Agriculture and Soil fertility management in Bhutan: An overview*

Karma Dema Dorji[1]

1. Introduction

The Kingdom of Bhutan lies on the southern slopes of the eastern Himalayas landlocked between China to the north and India to the south. It has a geographical area of 38,394 sq. km and stretches roughly 300 km east to west and 170 km north to south. The country is mostly mountainous and the elevation ranges from about 150 masl in the south to over 7,550 masl in the north, resulting in extreme variation in climate, vegetation and soils. Climatic zones range from the subtropics with high annual rainfall (5500 mm) in the south to alpine with low rainfall (400 mm) in the north. Agriculture is the mainstay of the Bhutanese economy contributing 22% to the GDP (Poverty Analysis Report 2007). Sixty nine percent of the people live in rural areas and derive their livelihood from subsistence agriculture.

About 72.5% of the land is under forest cover, 7.8% is arable land, 3.9% of pasture or meadows, 0.1% each under horticulture and settlement and the remaining areas are permanent snow, barren rocks and scrubland. Out of total cultivable land, 17.7% is wetland, 68.2% is dryland, 5.9% is orchard and the rest constitutes *pangshing*[2] and kitchen garden (Table 1 & 2).

The total population of the country in 2005 was 634,982. The urban population consisted of 196,111 (31%) persons while 438,871 (69%) were in the rural areas. The population for 2007 was projected at 658,888 (Statistical Yearbook of Bhutan 2007). The population density of 16 persons/sq. km is one of the lowest in the world. The annual rate of population growth is estimated at 2.5 percent.

Bhutan remained in self imposed isolation until 1960, with an economy which was purely agriculture driven. From 1961 onwards it opened up to the rest of the world and started its first five year plan (1961-1965). Within the last 45 years of the state-led planned development, Bhutan has made considerable achievement in its socio-economic development. The per capita income of US$ 700 is considered one of the highest in the region. Unlike other countries, Bhutan's approach to development is quite unique which is guided by a concept of "Gross National Happiness" (GNH). This holistic approach comprises four pillars: Good governance, Equitable and Sustainable socio-economic development, Environmental Conservation, and Preservation of culture and tradition. This approach basically ensures a balanced economic development with environmental and cultural conservations. It places people at the heart of development plans so as to enable them to achieve economic prosperity as well as happiness.

* Country Paper presented in the meeting of Asia-Pacific Net on Integrated Plant Nutrient Management & International Workshop on Sustainable Nutrient Management: Technology & Policy, May 27-31, 2008. Shijiazhuang, Hebei, China.

[1] Dy. Chief Soil Fertility & Plant Nutrition Officer, National Soil Services Centre, Ministry of Agriculture, Bhutan.

[2] Land not cultivated as intensively as dryland. Often kept fallow.

Table 1: % of area by land use types

Land use	Percentage of area
Forest Cover	72.5%
1. Parks and wildlife sanctuary	(of which) 26%
2. Biological corridors	9%
Pasture	3.9%
Horticulture	0.1%
Agricultural land	7.8%
Settlement	0.1%
Others[3]	15.6%

Source: Facts and figures of RNR Sector 2003.

Table 2: Arable agricultural land by land use type

Classification	Percent	Area (acre)
Wetland (irrigated)	17.67	68,294
Dryland (rainfed)	68.24	2,63,811
Pangshing	7.33	28,330
Orchard	5.87	22,701
Kitchen Garden	0.89	3,437
Total	**100**	**3,86,573**

Source: PPD, Ministry of Agriculture referred in Statistical Yearbook of Bhutan, 2007.

2. Agriculture in Bhutan

Although the share of agriculture in GDP has dropped from roughly 56% in 1980 to 22% in 2006, the Bhutanese economy is still dominated by agriculture as the single largest sector providing livelihood to almost 69% of the population. The decline in agriculture's contribution towards GDP is mainly due to the loss of productive agricultural land to other sectors. Besides, the growth in other sectors such as energy, transport and communication have created job opportunities in more lucrative sectors like construction and manufacturing resulting in rural to urban migration and hence farm labour shortage. There has been a significant increase in the hydropower contribution to GDP within the last few decades.

Bhutanese farmers are generally small and marginal. Farming is largely subsistence based mainly on traditional knowledge with relatively low intensity of farm inputs. Farm households are scattered in small, remote villages and each village comprises of a dozen to hundred households on average. Farming in Bhutan is difficult and labour intensive because of small land holding sizes on steep slopes with limited opportunity for any farm mechanization. The average land holding size of the farm households is less than 2.5 acres. About 14% of the households own less than 1.0 acre and 56% have land holdings between 1.00 and 5.00 acres, while rest of the households do not have any agricultural land and earn their living either by working as farm labourers or as tenants on others farmland (Figure 1).

Though the agricultural practices are constrained by factors associated with the rugged and steep terrain of the country, over the last few decades there have been some changes in the agricultural practice due to improved farming methodologies. The agriculture research centres and central programmes established in 1970s and 1980s provided technology options such as high yielding crop varieties, plant protection chemicals and inorganic fertilizers to increase food productions. However, these conventional inputs are either not readily available or are not easily adopted especially by the farmers in the remote areas. For example, a total of

[3] Others include permanent snow cover, barren rocks and scrubland

15 improved rice varieties for different agro-ecological zones have been released and although improved rice varieties provide higher yield, about 80% of the total rice production is still planted with traditional rice varieties.

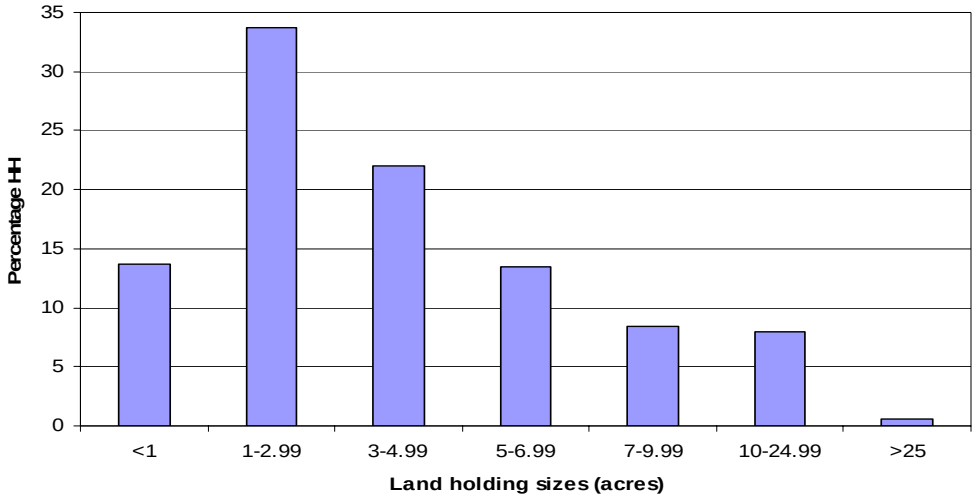

Figure 1: % of farm households by agricultural land holding sizes (acre). Source - Facts & Figures of RNR Sector 2003

The traditional varieties are popular for their taste and command a high premium price in the local market. Since farmers keep livestock, an important component of their farming system, they prefer varieties that provide enough food for them and fodder for their livestock. Thus, the traditional varieties with long straw lengths are still preferred over high yielding improved varieties with short straw lengths.

On the other hand, a number of exotic horticultural crops introduced were widely accepted by farmers. Fruits and vegetables that are available in the market are mostly introduced varieties. Improvement in transport and communication networks has also encouraged the farmers to grow not only for their own consumption but also for the market.

3. Farming systems

Out of several farming systems in Bhutan, dryland and wetland are the main farming systems. *Tseri* (shifting cultivation) used to be a major farming system in the east and east central regions of the country until recently. *Tseri* practice has been banned and no longer considered a land use type. *Tseri* lands are being converted into other land use types such as dryland and private forest. The country is divided into four regions, west, west central, east central and east. About 50% of the country's dryland is in the east while about 60% of the total wetland is in the west and west central region (Figure 2).

On dry land, maize is the predominant crop at lower altitude and at higher altitude (above 2,500 masl) potato, wheat and buckwheat are the main crops from dryland. On wetland (irrigated paddy fields), rice is cultivated up to 2,600 masl. The local rice crop is grown in rotation with wheat or potato in the warm temperate and with improved variety, mustard or pulses in dry subtropics while in the subtropics, rice may be the sole crop for the year under the irrigated/wetland farming system. Winter cropping of wetland is restricted by low winter temperatures at higher altitudes and lack of irrigation at lower altitudes. Winter cropping is greatest at mid altitudes with farmers growing wheat, mustard, barley, potatoes and winter

fodder such as oat (Table 3). Though the farming in Bhutan is largely subsistence, mandarin oranges at lower altitudes and apples at higher altitudes are the major cash crops, making an important contribution to GDP. Other important cash crops are cardamom, ginger and chilli. As shown in Figure 3, the area of land is largest under maize (70,000 ac) followed by paddy (48,000 ac). These two crops are grown mainly for home consumption while potato is grown intensively as cash crop. Different farming systems are spread over six agro-ecological zones formed based on temperature; precipitation and altitude.

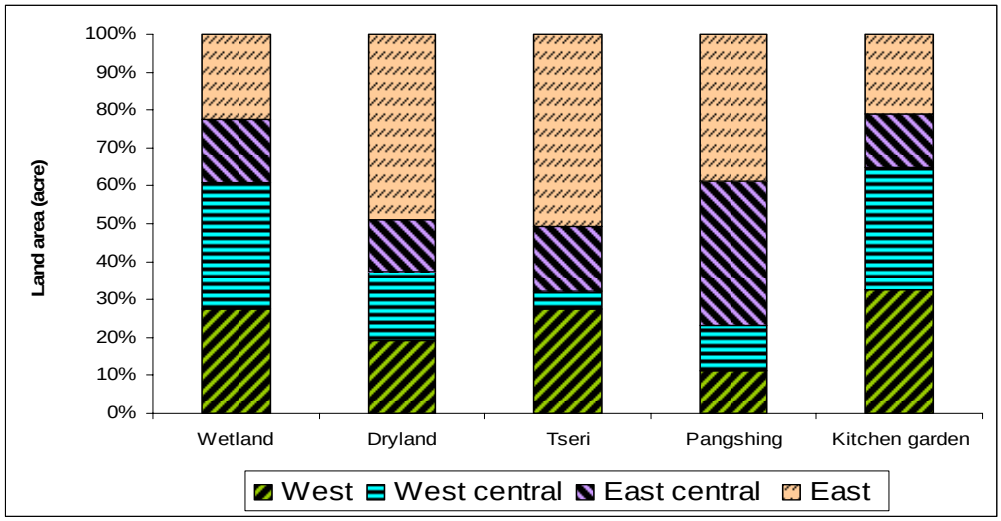

Figure 2: % of land use type in the four regions of the country. Source-RNR Statistics, 2003

Table 3: Agriculture in the agro-ecological zones of Bhutan

Agro-ecological Zone	Altitude (m.a.s.l)	Rainfall (mm/annum)	Farming system & major crops.
Alpine	3,600-4,600	<650	Barley, buckwheat, mustard and vegetables.
Cool Temperate	2,600-3,600	650-850	Barley, wheat & potato on dryland, buckwheat & mustard under shifting cultivation.
Warm Temperate	1,800-2,600	650-850	Rice on irrigated land, double cropped with wheat & mustard, barley & potato on dryland, temperate fruits, and vegetables.
DrySub-tropical	1,200-1,800	850-1,200	Maize, rice, millet, pulses, fruits & vegetables and wild lemon grass.
Humid Sub-tropical	600-1,200	1,200-2,500	Irrigated rice rotated with mustard, wheat, pulses & vegetables, tropical fruits.
Wet Sub-tropical	150-600	2,500-5,500	As for the humid zones-irrigated rice rotated with mustard, wheat, pulses, vegetables and tropical fruits.

Source: Ninth Plan, RNR Sector, Ministry of Agriculture, Bhutan.

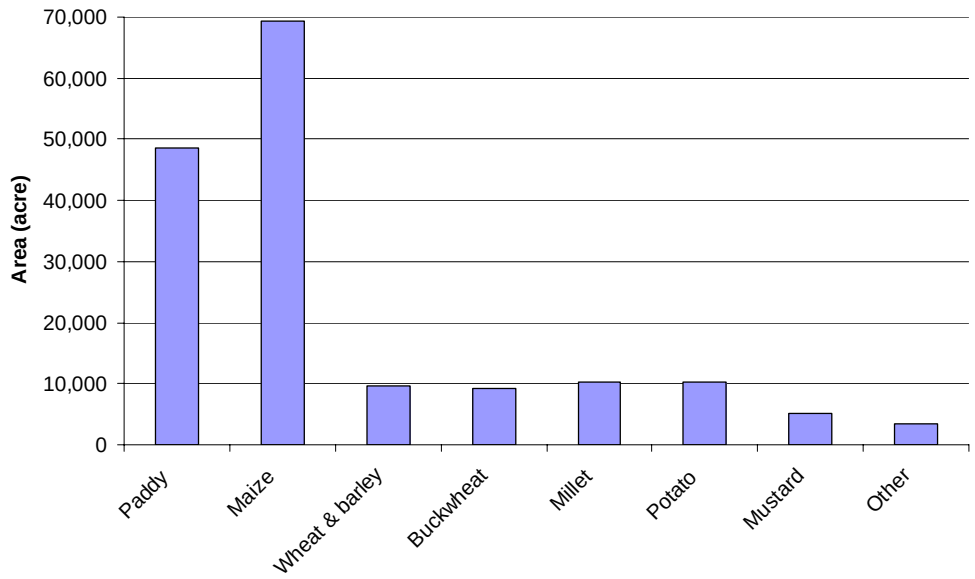

Figure 3: Area of land under major crops. Source-Selected RNR Statistics 2003, PPD, MoA

4. Soils of Bhutan

Geology is dominated by gneiss in the north and by low grade metamorphic rocks such as schists and phyllite in the south. Despite steep gradients, there are deep and well drained moderately or deeply weathered soils in Bhutan. Cultivation is limited largely by steep slopes, erosion risks and climate than by poor soils (Baillie, et al. 2004).

4.1 Soil nutrients status

Generally, the soil nutrient status of the Bhutanese soils is poor. The major concerns are a low pH and nitrogen, phosphate status and imbalanced base nutrition.

A nationwide soil fertility (SFM) survey was conducted in 1999/2000 to evaluate the basic assumption of 'low productivity of land and unsustainable soil fertility management practices'. A large number of soil samples (376) were collected and analysed. The Survey soil analytical results provide the most representative picture of the most current agricultural soil fertility status in Bhutan. Figure 5 shows the soil nutrient status.

The main features of the soils as indicated by the analytical results shown in Figure 4 are:

- Although the soils generally have low or very low pH (pH < 5.5), the aluminium toxicity is of limited concern except for some lowland subtropical soils. However, the predominant use of urea could exacerbate problems of low pH in the long run.
- In general the total organic carbon levels are adequate but total nitrogen levels are low or very low, as a result C:N ratios are favourable (<19).
- Available phosphorus (P) and potassium (K) are low in soils. Low available P is of greater concern as soil parent materials are generally K rich. Decreasing use of FYM and/or absence or inadequate P fertilizers application could deteriorate the soil P status.
- Base nutrition (BS%) and imbalance between exchangeable bases are of concern. BS% and total exchangeable bases are low or very low in most soils across the country.

- The low to very low exchangeable calcium (Ca) and magnesium (Mg) levels as compared to predominately moderate to high levels of exchangeable K are reflected by unfavourable Mg:K and Ca:K ratios. This unfavourable Mg:K ratio could indicate possible Mg deficit.

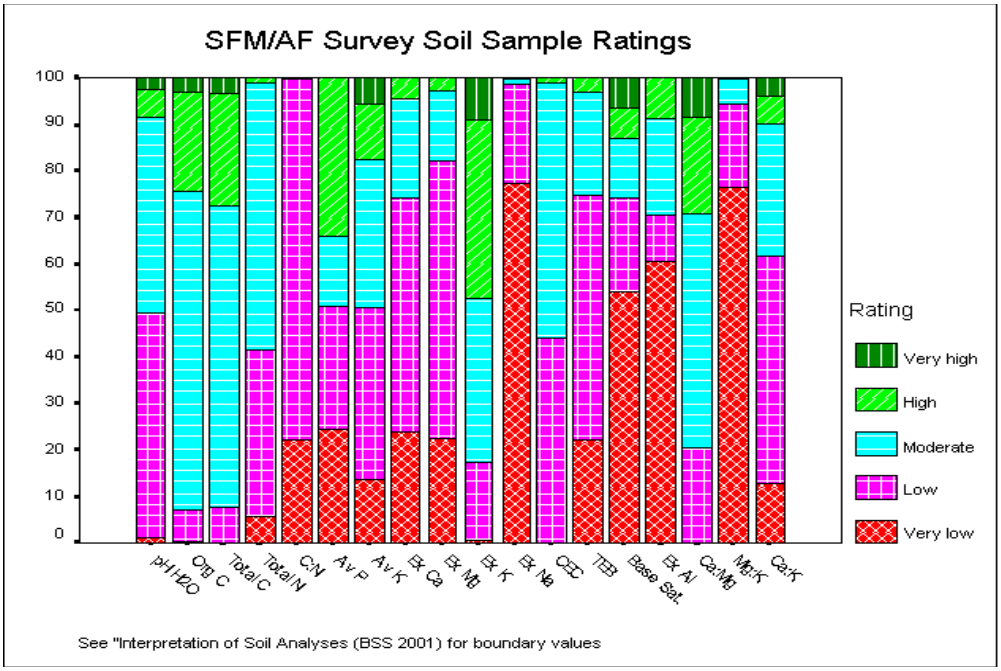

Figure 4: Soil nutrient status-rating chart for SFM survey samples. Source – Norbu & Floyd, 2001

The study also determined the most important factors determining variation in soil nutrient status.

- Dryland soils have a higher soil nutrient status rating than wetland soils for all variables except cation ratios where wetland soils have more favourable ratings.
- Warm temperate and dry subtropical soils have the most favourable soil nutrient status ratings and the humid and wet subtropical soils the worst.
- Geology is a significant factor affecting most variables.
- The relationship between management factors (e.g. use of fertilizers and household soil fertility management ability) and soil nutrient status is weak but positive.

5. Soil Fertility Management (SFM)

Plant nutrients are mostly derived from locally available organic sources such as crop residues, forest litters, fodder residues, green legumes and animal wastes. Farmers either use them individually or combine them to replenish the nutrients removed through crop harvests. Thus the traditional method of SFM is based on the integrated use of the forest as a source of fodder and leaf litter, livestock for dung and crops for crop residue. The quantity and quality of FYM vary from one location to another or among the households depending on household and livestock size. The sustainability of the traditional SFM system is very much dependent on the household labour availability and livestock number and management system. Farm labour shortage, decline in livestock size and increasing distance to forests for leaf litters are becoming more apparent, threatening the sustainability of the SFM system. Increased awareness among the farmers of the benefit of using inorganic fertilizers, increased access to fertilizers and farmers' enhanced purchasing power have changed the SFM practice to a

certain level. The current SFM practice therefore involves using some inorganic fertilizers along with the organic sources of plant nutrients.

Under the current SFM system, in general, about 5 to 7 tons of FYM is applied per ha^{-1} of cropped land. The nutrient content of a typical FYM (from 50%DM[4]) is 1.38% Nitrogen, 0.29% Phosphorus, 1.97% Potassium and 2.35% Calcium (RNRRC Bajo and SSF&PNM Project, 2001) corresponding to about 41 kg N/ha, 9 kg P/ha, 59 kg K/ha and 71 kg Ca/ha of cropped land. The amount of nutrients added through FYM alone is insufficient to ensure high yields and therefore inorganic fertilizer supplement is necessary. The national averages (Table 3) of the yields of various crops are still very low as compared to those from many other countries.

Table 4: Productions of major crops, 2007.

Crop	Area	Production	Yield
Rice	46,585	54,325	2.88 t/ha
Maize	53,938	90,566	4.10 t/ha
Potato	8,455	47,403	13.85 t/ha
Citrus	1,831,312[5]	53,938	29.45 kg/tree

Source: Investment Plans for Rice, Maize, Citrus and Potato, 2007.

5.1. Inorganic fertilizer

Fertilizers have only been available in Bhutan since the early 1960s and their use has been an important part of government agricultural development strategy to increase yields and production. Fertilizers use has increased over the years mainly due to their increased availability with the improvement in road access and distribution systems; effective promotion of their use through agricultural extension programmes; and their effectiveness, providing substantial and cost effective yield increases (Norbu & Floyd, 2001).

Until the seventh plan (1992-1997), the procurement and distribution of inorganic fertilizers were directly handled by the government agencies and since then it was privatized. There is only one agency (Druk Seed Corporation, DSC) authorised to import inorganic fertilizers. The corporation has trained commission agents to sell fertilizers directly to the clients. The fertilizer types and quantities imported are regulated by the Bhutan Agricultural Food Regulatory Authority (BAFRA) of the Ministry of Agriculture. Currently fertilizer prices are subsidized through indirect government support to the national marketing and distribution system.

The fertilizers distribution records show a steady increase in the amount of fertilizers imported and distributed over the years. The import of inorganic fertilizers increased from about 250 MT in 1960s to over 1000 MT in 1970s and 1980s. From 1989 to 1997, the import of fertilizer reached to 11,436 MT. The fertilizer distribution increased from about 1,730 MT in 1997 to 2,998 MT in 2006. This clearly indicates changing SFM system in Bhutan. However, the use of inorganic fertilizer in Bhutan is still very low as compared to many other countries. For example, in 2004, a total of about 2,833 MT of fertilizers was distributed which corresponds to about 23 kg of fertilizer per hectare of cropped land. This is equivalent to 9 kg of plant nutrients per hectare of land which is much lower than the world and Asian averages of 90 kg and 130 kg/ha per year, respectively (FAO, 2001, Norbu, 2008, unpublished).

[4] DM= dry matter
[5] Number of trees.

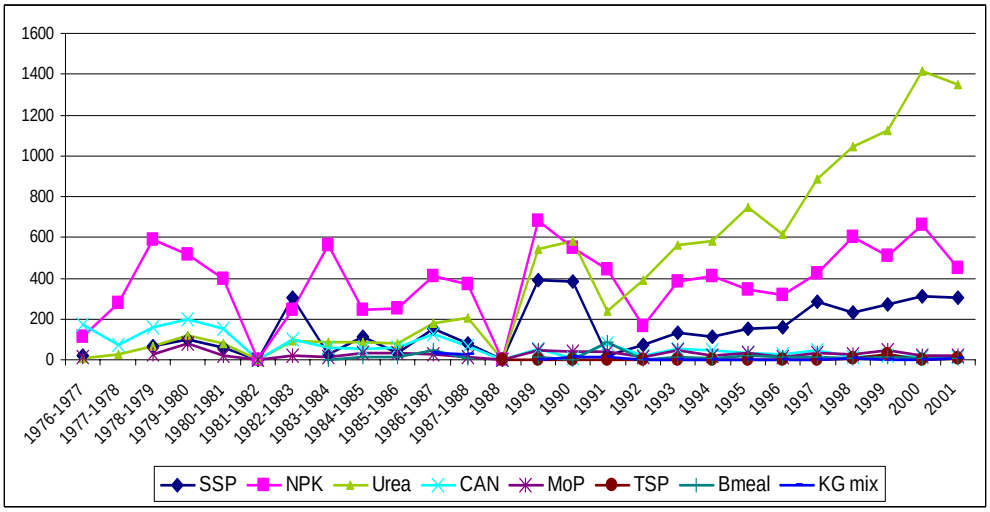

Figure 5: Type & quantity of inorganic fertilizer distribution by year (1976-2001)

The main inorganic fertilizers used in the country are urea (46% N), suphala (15-15-15) and Single super phosphate (16% P_2O_5). Within the last ten years, the distribution of urea was about 55%, suphala 28%, SSP 15% and MoP 1% of the national total (Norbu, 2008, unpublished). Urea is applied mostly in cereals particularly in rice and suphala and SSP in cash crops such as potatoes and apples. Records on the quantity of fertilizers used for different crops show that the majority of fertilizers are used for potatoes (about 50%), apples (25%), paddy (9%) and others[6] (13%) of the total consumption (Figure 6). Within the four regions, fertilizer distribution is highest in the eastern region (39%) followed by the western region (24%) and then by west central (19%) and east central (18%) regions (Figure 7). The reason for high consumption of fertilizers in the eastern and western regions is due to the application of higher quantities of fertilizers in potatoes (eastern region) and in apples orchards (western region).

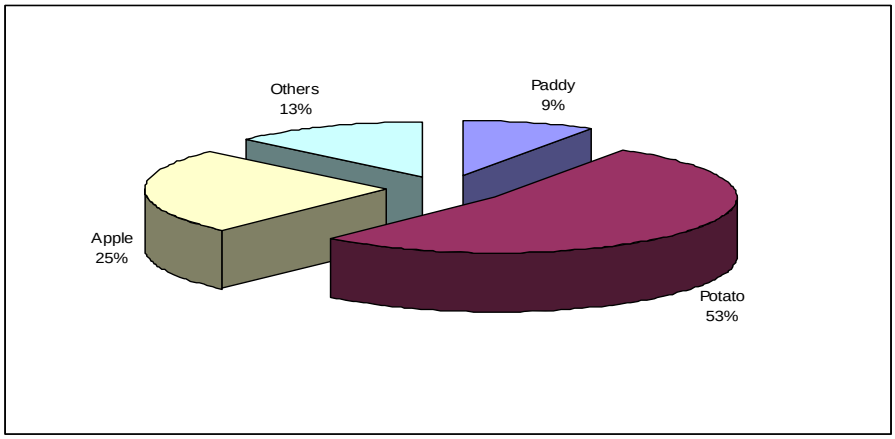

Figure 6: % of fertilizer applied to different crops

[6] Others include cereals like maize, wheat, buckwheat, etc.

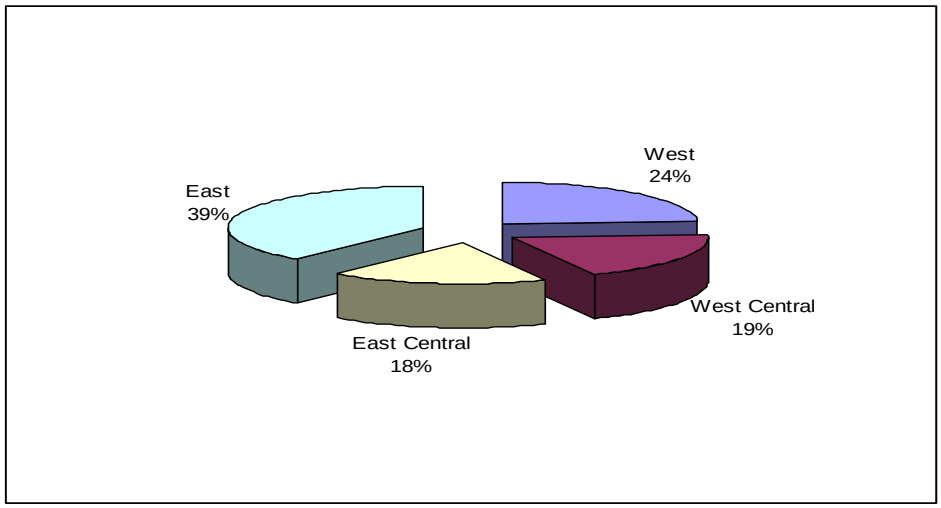

Figure 7: Region wise fertilizer distribution between 1997 to 2006

As shown in Figure 8, with the increase in fertilizer distribution, the gap between N and P, K is widening (from about 3:1:1 in early 1990 to 7:1:1 in 2005). NPK ratio at the national level is recorded at 6:1:1. This indicates a serious imbalance in nutrient use. Imbalance nutrient use is mainly related to the popularity of urea among the farmers. Urea is cheaper than the compound fertilizers; it is used in almost all the crops while the use of more expansive compound fertilizers is mostly on cash crops (potatoes and apples); immediate/visible crop response to urea application and inadequate knowledge on the importance of balance nutrient use. Imbalance of plant nutrient is a growing concern and is being addressed especially at the extension level through training, demonstration and on-farm trials.

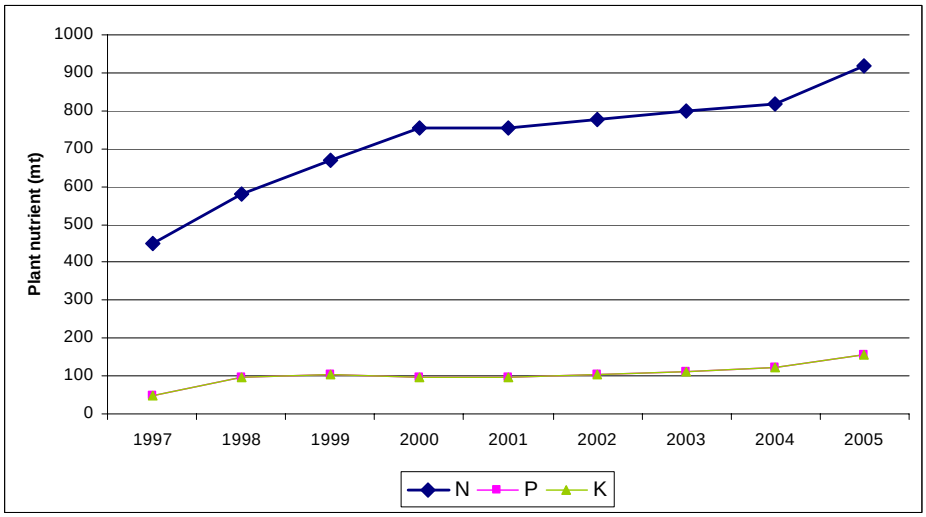

Figure 8: Distribution of plant nutrient (N, P_2O_5, K_2O) by year

5.2. Farmer Extension Fertilizer Use Trial (FEFUT)

Farmer-Extension Use Fertilizer Trial (FEFUT) is a popular on-farm trial on balance plant nutrient use implemented by research, extension and farmers jointly. FEFUT is conducted mainly with two objectives:

- To enable extension agents to implement participatory technology development with farmers (so that farmers will be able to develop locally appropriate fertiliser recommendations from field tested fertiliser use practices), and
- To determine the potential to economically improve crop production through the use of balance fertilizer and improved timing of fertiliser application in order to decide on the need for future fertiliser related research and extension programmes.

To address these two objectives, it is necessary to combine farmer field trials with the support to the extension staff on their ability to work with the farmers and to carry out these simple research trials.

Over 300 FEFUT trials on important crops such as rice, wheat and potato have shown a major difference in yields. With the shift in management of inputs such as usage of balanced nutrients, farmers have recorded yields of about 4 t/ac (RP) and 2 t/ac (FP) in wheat. In rice, with the application of balanced nutrients, the yields from RP and FP were about 3 t/ac and 1.9 t/ac respectively. FEFUT trials in potato have shown yields of 9 t/ac (RP) and 5.7 t/ac (FP) respectively. Through these trials, most of the farmers are more aware of the balance approach to SFM and the farmers have started applying balanced nutrients to most of the crops grown.

5.3. Organic Programmes

While the use of inorganic fertilizer is gaining popularity, other methods of SFM are also being promoted actively. Different cropping patterns such as crop rotation and intercropping with leguminous crops are encouraged to maintain or improve soil fertility apart from providing diversity in food crops. Composting and green manuring are also promoted especially in the southern and eastern regions of the country where the FYM production is less (mostly tethering system) and soil nutrients losses are high due to heavy rainfalls on light textured soils. In 1970s/80s, compost making was subsidised when a subsidy was also provided for inorganic fertilizers.

The Ministry of Agriculture has the National Organic Program (NOP) instituted to maintain if not strengthen the agricultural system which can still be considered largely natural. The Program works to develop and/or explore more scientifically the methods of organic farming and promote them among the farmers. The Program has recently developed a roadmap to organic agriculture in Bhutan and a framework for Organic Farming in Bhutan is being formulated.

5.4. Land Management Campaign

Being a mountainous country, surface runoff, landslides and seasonal floods are common problems across the country resulting in the loss of fertile soil and land productivity. To create awareness among the people (not just the farming community) on the importance of proper land management, the Ministry of Agriculture (MoA) started land management campaign (LMC) in 2005. Since then it became an annual event around the time of the "International Day for Desertification/Degradation". The aims of the LMC are to:

1. Create awareness on the importance of protecting land resources in a community living in a fragile ecosystem;
2. Be able to understand what the anthropogenic factors responsible for land degradation, soil erosions in particular are;
3. Introduce improved land husbandry technologies that include, agronomic, vegetative and structural measures;

4. Mainstream land management activities into the regular institutional plans of the agencies at all levels.

The LMCs have helped the people to understand the importance of proper land management. Unlike in the past, farmers' are now more willing to carryout soil conservation activities that do not generate direct income or immediate impact. Some farmers have replicated the technologies at their own initiatives.

6. Conclusion

With increasing population, it is necessary for the country to increase its crop production. This however, is a challenge because of the harsh conditions associated with the country's rugged terrain and constant competition from other sectors for the limited arable land and labour. Under such conditions, use of high yielding crop varieties and fertilizers are the only means to increase crop production. With the start of the planned development these inputs were made available in the country resulting in the farming practice to change. With the increase in production both in terms of quantity and variety, some farmers are able to grow not only for their own consumption but also for the market. However, most of the small, subsistence farmers cannot afford these conventional inputs. Often, the inputs are either not readily available or are not easily adopted especially by remote farmers. This could be a serious constrain in increasing the productions of food crops.

The rate of fertilizer application per hectare of cropped land has been increasing over the years. Higher rates of fertilizers are being applied in the regions where potato and apple are the main cash crops. With the increase in fertilizer distribution the gap between N and P,K has widened. This is mainly due to the popularity of urea and inadequate knowledge on the balance use of nutrients. This problem is being addressed especially at the extension level through on-farm trials, demonstrations and training.

Despite increased fertilizer distribution over the years, absolute levels of chemical fertilizer use are low compared to a global level. Therefore, the country can comfortably make use of fertilizers to increase its crop productions, at least for some-time to come. On the other hand, Bhutan could explore the benefits of organic farming, particularly in consideration of the growing lucrative markets for such products. Organic farming could be a viable option for Bhutan considering the following:

1. Majority of the farmers are small, subsistence farmers who cannot afford to invest heavily in agricultural inputs.
2. Limited scope for expansion of agricultural land due to the mountainous terrain and the government's policy to keep at least 60% forest cover.
3. At the commercial level, Bhutan cannot compete with its neighbouring countries like China, India and Bangladesh (with capacities for mass production) in an open market.
4. Bhutan has strong environment conservation policy and therefore it can exploit the benefits of having pristine environment.
5. Bhutan can exploit niche market for organic crops which can further be enhanced by the brand name "Bhutan".
6. Bhutan imports fertilizers and with time this could become an expensive affair.

With environmental protection as one of the guiding principles of the country's development programs, the intention is to minimize environmental degradation as far as possible, which would also mean keeping farming simple and free of excessive usage of chemicals. On the other hand, with increasing food price in recent times, use of inorganic fertilizers is necessary

to maintain or increase food production within the country. Therefore, to keep in line with the two objectives, Bhutan can neither make use of excessive inorganic fertilizers nor adopt a complete organic farming system. Therefore, soil fertility management in Bhutan will always be driven by the integrated use of plant nutrient sources i.e. organic and inorganic and this of course is the Best Management Practice.

References

Statistical Yearbook of Bhutan, (November 2007). National Statistics Bureau, Royal Government of Bhutan.

Commodity Chain Analysis, Rice, Maize and Potato, December 2007. Ministry of Agriculture, Royal Government of Bhutan and FAO – Netherlands Partnership Program (FNPP).

Investment Plan For Rice, Maize, Citrus and Potatoes, December 2007. Ministry of Agriculture, Royal Government of Bhutan and FAO – Netherlands Partnership Program (FNPP).

C. Norbu, (2007). Inorganic Fertilizer Distribution trend in Bhutan: After Privatization. Department of Agriculture, Ministry of Agriculture, Thimphu, Bhutan. (Unpublished).

I.C. Baillie, et. Al. (2004). Regolith and Soils in Bhutan, Eastern Himalayas. Bhutan Soil Survey, National Soil Servcies Centre, Ministry of Agriculture, Thimphu, Bhutan.

Facts and Figures of RNR Sector, 2003. Policy and Planning Division. Ministry of Agriculture. October 29, 2003.

Selected RNR Statistics, (2003). Policy and Planning Division. Ministry of Agriculture, Royal Government of Bhutan.

RNRRC Bajo and SSF&PNM Project, (April 2001). Management and Use of Farm Yard Manure in the Lingmutey Chhu Watershed: Results from a Household Survey. Department of Research and Development Services, Ministry of Agriculture.

Chencho Norbu and Christopher Floyd, (2001). Changing Soil Fertility Management in Bhutan: Effect on Practices, Nutrient Status and Sustainability. National Soil Services Centre, Ministry of Agriculture, Thimphu, Bhutan.

AF&SFM Survey, (1999/2000). Soil nutrient status and classes in Bhutan. SSF& PNM Project. National Soil Servcies Centre, Ministry of Agriculture, Thimphu Bhutan.