imported by the Trading Corporation of Pakistan (TCP), a public sector organization.

Fertilizer importers

At present the importers can be classified into four categories:

i. **Fertilizer manufacturers:** FFC and ECPL started joint imports in 1994, and Dawood Corporation Ltd. (DCL) joined them in 1995. This consortium continued importing urea and P (phosphate) fertilizer requirements until 1998. Thereafter each company resorted to importing on its own. The other manufacturers, Pak Arab (Fatima Group) and Pak American (Azgard Group), have also started their own imports.

ii. **Fertilizer indenters/importers:** Some of the local representatives of international fertilizer manufacturers and fertilizer trading houses also became fertilizer importers-cum-marketers. They supply fertilizer to other importing organizations and import consignments to market themselves. Such firms include Jaffer Brothers (Pvt.) Limited, Ace International (Pvt.) Limited, and Pacific Chartered.

iii. **New business parties** that entered into importing and marketing as a new venture.

iv. **Trading Corporation of Pakistan (TCP):** The function of TCP, a public sector organization, is confined to import of urea only. The quantity of imports and the various importers' share from July to December 2009 are presented in Table 5.

Table 5: Fertilizer imports – July to December 2009

Importer	Quantity ('000 tonnes)	Percentage share
Manufacturer/Marketer	404	22
Indenters/Importers	135	7
New business	320	17
TCP (urea)	1 000	54
Total	1 859	100

Source: *NFDC database, 2009*

TCP's 54 percent share is exclusively for urea. TCP's role as an importer will end once the country achieves surplus production by 2010–11, calling for measures to export. There will be no further subsidy on imported or locally produced products including urea.

Urea imports policy since 2005

Pakistan experienced a shortfall of urea in 2004–05. This necessitated imports but at that time international prices of urea had risen to about US$300/tonnes CFR Karachi. The price further escalated as high as US$850/tonne, raising the price differential between domestic and imported urea from US$10 to US$13 per 50-kg bag and subsequently reaching an all time peak of US$60 per 50-kg bag by July 2008. Even with weighted averaging of locally manufactured and imported urea, the price differential was very high. The GOP was not prepared to pass on such an increase to farmers as it would have adversely affected their financial returns. Instead the government decided to subsidize urea imports in order to bring their retail price to a par with the prevailing price in the domestic market.

The responsibility for importing the deficit quantity of urea was assigned to the Trading Corporation of Pakistan (TCP). This public-sector organization, having no experience of fertilizer imports, had been failing to arrange timely imports of urea since 2004–05. This fiasco was at its peak in 2008–09, when government as a temporary arrangement reverted back to marketing the imported urea through a defunct public-sector organization, National Fertilizer Marketing Limited (NFML). To aggravate the situation further, the urea was placed at utility stores, (government-subsidized food stores) of which there are very limited number. All these measures led to black-marketing, corruption and price escalation. Most of the farmers were deprived of this good government intervention and had to pay higher prices.

Financing of imports

When fertilizer imports were deregulated, concerns were expressed that the private-sector companies would not be able to arrange the financing required for imports. However, none of the manufacturers importing fertilizer had any problem either obtaining financing from commercial banks or using their own resources. The new importers had no difficulty either in obtaining bank credit.

Before deregulation, the availability of foreign exchange was very limited. Today, foreign exchange is tight but it is readily available from banks and the open market for fertilizer.

Fertilizer exports

Pakistan achieved self-sufficiency in urea production with some surpluses from 2001 to 2004. During these four years, 138 thousand tonnes of urea was exported. Then in 2005 urea imports started again as demand exceeded local production.

2.3 Fertilizer transport

The two means of transporting fertilizer from source to dealer/warehouse destination are road and rail. More than 90 percent of product is shipped by road because of the limitations on rail in terms of engine power and availability of wagons. Further, more than 60 percent of the track and wagons have outlived their usefulness. Another factor contributing towards lower use of rail to transport fertilizer is the relatively low priority accorded to fertilizer movement by GOP compared to wheat and oil products.

The inability of railways to meet the demand of fertilizer companies has exerted a lot of pressure on road transportation. The trucking industry is very resilient and has kept pace with the increasing demand not only of fertilizers but other commodities as well. The configuration of trucks has changed. In contrast to the 10-tonne trucks that were the norm before the 1990s, most trucks now have capacities of 30, 40, 50 or 60 tonnes. An efficient and dependable transport system is vital for placing products at the right place and time.

In 2007–08, a total of 6.24 million tonnes of fertilizers were domestically produced and 1.44 million tonnes imported. Thus about 7.68 million tonnes of fertilizer products had to be transported from the manufacturing plants or Karachi port to destinations in the fertilizer-consuming areas. Over 50 percent of local production has to be transported from the FFC and ECPL plants located on national highway N-5 within 65 km of each other. Assuming a uniform distribution of production (300 active days) throughout the year, 2.56 million tonnes of domestically produced fertilizer has to be transported daily, 55 percent of which come from the FFC and ECPL plants. However, in the peak demand period the requirement is higher. At these times transport is needed both for daily production and the fertilizer stocks stored at the plant warehouses.

In the case of imports, around 40 vessels carry fertilizer into Karachi port every year. During the peak period of October, November and part of December, two or three vessels can be discharging fertilizer cargo simultaneously. Further, the fertilizer stored at Karachi has to be shipped out during the same period as that from the manufacturing plants. As a result the demand for transport soars, causing port congestion and higher costs.

The constraints on transport are felt especially at Karachi and at the FFC and ECPL plants in Goth Machhi, Mirpur Methalo and Dharki. Marketing companies invariably have to submit to an ad hoc increase in freight rates during this period.

Freight costs have also increased substantially because of the increased capital, running and maintenance costs of the trucks. In the past few years the government has increased the price of diesel at a higher rate than petrol, resulting in high transportation costs for the fertilizer marketing companies. It has been calculated that a 10 percent increase in the price of diesel increases freight costs by 2 to 2.5 percent. Transportation normally accounts for around 69 percent of total marketing costs for companies operating nationwide.

Transportation by NLC

Before deregulation the National Logistic Cell (NLC) was responsible for transporting all imported fertilizers by road. They did this either with their own vehicles or through hired mechanical transport (HMT) from the market. However, since deregulation their role and share in fertilizer transportation has gradually decreased and at this stage is negligible.

The fertilizer manufacturers continue to utilize NLC transportation at their plants especially during the peak demand period. However, NLC's share in total road shipments is insignificant and their freight rates usually higher than those of private haulage contractors.

Fertilizer warehousing

Field warehousing is necessary because of the sharp seasonality of fertilizer demand and resulting variation in requirements. When the supply is surplus, warehousing requirements increase till the onset of the peak demand period when the dealers make their purchases. However, when a shortage or even a tight supply situation is anticipated the dealers make pre-season purchases to ensure availability in the peak demand season, thus reducing the fertilizer companies' warehousing requirements.

There is ample warehousing space and many parties ready to build custom made warehouses for the fertilizer companies.

It is very interesting to note that despite a massive increase in local production, supply and sales of fertilizer, warehousing requirements both in absolute terms as well as in percentage of sales have shrunk since 2000. This is well demonstrated in Table 6.

Table 6: Supply/demand balance

Year	Total Availability = Opening stock + production + imports	Consumption/ Sales	Gap	Gap (%)
	'000 tonnes			
2000	7 018	5 940	1 078	18.0
2005	8 092	7 688	404	5.2
2006	8 856	7 893	963	12.2
2007	8 309	7 553	756	10.0
2008	8 441	7 640	801	10.5

Source: *NFDC database, 2009*

Table 7: Warehousing capacities

Private sector	Quantity '000 tonnes	Percentage share
FFC	289	52.4
ECPL	85	15.4
Pak Arab	30	5.4
JBL/Others	20	3.6
Sub-total	**424**	**77**
Public Sector (NFML)	128	23
Grand Total	**552**	**100**

Source: *NFDC database, 2009*

As may be seen from the table, the highest inventory of 1.07 million tonnes was by the end of FY 2000 and the lowest 404 000 tonnes in FY 2005. Before privatization, inventories were generally higher, around 20 percent of sales. With deregulation and efficient distribution systems, the inventories have dropped to around 10 percent. The sector-wise field storage capacities of fertilizer companies are given in Table 7.

The warehouse space is also hired when stocks exceed the company's own capacities. The average cost is between US$0.5 to 0.7/tonne per month (US$ = Rs.82) depending upon the location. The importers also transfer product directly to dealers, who have variable capacities ranging from 10 to 30 tonnes each.

2.4 Fertilizer marketing and distribution

The fertilizer marketing scene underwent rapid changes after deregulation in 1993–94. Four provincial distribution agencies in the public sector disappeared from the scene, a number of private fertilizer importers-cum-marketers entered the market and a newcomer, Fatima Fertilizer Company, emerged as a major player. NFML, the largest pre-deregulation fertilizer company, lost its stature as its market share progressively diminished with the privatization of NFC's fertilizer plants. Private-sector companies increased their market share through acquisition of NFC's fertilizer plants, adding new capacities and expanding their existing production capacities by ridding them of bottlenecks. A major change was brought about in the pricing of imported fertilizers.

Marketing infrastructure

Manufacturers-cum-importers: The local fertilizer manufacturer/importers have a very elaborate marketing infrastructure comprising sales team, dealer network, technical/agronomic services departments and field warehousing facilities. Their set up is mature and time tested with full corporate responsibility. The major companies are FFC, ECPL, DH, Pak Arab (Fatima Group) Pak American (Azgard Group) and NFML, which was recently assigned the responsibility of marketing imported urea. The manufacturer/importers have also acquired storage space at Karachi which they utilize to store product that cannot be shipped directly from the vessel to field due to transportation constraints. The storage hire is temporary and it is released after the product is shipped to the field. The quantity stored in Karachi by manufacturer/importers is much less than that stored by new importers and it is for a shorter period.

New importers: These have either a non-existent or very scanty field infrastructure. Only JBL have employed small sales teams and acquired a few field warehouses. The other new importers utilize the fertilizer manufacturers' dealer networks to sell their products. Due to non-availability of field warehousing they hire warehouses in Karachi to store fertilizer which is in excess of their dealer demand. The product stored at Karachi is later shipped to upcountry destinations against dealers' purchase orders.

The storage of fertilizer at Karachi by the new importers keeps the product off the market. At times this gives the impression of a shortage and can result in an undue rise in the market price. Further, if adequate transport is not available at the peak demand period, the stored product can remain stuck in Karachi or have to be transported at a higher freight cost. On the other hand, storing fertilizer in Karachi facilitates demand-driven distribution, ensuring its availability at the right place.

It is felt that the new fertilizer importers should have a proper marketing infrastructure. They should also undertake promotional activities through farmer education programmes and provide agronomic services to the farming community.

Public and private sector market shares

Since deregulation the private sector companies' market share has been on the increase. The public sector share in the fertilizer market which used to be higher than that of the private sector at 55.9 percent in 1989–90 has dropped progressively (see Table 8).

Table 8: Public and private sector market shares (%)

	1989–90	1994–95	1999–00	2004–05	2007–08
NFML	48.1	33.8	25.2	17.3	2.47
Provincial Agencies	7.8	5.5	0.4	0.0	–
Public Sector	**55.9**	**39.3**	**25.6**	**17.3**	**2.47**
FFC	21.4	31.3	34.3	49.5	49.17
ECPL	9.0	15.9	16.6	17.9	20.81
DCL	13.7	9.9	8.5	6.2	8.23
Pak Arab (Fatima Group)	–	–	–	–	9.54
New Importers	–	–	–	–	2.95
Azgard (PAFL)	–	–	–	–	5.81
LCFL	–	–	–	–	1.02
Private Sector	**44.1**	**60.7**	**74.4**	**82.7**	**97.53**
Public + Private	**100**	**100**	**100**	**100**	**100**

Source: *NFDC database, 2009*

The public sector market share has been phased out with a consequent takeover by the private sector which presently accounts for 97.53 percent. The new importers' share has also shrunk because of intense competition from manufacturers/importers.

Fertilizer companies' market share of urea and other products

Table 9 gives the fertilizer companies' market share of the fertilizer marketers in urea, other products and total fertilizers for the year 2007–08. As may be seen from the table, FFC, who are also marketing the production of FFBL, were the volume leaders. The public sector organization NFML has almost been phased out.

Table 9: Market share of fertilizer marketers 2007–2008 (%)

	Urea	Other fertilizers	Total
NFML	2.0	0.47	2.47
FFC	59.0	23.5	49.17
ECPL	20.0	23.8	20.81
DCL	11.0	1.6	8.23
Pak Arab (Fatima Group)	2.0	29.8	9.54
Azgard (PAFL)	7.0	2.8	5.81
New Importers	0.0	14.7	2.97
Total	**100**	**100**	**100**

Source: *NFDC database, 2009*

Retail system

The retail system has changed complexion to a certain extent in the post deregulation period. Since the closure of the provincial distribution agencies it is in the hands of private dealers. Only a nominal percentage of retail operations are handled by cooperatives. These are active only in the Punjab and are funded by the Punjab Cooperative Bank. This year NFML will distribute imported urea through the dealer network. These are multiple dealers, representing different companies.

Dealer network

About 90 percent of fertilizer sales are through dealers. Fertilizer companies appoint dealers in their respective marketing areas, the number depending on sales volumes. These dealers serve as an important link between the fertilizer companies and the farmers. They also perform certain services on the company's behalf, such as distributing technical literature, helping to arrange farmers' meetings and informing the farmers about agronomic services provided by the company. The important attributes of a good dealer are his selling capability, ethical operations, good contacts and reputation in the market.

The profile of the dealers in the post deregulation period has changed in the sense that they have gained more experience, their average sales have increased because the fertilizer market has expanded, their financial position has considerably improved and their children are generally educated. Dealers have become much more knowledgeable about the supply-demand situation and some of them even keep a tab on international fertilizer prices. The numbers and sales volumes of dealers working for the fertilizer companies are given in Table 10.

It is difficult to calculate the number of dealers particularly those working for the new importers. As pointed out earlier this group usually utilizes the dealer networks of the major marketing companies. Although the total number of dealers exceeds 7 900, between 70 to 80 percent are multiple dealers representing more than one company. The estimated quantity handled per dealer is about 6 801 thousand tonnes with an average cropped area of about 3 000 ha.

Table 10: Fertilizer companies' dealer network 2007–08

Name of company	Approx. no. of dealers	Quantity sold ('000 tonnes)	Estimated quantity handled/dealer ('000 tonnes)
FFC	3 170	3 757	1 060
ECPL	1 800	1 590	883
Fatima Group	550	729	1 325
Daud Corporation	1 300	629	483
AZGARD Group	300	444	1 480
New Companies	200	225	1 125
LCFL (Al-Hamid)	–	78	–
NFML	600	189	445
Total	**7 920**	**7 641**	**965**

Source: *NFDC database, 2009*

When a dealer is appointed the fertilizer company takes a security deposit. The amount varies from company to company and can range from US$175 to US$4 500 for different categories of dealership.

Fertilizer dealers can be categorized as small (selling up to 500 tonnes per annum), medium (500 to 2 000 tonnes) and large (more than 2 000 tonnes). Good companies value all three categories but the medium dealers are many in number and are considered very important in achieving sales objectives.

Direct buyers

Direct buyers include owners of sugar mills, cotton gins and rice processing plants, cooperative societies, big agricultural farmers and progressive farmers. About 10 percent of fertilizer sales are to these buyers.

Agrimalls

The agrimall concept revolves around making all agricultural inputs available under one roof. Five notable companies joined hands to bring this concept into reality. They are: ECPL (fertilizer), Millat Tractors, Ali Akbar Company (pesticides), Pakistan State Oil Company (diesel) and the Bank of Punjab (agricultural loans). They created an organization which would give agrimall franchises to suitable business parties. The participating companies all ensure supply of their products to the agrimall. The complex provides a warehouse facility for fertilizer storage, a tractor workshop, a display/sales outlet for pesticide, a diesel filling station, bank premises and the agrimall office. The total investment for such a building is in the range of US$80 000 to US$100 000. The Bank of Punjab extends agricultural loans to the farmers for purchase of inputs and also to the owner of the agrimall.

The first phase of the plan was that 150 agrimall franchises would be operative throughout Pakistan. However, scarcely half of this number are operational and some have already been closed.

Fertilizer distribution costs and margins

There are costs incurred between the fertilizer factory (or port of entry for imports) and the farmgate, such as finance for transport, handling, storage, dealer's commission, etc. If the efficiency of the marketing system can be improved, it will obviously benefit the farmer directly. Since deregulation, private companies have been reluctant to share their exact marketing costs and margins. After detailed discussion and analysis of the data available, the following inferences can be drawn:

Imported fertilizers

The port handling charges on imported fertilizers account for approximately 12.5 percent of the CFR (cost and freight) cost. This includes a 4-percent withholding tax, stevedoring, bags, warehousing, labour, mark-up, etc. These margins will depend upon prevailing market conditions. The other major costs are transport to dealers' stores, warehousing in the event that storage is required, and dealers' commission. Most of the private importers arrange for the dealers to pick up their consignment from the port as and when the ship arrives, saving the cost of storage. Some importers even place their products with dealers without advance payment and ask them to pay back as and when the product is sold. Average transport costs are about US$28/tonne or US$1.4/bag. This constitutes about 7 percent of the current sale price of US$22/bag for imported DAP. Generally, the dealer's commission is US$0.25/bag. However, sale prices are not strictly regulated, so dealers can set their commission depending upon supply and demand for the product.

Locally produced fertilizers

The distribution costs of locally manufactured fertilizers are not reported as such and can only be estimated from annual reports or general discussion. This leads to a rough estimate of 5 percent of total sale proceeds. Other estimated costs are given in Table 11.

Table 11: Distribution costs of locally produced fertilizers

Cost item	Percentage share
Product transportation	69.0
Organization and management	21.0
Warehousing	2.9
Travel/communication/training	2.0
Rent/rates/taxes	1.9
Sales promotion	1.6
Miscellaneous (including dealer commission)	1.6
Total distribution cost	**100**

Source: *NFDC database, 2009*

The costs will vary with different production sites, marketing areas and company policy.

2.5 Other nutrient sources

Nutrient sources other than chemical fertilizers are organic materials such as farmyard manure (FYM), animal manures, crop residues, composts and biofertilizers. However, there has been no adequate attention paid to their proper collection, management and use, especially since inorganic fertilizers became commercially available. Renewed interest in organic recycling has emerged due to the high cost of fertilizers, deteriorating health of soils and environmental concerns.

Organic manures provide mainly nitrogen, phosphorus and potassium as well as small quantities of the secondary and micronutrients. Their value should not be measured only in terms of their nutrient contribution potential; their positive effects on the physical and biological properties of soil should also be taken into account. The addition of organic manures improves soil aeration and water-retention. When used in combination with inorganic fertilizers, organic manures increase the efficiency of the inorganic.

Organic fertilizers/manure

This consists mainly of FYM, poultry manure, crop residues, filter cake stillage from the sugarcane industry, slaughterhouse waste, sewage and sludge, city refuse and wastes from the food processing industries. None of these are being produced or marketed in an organized manner in the country. The farmers collect and use what is available on-farm. This is primarily FYM consisting mainly of animal droppings, straw and litter used as animal bedding and fodder residues. FYM has a variable nutrient value depending on the type of livestock and storage conditions. It has been estimated by the National Fertilizer Development Centre (NFDC) that over 1.5 million tonnes of nutrient are available from FYM in the country. Of this, nitrogen accounts for 726 000, P_2O_5 for 191 000 and K_2O for about 617 000 tonnes. About

50 percent of the dung in Pakistan remains uncollected. Of the animal dung that is collected about 50 percent is used as fuel in the form of dried cake. Whatever is collected for manuring is usually heaped on top of the ground with residues from fodder and other house sweepings. The nitrogen in the manure is subject to volatilization and leaching losses and the material that is finally spread on the fields may have low nitrogen content.

Poultry farmers sell bird droppings directly to farmers. None of the poultry farmers maintains records about either sales or use.

Most crop residues are used as animal fodder or as fuel, leaving very little for recycling. The sugar industry produces over 1.5 million tonnes of filter cake every year. This is also not recycled properly as a source of nutrient. Processed city waste and sewage are used for growing vegetables around the cities. These products are rich in nutrients but they may also contain heavy metals which is a matter for concern. Although composting plants have been installed at Lahore and Islamabad, difficulties have been experienced in marketing the finished product because of high production and transportation costs.

Biological sources/biofertilizers

At present there is no organized production and distribution at national level. There have been efforts by national research organizations to commercialize the products but without any significant success. The Pakistan Agricultural Research Council (PARC), National Institute of Biotechnology and Genetic Engineering (NIBGE) and the provincial agricultural research institutes are carrying out work on biological sources. All these institutions are isolating strains of rhizospheric bacteria, which have potential for mobilizing atmospheric N, both on legumes and non-legumes. In greenhouse, field and laboratory studies, effective micro-organisms, in combination with NPK, green manure and FYM, have shown significantly improved crops yields. The National Agricultural Research Centre (NARC) has isolated a number of rhizobium species for specific leguminous crops. NARC in collaboration with Engro Chemical Pakistan Limited (ECPL) has commercialized rhizobium species for chickpea with the trade name Biozot. A 500-gram packet sold at US$1. The project continued for three years (1996–98) and sold about 35 000 packets of Biozot. An average 25 to 40 percent yield improvement was recorded. The project was disbanded due to commercial non-viability.

At NIBGE, isolates were tested for their ability to produce indole acetic acid (IAA) in the rhizosphere and it was found that certain *Pseudomonas spp*. were most active. IAA, like 2, 4-D, can produce a nodule-like excrescence on the roots of wheat and has been shown to mobilize atmospheric N thereby. Thus the prospects of providing partial N nutrition of wheat by inoculation of soil with isolates of Pseudomonas appeared promising. NIBGE, using its facilities including different capacities of fermenters, has already marketed its biofertilizer for rice under the name Biopower. This product has been used on over 10 000 acres of rice-growing areas, and the farmers' response was good. NIBGE tried to develop and market biopower in coordination with the private sector but the arrangement did not take off effectively. The provincial agricultural research institutes produce and sell rhizobium inoculum for leguminous crops. Their sale to interested farmers is not more than 2 000 packets of 250 g each per year. The recommended rate is two packets per acre and the cost of each packet is between US$0.10 to US$0.25. Azolla and algae, although found useful at research level, have not so far been produced on a commercial scale.

2.6 Fertilizer credit

Fertilizer accounts for between 30 to 50 percent of spending on crop production by small and medium farmers who are usually resource-poor and find it difficult to find money to buy fertilizer and other agricultural inputs, being dependent on formal institutional and non-formal, private sources of credit. Agricultural credit for the purchase of inputs such as seed, fertilizer and pesticide has traditionally been termed a **production loan**, and for financing development activities such as the purchase of tractors, tubewell installation or land improvement, a **development loan**.

Credit policies and disbursement

The Government of Pakistan has framed and implemented several policies for providing and facilitating fertilizer credit to small farmers. With the increase in prices of agricultural inputs, especially fertilizers, the demand for credit has risen steeply. The government has therefore liberalized credit policies. Institutional credit as a production loan for seed, fertilizer and pesticides is available from Zarai Taraqiati Bank Limited (ZTBL), commercial and private banks and cooperatives. The limits on loans per ha have been raised in line with rising costs. Production-related disbursements increased sharply to about US$2.4 billion in 2007–08 due to rising input prices, accounting for 93.5 percent of total disbursement to the farm sector in FY 2008 (see Table 12).

Table 12: Credit disbursement and borrowers

Sectors	Number of borrowers in thousand					Amount in million US$[4]				
				% Change					% Change	
	FY 06	FY 07	FY 08	FY 07	FY 08	FY 06	FY 07	FY 08	FY 07	FY 08
Farm sector	1 036.4	1 009.1	1 197.1	-2.6	18.6	1 929	2 301	2 555	20.9	14.5
Production*	1 000.5	978.9	1 160.2	-2.2	18.5	1 758	2 142	2 389	23.5	15.0
Development**	35.9	30.2	36.8	-15.8	21.8	157	128	161	-17.5	29.3
Corporate	0.005	0.014	0.075	180.0	435.7	14	31	5	117.0	-83.0
*Non-farm loan****	62.4	52.7	90.4	-15.6	71.6	368	485	830	33.2	76.8
Total agrisector	**1 098.8**	**1 061.8**	**1 287.8**	**-3.4**	**21.3**	**2 297**	**2 786**	**3 385**	**22.8**	**25.3**

Source: *State Bank of Pakistan*

* *Includes seeds, fertilizers, pesticides etc. (fertilizer 60%)*

** *Includes land development, tractor, machinery etc.*

*** *Livestock, poultry, forestry and fishing.*

Of the total disbursement under production, about 60 percent is utilized for fertilizer. In 2007–08, total fertilizer sales at farm level were about US$2.0 billion. Credits advanced by banks for fertilizer are estimated at around US$1.0 billion. However, only 1.2 million out of 6.6 million farms in the country were covered.

Farmers can receive fertilizer and other inputs on credit and repay the loan with produce after the harvest at a pre-determined mark up. In Pakistan, non-government organizations (NGOs) such as the Kisan Board of Pakistan has organized a number of “Flaahi Markaz” based on cooperative principles. The board organizes the distribution of fertilizer to small farmers at crop harvest.

Under supervised credit schemes, a farmer’s credit line is established based on his farm plan. The main aim of such schemes is to provide farmers with credit in the most cost-effective way.

The 2009 task force on food security expressed concern about the low level of agricultural credit disbursement amounting to just 4 percent of the banks’ credit portfolio, against the 22 percent GDP contribution of agriculture. The task force suggested the following additional measures to improve the size and quality of agricultural credit:

- The revenue department of the provincial government should be directed to update land ownership records so passbooks can be issued. The lack of passbooks is an impediment to increasing the outreach of agriculture credit. The passbook system should also be introduced in Azad Jammu and Kashmir (AJK) and the northern area.
- The State Bank of Pakistan may hold quarterly review meetings at provincial headquarters to monitor agricultural credit disbursement and deal with any issues or problems that may arise.

[4] Pak Rs. = US$: FY 06 = 59.8, FY 07 = 60.63, FY 08 = 62.5

- ZTBL should have a leading role in microcredit and develop products for microcredit schemes, particularly for small, marginal and landless farmers. Other banks or organizations may also initiate microfinancing for the agriculture sector.

The effectiveness of credit can be enhanced by augmenting the flow of money through agencies maintaining close links with the ultimate consumers, i.e. the farmers. To increase fertilizer use, farmers' purchasing power has to be increased and attractive credit terms provided. Moreover, other parties involved such as manufacturers, importers and distributors, have also to be supported. The cost of non-formal credit through moneylenders, commission agents, ginning and husking mills, is generally between 20 to 40 percent higher. Small and resource-poor farmers depend on these sources and pay very high costs. Further reforms are required to improve the accessibility of small farmers to institutional credit.

2.7 Fertilizer quality control and regulation

Pakistan consumes about 7.8 million tonnes of fertilizer products, of which, 6.4 million tonnes is local production and the rest imported. At 2007–08 market, prices farmers spent over US$2 billion in purchasing this quantity. In addition, a number of products are being sold as fertilizers, amounting to millions of dollars. However, the quality of fertilizer is highly important as this has profound repercussions on soil productivity and farmers' production economics. Substandard fertilizers not only harm soils but also shake farmers' confidence in fertilizer use. As such, availability of quality fertilizers at affordable prices is necessary to meet the growing food requirements of the increasing population.

Extent of problem

Studies have been conducted to assess the extent and magnitude of fertilizer malpractices, both in qualitative and quantitative terms. The results show that problems of adulteration reported for various fertilizer products was in the order: DAP> NP> Urea. Short-weighing complaints were mainly reported for DAP and NP. Caking was found in TSP, DAP, NP and CAN bags. Bag tampering and restitching was also reported for DAP and NP. Some farmers also reported purchase of fake fertilizers. Micronutrients and other substandard biological products under different brands are frequently marketed and their mushroom growth has been observed. The Directorate of Soil Fertility, Punjab, alone registered 164 such products, but their quality control and quantity sold is not known. The provincial soil testing labs also analyse fertilizer samples collected for quality control. Table 13 shows that about 5 percent of samples collected were substandard. The farmers are aware of the quality aspects of fertilizer use but are not sure how to avoid using adulterated fertilizer on their crops. Some farmers were found to be conscious of the fact that they were being cheated by unscrupulous dealers or retailers selling them adulterated or underweight bags of fertilizer or small packets of "miracle fertilizers".

Table 13: Fertilizer samples analysed

Sr. No.	Province	Samples analysed	Standard	Substandard	Substandard percentage of total
1	Punjab*	19 765	18 863	902	4.6
2	Sindh**	1 221	1 149	72	5.9

Source: *NFDC database, 2009*
* *Total from 1999–00 to 2008–09*
** *Total from 2007–08 to 2008–09*

Quality control mechanism

Under the country's constitution agriculture is a provincial subject, so any legislation concerning agriculture at the federal level should either have the consent of the provinces or should be passed by the provincial legislative bodies. This constitutional requirement has been one of the major handicaps in introducing fertilizer legislation at the federal level.

The provinces of Punjab, Sindh and NWFP have formulated and enacted fertilizer legislation for quality control at the distribution level. The departments of agriculture in the respective provinces have been designated controllers. The executive district officers, agricultural extension, and district agriculture officers have been appointed deputy controllers and assistant controllers of districts and subdivisions respectively. They are authorised to check the sale of adulterated and fake fertilizers and can take samples for testing or analysis at a dedicated government fertilizer testing laboratory. Punishments for adulteration are prescribed in the Acts.

However, with the mushroom growth of companies marketing micronutrients, foliar fertilizers and growth hormones it is becoming increasingly difficult to check the quality parameters and monitor them at the production and sale points. There are about 164 companies registered with the Punjab Government and a significant number of unregistered companies do exist in the other three provinces. Most products marketed by these companies have been found substandard. The assistant controllers and inspectors monitor prices, stocks and malpractices, if any, to ensure the availability of high quality products at reasonable prices. Despite these measures, the current regulatory mechanism for quality control is not strong enough to check the proliferation of substandard products introduced under different names. The penalties are very lenient and the number of convictions negligible.

2.8 Subsidy and pricing policy

The main objective of the fertilizer pricing policy is to increase agricultural production through higher use of fertilizers. In the introductory stage, prices were fixed by the Ministry of Industry and the industrial policy played a pivotal role in promoting fertilizer use. Prices set by the government were considerably lower than procurement costs in the case of imported fertilizer and lower than production costs in the case of locally produced fertilizers. The difference between cost and sale prices was paid by the government in the form of subsidies. Although subsidies were paid on both domestically produced and imported fertilizers, the low-cost domestic producers were charged "development surcharges" to even out the end cost.

This incentive policy was quite successful in the sense that the objective of increased fertilizer use was being met. On the other hand, the subsidy bill reached exorbitant levels, around US$275 million in 1979–80, a substantial amount in the budget at that time. The government was obliged to review the situation in the light of the heavy burden on the budget.

Removal of subsidies

Subsidies on nitrogenous fertilizers were gradually phased out and by 1986 urea prices were no longer fixed. The timing of the subsidy withdrawal was optimal. As local urea production was sufficient to meet demand, prices did not increase significantly. It was only from 1987, when demand exceeded domestic production, that the price of imported urea became higher than locally produced urea. A system of pooling imported and domestically produced urea prices was set in motion in order to fix a uniform sale price without subsidy. In this way subsidy on urea could be avoided between 1985–86 and 2004–05.

However, the subsidy burden continued to increase because of increased import of phosphate fertilizers. Consequently, subsidies on phosphate were abolished in 1993. This again happened at a time when world prices were low, resulting in only a limited price increase in the initial phase. The last step in deregulating the domestic fertilizer price was the removal of fixed prices for potash fertilizers in 1995. With this, the involvement of the government in the fertilizer market ended, with direct subsidies eliminated. The private sector was allowed to import and provincial quotas were abolished. In the meantime, the country achieved self-sufficiency in urea production and private companies started to import phosphatic and other fertilizers. There was no subsidy on fertilizers for eight years between 1996–97 and 2003–04.

Taxation of fertilizer sales

The GOP imposed a general sales tax (GST) on locally produced urea fertilizer at the rate of 15 percent of the selling price, effective from April 2001. Because of the variation in prices from one company to another (and also frequent seasonal price variations), the GOP set a deemed price of US$111/tonne[5] for calculating the GST and increased this to US$132/tonne with effect from July 2004. However, to provide relief to farmers, the deemed price of urea was adjusted to US$77/tonne in August 2004.

DAP and other fertilizers became liable to GST as of 25 November 2003. The deemed price of DAP for calculating GST was set at US$155/tonne and revised in June 2004 to US$77/tonne. From February 2005, sulphate of potash (SOP) and muriate of potash (MOP) were also brought into the GST net at a deemed price of US$77/tonne. The taxation increased the cost of agricultural production for farmers, because was no subsidy. However, due to an increase in prices of fertilizers in the international market, GST was abolished in July 2009.

Pricing of imported fertilizers

The fertilizers imported by the private sector were not subsidized, so their pricing mechanism was simple. It was based on components such as the f.o.b. price, freight charges, port handling, inland transport, warehousing, taxes and profit margins. Imported fertilizers have to be transported from Karachi to a wide variety of destinations and consequently incur different freight costs. This has led some companies to introduce freight-related pricing for both imported fertilizers and for the local production. The marketing area has been divided into a number of freight zones and the cost of transport to each zone added to the ex-Karachi retail price of the product. This has resulted in different retail prices in different zones. Freight-related pricing has had the following advantages:

- It has eliminated the incentive for dumping.
- Distant and remote areas receive deliveries.
- The sales reflect actual demand at the various destinations.

Re-introduction of subsidies since 2004–05

Urea

The cost of imported urea escalated in the international market from mid-2004. At one time, the price differential between domestic and imported urea ranged between US$8 and US$15 per 50-kg bag. The imported price of urea being so high, the government had to subsidize urea to provide relief to the farmers.

The deficit quantity of urea was imported by a public-sector organization, the Trading Corporation of Pakistan (TCP). This fertilizer was then sold on to urea manufacturers at a subsidized price. Each firm was allocated a share of these imports in proportion to its share in total domestic production. This allowed the shortfall to be made up without increasing the retail price. For the last two seasons TCP imports of urea have been marketed at subsidized rates by the government through NFML, an almost defunct public-sector organization. This practice is expected to continue until the *kharif* (monsoon) season 2010, after which new fertilizer plants will start urea production and the subsidy will be eliminated.

Phosphate and potash fertilizers

It was noted with concern by GOP that because urea is cheap and phosphatic fertilizer expensive, the objective of balanced fertilizer use is not being achieved. In 2006–07 the government therefore decided to subsidize phosphatic fertilizers to promote phosphate use. The subsidy on phosphate and potash fertilizers

[5] One US$ = Rs.60.00

was paid on imported as well as locally produced products. The subsidy per bag of imported DAP and MAP was fixed at US$4 on 1 October 2006 and increased to US$28 in 2008–09, when the international price of DAP touched US$1 300/tonne.

The C&F price of imported DAP was also applied to locally produced DAP as an ex-factory price for calculating subsidy. The difference between the C&F price plus incidentals plus the importers' profit margin was covered by the government as a subsidy. The subsidy paid by government since 2005–06 is given in Table 14. It reached as high as US$523 million in 2008–09. The subsidy on phosphate and potash fertilizers has been removed since July 2009 as international prices have stabilized.

Table 14: Fertilizer subsidy paid by government (US$ million)

Year	Subsidy on locally produced fertilizer	Subsidy on imported fertilizers	Total	Exchange US$1 = Rs.
1996–97	–	–	–	
2003–04	–	–	–	
2005–06	133	–	133	60
2006–07	57	228	285	60
2007–08	50	281	331	62
2008–09	183	340	523	78
2009–10 Estimated	162	–	162	82

Source: *NFDC database, 2009*

Gas: the indirect subsidy

The previous section has described explicit subsidies for final product but not the implicit subsidy for fertilizer manufacturing, i.e. natural gas. The fertilizer sector in Pakistan consumes about 20 percent of the total gas supply. The prices of this gas, supplied as feedstock to the fertilizer manufacturers, are not only lower than those charged to other users but also lower than the cost of furnace oil. Pursuant to the 1989 fertilizer policy, gas companies entered into contractual agreements with fertilizer companies to ensure that the price of gas would be frozen for 10 years from the date of the plants' first operation. The prices duly remained unchanged till 1999. The government then revised the price of feedstock gas for those plants that had been in operation for ten years. The new feedstock prices are equivalent to about 40 percent of the price of gas used as fuel. This is despite the fact that the gas subsidy (difference between price of feedstock and fuel) increased from US$190 million in 1999–2000 to US$405 million in 2008–09.

The fertilizer policy of 2001 ensured that gas prices were fixed in such a way that domestic producers were able to compete with Middle East exporters in order to meet the future demand for fertilizer. The policy therefore states that the price of feed gas will be the Middle East price prevailing on the date the General Sales Agreement (GSA) is signed or $0.77/MMBTU, whichever is higher (less the discount of 10 percent). Further, this price is to remain in force for a period of ten years from the date of commissioning. This price is to be determined by the Oil & Gas Regulatory Authority of Pakistan (OGRA), from published international data, in dollar terms, on the principle of general parity with the price prevailing in the Middle East. Fuel is to be treated at par with other industrial consumers. Under this policy the import of phosphoric acid and rock phosphate was also exempted from any duty and tax.

The question is often raised whether the savings accruing to the urea producers on account of the gas subsidy are passed on to farmers. The farming community and some government officials are of the opinion that the fertilizer industry is reaping healthy profits from the subsidy and that the benefit is not being passed on to farmers. The net profitability of the industry is on the increase and return on equity (ROE) is about 30 percent. On the other hand, the fertilizer industry takes the view that domestically produced urea has remained cheaper than imported urea. They claim they are passing on the benefit of the subsidy to the end users, the farmers, paying heavy taxes to government and ploughing back a substantial part of their savings into expansion and new investments.

2.9 Fertilizer demand

Methodologies

Studies conducted over time on demand analysis of fertilizers show that demand is a function of a time trend, and of the relative current prices of fertilizers and crops (an index of fertilizer prices divided by the implicit price deflator for major and minor crops). An alternative approach relates fertilizer demand to a time trend, the average current price for fertilizers and the value of the prior year's farm income per hectare of crops (GDP generated by major and minor crops at current prices per hectare of land). Inflation – adjusted income and fertilizer prices relative to crop prices were also used. The income terms of trade (ITOT) were used as an indicator of the annual changes in the real incomes of crop farmers. ITOT is calculated as follows:

$$\frac{\text{(price received by farmers for all crops) * (index of crop output)}}{\text{prices farmers pay for inputs and consumer goods}}$$

The changes in the relative prices of fertilizers and crops and in the farmers' ITOT were found to have a major influence on fertilizer demand (Suleman, 1984; G.R. Allen, 1984).

The availability of irrigation water in Pakistan is also an important determinant of fertilizer use. Fertilizer credit, while a potential determinant, does not appear to be measurable. Fertilizer price is of course a major determinant of demand.

A recent study by FAO/NFDC (2006) estimated demand functions for major fertilizer nutrients from the time series data between 1980–81 and 2004–05 in order to examine the role of relevant economic and technical factors in the context of fertilizer use in Pakistan. The results of linear demand functions and log linear demand functions for nitrogen showed a price inelasticity of demand for nitrogen fertilizers. However there was an inverse relationship between the real price of phosphate and its offtake. It suggests that the rising prices of phosphate had an adverse impact on its demand.

Demand forecast

Fertilizer demand estimates based on the different methodologies discussed in the preceding sections are reflected in the medium term development framework (MTDF) 2005–10 (Planning Commission 2005) and the NFDC update to 2014–15. The demand estimates take into account growth in GDP, farmers' income, water availability and international trends in agriculture development and fertilizer use. The projected demand and actual consumption between 2004–05 and 2008–09 are given in Table 25. In fact, MTDF reflected growth of N, P_2O_5 and K_2O at the rate of 3, 7 and 12 percent, respectively and the aggregated growth of all nutrients at the rate of 4 percent per annum. The actual trend (see Table 15) shows that N consumption was close to projections, whereas phosphates fell short of projected demand. There were various reasons for this deviation: a particularly sharp rise in prices at international and national levels, particularly of phosphates (urea prices remained affordable being local production), delayed imports and a change of government which took time to take stock of the situation and make decisions.

The practice of projecting annual demand is an important tool in the hands of the government for proper planning and budgetary provision of foreign exchange and subsidy, if involved.

Table 15: Demand forecasts ('000 tonnes)

Year	Projected demand				Actual consumption				Deviation
	N	P_2O_5	K_2O	Total	N	P_2O_5	K_2O	Total	Total
2004–05	2 630	754	25	3 409	2 630	754	25	3 409	–
2005–06	2 709	807	28	3 544	2 927	851	27	3 805	+261
2006–07	2 790	863	31	3 684	2 650	979	43	3 642	-42
2007–08	2 960	968	40	3 988	2 925	630	27	3 582	-406
2008–09	2 960	988	40	3 988	3 017	632	27	3 676	-659
2009–10	3 045	740	28	3 813					
2010–11	3 136	777	30	3 943					
2011–12	3 230	815	31	4 077					
2012–13	3 327	856	33	4 216					
2013–14	3 427	899	34	4 361					
2014–15	3 530	944	36	4 510					

Source: *NFDC database, 2009*

2.10 Fertilizer use and crop productivity

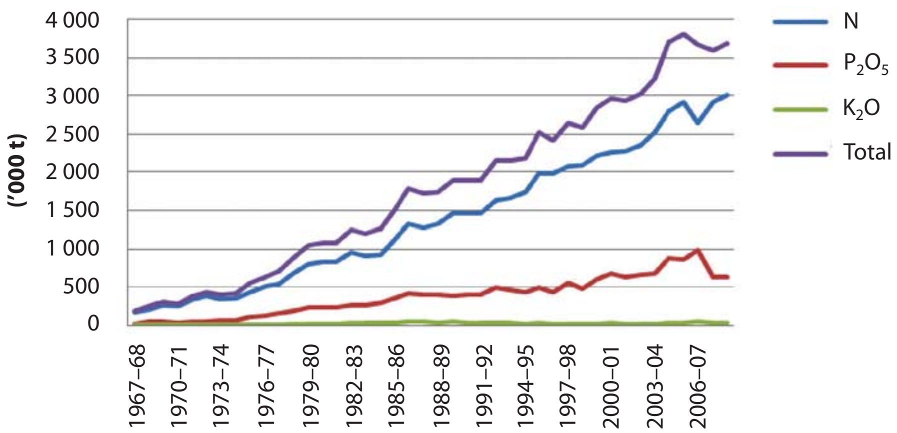
The consumption of fertilizer in Pakistan is measured through "offtake" which is defined as the quantity of fertilizer removed from factory, storage depot or warehouse to the dealers and retailers. The latter sell their stocks to the farmers whose purchases or consumption approximate to offtake, also used as a proxy for farm consumption.

Fertilizer use trends

Pakistan started using mineral fertilizers in the early 1950s, but usage picked up momentum beginning in the mid-1960s with the introduction of high-yielding varieties (HYVs). The offtake of total nutrients touched one million tonnes in the early 1980s, two million in the early 1990s, and three million in 2002–03. Fertilizer nutrient consumption in 2008–09, reached 3.7 million nutrient tonnes. Nutrient consumption since the mid-1960s is depicted in Figure 1.

Fertilizer consumption has shown an impressive growth but has remained skewed in favour of nitrogen. This unbalanced use is a matter of serious concern for policy-makers, researchers and extension workers. Nitrogen consumption increased from 103 kg/ha in 2001 to 128 kg/ha in 2009. P consumption decreased from 42 kg/ha in 2007 to 28 kg/ha in 2009. K use is negligible (see Table 16).

Figure 1: Fertilizer nutrient consumption in Pakistan



Source: *NFDC database*

Table 16: Nutrient consumption growth pattern

Year	Consumption ('000 tonnes nutrients)				Consumption (kg/ha*)			
	N	P_2O_5	K_2O	Total	N	P_2O_5	K_2O	Total
2001	2 265	677	23	2 965	103	31	1	135
2002	2 285	625	19	2 929	103	28	1	132
2003	2 349	650	21	3 020	108	30	1	139
2004	2 527	674	22	3 223	110	29	1	140
2005	2 796	865	33	3 694	123	38	2	163
2006	2 927	851	27	3 805	127	37	1	165
2007	2 650	979	43	3 672	112	42	2	156
2008	2 925	630	27	3 582	124	27	1	152
2009 Est.	3 035	651	25	3 711	128	28	1	157

* *Gross cropped area*

Until 2006–07 the growth rates of N, P and K were impressive. This was particularly the case for P and K, where the compound annual growth rate (CAGR) from 1995–96 to 2006–07 was about 6.4 percent for P and 3.3 percent for K. This was as a result of government policy to subsidize phosphate fertilizers in 2005–06 to improve balanced use at farm level. It is evident from the consumption trend in 2006–07 and a substantial improvement in N:P ratio to 2.7, which was the lowest in the history of fertilizer use in the country (see Annex 2). The subsequent negative growth was caused by a surge in international prices and the government's failure to intervene at the right time.

The fertilizer use trend in relation to crop yields can also be judged by consumption in kg/ha on cropped area. It has reached a level of about 152 kg/ha at a CAGR of 2.4 percent since 1995–96 (see Annex 2).

Seasonal fertilizer use trends

Agricultural crop seasons do not coincide with the fiscal year. Fertilizer consumption at fiscal year level gives the general trend. It is more clearly defined by crop season. There exist two distinct crop seasons in Pakistan. One is the kharif season (summer) from April to September. The main kharif crops are cotton, paddy, sugarcane and maize. The second is the rabi season (winter) from October to March. The major crops are wheat and oilseeds. The fertilizer offtake in nutrients for both seasons since 1995–96 is given in Table 17.

Table 17: Fertilizer consumption by nutrient ('000 tonnes)

Period	N	P_2O_5	K_2O	Total	N	P_2O_5	K_2O	Total	Percent share of total	
	Kharif Season				Rabi Season				Kharif	Rabi
1995–96	862	161	13	1 036	1 071	315	15	1 401	43	57
1996–97	1 050	209	6	1 265	941	233	4	1 178	52	48
1997–98	981	153	7	1 141	1 089	359	13	1 461	44	56
1998–99	987	201	6	1 194	1 070	263	15	1 348	47	53
1999–00	1 075	217	8	1 300	1 133	363	10	1 506	46	54
2000–01	1 134	312	9	1 455	1 211	360	14	1 585	48	52
2001–02	1 049	329	8	1 386	1 111	295	9	1 414	50	50
2002–03	1 117	258	9	1 384	1 201	422	12	1 634	46	54
2003–04	1 183	210	9	1 402	1 346	458	13	1 816	44	56
2004–05	1 287	330	10	1 627	1 435	455	14	1 903	46	54
2005–06	1 385	402	21	1 808	1 529	476	12	2 017	47	53
2006–07	1 258	252	9	1 519	1 400	686	33	2 119	42	58
2007–08	1 384	354	16	1 754	1 592	405	14	2 011	47	53
2008–09	1 333	158	15	1 506	1 580	375	10	1 965	43	57
CAGR	**3.4**	**-0.1**	**1.1**	**2.9**	**3.0**	**1.4**	**-3.1**	**2.6**	**–**	**–**
Average	**1 149**	**253**	**10**	**1 413**	**1 265**	**390**	**13**	**1 668**	**46**	**54**

Source: *NFDC database*

The data show that rabi consumption is almost invariably higher (54 percent) than kharif (46 percent). This pattern is static over the years. Nitrogen consumption in the kharif season increased consistently every year since 1995–96, with a compound growth rate of about 3.4 percent per annum. In contrast the growth in phosphate consumption was showing recovery till 2005–06, but there has been a setback in the last three seasons, resulting in overall static growth.

Fertilizer use by product

Of the numerous fertilizer products used by farmers in Pakistan over the years the most dominant has been urea followed by DAP. Together they constitute about 85 percent of total product consumption. Table 18 shows the consumption of various fertilizer products between 1999–2000 and 2008–09. The ammonium sulphate (AS) plant has closed down so AS is no longer available. The consumption of CAN and NP has remained static, in line with the production capacity of the country.

Table 18: Fertilizer product consumption ('000 tonnes)

Year	Urea	CAN	AS	SSP (18%)	DAP	MAP	NP	TSP	SOP/ MOP	NPKs	Total
2000	3 999.0	371.0	25.0	61.0	1 062.0	–	371.0	25.0	31.0	0.0	5 945.0
2001	4 047.0	382.0	16.0	172.0	1 204.0	–	362.0	15.0	35.0	11.0	6 244.0
2002	4 185.0	308.0	17.0	166.0	1 103.0	–	310.0	8.0	17.0	64.0	6 178.0
2003	4 262.0	359.0	16.0	211.0	1 098.0	12	374.0	4.0	19.0	69.0	6 424.0
2004	4 636.0	356.0	17.0	197.0	1 068.0	48	392.0	27.0	15.0	93.0	6 849.0
2005	5 120.0	330.0	1.0	161.0	1 374.0	108	355.0	81.0	24.0	129.0	7 686.0
2006	5 405.0	314.0	5.0	120.0	1 385.0	115	368.0	58.0	29.0	99.0	7 553.0
2007	4 678.0	338.0	2.0	179.0	1 612.0	124	421.0	65.0	56.0	82.0	7 557.0
2008	5 579.0	345.0	–	156.0	1 088.0	54	274.0	14.0	24.0	106.0	7 641.0
Avg.	4 656.78	344.78	11.0	158.11	1 221.56	51.22	358.56	33.0	27.78	72.56	6 897.44
% share	67.51	4.99	0.15	2.29	17.71	0.74	5.19	0.47	0.402	1.05	100

Source: *NFDC database, 2009*

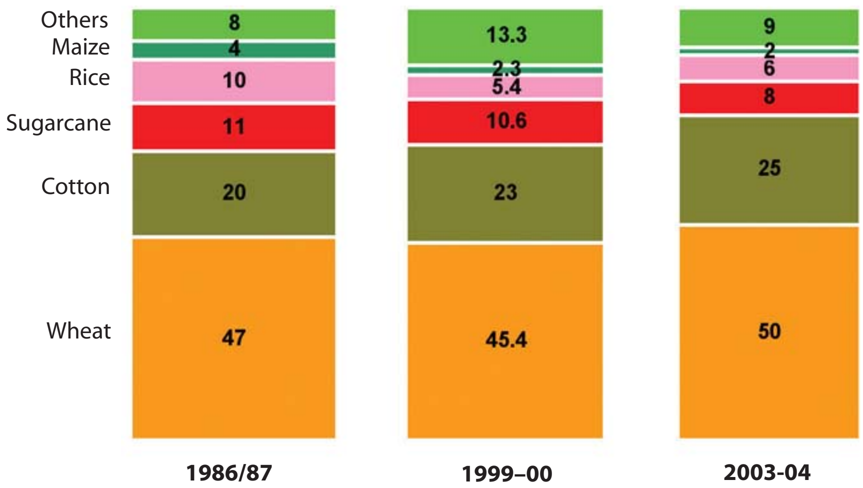
Use of secondary and micronutrients

Among the secondary nutrients, only sulphur has been researched. It has been found that, over time, a deficiency has occurred in soils in specific areas. There is no marketing of this nutrient as elemental sulphur (S), but small quantities are being added to the soils through SSP and SOP. There is convincing evidence about the prevalence of micronutrient deficiencies and the highly cost-effective impact of their application on a number of crops. However, micronutrient use is currently negligible compared to actual requirements. It is limited to the use of zinc (Zn) in rice, potato and citrus; boron (B) in cotton and rice; and iron (Fe) in apple and citrus. The potential micronutrient fertilizer requirement in the country is estimated to be about 5 730 tonnes of zinc and 3 100 tonnes of boron per annum. There are several companies selling micronutrient products that are registered with provincial agriculture departments. Unfortunately no sales data are kept. It is generally believed, both at policy level and in the agricultural extension organizations, that most of these products are substandard or counterfeit. Farmers are being robbed in the name of these so-called miracle products. Only two of the major fertilizer companies i.e. FFC and ECPL sell zinc and boron in an organized manner. In 2008 FFC sold 16 tonnes of products containing Zn and ECPL sold 7 181 tonnes of B. The main reasons micronutrients are not used are ignorance about the need for them, difficulty in accessing the products, dubious fertilizer quality and application problems for the growers. These all need to be addressed at the appropriate level.

Fertilizer use by crop

A number of field studies and surveys have been conducted to assess what share of total fertilizers is consumed by each crop. The results of three surveys conducted by NFDC, one during a regulatory regime (1986–87), and two after reforms (1999–2000; 2003–04) clearly indicate that wheat and cotton together consumed the lion's share (see Figure 2).

Figure 2: Crop-wise fertilizer use (%)



Source: *NFDC*

Farming structure and fertilizer use

The farming structure, i.e. size of farm, number of farms and cropped area, has been reported by the agricultural census of Pakistan. The total reported farms are 6.6 million with a cropped area of more than 20 million ha. The number and area of farms owned by small, subsistence and large farmers is given in Table 19.

Table 19: Numbers of small, subsistence and large farms

Size of farm ha	Number of farms '000	Area '000 ha	Percentage of total	
			Farms	Area
<1	2 389	1 150	36	5.7
1 to 2	1 426	1 978	22	9.8
Small farms 1 to 2	*3 815*	*3 128*	*58*	*15.5*
2.5 to 5	1 858	5 637	28	28.0
5 to 10	581	3 846	10	19.0
Subsistence/medium farms 2.5 to 10	*2 439*	*9 483*	*38*	*47*
10–20	261	3 284	4.6	16.3
>20	107	4 275	1.4	21.2
Large farms >10	*368*	*7 559*	*6*	*37.5*
Total	**6 622**	**20 170**	**100**	**100**

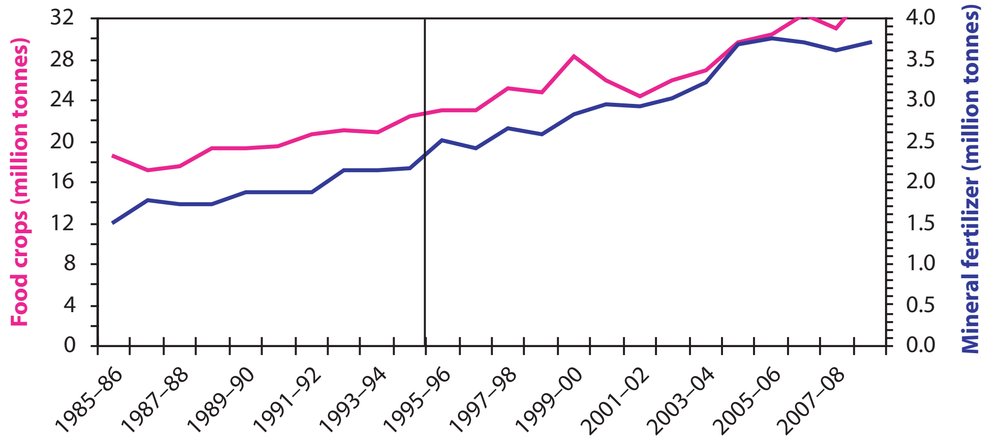
Source: *NFDC*

The table shows that small farms of less than 2 ha constitute 58 percent of the total, with only 15.5 percent of cropped area. Against that, large farms of more than 20 ha, constitute 6 percent of the total but account for 37.5 percent of cropped area. The 58 percent of small resource-poor farmers are vulnerable to food insecurity, particularly when input prices escalate beyond their purchasing power. Precise information about fertilizer use by farm size is not available, but surveys conducted by NFDC reveal that small farms mostly use the cheapest – urea. This leads to unbalanced use and low productivity. The medium-size farms tend to use both N and P fertilizers. Among these farms, about 60 percent use fertilizers close to the recommended rates. Most of the large farms are moving towards commercial farming, but many of them are inefficient.

Fertilizer use and production of food crops

The population of Pakistan increased from 142.35 million in 2000–01 to 164.5 million in 2008–09, a growth rate of about 2.1 percent per annum. During the same period, the availability of cropped area per capita decreased from 0.16 to 0.14 ha. The decreasing land per capita ratio has added to pressure to improve productivity per unit of land. The relationship between total fertilizer consumption since 1990–91 and production of food crops is presented in Figure 3.

Figure 3: Relationship between total fertilizer consumption and cereal production



Source: *NFDC*

Fertilizer consumption increased from 1.9 million tonnes in 1990–91 to 3.7 million tonnes in 2008–09. Correspondingly, the production of food crops increased from 19.6 million tonnes to 35 million tonnes. Fertilizer use and food production since 2001 are presented in Table 20. The production per capita increased from 182.5 kg in 2000–01 to about 212 kg in 2008–09. Per capita fertilizer use also increased. There appears to be a positive relation between fertilizer use and food grain production.

Table 20: Fertilizer consumption and food grain production

Year	Population (millions)	Nutrient consumption '000 tonnes	Foodgrains '000 tonnes	Fertilizer use (kg/capita)	Food production (kg/capita)
2001	142.35	2 965	25 987	20.8	182.5
2002	145.28	2 929	24 311	20.0	167.3
2003	148.21	3 020	25 889	20.4	174.6
2004	151.09	3 223	26 855	21.3	177.7
2005	153.96	3 694	29 905	23.9	194.2
2006	156.77	3 805	30 396	24.3	193.8
2007	159.06	3 672	32 337	23.0	203.3
2008	162.32	3 582	31 198	22.0	192.2
2009	164.50	3 711	34 953	22.5	212.4
CAGR	**1.8**	**2.8**	**3.7**	**0.9**	**1.9**

Source: *NFDC*

Note: *Foodgrain crops in Pakistan are wheat, rice, maize, sorghum, millet and barley. However, the main staple is wheat which accounts for 67% of total foodgrains.*

Fertilizer use and crop yields

Pakistan was among the South Asian countries to benefit from the Green Revolution. Wheat and cotton yields in 2008–09 were triple those in 1966–67. The yields of other major crops such as rice and maize doubled. Despite this the yields obtained are between 40 to 70 percent of economic yield potential. Fertilizer use and yields of major crops in selected years with CAGR are given in Table 21.

Table 21: Crop production, yield and fertilizer use

Year	Wheat		Cotton		Rice		Maize		Sugarcane		Fertilizer use	
	’000 tonnes	kg/ha	’000 tonnes	kg/ha	’000 tonnes	kg/ha	’000 tonnes	kg/ha	’000 tonnes	kg/ha	’000 tonnes	kg/ha
1966–67	4 266	812	443	286	1 343	968	578	1 061	21 635	33 847	117	7
1976–77	9 144	1 431	435	233	2 737	1 565	764	1 224	29 523	37 500	631	35
1986–87	12 016	1 559	1 320	527	3 486	1 688	1 111	1 361	29 926	39 600	1 784	85
1996–97	16 651	2 053	1 594	506	4 305	1 912	1 491	1 607	41 998	43 500	2 413	105
1999–00	21 079	2 491	1 912	641	5 156	2 050	1 652	1 718	46 333	45 900	2 833	124
2000–01	19 024	2 325	1 825	624	4 803	2 021	1 643	1 741	43 606	45 400	2 964	135
2001–02	18 227	2 262	1 805	579	3 882	1 836	1 664	1 768	48 042	48 100	2 929	133
2002–03	19 183	2 388	1 737	622	4 479	2 013	1 737	1 857	52 056	47 300	3 020	137
2003–04	19 500	2 373	1 709	572	7 848	1 970	1 897	2 003	53 419	49 700	3 222	147
2004–05	21 391	2 540	2 486	772	4 992	1 995	2 775	2 933	45 295	47 830	3 694	162
2005–06	21 277	2 518	2 215	714	5 547	2 116	3 110	2 985	44 666	4 925	3 805	165
2006–07	23 295	2 715	2 187	711	5 430	2 074	3 088	3 036	54 742	5 320	3 672	156
2007–08	20 959	2 451	1 982	650	5 563	2 212	3 605	3 427	63 920	51 506	3 582	152
2008–09	23 420	2 584	2 010	715	6 952	2 346	4 036	3 610	50 045	48 634	3 711	157
CAGR	**14.0**	**9.3**	**12.3**	**7.3**	**13.5**	**7.0**	**16.0**	**9.9**	**6.0**	**2.8**	**30.0**	**27.0**

Source: *NFDC*

2.11 Research and knowledge base

Pakistan has a strong research base on soil fertility and plant nutrition management. There are several research institutes working at federal and provincial levels. The major institutes with a strong component of research on soils and fertilizers are listed below.

- Pakistan Agricultural Research Council (PARC)
- provincial soil fertility institutes in all four provinces
- provincial agricultural research institutes having a directorate or section dealing with soils and fertilizers
- Nuclear Institute for Agriculture and Biology

Over the years these institutes have generated voluminous data to improve fertilizer use at farm level. The focus has been on formulating the optimum economic recommendations for farmers, fertilizer use losses, soil test crop response calibration, evaluation of sources, integrated nutrient management, method and time of application, improving fertilizer use efficiency etc. The current level of fertilizer use owes much to this research base. However, despite vigorous efforts fertilizer use efficiency has been low as explained in the preceding paragraphs.

Fertilizer technologies and practices

There are several promising technologies and practices for increasing agricultural production. The unfulfilled potential for each of these technologies or practices varies markedly depending on current practices and local constraints to technology adoption. Some possible opportunities are:

- balanced nutrition to allow optimum utilization of applied nutrients;
- split N applications to better match N requirements of crops throughout the growing season;
- integrated plant nutrient management;
- more efficient fertilizer products that better synchronize N release and crop N demand (e.g. controlled slow-release fertilizer);
- fertilizer additives to reduce N losses (e.g. urease and nitrification inhibitors);
- site-specific N management: prescriptive (before planting), corrective (using in-season diagnostic tools), or both;
- genetic improvement in nutrient recovery or utilization efficiency of some crops (primarily those that have received little attention from breeders in the past).

Efficiency of fertilizer use

Despite impressive increases in fertilizer consumption in Pakistan, crop yields have not increased proportionately. It is estimated in studies of farm yields that between 20 to 50 percent of the N applied in fertilizer is recovered in the crop during the year of application. In most cases, between 15 to 20 percent of applied P fertilizer is utilized by the first crops, but part of the residual P remains available over a period of time to succeeding crops. Most of the fertilizer Zn is fixed by calcareous alkaline soils and only a small fraction remains available. Besides affecting the productivity of some crops such as rice, low Zn availability also affects the efficiency of N and P fertilizers.

Several factors contribute to reduced fertilizer efficiency. They include: poor seed bed preparation, poor quality of seed and improper seeding, delay in sowing, unsuitable crop variety, inadequate irrigation/drainage, weed infestation, pest and disease attacks and improper and unbalanced fertilizer application. The contribution of the various factors to reduced efficiency varies under different conditions.

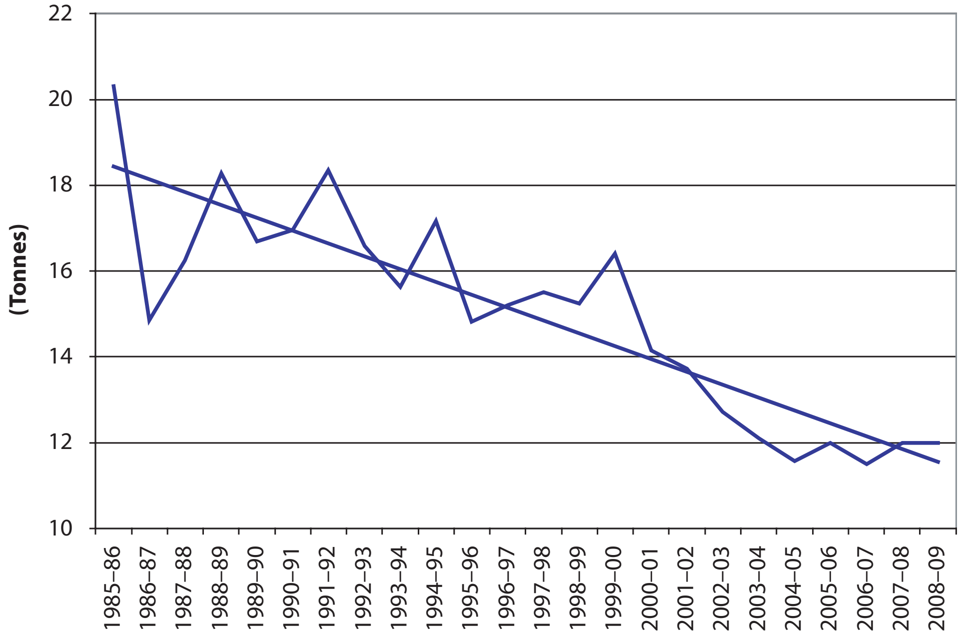
Nutrient use efficiency trends

Nutrient use efficiency generally decreases with increasing rates of application. At low levels of application, the increase in yield is larger. As application rates increase, incremental yield gains become smaller because yield determinants other than fertilizer become increasingly limiting as the maximum yield potential is approached.

The measures of efficiency used were (i) agronomic efficiency, (ii) recovery efficiency, (iii) removal efficiency and (iv) physiological efficiency. Another term, which can have wider application, is the partial factor productivity of nutrients (PFPN) an aggregate efficiency index. This will also be used here. It includes contributions to crop yields derived from uptake of indigenous soil nutrients, fertilizer uptake efficiency, and the efficiency with which nutrients required by the plant are converted into grain yield.

This technique has been used to measure the fertilizer uptake efficiency (FUE) of wheat which accounts for about 50 percent of total fertilizer consumption. Figure 4 plots tonnes of wheat produced per tonne of NPK over the past 20 years. It shows a steadily declining production response to nutrients. The period between 1985–86 and 2004–05 shows a continuing downward trend. The ratio was about 20 in 1985–86 and went down to about 12 in 2004–05 and almost stabilized. This trend means that although increasing amounts of fertilizer helped to raise the total wheat yield, nutrient use efficiency declined. This trend results in reduced economic benefits to farmers.

Figure 4: Tonnes of wheat production/tonne of nutrient (NPK) application



Source: *NFDC*

Balanced fertilizer use improves efficiency

Research in Pakistan has shown that the balanced use of fertilizer is the most important component of crop production technology, contributing about 40 percent to the yield in wheat, maize and rice. Plant population and weed control turned out to be the other important factors affecting yield.

Table 22 provides a summary of two years' field demonstration results conducted on farmers' fields under the IMPHOS/FAO/NFDC coordinated programme on the Impact of balanced fertilizer use on crop productivity. This shows that standard application of 120 kg N + 90 kg P_2O_5 + 60 kg K_2O ha^{-1} resulted in a 147 percent increase in wheat productivity. The contribution of nitrogen to this was 60 percent, phosphate 76 percent and potash 11 percent. Roughly similar results were obtained for all the other crops. The relatively low response to K may be due to aggregation of data.

Table 22: Impact of balanced fertilizer use on crop yields (average of two years)

Crops	No. of Trials	Yield in kg ha^{-1}				% increase over control		
		O	N	NP	NPK	N	NP	NPK
Wheat (Irrigated)	99	1 636	2 618	3 864	4 043	60	136	147
Wheat (Rainfed)	24	1 347	2 104	2 631	–	56	95	–
Cotton	25	1 187	1 809	2 262	2 400	52	91	102
Rice (IRRI)	11	2 391	3 663	4 782	4 940	53	100	107
Rice (Basmati)	25	1 833	2 823	3 742	3 837	54	104	109
Maize	12	1 789	2 893	4 372	4 656	62	144	160
Sugarcane	5	36 500	46 475	89 225	101 125	27	144	177

Source: *NFDC reports*.

Timing and method of fertilizer application

Fertilizer best management practices (FBMPs) have been developed with respect to the timely and best methods of applying fertilizer. These vary, depending on the type of nutrient, product quality, soil type, crop to be grown, source of irrigation and the physiological stage of crop growth. The broad parameters for nitrogen have been to split it into two to three applications depending upon soil type and stage of crop growth. The banding of N and P has also been found very effective. In crops following legumes, the N rates should be reduced between 20 to 40 kg/ha depending on the biomass of leguminous crops. Mixing P with well rotted FYM and using P dissolved in water have been found to improve efficiency effectively. The micronutrients B and Zn should be banded with major nutrients or broadcast after mixing with five times their volume of well pulverized soil. Foliar application of micronutrients is also recommended.

Integrated Nutrient Management (INM)

In the beginning, organic manures were the only source of plant nutrients for crop production. Animal wastes contributed the major proportion. Green manuring was another source. Around the 1950s, Rhizobium inoculation of *berseem* was introduced by the Agriculture Research Department. With the introduction of mineral fertilizers on a commercial scale in the early 1960s, emphasis on the use of farmyard and green manure started decreasing. The miraculous crop responses to N fertilizers and later on to P fertilizer, diverted farmer's attention significantly from the use of mineral fertilizers.

With the passage of time, mineral fertilizer use increased but the farmers continued using the FYM available at their farms. In a survey (NFDC, 2000) it was found that 49 percent of farmers use FYM. The work on INM in Pakistan can be summarized as follows:

- Organic and bio-sources cannot completely substitute for chemical fertilizer in view of the intensification of agriculture and need for national food security. However, they are very important to maintain soil fertility and crop productivity.
- Mineral fertilizers, especially N fertilizers, can be substituted by green manures or composted FYM in a range between 15 to 50 percent. However, this will depend upon type of soil and level of fertilizer use.
- Organic sources such as animal droppings, crop residues, sugarcane industry filter cake etc., have considerable potential to supplement inorganic fertilizer, but they are not properly managed. Fresh FYM has given much smaller responses than composted FYM.
- Incorporation of green manure into the soil well before planting rice has proved more beneficial than incorporation immediately before planting.
- Biological fertilization research is showing promising results in Pakistan. NIBGE, PARC and the provincial agricultural institutes sell packets of micro-organisms to farmers for soil inoculation, prior to sowing specific leguminous crops and rice on a commercial basis. Nevertheless, biological fertilization on a large scale appears only a long-term prospect. The products on sale were Biopower and Biozot.

At this stage recommendations on INM based on soil analysis are not formulated and disseminated to farmers. It is important that researchers and extension workers translate research results and transfer INM to farmers. The message could be conveyed even through electronic and print media that farmers must use organic and biological resources to supplement inorganic fertilizers and improve their efficiency.

Farm advisory services: public/private sectors

There are extensive agricultural extension services at provincial level to guide farmers on the optimum use of nutrients. The district soil fertility labs also advise farmers on fertilizer use based on soil analysis. The major players in production and marketing i.e. FFC, ECPL, Fatima Group and DH maintain a presence in the field to provide agronomic services to the farmers on fertilizer use. FFC has a well established network of agronomic teams running advisory centres with soil analysis facilities. They have five mobile laboratories which stay at one location for two to three years then shift to another place. They also conduct field demonstrations to promote balanced fertilizer use. ECPL also has two soil testing laboratories. They are also prominent in agronomic field activities. Fatima group is a new entrant in the field and has the limited activities at this stage. DH has almost curtailed its agronomic operations. Of the private importers only JBL maintains a field presence; the others only import and sell. Farmers' associations and chambers of commerce do exist in all four provinces but they play a limited role in any research and development activities.

Environmental aspects

Scientists know that major losses of N are through volatilization and have recommended timely and efficient methods of application to minimize the problem. Nitrate pollution in drinking water has not been reported where nitrogen is applied. However, in areas where organic manures are dumped over time isolated cases are reported. There is no regulatory measure or mechanism to check these losses. However, with increased awareness concern about environmental issues is growing.

2.12 Soil fertility, crop response and fertilizer recommendations

Soil fertility status

The soil analysis and field trials data generated by public and private sector research organizations in the country reflect a general agreement about the universal deficiency of N in all the soils. In the case of P, more than 80 percent of soils have inadequate soil phosphorus or can be termed deficient. In the case of K, the picture is not so clear. The reports state that deficiency of K exists in up to 30 percent of soils, but crop responses to K are erratic and its use is negligible. Of the micronutrients, field-scale deficiencies of economic significance exist in the case of Zinc (Zn), Boron (B) and Iron (Fe).

The organic matter content of the majority of cultivated land averages around 0.5 percent. The soils are generally calcareous and alkaline in nature.

Soil testing facilities

There is a network of soil testing laboratories in the country, 58 in the public sector and eight in the private sector. These exist to assist the farmers with site-specific recommendations based on soil tests. Some details of the laboratory facilities and soil samples analysed are given in Table 23 and in more detail in Annex 3. In many cases the district-level labs are not fully equipped and are particularly lacking in facilities for micronutrient and plant analysis.

Table 23: Soil testing labs and soils analysed (2007–08)

Province/ Company	No. of labs	Samples analysed			
		Soil	Water	Fertilizer	Total
Punjab	34	198 443	53 557	1 910	253 910
Sindh	13	42 092	7 208	743	50 043
NWFP	10*	10 200	–	273	10 473
Baluchistan	1**	2 500	1 500	–	4 000
Sub total	58	253 235	62 265	2 926	318 426
FFC	5	27 053	–	–	27 053
ECPL	2	7 030	–	–	7 030
G. Total	**65**	**287 318**	**62 265**	**2 926**	**352 509**

Source: *NFDC*
* *14 additional labs at farm service stations being established*
** *8 additional labs being established*

Soil fertility maps have not been established for the districts or crop production zones. NFDC made an attempt at this work and produced generalized fertility status maps for nine crop production regions. The work on soil tests and crop response calibration was carried out at different research stations specifically to establish critical levels of nutrient sufficiency/deficiency and to formulate recommendations based on soil analysis. However, the farmers are not fully satisfied with the performance of the soil testing laboratories. In most cases, they receive generalized recommendations even when the soil samples have been analysed.

Crop response to nutrients

The quantitative increase in yield with application of fertilizers is termed the crop response to fertilizers. It is measured as kilograms of additional yield per kg of fertilizer use. The data generated have been used to formulate fertilizer recommendations as well as to calculate the economics of fertilizer use. The soil fertility organizations of all four provinces in Pakistan have conducted thousands of trials to assess the response of various crops to N, P and K. Most of these trials were single replication and conducted on farmers' fields. NFDC collected, collated and analysed data from these trials for a ten-year period and derived response equations. Table 24 shows the response of important crops to nutrients applied at optimum rates. The data are derived from the above trials.

Table 24: Crop response to nutrients

Crop	No. of trials	Kg yield/kg nutrient			
		N	P_2O_5	K_2O	NPK
Wheat (Irrigated)	3 866	10.0	8.0	3.0	8.0
Wheat (Rainfed)	1 038	9.6	6.7	4.0	7.0
Rice (IRRI)	655	10.3	10.4	3.2	8.8
Rice (Basmati)	965	8.9	6.3	6.8	7.7
Maize (Irrigated)	1 800	8.1	7.4	3.9	7.0
Seed cotton	1 996	3.3	4.0	1.5	2.8
Sugarcane	628	135	110	43	104

Source: *NFDC*

With the support of the World Phosphate Institute (IMPHOS) and FAO, NFDC implemented a phosphate promotion research project from 1987 to 2005 jointly with soil fertility and agricultural extension organizations. The project conducted 712 demonstration trials on seven crops in all four provinces. The average response of irrigated wheat was 6.6 kg for N, 12.0 kg for P and 9.1 kg for NP. The main cropping systems, determined by land type and microclimate, are: i) Cotton-Wheat, ii) Rice-Wheat, iii) Mixed cropping (sugarcane and maize base), iv) Rainfed cropping (Wheat, Maize, Millet, Pulses, etc.). Unless moisture is a constraint, as in rainfed areas, the norm in irrigated areas is generally two crops a year. Most farmers have mixed cropping because they try to produce multiple crops as well as maintain livestock. The crop response to wheat by region is given in Table 25.

The response to NP application is always higher due to the interactive effect of N and P.

Table 25: Wheat response to fertilizers in different crop zones

Zone	No. of trials	Kg/ha nutrients N – P – K	kg grain/Kg nutrient			
			N	P	K	NPK
Cotton	16	160–114–62	6.1	8.3	3.7	6.4
Mixed crops	8	160–114–62	5.4	10.8	3.8	6.9
Rice	9	160–114–62	4.8	6.6	3.0	5.1
Rainfed	1	100–62–62	8.1	9.7	3.0	6.9

Source: *NFDC*

Note: *Actual trial data, Soil Fertility Punjab 2007–08*

Fertilizer recommendations for crops

Fertilizer recommendations are developed to quantify the amount of nutrients to be applied to various crops via fertilizers. Recommendations are based on the average values of crop responses, at several locations typical of the area, to graded rates of fertilizers. The data are collected for several years. Crop responses are evaluated and interpreted on the basis of economics, level of soil productivity (in terms of yield), previous cropping, soil texture and irrigation or rainfall. Site-specific recommendations are given only for those crops where analysis of soil samples indicates a higher level than deficient. N and P are widely deficient. Advice to farmers is based on type of soil, previous crop and management level, etc. The generalized recommendations for different crops in all four provinces are given in Annex 4.

Studies have shown that the farmers' actual fertilizer use is falls well short of the recommendations. For wheat most farmers use nitrogen close to the recommendations in irrigated areas, but phosphate use trails behind and use of potash is negligible. It has been estimated that cotton farmers use excessive N compared to other nutrients. At aggregated nutrient level, about 80 percent of farmers use N close to the recommended rate whereas phosphate use at the recommended level is adopted by only 40 percent of farmers. The use of potash and micronutrients is negligible. The major constraints to balanced fertilizer use are: (i) high prices of P&K compared to N, (ii) low in-country production base of P and K fertilizers (iii) non-availability of P and K at the right time and place and (iv) excessive promotion of urea by local producers.

2.13 Economics of fertilizer use

Profitability is usually the main motivation for using fertilizer. The factors impacting on its use by farmers in Pakistan are:

- the price relationship between fertilizers and crop commodity;
- the physical response of crop (yield to fertilizer application);
- economic returns on investment;
- the farmers' cash flow or availability of credit;
- the land tenure system;
- availability of quality fertilizers at the right place, time and competitive price; and
- availability of supporting inputs such as water, seed, pesticides and labour, etc.

Fertilizer prices

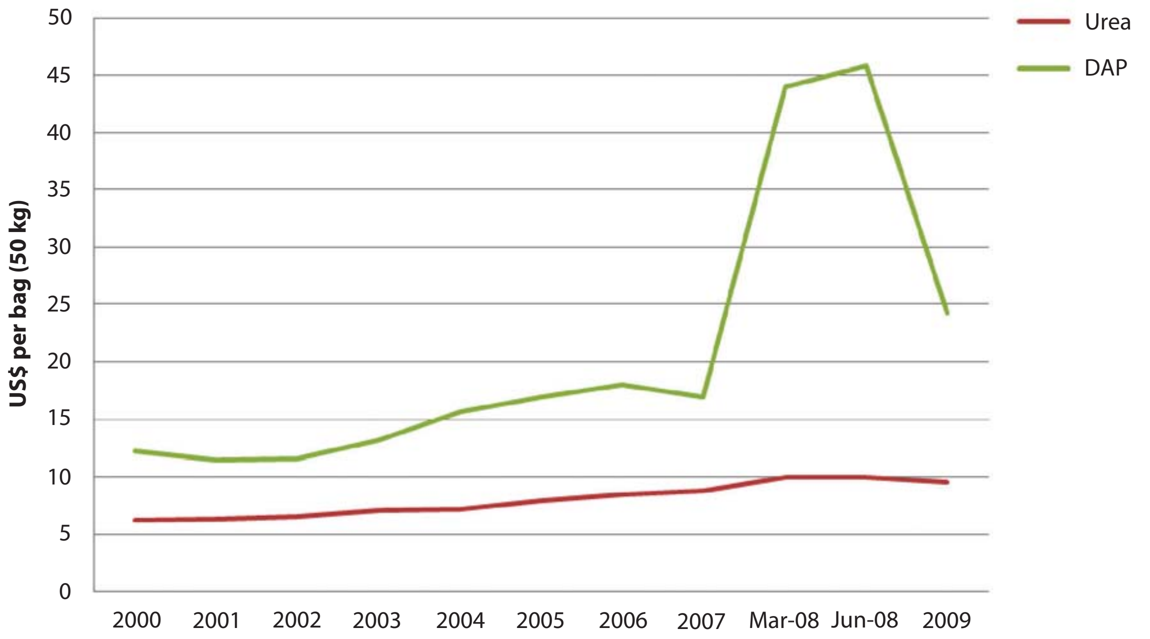
The relative prices of two principal products, urea and DAP, have changed over the years. The average prices at end of each financial year since 2000 are presented in Figure 5, which shows extreme volatility in DAP prices after 2007.

Commodity prices

Pakistan's Government has a history of intervention in commodity markets, ranging from monopoly procurements and exports to minimum support prices. The monopoly procurement and exports were stopped in the 1980s and 1990s as part of various structural reform programmes. The scope of the minimum support price programme has also been curtailed. The crops covered under the programme up to the 1990s included wheat, rice, cotton, sugarcane, gram, potato, onion and oilseeds. Late in 2001, the programme was limited to wheat, rice, cotton and sugarcane. In recent years a support price is announced and implemented for wheat only. There are occasional interventions for rice and cotton, in the event that prices fall sharply. The sugarcane prices are left to the provinces. The support price of wheat and the market/relevant producer prices of seed cotton, basmati paddy, IRRI paddy and sugarcane are presented in Figure 6.

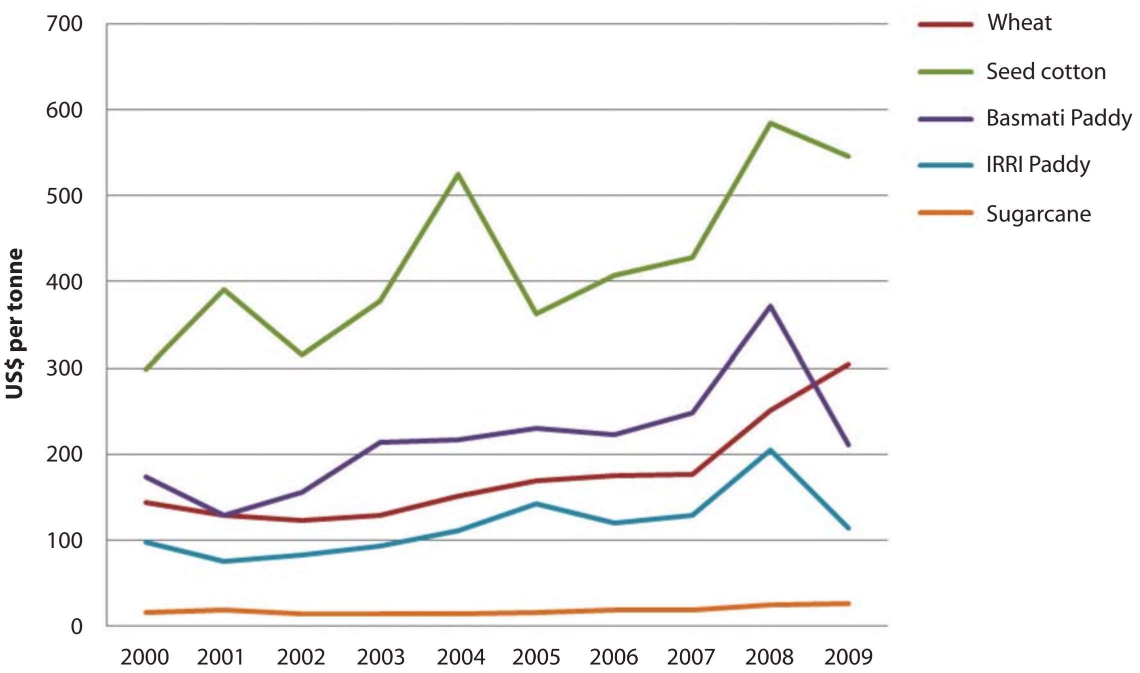
The figure shows modest increases in commodity prices over time. In the last two years, the prices of all commodities have gone down except for wheat and sugarcane. The wheat crop for 2008–09 was very remunerative due to an increase in support price from US$250/tonne to US$304/tonne. The increase was announced at the right time which encouraged farmers to bring more area under wheat and use more inputs. The result was that national wheat production was greater by about two million tonnes than the preceding year. Government has encouraged private sector participation in commodity marketing by facilitating cash credit and removing restrictions on movement with the objective of ensuring attractive prices to the farmers.

Figure 5: Retail prices of urea and DAP



Source: *NFDC*

Figure 6: Nominal producer prices of important crops



Source: *NFDC*

Relationship between fertilizer and commodity prices

The relationship between input and output prices is critical in determining economic viability, hence the level of fertilizer adoption and use. The prices of major fertilizer nutrients and crop outputs have increased at different rates. Therefore, it is useful to examine the changes in their ratios in order to ascertain whether the relationship is favourable or otherwise to their continued use. Accordingly, the nominal prices of N and P were divided by the prices of crops in order to calculate the quantity of produce needed to purchase a given level of the each fertilizer.

Table 26 shows that the farmers have to sell far more commodities for the purchase of P compared to N, so most small farmers use N only. In 2009, farmers purchased 1 kg of N for 1.4 kg of wheat compared to 1 kg of P for 4.6 kg of wheat. This is one of the major reasons of unbalanced use.

Table 26: Commodity kg to buy 1 kg of N, P & K

Year	Kg wheat required to purchase/kg			Kg IRRI rice required to purchase/kg			Kg basmati rice required to purchase/kg		
	N	P	K	N	P	K	N	P	K
2000	1.8	2.5	2.9	3.0	4.7	4.8	1.4	2.1	2.2
2005	2.0	3.5	3.9	2.4	4.3	4.8	1.4	2.5	2.8
2006	2.1	3.7	4.6	3.0	3.0	6.5	1.6	2.9	3.5
2007	2.0	3.1	3.1	2.9	4.3	5.0	1.5	2.2	2.6
2008	1.6	4.7	4.7	2.0	5.9	4.8	1.0	3.2	2.6
2009	1.4	4.6	4.6	–	–	–	–	–	–

Source: *NFDC*
Note: *N – Urea, P_2O_5 – DAP and K_2O – SOP*

Value-cost ratio (VCR)

Another criterion used to quantify the economics of fertilizer use is the value-cost ratio (VCR) – the ratio between the value of the additional crop yield and the cost of fertilizer:

$$\text{VCR} = \frac{\text{Value of yield increase}}{\text{Cost of fertilizer used}}$$

A VCR of 2.0 represents a 100 percent return on money invested in fertilizer. A VCR above 2.0 is considered a profitable margin for fertilizer use. The VCRs of two important food crops (wheat and rice) based on the most recent GNRs reported by different organizations are presented in Table 27.

Table 27: VCRs of wheat and rice

Crop	GNR (kg/kg of nutrient)			VCR		
	N	P	K	N	P	K
Wheat (Irrigated)	6	9	3	4.5	1.9	0.6
Wheat (Rainfed)	7	10	4	5.0	2.2	0.8
Rice (IRRI)	8	8	3	3.9	1.2	0.4
Rice (Basmati)	6	8	4	5.4	2.1	1.0

Source: *NFDC*
i. *Price per kg (US$): N – 0.41, P – 1.39, K – 1.4*
ii. *Commodity price per kg (US$): Wheat – 0.30, Rice (IRRI) – 0.20, Rice (basmati) – 0.37.*
All prices are for 2008–09

The GNR to N declined with increasing rates of application, but the VCR is very impressive compared to that of P. This is mainly because N is less than one-third the price of P. This in turn encourages the farmers to use more N. The GNR of K and so its VCR is low. However, the need for K is very site-specific and in pooled data, specific sites are generally averaged out. In any case the use of K at farm level is negligible.

Economics of balanced use

Using the data from trials they had conducted, NFDC/IMPHOS/FAO successfully made a case for the subsidy of P fertilizers. They calculated from crop response data that, if 50 percent of farmers across all crop production regions were to adopt balanced use of fertilizers, it would result in an average increase of 30 percent in national crop production. This translates into 4.4 million tonnes of wheat, 2.8 million tonnes of rice, 1.3 million tonnes of maize and a financial gain of US$1.5 billion.

2.14 Soil health management

Increasing population growth and demand for additional food have put a tremendous pressure on the soil to sustain crop yields to meet the demand of a burgeoning population. The issues related to soil health are compaction, low levels of organic matter, soil salinity/water-logging, use of brackish water for irrigation and excessive depletion of soil nutrients with crop production.

Soil inventory

The total geographical area of Pakistan is 79.6 million ha and only 27.7 percent of this is cropped. The Soil Survey of Pakistan (SSP) has classified the land resources according to their potential. Eight land capability classes have been established on the basis of their suitability for sustained agricultural production. These are:

- Class I, very good agricultural land, soils having no limitations for general arable use;
- Class II, very good agricultural land, soils with minor limitations;
- Class III, moderate agricultural land, soils with moderate limitations;
- Class IV, poor or marginal agricultural land, those with severe limitations;
- Class V, good forest or rangeland, soils with no limitations for forestry or range development;
- Class VI, moderate forest or rangeland, soils with moderate limitations;
- Class VII, poor forest or rangeland, soils with severe limitations;
- Class VIII, agriculturally unproductive or non-agricultural land, soils with no potential for any type of agriculture, including forest or range.

The inventory of soil resources is given in Annex 5. However, recent updating of the land resources inventory shows that between 15 to 20 percent of class I and class II irrigated lands has degraded to class II and class III lands respectively over the last 10 to 20 years. The degradation has mainly been caused by surface salinization/sodication from irrigation with poor quality tubewell water, depletion of soil nutrients and excessive irrigation of relatively sandy or loamy soils used for rice cultivation. The degradation of class III and class IV lands is estimated to be relatively low while, on the other hand, some class VII (saline/saline-sodic) land has been upgraded to classes III and IV through the extension of irrigation and management.

The estimated degradation of class I and class II lands implies between 10- to 15-percent decline in agricultural production potential, which has resulted from mismanagement of the land resource over just the last two decades. This indicates an alarming rate of deterioration in the agricultural potential of land of 5 percent per decade because of injudicious land resource management.

Depletion of soil fertility

Depletion of soil nutrients caused by intensive cropping with partial replacement of N and P places a heavy drain on soil with every crop. The gross addition and removal of nutrients based on crop production and nutrient use of 2007–08 is presented in Table 28 and by crop in Annex 6.

Table 28: Nutrient balance in soils ('000 tonnes)

Nutrient	Removal	Replenishment through fertilizers	Gap
N	3 507.989	3 035	-472.99
P	964.1427	651	-313.14
K	3 732.328	25	-3 707.33
Total	**8 204.459**	**3 711**	**-4 493.46**

Source: *NFDC*

Table 28 shows the negative balance of major nutrients in the soil implying that fertility depletion is a continuous process. In addition to NPK, micronutrients Zn, B and Fe are also being removed. The highest negative balance appearing is potash. Pakistan is one of the lowest potash consuming countries. Even if the K supply is sufficient, as is claimed, because of high supply by soil and irrigation water, there is no doubt that a very low K:N ratio in combination with secondary and micronutrient deficiencies contributes to low N use efficiency.

3. Policy gaps and suggested framework

Policy gaps have been identified throughout this report and general recommendations set out. In the present section, the more urgent specific proposals are outlined. Action should be taken within the next two or three years on the following issues at least:

- With the commissioning of two urea plants in 2010, there will be a surplus of between 0.5 and 0.8 million tonnes. The enhanced urea production capacity should be enough to cover Pakistan's own needs for at least five to seven years as no area expansion is envisaged because of serious constraints of irrigation water. It is inequitable to allow concessionary gas for further urea production unless national policy is to export urea. The present rate of N application on cropped area is about 128 kg/ha, a reasonable level. The future emphasis should be to achieve higher productivity per unit applied N rather than to apply more N for less return. In many European countries, the application rates are the same as were applied in the 1980s but productivity per unit of applied nutrients has significantly improved.

- The private sector should continue to import and market fertilizer. The recent government intervention should have been restricted to paying subsidy, leaving import and distribution to private sector. The fertilizer review committee (FRC) in MINFA with support of NFDC should closely monitor supply and demand and arrange the import schedule in plenty of time.

- Fertilizer subsidies offer the easiest route to supplying cheap fertilizer. However, this policy recently proved counterproductive again. Despite the good intentions of the government in offering substantial subsidies, the farmers derived minimum benefit. The subsidies were for the most part pocketed by middlemen and special interest groups. This caused losses both to the government and the farmers. Such interventions should be well thought out, well implemented and properly monitored. Alternative options to fertilizer subsidies such as institutional credit, an expanded research programme and increased expenditure on rural infrastructure for farmers might be considered. Increasing expenditure on agricultural research is always characterized by high pay-offs and should be accorded a high priority.

- National agreement does exist on efficient and balanced use of nutrients but lacks direction at policy level. The current NP ratio of 4.7 is alarming, the worst since 1997–98. Fertilizer should be promoted on radio and television, and crash programmes held in the field by extension officers and fertilizer dealers. Field activities should be especially tailored to small farmers who use the least P. Equally important, the fertilizer industry should be pressed to consider the wider national implications of its aggressive sales promotion of urea and to realize the urgent need to broaden its activities on other nutrients.

- An urgent reassessment should be made of all options to introduce fertilizer blending as soon as possible on large scale for crop-specific formulations. Blending offers the easiest route to achieving balanced crop nutrition but may not be as profitable as direct sale of products such as urea or DAP. Government has to consider this option, otherwise with new urea plants the excessive use of N will be at the expense of P, K, and micronutrients.

- A serious attempt should be made to promote the use of organic and bio-sources and develop integrated nutrient management (INM) practices in the country. For this purpose focused research, extension and development programmes are needed. It is important to commercialize the production, sale and use of biofertilizers at farm level.

- Efforts should be stepped up to prospect for P and K resources in Pakistan. Local reserves of rock phosphate already identified have not yet been developed for utilization in local production of phosphatic fertilizers. The import of rock phosphate is still continuing. This needs serious consideration and a policy decision to use local resources.

- There should be a considerable redirection of research efforts in crop nutrition and fertilizer use. These should include reducing the number of dispersed or replicated single season trials in favour of a smaller number of long-term experiments to investigate crop yield sustainability. In addition, continued emphasis should be given to INM research, foliar fertilization, and research on the nutritional requirements of new high value crops.

- The current fertilizer recommendations are too broad and, in some cases, outdated and unrealistic. They should be made more domain specific, be applicable to cropping systems, should include micronutrient recommendations, and above all be financially affordable by small farmers.

- Farming system research should be given much attention to achieve crop diversification for small farmers so that they have the opportunity to earn more income through small scale high value crops. Supporting research, extension and marketing advice will be needed.

- A review of experience with block demonstrations should be carried out with a view to bettering the development of community agricultural activity. It is unlikely that geographical blocks can prosper but community groups could be stimulated through fostering mutual benefits.

- In general, fertilizer subsidies will not be introduced with present government policies except in very exceptional cases. This happened most recently when the DAP price touched US$1300/tonne. However, a cheap fertilizer-seed-pesticide credit package directed specifically to poor small farmers would be of considerable value. The target beneficiaries should be well identified and monitored.

- Although this is at broader level, institutional approaches such as cooperatives, land reform and extension services with redirected emphasis should be the focal point of government policies for rapid growth of agricultural production and alleviation of the small farmers' problems.

- The present system for quality control of fertilizers is faulty. The fertilizer industry has always opposed any federal legislation to control the quality of production and imports. They use the pretext that these are standard products already certified by the exporters and locally determined by technological processes. Fertilizer control acts have been promulgated by provincial governments to provide a framework for monitoring quality at marketing and distribution levels. Enforcement of this legislation has been weak and there have been no notable convictions. A rapid growth of new products has been noted in the name of organics, bio, foliar, miracle and micronutrients. The manufacturers have succeeded in having themselves registered at provincial level but there is no proper monitoring of their production capacity, quality of product, volume of sales or price. The provinces should revisit the present fertilizer control acts to cope with emerging challenges so as to safeguard the interest of farmers.

- There exists a network of soil testing labs in the public sector to assess soil fertility status and advise the farmers on plant nutrition management. Most of the labs are in Punjab (34) which consumes about 68 percent of total fertilizer used, followed by Sindh with 13, NWFP with 10 and Baluchistan with one operational out of five. In Sindh, five more labs are under development whereas in NWFP 19 more labs are being established at the Model Farm Services Centre. In Baluchistan, only one lab at Quetta is operational. Four labs established in different parts of the province are partially equipped and may start analysis when all proper facilities and staff are provided. Despite this widespread network of soil labs and thousands of samples analysed every year, soil mapping and nutrient indexing have not been done to monitor soil fertility changes over time. The advisory service related to amendment of saline/sodic soils is effective whereas on fertilizer use recommendations are quite generalized. The service needs a thorough review and appropriate action taken in order to benefit from these labs. They need to help improve site-specific and efficient plant nutrition recommendations at farm level.

- The NFDC should have a greater role in future. It must provide intellectual leadership to the fertilizer sector to cope with emerging challenges and developments. While the institution is in reasonable shape, its role needs to be strengthened in plant nutrition management studies, demand forecasting and suggesting timely policy interventions. NFDC should reassess and strengthen its relations with the provincial, national and international institutions working towards a common goal.

- With the privatization and deregulation of the fertilizer sector, there doesn’t appear any GOP control on production, imports, distribution and marketing, especially of the retail price to farmers and users. The producers/importers and GOP undertake a general review of the fertilizer sector through the fertilizer review committee which has no legal authority. However, the expansion of fertilizer commodity sales to a level of over US$2 billion/year calls for a proper regulation and monitoring mechanism. The best option at this stage would be to constitute an independent body as the fertilizer regulatory authority with a mandate to supervise the overall interests of all stakeholders. The revival of the defunct FID at this stage should be avoided as it would duplicate the functions of the well established institution, NFDC.

References

APC. *Price Policy reports for various crops*. Agricultural Prices Commission.

Ahmad, N. & Rashid, M. 2003. *Fertilizers and their use in Pakistan*. Islamabad, NFDC Planning and Development Division.

Ahmad, N.A. & Tila, M. 1998. Fertilizer, plant nutrition management and self-reliance in agriculture. *The Pakistan Development Review* 37: 217–233.

Annual reports 2008 FFC, ECPL and DH

Ayub, M.A. 1975. An econometric study of the demand for fertilizer in Pakistan. *The Pakistan Development Review*. 14: 1.

Dobermann, A. 2005. *Nitrogen use efficiency state of the art*. IFA international workshop on enhanced-efficiency fertilizers. Frankfurt, Germany, 28–30 June 2008.

FAO. 1998. Plant nutrition for sustainable agricultural development in Pakistan. Rome.

FAO. 2002. *Water and fertilizer use in selected countries*. Rome.

FAO. 2004. *Fertilizer use by crops in Pakistan*. Rome.

FAO/NFDC. 2006. *The impact of deregulation on the fertilizer sector and crop productivity in Pakistan*. Rome/ Islamabad.

FAO/IMPHOS/NFDC 2006. *Balanced fertilization through phosphate promotion at farm level*.

Government of Pakistan. 2003. Pakistan agricultural census 2000. Lahore, Pakistan, Agricultural Census Organization.

GOP. 2008. *Agricultural statistics of Pakistan*. Islamabad, Ministry of Food, Agriculture and Livestock, Government of Pakistan.

GOP. 2005. *Medium term development framework 2005–10*. Islamabad, Planning Commission, Government of Pakistan.

GOP. 2009. *Pakistan economics survey 2008–09*. Islamabad, Finance Division, Government of Pakistan.

GOP. 2009. *Task force on food security*. Islamabad, Planning Commission, Government of Pakistan.

NFDC. 1989. Crop response to fertilizers. *Publication No. 5/89*. Islamabad, NFDC.

NFDC. 1992. Pakistan fertilizer: a study on policies and recommendations for de-regulation and privatization of fertilizer importation and marketing. *Chemonics International, Asianincs International and NFDC Policy Report 8/92*, Islamabad, NFDC.

NFDC. 2000. *Fertilizer use at farm level in Pakistan*. Islamabad, NFDC.

NFDC. 2007. *Fertilizer related statistics*. Islamabad, NFDC.

NFDC. 2005. *Fertilizer use survey, a micro-level assessment of the situation in Pakistan*. Islamabad, NFDC.

NFDC/FAO. 1984. *Review of fertilizer pricing and subsidy policies and of fertilizer marketing and production in Pakistan, by G.R. Allen*. Consultancy report, NFDC/FAO.

SFSSTI. 2008. *Annual Report*. Lahore, Pakistan, Soil Fertility Survey and Soil Testing Institute, Government of Punjab, Pakistan.

SBP. 2008. *Annual Report 2007–08*, Islamabad, State Bank of Pakistan.

Annexes

Annex 1: Fertilizer production capacity and actual production (2008–09)

Company	Plant location	Product	Design capacity ’000 tonnes	Production 2008–09 ’000 tonnes	% capacity utilization
Dawood Hercules (DH)	Sheikhupura	Urea	445	511	115
Engro Chemical Pak Ltd. (ECPL)	Dharki/Sukkar	Urea	850	928	109
(AZGARD) Pak American	Daud Khel/ Mianwali	Urea	346	383	111
Fauji Fertilizer Co. (FFC)	Machhi Goth/ R.Y. Khan	Urea	1 330	1 675	126
-do-	Mirpur Mathelo	Urea	574	704	123
Fauji Fertilizer Bin Qasim Ltd. (FFBL)	Karachi	Urea (G)	551	615	112
Pak Arab (Fatima Fertilizer)	Multan	Urea	120	105	88
	Sub Total	*Urea*	*4 216*	*4 921*	*117*
Fauji Bin Qasim (FFBL)	Karachi	DAP	720	534	74
Pak Arab (Fatima Fertilizer)	Multan	CAN	340	350	103
-do-	-do-	NP	350	315	90
Engro Chemical Pak Ltd. (ECPL)	Karachi	NP	40	23	58
-do-	Karachi	NPK’s	100	58	58
LCFL (Al-Hamid)	Jaranwala	SSP	80	89	110
HPFL	Haripur	SSP	82	89	110
	Grand Total (all production)		*5 928*	*6 377*	
New Capacity					
ECPL	Dharki Sukkar	Urea	1 300		
Fatima Group	Multan	Urea	500		
-do-	-do-	CAN	450		
-do-	-do-	NP	350		
-do-	-do-	NPK	200		

Source: *NFDC*

Annex 2: Total fertilizer consumption and use kg/ha

Fiscal Year	'000 Nutrient t				kg/ha	N:P
	N	P_2O_5	K_2O	NPK		
1995/96	1 991	495	30	2 515	111	4.0
1996/97	1 985	420	9	2 413	106	4.7
1997/98	2 075	551	20	2 646	115	3.8
1998/99	2 097	465	21	2 583	113	4.5
1999/00	2 218	597	19	2 833	125	3.7
2000/01	2 264	676	23	2 963	135	3.3
2001/02	2 285	625	19	2 929	132	3.7
2002/03	2 349	650	21	3 020	139	3.6
2003/04	2 527	674	22	3 222	140	3.7
2004/05	2 796	865	33	3 694	163	3.2
2005/06	2 927	850	27	3 804	165	3.4
2006/07	2 648	979*	43*	3 671	156	2.7
2007/08	2 925	630	27	3 582	152	4.6
2008/09	3 017	632	27	3 676	157	4.7
CAGR	*3.2*	*1.9*	*-0.8*	*3.0*	*2.4*	–

Source: *NFDC database*

* *CAGR up to 2006/07 was 6.4% for P and 3.3% for K*

Annex 3: Soil testing laboratories – location, capacity and samples analysed

	Location	Capacity (samples/annum)	Actual samples analyed	Capacity utilization (%)
A. Punjab				
1	Bahawalpur	8 000	3 471	43.39
2	D.G. Khan	8 000	1 400	17.50
3	Faisalabad	8 000	9 957	124.46
4	Gujranwala	8 000	6 500	81.25
5	Lahore	8 000	17 394	217.43
6	Multan	8 000	5 947	74.34
7	Rawalpindi	8 000	2 901	36.26
8	Sargodha	8 000	6 728	84.10
9	Attock	5 000	5 784	115.68
10	Bahawalnagar	5 000	2 156	43.12
11	Gujrat	5 000	5 000	100.00
12	Jhang	5 000	13 157	263.14
13	Jhelum	5 000	1 586	31.72
14	Kasur	5 000	4 284	85.68
15	Mianwali	5 000	4 340	86.80
16	Muzaffargarh	5 000	9 120	182.40
17	R.Y. Khan	5 000	5 134	102.68
18	Sahiwal	5 000	5 468	109.36
19	Sheikhupura	5 000	5 786	115.72
20	Sialkot	5 000	5 369	107.38
21	Vehari	5 000	10 104	202.08
22	Layyah	5 000	8 384	167.68
23	Bhakkar	5 000	2 500	50.00
24	Chakwal	5 000	4 074	81.48
25	Khanewal	5 000	6 696	133.92
26	Khushab	5 000	4 121	82.42
27	Okara	5 000	5 811	116.22
28	Rajanpur	5 000	4 587	91.74
29	T.T. Singh	5 000	8 604	172.08
30	Hafizabad	5 000	1 797	35.94
31	M.B. Din	5 000	8 126	162.52
32	Narowal	5 000	5 103	102.06
33	Lodhran	5 000	3 054	61.08
34	Pakpattan	5 000	4 000	80.00
	Sub-total	*194 000*	*198 443*	*102.29*

Location		Capacity (samples/annum)	Actual samples analyed	Capacity utilization (%)
B. Sindh				
1	Tandojam	2 000	1 650	82.50
2	Nawabshah/Sakrand	2 000	2 171	108.55
3	Mirpurkhas	2 000	1 542	77.10
4	Sanghar	2 000	1 522	76.10
5	Sukkur	2 000	1 678	83.90
6	Thatta	2 000	1 180	59.00
7	Shikarpur	2 000	1 637	81.85
8	Badin	2 000	525	26.25
9	Khairpur	2 000	1 611	80.55
10	Dadu	2 000	855	42.75
11	Jacobabad	2 000	447	22.35
12	Malir	2 000	228	11.40
13	Nowshero-feroz	2 000	2 600	130.00
	Sub-total	*26 000*	*17 646*	*67.87*
C. NWFP				
1	Peshawar	2 000	1 800	90.00
2	Charsadda	1 000	800	80.00
3	Kohat	10 000	750	7.50
4	D.I. Khan	2 000	1 500	75.00
5	Mardan	1 500	1 200	80.00
6	Haripur	1 200	1 000	83.33
7	Mingora	1 400	1 300	92.86
8	Bannu	1 300	800	61.54
9	Buffa	500	400	80.00
10	Norang	800	650	81.25
	Sub-total	*21 700*	*10 200*	*47.00*
D. Baluchistan				
1	Quetta	4 000	2 500	62.50
	Sub-total	*4 000*	*2 500*	*62.50*
	Grand Total	*245 700*	*228 789*	*93.12*

Source: *NFDC*

Annex 4: General fertilizer recommendations

Crop	Nutrient dosage (kg/ha)											
	Punjab			Sindh			NWFP			Baluchistan		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Wheat (Irrigated)	75–160	60–110	60	130–170	60–90	50	120–150	60–90	50	90–120	60	30
Wheat (Rainfed)	60–110	60–75	60	–	–	–	60–100	50–80	30	57	57	–
Rice (IRRI)	134–170	67–100	60	134–180	67–100	50	120–150	90	60	100	60	50
Rice (Basmati)	67–134	67	60	90	45	–	60–90	60	60	90	40	–
Maize (Irrigated)	90–170	90–120	60–90	130–160	75	50	90–120	60	50	–	–	–
Maize (Rainfed)	60–90	60	–	–	–	–	60–120	60–90	30–60	–	–	–
Potato	150–200	100–125	100–125	134–165	85	100	60–120	60	30–60	120	80	40
Sugarcane	170–270	60–110	60–120	200–300	100–125	100–170	120–175	100	100	–	–	–
Cotton	112–170	60	60	90–140	60	50	60–80	60	30	90	60	30

Source: *NFDC*

Note: *Zn is recommended for wheat at a rate of 5–12 kg/ha based on soil analysis and for rice @ 12.5 kg/ha. B is recommended for rice and cotton based on soil analysis*

Annex 5: Agricultural potential/extent of different land capability classes in Pakistan

Land capability class/Agricultural Potential	Area in thousand ha (% of total area surveyed)				
	Punjab	Sindh	NWFP*	Baluchistan	Pakistan
a) *ARABLE LAND*					
i. Very good agricultural land (land with very high potential for irrigated agriculture)	3 486 (16.9)	1 098 (9.6)	190 (1.5)	589 (1.9)	5 363 (7.1)
ii. Good agricultural land	3 679 (17.8)	2 327 (20.3)	534 (4.2)	469 (1.5)	7 009 (9.3)
Land with high potential for irrigated agriculture	3 679 (17.8)	2 327 (20.3)	506 (4.0)	469 (1.5)	6 981 (9.3)
Land with high potential for rainfed agriculture	0 (0)	0 (0)	2.8 (0.2)	0 (0)	28 (**)
iii. Moderate agricultural land:	2 395 (11.6)	1 497 (13.1)	688 (5.4)	308 (1.0)	4 888 (6.5)
Land with moderate potential for irrigated agriculture	1 208 (5.8)	1 178 (10.3)	141 (1.1)	110 (0.4)	2 637 (3.5)
Land with moderate potential for rainfed agriculture	677 (3.3)	0 (0)	524 (4.1)	190 (0.6)	1 391 (1.9)
Land with moderate potential for flood/torrent watered agriculture	510 (2.5)	319 (2.8)	23 (0.2)	8 (**)	860 (1.1)
iv. Poor (marginal) agricultural land	1 440 (7.0)	743 (6.5)	628 (4.9)	813 (2.7)	3 624 (4.8)
Land with low potential for irrigated agriculture	579 (2.8)	47 (0.4)	56 (0.4)	12 (0.1)	694 (0.9)
Land with low potential for rainfed agriculture	861 (3.2)	696 (6.1)	572 (4.5)	801 (2.6)	2 930 (3.9)
b) *NON-ARABLE LAND*					
v. Good forest or grazing land (land with high potential for forestry or range development)	0 (0)	0 (0)	171 (1.3)	0 (0)	171 (0.2)
vi. Moderate forest or grazing land (land with moderate potential for forestry or range development)	262 (1.3)	8 (0.1)	915 (7.1)	85 (0.3)	1 270 (1.7)
vii. Poor forest or grazing land (land with low potential for forestry/range development)	4 611 (22.3)	2 226 (19.4)	3 255 (25.4)	8 555 (28.1)	18 647 (24.8)
viii. Non-agricultural land (land with no or very low potential for agriculture)	4 160 (20.2)	3 188 (27.8)	5 724 (44.6)	19 489 (64.0)	32 561 (43.2)
Unclassified land (Land not classified, being occupied by buildings, graveyards, rivers, lakes, ice. etc.)	592 (2.9)	365 (3.2)	719 (5.6)	159 (0.5)	1 835 (2.4)
TOTAL AREA SURVEYED	*20 625*	*11 452*	*12 824*	*30 467*	*75 368*

Source: *Alim and Mirza, (1998), and updated with available information*

* *Includes NWFP, FATA, PATA and Northern Areas.*

** *Less than 0.1 percent*

Annex 6: Gross nutrient removals

Crop	Production ('000 tonnes)	Nutrient removal (kg/tonne)			Nutrient removal ('000 tonnes)			Total nutrient removal ('000 tonnes)
		N	P_2O_5	K_2O	N	P_2O_5	K_2O	
Wheat	23 421	25	9	33	585.53	210.79	772.89	1 569.21
Rice	6 952	20	11	30	139.04	76.47	208.56	424.07
Maize	4 036	20	8	20	80.72	32.29	80.72	193.73
Other Cereals	544	20	10	20	10.88	5.44	10.88	27.20
Pulses	755	55	12	40	41.53	9.06	30.20	80.79
Oilseed Crops	789	70	25	80	55.23	19.73	63.12	138.08
Potato	2 539	7	1.3	10.7	17.77	3.30	27.17	48.24
Sugarcane	50 045	1.2	0.46	1.44	60.05	23.02	72.06	155.14
Cotton (Seed)	35 457	62	14	60	2 198.33	496.40	2 127.42	4 822.15
Total					*3 189.08*	*876.49*	*3 393.03*	*7 458.60*
Add 10% for fodder and others					318.91	87.65	339.30	745.86
Grand Total					*3 507.99*	*964.14*	*3 732.33*	*8 204.46*

Source: *NFDC*

Sri Lanka

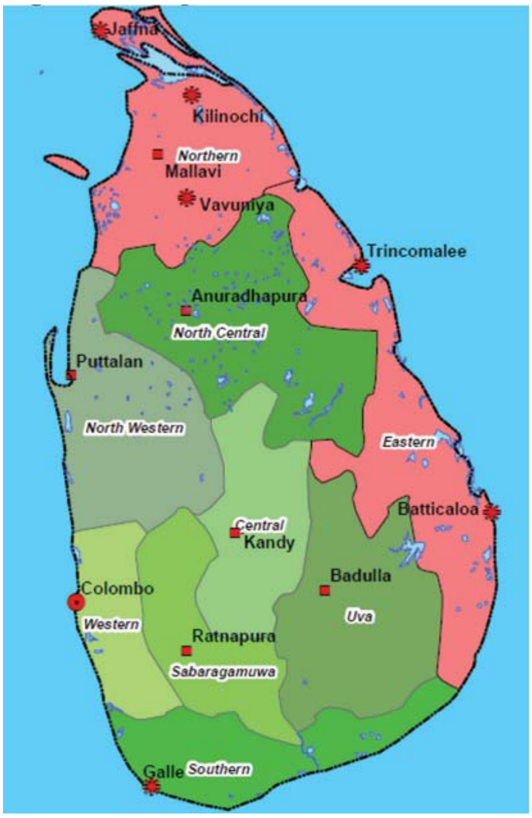
by

R.V. Misra

1. Background

Sri Lanka is situated in the Indian Ocean and lies between latitude 5°55′ and 9°50′N and longitude 79°42′ and 81°53′E (see Figure 1.1).The total land area of the island is 65 610 sq km. Population is estimated to be 20 million. The contribution to the gross domestic product (GDP) by agriculture is estimated to be 12.1 percent. Contribution to the GDP in the agriculture sector by rice is 13.8 percent and other food crops 33.8 percent.

Figure 1.1 Map of Sri Lanka



Food security situation

Sri Lanka is an agricultural country with diverse agro-climate and land resources. Aside from low per capita land availability, soil fertility generally limits crop production and would require considerable attention and support.

The food balance sheet, cereal production and cereal imports for Sri Lanka are provided in Table 1.1.

Food security is "when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy lifestyle". Rice and wheat imports for 2007 and 2008 are given in Tables 1.2(a) and 1.2(b). About 25 percent of the available supplies are met through imports.

As part of the millennium development goals (MDG), Sri Lanka pledged to eradicate hunger and committed the country to a basic target of reducing by half the number of undernourished people in the world by 2015.

Table 1.1: Food balance sheet, cereal production and cereal imports

Items	Quantity ('000 tonnes)				Per capita availability			
	Produc-tion	Gross Imports	*Supply	**Food (Net)	Food (g/day)	Calories per day	Protein (g/day)	Fat (g/day)
Cereals 2004	2 668.2	1 181.3	3 846.2	2 584.4	363.8	1 261.9	28.5	2.4
Cereals 2005	3 294.7	1 065.1	4 349.9	2 944.8	410.2	1 422.7	32.4	2.7
Cereals 2006	3 396.0	797.6	4 190.0	2 800.0	385.7	1 337.0	29.8	2.3
Cereals 2007	3 193.1	834.3	4 027.9	2 652.4	363.1	1 258.6	27.7	2.1

* *(Production + imports) – (Change in stocks + exports)*
** *Quantities for seed, animal feed, waste, manufacturing excluded*

Table 1.2(a): Imports of rice and wheat

Commodity	Quantity (tonnes)	Value ('000 Rs)**	CIF Price (Rs/kg)**	Quantity (tonnes)	Value ('000 Rs)**	CIF Price (Rs/kg)**
	2007			2008*		
Rice	88 002	4 261 025	48.43	84 072	4 730 276	56.26
Wheat Grain	854 836	22 754 944	26.62	954 211	42 396 913	44.43
Wheat Flour	5 797	229 160	39.53	2 082	109 976	52.82

Source: *External Trade Statistics, Sri Lanka Customs; * Provisional; ** Sri Lankan Rupees;*
US$1 = 74 Sri Lankan Rupees

Table 1.2(b): Imports of rice and wheat

Commodity	Quantity (tonnes)	Value ('000 Rs)	FOB Price (Rs/kg)	Quantity (tonnes)	Value ('000 Rs)	FOB Price (Rs/kg)
	2007			2008*		
Rice	2 884	197 540	68.49	3 854	425 705	110.46
Wheat Flour	138 911	5 094 916	36.68	2 082	6 533 415	62.42

Source: *External Trade Statistics, Sri Lanka Customs;*
** Provisional*

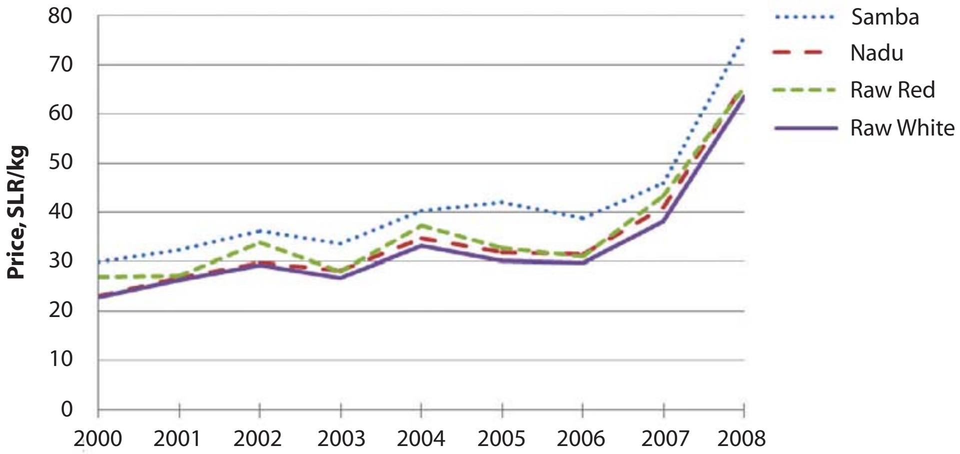
Impact of soaring food prices

The prices of many staple food commodities have increased substantially over the past several years. As a result, many developing countries are facing large food import bills. Despite the decline in international prices in the second half of 2008, in December 2008 FAO's food price index was 28 percent higher than in 2005. The retail price of rice in Sri Lanka over the past few years is given in Figure 1.2 and Table 1.3. Because of the dependency of many developing countries on imported food commodities, increasing food prices have important implications for growth and development.

At the micro level, poor households in both food importing and food exporting countries are exceptionally vulnerable to increases in food prices, given the large proportion of total expenditure on food and the constraints they face in terms of low income and capital endowment. Many countries are currently faced with difficult choices on how to respond to the global increases in food prices.

Food importing countries that rely heavily on tradable cereals for their diets are extremely vulnerable to global food price shocks. Food price increases directly affect purchasing power, thereby increasing the incidence of poverty as well as government expenditure. A deterioration of the terms of trade may destabilize the economy and hinder economic growth.

Figure 1.2: Retail price of rice in Sri Lanka



Source: *Hector Kobbekaduwa Agrarian Research and Training Institute*

Table 1.3: Wholesale and retail prices of rice (Rs/kg)

Commodity	2007		2008	
	Wholesale price	Retail price	Wholesale price	Retail price
Samba-I	42.92	49.64	72.61	73.45
Samba-II	41.43	45.48	70.61	76.43
Samba-III	39.78	42.62	68.18	71.76
Nadu-I	36.95	42.48	62.17	67.78
Nadu-II	35.40	39.34	59.90	64.29
Raw Red	39.22	43.35	60.45	65.34
Raw Wheat	34.31	38.26	58.72	63.44

Source: *Hector Kobbekaduwa Agrarian Research and Training Institute*

Households react differently to price increases. Urban and rural households that are net food buyers may lose, as they have to pay more to maintain adequate consumption levels. On the other hand, some rural households, especially those that are net producers of staple foods, or those whose wages may increase by more than the increase in food prices as a result of increased demand in rural labour markets, could benefit.

The price rise in international markets has a significant effect on global food security. For the people on small farms, it means more difficulties.

Smallholders and food production

Smallholder farms are often very efficient in terms of unit area production. Helping smallholder farmers can contribute to a country's economic growth and food security. With the required support provided through right investments, appropriate policies and development programmes, smallholder farmers have substantial potential to increase food production and contribute to greater food security.

The agricultural sector in Sri Lanka consists of both a smallholding sector and a corporate sector. Smallholders constitute the main foodgrain crop sector and agricultural export sector. The contribution of the corporate sector is minimal (see Table 1.4 and Figure 1.3).

The plantation crop sector consists of both smallholder and corporate sectors, but the smallholding sector is dominant in numbers.

Table 1.4: Holding size and number of holdings in agriculture and plantation sectors

a. Agriculture sector

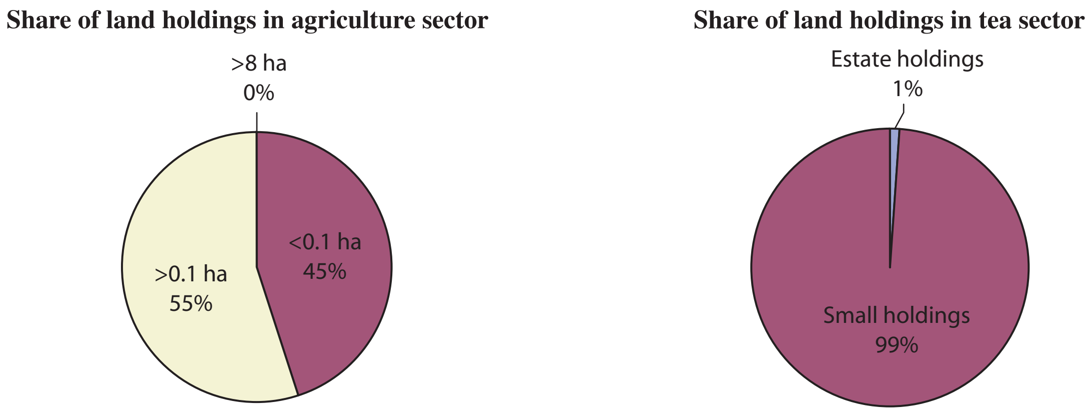
Sector	Smallholding sector				Estate sector		All sectors	
	(less than 0.10 ha)*		(0.10 ha and above)**		(8 ha and above)			
	No. of Holdings	Extent (ha)	No. of Holdings	Extent (ha)	No. of Holdings	Extent (ha)	No. of Holdings	Extent (ha)
Agriculture	1 462 904	81 822	1 783 473	1 475 997	6 577	384 843	3 252 954	1 942 662

b. Plantation sector

Sector	Smallholding sector		Estate sector		Total	
	No. of holdings	Extent (ha)	No. of holdings	Extent (ha)	No. of holdings	Extent (ha)
Tea	263 018	93 761	1 740	118 955	264 758	212 716
Rubber	82 166	50 451	1 331	66 026	83 497	116 477
Coconut	799 357	176 302	975 659	323 489	71 347	394 836

Source: *Department of Census and Statistics*

Figure 1.3: Share of land holdings in agriculture and tea sectors by number



Source: *Department of Census and Statistics*

Role of sustainable fertilizer and soil fertility management policies

To maintain the same level of per capita agricultural production, or to improve it, total agricultural production must increase. Limitations relating to additional land that can be brought under cultivation in Sri Lanka increase the critical role of fertilizers and other agricultural inputs in attaining agricultural production targets. Agricultural soils generally are low in organic matter, have low available plant nutrient status and require sound fertilizer use and soil fertility management.

Sustainability of the soil resource may be endangered if it is not managed properly. This may lead to economic problems for the farmers through lowered productivity as well as having an adverse impact on the environment. The decline in the soil resource base may be caused by depletion of nutrients, soil erosion or by development of problems such as acidity, salinity, alkalinity, water logging, and decline in vegetative cover.

Improper use of fertilizers may lead to environmental problems. The presence of nitrates in drinking water, eutrophication of lakes and build-up of heavy metals such as cadmium are increasingly being observed.

Agriculture in Sri Lanka

Sri Lankan agriculture consists of three main sectors viz. food crops, plantation crops and export agriculture.

Food crops

The food crop sector consists of rice, other field crops such as maize, legumes (green gram, black gram, cowpea, soybean) oilseed crops (groundnut, sesame) onion (big and red), chillies and other cereals such as millet and sorghum. The horticultural sector consists of root and tuber crops such as potatoes, sweet potato, cassava and yams, vegetables and fruits. All food crops come under the purview of the Department of Agriculture, Ministry of Agriculture Development and Agrarian Services. Most of the food crops are grown in the low country dry zone. Exotic vegetables are mainly grown in upcountry and mid country wet and intermediate zones, whereas local vegetables are grown in the low country wet zone. There are two distinct cropping seasons viz. *Maha* and *Yala*. During the *Maha* season the crops are all grown under both rainfed and supplementary irrigation, while during the *Yala* season when there is less rainfall, they are grown mainly under supplementary irrigation.

Plantation agriculture

The plantation crops are tea, rubber and coconut, and this sector comes under the purview of the Ministry of Plantation Industries. These crops are mainly grown in the wet zone. Tea is found in up, mid and low countries. Fertilizer consumption by tea is second only to rice. Rubber is mainly confined to Kegalle and Kalutara districts and parts of Ratnapura district. Coconut is grown in Kurunegala Gampaha and Puttalama districts. The institutes of tea, rubber and coconut conduct research on these crops. Development work relating to this sector is undertaken by various organizations such as the Tea Smallholding Development Authority, Sri Lanka Tea Board, Rubber Development Department, Coconut Development Authority, and Coconut Cultivation Board in addition to the corporate sector. Fertilizer consumption of both rubber and coconut is about 50 percent of the recommended quantity.

Export crops

Sri Lanka is known for its spices, which it exports to many countries. The export agriculture sector consists of three types of crops: spices such as cinnamon, black pepper, cloves, cardamom and nutmeg; beverage crops such as cacao and coffee; and essential oils such as lemon grass and citronella. Cinnamon is the major export crop. The research and development support to this sector is provided by the Department of Export Agriculture.

CROP PRODUCTION

Rice

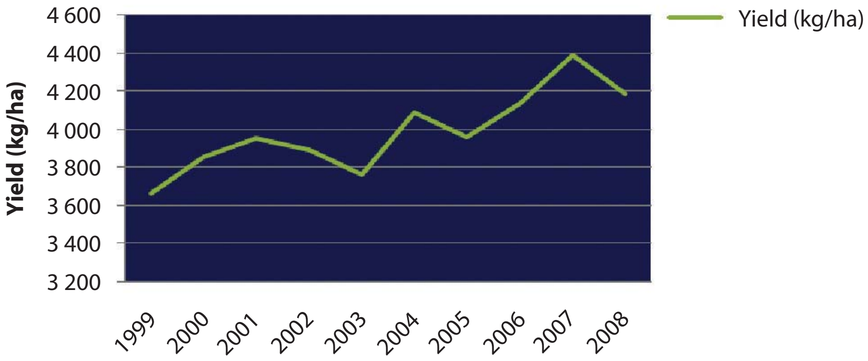
Rice is the main food crop. Total production as well as yield per unit area has steadily increased over the past few years (see Table1.5 and Figure 1.4).

Table 1.5: Rice production, area cultivated and average yield (1999–2008)

Item/Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Production ('000 tonnes)	2 857	2 860	2 695	2 859	3 071	2 628	3 246	3 342	3 131	3 875
Area harvested ('000 ha)	874	832	765	820	911	643	819	808	714	925
Yield (kg/ha)	3 666	3 858	3 953	3 893	3 761	4 086	3 963	4 137	4 389	4 184

Source: *Department of Census and Statistics*

Figure 1.4: Rice yields in Sri Lanka



Source: *Department of Census and Statistics*

Other food crops

Table 1.6 gives production, areas cultivated and mean yield of other food crops such as millet, maize, green gram, cowpea, black gram, red onion, big onion and green chillies in Sri Lanka. Since production of all these crops is insufficient, Sri Lanka imports enough to meet requirements. However, the government has plans to increase the production of all these crops under the food production driven national programme, *Api Wawamu Rata Nagamu*.

Table 1.6: Area, production and yields of other food crops, roots and tubers

Crop	2008		
	Area (ha)	Production (tonnes)	Yield (tonnes/ha)
Finger Millet	6 384	6 552	1.03
Maize	51 917	112 527	2.17
Sorghum	171	214	1.25
Meneri	52	30	0.58
Green gram	9 363	8 878	0.95
Cowpea	12 186	11 952	0.98
Soyabean	1 253	3 032	2.42
Black gram	8 321	9 477	1.14
Sesame	9 522	6 337	0.67
Groundnut	10 274	10 251	1.00
Red onion	4 994	49 290	9.87
Big onion	4 091	57 371	14.02
Chilli (green)	15 056	51 003	3.39
Chilli (dry)**		12 750	0.85
Total	133 584	339 664	
Root & Tubers			
Cassava	24 261	240 731	9.92
Sweet potato	7 124	52 466	7.36
Potato	4 869	74 814	15.37
Total	36 254	368 011	
Grand Total	169 838	707 675	

Source: *Department of Census and Statistics;*

* *Total Production – excluding green chilli;*

** *Dry chilli conversion ratio: 4 kg green chilli for 1 kg dry chilli.*

The crops are grown in the uplands of the dry zone under rainfed conditions. Although fertilizer recommendations have been formulated and demonstrated in farmers' fields, the farmers use less or no fertilizer in this sector due to the high risk factor. The provisions of the current fertilizer subsidy scheme have not been extended to this sector and fertilizer use is low.

Horticultural crops

Various horticultural crops are cultivated. Area and production of the main horticultural crops are indicated in Table 1.7.

Table 1.7: Area and production of fruit crops

Crop	2007			2008		
	Area (ha)	Production		Area (ha)	Production	
		('000 fruits)	(tonnes)		('000 Fruits)	(tonnes)
Banana	49 420	32 419*	389 028	47 682	33 121*	397 452
Lime	9 319	168 255	5 048	9 889	166 821	5 005
Mango	25 289	424 701	70 075	25 747	394 598	65 109
Orange	4 578	31 910	3 989	5 149	28 847	3 606
Papaw	6 579	33 655	21 876	6 276	38 361	24 935
Passion fruit	358	5 703	485	434	4 807	409
Pineapple	4 777	44 421	55 527	4 902	43 480	54 350
Cashew	21 892		6 652	22 472		6 625
Rambutan				3 666		19 874
Avocado				1 325		3 394
Guava				1 159		4 261
Mandarin				381		296
Pomegranate				830		3 692
Watermelon				209		6 461

Source: *Department of Census and Statistics*

** Banana production in '000 bunches*

Plantation crops

Plantation crops play a vital role in Sri Lankan agriculture, contributing 2.8 percent to the national GDP and earning valuable foreign exchange. Of the three plantation crops, tea is the main one. Although the cultivated area remains unchanged in these crops, total production and productivity have increased over the last decade. This can be seen particularly in the tea and rubber sectors. Smallholding farmers dominate in all three crops. For example 59 percent of the land under tea is owned by smallholders, 85 percent of whom own less than 1 ha. The smallholding sector accounts for about 74 percent of the total tea production. The Tea Small Holdings Development Authority (TSHDA) is the main organization looking after the interests of this sector. Corporate-sector land holdings vary between 300 and 1 500 ha managed by several companies. The area, production and yield of plantation crops are given in Table 1.8.

Table 1.8: Area, production and yield of plantation crops

Tea

	Unit	2006	2007
Production	million kg	310.80	304.60
High Grown	million kg	74.70	72.50
Medium Grown	million kg	51.50	54.50
Low Grown	million kg	184.60	177.70
*Extent**			
Total Extent	'000 ha	212.70	212.70
Extent in bearing	'000 ha	181.40	181.40
Replanting	ha	1 390.30	1 482.30
New Planting	ha	5.10	7.10

Source: *Sri Lanka Tea Board; Tea Small Holdings Development Authority; Department of Census and Statistics*

Rubber

	Unit	2006	2007
Production	million kg	109.20	117.60
Area			
Under Cultivation	'000 ha	120.00	120.00
Under Tapping	'000 ha	97.00	94.00
Replanting	ha	4 353.00	5 192.00
New Planting	ha	1 900.00	2 034.00
Yield	kg/ha	1 128.00	1 261.00

Source: *Rubber Development Department*

Coconut

	Unit	2006	2007
Production	million nuts	2 785.00	2 869.00
Total Extent	'000 ha	395.00	395.00
Replanting	ha	3 865.00	2 528.00
New Planting	ha	4 101.00	2 955.00

Source: *Coconut Development Authority; Department of Census and Statistics*

Export crops

The agricultural export crop sector contributes significantly to foreign exchange earnings. The sector is dominated by cinnamon and black pepper. Other export crops are cloves, cardamom, nutmeg, vanilla, coffee, cacao, beetle leaves, areca nut, citronella and lemon grass.

Black pepper, cloves, cardamom, nutmeg, vanilla, coffee, cacao and areca nut are grown in home gardens particularly in the "Kandian home garden system" in the mid country wet and intermediate zones. No fertilizer is added to these crops. Betel leaves are grown in low country intermediate zone by smallholding farmers. Fertilizers are used at recommended levels for this crop to achieve the required export quality. Citronella and lemon grass are mainly grown in up, mid and low country dry zones. Little fertilizer is used for this sector. Table 1.9 gives area, production, export volumes and values of export crops.

Table 1.9: Area, production, export volumes and values of export crops

Crop	2008			
	Area (ha)	Production (tonnes)	Export (tonnes)	Value ('000 Rs.)
Coffee	8 098	3 035	85	25.8
Cocoa	2 377	735	444	132.1
Cinnamon (Quills)	30 041	15 924	12 184	8 927.6
Cardamom	2 948	71	12	29.0
Clove	7 870	8 053	6 095	3 482.6
Pepper	30 866	13 175	6 236	2 841.3
Citronella	990		22	50.3
Nutmeg	1 107	4 702	1 581	788.4
Betel			3 002	720.6
Areca nut		15 863	2 847	344.4

Source: *Department of Exports Agriculture;*
* Provisional

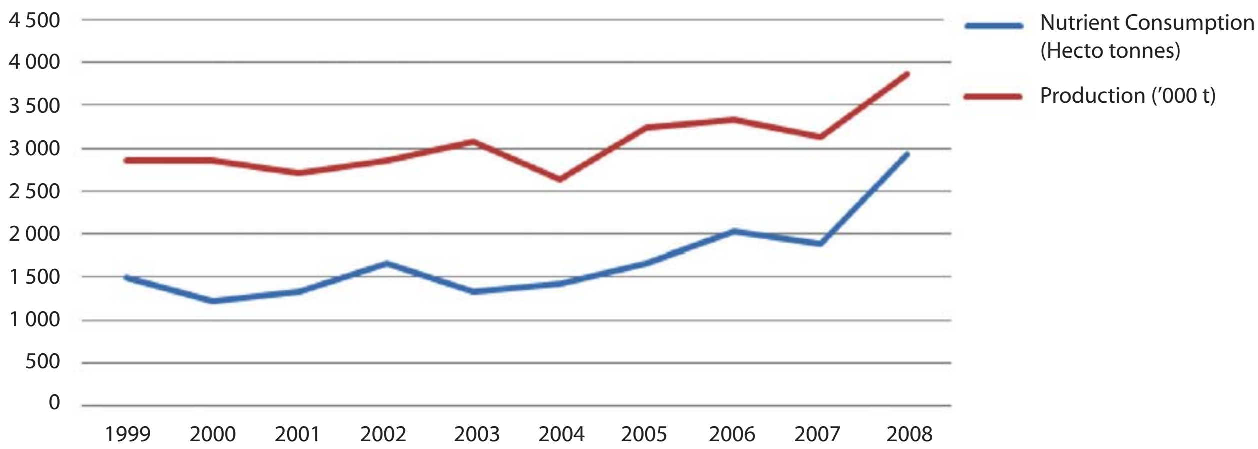
Fertilizer use in agriculture

Fertilizer use for agricultural production has been growing. Crop-wise nutrient use for various crops over the past few years is presented in Table 1.10. Rice has the major share in fertilizer consumption (78 percent). A direct relationship between rice yields and fertilizer consumption can be observed (see Figure 1.5).

Table 1.10: Crop wise use of total fertilizer nutrients ('000 tonnes)

Year	Paddy	Tea	Rubber	Coconut	Tobacco	OFC	EAC	Others	Total
1999	149.7	63.6	3.8	16.4	1.3	16.3	3.5	8.7	263.3
2000	121.7	79.2	5.5	13.9	1.2	14.7	3.1	10.5	249.8
2001	133.2	72.2	3.4	11.9	0.9	12.4	2.9	11.0	247.9
2002	165.6	73.8	2.7	16.4	0.9	15.8	2.9	11.8	289.9
2003	132.8	63.8	3.3	16.5	1.1	23.4	3.6	8.2	252.7
2004	141.8	69.4	3.7	14.4	1.7	19.6	3.9	6.7	261.2
2005	166.4	71.1	3.8	13.9	0.8	19.0	3.2	6.1	284.3
2006	201.6	75.2	8.3	20.4	0.8	17.9	4.1	8.3	336.6
2007	188.5	72.8	7.3	18.8	0.1	14.3	4.5	9.7	316.0
2008	292.6	54.0	4.0	9.8	0.0	8.1	1.8	4.6	374.9

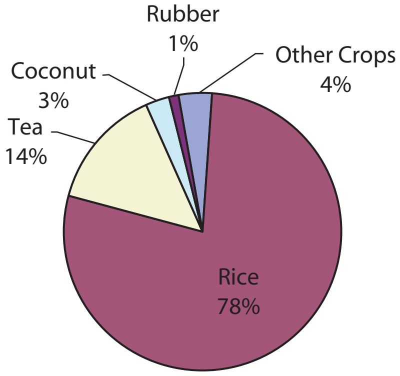
Figure 1.5: Rice production as affected by fertilizer use



Source: *Department of Census and Statistics*

Consumption of fertilizers by various crops is in the order: rice>tea>coconut>tobacco>other food crops>rubber>export crops (see Figure 1.6).

Figure 1.6: Share of crops in plant nutrient use



Source: *National Fertilizer Secretariat*

Most of the increase in fertilizer consumption over previous years can be attributed to rice. However, in the case of other crops consumption has either remained stagnant or shows wide fluctuations from year to year.

2. Fertilizer and soil fertility management policies – a review

2.1 Fertilizer production

Deposits of rock phosphate, the only known indigenous fertilizer resource, were discovered at Eppawala in 1971. A government-owned company, Lanka Phosphate Ltd. (LPL), has the mining rights. Potential reserves are estimated at 50 million tonnes of apatite rock. Present production of Eppawala rock phosphate (ERP) is between 40 000 and 50 000 tonnes with an average total P_2O_5 content of 28 percent and citrate soluble content of 4 percent P_2O_5 (see Table 2.1). Large quantities of ERP are used for tea, rubber and coconut. However, the rubber and coconut farmers use only half of the recommended dose for their crops. If the farmers were to use the recommended rates there could be an additional requirement of 30 000 tonnes per annum. This could be easily met since there are currently no limiting factors on additional production.

Table 2.1: Annual production and sales of Eppawala rock phosphate

Year	Production (tonnes)	Sales (tonnes)
2001	35 503	38 944
2002	39 378	39 592
2003	44 711	39 628
2004	41 145	46 547
2005	44 389	44 210
2006	42 274	39 426
2007	39 183	45 101
2008	36 782	33 252

Source: *National Fertilizer Secretariat*

High quality Eppawala rock phosphate (HERP), with 40 percent total P_2O_5 and between 6 to 7 percent citrate soluble P_2O_5 content is also produced, mainly for use on fruit crops and spices. HERP is obtained by crushing pure apatite.

Dolomite, a soil ameliorative, is mined in the Central Province of Sri Lanka. It is used as a liming material for tea, fruit crops, vegetables and potatoes.

2.2 Fertilizer imports

Sri Lanka imports chemical fertilizer to meet its requirements with 780 000 tonnes imported in 2008. About 58 percent of this was urea. MOP and TSP accounted for 18 and 13 percent, respectively of total fertilizer import. Other fertilizers with small percentage shares listed in Table 2.2 are also imported. Percentage shares of major fertilizer imports are depicted in Figure 2.1.

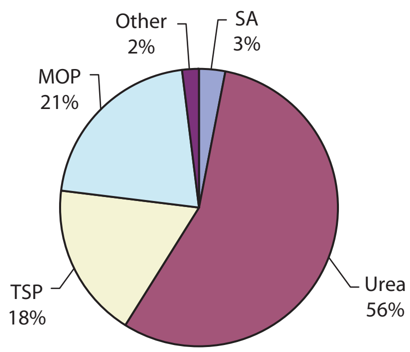
Table 2.2: Imports of fertilizers and their percentage share

Fertilizer	2006		2007		2008	
	Quantity	Share %	Quantity	Share %	Quantity	Share %
SA	60 681	8.88	50 258	9.33	26 052	9.33
Urea	366 199	53.60	311 192	57.75	433 039	57.75
RP	205	0.03	200	0.04	215	0.04
TSP	81 930	11.99	71 588	13.29	141 676	13.29
MOP	159 908	23.41	98 096	18.21	165 519	18.21
NPK-1+			371	0.02	3 758	0.02
NPK-3+	225	0.03		0		–
Kieserite	5 791	0.85	4 193	0.78	4 611	0.78
ZS	571	0.08	506	0.08	786	0.08
SOP	2 363	0.35	137	0.02	168	0.02
AP	100	0.01	27	0.01	350	0.01
SSP	3 868	0.57	1 280	0.24	1 824	0.24
Others	1 311	0.19	1 352	0.33	2 205	0.25
TOTAL	683 152	99.99	539 200	100.02	780 203	100.02

Source: *National Fertilizer Secretariat*

Figure 2.1: Percentage composition of fertilizer imports by type of fertilizer

Share of fertilizers in imports



Source: *National Fertilizer Secretariat*

Sri Lanka imported high citric acid soluble rock phosphate till a few years ago. However, with the introduction of HERP, there are scarcely any imports of rock phosphate fertilizers.

The share of various fertilizer companies in fertilizer imports is depicted in Table 2.3.

Table 2.3: Fertilizer companies' shares of imports

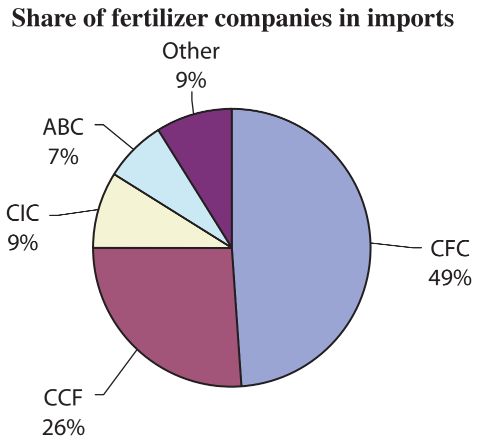
Company	2007		2008	
	Quantity	Share	Quantity	Share
CFC	218 408	40.51	386 101	49.49
SRI	2 626	0.49	2 214	0.28
ABC	24 752	4.59	56 922	7.30
CIC	58 113	10.78	67 827	8.69
CTC	–	–	5 677	0.73
HAFL	20 863	3.87	18 481	2.37
SEL	1 145	0.21	243	0.03
MIL	860	0.16		–
TSF		–	1 235	0.16
ACFL	2 357	0.44	727	0.09
ETA	15 163	2.81	18 657	2.39
CCF	157 088	29.13	200 832	25.74
LGF	3 564	0.66	884	0.11
AGST	34 261	6.35	20 401	2.61
TOTAL	539 200	100	780 201	100

Source: *National Fertilizer Secretariat*

Several companies are engaged in the fertilizer industry in Sri Lanka. However, 91 percent of the market is controlled by only four. These are Ceylon Fertilizer Company Ltd. (49.49 percent) Colombo Commercial Fertilizer Co., Ltd. (25.74 percent), CIC Agri-Business (8.69 percent) and A. Baur & Co. (7.30 percent). The Ceylon Fertilizer Company Ltd. (CFC) and Colombo Commercial Fertilizer Co., Ltd. (CCF) are in the public sector; the other two are private. Until the beginning of the subsidy scheme towards the end of 2005, the market shares of different fertilizer importing companies were rationally stabilized.

At present the government channels the entire subsidy through state-owned companies. This has considerably affected the companies' market share and adversely affects private companies (see Figure 2.2). Nearly 75 percent of imported fertilizer is used for rice.

Figure 2.2: Percentage share of fertilizer imports by importing company



Source: *National Fertilizer Secretariat*

The National Fertilizer Secretariat (NFS), established by Act of Parliament in 1988, monitors the various aspects of fertilizer imports.

Colombo is the main handling port for imported fertilizers. However, the handling facilities are geared more towards cargoes from container ships rather than material imported as bulk. The ships have to wait for berthing and, because of insufficient draft, problems are encountered in receiving big vessels.

2.3 Fertilizer transportation and warehousing

Fertilizer transport is mainly by road which is economical for short distances being quicker with lower transit losses. Rail transport is limited, though cheaper for long distances. Water transport is a low energy/ low cost option but yet to develop.

The seasonal nature of the demand for fertilizers makes it imperative to have stocks in primary or secondary storage points for subsequent distribution. Most fertilizer companies have warehouses in Colombo. The major fertilizer player Ceylon Fertilizer Company Ltd. (CFC) has two major warehouses in Hunupitiya (Colombo) and Polonnaruwa in the North Central Province, with storage capacities of 78 000 and 15 000 tonnes, respectively. The company has 50 district fertilizer stores with an aggregate storage capacity of 48 000 tonnes and linked by a computer system. Similarly, CIC Agribusiness and A. Baur & Co. each have warehouses with a capacity of 30 000 tonnes in Colombo, besides smaller capacity storages in various regions. The warehouses are well connected by road.

Inadequate field-level warehousing capacity is a major constraint to ensuring timely availability of fertilizers and the problem is especially acute in the northern and eastern areas of the country.

Fertilizer companies try to keep transit and warehousing losses to the minimum and observe quality control measures.

At present, around 10 percent of national requirements are kept as buffer stocks.

2.4 Other nutrient resources

Organic fertilizer use

Rice straw is a valuable source of carbon, potassium and silicon as well as organic manure. It is also very cheap. However, a large number of farmers burn the straw at the threshing site especially when there is no alternative means of disposal. There is still low acceptance of rice straw as a source of organic manure. Some possible reasons could be: cost and inconvenience of transporting the bulky material to the field, unavailability of simple and inexpensive methods to apply straw to the fields, and likely delays in land preparation for the next crop.

Rice straw could be applied in combination with recommended chemical fertilizers. The straw must be incorporated into the soil two to three weeks before land preparation or three to four weeks before rice planting.

Use of animal wastes for rice cultivation is very limited. The cost of transporting animal manure is too high to permit its application for rice. As far as possible, organic manure should be generated in the field itself or its near vicinity. In certain situations, provincial councils have been procuring organic manures from the private sector on a tender basis and making them available to the farmers on a subsidized basis (50 percent). Such practices, besides promoting malpractice and leading to quality control concerns, may also lead to a loss of initiative by the farmers. A preferred option would be to help farmers prepare their own manure.

Use of green manure in rice cultivation is not widespread. *Gliricidia maculata* and *Tithonia diversifolia* have shown promise as green manure crops and can provide up to nine tonnes/ha of biomass. Studies on the use of *Sesbania sesban* and *S. rostrata* as in-situ green manures for lowland rice reveal that they can supply up to 50 percent of the recommended N fertilizer.

There is intensive up-country use of cattle and poultry manure for potato and vegetable cultivation. Poultry manure is generally used at the rate of 10 to 15 tonnes/ha per crop. Application of cattle manure is in the range of 20 to 30 tonnes/ha per crop. For vegetable cultivation, sunken beds are prepared and filled with cattle manure then covered with a soil layer. Chemical fertilizer mixtures blended with soil are applied and the beds irrigated one or two days before planting. In the case of potato, cattle manure or poultry manure is spread along the furrows and covered with a layer of soil. Chemical fertilizer mixtures are applied and furrows irrigated one or two days before planting potato tubers.

An organic fertilizer bureau (OFB) in the Ministry of Agriculture has been set up. Its main objective is to increase the production and use of organic fertilizers. To help farmers in adopting the rational use of urea and balanced use of available organic and inorganic fertilizers, a national policy for the promotion of an integrated plant nutrition system (IPNS) is under implementation. However, the field level adoption of IPNS is low.

Biofertilizers

Use of biofertilizers is limited. More research efforts are needed to explore the feasibility of their use at the field level.

2.5 Soil fertility, crop response and fertilizer recommendations

Soil test-based nutrient management for food crops was introduced by the Department of Agriculture in 1993 and is still continuing. Nine regional laboratories were established under the programme. The programme was successfully implemented in the initial stages with financial support from the government. Currently however, there is no financial support for the soil testing service. In addition the laboratories are short of technical and analytical staff, rendering them almost defunct. Fertilizer recommendations have lost their significance for a major food crop such as rice in view of the supply of subsidized fertilizers. In recent years, little information about soil test-crop response has been generated.

The tea, coconut and rubber sectors have their own soil testing laboratories, run by the research institutions. These laboratories are supported with adequate funds and have staff to run them.

It is mostly improved rice varieties that are cultivated and these are highly fertilizer responsive. Recently, short duration improved varieties have been identified for which fertilizer recommendations need to be evolved. For maize cultivation, fertilizer-responsive hybrid varieties are in use. However, fertilizer recommendations for these varieties have yet to be developed.

Fertilizer application in the rubber and coconut sectors is lower than the recommended levels. Soil test based fertilizer recommendations are followed to a good extent in the case of tea.

Soil fertility maps are not available at local or national level. Soils with exchangeable K less than 75 mg/kg and P_2O_5 less than 10 mg/kg are considered deficient in the respective nutrients. Crop response to the application of particular nutrients has been observed. The available phosphorous and exchangeable potassium status of soils in various zones is provided in Tables 2.4 and 2.5.

Table 2.4: Distribution of soil samples (%) in available P (Olsen's) categories

Region	Available P (P_2O_5 mg/kg)			
	0–10	10–20	20–30	>30
LCDZ	62.9	16.4	10.0	10.6
LCIZ	79.6	13.4	2.4	4.6
LCWZ	67.9	19.5	6.0	6.6
MCWZ	75.1	14.6	3.9	6.3
MCIZ	74.4	16.3	3.2	6.1
UCIZ	30.8	16.9	6.1	46.2

Source: *Soil Testing Service, Department of Agriculture*

With the use of high yielding varieties, micronutrient deficiencies are cropping up. Widespread Zn deficiency symptoms have been observed throughout the country and soil analyses have shown that the level of Zn in the soil is lower than the critical Zn level for rice. Also, a good response to application of Zn fertilizers to rice has been observed in the trials conducted at farmers' fields.

Table 2.5: Distribution of soil samples (%) in exchangeable potassium categories

Region	Exchangeable K (mg/kg)			
	0–75	75–150	150–400	>400
LCDZ	67.8	24.8	6.9	1.4
LCIZ	80.3	14.0	4.6	1.1
LCWZ	75.5	17.9	5.9	0.7
MCWZ	75.1	17.6	6.3	1.0
MCIZ	68.4	19.5	9.9	2.2
UCIZ	33.1	30.0	30.8	6.2

Source: *Soil Testing Service, Department of Agriculture*

Fertilizer recommendations for rice

Fertilizer recommendations based on the target yield levels have been prescribed for rice for each of the agro-ecological zones (see Tables 2.6, 2.7, 2.8 and 2.9). Zinc sulphate at the rate of 5 kg/ha once a year is recommended.

In addition to the inorganic fertilizer the following organic manures are recommended to attain higher yields:

- 5 tonnes straw/ha – (straw removed from previous crop before or after first ploughing);
- 2.5 tonnes green manure/ha one week before levelling;
- 5 tonnes cowdung or 2.5 tonnes poultry manure/ha one week before levelling;
- 500 kg charred husk/ha just after levelling.

Table 2.6: Fertilizer recommendation for rice – low-country, dry & intermediate zones (yield – 5 tonnes/ha)

Variety duration and application time	Nutrients (kg/ha)		
	N	P_2O_5	K_2O
Basal	5	30	20
At 3 months			
1st top dressing (2 WAS/2 WAP)	40		
2nd top dressing (6 WAS/5 WAP)	55		15
At 3 1/2 months			
1st top dressing (2 WAS/2 WAP)	30		
2nd top dressing (5 WAS/4 WAP)	45		
3rd top dressing (7 WAS/6 WAP)	20		15
At 4-4 1/2 months			
1st top dressing (2 WAS/2 WAP)	25		
2nd top dressing (5 WAS/5 WAP)	30		
3rd top dressing (8 WAS/7 WAP)	40		15

Source: *National Fertilizer Secretariat*

Fertilizer recommendations for tea

Nursery tea

Two nursery mixtures, T65 MAP and T65 DAP, containing mono ammonium phosphate and di-ammonium phosphate respectively, are recommended, at the rates of 35 g and 70 g in 5 litres of water m^{-2} at fortnightly intervals, for two growth stages. The two mixtures differ only in the source of P. The option to have two P fertilizer sources is to allow growers a choice, depending on availability.

Table 2.7: Fertilizer recommendation for rice – up-country & mid-country, wet & intermediate zones (yield – 5 tonnes/ha)

Variety duration and application time	Nutrients (kg/ha)		
	N	P_2O_5	K_2O
Basal	5	40	20
At 3 months			
1st top dressing (2 WAS/2 WAP)	35		
2nd top dressing (6 WAS/5 WAP)	40		20
At 3 1/2 months			
1st top dressing (2 WAS/2 WAP)	20		
2nd top dressing (5 WAS/4 WAP)	35		
3rd top dressing (7 WAS/6 WAP)	20		20
At 4-4 1/2 months			
1st top dressing (2 WAS/2 WAP)	15		
2nd top dressing (5 WAS/5 WAP)	25		
3rd top dressing (8 WAS/7 WAP)	35		

Source: *National Fertilizer Secretariat*

Ground application of either of the mixtures is recommended, along with foliar spraying of zinc sulphate ($ZnSO_4$) at the rate of 14 g in 4.5 litres of water, sufficient for wetting 4 500 plants.

Table 2.8: Fertilizer recommendation for rice – low country and wet zone mineral soils, group I (tonnes/ha yield)

Variety duration and application time	Nutrients (kg/ha)		
	N	P_2O_5	K_2O
Basal	10	30	22
At 3 months			
1st top dressing (2 WAS/2 WAP)	20		22
2nd top dressing (6 WAS/5 WAP)	20		22
At 3 1/2 months			
1st top dressing (2 WAS/2 WAP)	15		22
2nd top dressing (5 WAS/4 WAP)	15		22
3rd top dressing (7 WAS/6 WAP)	15		
At 4-4 1/2 months			
1st top dressing (2 WAS/2 WAP)	10		22
2nd top dressing (5 WAS/5 WAP)	20		22
3rd top dressing (8 WAS/7 WAP)	15		

Source: *National Fertilizer Secretariat*

Immature tea

The fertilizer mixture T 200 is recommended for immature tea. This should be applied from the planting stage in the field to the commencement of plucking. The mixture T 750, which includes appropriate quantities of the nutrients N, P, K and Mg, is recommended from the commencement of plucking to the 1st prune. Where symptoms of deficiency are manifested, the amelioration of soil pH with dolomitic limestone, and foliar fertilization with Zn and other nutrients in the proper combinations are also important during the immature phase.

Table 2.9: Fertilizer recommendation for rice – low country and wet zone mineral soils, group II (5 tonnes/ha yield)

Variety duration and application time	Nutrients (kg/ha)		
	N	P_2O_5	K_2O
Basal	5	40	20
At 3 months			
1st top dressing (2 WAS/2 WAP)	35		
2nd top dressing (6 WAS/5 WAP)	40		20
At 3 1/2 months			
1st top dressing (2 WAS/2 WAP)	20		
2nd top dressing (5 WAS/4 WAP)	35		
3rd top dressing (7 WAS/6 WAP)	20		20
At 4-4 1/2 months			
1st top dressing (2 WAS/2 WAP)	15		
2nd top dressing (5 WAS/5 WAP)	25		
3rd top dressing (8 WAS/7 WAP)	35		20

Source: *National Fertilizer Secretariat*

Mature tea

The response of the tea plant to fertilizers is influenced by several factors, such as climate, soil, plant and cultural practices. These factors vary widely between tea-growing regions, and therefore the plant response to fertilizer is different from one region to another

In the current recommendations for mature tea, regional differences have been taken into account, in order to optimize the productivity and profitability of the tea lands. The optimum levels or ranges of N, P, and K_2O for seedling and vegetatively propagated tea were first established. These are given in Table 2.10. Thereafter, three model basal mixtures each, for seedling and vegetatively propagated tea, were formulated, so as to apply the lowest level of the optimum range for N, and the required amounts of P and K in each category. In the case of K, the required amount was taken as the mid-point (approximated wherever necessary) of the optimum range of potash for each region. The recommended forms of N, P and K are urea (4 percent of N), ERP (28.5 percent of P_2O_5) and muriate of potash (60 percent of K_2O), respectively.

Table 2.10: Optimum nutrient levels or ranges

Type of tea	Agro-climatic region			
	Up-country	Mid-country	Low-country	Uva
Seedling (kg/ha/year)				
N	90–220	90–180	90–140	90–220
P_2O_5	25	25	25	25
K_2O	70	70	50	70-100
VP				
N	270–400	270–400	270–400	270–400
P_2O_5	35	35	35	35
K_2O	100–140	100–140	100	140

Source: *Tea Research Institute*

As with immature tea, mature tea may require the amelioration of soil pH with dolomitic limestone and foliar fertilization with Zn and other nutrients in the proper combinations, depending on the manifestation of deficiency symptoms.

The compositions of the model basal mixtures are given in Table 2.11.

Table 2.11: Composition of model basal mixtures (figures in kg)

For seedling tea			
	ST/UM	ST/LC	ST/UVA
Urea	196 (90N)	196 (90N)	196 (90N)
ERP	87 (25 P_2O_5)	86 (25 P_2O_5)	89 (25 P_2O_5)
MOP	117 (70 K_2O)	83 (50 K_2O)	150 (90 K_2O)
	400	365	435
N: P_2O_5: K_2O	2.5:6.2:17.6	24.7:6.7:13.6	20.7:5.8:20.7
For VP Tea			
	VP/UM	VP/LC	VP/UVA
Urea	587 (270N)	587 (270N)	587 (270N)
ERP	123 (35 P_2O_5)	126 (35 P_2O_5)	125 (35 P_2O_5)
MOP	200 (120 K_2O)	167 (100 K_2O)	233 (140 K_2O)
	910	880	945
N: P_2O_5: K_2O	29.7:3.9:13.2	30.7:4.1:11.4	28.6:3.8:14.8

Source: *Tea Research Institute*

The designation of the mixtures is as follows:

ST/UM = Seedling tea mixture for the up- and mid-country; ST/LC = Seedling tea mixture for the low-country; ST/UVA = Seedling tea mixture for the UVA; VP/UM = VP tea mixture for the up- and mid-country; VP/UVA = VP tea mixture for the UVA.

Recent research on fertilization has been directed towards developing cost-effective approaches that will supply the nutrients necessary for enhancing yields and made tea quality, while at the same time minimizing environmental degradation and hazards to human and animal life.

The response of tea, in terms of growth and yield, to applied fertilizer or "plant nutrients" is influenced by factors such as climate, soil, plant genotype and a host of management practices. These factors vary widely between regions and sites, so much so that the response by the plant to fertilizer regimes will differ between districts and growing sites.

To further enhance productivity and tea quality, it is therefore apparent that there is a need to develop regional and site-specific fertilizer schedules. These will have to take into account soil type, soil fertility and the need for soil amelioration. As a means of achieving this goal, the Tea Institute is establishing well equipped regional laboratory facilities.

Fertilizer recommendations for coconut

Coconut is an important plantation crop. However, fertilizer use by the farmers is low. Coconut accounts for about 2.6 percent of total fertilizer use.

Fertilizer recommendations for the coconut crop in various agro-climatic zones are provided in Tables 2.12, 2.13 and 2.14.

Table 2.12: Fertilizer recommendations (g/plant) for young coconut plants until bearing – wet and intermediate zones

Fertilizer	Age of the plant							
	6 months	1 year	1 1/2 year	2 years	2 1/2 years	3 years	3 1/2 years	4 years and until bearing
Urea	190	235	235	305	305	375	375	470
Rock phosphate	420	530	530	690	690	850	850	1 060
Muriate of potash	190	235	235	305	305	375	375	470
Dolomite	500	500	500	500	500	500	500	500

Source: *National Fertilizer Secretariat*

Table 2.13: Fertilizer recommendations (g/plant) for young coconut plants until bearing – dry zone

Fertilizer	Age of the plant							
	6 months	1 year	1 1/2 year	2 years	2 1/2 years	3 years	3 1/2 years	4 years and until bearing
Urea	190	235	235	305	305	375	375	470
Rock phosphate	270	330	330	490	490	600	600	660
Muriate of potash	190	235	235	305	305	375	375	470
Dolomite	500	500	500	500	500	500	500	500

Source: *National Fertilizer Secretariat*

Table 2.14: Fertilizer recommendations (g/plant) for adult coconut plants

Fertilizer	Wet and intermediate zone	Dry zone
Urea	800	800
Eppawala rock phosphate	900	–
Rock phosphate	–	600
Muriate of potash	1 600	1 600
Dolomite	1 000	1 000

Source: *National Fertilizer Secretariat*

2.6 Soil health management

Depletion of soil organic matter

Soil organic matter content is one of the key parameters influencing soil fertility and productivity. Most soils in the main rice-growing areas are low in organic matter. Cation exchange capacity levels in the majority of the soils being lower, retention of plant nutrients is also low. Increasing the organic matter content of soils in the tropics is a difficult task. The seasonal applications of organic materials can play a useful role here.

Depletion of plant nutrients

The decline of soil fertility in Sri Lanka is due mainly to depletion of soil organic matter and loss of plant nutrients. Soil analytical studies conducted in various parts of the country reveal that low plant nutrient content is a major threat to crop production. Loss of plant nutrients due to leaching and runoff is also high.

Rice-growing soils in Sri Lanka have a low content of P in available form. In general, the P-fixing capacity of most soils is high. Soil analysis conducted in different areas show that between 63 to 80 percent soils are low in available P. The exception is some soils which grow potato and vegetables in rotation with rice in the up-country intermediate zone (UCIZ). Low available P status is also prevalent in soils of the UCWZ, UCIZ, and UCWZ.

Field crops on rainfed uplands receive inadequate fertilizer phosphorus. As a result, soils are relatively low in available P.

Almost 50 percent of the rice-growing soils in the LCWZ have exchangeable K content of less than 58 mg/kg, which is considered the critical soil K level for mineral or alluvial soils. It has also been observed that there is a declining trend in these soils when rice is grown continuously. In LCWZ, 83 percent of sites had a low soil K.

In both UCWZ and UCIZ, cultivation of vegetable and tuber crops is intensive. In the UCWZ, vegetables are cultivated throughout the year in rotation with potato. In the UCIZ, vegetables are grown under upland rainfed, irrigated and lowland rice-based cropping systems. Due to the hilly nature and high rainfall in this region, soils are rather poor in plant nutrient contents.

Excessive build-up of P

Excessive build-up of P has been observed in many intensive vegetable-growing soils. The condition is caused by indiscriminate use of organic and chemical fertilizers. Build-up of phosphorus in some potato and exotic vegetable growing soils in the up-country area, particularly in UCWZ and UCIZ, has been reported. Similarly, occurrence of high available P due to the use of high rates of deep litter as well as chemical fertilizers was observed in leafy vegetable-growing soils in the LCWZ.

Micronutrient deficiencies

Studies on micronutrients are rather limited in Sri Lanka. Rice-growing soils particularly in the dry and intermediate zones are deficient in Zn and Cu. Mn deficiency in some areas is also reported.

Micronutrient toxicities

Toxic levels of Fe in paddy soils have been observed in the LCWZ. In general, 30 000 ha of cultivated rice lands in the LCWZ are thought to have a potentially iron toxic condition.

Citrus-growing soils in the Uva region are deficient in available Zn, Fe and Cu content. Zinc and boron deficiency in citrus and papaya, respectively, is widespread in Sri Lanka.

Nutrient balance

Rice is a biannual crop and it removes considerable amounts of nutrients especially potassium and silica. Whether it is total removal depends on the yield. Nutrient removed by rice crop results in a negative balance of P and K even with the application of Department of Agriculture (DOA) recommended levels.

Soil Conservation

Soil erosion is a potential threat especially for uplands and requires constant attention. To prevent soil degradation through erosion, in 1951 the government enacted Soil Conservation Act No. 25. There is a need for regular refresher programmes for extension personnel and awareness programmes for the farmers on the adoption of field-level soil conservation measures to check and control soil erosion.

Problem soils

Salinity is a conspicuous problem. In addition to problems in the low-lying coastal areas of the country, inland salinity has been developing in areas with major irrigation schemes.

Poor water management practices and methods of drainage adopted by farmers aggravate the situation. The area under saline soils is gradually increasing and is estimated to be about 15 000 ha. Little has been done to address the problem. The present recommendations for overcoming the situation relate to application of organic manure and cultivation of salt-tolerant varieties.

Most of the upland areas under tea cultivation are acidic and dolomite is applied as a corrective.

Biodiversity

At present no studies have been carried out to study and monitor the effect of current agricultural practices on soil biota.

Conservation agriculture

Although there is ample scope for conservation agriculture, especially in the plantation sector, the practice is yet to be recommended and adopted at the field level.

2.7 Demand assessment

In order to assess seasonal fertilizer requirements the Department of Agrarian Services collects data on the types of food crop to be grown, area to be cultivated and average fertilizer use. This is done by village-level field officers, the agricultural research and productivity assistants. The information so collected in collaboration with the farmers' organizations is furnished to the divisional agricultural committees' located in the agrarian service centres (ASCs). There are 556 ASCs in the country. The ASCs in turn relay the data to the district agricultural committees (DACs), which finalize the district requirements. The requirements so worked out are consolidated at the level of the Agrarian Service Commissioner General and communicated to the National Fertilizer Secretariat, for planning fertilizer procurement and supplies. No mechanism exists for mid- and long-term demand assessments/forecasts.

2.8 Fertilizer marketing and distribution

Government-owned agencies have the major share of procurement and distribution. Four major companies dominate the marketing scene. The Ceylon Fertilizer Company Ltd. (CFC) holds nearly 50 percent of market share, while the Colombo Commercial Fertilizer Co., Ltd. (CCF), CIC Agri Business (CIC) and A. Baur & Co. (ABC) control 26, 9 and 7 percent of the market, respectively. Each company has its own distribution network. The decreasing share of the private sector is a cause for concern.

The existing system with differential rates of subsidy has led to distortions in the market. The functions of the present set-up are concerned mainly with the distribution of subsidized fertilizers and administration of the subsidy. Distribution of the subsidized fertilizer, i.e. most of it, is routed through and monitored by the state-owned agencies. However, loopholes and leakages in the system are inevitable.

There is a shortage of retail outlets in the rural interior. However, the establishment of around 553 ASCs in areas where input supply was a constraint has improved both access and timely availability of fertilizers for the farmers. The ASCs also handle other agro-inputs, thus ensuring their integrated supply and distribution.

Fertilizer is usually packed in 50-kg bags and the preferred container is made of woven polypropylene with a low-density polyethylene liner. Fertilizer packs with a net content of 25 kg are also marketed to meet the requirements of small farmers.

The fertilizer companies are reluctant to share the details of marketing costs and margins. However, there is thought to be good scope for reducing marketing costs through improvements in the marketing management system.

2.9 Credit

The agrarian banks maintain branches in the ASCs to provide credit to the farmers. However, with the current high subsidies the farmers' need for fertilizer credit is limited. This is especially true for rice, the major foodgrain crop, which is also the major consumer of fertilizer.

Where loan recovery is concerned, the most efficient systems have been those linked with crop collectors, such as those in the Sri Lankan tea sector.

In general, the fertilizer suppliers give the dealers credit. The arrangement is that payment is made within a specified interest-free period to enable the dealers to hold sufficient stocks to meet seasonal demand.

2.10 Fertilizer pricing and subsidy

The present fertilizer subsidy scheme was initiated in 2005 for rice cultivation. Under the scheme 50 kg of fertilizer were provided to farmers at a subsidized rate of Rs.350. In 2006, the subsidy was extended to other field crops such as chillies, maize, onion and vegetables that are cultivated in rice lands. The scheme was recommended at a rate of Rs.1 000 for 50 kg of fertilizer for smallholders (less than 2 ha) cultivating tea, rubber and coconuts. In 2007, the market prices of 50-kg bags of urea, MOP and TSP were Rs.2 600, 2 600 and 2 750 respectively. The farmers had the benefit of about an 87-percent price subsidy for these three major types of fertilizer.

In 2008, the world market price of fertilizers increased further, and in July 2008 the market prices for 50 kg of urea, MOP and TSP were Rs.4 200, 6 337 and 6 150, respectively. At this price level, the subsidy levels of urea, MOP and TSP were 92, 94 and 94 percent, respectively. In November 2009, the market price of fertilizer decreased to Rs.2 750, 4 600 and 3 000 for 50 kg of urea, MOP and TSP, respectively. At this price level, the subsidy levels for urea, MOP and TSP worked out at 87, 92 and 88 percent, respectively.

Subsidized and market prices of the main fertilizers for the past several seasons are provided in Table 2.15.

Table 2.15: Subsidized and market prices for main fertilizers

Season	Subsidized price Rs/50 kg bag*			Market price Rs/50 kg bag*		
	Urea	TSP	MOP	Urea	TSP	MOP
2004 *Yala*	550	–	–	1 300	–	–
2004/2005 *Maha*	550	–	–	1 700	–	–
2005 *Yala*	550	–	–	1 650	–	–
2005/2006 *Maha*	550	–	–	1 700	–	–
2006 *Yala*	350	350	350	1 785	1 500	1 132
2006/2007 *Maha*	350	350	350	1 785	1 500	1 450
2007 *Yala*	350	350	350	2 125	1 688	1 525
2007/2008 *Maha*	350	350	350	2 462	2 953	2 405
2008 *Yala*	350	350	350	2 924	5 068	3 585
2008/2009 *Maha*	350	350	350	5 350	7 709	6 612

Source: *National Fertilizer Secretariat*
** 1 US$ = 115 Sri Lanka Rupees*

The value of the subsidy, calculated on the basis of usage, in selected districts is given in Table 2.16. The value ranges from Rs.16 512 (Kandy) to 28 027 (Polonnaruwa) per hectare.

Table 2.16: Fertilizer usage by rice farmers and value of subsidy

District	Irrigation type	Average use of fertilizers (kg/ha)				Value of subsidy at market price (Rs/ha)
		Urea	TSP	MOP	Total	
Anuradhapura	Major	247	91	72	410	22 788
Polonnaruwa	Major	336	94	82	511	28 027
Mahaweli-H	Major	269	94	77	440	24 406
Ampara – West	Major	282	106	86	474	26 493
Ampara – East	Major	272	94	82	447	24 945
Hambantota	Major	282	94	91	467	26 259
Kurunegala	Rainfed	220	69	74	363	23 057
Gampaha	Rainfed	119	57	82	257	17 404
Kandy	Rainfed	116	59	72	247	16 512
Kalutara	Rainfed	109	64	37	277	19 375

Source: *Socio-Economics and Planning Centre, Department of Agriculture*
Note: *Analysis is based on the cost and returns of Maha* 2008/09

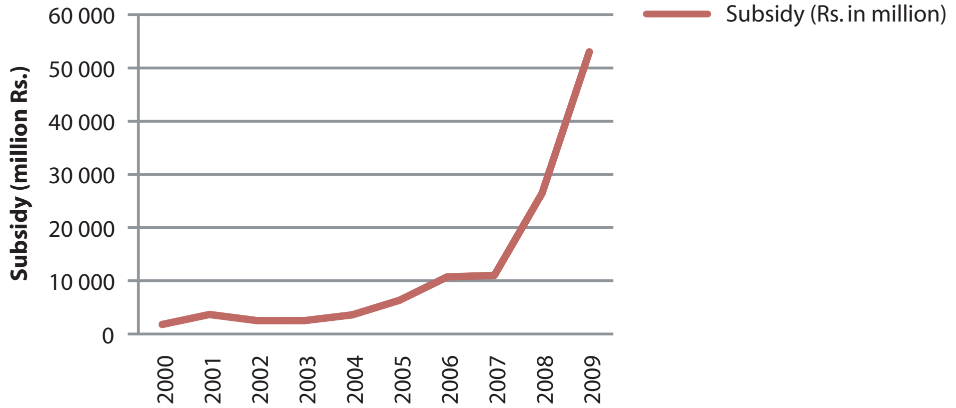
The current level of subsidy has assumed staggering proportions. The amount for the current year (2009) is estimated as Rs.53 billion (see Table 2.17 and Figure 2.3).

Table 2.17: Growth of fertilizer subsidy

Year	Rice (million Rs)	Tea (million Rs)	Total subsidy (million Rs)*
1994	610.000	–	610.000
1995	1 346.000	–	1 346.000
1996	1 500.000	–	1 500.000
1997	1 894.270	–	1 894.270
1998	2 215.340	–	2 215.340
1999	1 390.018	–	1 390.018
2000	1 765.973	–	1 765.973
2001	3 648.994	–	3 648.994
2002	2 446.000	–	2 446.000
2003	2 487.000	–	2 487.000
2004	3 571.762	–	3 571.762
2005	6 285.520	–	6 285.520
2006	10 696.250	3.180	10 699.430
2007	10 167.060	831.210	10 998.270
2008	24 314.990	2 067.970	26 382.960
2009 (to September)	47 412.400	1 680.090	49 092.490

Source: *National Fertilizer Secretariat*
Figures in Sri Lankan Rupees; 1 US$ = 115 Sri Lanka Rupees

Figure 2.3: Growth of fertilizer subsidy over the years



Source: *National Fertilizer Secretariat*

The present pattern of subsidy, besides being a burden on the state exchequer, is leading to a number of adverse effects such as:

- distortion of the fertilizer market;
- leaving room for malpractice;
- overuse and unscientific use of fertilizers;
- distorted pricing pattern;
- distortions in the marketing and farm advisory services;
- reduced emphasis on other nutrient sources and IPNS.

2.11 Economics of fertilizer use

The prices of inputs and outputs affect the profitability of fertilizer use. A study undertaken by the Socio-Economics and Planning Centre, Department of Agriculture, examines the cost-benefit for the current scenario and the impact of fertilizer subsidy reduction. A cost-benefit analysis of rice cultivation, with and without a fertilizer subsidy, and for different water regimes (major and rainfed irrigation) is given in Table 2.18. The complete removal of the fertilizer subsidy could increase the cost of rice cultivation by 22 to 24 percent in major irrigation schemes. The increase would be in the range of 13 and 23 percent for rainfed rice cultivation in the wet and intermediate zones.

Table 2.18: Cost of rice cultivation: with and without fertilizer subsidy

District	Irrigation type	Cost of Rice Cultivation (Rs./ha)		% increase in cost due to complete removal of fertilizer subsidy
		Total cost with fertilizer subsidy	Total cost without fertilizer subsidy	
Anuradhapura	Major	82 730	105 518	22
Polonnaruwa	Major	77 306	101 658	24
Mahaweli-H	Major	76 671	101 077	24
Ampara – West	Major	77 321	103 814	26
Ampara – East	Major	78 828	103 772	24
Hambantota	Major	85 138	111 397	24
Kurunegala	Rainfed	74 634	84 291	13
Gampaha	Rainfed	82 441	98 052	19
Kandy	Rainfed	89 760	104 548	16
Kalutara	Rainfed	74 559	92 000	23

Source: *Socio-Economics and Planning Centre, Department of Agriculture*
Note: *Analysis based on the cost of production of Maha 2008/2009.*

A sensitivity analysis was conducted to evaluate the changes in cost of rice cultivation under different subsidy levels. The results are summarized as follows:

- At the prevailing farmgate price[6], the current fertilizer subsidy (between 87 and 92 percent) level, and 75 percent subsidy levels provide sufficient incentives for rice production under all water regimes (major, minor and rainfed).
- In order to assure a profit margin of at least 50 percent for farmers, the farmgate price should be about Rs.30/kg.
- If the farmgate price of rice prevails at around Rs.30/kg, a 50-percent reduction in fertilizer subsidy makes no severe impact on rice cultivation in high-yield potential areas. The incentives for producers in wet and intermediate zones will decrease but positive incentives remain for most districts (see Table 2.19). Even a marginal increase in rice price can increase the profitability further.

[6] Price 1: Market price for rice (Rs/kg) in 2008–09 Maha: Anuradhapura 30.10, Polonnaruwa 30.41, Mahaweli-H 30, Ampara – West 29, Ampara – East 28.66, Hambantota 27.81, Kurunegala 35.82, Gampaha 35.92, Kandy 28, and Kalutara 32.

Table 2.19: Costs and returns of rice cultivation under 50 percent fertilizer subsidy

District	Irrigation type	Cost (Rs/ha)	Gross income (Rs/ha)	Profit (Rs/ha)
Anuradhapura	Major	92 689	151 073	58 383
Polonnaruwa	Major	87 959	182 372	94 413
Mahaweli	Major	87 334	168 800	81 466
Ampara – West	Major	88 908	146 790	57 882
Ampara – East	Major	89 735	160 977	71 242
Hambantota	Major	96 634	180 243	83 610
Kurunegala	Rainfed	83 619	132 535	48 916
Gampaha	Rainfed	89 350	119 331	29 983
Kandy	Rainfed	96 303	73 655	-22 633
Kalutara	Rainfed	82 313	85 442	3 129

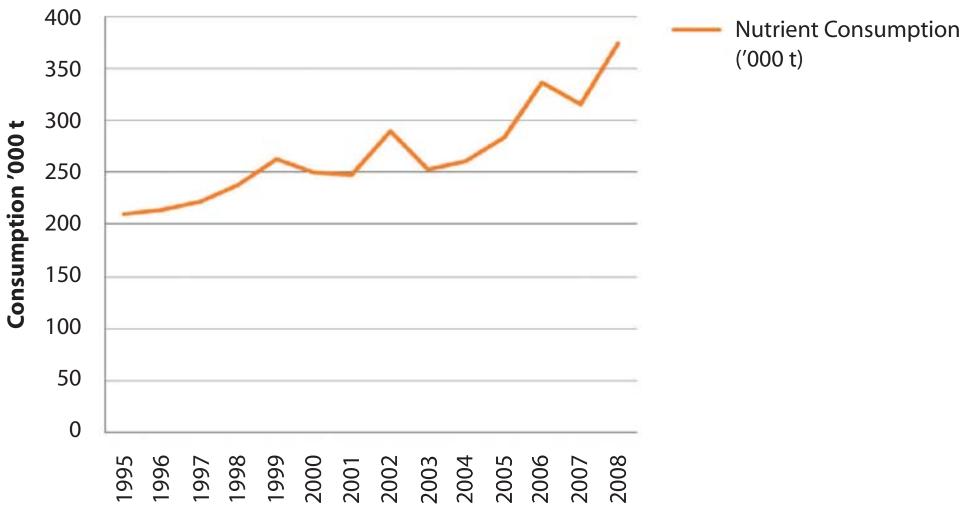
Source: *Socio-Economics and Planning Centre, Department of Agriculture*
Note: *Farmgate price Rs.30/kg; analysis based on cost and returns of Maha 2008–2009*

2.12 Fertilizer use

Fertilizer consumption growth and foodgrain production

There has been a steady growth in fertilizer consumption over the years (see Figure 2.4). Nutrient consumption has increased from 210 000 tonnes in 1995 to 375 000 tonnes in 2008.

Figure 2.4: Consumption of plant nutrients over the years in Sri Lanka



Source: *National Fertilizer Secretariat*

A positive relation is revealed between nutrient consumption and foodgrain production. For rice, while the nutrient consumption registered an increase from 150 000 tonnes in 1999 to 250 000 tonnes in 2008, during the same period rice production increased from 2.9 million tonnes to 3.9 million tonnes (see Figure 1.6).

Product use pattern

Urea is the most widely used form of nitrogen fertilizer. The introduction by the government of a subsidy scheme for urea has led to increased demand. Ammonium sulphate is the second major nitrogen fertilizer used.

Triple superphosphate (TSP) is the most dominant phosphorus fertilizer used for short-duration crops such as rice, vegetables and other crops. About 80 percent of TSP is utilized for paddy cultivation. The balance is used mainly for vegetables, other food crops (OFC) and fruit crops. Eppawala rock phosphate is mainly used for fruit crops grown in the wet zone of Sri Lanka.

Muriate of potash (MOP) is the second most dominant fertilizer used in the country. Another minor source of potash, sulphate of potash (SOP) is used on a limited scale for chloride-sensitive crops.

The most popular compound fertilizer used is granular NPK. Various grades of physical fertilizer mixtures are available in the market.

Soil amendments and secondary and micronutrient carriers

Dolomite is available locally and is used as a soil ameliorative for acid soils. It is mainly used for potato, vegetables and other horticultural crops. It is also used as a source of the secondary nutrient, magnesium, for tea plantations.

Kieserite is imported in small quantities, mainly for horticultural crops. Epsom salt is used to correct magnesium deficiencies in fruits, vegetables and OFC.

With regard to micronutrients, zinc deficiency is a common problem for rice grown in the dry and intermediate zones and in fruits, especially citrus. Zinc sulphate is used to correct the deficiency.

Crop-wise fertilizer use

Rice

Rice consumes the largest part of chemical fertilizers. The main fertilizers used for rice cultivation are urea, TSP and MOP. Many farmers in the dry and intermediate zones use the recommended levels of chemical fertilizers, but farmers in the wet zone use less than the recommended levels.

In addition to NPK fertilizers, the DOA has recommended an annual application of zinc sulphate at the rate of 5 kg $ZnSO_4$/ha for rice cultivation.

Vegetables

Unlike the general pattern of low fertilizer use in paddy and OFC, most vegetable farmers use high quantities of chemical as well as organic fertilizers. The level used for the vegetable crops is almost two to three times the quantity recommended by the DOA. This may be due to the favourable crop/price relationship for vegetables.

Other field crops

Since OFC are mainly grown under rainfed conditions, general fertilizer use is low. OFC crops mainly depend on soil nutrient reserves rather than on fertilizers.

Cash crops

For cash crops such as onion and chillie, high rates of fertilizers are used. Overuse of chemical fertilizers for onion has been reported in some areas.

Plantation crops

After rice, tea is the major consumer of fertilizers. For rubber and coconut, farmers do not apply the recommended dose and their share in overall consumption is low.

Fruit crops

Except for a few commercial growers, most small-scale farmers use very low doses or even apply no chemical fertilizers for many fruit crops. Crop-wise fertilizer use is given in Table 2.20.

Table 2.20: Nutrient consumption (tonnes) by various crops (2008)

Nutrient	Paddy	Tea	Rubber	Coconut	OFC	EAC	Tobacco	Others	Total	Share
N	165 299	33 694	1 517	3 132	2 663	718	7	2 335	209 365	55.8
P205	58 183	4 722	1 083	1 637	2 152	438	7	829	69 049	18.4
K20	69 089	15 054	1 240	4 897	3 192	685	8	1 449	95 612	25.5
TOTAL	292 571	53 470	3 840	9 666	8 007	1 841	22	4 613	374 026	
Share	78.2	14.3	1.0	2.6	2.1	0.5	0.0	1.2	100	

Source: *National Fertilizer Secretariat*

Fertilizer use across regions

Because of variation in soil types, agro-climatic conditions and crops grown, a direct comparison of fertilizer use across the regions is not a meaningful measure of the stage of fertilizer use in different regions.

Use of organic and biofertilizers

Use of organics is quite high for commercial crops like potato and vegetables. However, use of rice straw in rice fields is still neglected. As a policy, DOA is promoting the use of organics.

Use of biofertilizers is limited and is still in its infancy. More research and adaptive trials are needed.

Integrated plant nutrition system

Studies of plant nutrition management have shown that, in many cropping systems, management through the judicious, combined use of organic and chemical fertilizers would lead to sustainable crop production, as well as overall soil improvement. IPNS has been accepted by the DOA as a policy measure. However, adoption at the field level is low. It has been demonstrated that IPNS provides significantly higher rice yields and value-cost Ratio (VCR) over other treatments (see Table 2.21)

Table 2.21: Rice yield and VCR with IPNS and other fertilizer practices

Treatment	Yield (tonnes/ha)	VCR
Mean yield without chemical fertilizer	3.0	2.68
Mean yield with chemical fertilizer	4.5	2.64
Mean yield with chemical fertilizer + rice straw	6.0	5.02
Mean yield with chemical fertilizer + rice straw + cow dung + green manure	9.8	8.22

Source: *National Fertilizer Secretariat*

2.13 Fertilizer quality control

The National Fertilizer Secretariat has been entrusted with the responsibility for fertilizer quality control, and empowered to take decisive action in this regard. In order to ensure quality, the following measures are to be adopted:

- ensuring quality certificates before shipment;
- sampling and analysis at port/bonded warehouse;
- sampling and analysis at the blending/producing stage;
- sampling and analysis at distribution and marketing stages.

The Sri Lanka Standards Institution has laid down specifications for various fertilizer products. Samples for analysis are referred either to the institute's laboratory or the Industrial Technology Institute laboratory. However, field-level monitoring is inadequate due to lack of infrastructure, funds and manpower.

2.14 Research and knowledge base

There are several institutions devoted to research on prime crops, such as the Rice Research and Development and Tea Research Institutes. The institutions need to continue their existing focus on fertilizer use efficiency research. The subject of biofertilizers needs to be explored further.

The soil testing service needs to be rejuvenated. Soil test based recommendations for recently evolved varieties, especially maize and short duration rice, are yet to be evolved through on-farm research.

Although there is a substantial extension force, its main function at present relates to distribution of subsidized fertilizers and administration of subsidies, leaving little time for extension and field activities to promote scientific and integrated use of chemical, organic and bio-nutrient resources.

2.15 Environmental aspects

In the east, north and some parts of northwestern Sri Lanka the soils are predominantly permeable with shallow water tables, which are susceptible to leaching with high application of fertilizers. The risk of the ground and surface water of the central highlands becoming polluted is also high. In the Kalpitiya Peninsula leaching of chemical fertilizer from intensively cultivated lands has been found to elevate the concentration of nitrates in groundwater.

In the up-country potato and vegetables, the levels of chemical fertilizer applied are almost double or triple the quantity recommended by the DOA. In addition, use of high rates of animal manure is common. The hilly nature of the terrain and high rainfall provide conditions conducive to nutrients being washed into the water resources.

Hilly terrain with a high use of phosphatic fertilizers plus the risk of erosion increases the probability of phosphates getting into the water streams. Intensive phosphatic fertilizer use enhances the risks of cadmium build up in soils, which needs monitoring.

2.16 Coordination and monitoring

Coordination and monitoring functions were assigned to the National Fertilizer Secretariat (NFS) by a 1988 Act of Parliament. The act provides for the regulation of importation, manufacture, formulation, distribution and quality control of fertilizers. However, as the central focal point, NFS needs to broaden its functions in order to serve the interests of fertilizer and soil fertility management effectively. This would require suitable strengthening measures for NFS.

3. Policy gaps and framework for a sustainable fertilizer and soil fertility management policy

Fertilizer use and soil fertility management are the core support elements of a high-yield agricultural production programme. About one-third of the increase in cereal production worldwide is attributed to fertilizer use. Assessment of existing national fertilizer management practices and policies and appropriate recommendations relating to sustainable soil fertility management and fertilizer use strategies and policy are imperative in the present context of providing sustainability to the system.

A policy framework for a sustainable fertilizer and soil fertility management programme is suggested here. This is based on the review and analysis of the prevailing policies and programmes provided in Chapter 2. It takes into account the availability of resources, the factors and constraints involved and their inter-relationships and possible effects of interventions. An account of the gaps in policy and suggested policy measures to achieve sustainability are given in the following text.

3.1 Policy relating to fertilizer availability and demand assessment

The adequate and timely availability of fertilizer, as an essential input for agricultural production, must be ensured through strong policy support measures in order to provide food security to the population of Sri Lanka.

Demand assessment is the first step towards planning adequate and timely availability. While short-term assessment meets immediate requirements, medium- and long-term demand assessments are essential tools for perspective planning.

There is a need for realistic assessment of demand for fertilizers. Overestimation of demand leads to a high inventory carrying cost, deterioration in the quality of fertilizers because of prolonged storage, and liquidity problems. Underestimation of demand results in scarcities, rises in the farmers' costs and finally to lower agricultural production due to inadequate quantities applied to the crops.

An effective mechanism for assessment of short-term requirements based on subsidy provisions exists in the country. Individual farmers' requirements are calculated on the basis of area under cultivation and general fertilizer requirements. Demand figures based on an exercise done by a field level officer in consultation with the farmers and Farmers' Societies are forwarded to the Agrarian Service Centres to authorize release of fertilizers to the farmers. The demand figures generated at field level are consolidated at the national level by the National Fertilizer Secretariat.

A suitable methodology for medium-term demand estimations for Sri Lanka, which are currently unavailable, needs to be adopted. Various approaches used for such forecasting in developing countries are available through a recently conducted study by RAP (2009). A suitable methodology that took into account the country's needs and available resources could be chosen for making such forecasts. The National Fertilizer Secretariat, the main national coordinating agency, could be provided with adequate professionals to carry out such a task.

3.2 Policy relating to ownership and management of fertilizer sector

Like many developing countries, there is a general preference in Sri Lanka for state ownership and management of fertilizer production, import and distribution. The government-owned corporations are the preferred business entities and enjoy a monopoly status. Ceylon Fertilizer Corporation and Colombo Commercial Fertilizers are the major state-owned procurement agencies holding more than 75 percent share of the fertilizer market. The rock phosphate production unit, Lanka Phosphates Ltd., is also a public sector organization.

Management difficulties are likely to be inherent in such state-owned entities. The lack of strong motivation usually leads to operational inflexibility, with the result that the organizations are not usually induced to adapt readily to changing market environments. In order to provide long-term improvements, policy should consider the gradual privatization of state-run fertilizer production units, import organizations and distributors, and, to the extent possible, private sector solutions to most of the problems.

3.3 Policy relating to fertilizer production

There being no suitable raw materials excepting the Eppawala rock phosphates (ERP) in Sri Lanka, development of indigenous fertilizer production capabilities is limited.

The government should ensure that comprehensive raw material surveys are carried out and that these are regularly reviewed in the light of new technical developments. It is understood that during the past 30 years, only mining activities have been carried out and no further exploration has been done. The southern areas of the country offer good scope for exploration; substantial deposits of rock phosphates are expected at some locations.

Present production of ERP is in the order of 50 000 tonnes with an average total P_2O_5 content of 28 percent and citrate soluble content of 4 percent P_2O_5. Large quantities of ERP are used for tea, rubber and coconut. However, the farmers use only half of the dose recommended for rubber and coconut. If they were to use the recommended doses another 30 000 tonnes of ERP would be required per annum. This requirement can be easily met since there are presently no limiting factors on additional production.

Another higher grade of rock phosphate, HERP, with 40 percent total P_2O_5 and 6 to 7 percent citrate soluble P_2O_5 content is also being produced, mainly for fruit crops and spices.

Product development based on utilization of ERP may provide avenues for import substitution. It is understood that a proposal for production of single superphosphate has been pending for sometime. While the rock phosphate requirements can easily be met through ERP, sulphur will have to be either imported or could be generated locally through sulphur removal from petroleum.

Production capacities in the vicinity of ports based on import of intermediates such as ammonia and phosphoric acid, as in the case of DAP/MAP, could be considered in the long term, and the feasibility of setting up joint ventures could be explored. However, if the economic justification is found to be weak or project management and subsequent plant operation expected to be poor, the idea may have to be dropped.

Capacity building for human resources in the production sector is another aspect which should receive constant attention.

3.4 Policy concerning fertilizer imports

Importing the major requirement is usually the only option to meet most of the fertilizer requirements. There may be no medium-term alternatives in view of the absence of indigenous raw materials in Sri Lanka.

Imports are expensive in terms of foreign exchange and this can become acute when international fertilizer prices are high. There is no effective way of isolating the country from the inevitable fluctuations in the international fertilizer market. However, government policy can help to minimize any consequent problems.

The timely provision of foreign exchange will help importers to buy at the most opportune moment. Policies that facilitate the timely issue of foreign exchange for fertilizer imports are needed. Also, coordination between the central bank, Ministry of Finance and the importers needs to be strengthened.

Heavy reliance on imports implies that domestic fertilizer prices will tend to be affected by international market prices (unless subsidies are adjusted). The flow of material in the domestic market is also dependent on the smooth running of the purchasing and supply chain from the foreign supplier to the importer's main warehouse. Any unexpected delay can cause a local shortage resulting in a lower harvest and lower food security. In view of the foregoing, the necessary safety nets need to be built into the system. A good option usually involves designation of only a few specialized institutions to undertake purchase of fertilizer and provide a central base for distribution to the main transit warehouses. This has the following key advantages:

- It secures lower import prices by purchasing large quantities.
- It provides economies of scale for port warehousing and transport to main transit warehouses.
- Specialization in fertilizer procurement enables the organization to build up skill and experience in assessing demand, negotiating prices, planning the arrival of supplies and minimizing product losses during port handling and forwarding.
- Equalizing the prices of successive consignments maintains price stability throughout the year.
- Ceylon Fertilizer Corporation and Colombo Commercial Fertilizers are the major state-owned procurement agencies in Sri Lanka. Together they hold about 75 percent of the total quantum of fertilizers imports. The remaining 25 percent share is held by private-sector companies.

3.5 Policy relating to minimization of import costs

Although the crop price is the most important factor affecting the demand for fertilizers, the price paid for fertilizers is also significant. Governments have a major part to play in ensuring that farmers receive fertilizers at the lowest possible cost commensurate with a reliable and timely supply.

In a country like Sri Lanka, where fertilizers are imported, the most significant factor is the cost delivered to the port. The fertilizer f.o.b. price, the cost of shipping, discharging, bagging and loading to truck at the port of delivery are important components. There is usually scope for reducing costs and government policy can be of help in various ways:

- Maintaining a stable exchange rate will stabilize import costs.
- An adequate supply of foreign exchange will make it possible to import at the right time to meet demand.
- Fertilizer imports should be kept free from import taxes and duties.
- Port and agency charges should be kept under constant scrutiny and compared with charges in other similar ports, and corrective measures taken accordingly.

Internal transport cost, comprising labour charges; transport machinery depreciation, maintenance and repair; insurance; fuel; and taxes and duties is an important cost component. Costs increase due to high taxes, duties levied by the government itself and this may be an obvious area for policy action to reduce costs.

3.6 Policy relating to port development and port handling facilities

Colombo is the main handling port for imported fertilizers. However, the facilities at the port are more geared towards receiving containers rather than material imported as bulk. The ships have to wait for berthing. Because of the insufficient draft, problems are encountered in receiving big vessels. While the expansion plan for Colombo port is in progress, there is a need to develop Hambantota and Trincomalle as fertilizer handling ports. While Hambantota can take care of the southern parts of the country, Trincomalle can serve the east and north. Development of these ports to handle fertilizer will lead to a reduction both in logistical costs and gaps in supplies.

There is always scope for improvement of mechanical offloading equipment and facilities must be sufficient to deal smoothly and efficiently with the expected rates of delivery.

Handling methods which result in damage to bags, such as using hooks, must be eliminated. Storage facilities must be clean and dry and there must be sufficient space to keep the different products separate and permit easy removal from store.

In the case of fertilizers imported in bulk and bagged either at the port or at inland centres, adequate controls are needed to ensure that the quality and weight of the bagged fertilizer conform to the desired specifications. The rate of bagging at the port should not become a bottleneck in fertilizer movement.

In order to check the quality of imported fertilizers, fertilizer samples are drawn from the consignments by the National Fertilizer Secretariat and sent for analysis. Till such time as the analytical report is received, the consignment has necessarily to be kept in a warehouse, incurring warehousing charges. Speedy clearance of the stocks based on analytical results should be ensured and delays curtailed.

3.7 Policy relating to fertilizer transportation and warehousing

The first criterion of effectiveness in fertilizer distribution is that the product be available at the right place, at the right time and in the right quantity. To a large extent this depends on the existence of suitable means of transport and storage facilities. Economical ways to tackle transport and storage problems may be found through good management and effective planning.

Transportation

At present in Sri Lanka, most fertilizer is transported by road. Road transportation is economical for short distances since it is generally quick, the number of handlings is few, losses in transit are low and it offers the possibilities for return loads and competitive pricing. To obtain the maximum benefits from road transport, fuel costs can be reduced by proper route planning and by ensuring return loads. Partly laden trucks and long detours to deliver only small quantities need to be avoided since they lead to unnecessary costs.

Rail is usually preferred for haulage over long distances because of lower cost per unit of material transported. The important factor is the reduction of the turnaround period of the rail wagon. This is possible through movement in a full trainload to a single destination. However, there is currently a dearth of railheads properly equipped to receive and handle such loads within a reasonable time.

One of the objectives of future planning should be the identification and development of the facilities needed at selected railheads to receive and handle the trainloads within the shortest possible time. Transit warehouses will also have to be developed at the railheads.

Water transportation, even with its limitations, offers a low energy/low cost alternative and is a particularly attractive option. However, in spite of its long coastline and inland waterways, water transportation of fertilizers is yet to develop. Suitable vessels will have to be sourced and receiving and handling facilities developed at selected locations.

A national level planning exercise relating to fertilizer logistics involvingroad, rail and water transportation should be carried out to evolve and develop an effective, economic and feasible transportation model for fertilizer movement.

Warehousing

The seasonal demand for fertilizers in the *Maha* and *Yala* seasons makes it imperative that fertilizer stocks are held in primary or secondary storage points for subsequent distribution. Storage time at port must be kept to the minimum because of humidity considerations. However, there must be sufficient space to permit quick reception of the ship's cargo.

Inadequate warehousing capacity at the field level, especially in the north and east, is one of the major bottlenecks in timely availability of fertilizers during the peak season. More investment is needed to provide for additional warehousing capacities at the field level.

National level planning is needed in regard to the location and extent of storage capacity, taking into account economic considerations and fertilizer movement. This would go a long way to economizing on marketing costs and ensuring timely availability of the fertilizers to the farmers. Such an exercise would have to be done in a coordinated manner with the full participation of all the stakeholders in the fertilizer sector.

Buffer stocks

An importing country like Sri Lanka is vulnerable to price and supply fluctuations in the world market and to supply shortfalls arising from higher than expected demand. Some buffer stocks are therefore advisable. Currently around 10 percent of the national requirements are kept as buffer stocks.

3.8 Policy relating to fertilizer products to be marketed

Fertilizer marketing policies should ensure that appropriate products at appropriate prices are made available to the farmers. Among the various fertilizer imports, urea (46:0:0), TSP (0:46:0) and MOP (0:0:60) have the major share. Single superphosphate (16 percent P_2O_5) is also imported. Greater procurement and use of DAP (18:46:0), which has a higher analysis than SSP and TSP, may be explored for those areas where it can be suitably used, in order to make economies in procurement price, bagging, transportation, handling and marketing costs per unit of nutrient.

In addition to the straight fertilizers, there are a number of physical mixtures available in the market. Apart from the grades recommended by the research institutions, there is a horde of mixture grades. The desirability of such mixtures is questionable on account of quality control considerations. There is no uniformity of nutrients in the mixtures quite apart from the types of fillers used and high per unit nutrient costs. The usual argument advanced is that the prevailing ignorance of the farmers makes it difficult for them to blend the straight fertilizers in the desired proportions. However, the argument is invalid in the sense that most fertilizers presently used by smallholding farmers (especially for rice) are in the form of straight fertilizers only. There is a definite need to bring down the number of the various grades of fertilizer mixtures.

A peculiar situation exists whereby under the subsidized scheme all fertilizer mixtures are made available at the same price irrespective of their grades (nutrient content). This disparity needs to be corrected and the prices of the mixtures fixed on the basis of their nutrient content.

3.9 Policy relating to fertilizer marketing and distribution

The marketing function aims at efficient distribution so as to ensure that the right products are available to the farmer at the right time and at the optimum price, consistent with the provision of a reliable supply. Increasing sales of fertilizers is another important function to benefit not only the marketers but also the farmers.

The overall goal of marketing policies should be to enhance effectiveness by providing farmers with appropriate products on time and to improve efficiency by lowering or eliminating unnecessary marketing and distribution costs.

Government-owned agencies control most procurement and distribution. While physical distribution is relatively easy to organize, particularly under the existing government-dominated system, genuine marketing can only occur when there is better scope for open competition. Providing an element of choice or extending the existing level of choice to the farmer is probably the single most important factor in improving the performance of the market. At the wholesale/retail level, policy should be directed to initiating or promoting a more competitive market situation. Apart from introducing competition it would provide for lower costs.

The various segments of the market, i.e. rice and tea smallholdings, coconut and rubber growers, export crops, other food crops and horticultural crops need to be catered for appropriately. The existing system, with its differential rates of subsidy, has led to distortions in the market. The functions of the present set-up relate mainly to distribution of subsidized fertilizers and administration of subsidy, neglecting other aspects.

Many farmers would be more inclined to buy fertilizers if retail outlets were within easy walking distance, ideally about two kilometres. Unfortunately there is a shortage of retail outlets in the rural interior. The establishment of 553 agrarian service centres, in areas where input supply was a constraint has gone some way to improving access. However, the policy needs to be taken further to provide sustainability to the fertilizer marketing and distribution system.

Fertilizer is usually packed in 50 kg bags made of woven polypropylene with a low-density polyethylene liner. Packs weighing 25 kg are also marketed to meet the requirements of small farmers. Even though the smaller packs cost more to market, their provision is helpful in facilitating small farmers' access to fertilizers.

Policy should take into account the need for marketing systems to have an adequate margin built into the price structure. This is needed to cover actual costs of transport, storage, administration and overheads as well as the mark-up to return a reasonable profit and to compensate for the risks that any business venture faces.

Costs can be reduced by careful monitoring and strict control of the marketing operations. Seasonal overloading of transport facilities can be avoided by introducing off-season prices for early delivery of fertilizers. To reduce the number of intermediate stores and numerous fertilizer handling operations, fertilizer should be transported directly from factory, port or major warehouse to dealers and retailers. Policy measures need be drafted accordingly.

3.10 Policy relating to capacity building in the fertilizer marketing system

An adequate, properly trained workforce is a prerequisite for implementing fertilizer marketing policies. To achieve this, capacity building programmes are needed at various levels.

- Senior managers: The programme focus should be on how the marketing functions can be effectively integrated to provide an efficient marketing system.
- Distributors and dealers: The programme should place emphasis on the efficient operation of a fertilizer retailing business. It should also emphasize the need for the participants to acquire sufficient knowledge of fertilizer use so that they can assist the farmers in making correct decisions about fertilizer purchase and application.
- Field-level staff: These need to be trained in skills relating to the upkeep of sales points, store-keeping, loading and offloading fertilizers, avoiding damage to the bags and minimization of losses during transport, handling and storage.

Policies should ensure that such programmes are conducted regularly and at all levels with the help of professionals. This will enhance the human resource capabilities of the stakeholders in an efficient manner and with the full support of experts on the subjects.

3.11 Policy relating to fertilizer credit

Access to credit is important for the farmer because of the long period that elapses between the purchase of inputs such as fertilizer and the time when the harvested crop is finally sold. The usual sources are banks, local traders or cooperatives. From the policy angle, while credit provision is necessary, loan repayments are equally important. Otherwise there is a risk that financial institutions may fail.

The agrarian banks maintain branches in the ASCs to provide credit to the farmers. However, while highly subsidized fertilizer is available (in some instances subsidies cover as much as 90 percent of total cost) the farmers' need for fertilizer credit is limited. This is especially the case for rice, the major foodgrain crop, which is also the major consumer of fertilizer.

As far as loan recovery is concerned, the most efficient recovery systems have been those linked with crop collectors, such as exist in the Sri Lanka tea sector. Crop marketing institutions, especially in the commercial/export and plantation crop sector, can be effective instruments for supply of fertilizer on credit against purchase of the crop.

To summarize, policies should be put in place to provide adequate, timely credit for the farmers. This should be done in a cost-effective manner with effective systems in place for timely loan repayment.

Credit is also 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. However, the dealers' financial needs increase in line with an increase in volume of sales. To meet these needs, they require recourse to commercial or government banks and other institutional lending agencies. In the event of a rise in the price of domestic fertilizer, additional credit may be granted.

3.12 Policy relating to profitability of fertilizer use

Profitability of fertilizer use is an essential condition for its adoption by the farmers. A cost-benefit analysis for rice cultivation at current rates of subsidy and the prevailing market price for rice reveal that fertilizer use is quite profitable.

The average use of fertilizers in major irrigated rice areas is in the order of 130 kg/ha N, 44 kg/ha P_2O_5 and 49 kg/ha K_2O. National average yields are around 4.1 tonnes/ha. Currently the quantum of subsidy per hectare on the above-mentioned rates of fertilizer application is around US$223 per hectare. On average the total cost of cultivation (with subsidy) works out at US$697 and gross income at US$1 485 per hectare at the prevailing market price of rice for irrigated areas. Studies reveal that fertilizer use will remain profitable for both irrigated and rainfed areas even if the subsidies are reduced by 50 percent, given the current output price.

3.13 Policy relating to pricing and subsidies

In Sri Lanka subsidies have been used for many years to encourage the use of fertilizer. This is still very much the case, and the present agriculture production environment is oriented towards high levels of fertilizer subsidy. In general, subsidies account for over 90 percent of the price of fertilizers for the rice farmers. Although they have been a useful policy tool, at the present rates subsidies have assumed staggering proportions. The fertilizer subsidy for 2009 is estimated as Rs.53 billion.

The present scheme of subsidy for paddy was initiated in 2005 and, under the scheme, a 50 kg bag of fertilizer (urea/TSP/MOP) is provided to rice farmers at a subsidized price of Rs.350. In 2006, the fertilizer subsidy was extended to other field crops such as chillies, maize, onion and vegetables that are cultivated in rice fields. Fertilizers were made available for smallholders (less than 2 ha) cultivating tea, rubber and coconut at a subsidized price of Rs.1 200 per 50-kg bag in 2006. In 2009, the prices were reduced further, to Rs.1 000 per 50-kg bag of urea and NPK mixtures.

In *Maha* 2008-2009, the market prices of urea, TSP and MOP were as high as Rs.5 350, 7 709 and 6 612 per 50-kg bag, respectively. With the decrease in international prices by November 2009, domestic market prices of fertilizers were around Rs.2 750, 4 600 and 3 000 per 50-kg bag for urea, MOP and TSP, respectively. At this price level, the subsidies on urea, MOP and TSP were around 87, 92 and 88 percent, respectively for the major fertilizer-consuming crop – rice.

The present pattern of subsidy besides being a burden on the state exchequer is leading to a number of adverse effects such as:

Distortion of the fertilizer market: There is little competition in the market so little room exists for suppliers other than the state-owned institutions to market the product. Because the procurement and distribution of subsidized fertilizer by state-owned agencies constitute the major part of the business, the private suppliers' share has been shrinking. In the long run this may lead to the withdrawal of private players from the market.

Malpractice: With the differential rates of subsidy for different crops and segments of the farming community, there is every scope for fertilizers being diverted to other sectors for which they are not intended. Estimating requirements for individual farmers is dependent on the sole judgement of the field level officers, which leaves room for malpractice.

Overuse and unscientific use of fertilizers: The high level of subsidies is in many instances leading to overuse and inefficient use of fertilizers by the farmers. This is wasteful, resulting as it does in higher actual production costs and possible threats to the environment.

Distorted pricing pattern: Under the subsidized scheme, the price of a 50-kg bag of fertilizer is the same, irrespective of its nutrient content which is a serious anomaly. Prices need be fixed on the basis of nutrient type and content.

Distortions in the marketing and farm advisory services: The personnel of the marketing institutions and farm advisory services spend much of their time distributing subsidized fertilizers and administering the subsidy. They have little time available for providing guidance and services to the farmers to enhance crop productivity through adoption of the latest technology. The pattern of large-scale subsidized fertilizer use has also eroded the scientific base for promotion of balanced and efficient fertilizer use. Farmers do not adopt soil test recommendations, preferring to base fertilizer requirements on general recommendations.

Lower emphasis on other nutrient sources and IPNS: The availability of cheap subsidized fertilizers is leading to neglect of other nutrient sources and non-adoption of integrated plant nutrition practices. The government seriously intends to tackle this matter.

Financing the subsidies requires higher taxes and increased external borrowing. Although the subsidies have increased the use of fertilizer, the cost is very high. They played a significant role when fertilizers were first introduced but their relevance in the present context of high fertilizer use is much diminished.

Targeted subsidies, as in the case of small and marginal farmers, may be an option. However, such a scheme needs to be well administered to ensure that the benefit reaches the intended sectors without leakages. Further, studies revealing that farmers would still find it profitable to grow rice even if subsidies were reduced by 50 percent, should be reason enough for a phased and gradual reduction of the subsidy burden on the state exchequer.

3.14 Policy relating to quality control

The Regulation of Fertilizer Act No. 68 of 1988 enacted by Parliament makes the necessary provisions to regulate the importation, manufacture, formulation, distribution and quality control of fertilizers. The

National Fertilizer Secretariat has been entrusted with the responsibility for fertilizer quality control and is empowered to take whatever action is necessary in this regard.

The following measures should be adopted to ensure quality:

- obtaining quality certificates before shipment;
- sampling at the port or bonded warehouse and analysis;
- sampling and analysis at the blending or producing stage; and
- sampling and analysis at distribution and marketing stages.

The Sri Lanka Standards Institution has laid down standard specifications for various fertilizer products. Samples for analysis are referred either to their own laboratory or the Industrial Technology Institute laboratory.

Despite the various provisions outlined above, the fertilizer quality programme suffers from a dearth of infrastructure, financial as well as of manpower resources, at the National Fertilizer Secretariat. The collection and analysis of samples from the field are hampered because the current analytical capacity is inadequate. The NFS has no financial provision to meet quality assurance expenses of the fertilizers. At present these are borne by the entrepreneurs. The lack of these resources is resulting in inadequate quality control at field level.

The establishment of a central quality control laboratory under the direct charge of NFS with adequate funds and trained personnel should be considered as a policy measure to make the fertilizer quality programme effective.

3.15 Policy relating to efficient fertilizer use and fertilizer use R&D

Because highly subsidized fertilizer use is in vogue, the farmers tend to ignore efficient fertilizer use practices. This leads to huge economic costs, both in terms of the waste of fertilizers and lost income.

Packages of practices relating to efficient fertilizer use have been evolved at many research institutions. These include application of the correct dose of fertilizers at the right time and in the right manner. However, these recommendations have lost their significance. The present supply of subsidized fertilizers is based on general requirements as against site-specific recommendations based on soil tests.

The soil testing service, which is almost defunct, needs to be revived. Although nine regional soil testing laboratories were established, there are not enough funds or staff to run them. There are no soil fertility maps at the local or national level. These need to be generated through a systematic on-going soil analysis programme. Some new short-duration rice varieties have been identified by the Rice Research and Development Institute, for which suitable fertilizer recommendations are yet to be evolved. Similarly for the new hybrids of maize, suitable fertilizer recommendations have to be established through soil test-crop response studies.

With more and more exploitation of land for agricultural production and the use of high-yielding varieties and high analysis fertilizers, micronutrient deficiencies are cropping up. There is a need to develop and strengthen micronutrient analytical capacities.

To further enhance the productivity and quality of tea, there is a need to develop regional and site-specific fertilizer schedules taking into consideration soil type, soil fertility and the need for soil amelioration.

Agricultural research is a prime government responsibility and the government should give high priority to funding research institutions. There are several institutions devoted to research on prime crops such as the

Rice Research and Development Institute and the Tea Research Institute. The institutions need to continue their existing focus on fertilizer use efficiency research. Development of more efficient fertilizer products, use of rice straw for rice fertilization, measures to improve soil organic matter content, biofertilizers and integrated use of nutrients are some of the areas which need continued attention.

Advantage should be taken of advances in the field of Information Technology to overcome the complexities arising from the interaction of numerous factors in the soil-plant system. Models of various soil-plant systems could be developed to serve as powerful tools in resource management. Development of simulation models could be helpful in understanding the role of many variables in fertilizer use efficiency and optimization of resource utilization.

An effective fertilizer policy must take the above-mentioned factors into account and make suitable provision to deal with the issues.

3.16 Policy relating to development and use of supplementary nutrient resources and development of Integrated Plant Nutrition System

The present government policy lays emphasis on increased production and use of organic manure. An organic fertilizer bureau (OFB) has been set up in the Ministry of Agriculture. Its main objective is to increase the production and use of organic fertilizers.

FYM and compost are intensively used for certain crops such as vegetables. However, use of rice straw as an organic manure resource, which has a vast potential, is still to pick up in many areas. More detailed studies are needed to identify the farmers' constraints and ways to tackle them. The availability of cheap chemical fertilizers at subsidized rates has also resulted in a setback to the organic manure production programme.

The provincial councils have procured some organic manure from the private sector on a tender basis and made them available to the farmers on a subsidized basis (50 percent). Such practices, besides promoting malpractice and leading to quality control concerns, may also lead to a loss of initiative by the farmers. A better option would be to help farmers prepare their own manure.

Use of biofertilizers is limited. More research efforts are needed to explore the feasibility of biofertilizer use at the field level.

In order to support soil fertility management effectively, it is prudent to adopt environmentally-friendly plant nutrition management technologies such as IPNS. Integrated nutrient supply and management through the judicious use of organic, chemical and biofertilizers in the various cropping systems has been to found sustain long-term crop production. The use of IPNS is advantageous as it helps to improve fertilizer use efficiency, improve long-term soil fertility, increases the benefit-cost ratio of crop production and provides for a better environment. IPNS practices are also being promoted by the OFB. Although IPNS is accorded a high priority, field level adoption by the farmers is low. Special emphasis should be given to participatory on-farm research on IPNS to develop location-specific IPN recommendations in relation to specific cropping systems. There is a need for intensive extension efforts to provide the technology, management skills and motivation. Farmers' Field Schools could also impart the IPNS skills to the farmers. The subject should be included in the FFS curricula.

3.17 Policy relating to efficient fertilizer use and fertilizer use R&D

Current soil fertility levels and soil health for the various agro-ecological zones have yet to be mapped mainly because of the inadequacies of the soil testing programme. In the interest of sustainable soil fertility management, there is a definite need to evolve a system for regular assessments and monitoring of soil health.

Soil fertility varies widely, but major nutrient deficiencies are generally thought to be widespread. Secondary and micronutrient deficiencies have also been cropping up. Tropical climates do not permit a build-up of organic matter and most of the soils have low organic matter content. Soil salinity and acidity problems are also encountered especially as an after effect of a tsunami. In certain areas the presence of nutrient toxicities such as iron are observed.

Benchmark studies need to be planned for each agro-ecological system to assess and monitor the health of the soil at regular intervals and to establish what changes are occurring as a result of current agricultural practices especially the input use. Assessment and monitoring of the following aspects are important:

- changes brought about in soil fertility status with regard to major, secondary and micronutrients;
- alterations in soil organic matter content;
- buildup of nutrient toxicities including heavy metals in the soil system;
- development of problems relating to salinity/acidity,
- soil biodiversity especially relating to micro-flora.

3.18 Policy aspects for preventing/mitigating adverse effects of fertilizer over usage on environment

Fertilizer use has allowed farmers to achieve continuous high yields on the same land for many years. However, many farmers now tend to overdose with fertilizers. The highly subsidized regime has also promoted overuse of fertilizers. Further, in many situations, the failure to adopt improved cropping packages or their part adoption leads to lower nutrient uptake resulting in environmental pollution.

Intensive agriculture associated with increased fertilizer use has resulted in groundwater pollution in certain areas. In the east, north and some north-western parts of Sri Lanka the soils are predominantly permeable with shallow water tables, more susceptible to leaching, making the groundwater potentially hazardous. The groundwater and surface water of the central highlands are becoming polluted too with high application of nitrogenous fertilizers from both inorganic and organic sources.

The rates of fertilizer applied to potato and vegetables in the up country are much higher than the recommended doses. In fact the levels of chemical fertilizer applied by farmers to these crops are almost double the quantity recommended. Using high rates of animal manure is also common in the up country. The quantities added range from 10 to 15 tonnes/ha of poultry manure and from 20 to 30 tonnes/ha of cattle manure.

Nutrients applied in excess, especially nitrogen, and not taken up by the crop, are likely to be lost to the environment. Efficient fertilization is synonymous with the minimization of nutrient loss to the environment. Correct fertilization must be accompanied by other appropriate agricultural practices. Erosion control measures can effectively check phosphorus pollution. Minimum tillage and soil conservation measures are very effective in protecting surface water from the effects of phosphates transported with eroded soil.

In order to control the overuse of fertilizers, promote their efficient use and check their adverse effects, the policies should take into account the need for the following:

- strengthening of soil testing facilities for major and micronutrients and promoting the adoption of site-specific soil test based fertilizer use recommendations;
- promotion of improved agronomic and efficient fertilizer use practices;
- enhanced support for fertilizer use efficiency related R&D;
- adoption of IPNS at the farmers' level;

- adoption of soil conservation measures;
- establishment of a monitoring system for natural resource pollution;
- enactment of regulations to prevent environmental pollution.

3.19 Policy aspects related to expansion of knowledge base for promoting efficient use of fertilizers

Agricultural extension should be seen as a prime government responsibility, although other stakeholders such as the fertilizer industry and NGOs may also undertake such activities. A high degree of priority needs to be given to the extension sector.

Extension workers must make use of demonstrations, farmers' meetings, crop seminars/festivals, field days, group discussions and audio-visuals to disseminate the technology pertaining to efficient fertilizer use and IPNS and help farmers adopt the same. Regular farm visits by the extension personnel must be ensured.

Farmers' participation in extension activities is extremely important. Lead farmers should be involved to a considerable extent and their help should be obtained to spread information and implement field programmes effectively.

Village-level fertilizer retailers can play a useful role in providing the farmers with the information they need in regard to product suitability, dosages and efficient application methods. They should also give advice on handling and mixing fertilizers in suitable proportions for the farmers to make mixtures tailored to their requirements.

The extension field force must be capable of understanding the scientific findings evolved through research and translate them into language that the farmers can understand. They should also be able to provide the farmers with recommendations based on these findings. Another function is to provide feedback to the research community on the problems faced by the farmers in adopting new technology. An example is the use of rice straw for field application. It is recommended for rice farmers, but there are practical difficulties in adopting it. These need to be understood and solutions to the difficulties found.

There should be regular training and briefings for the extension field force to keep them abreast of the latest technological developments.

Although there is a substantial extension force in Sri Lanka, its main function at present relates to the distribution and administration of subsidized fertilizers. This leaves little time for extension and field activities to promote scientific and integrated use of chemical, organic and bio-nutrient resources.

3.20 Policy aspects for effective coordination and monitoring of various aspects related to fertilizers

The effective planning, development and implementation of a national fertilizer and soil fertility management programme involves various activities such as procurement, production, demand forecasting, logistics, marketing and distribution, quality control, efficient use and soil fertility management. This calls for effective coordination to provide the system with much needed sustainability.

Several institutions are involved in the process of implementing the programme, and their efficient functioning needs to be ensured through provision of information and expert guidance. An apex institution capable of such coordination is therefore important.

Monitoring is also important. To be fully effective, the monitoring institution should be delegated adequate authority.

Some of the salient areas on which a coordinating and monitoring unit should focus upon include the following:

- advice to the government on fertilizer and soil fertility management policies;
- fertilizer demand assessment for the short, medium and long term;
- import procedures, tendering and handling at port;
- keeping a track of international fertilizer market and fertilizer prices;
- coordination of foreign exchange requests for imports;
- national fertilizer production;
- registration of importers, manufacturers and dealers;
- market development;
- undertaking studies on fertilizer demand, supply and price trends, marketing costs and margins, and logistics;
- quality control of fertilizers;
- studies relating to the impact of fertilizer use on productivity, and identifying problems faced by the farmers;
- compiling and analysing statistics on various aspects of fertilizers and soil fertility management; and
- suggesting measures to promote IPNS to improve crop response and the efficiency of fertilizer use in order to maximize returns and farm income.

In Sri Lanka, many of the above-mentioned functions are assigned to the National Fertilizer Secretariat (NFS) whose functions are explained above.. Being the central focal point, NFS may take on some the additional functions outlined above in order to serve the interests of fertilizer and soil fertility management effectively.

In order to carry out the coordination and monitoring functions, NFS will need strengthened in terms of finance, staffing and infrastructure. This will have to come from the government.

It is imperative that an effective and sustainable fertilizer and soil fertility management policy framework should take into account the above-mentioned policy gaps and related issues.

While keeping the above in mind, the main policies requiring government support are:

- formulation and implementation of strategies leading to a self-sustaining agricultural production programme largely independent of outside financial assistance;
- measures for improving the terms of trade for agriculture and profitability of input use;
- improving individual property rights to encourage farmers to take more interest in building up long-term soil fertility.
- exercising a check on inflation by reducing expenditure and tightening monetary policy since inflation seriously hampers the procurement of imported fertilizer;
- measures for improved infrastructure such as roads to facilitate transportation of both fertilizers and crop produce;
- development of irrigation resources to enhance crop response to agricultural inputs;
- policy measures to promote the growth of a healthy and efficient fertilizer sector, with enhanced private sector involvement, accompanied by regular review of governmental controls to make them fit for purpose;

- exploring the economic and technical feasibility of off-shore fertilizer manufacturing facilities based on import of intermediates;
- participation and investment in joint sector projects in countries with abundant raw materials for fertilizer manufacture;
- measures for enhanced exploration of raw material deposits;
- exploring the utilization of indigenous raw materials for production of finished, good quality fertilizer products;
- strengthening the mechanism for realistic demand assessment and forecasting;
- providing adequate and timely availability of foreign exchange for fertilizer imports and adopting policy measures aimed at minimizing import and handling costs;
- development of ports and port handling facilities;
- Development of an appropriate mix of fertilizer transportation mode and strengthening the existing transportation infrastructure,
- development of an adequate and evenly distributed warehousing and retail network;
- monitoring, administering and rationalizing fertilizer prices and subsidies to see that they serve the national interest;
- ensuring adequate provision of agricultural credit for the farmers;
- promoting fertilizer distribution channels appropriate to the marketing and economic situation;
- measures for keeping overall marketing costs as low as possible;
- providing and enforcing an effective legal framework to ensure the availability of good quality fertilizers and giving institutional support for fertilizer testing and quality control;
- providing the institutional, technological and R&D support needed for soil fertility management, promotion of efficient fertilizer use, IPNS, soil testing and propagation of conservation agriculture;
- devising a mechanism for monitoring soil health and adopting measures to check over-use of fertilizers;
- strengthening the technology transfer mechanism and maintaining its efficiency through regular capacity building programmes;
- strengthening the national coordination and monitoring body to oversee the various aspects of sustainable fertilizer use and soil fertility management.

Guidelines
for
fertilizer demand assessment/forecasting

by

T.K. Chanda

CHAPTER – I

Relevance of fertilizer demand assessment to national fertilizer policy planning

It is widely acknowledged that fertilizer is a vital input that enhances agricultural production. According to studies made by various organizations, over 50 percent of the increased grain production results from using fertilizers. The economies of Asian countries are predominantly based on agriculture and fertilizer will continue to be a key input for increasing agricultural production.

Fertilizer demand is seasonal whereas production is continuous. Consumption is at the peak level for only two to three months in each agricultural season. Arrangements for adequate supplies of fertilizers to every corner of the country have to be planned in advance. The fertilizer has to be stored and positioned for sale before demand peaks. This can be accomplished with the support and cooperation of all the stakeholders, *viz.* manufacturers, importers and suppliers of fertilizers. To fulfil the objective of delivering adequate amounts of fertilizer throughout the country in time, there is need for realistic assessment of demand. Overestimation of demand leads to a glut in the market resulting in high inventory in the ports, factory silos and field warehouses. This in turn causes deterioration in the quality of the fertilizers due to prolonged storage. Lengthy storage involves high inventory carrying costs and creates liquidity problems for both domestic manufacturers and importers/suppliers of fertilizers. Underestimation of demand creates scarcity of fertilizer in the market with adverse effects on farm yields.

National agricultural development plans are based partly on the forecast of demand for fertilizers. These forecasts provide a base for estimating sales volume and devising marketing plans. Demand forecasts also provide a useful platform for production planning. A company's expected sales are estimated by assessing its market share in each area of the country. Based on the sales forecast, the company plans production. A production plan based on demand forecasts lays down what quantities of various fertilizers have to be manufactured each month. The supplies of feedstock needed to manufacture the fertilizers (natural gas, naphtha, fuel oil, etc.), intermediates (ammonia, phosphoric acid) and raw materials (rock phosphate, sulphur) are imported or purchased on the domestic market. Demand forecast is also helpful in assessing the requirement for working capital and other assistance from the financial institutions to meet production targets.

The demand forecast is needed prior to the first stage of the import process. This is when offers are received and evaluated. Next, terms and conditions, payment procedures and the delivery schedule are determined. From the date when offers are received to delivery at farm level takes more than two months. The time lag between the arrival of a consignment and fertilizer application can be reduced significantly if the forecast is realistic. This avoids the costs of extra handling and storage when moving stocks to primary points for onward sale to wholesalers. Demand forecasts have a special significance for developing countries largely dependent on fertilizer imports. Landlocked countries that have to use the port and transportation facilities of neighbouring countries require advance planning, well ahead of the cropping season, for which a realistic demand forecast is indispensable.

Fertilizer marketing is guided by the demand forecast when arranging storage at strategic locations, placing orders for railway wagons and trucks and activating the sales points to accomplish the expected volume of business. An accurate demand forecast helps to optimize transport costs, minimize time in storage and avoid wasteful inter-store movements.

CHAPTER – II

Factors affecting fertilizer demand

Asian countries are predominantly based on agriculture and characterized by small holdings. The farmer's per capita income is low. Because fertilizer is a costly input, the benefit from its application should be reasonably high to motivate farmers to use it. In other words, the cost benefit ratio of fertilizer use should be attractive. The trends in consumption in these countries show the importance and awareness of the use of fertilizers. The demand for fertilizer depends upon various factors, including soil type, rainfall and irrigation, crop type, quality seeds, access to credit, prices of inputs, output prices etc.

Soil type

The use of fertilizer depends upon the fertility status of the soil whose type and characteristics should be known before fertilizers are applied. The recommended doses are based on soil analysis. Inadequate soil testing facilities are a limiting factor on proper dosage in developing countries. Nutrient mining is continuous because per hectare use of fertilizer nutrients is frequently too low. There is a need for judicious application of nutrients to maintain nutrient balance in the soil.

Rainfall and irrigation

Rainfall and its distribution over time and space is one of the basic factors which influence fertilizer consumption, particularly in the rainfed areas. Even if all other factors are favourable, failure of seasonal rains adversely affects demand. The failure of the rains increases the risk to the farmer of using fertilizer and may make him reluctant to use it even if he has resources at his disposal.

The scenario is different in the irrigated areas. The ready availability of water means that most farmers in these areas apply fertilizers. So, fertilizer use per hectare is significantly higher in irrigated areas than in rainfed areas.

Crop type

Demand for fertilizer depends upon the type of crops grown in the cultivable areas. Fertilizers are mostly used on the following groups: foodgrains (cereals and pulses), oilseeds, sugarcane, fibres (cotton, jute, and mesta), fruits and vegetables and plantation (tea, coffee, rubber). Per hectare use of fertilizer varies from crop to crop. Total use of fertilizer is the function of per hectare use and the area covered under each crop.

Crop varieties

Fertilizer demand is influenced by improved and high-yielding crop varieties. Improved varieties require higher fertilizer use and produce better yields. Cultivation of high yielding varieties (HYV) along with fertilizer use and irrigation has transformed the agricultural production scenario.

Credit

In developing countries the purchasing power of most farmers is weak. They do not have enough liquidity to buy their entire requirement of fertilizer and have to depend on credit. Credit is available both from financial institutions (commercial banks, cooperatives) and private sources. It is better to borrow from financial institutions because their interest rate is lower than that of private lenders. If credit is available at an affordable interest rate, there is scope for rise in demand for fertilizer.

Fertilizer price

Fertilizer demand is price sensitive, particularly in developing countries where farmers are resource poor. When the fertilizer price goes up sharply in relation to the produce price, consumption tends to fall. During the first half of 2008, there was an unprecedented increase in the prices of finished fertilizer, its intermediates and raw materials. This seriously influenced fertilizer use worldwide, leading to a significant decline in demand. However, in those countries where fertilizer prices are partly or fully subsidized, the demand for fertilizer remained relatively unaffected.

Output price

Last but not the least is the influence on fertilizer demand exerted by the output price of crops. If this is attractive, farmers do not hesitate to spend more on fertilizer. There are examples of high use of fertilizers on high value crops as well as on foodgrains. Foodgrains are generally grown for home consumption. This is particularly true of small and marginal farmers. However, commercial and export based crops, on which farmers tend to use more fertilizer, are remunerative. In those countries where the foodgrain requirement is low and they can afford to import food, more fertilizer is used on commercial or export based crops.

CHAPTER – III

Types of demand forecasts and approaches

Demand forecasts may be grouped into three broad categories, viz., short-term, medium-term, and long-term.

Short-term demand forecasts are made for the next season or year at the most. Medium-term projections generally spread over five to six years. Long-term demand projections are made for a lengthy period of about 10 to 20 or even 30 years.

Short-term/medium-term

Short-term/medium-term demand forecasts are useful to:

- Make arrangement for adequate and timely availability of fertilizers to the farmers.
- Prepare plans for production and import of finished fertilizers.
- Prepare plans for import of raw materials for domestic production.
- Allocate foreign exchange for imports. Explore assistance from donors if fertilizer import is partly or fully dependent on donor countries.
- Monitor overall supply-demand balance to avoid build-up of excessive inventories.
- Make arrangement for storage and transportation (berthing facilities at port, railway wagons, etc.)
- Make arrangement for agricultural credit.
- Arrange working capital from the banks for sustained domestic production.
- Make investment decisions to revamp or install new domestic fertilizer capacity and/or undertake joint ventures for assured supply of fertilizer, raw materials and intermediates.

Long-term

Long-term demand forecasts are useful to:

- Frame policies for progressive improvement in the nutrient balance in soil.
- Set a long-term target for agricultural growth.
- Assess long-term requirement of fertilizer and formulate policies to increase domestic capacity or undertake joint venture abroad for assured supply of fertilizer, raw materials and intermediates.
- Formulate development plans, infrastructure development, etc.
- Work out long-term strategies for promotion and extension of plant nutrients.
- Formulate strategic research and development plans in soil fertility and plant nutrition.

There is need for review and adjustment of mid-term projections annually and long-term projections periodically.

Forecasting approaches

Various agencies have different approaches to making demand forecasts. These may be grouped into the following four broad categories:

(i) need-based approach;
(ii) crop area approach;
(iii) time series approach;
(iv) causal approach.

Need-based approach

A need-based approach is used when fertilizer demand is to be calculated to fulfil a desired condition. The desired conditions may vary. For example what should the level of demand for fertilizer be to:

(i) achieve a specific rate of growth in foodgrain production and other crops?

(ii) achieve a foodgrain production target to meet adequate consumption requirement for projected population?

(iii) maintain a desired nutrient balance in the soil?

Crop area approach

The crop area approach relates to the fertilizer requirement to achieve the target area coverage for various crops at expected fertilizer application rates.

Time series

The time series approach relies on historical data to analyse the pattern of demand in the past to forecast the future. The assumption underlying this approach is that future demand is a continuation of the past. There is a need for several years' reliable data for this approach.

Causal

The causal approach seeks to establish a cause-effect relationship between fertilizer demand and other independent variables, such as pattern and distribution of rainfall, availability of seeds, irrigated area, availability of credit, fertilizer price, crop output price, etc. The approach captures the influences of these variables to make predictions for future years.

The above four approaches are complementary to each other. The first, i.e. the need-based approach is normally used for working out medium- or long-term projections. The second, *viz*. the crop area approach may be used for short- or medium-term projections of demand. The third, i.e. the time series approach is appropriate for medium-term projections. The fourth, *viz*. the causal approach may also be used for medium-term projections. While the first approach is normally used for working out potential demand, the others are mostly used to assess the effective demand, i.e. the demand which is likely to take place.

CHAPTER – IV

Forecasting methodologies/models

Over time experts have devised different methods of forecasting demand. There is no single model that can give a completely accurate prediction. An error of ±5% is a fairly good prediction when actual values are compared with the forecast values in future. The selection of a suitable method is governed by the purpose to be served by the forecast. The following section deals with various methods in general use for forecasting demand.

When estimating future demand for fertilizer, there is need for clear understanding of the difference between potential demand and effective demand. **Potential demand** is the ideal level of fertilizer application under the circumstances in which a particular crop is cultivated. It may be derived:

- by calculating on the basis of projected area under each major crop and recommended level of fertilization of each crop, i.e. the input approach;
- from a food production target to meet the nutritional needs of the population and then applying appropriate crop production: nutrient response ratio, i.e. the output or end-use approach.

Effective demand is that which is likely to take place in the short or medium term. This may be derived from:

- crop area and application rate (likely area under various crops x likely nutrient application rates);
- growth rate method (simple/compound);
- growth rate modified by crop area and expert opinion method;
- trend method and extension of trend (linear, second degree parabola, etc.);
- causal method (multiple regression).

The following section deals with the details of the various methodologies that may be used for estimation of both potential and effective demand. The selection of a methodology depends upon the objective behind an organization's estimation of demand.

Model 1: Crop area and application rate method

According to this methodology, demand for fertilizer is determined by two basic factors, i.e. area under various crops and corresponding application rates of fertilizer nutrients on the respective crops. Initially, actual application rates of fertilizers are assessed at the field level and then aggregated/consolidated at district/province/state levels. The expected application rate on each crop multiplied by expected area under the specific crop gives the crop-wise projected demand for fertilizers at district/province/state levels. The aggregates of state/province/district data give the country-level demand. In this context, the FAO Integrated Plant Nutrition Service (IPNIS) database http://www.fao.org/ag/agl/agll/ipnis/index.asp may be useful for finding out the use of fertilizers by farmers (limited to selected countries).

Model 1 shows that demand for fertilizer is the function of crop area and application rates. Details are shown below.

Consumption of fertilizer nutrient = crop area x application rate. The model is expressed through the following formulae:

$$\sum_{i=1}^{n} CN = AC_1 \text{ x } ARN_1 + AC_2 \text{ x } ARN_2 + AC_3 \text{ x } ARN_3 + \ldots\ldots\ldots + AC_n \text{ x } ARN_n \ldots\ldots. (1)$$

$$\sum_{i=1}^{n} CP = AC_1 \text{ x } ARP_1 + AC_2 \text{ x } ARP_2 + AC_3 \text{ x } ARP_3 + \ldots\ldots\ldots + AC_n \text{ x } ARP_n \ldots\ldots\ldots. (2)$$

$$\sum_{i=1}^{n} CK = AC_1 \text{ x } ARK_1 + AC_2 \text{ x } ARK_2 + AC_3 \text{ x } ARK_3 + \ldots\ldots\ldots + AC_n \text{ x } ARK_n \ldots\ldots. (3)$$

where

$\sum CN$ = total consumption of nitrogen on all crops
$\sum CP$ = total consumption of phosphorous on all crops
$\sum CK$ = total consumption of potash on all crops
AC_1 = area under crop 1, Similarly
AC_n = area under n^{th} crop
ARN_1 = application rate of nitrogen for crop 1. Similarly
ARN_n = application rate of nitrogen for n^{th} crop
ARP_1 = application rate of phosphate for crop 1. Similarly
ARP_n = application rate of phosphate for n^{th} crop
ARK_1 = application rate of potash for crop 1. Similarly
ARK_n = application rate of potash for n^{th} crop
Here, N, P and K taken as examples. Similar calculations can be made for other nutrients, if required.

An example of this methodology is given in **Annex 1.**

The data required for this methodology are: (i) target area under various crops for the projected year, (ii) estimates of area fertilized and (iii) average application rates of fertilizers on various crops, taking into account factors like use of HYV seeds, irrigation, etc. For this, there is a need for ground level data from extension agencies, agricultural universities, state/provincial departments of agriculture, etc.

The method is suited for working out potential demand. However, it may be converted to short-term effective demand as well if the two basic pieces of information, i.e., target area set for each crop area materializes and fertilizer application rates are realistic. This needs a good ground level survey to provide reliable data.

Through this methodology, fertilizer demand can be determined directly for each crop subject to the availability of the required data. More importantly, a fresh demand assessment can be calculated if there are changes in crop area or application rates. However, it is limited by availability of reliable data on average application rates for each crop and fertilized area.

Model 2: Response ratio method

The use of fertilizer depends upon crop response. In other words, how much extra yield is obtained by using a unit of nutrient/fertilizer? Generally, the application of fertilizer is lower than the removal of nutrients from the soil by the plants, particularly in developing countries. Over the years this causes depletion of soil nutrients so that more external nutrients are required to achieve the same output. In other words, this causes deterioration in the response ratio unless the situation is rectified through proportionately higher use of plant nutrients. Results of research data are available on response of fertilizer nutrients by various crops in most countries. The demand for fertilizer can be calculated by adopting the response ratio method. According to this methodology, the requirement of each fertilizer nutrient can be worked out by multiplying response ratio data (crop response coefficient) with additional production figures of various crops between base and projected years. The forecast of demand for fertilizer may be estimated as follows:

D_t = AC x CR

where

D_t = demand for fertilizer in the t^{th} year

AC = additional crop production, i.e., $C_t – C_0$ where C_t = crop production in the t^{th} year, C_0 = crop production in the base year

CR = crop response coefficient. Additional grain obtained by applying one kg of fertilizer nutrients (N+P+K) on the soil.

An example of the methodology is included in **Annex 2.**

Basic data required for the model are (i) production figures of various crops for base and projected years and (ii) data on crop response coefficient of N, P and K for the same crops. In the event that crop response coefficients for all crops are not available, the estimates of demand can be prepared for foodgrain crops and total demand can be extrapolated by adopting percentage share of food crops vis-à-vis other crops to total nutrient consumption. A typical share of fertilizer use by foodgrains to total fertilizer consumption can be about 65 to 70 percent.

The response ratio methodology has the advantage of estimating fertilizer demand for each crop. However, it involves too many assumptions. Moreover, in using this methodology, it is assumed that the response ratio and soil nutrient ratio remain constant over the medium term. Due to technological breakthroughs (variety, irrigation, fertilizer use efficiency, etc.), response ratio may improve. Or, due to over-exploitation of nutrients from the soil, soil health problems (salinity, alkalinity, etc.) may result in the decline of the response ratio. This method is applicable for working out potential demand.

Model 3: Population nutrition method

Population nutrition method refers to working out the demand for fertilizer by using the projections of population and the per capita need for foodgrains. The following steps may be followed to predict demand for fertilizer nutrients under this approach.

Step 1: net requirement of foodgrains = population x average per capita net availability of foodgrains.

Step 2: gross requirement of foodgrains **=** net requirement of foodgrains/87.5 percent.
The balance of 12.5 percent is for seeds, feed requirements and wastes.

Step 3: additional requirement of foodgrains = gross requirement of foodgrains in future years – actual consumption of foodgrains in the base year.

Step 4: additional demand for fertilizer for foodgrains = additional requirement of foodgrains x response ratio of fertilizer use.

Step 5: additional demand for fertilizers (N+P+K) for all crops (65 percent on foodgrains and 35 percent on other crops) = additional requirement of fertilizer for foodgrains/65 percent However, this ratio will vary depending upon the area under foodgrains and other crops in different countries.

Step 6: total demand for fertilizer nutrients (N+P+K) = consumption of fertilizer in the base year + additional requirement of fertilizer nutrients (N+P+K) in future years.

Step 7: nutrient-wise demand:

demand for N = requirement of total nutrients x Ratio of N/Ratio of N+P+K
demand for P = requirement of total nutrients x Ratio of P/Ratio of N+P+K
demand for K = requirement of total nutrients x Ratio of K/Ratio of N+P+K

An example of the methodology is shown in **Annex 3.**

The data required for the methodology are (i) population data for the projected years, (ii) data on per capita net availability of foodgrains, (iii) response ratio of fertilizer (average N+P+K) to foodgrains and (iv) percentage share of foodgrains vis-à-vis other crops to fertilizer consumption.

This method is applicable for working out potential demand. The methodology determines an ideal requirement of fertilizer for foodgrains and derives requirement for other crops. However, it has a couple of limitations. It does not assume shift in food intake from cereals to meat/poultry products. Neither does it assume the diversification of foodgrains to other crops. The fixed response ratio and NPK use ratio assumed in this method may undergo changes with the passage of time.

Model 4: Agricultural output method

Fertilizer is applied to both food and non-food crops although more to the former. The demand for fertilizer may be derived through setting a target of growth in total agricultural production. The agricultural output method refers to demand as the quantity of fertilizer needed to produce a specified level of agricultural output, or quantity of fertilizer required to attain a specified growth rate in agricultural output. The National Centre for Agricultural Economics and Policy Research (NCAEPR), New Delhi developed and used this method in 2005 to work out the national fertilizer nutrient requirement for 2011. According to this method, the demand for fertilizer may be estimated as follows:

$$D_t = D_0 \, [g * 1/n]^t \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where

D_t = demand for fertilizer in the t^{th} year
D_0 = demand for fertilizer in the base year
g = growth rate in agricultural output to be achieved through increase in fertilizer use
n = production elasticity of agricultural output with respect to fertilizer

Growth rate in agricultural output to be achieved through increase in fertilizer use may be computed from target rate of growth of agricultural output towards the terminal year. It is hypothesized that in the medium term there are four sources of agricultural output growth as follows:

(1) fertilizer, (2) irrigation, (3) crop diversification from foodgrains to high value crops, (4) total factor productivity (representing effects of technology, infrastructure, better management, etc.).

Considering output as a function of the above four factors, the agricultural output growth equation may be expressed as follows:

$$\frac{dY}{Y} = E_Y^F \frac{dF}{F} + E_Y^I \frac{dI}{I} + E_Y^D \frac{d(YD)}{YD} + TFP \quad \ldots\ldots\ldots\ldots \quad (2)$$

$\frac{dY}{Y}$ = *rate of growth in crop output*

E_Y^F = *elasticity of crop output with respect to fertilizer*

E_Y^I = *elasticity of crop output with respect to irrigation*

E_Y^D = *elasticity of crop output with respect to diversification of area away from foodgrains*

$\frac{dF}{F}$ = *rate of growth in fertilizer*

$\frac{dI}{I}$ = *rate of growth in irrigation*

$\frac{d(YD)}{YD}$ = *rate of growth in area shift*

TFP = *growth rate in total factor productivity. Total factor productivity is a variable which accounts for effects in total output not caused by inputs.*

Equation (2) can be re-expressed as follows

$$\frac{dF}{F} = [\frac{dY}{Y} - E_Y^I \frac{dI}{I} - E_Y^D \frac{d(YD)}{YD} - TFP]/E_Y^F \quad \text{..................} \; (3)$$

Equation (3) gives the growth rate in fertilizer that would be needed to attain a specified level of growth in output. To arrive at that, it is necessary to estimate what growth rate in output is achievable through expansion of irrigation, crop diversification and total factor productivity (TFP). This may be computed by multiplying elasticity of crop output with respect to the concerned variables with a plausible growth rate in that variable. The magnitude of growth rates in output achievable through irrigation, diversification and TFP is subtracted from the target growth rate to calculate the remaining growth rate that needs to be achieved by increasing fertilizer use. This remaining growth rate is then divided by production elasticity of output to find the growth rate in fertilizer required to raise output to specified level.

This exercise involves estimation of elasticity, future growth in irrigation, crop diversification and TFP. Elasticities of crop output with respect to irrigation and fertilizers may be obtained from estimated production function. The production function may be used for each administrative unit (state/province/district) using time series data on value of crop output, use of NPK, area under irrigation, rainfall and some other variables considered relevant. The value of crop output may be used as a dependent variable and all production functions are estimated after log linear transformation of raw data. Only statistically significant coefficients may be used to choose coefficients of elasticities.

Elasticity for crop output in relation to fertilizer, i.e., E_Y^F may be computed using the following formula.

The percentage change in crop output is dY/Y, while the percentage change in fertilizer consumption is dF/F.

Thus, elasticity is: [(dY/Y) / (dF/F)].

This can be rewritten as E_Y^F = (dY/dF) x (F/Y)

The basic time series data needed for this methodology are (i) value of agricultural output, (ii) fertilizer consumption, (iii) gross irrigated area, (iv) gross cropped area, (v) area under foodgrains and non-foodgrains and (vi) total factor productivity.

The model may be used to measure medium-term potential demand. The model refers to demand as quantity of fertilizer required to attain a specified growth rate in agricultural output. The definition of value of agricultural output varies from country to country. In some cases, the value of ancillary activities like forestry, fishing and livestock is included in total value of agricultural activity under gross domestic product (GDP). But, as mentioned earlier, fertilizer use is mostly confined to a few crops in most Asian countries, viz., foodgrain crops (cereals and pulses), oilseeds, fruits and vegetables, sugarcane, cotton, jute, tobacco, etc.

Model 5: Growth rate method

The simple growth rate model is quite often used to predict the short-term/medium-term demand. Assume there are two major fertilizer seasons in a year, fertilizer season 1 covering April to September and fertilizer season 2 the period October to March. In order to work out demand for each nutrient for season 1 for each administrative unit (district, province, state, etc.) take the average growth rate in the consumption of each fertilizer nutrient for the past three to five years of season 1, ignoring abnormal years. Thereafter, by adopting average growth, estimate the demand for season 1 of the ensuing year, assuming normal weather conditions. This estimate should be prepared well before the onset of the fertilizer season for each state/province/district. These estimates may be discussed at length by the state/provincial governments and may be moderated based on various factors. These include the expected changes in area under irrigation, area under high-yielding variety (HYV) seeds, credit availability, opening stocks of each nutrient, number of sales points, etc. over the past commensurating the predicted average growth rate. An example of this calculation is given in the working sheet attached as **Annex 4.**

Data on fertilizer consumption for the past years are required for this model. This methodology is simple to apply. It is applicable under normal situations. The model can be applied for working out short-term effective demand for the ensuing season or the next year. If there are aberrations in consumption of fertilizers on account of steep increase in input prices, depression in the business cycle, etc. then the model does not have the flexibility to change the forecast value with a new growth rate. In this situation, it has to be moderated in a subjective manner.

Model 6: Growth rate/crop area/expert opinion method

The growth rate/crop area/expert opinion based method is an improvement on the simple growth method. This is a concept introduced for assessing *short-term demand* and preparing a fertilizer supply plan for the administrative units (district/province/state). This method is used to estimate the gross requirement (expected consumption) of each nutrient and product for the next season(s) for each administrative unit (district/province/state). It takes into account growth in consumption of fertilizers in the corresponding past seasons, best fertilizer consumption in the past, expected area to be covered under various crops, average application rates of fertilizers, expansion in irrigation, availability of seeds, credit, addition of sales points, etc. The gross requirement figures for each administrative unit are sent to the Central Ministry (Ministry of Agriculture/Extension) for review. On the supply front, the fertilizer manufacturers assess their plant-wise expected production of various fertilizers for the ensuing season and give the production plan to the Central Ministry (Ministry of Agriculture/Extension).

Expert Review – 1st stage

The experts in the Central Ministry of Agriculture monitor and review the feasibility of the forecasts sent by state/provincial governments in advance. The ministry also reviews the production plans of individual fertilizer companies to assess the fertilizer availability from indigenous production units and to work out the import requirements.

Expert Review – 2nd Stage

After the 1st stage review, the Central Ministry of Agriculture calls for meetings in each zone/administrative unit on the eve of each season with participation of various stakeholders, *viz.*, the representatives of the Department of Agriculture/Extension of each administrative unit/zone, the relevant central government officials, representatives of fertilizer manufacturing and marketing organizations, etc. Detailed discussions are held regarding the reliability of the gross requirement estimated by the administrative unit, after which the gross requirements are finalized.

Drafting the supply plan

Once the gross requirement is finalized, the supply plan for each manufacturer is firmed up on the basis of net requirement. The formula for net requirement is

$$NR = GR - OS + PS$$

where

GR = gross requirement

NR = net requirement

OS = opening stock at the beginning of the season

PS = pipeline stock

The difference between the net requirement and aggregates of the supply plans of each fertilizer company in each administrative unit is met through imports. In the event that the net requirement and supply plan match, there is no need for allocation of imported fertilizers. The successful implementation of the system depends upon the effective coordination. An example of the methodology is given in the working sheet attached as **Annex 5.**

A variety of data are used in this method. These include:

(i) actual and growth in consumption of fertilizers in the past five years during the season in question; (ii) best consumption in the past five years during that season; (iii) area coverage under different crops; (iv) area under irrigation; (v) availability of quality/improved seeds; (vi) opening stock of fertilizers with administrative units (both product and nutrient); (vii) production estimation by fertilizer manufacturers; and (viii) number of fertilizer sales points.

This is a well planned system which has an integrated and transparent approach. It is a concept which was introduced in India in the mid-1970s and has worked quite well over the years. The system involves the participation of the main stakeholders, *viz.,* policy makers, fertilizer manufacturers, importers, major distributors, other input manufactures/agencies (seed, pesticide, and agricultural implements), etc. It facilitates equitable distribution of fertilizer across the country. It allows rational import planning of fertilizers. It also helps with transportation costs by disallowing criss-cross movement of fertilizers. The model may be used effectively for calculating short-term effective demand.

The limitation with this model is that it is not applicable for medium- and long-term forecasts.

Model 7: Time series analysis and trend extension methods

This method of forecasting analyses historical data of about 25–30 years to estimate the trend in demand growth and extend it into the future to forecast future demand for fertilizer. Time series analysis helps in: (i) understanding past behaviour, (ii) planning future operations, (iii) evaluating current accomplishments, (iv) facilitating comparison between different time series and important conclusions drawn there from.

Time series data generally have four components, (1) secular**,** (2) seasonal, (3) cyclical and (3) irregular. (1) *Secular* refers to changes that have occurred as a result of the general tendency of the data to increase or decrease. For example, there is a general tendency of growth in population at a specific rate. (2) *Seasonal* refers to the changes that occur in a year due to seasonal variations. For example, change in offtake of fertilizer is because of change in climate and weather conditions. The offtake of fertilizer in June–September is high in some tropical countries due to good rainfall during that period. (3) *Cyclical* variations refer to changes in demand for various products, including fertilizer, as a result of business conditions, weather, etc. Analysis of long time series data mostly show failure of rainfall leading to drought after a specific period. Likewise, booms and depressions in business are cyclical. In both cases, demand for fertilizer changes significantly. (4) When changes in demand take place as a result of unforeseen situations, like flood, earthquake, etc. these are called *irregular* and erratic variations.

When analysing time series data, the growth rate is determined by fitting a suitable mathematical equation that approximates the historical trend. For example, the trend can be linear, i.e. a straight line, the degree of the slope of the straight line indicating the quantity of annual increase in demand. The trend can be non-linear, such as a second degree parabola. The method of least squares may be used either to fit a straight line trend or a parabolic trend. With the help of the least square method, a trend line is fitted in such a manner that the following two conditions are satisfied:

i. The sum of deviations of actual values of Y and the computed values of Y is zero.
ii. The sum of the squares of deviations of the actual and computed values of Y is least from this line.

Linear trend

The equation of the linear trend is:

$Y = a + bX$

where

"Y" = dependent variable (fertilizer consumption), "X" = explanatory variable (crop area/irrigated area/HYV area/fertilizer price, etc.),

"a" is the Y intercept or the computed trend figure of the Y variable, and "b" represents the slope of the trend line or the amount of change in the Y variable that is associated with a change of one unit in the X variable.

The specimen working sheet is attached in **Annex 6.**

The linear or straight trend may be applicable for those series in which period to period changes are constant or near to constant in absolute amount. For example, in situations where fertilizer consumption has increased at a more or less constant amount in the past and the country expects its consumption to increase at the same pace in future. But it may be noted that very few time series exhibit such type of constant change over a period of time.

Non-linear Second degree parabola trend

The equation of the non-linear second degree parabola trend is:

$Y = a + bX + cX^2$

where

"Y" = dependent variable (fertilizer consumption), "X" = explanatory variable (crop area/irrigated area/HYV area/fertilizer price, etc.), "a" is the Y intercept, "b" is the slope of the curve at the origin and "c" is the rate of change in the slope.

The second degree trend equation is considered to be an appropriate model for the trend component of a time series when the data appear not to fall in a straight line. For example, in the time series fertilizer consumption has been affected in the past due to sudden unforeseen changes, such as abrupt increase in the price of fertilizers and rainfall failure.

Demand estimation by the trend extension method is useful provided several years' (25 to 30 years) data are available and growth trends are clear and well established. It is not suited to situations where fertilizer usage is at an elementary stage. Proper care has to be taken in the selection of the trend under both linear and non-linear trends. Moreover, this method is not flexible. The addition of one more observation makes it necessary to do all the computations again.

Model 8: Multiple regression method

Regression analysis is the statistical technique that identifies the relationship between two or more quantitative variables: a dependent variable, whose value is to be predicted, and an independent or explanatory variable (or variables), about which knowledge is available. Multiple regression method finds out the cause and effect of each variable which influences fertilizer consumption. It is a "general linear model" with a wide range of applications.

Under this approach, a large number of variables may initially be considered in the model. Based on the past data and future plans of the government for expansion in irrigated area, HYV area, pricing policy, rainfall, credit availability, sales points, etc. the predicted values of the variables may be worked out for the specified period. Of these, the ones which are statistically significant, may be considered. For instance, the following variables have been considered based on their statistical significance and stability of functional relationship to forecast demand for a specified period.

1. irrigated area;
2. area under HYV;
3. fertilizer (nutrient) prices;
4. rainfall (as a percentage of long-term average value);
5. lagged dependent variable (Fertilizer consumption in the previous year).

The data may be transformed into logarithmic form in order to reduce the variations and bring uniformity in the expression of units of different variables. The following functional form of equation is used:

$$\text{Log } Y_{it} = C + b_1 \text{Log}X_{1t} + b_2 \text{Log}X_{2t} + \ldots\ldots + bn\text{Log}Xnt + U_t$$

where

Y = dependent variable, X_1, X_2 to X_n are explanatory variables. U_t is the random variable. Three different equations may be generated for N, P_2O_5 and K_2O

$$(1)\ \text{Log}Y_{Nt} = C + b_1\text{Log}I_t + b_2\text{Log}H_t + b_3\text{Log}P_{Nt} + b_4\text{Log}P_{Pt} + b_5\text{Log}R_t + b_6\text{Log}Y_{Nt-1}$$

$$(2)\ \text{Log}Y_{Pt} = C + b_1\text{Log}I_t + b_2\text{Log}H_t + b_3\text{Log}P_{Pt} + b_4\text{Log}P_{Nt} + b_5\text{Log}R_t + b_6\text{Log}Y_{Pt-1}$$

$$(3)\ \text{Log}Y_{Kt} = C + b_1\text{Log}I_t + b_2\text{Log}H_t + b_3\text{Log}P_{Kt} + b_4\text{Log}R_t + b_5\text{Log}Y_{Kt-1}$$

where

Y_N = consumption of N
Y_P = consumption of P_2O_5
Y_K = consumption of K_2O

t = years

I = percentage of gross irrigated area to gross cropped area

H = percentage of area under HYV to gross cropped area

R = rainfall (as percentage of long-term average value)

P_N = price of N through urea

P_P = average price of P_2O_5 through DAP and SSP

P_K = price of K through MOP

Y_{Nt-1}, Y_{Pt-1} and Y_{Kt-1} represent lagged variable (fertilizer consumption in the preceding years) for N, P and K, respectively.

The equations mentioned above may be regressed by the ordinary least square method (OLS). The results will be found satisfactory with various combinations of selected variables. An example is given below:

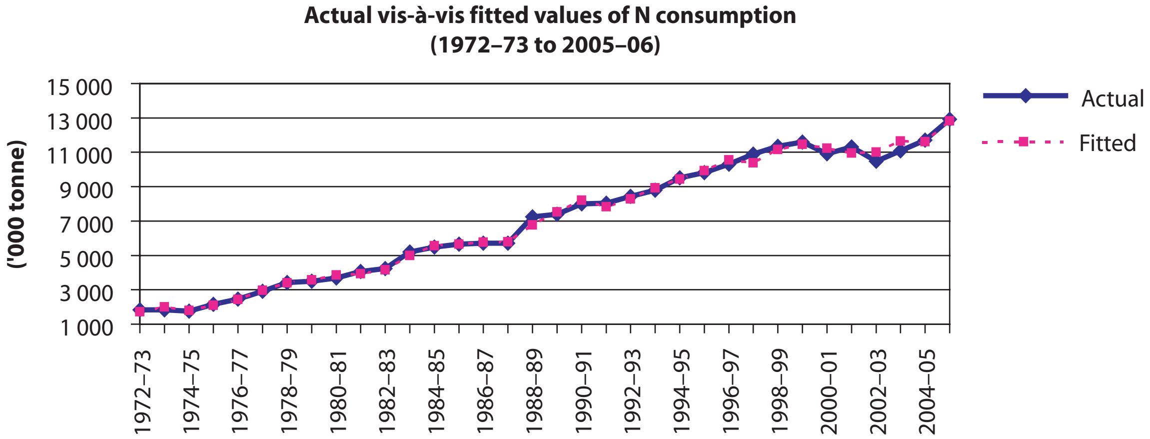
	Dependent variable: Consumption of Nitrogen (N)		
	Coefficient	**t-statistic**	**Probability**
Constant	-1.748298	-2.845725	0.0084
LN price	-0.264981	-3.185418	0.0036
LP price	0.048777	1.118230	0.2733
LPI area	0.658105	2.376680	0.0248
LPH area	0.644672	4.570658	0.0001
LP rainfall	0.300425	4.594392	0.0001
LN Con (-1)	0.567898	7.033618	0.0000
R^2	0.997073		
Adjusted R^2	0.996423		

LN price = log of N price (through urea), LP price = log of P price (through weighted average price of DAP and SSP), LPI area = log of percentage of irrigated area to gross cropped area, LPH area = log of percentage of HYV area to gross cropped area, LP rainfall = log of rainfall (as percentage of long-term average value), LN Con (-1) = log of lagged variable, i.e., consumption of fertilizer of N in the preceding year.

The variables included in the equation explained 99.7 percent variation in demand for nitrogen. R^2 and adjusted R^2 are highly significant. The effects of irrigation and HYV are strong on the consumption of nitrogen (N). As shown in the table above, a 1 percent increase in area under irrigation resulted in 0.66 percent increase in the consumption of N. Similarly, a 1 percent increase in area under HYV led to a 0.64 percent increase in the consumption of N. A 1 percent increase in the long-term average value of rainfall led to 0.30 percent increase in the consumption value of N. A 1 percent increase in the prices of N resulted in the decline in consumption of fertilizers by 0.26 percent and vice versa.

The manual process of calculation by this method is lengthy. However it can be calculated by using EViews software. The steps to be followed when using the software are laid down in **Annex 7.**

An example of the actual and fitted value for the past period is shown in this graph.



The multiple regression method requires a set of time series data for about 25 to 30 years on various factors influencing fertilizer consumption.

The advantage of the multiple regression method is that it serves as a measure of the degree of association between the dependent variable (e.g. fertilizer consumption) and a group of independent variables (e.g. rainfall, irrigated area, HYV area, fertilizer prices, credit, etc.). It may be recalled that during the mid-1970s, fertilizer prices sky rocketed. Similarly, the first half of the year 2008–09 witnessed an unprecedented increase in the prices of fertilizers, raw materials and intermediates. In both periods fertilizer consumption was seriously affected with the farmers understandably reluctant to invest in fertilizer. Under such a scenario, driven by policy changes, any trend line method may not be appropriate to forecast demand. The multiple regression method is the best approach for prediction in such cases. Moreover, the multiple regression method offers several techniques for deciding which the single best predictor is. It also serves as a measure of how well the calculated plane of regression fits and consequently as a measure of the general degree of accuracy of estimates made by reference to the equation for the plane of regression. This method is suitable for working out medium-term effective demand.

However, when estimating equations by ordinary least square (OLS), one should be careful about the possible occurrence of multi-colinearity and autocorrelation. The multi-colinearity in each estimation should be checked from the correlation matrix. The significance level of the estimated coefficients associated with the independent variation give us information about the role of the independent variable in explaining variation of the dependent variable.

The model is suitable for calculating medium-term demand projections.

CHAPTER – V

Selection of a suitable model

The preceding section dealt with details of various methodologies which may be used for estimation of future demand. Each model has its own merits and demerits. The selection of a suitable method depends upon the purpose that the forecast serves.

The objectives may range from fulfilling an immediate need to arrange a timely supply of fertilizer to long-term decisions concerning the creation of fertilizer production capacity, exploring a joint venture abroad, long-term import planning, development of research facilities, strengthening promotion and extension facilities, infrastructure development, etc.

When the objective is to make immediate arrangements for fertilizers to ensure their timely availability across the country in the next season or year, the following methods should be used: **crop area and application rate method, growth rate method, or growth rate/crop area/expert opinion method**. These may be used according to the availability of the required data.

If the purpose is to take investment decisions on revamping or modernizing existing fertilizer plants, creation of new capacities, medium-term arrangements for the assured supply of raw materials/ intermediates for domestic production or import planning, **trend extension or multiple regression method** may be applied.

If the task before the government is to make a sustained level of foodgrains available to the growing population, the **population nutrition method** may be suitable.

If there is ambitious planning to achieve a target level of agricultural output in the medium or long term, the **agricultural output method or response ratio** method may be applied.

Table 1 presents a summary of alternative methods of demand forecasts.

Table 1: Summary of demand forecast methodologies

Model	Methodology	Database requirement	Advantages	Disadvantages	To forecast
1.	Crop area and application rate method	1. Estimates of area under various crops. 2. Estimates of area fertilized. 3. Average application rates of fertilizers on various crops.	1. Crop-wise fertilizer demand can be estimated. 2. Fresh demand may be calculated if there are changes in crop area or application rates.	1. Difficulties in obtaining data on average application rates for each crop. 2. Fertilized area data are approximate.	Short-term effective demand/medium-term potential demand
2.	Response ratio method	1. Production figures of various crops for base and target year. 2. Crop response coefficient of N, P and K by the same crops.	Crop-wise fertilizer demand can be estimated.	1. Too many assumptions 2. Response ratio and nutrient ratio assumed constant. Response may improve or deteriorate.	Potential medium- and long-term demand

Table 1: *(continued)*

Model	Methodology	Database requirement	Advantages	Disadvantages	To forecast
3.	Population nutrition	1. Population data for the projected years. 2. Data on per capita net availability of foodgrains. 3. Response ratio of fertilizer (average N+P+K) to foodgrain. 4. Percentage share of foodgrains vis-à-vis other crops to fertilizer Consumption.	Estimates requirement of fertilizer for foodgrains and derives fertilizer requirement for total crops.	1. Does not assume: (i) shift in food intake from cereals to meat/ poultry products; (ii) diversification of foodgrains to other crops. 2. Assumes fixed response ratio and NPK use ratio. There may be changes in these ratios. 3. The methodology is not applicable for a country solely/ partly dependent on imports of foodgrains.	Potential medium- and long-term demand
4.	Agricultural output method	1. Value of agricultural output. 2. Fertilizer consumption. 3. Gross irrigated area. 4. Gross cropped area. 5. Area under foodgrains and non-foodgrain. 6. Total factor productivity.	1. Comprehensive methodology. 2. Flexible.	1. Value of agricultural output includes all crops and in some cases livestock, fishery, etc. 2. Fertilizer use is confined to major crops only.	Potential medium-term demand
5.	Growth rate method	Data on fertilizer consumption for the past years.	1. Simple to apply. 2. Applicable under normal situations.	1. Rigid; 2. Ignores abnormal years.	Effective short- and medium-term demand
6.	Growth rate/crop area/ expert opinion method	1. Actual and growth in consumption of fertilizers in the past 5 years during the specific season. 2. Best consumption in the past 5 years during the specific season. 3. Area coverage under different crops.	1. A well planned system. 2. An integrated and transparent approach. 3. Participation of main stakeholders. 4. Facilitates equitable distribution of fertilizer across the country.	1. Does not take care of unforeseen abnormal situation. 2. Not applicable for medium- and long-term forecasts.	Effective short-term demand

Table 1: *(continued)*

Model	Methodology	Database requirement	Advantages	Disadvantages	To forecast
		4. Area under irrigation. 5. Availability of quality/improved seeds. 6. Opening stock of fertilizers with administrative units (both product and nutrient). 7. Production estimation by fertilizer manufacturers. 8. Number of fertilizer sales points.	5. Rational import planning of fertilizers. 6. Avoids criss-cross movement of fertilizers.		
7.	Time series analysis and trend extension methods		1. The linear trend applicable if period to period changes in fertilizer consumption are constant or near to constant in absolute amount. 2. The second degree parabola trend equation is appropriate for the trend component of a time series when the changes in fertilizer consumption are not constant.	1. Very few time series of fertilizer consumption exhibit constant change over a period of time. 2. Rigid. Addition of one more observation needs re-computation.	Effective medium-term demand
8.	Multiple regression method	Historical data for past 30 years of the following: 1. Gross cropped area. 2. Irrigated area. 3. Rainfall as % of long term average. 4. Area under HYV crops. 5. Fertilizer nutrient prices. 6. Availability of credit. 7. Fertilizer sales points. 8. Government plans for future on above areas.	1. Gives degree of association between dependent and independent variables which influence fertilizer consumption. 2. Multiple techniques for deciding the single best predictor. 3. Serves as a measure of goodness of fit and general degree of accuracy of estimates.	Occurrence of multicollinearity	Effective medium-term demand

The application of the various methodologies mentioned above needs a large database. Most of the information is available with government departments. Table 2 shows the basic statistics needed for forecasting and the likely source of data.

Table 2: Basic data sets needed for forecasting

Sl. No.	Type of Data	Likely source[1]
1	Fertilizer types and quantities imported each year	Ministry of Agriculture or Ministry of Supply or Ministry of Chemicals and Fertilizers
2	Domestic production by fertilizer types and quantities each year	Ministry of Industry/Ministry of Chemicals and Fertilizers
3	Farmgate prices of different fertilizer types	Ministry of Agriculture
4	Fertilizer opening stock with manufacturers, primary distributors and at ports each year	Ministry of Agriculture
5	Quantity of fertilizer consumed each year by fertilizer type and in terms of nutrient	Ministry of Agriculture
6	Total arable land	Ministry of Agriculture
7	Area under main crops (periodical census and/or sample survey)	Ministry of Agriculture
8	Production of foodgrains and other crops each year	Ministry of Agriculture
9	Area under irrigation	Ministry of Irrigation
10	Details of irrigation projects under construction	Ministry of Irrigation
11	District/Province/State-wise rainfall data by month and year	Department of Meteorology
12	Area under high-yielding varieties (sample survey)	Ministry of Agriculture
13	Recommended nutrient dosage for each main crop for each zone	Department of Extension or Agricultural Research Institute or the Agricultural University
14	Actual fertilizer applied to each main crop (sample survey)	Ministry of Extension or State Departments of Agriculture
15	Crop credit disbursements each year	Central Bank or Agricultural Development Bank
16	Number of fertilizer outlets by district-private, public and cooperatives	Ministry of Agriculture or Ministry of Trade
17	Procurement or floor prices for main crops	Ministry of Agriculture of the Civil Supplies Department
18	Market prices of main crops each year	Ministry of Agriculture or the Civil Supplies Department
19	Price subsidy for inputs	Ministry of Agriculture or Ministry of Finance
20	Results of fertilizer response trials on different crops	Department of Extension or Agricultural Research Institute or the Agricultural University
21	Population data	Department of Census
22	Per capita nutritional availability/requirements	Department of Planning or Department of Nutrition and Health
23	GDP and value of agricultural produce	Ministry of Planning
24	Total factor productivity	Ministry of Planning

[1] *Names of sources are typical and given as examples; may vary from country to country*

Conclusion

Fertilizer demand is influenced by a variety of factors and it is difficult to make very accurate predictions. However, there is a need for realistic demand forecasts so that national governments can make realistic plans to ensure the adequate availability of fertilizer across the country in time. Overestimation of demand leads to high inventory resulting in high interest and storage cost, product loss and loss in foreign exchange. Underestimation causes scarcity resulting in steep increases in farmers prices (unless fertilizer is subsidized) and reduction in fertilizer use and finally lost production of foodgrains and other principal crops.

Over the years various organizations and researchers have developed different forecasting methodologies. The selection of a specific model depends upon the purpose for which the forecast is to be used. The government's objective may concern either the immediate future or long-term planning decisions. There is a wide range of objectives. These include:

- arranging an adequate quantity of fertilizers from domestic manufacturers or importers for the next season;
- planning the supply of raw materials for domestic production;
- transportation and storage plans;
- long-term decisions on restoration of nutrient balance in the soil, creation of new domestic capacity or joint ventures abroad;
- research and extension facilities;
- infrastructure development

A proper methodology should be selected keeping in mind the objective in the background. The demand forecasts should be periodically reviewed and adjusted in the light of changing circumstances.

References

Chand, R. 2005. *Demand for urea towards 2011*. NCAEPR

Gupta, S.P. & Gupta, A. 2008. *Statistical Methods*

Parthasarathy, N.S. 1994. *Demand forecasting for fertilizer marketing*. Rome, FAO www.fao.org/DOCREP/003/T4240E/T4240E23.htm

NCAER. 1978. Projection of fertilizer demand – general. *Fertilizer demand study, final report*. (1). NCAER

GOI. 2007. *Report of the working group on fertilizer industry for the eleventh plan*. New Delhi, Department of Fertilizers, Ministry of Chemicals & Fertilizers, Government of India

Annex 1

Crop area and application rate method									
Crop	**Total area (hectare)**	**Approx. Fertilized area (%)**	**Application rate (kg/hectare)**			**Fertilizer consumption (tonnes)**			
			N	**P**	**K**	**N**	**P**	**K**	**Total**
(1)	(2)	(3)	(4)	(5)	(6)	(7) = (2 x 3/100 x 4)/1 000	(8) = (2 x 3/100 x 5)/1 000	(9) = (2 x 3/100 x 6)/1 000	(10) = (7 + 8 + 9)
Rice	100	80	90	40	20	7.20	3.20	1.60	12.00
Wheat	100	90	95	40	20	8.55	3.60	1.80	13.95
Sorghum	100	60	50	40	10	3.00	2.40	0.60	6.00
Maize	100	65	65	15	5	4.23	0.98	0.33	5.53
Soybean	100	60	25	25	5	1.50	1.50	0.30	3.30
Sugarcane	100	95	130	50	20	12.35	4.75	1.90	19.00
Fruits	100	50	110	70	70	5.50	3.50	3.50	12.50
Vegetables	100	80	100	60	45	8.00	4.80	3.60	16.40
Cotton	100	90	90	50	15	8.10	4.50	1.35	13.95
Jute	100	90	50	25	25	4.50	2.25	2.25	9.00
Total nutrient						**62.93**	**31.48**	**17.23**	**111.63**

The above total nutrient figures may be transformed into fertilizer materials. An example shown below:

	Urea	**DAP**	**MOP**	**Total**
Total material	**110.02** (62.93– (68.42 x 0.18)/ 0.46)	**68.42** (31.48/ 0.46)	**28.71** (17.23/ 0.60)	**207.15**

Note: *If the above is considered a demand forecast for a district/province/state, then the sum of district/province/state figures will give national demand.*

Annex 2

Response ratio method												
Crop	Production ('000 tonnes)			Response (in kg) of each crop per kg. of total fertilizer nutrients (N+P+K) used	Additional requirement of total fertilizer nutrients (N+P+K) (tonnes)	Ratio of NPK use			Total requirement of fertilizer nutrients in the terminal year			
	Base year (Actual)	Target year	Additional			N	P	K	N	P	K	Total
(1)	(2)	(3)	(4) = (3–2)	(5)	(6) = (4/5)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Rice	95	105	10	10.64	939.8	4.25	1.75	1	570.6	235.0	134.3	939.8
Wheat	80	100	20	6.78	2 949.9	23.52	10.16	1	2 000.6	864.2	85.1	2 949.9
Sorghum	8	12	4	5.09	785.9	6.20	4.65	1	411.2	308.4	66.3	785.9
Pearl millet	10	15	5	4.61	1 084.6	13.00	3.00	1	829.4	191.4	63.8	1 084.6
Maize	20	25	5	13.44	372.0	173.00	19.30	1	333.0	37.1	1.9	372.0
Pulses	15	17	2	8.75	228.6	26.12	6.32	1	178.5	43.2	6.8	228.6
Groundnut	10	15	5	5.74	871.1	3.40	3.22	1	388.7	368.1	114.3	871.1
Mustard	6	8	2	5.22	383.1	3.92	2.73	1	196.3	136.7	50.1	383.1
Soybean	10	15	5	5.44	919.1	5.70	6.11	1	409.0	438.4	71.8	919.1
Sugarcane	340	360	20	500.00	40.0	6.17	2.39	1	25.8	10.0	4.2	40.0
Cotton	26	30	4	6.33	631.9	5.82	3.34	1	362.0	207.7	62.2	631.9
Jute	10	15	5	4.00	1 250.0	2.14	0.99	1	647.7	299.6	302.7	1 250.0
Fruits	60	70	10	5.00	2 000.0	1.57	1.03	1	872.2	572.2	555.6	2 000.0
Vegetables	115	120	5	50.00	100.0	2.23	1.28	1	49.4	28.4	22.2	100.0
Total									**7 274.4**	**3 740.5**	**1 541.1**	**12 556.0**

Annex 3

Population nutrition method									
Sl. No.	**Item**	**Unit**	**Year T_0**	**Year T_1**	**Year T_2**	**Year T_3**	**Year T_4**	**Year T_5**	**Year T_6**
1	Population	Million No.	470	500	550	600	650	700	750
2	Net availability of foodgrains (460 grams per capita per day)	Kg per annum	168	168	168	168	168	168	168
3	Net requirement of foodgrains (Item 1 x Item 2)	Million tonnes	79	84	92	101	109	118	126
4	**Gross requirement of foodgrains (Item 3/87.5%*)**	Million tonnes	**90.00**	**95.94**	**105.54**	**115.13**	**124.73**	**134.32**	**143.91**
5	Additional requirement of foodgrains on the level of base year, i.e. Year T_0	Million tonnes		5.94	15.54	25.13	34.73	44.32	53.91
6	Response ratio of fertilizer nutrients (N+P+K) to foodgrains			1:6	1:6	1:6	1:6	1:6	1:6
7	Additional demand for fertilizers for foodgrains (N+P+K) (Item 5 x response ratio)	Million tonnes		0.99	2.59	4.19	5.79	7.39	8.99
8	Additional demand for fertilizers for all crops (N+P+K) (65% on foodgrains and 35% on other crops)	Million tonnes		1.52	3.98	6.44	8.90	11.36	13.82
9	**Total demand for fertilizers for all crops (Total consumption of N+P+K during the base year (T_0) + Additional consumption in the respective years)**	Million tonnes	**10**	**11.52**	**13.98**	**16.44**	**18.90**	**21.36**	**23.82**
10	Nutrient-wise demand (NPK use ratio = 5:2:1)								
	N	Million tonnes	6.25	7.20	8.74	10.28	11.82	13.35	14.89
	P	Million tonnes	2.50	2.88	3.50	4.11	4.73	5.34	5.96
	K	Million tonnes	1.25	1.44	1.75	2.06	2.36	2.67	2.98

* = *The balance 12.5% is projected to be provided for seeds, feed requirements and wastes.*

Assumptions:
1. *Net availability of foodgrains – 460 grams per day.*
2. *Response ratio of fertilizer nutrients (N+P+K) to foodgrains – 1:6.*
3. *NPK use ratio = 5:2:1*

Annex 4

Growth rate method

Nitrogen

State/ Province	Growth in consumption of N over previous season 1 (%)						Consumption in the base year* (tonnes)	Demand in the ensuing season 1
	Preceding seasons					Average growth		
	Year 1	Year 2	Year 3	Year 4	Year 5 (Current year)			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9) = [(Col. 8) + (Col. 8 x Col. 7)/ 100]
1	2	2.5	3.0	2.4	4.0	2.78	100.00	102.78
2	3	3.5	2.3	-2.6	3.5	3.08	200.00	206.15
3	5	4.0	4.0	3.0	5.0	4.20	250.00	260.50
4	1	-1.5	1.6	1.3	2.0	1.48	125.00	126.84
5	4	3.0	4.0	2.0	5.0	3.60	150.00	155.40
Country Total							**825.00**	**851.67**

Phosphate

State/ Province	Growth in consumption of P over previous season 1 (%)						Consumption in the base year* (tonnes)	Demand in the ensuing season 1
	Preceding seasons					Average growth		
	Year 1	Year 2	Year 3	Year 4	Year 5 (Current year)			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9) = [(Col. 8) + (Col. 8 x Col. 7)/ 100]
1	2.5	3	3.5	2.6	5.0	3.32	50.00	51.66
2	3.5	4	4.5	-3.0	6.0	4.50	70.00	73.15
3	6.0	-5	5.0	4.0	2.0	4.25	100.00	104.25
4	2.0	3	2.5	2.0	2.5	2.40	40.00	40.96
5	5.0	4	5.0	3.0	-5.0	4.25	50.00	52.13
Country Total							**310.00**	**322.15**

Potash

State/ Province	Growth in consumption of K over previous season 1 (%)						Consumption in the base year* (tonnes)	Demand in the ensuing season 1
	Preceding seasons					Average growth		
	Year 1	Year 2	Year 3	Year 4	Year 5 (Current year)			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9) = [(Col. 8) + (Col. 8 x Col. 7)/ 100]
1	1.5	2.0	2.5	2.0	3.5	2.30	25.00	25.58
2	2.5	3.0	2.0	-2.0	3.0	2.63	35.00	35.92
3	4.5	3.5	3.5	2.0	4.5	3.60	50.00	51.80
4	1.0	2.0	2.0	-1.5	1.5	1.63	20.00	20.33
5	3.5	2.5	3.5	1.5	4.5	3.10	25.00	25.78
Country Total							**155.00**	**159.39**

** in season 1 of the current year*

Annex 5

Growth rate/Crop area/Expert opinion

Supply plan of fertilizer nutrients – Season 1

(tonnes)

Sl. No.	Particulars	State 1			State 2			State 3		
		N	P	K	N	P	K	N	P	K
1	Gross requirement	1 000	800	600	400	300	100	600	300	150
2	Opening stock as of 1 April	100	80	60	40	30	10	60	30	15
3	Net requirement (1-2)	900	720	540	360	270	90	540	270	135
4	Pipeline requirement (5% of Net req.)	45	36	27	18	13.5	4.5	27	13.5	6.75
5	Allocation (3 + 4)	945	756	567	378	283.5	94.5	567	283.5	141.75
	Supplies to be made by manufacturers									
	1	120	60	30	60	50	10	100	80	40
	2	80	40	20	40	20	10	140	70	35
	3	200	120	60	70	30	5	130	65	30
	4	200	130	70	20	10	5	120	60	30
	5	100	50	25	23	30	30	77	8.5	6.75
6	Total supplies to be made by manufacturers	700	400	205	213	140	60	567	283.5	141.75
7	Balance to be supplied from imports (5 – 6)	245	356	362	165	143.5	34.5	0	0	0

Annex 6

Time series analysis and trend extension

Formula of linear equation:

$Y = a + bx$

Where "Y" = dependent variable (fertilizer consumption), "X" = explanatory variable (crop area/irrigated area/HYV area/fertilizer price, etc.), "a" is the Y intercept or the computed trend figure of the Y variable, and "b" represents the slope of the trend line or the amount of change in Y variable that is associated with a change of one unit in X variable.

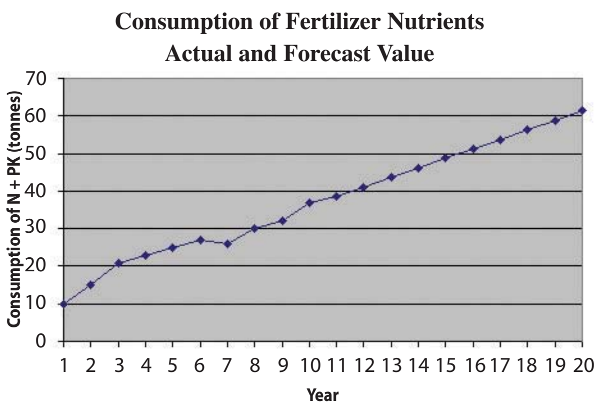
In order to determine the values of the constants a and b, the following two normal equations are to be solved.

$\sum Y = Na = b\sum X$

$\sum XY = a\sum X + b\sum X^2$

Example:

Year	Total cropped area (Million hectares)	Fertilizer nutrients (N+P+K) consumption ('000 tonnes)
	X	Y
1999	1	10
2000	2	15
2001	3	21
2002	4	23
2003	5	25
2004	6	27
2005	7	26
2006	8	30
2007	9	32
2008	10	37
	a	10.667
	b	2.533



Forecast value

Year	Y = a + bX Total cropped area (Million hectares)	Forecast of fertilizer nutrients (N+P+K) demand ('000 tonnes)
2009	11	38.5
2010	12	41.1
2011	13	43.6
2012	14	46.1
2013	15	48.7
2014	16	51.2
2015	17	53.7
2016	18	56.3
2017	19	58.8
2018	20	61.3

Annex 7

Multiple regression method	
The exercise can be done by using EViews 3 software	
Operational Steps:	
1	Open Eviews.
2	Click File -> New -> Workfile.
3	Select 'Annual' in the workfile frequency, then select the range of data (year) in the 'start date' and 'end date', then click 'OK'.
4	A work file with 'UNTITLED' will appear in the screen.
5	Click 'save' to save the file in a folder and put the appropriate name of the file.
6	Click 'object' -> 'New object'-> type of object 'series', put name of the object in 'Name of the object' box, click 'OK'.
7	Select the object and double click to enter the data on it.
8	Put the cursor in the first series and click 'Edit' to feed the data.
9	Click 'File' -> 'save' to save the current file.
10	Repeat steps 6 to 8 to add new objects to the file. *Note: These objects will be treated as variables at the time of analysing the data. Variables must be in two types i.e. dependent and independent variables. The entries of dependent variables would be up to the level of available data, whereas the entries of independent variables should be into the forecast year.*
11	You may create the variable by using the existing variable. Example: if we want to 'log' a particular variable say 'test', then use 'Procs' -> 'Generate series' enter equation, 'ltest = log(test)', where 'ltest' is the name of the new variable which is the log of variable 'test'.
12	Enter the range of samples in the 'Sample' box. The range should match your data range. Click 'OK'.
13	You can view the data by double clicking in the variable.
14	Now to generate the equation, click 'Genr', enter the equation. To enter the equation, first variable should be dependent variable followed by constant space 'C' and the other variables which influence the dependent variable. Set the method appeared in the 'Estimation Setting' box, then click 'OK'. The statistical results will appear on the screen. You may take the printout of the results for your use. If one of the variables does not get satisfactory results, then drop that variable. A fresh equation is required in such cases. You may add or delete as many variables for generating the equation. Generally, the names of the equation would be 'equ01', 'equ02', and so on. You may rename these file names.
15	To obtain the forecasted values, use the equation, click 'Forecast', verify the file name, enter the sample range for forecast, then click 'OK'. A line graph will appear on the screen. Close the window and see the forecasted value by double clicking the forecasted file. If you have used log data in generating equation, then anti-log the forecasted file by using the following steps.
16	Click 'Genr', enter equation, 'fvtest' = exp(ltestf), where, 'fvtest' is the absolute value of forecasted series, 'exp' is the exponential of the log forecasted variable 'ltestf'.
17	Now, double click the forecasted variable to see the absolute values.

ISBN 978-92-5-106914-1
I2308E/1/06.11