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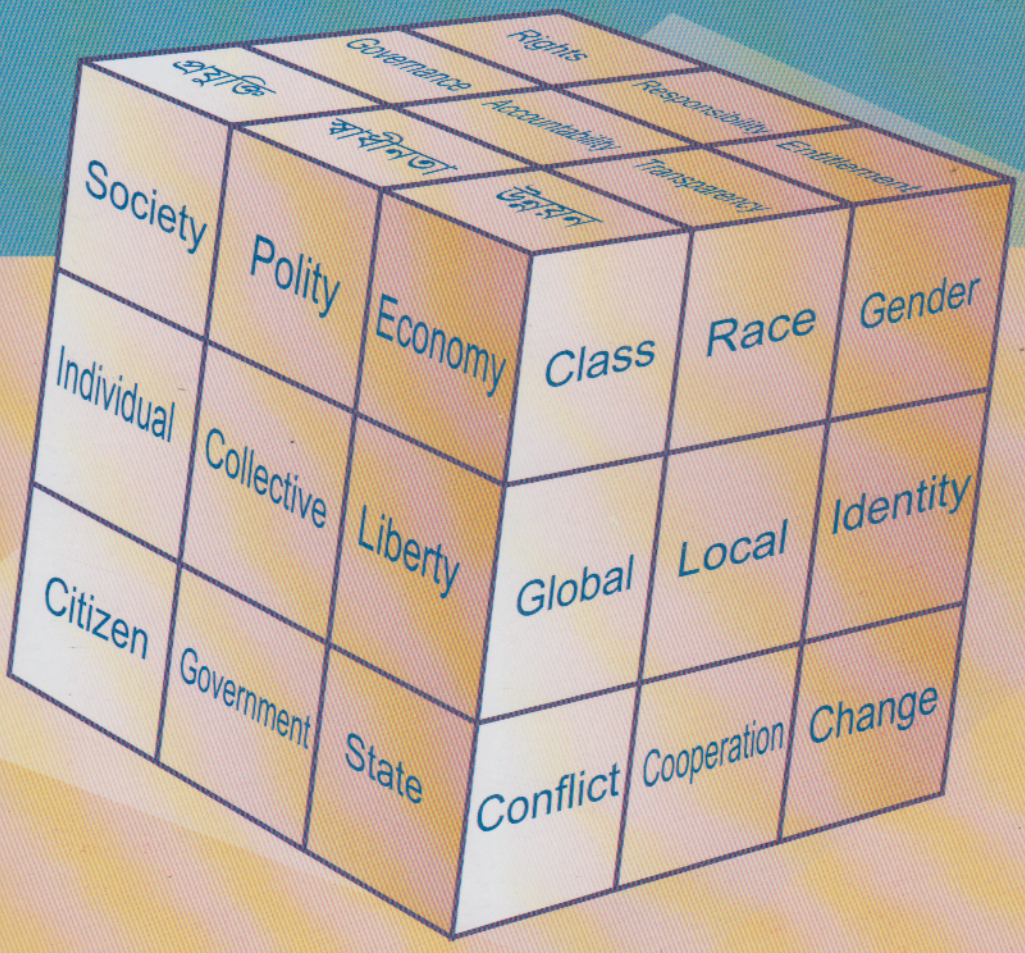

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A Long Run Perspective on Food Security and Sustainable Agriculture in South Asia

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This article provides a long run perspective on food security and sustainable agriculture in South Asia. The long run estimates, based upon the trends in agricultural production for the last 47 years (1961 – 2007), suggest that above 17 percent of total population in South Asia may face food insecurity by 2050 and 35 percent population by 2100 due to shortage of staple. The present study also reveals that food security situation might be more vulnerable due to climate change. Although, agricultural production has increased in the said period, the sustainability of such increased production remains questionable. The current study estimates that fertiliser application has increased 890 times during the period of 1975 to 2005 in Bangladesh. A simulation exercise using DSSAT finds that production increases when the application of urea (N: nitrogen) is 120 -180 kg per hectare. If the current use of 110 – 150 kg per hectare goes beyond that threshold level (180 kg per hectare), the production yield might decline. Soil fertility is decreasing due to use of huge amount of chemical fertilisers. This is not at par with sustainable conception of agriculture. Moreover, irrigation has mainly depended on the groundwater. The application of groundwater water has increased many times to augment production, causing increased salinity of soil and declined fertility of land. Besides, pesticide and herbicide are also used at a significant high rate. Furthermore, the average availability of agriculture land per person has also reduced by more than 50 percent during the period between 1961 and 2007.

Introduction

A direct relationship exists between the agriculture and the food security. The developing and least developed countries in South Asia are facing a major constraint to supply enough food to meet basic daily demand of their increasing population. Faster development of their agricultural sector has enabled the countries in South Asia to make some dent in food security through increased production. The agriculture sector in these countries is facing certain emergent challenges in addition to old ones. These include: decrease in arable land, fragmentation of land, over use of fertilisers, pesticides, and water, decline in soil fertility etc. Besides, climate changes in recent decades in the forms of natural calamities like droughts, floods, fluctuations in rainfall pattern, cyclones, and sea level rise also pose serious threat to production of agricultural produces. Therefore, these emerging conditions make the challenge of ensuring food security for all more acute.

The concept of food security has evolved over a period of time. Until the early 1970s, adequate availability of food grains at the national level was considered a measure of food security (Mittal and Sethi, 2009). In 1974, World Food Conference added another dimension to food security when it emphasized, apart from the overall availability, stability of food supplies within and over the years. The World Food Conference (1974) declared that every man, woman and child has inalienable right to be free from hunger and malnutrition (FAO, 1996). In 1983, Food and Agricultural Organization (FAO) expanded its concept and stated that food security was about "ensuring that all people at all times have both physical and economic access to the basic food that they need *(ibid.)*." Afterward, the

1996 World Food Summit redefined the concept of food security and included three main aspects - demand, vulnerability and nutritional aspects - into account. At the summit, countries agreed that food security would exist 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 (FAO, 1999). In 2002, FAO gave a functioning definition of food security for all countries. Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life (FAO, 2003). Therefore, at minimum, to achieve food security four components - availability, accessibility, stability and utilization - are needed.

Impacts of climate change on food production have been quantified in numerous studies under various sets of assumptions. For example, Basak (2009), Basak *et al.* (2009), Mahmood *et al.* (2003), Mahmood (1998), Karim *et al.* (1996) have carried out assessments on the impacts of climate change and variability on rice production in Bangladesh.

The present article provides a long run perspective on food security and sustainable agriculture in South Asia. The paper examines the current patter of agricultural production to investigate into the sustainability of such increased production. The research also analyses the potential effects of changing climatic condition and increasing population on food security in South Asian countries to identify the gap between demand and supply with regard to food security. The paper ends with some recommendations to achieve sustainable agricultural production in South Asia.

Agriculture in South Asia

Agriculture plays a pivotal role in the economies of these countries, despite its gradual decline of share in gross domestic product (GDP). Agriculture also claims a higher share in the total trade even in countries with lower share of agriculture to GDP (FAO, 1999). Within South Asia, value added of agriculture as percentage of GDP is highest in Afghanistan which is 36 percent while Sri-Lanka stands lowest and the countries in between are Bangladesh, Bhutan, India, Nepal and Pakistan. A comparative picture of agriculture growth rate in Bangladesh, Bhutan, India, Nepal, Pakistan and Sri-Lanka shows positive sign except for Maldives. Agriculture is the main occupation of the people of South Asian countries. Nepal occupies the top in terms of employment in agricultural sector. India accounts for next position of employment in agriculture, followed by Pakistan, Sri-Lanka, and Maldives, respectively (Table – 1).

Table 1: Status of Agriculture Sector in South Asia

Countries	Value added as % of GDP in agriculture, 2006	Agriculture growth rate (Annual % growth, 2006)	Employment in agriculture (% of total employment)
Afghanistan	36	-	-
Bangladesh	20	4.94	51.70 (2003)
Bhutan	22	1.67	-
India	18	2.68	52.00 (2007)
Maldives	--	-0.65	17.30 (2003)
Nepal	34	1.19	66.40 (2001)
Pakistan	19	1.58	43.00 (2005)
Sri-Lanka	16	4.71	33.50 (2004)

Source: World Development Indicators (WDI), 2008

It is observed that agriculture GDP of South Asian countries gradually decreased (Table – 2). As regards changes in the share of GDP share, during the period between 1990-92 and 1995-97, the highest change occurred in Nepal which was 7.15 percent and the most declining situation was observed in Bhutan (7.59 percent) during the period

between 1995-97 and 2003-05. The decline is mainly for high rate of population growth, high concentration of poor households, labour migration to the non-agricultural sector, low per capita income, etc.

Table 2: Change of Share of Agriculture Sector in GDP

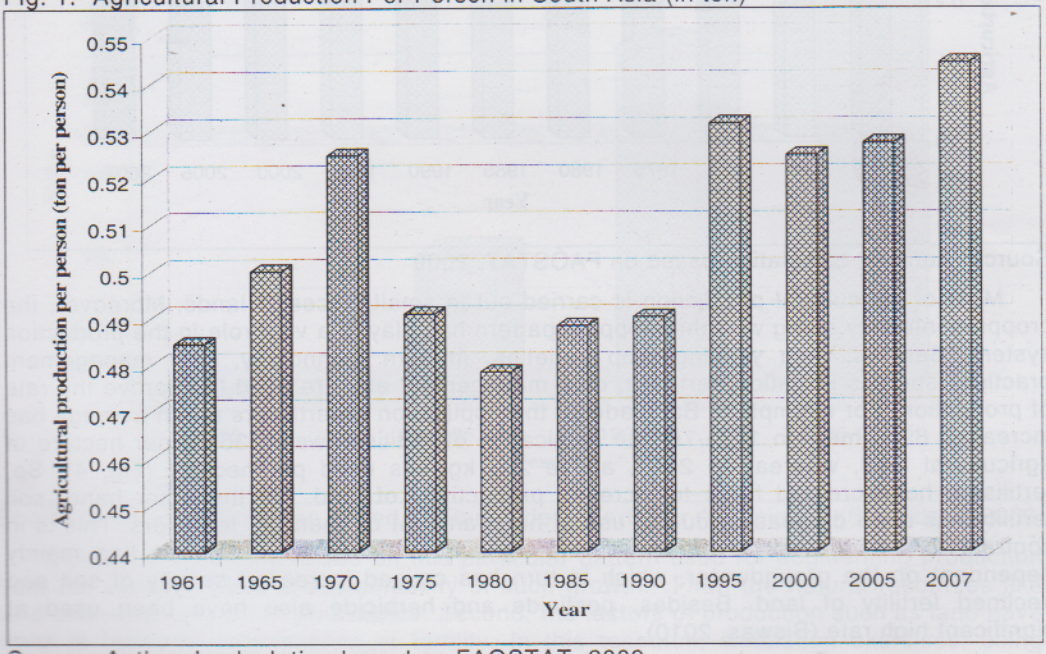
Countries	% Share of agriculture in GDP		
	1990-92	1995-97	2003-05
Afghanistan	-	-	40.61
Bangladesh	30.00	25.95	20.98
Bhutan	35.38	32.52	24.93
India	29.31	26.66	19.34
Maldives	-	-	-
Nepal	48.72	41.57	36.36
Pakistan	26.03	26.11	22.34
Sri-Lanka	26.31	22.44	18.04

Source: FAO, 2009 and WDI, 2008

Agricultural Production, Land and Population in South Asia

All agricultural products directly or indirectly contribute towards food security. For example, jute, wool, etc. do not provide food directly but indirectly those crops provide food security by supplying money to access food. In this study, twenty agricultural crops are selected on the basis of ranking in production to understand the pattern of growth in production. Moreover, agricultural land and population also play vital roles in determining whole production system and food security of a country. Therefore, it is necessary to examine the changing patterns of production along with the land and population. Land and production data for the last 47 years are collected from the Food and Agricultural Organization (FAOSTAT, 2009).

Fig. 1: Agricultural Production Per Person in South Asia (in ton)

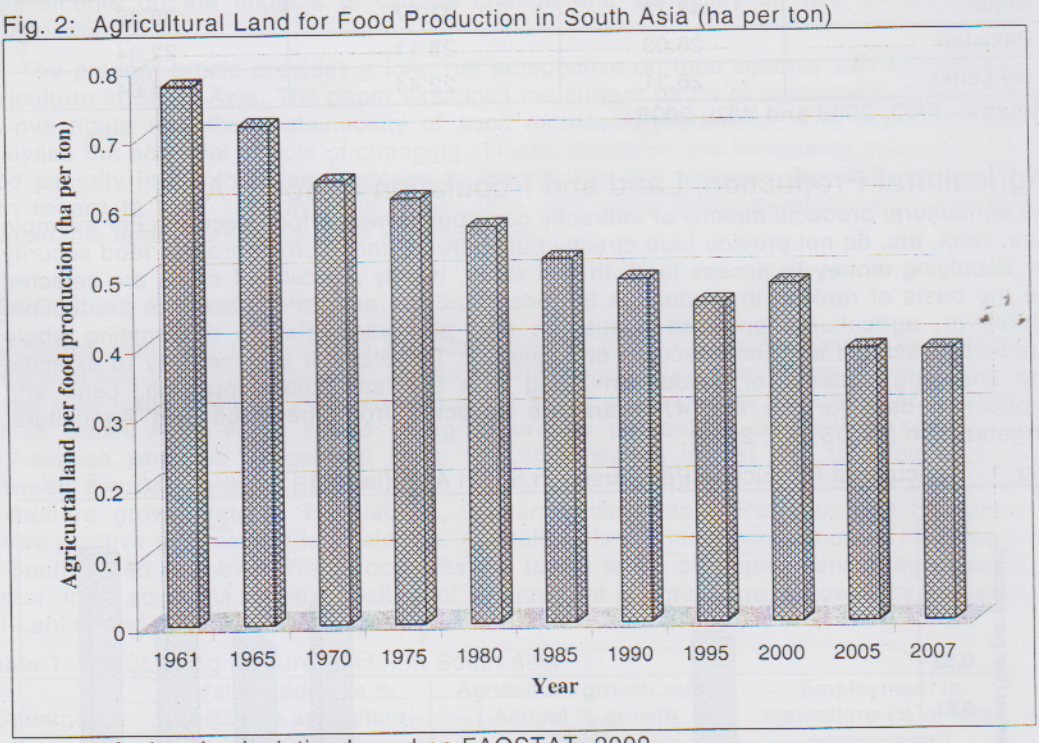


Source: Authors' calculation based on FAOSTAT, 2009

A trend analysis of the last 47 years (1961 – 2007) suggests that agricultural production per person is gradually increasing and in 2007, it reached 0.544 tons per person. After 1985, food production increased at a significant rate, primarily due to applications of high yielding crop varieties, modern technology, new management practices (Fig.1).

The increased production might be assumed as one of good indicators for food security in South Asia, but its future sustainability is plagued with questions. The availability of agricultural land for food production is continuously decreasing and it has reduced by two folds in the last 47 years from 0.45 ha in 1961 to 0.21 ha in 2007. The production has increased as the farmers have used input at a higher rate on the same piece of land to keep pace with the level of production. For example, it is found that in 1961 one metric ton of food was produced from 0.75 ha of land, whereas the same production was achieved in 2007 from the land below 0.4 ha (Fig. 2).

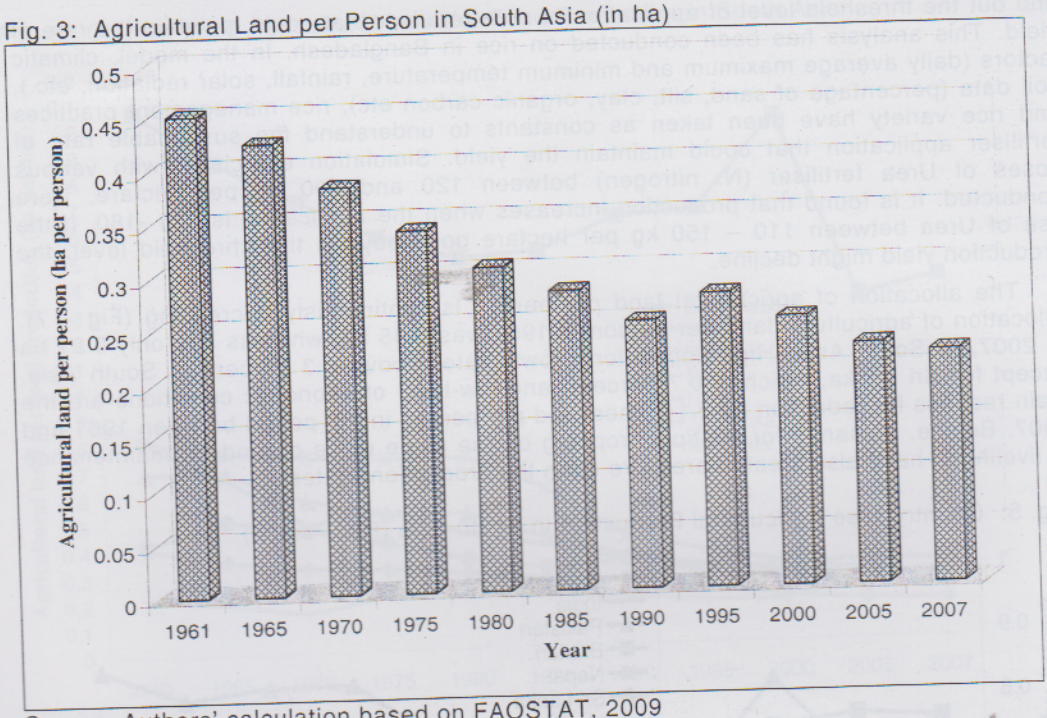
Fig. 2: Agricultural Land for Food Production in South Asia (ha per ton)



Source: Authors' calculation based on FAOSTAT, 2009

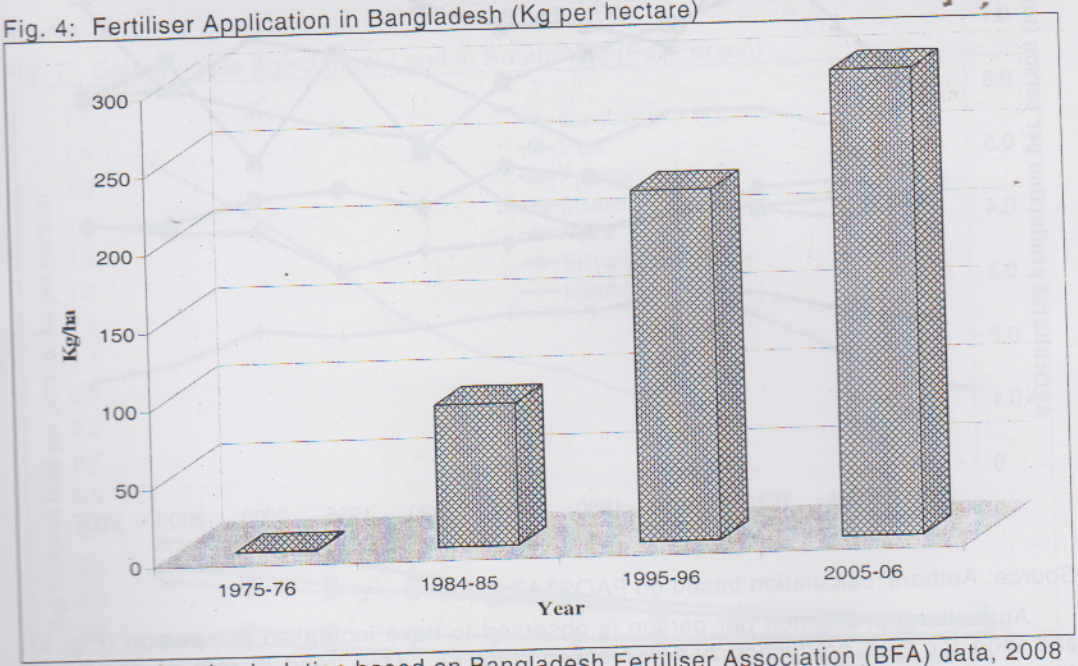
Most of agricultural production is carried out in small pieces of lands. Moreover, the cropping intensity along with the cropping pattern has played a vital role in the production system. Besides, high yielding crop varieties, modern technology, new management practices such as irrigation, fertiliser, crop management etc, are used to improve the rate of production. For example in Bangladesh, the application of fertilisers on an average has increased 890 times. In 1975-76, the application of fertilises was 0.36 kg per hectare of agricultural land, whereas in 2007, above 298 kg was used per hectare (Fig. 4). So, fertilisers have created force to increase productivity of land. On the other hand, soil fertility has been decreasing due to use of huge amount of chemical fertilisers. This is in contrast to the conception of sustainable agriculture. Moreover, irrigation has mainly dependent on the groundwater, which in turn has caused increased salinity of soil and declined fertility of land. Besides, pesticide and herbicide also have been used at significant high rate (Biswas, 2010).

Fig. 3: Agricultural Land per Person in South Asia (in ha)



Source: Authors' calculation based on FAOSTAT, 2009

Fig. 4: Fertiliser Application in Bangladesh (Kg per hectare)



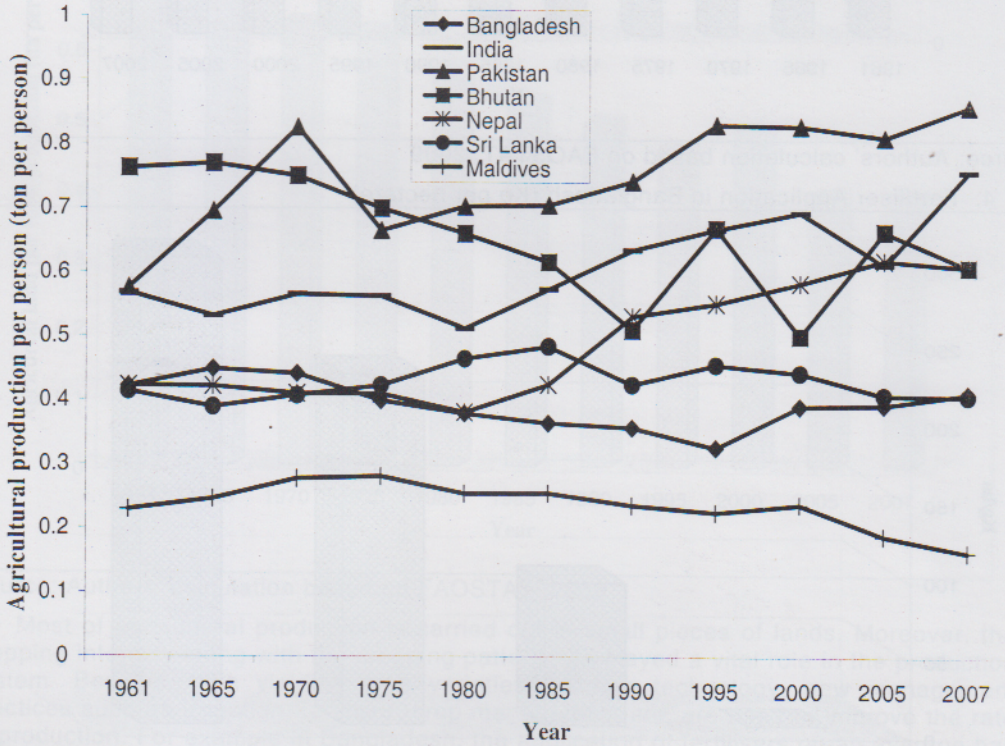
Source: Authors' calculation based on Bangladesh Fertiliser Association (BFA) data, 2008

Questions are being raised on this particular pattern used for augmenting production from the vantage point of sustainability of such growth. First, the natural resources like land and water are not in abundance. Second, the factors of production such as land have limits in terms of maintenance of fertility. In this research, simulation exercises, using Decision Support System for Agrotechnology Transfer (DSSAT), have been conducted to

find out the threshold level of application of urea fertiliser that could maintain the rate of yield. This analysis has been conducted on rice in Bangladesh. In the model, climatic factors (daily average maximum and minimum temperature, rainfall, solar radiation, etc.), soil data (percentage of sand, silt, clay, organic carbon etc), rice management practices and rice variety have been taken as constants to understand the sustainable rate of fertiliser application that could maintain the yield. Simulation exercises, with various doses of Urea fertiliser (N: nitrogen) between 120 and 200 kg per hectare, were conducted. It is found that production increases when the application is 120 -180. If the use of Urea between 110 – 150 kg per hectare goes beyond that threshold level, the production yield might decline.

The allocation of agricultural land per person is continuously decreasing (Fig – 7). Allocation of agricultural land per person in 1961 was 0.45 ha, whereas it is only 0.21 ha in 2007, in South Asia. High population growth rate (above 1.3 percent in South Asia, except for Sri Lanka, which is 0.7 percent) and low-level of economic conditions are the main reasons for reduction by 2.14 times land per person in the period between 1961 and 2007. Beside, demands for multiple cropping on the same piece of land for maintenance of livelihood have also created pressure upon the production system.

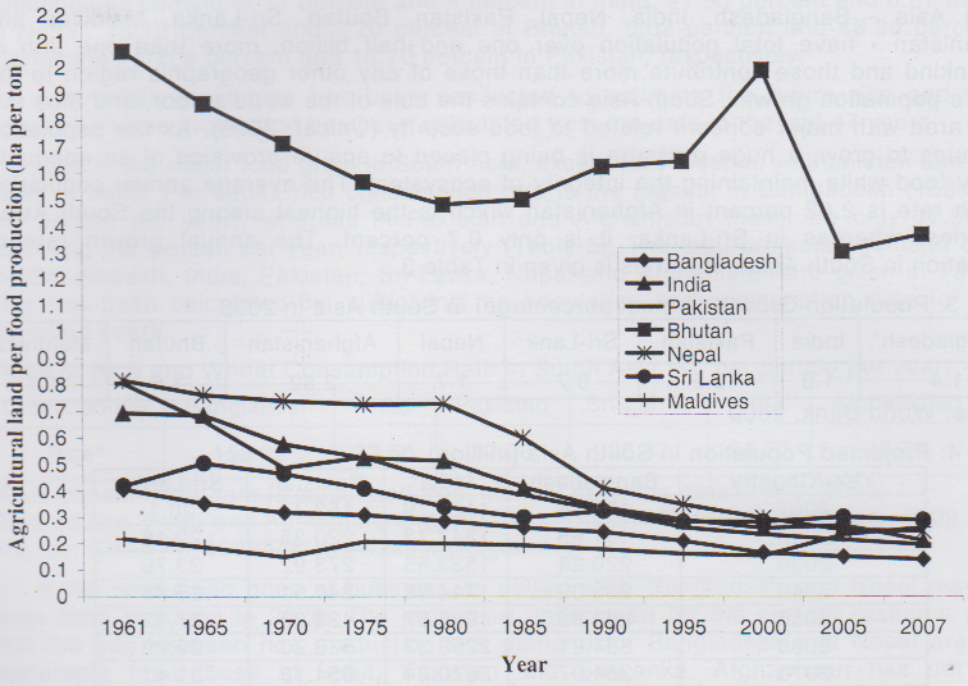
Fig. 5: Country-wise Agricultural Production in South Asia (Per Person)



Source: Authors' calculation based on FAOSTAT, 2009

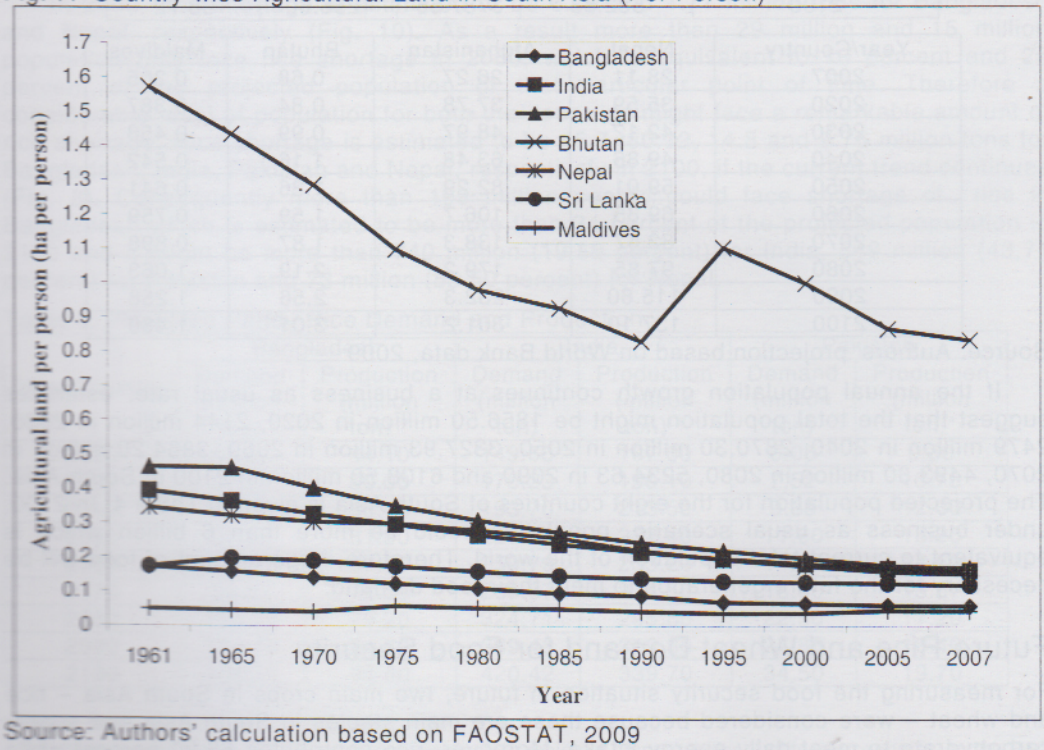
Agricultural production per person is observed to have increased per person (Fig. 5) and land for food production has decreased (Fig. 6). This trend in rate of decline is comparatively higher for India, Pakistan and Bhutan (Maldives is not comparable to the other countries, because the maximum agricultural production comes from the fisheries and other water related resources).

Fig. 6: Country-wise Agricultural Land for Food Production in South Asia



Source: Authors' calculation based on FAOSTAT, 2009

Fig. 7: Country-wise Agricultural Land in South Asia (Per Person)



Source: Authors' calculation based on FAOSTAT, 2009

Future Population in South Asia

South Asia - Bangladesh, India, Nepal, Pakistan, Bhutan, Sri-Lanka, Maldives and Afghanistan - have total population over one and half billion, more than one fifth of humankind and those contribute more than those of any other geographic region to the world's population growth. South Asia contains the bulk of the world's poor, and thus this is an area with major concern related to food security (Unicef, 2006). As the population continues to grow, a huge pressure is being placed to ensure provision of an adequate supply food while maintaining the integrity of ecosystem. The average annual population growth rate is 2.62 percent in Afghanistan which is the highest among the South Asian countries, whereas in Sri-Lanka, it is only 0.7 percent. The annual growth rate of population in South Asian countries is given in Table 3.

Table 3: Population Growth (annual percentage) in South Asia in 2008

Bangladesh	India	Pakistan	Sri-Lank	Nepal	Afghanistan	Bhutan	Maldives
1.4	1.3	2.2	0.7	1.7	2.62	1.6	1.7

Source: World Bank, 2009

Table 4: Projected Population in South Asia (million)

Year/Country	Bangladesh	India	Pakistan	Sri-Lanka
2007	157.75	1124.79	162.48	20.1
2020	191.65	1347.73	220.35	22.16
2030	220.24	1533.55	273.92	23.76
2040	253.09	1744.98	340.51	25.48
2050	290.83	1985.57	423.29	27.32
2060	334.21	2259.33	526.20	29.29
2070	384.07	2570.84	654.13	31.41
2080	441.35	2925.29	813.15	33.68
2090	507.18	3328.62	1010.80	36.11
2100	582.83	3787.55	1256.60	38.72

Year/Country	Nepal	Afghanistan	Bhutan	Maldives
2007	28.11	26.27	0.68	0.305
2020	35.59	37.78	0.84	0.387
2030	42.12	48.97	0.99	0.458
2040	49.86	63.48	1.16	0.542
2050	59.01	82.29	1.36	0.641
2060	69.85	106.7	1.59	0.759
2070	82.67	138.3	1.87	0.898
2080	97.85	179.2	2.19	1.063
2090	115.80	232.3	2.56	1.258
2100	137.10	301.2	3.01	1.489

Source: Authors' projection based on World Bank data, 2009

If the annual population growth continues at a business as usual rate, estimates suggest that the total population might be 1856.50 million in 2020, 2144 million in 2030, 2479 million in 2040, 2870.30 million in 2050, 3327.93 million in 2060, 3864.20 million in 2070, 4493.80 million in 2080, 5234.63 in 2090 and 6108.50 million in 2100 in South Asia. The projected population for the eight countries of South Asia is given in Table 4. In 2100, under business as usual scenario, population could be more than 6 billion which is equivalent to current total population of the world. Therefore, huge amount of food will be necessary for the future generation to meet their food demand.

Future Rice and Wheat Demand for Food Security

For measuring the food security situation in future, two main crops in South Asia – rice and wheat – were considered because these are main staples in South Asia and supply carbohydrate to meet daily energy intake. Moreover, rice contributes 66.20 percent while

wheat comprises of 1.62 percent of the major twenty crops in Bangladesh.[1] These two commodities constitute 17 percent and 9 percent in India, 21.55 percent and 8.87 percent in Nepal, 18.12 percent and 2.20 percent in Bhutan, 6.02 percent and 48.90 percent in Afghanistan and 6 percent and 16.70 percent in Pakistan, respectively.

A simulation exercise has been conducted to estimate the future rice and wheat demand. Future production has been calculated from the data of the last 47 years.

Rice is the major food grain in South Asia, except for Pakistan, Afghanistan and some parts of India. Per capita rice consumption rate is the highest in Bangladesh (153.03 Kg per person per year), whereas in Pakistan and Afghanistan these are only 17.96 and 16.70 Kg per person per year, respectively (Table-5). The total projected demand of rice for Bangladesh, India, Pakistan, Sri-Lanka, Nepal and Afghanistan are given in Table 6. This has been calculated by multiplying the population and consumption data for those specified years.

Table 5: Rice and Wheat Consumption Rate in South Asia (Kg per person per year)

Crop/Country	Bangladesh	India	Pakistan	Sri-Lanka	Nepal	Afghanistan
Rice*	153.02	72.56	17.96	96.37	88.72	16.70

*Rice consumption rate is calculated from the last 40 years data (1964 -2003).
Data source: Food and Agriculture Organization, FAOSTAT Update as of July, 2009.
Source: CIMMYT, 1998/99, (www.cimmyt.cgiar.org)

If the production goes at business as usual rates, Bangladesh and Nepal may face huge food shortage in 2020. The projection undertaken for the current research shows that the gap between rice production and demand for Bangladesh and Nepal are more vulnerable than those of India, Pakistan and Sri-Lanka. Afghanistan has not been considered as production significance level is below 90 percent and rice production and consumption data for Bhutan and Maldives for such long periods are not available.

In 2050, rice shortage is estimated to be 6.79 and 1.71 million tons for Bangladesh and Nepal, respectively (Fig. 10). As a result more than 29 million and 15 million population may face rice shortage in 2050, which is equivalent to 10 percent and 25 percent of the projected population of that particular point of time. Therefore a considerable level of population for both the countries might face a remarkable amount of rice shortage. Rice shortage is estimated to be 45.7, 80.72, 14.8 and 9.76 million tons for Bangladesh, India, Pakistan and Nepal, respectively in 2100, if the current trend continues (Fig. 8). Consequently more than 199 million people could face shortage of rice in Bangladesh which is estimated to be more than 34 percent of the projected population in 2100 and it might be more than 740 million (19.58 percent) for India, 549 million (43.71 percent) for Pakistan and 73 million (53.50 percent) for Nepal.

Table 6: Projected Paddy Rice Demand and Production

Year/Country	Bangladesh		India		Pakistan	
	Demand (million ton)	Production (million ton) *	Demand (million ton)	Production (million ton) *	Demand (million ton)	Production (million ton)*
2020	44.87	44.10	149.60	167.00	6.05	9.30
2030	51.56	50.00	170.23	190.10	7.52	10.75
2040	59.25	55.40	193.70	213.50	9.35	12.00
2050	68.09	61.30	220.40	232.40	11.60	13.20
2060	78.25	67.50	250.79	253.20	14.50	14.52
2070	89.92	72.30	285.37	274.50	18.00	15.57
2080	103.30	79.20	324.71	295.80	22.30	17.20
2090	118.70	84.70	369.48	319.80	27.80	18.40
2100	136.50	90.80	420.42	339.70	34.50	19.70

[1] This twenty crops have been used in this research to maintain comparability of different countries as the FAO time series is only available for these crops.

Year/Country	Sri-Lanka		Nepal		Afghanistan	
	Demand (million ton)	Production (million ton) *	Demand (million ton)	Demand (million ton)	Production (million ton) *	Demand (million ton)
2020	3.27	3.80	4.83	3.27	3.80	4.83
2030	3.50	4.30	5.72	3.50	4.30	5.72
2040	3.76	4.80	6.77	3.76	4.80	6.77
2050	4.03	5.30	8.01	4.03	5.30	8.01
2060	4.32	5.80	9.48	4.32	5.80	9.48
2070	4.63	6.30	11.20	4.63	6.30	11.20
2080	4.97	6.70	13.30	4.97	6.70	13.30
2090	5.33	7.30	15.70	5.33	7.30	15.70
2100	5.71	7.70	18.60	5.71	7.70	18.60

Source: Authors' calculation based on FAOSTAT and World Bank data, 2009
*: Level of significance above 90%; **: Level of significance below 90%

Table 7: Projected Wheat Demand and Production

Year/Country	Bangladesh		India		Pakistan	
	Demand (million ton)	Production (million ton) **	Demand (million ton)	Production (million ton) *	Demand (million ton)	Production (million ton) *
2020	4.55	1.68	97.52	98.10	30.46	26.00
2030	5.23	1.88	111.00	112.80	37.87	30.20
2040	6.01	2.08	126.30	130.20	47.07	34.10
2050	6.91	2.25	143.70	145.10	58.52	38.00
2060	7.94	2.45	163.50	159.60	72.74	42.00
2070	9.13	2.65	186.00	175.90	90.43	46.20
2080	10.50	2.83	211.70	191.00	112.40	50.40
2090	12.10	3.02	240.90	206.20	139.70	54.30
2100	13.80	3.25	274.10	232.20	173.70	58.20
Year/Country	Sri-Lanka		Nepal		Afghanistan	
	Demand (million ton)	Production (million ton) **	Demand (million ton)	Production (million ton) *	Demand (million ton)	Production (million ton) **
2020	1.24	0.011	1.69	1.71	7.34	2.80
2030	1.33	0.012	2.00	2.10	9.52	3.00
2040	1.43	0.012	2.37	2.35	12.30	3.20
2050	1.53	0.013	2.80	2.62	16.00	3.30
2060	1.65	0.014	3.32	2.93	20.70	3.40
2070	1.76	0.015	3.93	3.21	26.90	3.50
2080	1.89	0.016	4.65	3.52	34.80	3.60
2090	2.03	0.016	5.50	3.84	45.20	3.70
2100	2.17	0.017	6.51	4.20	58.60	3.80

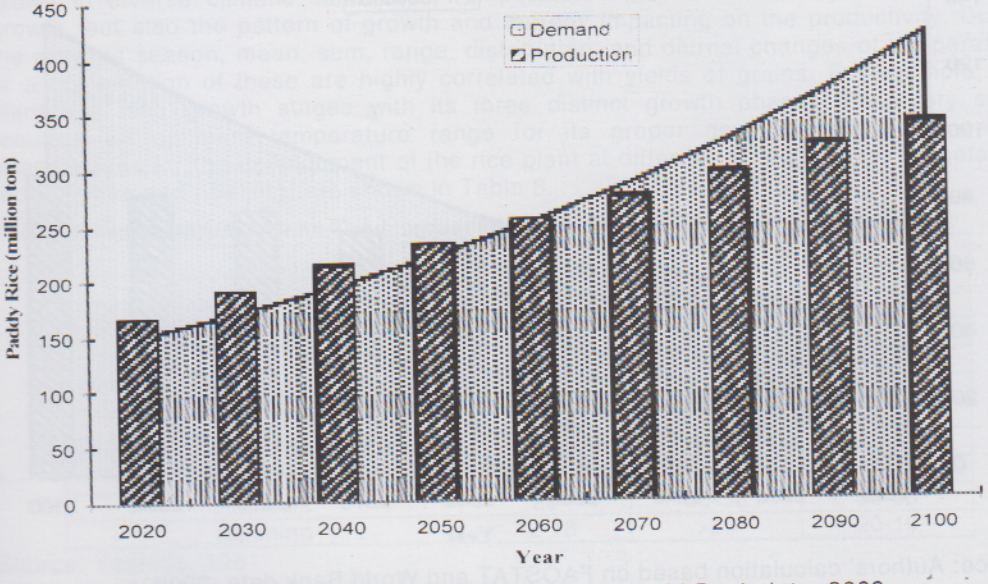
Source: Authors' calculation based on FAOSTAT and World Bank data, 2009
*: Level of significance above 90%; **: Level of significance below 90%

Wheat production involves a large area in South Asia where more than 100 million tons are produced annually on an average. The wheat producing countries are India, Pakistan, Afghanistan, Nepal and Bangladesh in the order of volume of production. The highest amount of wheat is produced in the Ganges and Nurmada basins of India and the Indus River Valley of Pakistan. India is one of the largest wheat producers in the world and consumption rate is 67 Kg per person per year. Afghans are the highest per capita wheat consumers (180 Kg per person per year) in South Asia, whereas average Bangladeshi consumes only 22 Kg in a year.

Based upon the data of wheat for last 47 years, a simulation exercise has been conducted for the current research. The projected situation is more susceptible in terms of wheat compared to that of rice production, if the business as usual situation persists

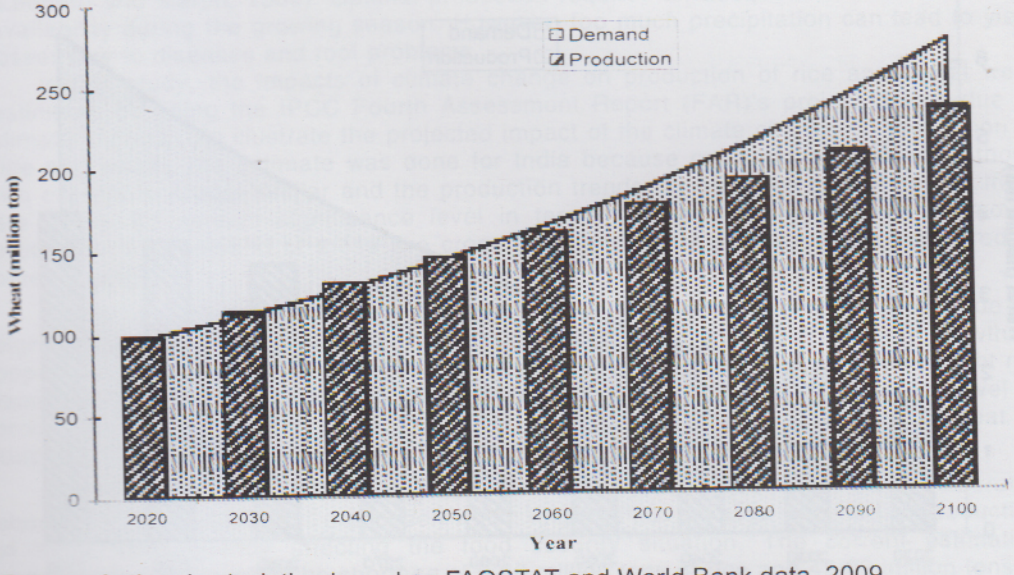
(Table - 7). The research estimates find a daunting challenge for Pakistan and Afghanistan in meeting future demand. Figure 9 and 11 show that the future wheat demands and supply for India and Nepal, respectively.

Fig. 8: Projected Rice Demand and Production in India (Year wise)



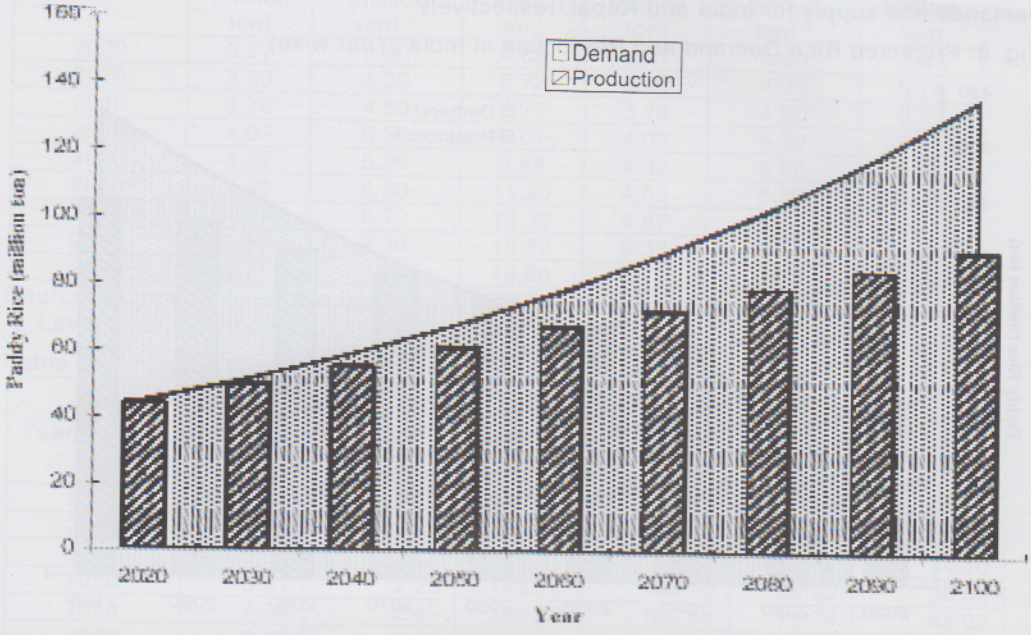
Source: Authors' calculation based on FAOSTAT and World Bank data, 2009

Fig. 9: Projected Wheat Demand and Production in India (Year wise)



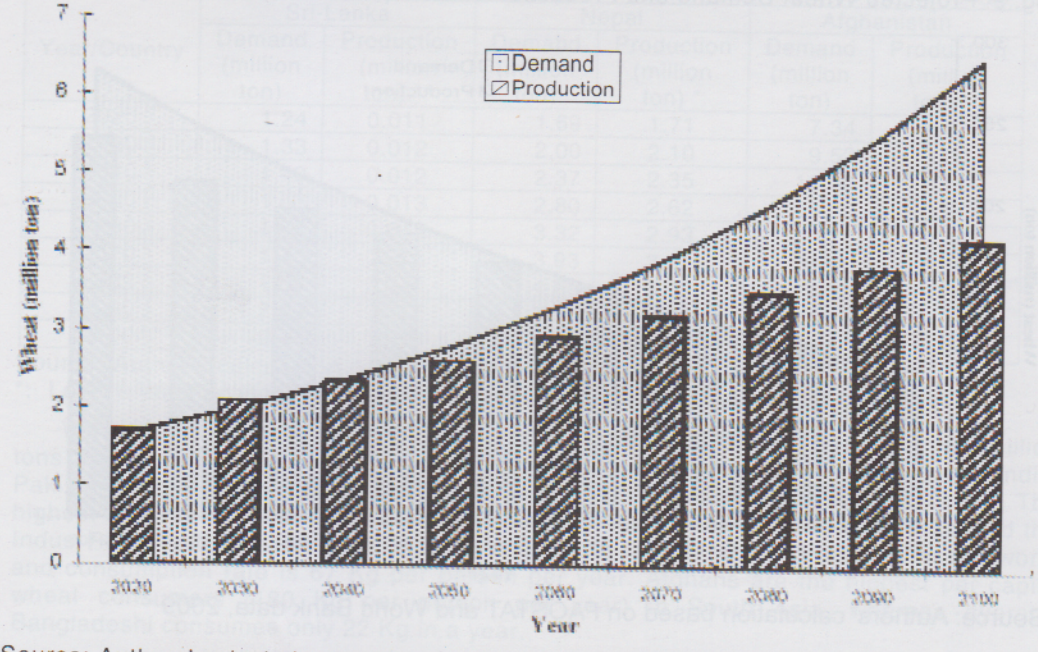
Source: Authors' calculation based on FAOSTAT and World Bank data, 2009

Fig. 10: Projected Rice Demand and Production in Bangladesh (Year wise)



Source: Authors' calculation based on FAOSTAT and World Bank data, 2009

Fig. 11: Projected Wheat Demand and Production in Nepal (Year wise)



Source: Authors' calculation based on FAOSTAT and World Bank data, 2009

Impacts of Climate Change on Food Production

Agriculture is one of the most sensitive sectors in terms of climate change (Cline, 2007), as it is affected by temperature, rainfall pattern and likelihood of extreme events such as droughts, floods, cyclones, salinity intrusion etc. Agricultural crops in South Asia are grown in diverse climatic conditions. Temperature influences not only the duration of growth, but also the pattern of growth and thereby impacting on the productivity. During the growing season, mean, sum, range, distribution, and diurnal changes of temperature, or a combination of these are highly correlated with yields of grains. For example, rice plant has nine growth stages with its three distinct growth phases and every stage requires an optimum temperature range for its proper development. The critical temperatures for the development of the rice plant at different growth phases (vegetative, reproductive and ripening) are shown in Table 8.

Table 8: Temperature for the Development of Rice plant at Different Growth Stages

Growth stages	Critical temperature (0C)		
	Low	High	Optimum
Germination	16-19	45	18-40
Seedling emergence	12	35	25-30
Rooting	16	35	25-28
Leaf elongation	7-12	45	31
Tillering	9-16	33	25-31
Initiation of panicle primordia	15	-	-
Panicle differentiation	15-20	30	-
Anthesis	22	35-36	30-33
Ripening	12-18	>30	20-19

Source: Yoshida, 1981

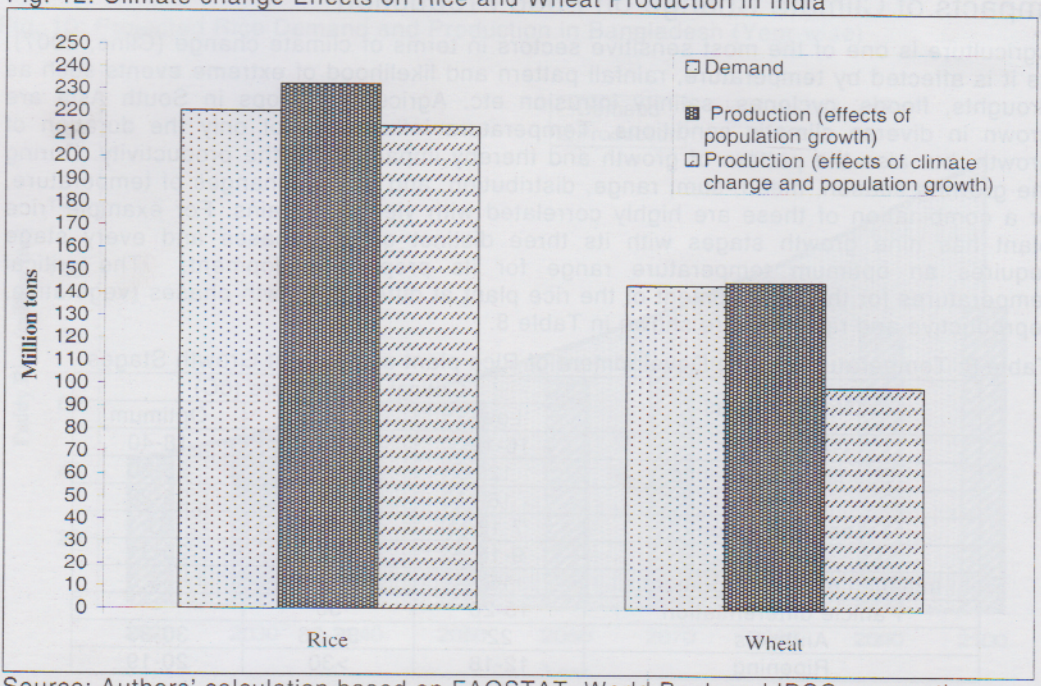
The optimum growing temperature for wheat is about 250C, with minimum and maximum growth temperatures of 30C to 40C and 300C to 320C, respectively (Briggle, 1980). It can be grown in locations with precipitation ranging from 250 to 1750 mm (Leonard and Martin, 1963). Optimal production requires an adequate source of moisture availability during the growing season. However, too much precipitation can lead to yield losses due to diseases and root problems.

In this study, the impacts of climate change on production of rice and wheat were estimated by using the IPCC Fourth Assessment Report (FAR)'s projected loss due to climate change. To illustrate the projected impact of the climate change on production of rice and wheat, the estimate was done for India because consumption pattern of those two cereals is almost similar and the production trends for both rice and wheat for India are above 90 percent significance level in terms of regression coefficient. Moreover production and demand of these two crops are significantly higher in India compared to other countries.

The IPCC FAR notes that the production of rice and wheat could fall worldwide by eight percent and 32 percent, respectively by 2050 (Easterling, 2007). If only growth of population is taken as the only variable, the previous analysis shows that India might not face rice and wheat shortage till 2050. Even, if India can maintain the current level of production, India might have about 12 million tons of rice and 1.4 million tons of wheat as surplus in 2050 (Table-9).

But when the climate change effects are considered, there might be considerable shortage of rice and wheat production which might affect the total agricultural production in India, consequently affecting the food security situation. The current estimation suggests that there might be shortage of 6.60 million tons of rice and 45.03 million tons of wheat in 2050. Consequently, rice shortage might affect more than 90 million and wheat shortage might affect 672 million people. Thus more than four percent of the projected population in 2050 might be affected in terms of rice while 33 percent could be affected in terms of wheat (Fig. 12). Similar results might happen for others South Asian countries.

Fig. 12: Climate change Effects on Rice and Wheat Production in India



Source: Authors' calculation based on FAOSTAT, World Bank and IPCC assumption

Table 9: Climate Change Effects on Rice and Wheat Production in India in 2050

Crop	Phenomenon	Demand (million tons)	Production (million tons)	Achievements /Shortage (million tons)
Rice	Effects of population growth	220.40	232.40	+12.00
	Effects of climate change and population growth	220.40	213.80	-6.60
Wheat	Effects of population growth	143.70	145.10	+1.40
	Effects of climate change and population growth	143.70	98.67	-45.03

Source: Calculation based on FAOSTAT, World Bank and IPCC assumption

Discussion and Conclusions

The food production has increased by creating huge pressure on agricultural land through higher doses of inputs and/or crop intensity. Applications of huge amount of ground water, pesticide, herbicide, chemical fertiliser are continuously increasing in the agricultural sector. But every agricultural input has a maximum limit to contribute to the production system. Therefore, if the current practise continues, the system might turn out to be unsustainable.

The study estimates that the population in South Asia could be above six billion in the end of the century. Therefore a huge amount of rice and wheat (the main cereal crops in South Asia) might be required to meet the demand and to avoid severe food shortage.

It is more important for the region to have a long term strategy to achieve food security for all. Food security in South Asia could be strengthened by increased national production of food, increased diversification of economy, increased employment and

income generating opportunities, and increased investment in this sector to achieve higher economic growth.

Increasing productivity through sustainable agricultural production practices requires new knowledge both to maintain yields and to improve the quality of production. This would imply substantial investments in agricultural research and outreach programmes to disseminate technology know-how, effective communication that improves farmers' access to market information.

Environmental conditions within all these countries are not the same. There are some heavy rainfall sub-regions, some are drought prone, some flood-plains and cyclone affected. This climatic variability is closely related with crop production. Therefore, development and use of temperature and drought tolerant crop varieties that can withstand the adverse efforts of climate change are important.

Certainly improved technology may assist in more effective management in agricultural sectors, but it can not produce an unlimited flow of those vital natural resources which are the raw materials for sustained agricultural production. For instance, fertilisers enhance the fertility of eroded soils, but human being cannot make topsoil. Indeed, fertilisers made from finite fossil fuels are presently being used to compensate for eroded topsoil. But this form of supplement for reduction in erosion of soil fertility is not sustainable. In this study it is found that the application of fertilisers in Bangladesh has increased on an average more than 850 times during the period of 1975 – 2005 (from 0.36 kg/ha in 1976 to 298 kg/ha in 2007). The huge application of chemical fertilisers creates extra pressure on the soil to increase productivity of the land, which is not sustainable for agriculture. Besides, the supply of ground water is not only used for agriculture but also for industry and public sector. Every year a huge amount of water is withdrawn from the ground for irrigation and other purposes, resulting in continuous lowering of ground water table. Therefore, an appropriate strategy is needed for use of surface water via construction and improvement of surface water bodies for supplying irrigation water and developing new surface irrigation related projects for sustaining agricultural sector.

Strategies for the future must be based first and foremost on the conservation and careful management of land, water, energy, and biological resources needed for food production. In that situation cropping pattern must be selected on the basis of available natural resources. For example, cropping pattern in most of the sub-regions in Bangladesh is rice based. Same types of crops are grown on the same piece of land, damaging the soil fertility. Therefore, there is a need for change in cropping pattern for improving health of soil to sustain agriculture. This calls for new strategy for conservation of land, water, energy, biological resources and productive environment in a sustainable way.

In this study it is found that the total population in South Asia, if adequate actions are not taken, may reach to the peak of 2870.30 million in 2050 and 6108.50 million in 2100. If agricultural production is not enough to meet the demand and associated food security related measures are not taken, a major part of population will be deprived from food and will remain hungry and undernourished. Policy support for agricultural research and development to develop and transfer appropriate and efficient technologies will be vital for the realization of such measures in ensuring sustainable crop production.

As the key drivers of climate change with high variances are still unfolding, it is difficult to predict what would be the exact situations in this region. Moreover, the lower investment in agriculture by the countries in South Asia largely undermines the needs of increasing agriculture production and supports for small and marginal farmers. Until this trend is changed, South Asia may face chronic food insecurity and hunger.

In this region one of the most common policy responses to food security is social protection system, mainly targeted at household level food insecurity. Though in some countries food security programmes have taken care of some aspects of household level income insecurity, there is an absence of comprehensive social security programmes.

At least theoretically, food security definition captures other policy areas linked with income and livelihoods security but there are still gaps to combine all these policy links together. Moreover, the existing policies are not being implemented effectively, which in turn is raising concerns on affordability and accessibility to food. During last few decades, dependence on food aid and food imports have increased. Due to changes of climate, this dependency may further increase and create more pressure on food stability. In this context, the issue of food security not only put the existing policies at questions but also requires a region wide comprehensive intervention and steps.

At South Asia level, the idea of food bank was initiated to combat food insecurity at any emergency situations. In last SAARC summit, there was an attempt to materialize this with the growing concerns of facing more natural hazards and global food instability. This initiative undoubtedly might foster the more regional cooperation.[2] However, proper infrastructure, location of storage etc. remain the main issues to be considered further.

Another important tool is to have effective local and regional market. The starting point for such integration is South Asia Free Trade Agreement (SAFTA), which has remained non-functional compared to those of ASEAN blocks. In terms of addressing the food security issue at a regional level, it is necessary to have a functioning trade pact that also respond to the level of economic development of each of the country. A recent experience of non availability of food from the global market as well as from within regional sources exhibits the urgency of such a trade deal within the region.

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[3] The joint projects would augment food production, invest in agriculture and related industries, conduct agricultural research, share technology, assist in procurement and distribution, as well as manage climatic and disease-related risks. The bank would hold 241,580 metric tonnes (MT) in rice and wheat reserves, contributed by each SAARC member, including Bangladesh (40,000MT), Bhutan (180MT), India (153,200MT), the Maldives (200MT), Nepal (4,000MT), Pakistan (40,000MT), and Sri Lanka (4,000MT). Afghanistan's share would be decided later. The reserves would remain the property of the individual member country and would be in addition to any national reserves. http://www.irinnews.org/report.aspx?ReportID=79689

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