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K.S. Kavi Kumar,
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Enamul Haque,
L. Venkatachelam
and
Girish Nath Bahal

MADRAS SCHOOL OF ECONOMICS
Gandhi Mandapam Road
Chennai 600 025
India

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K.S. Kavi Kumar
Madras School of Economics, Chennai, India
kavi@mse.ac.in; kavikumar@gmail.com

Kamal Karunagoda
Department of Agriculture, Perdaeniya, Sri Lanka

Enamul Haque
Economic Research Group, Dhaka, Bangladesh

L. Venkatachelam
Madras Institute of Development Studies, Chennai, India

and

Girish Nath Bahal
Global Development Network, New Delhi, India

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MADRAS SCHOOL OF ECONOMICS
Gandhi Mandapam Road
Chennai 600 025
India

Phone: 2230 0304/2230 0307/2235 2157
Fax : 2235 4847/2235 2155
Email : info@mse.ac.in
Website: www.mse.ac.in

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Abstract

Notwithstanding its impressive economic growth, food insecurity in South Asia continues to be a stark reality for a large number of households. Despite several successful policy interventions by Governments, the number of mal-nourished children and adults remain alarmingly high in the region – higher than those in Sub-Saharan Africa. Agriculture continues to be a very important livelihood option for a vast majority of rural population, even though the sector's contribution to the economy is shrinking. Against the backdrop of increasing divide between farm and non-farm income levels, this paper examines the potential long-term challenges that further aggravate the food insecurity in the region. Discussing the threats posed by changing demographic structure and urbanization, changing climate, increasing land and water scarcities for food production and food price volatility, the paper suggests several interventions could improve the food security situation in future. Among other things, the paper suggests strong emphasis on rice research; support for smallholder farmers for addressing risk and uncertainty and information deficit; improving agricultural and rural investment; land reforms; and women empowerment.

Keywords: *Food Security; Agriculture; Smallholder Farmers; Climate Change; South Asia*

JEL Codes: *Q16, Q18, Q54, R11*

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INTRODUCTION

The food insecurity in South Asia is discussed considerably in the academic and policy circles. As revealed by the Global Hunger Index (GHI), the hunger in South Asian region continues to be worrying with the region lagging behind the World average by more than two decades (von Grebmer et al., 2011). While almost all South Asian countries have high GHI scores, there are significant regional variations. India and Bangladesh continue to have relatively high GHI compared to Pakistan, Nepal and Sri Lanka. All the South Asian nations are highly dependent on agriculture as this sector continues to be an important source of livelihood for millions. While the share of agriculture in gross domestic product (GDP) is declining – from close to 30 percent in 1990 to about 20 percent in 2010, the employment share in agriculture continues to be high – with a slight decrease from 59.5 percent in 1990 to 53.5 percent in 2009. Given such high dependence on agriculture, attempts to address food security issues in South Asia should place greater emphasis on agricultural sector. Available evidence also suggests that for many developing countries greater focus on the agricultural sector will provide "the fastest and surest way out of poverty" for millions of people (ILO, 2005).

While a large number of factors affecting the food security have been identified in the literature, attempts to effectively address them met with only partial success as evidenced by continuing high food insecurity in many South Asian countries. Furthermore, with higher malnutrition levels than Africa, the South Asian Enigma in the context of food security is well known (Dev and Sharma, 2010). Thus, there is a 'deficit' in the current attempts to address food security problems in South Asia. However, new challenges continue to emerge that further threaten the food security situation. Critical questions that merit attention include, (i) what are the emerging stresses on South Asian food security from the agricultural perspective; (ii) what are the priority policy options specific to

South Asia for addressing some of the important long-term challenges to food security. This paper addresses these questions and implicitly also attempts to answer whether addressing the new and emerging challenges would be effective in the presence of 'deficit' in addressing present-day food security concerns and argues in favour of an integrated approach.

The paper is structured as follows: The next section provides an overview of the food security situation and rural livelihood options in South Asia. The following section discusses the long-term challenges to food security under five broad heads – climate change, demographic change, natural resource constraints, technology adoption and infrastructural constraints, and global food price volatility. Possible response strategies in addressing the present and future challenges are discussed in the next section. Finally, the last section concludes and summarizes the policy priorities for South Asia.

FOOD SECURITY AND RURAL LIVELIHOODS IN SOUTH ASIA: PRESENT STATUS

The Food and Agricultural Organization's expert consultation in 2002 provided a working definition for food security by stating that, '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, 2002). For operational purposes food security is broadly considered to consist of four key aspects: (i) food availability; (ii) food access – which captures an individual's ability to avail food; (iii) food utilization – which takes into account food preparation, storage and utilization, food safety, nutritional safety and dietary balance; and (iv) food vulnerability – which reflects the dynamic nature of the food security concept and assesses the vulnerability of population to food insecurity due to a variety of reasons including social and economic reasons. While indices such as GHI and

Food Security Index (constructed for the South Asian countries by Iqbal and Amjad (2011)) are helpful in getting an overview, the actual outcomes such as malnutrition often provide a more accurate picture. The following section provides a detailed discussion on extent and effects of malnutrition in South Asia.

Malnutrition in South Asia

Under nutrition is more than just access to food. Health, care and a health environment are equally necessary conditions for good nutrition. Young children, particularly in the first two years of their lives, are most vulnerable to becoming malnourished, and the consequences too are particularly serious at this time. Household income poverty may not be the most important constraint to the growth of an infant. Other capabilities, including those relating to health and care, are likely to be critical determinants. For such young children, human resources such as knowledge and time of caregivers are likely to be more important than income.

The most common measure of "malnutrition" is the anthropometric status of under-five-year-old children. A child's weight, height and age permit determination of the degree of underweight, stunting or wasting, and such measures are usually considered as proxies of "protein-energy malnutrition". Weight-for-age is the universally recognized summary indicator, albeit with the qualification that micronutrients as well as such macronutrients as energy and protein may affect child growth and hence the underweight measure. Protein-energy malnutrition is increasingly seen as potentially too restrictive a term when applied to the anthropometric status of a child. Wasting, or low weight for height, is usually the result of acute significant food shortage and/or disease. Stunting is defined as having a height (or length)-for-age more than two standard deviations below the median.

Many children are underweight or stunted because of inappropriate infant feeding and care practices, poor access to health services or poor sanitation. Under-nutrition's most damaging effect occurs during pregnancy and in the first two years of life. Nutrition programs have been low priority in the regional countries because malnutrition is often invisible and unawareness of the impact of malnutrition (death, disease and low intelligence). Malnutrition undermines economic growth and economic costs are substantial. Individuals lose lifetime earnings because of malnutrition and a country can lose income.

Though South Asia fares better than Sub-Saharan Africa in terms of various determinants of food security (viz., poverty, per-capita income, per-capita dietary energy supply etc.), it has a worse record in terms of outcomes such as malnutrition. Smith and Wiesmann (2007) report that close to half of the under-five children in South Asia suffer from underweight, while the figure in Sub-Saharan Africa is about 31percent. Percentage of underweight women is almost four times higher in South Asia compared to about 11 percent in Sub-Saharan Africa. According to the UNICEF, there are 24 developing countries with wasting rates of 10 per cent or more, indicating a serious problem urgently requiring a response and all the South Asian countries are belonging to this group. Of the five largest South Asian countries, the percentage of under-five children with underweight has decreased during 1990s to 2000s: Bangladesh - 65.8 percent to 21.6 percent; India – 61 percent to 43.5 percent; Nepal - 42.9 percent to 38.8 percent; Pakistan - 40.4 percent to 31.3 percent and Sri Lanka - 38.1 to 21.6 percent.

However, the improvement in percentage terms since the 1990s has only just kept pace with population growth and thus the absolute

number of underweight children has only dropped by a smaller percentage[1].

Stunting, or low height for age, is caused by long-term insufficient nutrient intake and frequent infections. Stunting generally occurs before age two, and effects are largely irreversible. These include delayed motor development, impaired cognitive function and poor school performance. Nearly half of the children less than five years of age in South Asia are stunted (see Table 1). Malnutrition has damaging physical and mental consequences for people, households and communities. It can reduce a person's productivity and a child's cognitive development. Ultimately malnutrition thus hinders the economic and human development of the region and the alarming situation in South Asia calls for immediate intervention. Within the South Asian region, Bangladesh, Nepal and Sri Lanka show a decline in the prevalence of undernourishment. By contrast, India, Pakistan and Maldives show not much change in prevalence of undernourished people. In fact, the number of under nourished people has increased in India, Maldives, Nepal and Pakistan over the period 1991 to 2007 (see Table 2).

After the introduction of Green Revolution technology in mid-1960s, the South Asian region had considerably enhanced its food production. The per-capita food production increased from 157.6 kg in 1971-73 to 176.3 kg by 1988-90. Correspondingly the per-capita food consumption also increased in the region. However, in comparison to other developing regions like North Africa and West Asia[2], the per-capita food consumption in South Asia remained stagnant even when the per-capita incomes registered impressive growth in recent times. These low levels of consumption contributed to the persistent hunger and

[1] The statistics are compiled from www.unicef.org country database.

[2] The per-capita food consumption in these regions during 2008-10 was 377.1 kg and 344.3 kg, respectively.

malnutrition in South Asia. Much of the discussion on future demand for food is based on lower normative values applicable to South Asia. However, if hunger and malnutrition are to be effectively addressed, higher normative per-capita consumption values applicable to other better performing developing countries must be adopted, which will substantially increase the future demand for food and hence will have implications for food security in the region.

Table 1: Malnutrition of Children: South Asia

Indicators	Bangladesh	Bhutan	India	Maldives	Nepal	Pakistan	Sri Lanka
Population (thousands), 2009, under 5	16463	70	126114	27	3505	24121	1784
percent of Infants with Low Birth Weight, 2005-2009	22	9	28	22	21	32	17
percent of Under-fives (2003 -2009) Suffering from Underweight, moderate & severe	41	14	43	26	39	31	21
percent of Under-fives (2003 -2009) Suffering from: Wasting, moderate & severe	17	3	20	13	13	14	15
percent of Under-fives (2003 -2009) Suffering from: Stunting, moderate & severe	43	48	48	32	49	42	17
percent of Population using Improved Drinking-water Sources 2008	80	92	88	91	88	90	90
percent of Population using Improved Sanitation Facilities 2008	53	65	31	98	31	45	91
Total Adult Literacy Rate (percent), 2005-2008	55	53	63	98	58	54	97

Source: Compiled from UNICEF Country Data-base, www.unicef.org .

Table 2: Under-nourished Population in South Asia

(in millions, and as proportion of total population in brackets)

Countries	1991	1996	2000	2007
Bangladesh	44.4 (38 percent)	54.2 (41 percent)	42.3 (30 percent)	41.4 (26 percent)
India	177 (20 percent)	167.1 (17 percent)	208.0 (20 percent)	224.6 (19 percent)
Maldives	0.0485 (9 percent)	0.0495 (9 percent)	0.05052 (8 percent)	0.0515 (10 percent)
Nepal	4.2 (21 percent)	4.4 (20 percent)	4.6 (18 percent)	4.7 (17 percent)
Pakistan	29.5 (25 percent)	26.8 (20 percent)	36.3 (24 percent)	42.8 (25 percent)
Sri Lanka	4.8 (28 percent)	4.5 (25 percent)	3.9 (20 percent)	3.9 (20 percent)

Source: World Bank (2011).

Rural Economies of South Asia

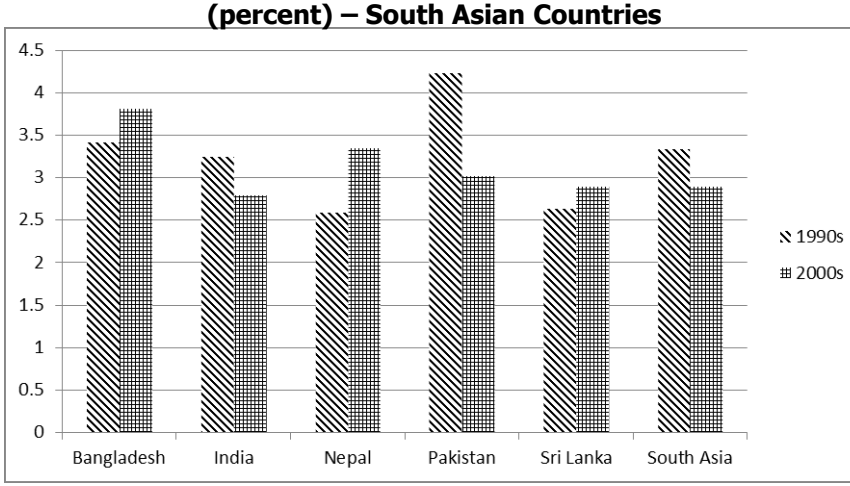
As shown in table 3, the South Asian economies are still predominantly rural in nature. With more than two thirds of the population living in the rural areas, agricultural continues to be the main source of livelihoods for a large proportion of the work force. With the exception of Sri Lanka, nearly a third or more of the rural population in South Asian countries live below the poverty line. Share of agriculture in gross domestic product (GDP) in South Asia has registered a declining trend – from close to 30 percent in 1990 to about 20 percent in 2010. The employment share in agriculture at the same time continues to be high – with a slight decrease from 59.5 percent in 1990 to 53.5 percent in 2009. Further, as shown in figure 1 the annual growth rate of value added in agriculture has registered decline in 2000s (compared to 1990s) in South Asia following the trend in India and Pakistan.

Table 3: Importance of Agriculture in South Asia

Countries	Rural Population (percent)		Employment in Agriculture (percent)		Share of Agriculture in GDP (percent)		Poverty Rate (rural; percent)	
	1981	2007	1981	2006	1981	2007	Early 1990s	2000 and After
Bangladesh	85	73	62	48	32	19	55.2	43.8
Nepal	94	83	90	60	61	34	43.3	34.6
Pakistan	72	64	53	43	31	21	33.4	35.9
Sri Lanka	81	85	47	32	28	12	27	7.9
India	77	71	69	55	34	18	37.3	30.2

Source: IGC (2010).

Figure 1: Annual Growth Rate of Agriculture Value Added (percent) – South Asian Countries



Features of Agriculture in South Asia Influencing Food Security

Declining Arable Land: As shown in table 4 arable land available for agriculture has registered significant decline in all South Asian countries (with the exception of Sri Lanka). The changes in per capita arable land would be serious a challenge to maintain food availability and decline in

availability may require consistent improvement of productivity. The South Asian countries have increased the productivity of all most all crops. Further, sustaining the growth in productivity will be a challenge for improving the food security.

Table 4: Availability of Per-capita Arable Land – South Asian Countries

Arable Land per capita (ha/person)	Bangladesh	Bhutan	India	Maldives	Nepal	Pakistan	Sri Lanka
1980/a	0.11	0.30	0.23	0.02	0.15	0.24	0.059
2010/b	0.054	0.18	0.13	0.01	0.08	0.12[@] (2008)	0.06
Ratio (b/a)*100	49.1	60.0	56.5	50.0	53.3	50.0	101.7

Note: [@] data for 2008; Source: World Bank (2011) .

Declining Productivity: Though the yields of major cereal crops – rice and wheat – continue to increase in South Asia, the annual growth rates are slowing. This has been established by careful micro level studies of wheat and rice yields in the Indo-Gangetic Plain (Murgai et al., 2001; Ladha et al., 2003) and in the irrigated rice growing states of India (Janaiah et al., 2005). The average annual growth rate of the yield of cereal crops in India declined significantly over the period 1981 to 2005 (Mittal and Sethi, 2009). The trend has not been unequivocal among other South Asian economies, but there are definite signs of decline in yield growth (see Table 5). In a comprehensive assessment of growth of total factor productivity and its contribution to production growth over the past three decades for several South Asian countries, Kumar et al. (2008) have analyzed major crops, major crop systems, and crop and livestock sectors. The study concluded that while encouraging total factor productivity growth in crop and livestock sectors has been observed for Pakistan and Bangladesh, increasingly more cases of deceleration in total factor productivity growth are being reported in India (except for the rice in eastern and southern states). These trends, if not reversed through

concerted efforts, could have serious adverse implications for food security in the region.

Table 5: Annual Growth Rate in Yield of Cereal Crops: South Asia

(in percent)

Countries	1981-85	1986-90	1991-95	1996-2000	2001-05
India	4.17	5.59	2.3	1.39	0.63
Bangladesh	2.77	4.33	-0.53	6.25	2.28
Pakistan	-1.41	0.15	2.26	4.14	3.98
Sri Lanka	2.58	-0.57	0.66	2.26	0.70
Nepal	1.38	5.92	0.73	2.57	1.91

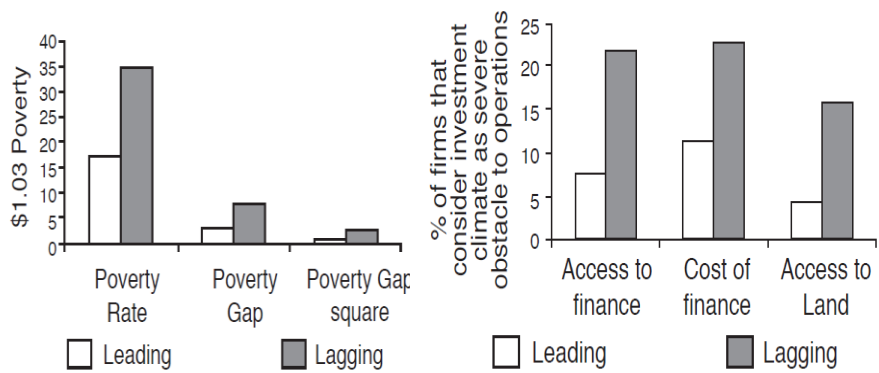
Source: Mittal and Sethi (2009).

Declining Agricultural Investment: Capital investments in agriculture are declining in South Asia and in fact are below the amount spent on agricultural subsidies. In India, for instance, while investment as a proportion of GDP has been rising since 1970s, agricultural investment as a share of total investment recorded fall since 1980s. Despite mild recovery between 1999-2000 and 2002-03, the agricultural investment continued its downward trend (Jha, 2007; Mitra, 2010). The declining investment in agriculture has resulted in substantial deficit in rural infrastructure in almost all South Asian economies. Agricultural subsidies on the other hand have been increasing since 1980s. These subsidies on power, fertilizer and irrigation had significant adverse impact in the form of soil damage, salinization, and lowering of water table, which in turn could have long-term implications for food production.

Leading vs Lagging Regions: The discussion at the country level masks wide regional differences at the sub-national level. As argued by Ghani (2010) the problmes of South Asia, including the food security issues, are concentrated in the lagging regions. Defining lagging region as one with per capita income below the national average, the study identifies for instance, Arunachal Pradesh, Assam, Bihar, Chhattisgarh,

Jharkhand, Madhya Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Orissa, Rajasthan, Tripura, Uttar Pradesh, Uttarakhand and West Bengal as lagging regions in India. Similarly, in Pakistan, NWFP and Balochistan are considered as lagging regions. In Bangladesh, barring Dhaka other regions are considered as lagging. In Sri Lanka, Central, Eastern, North-Central, North-Western, Northern, Sabaraga-muwa, Southern, and Uva are lagging regions. In Nepal, Eastern region, the Far-Western region and Mid-Western region are lagging regions. It is argued that while the economic mass is concentrated in the leading regions, the poverty mass is concentrated in the lagging regions of South Asia. Figure 2 shows the contrast between the lagging and leading regions of South Asia for a few indicators. The leading-lagging regions differentiation is partly due to continuing large gaps in crop producitivity across regions. For instance in India, the states with high worker productivity in general have substaintially higher crop yields (for rice, wheat, maize and cotton) compared to states with low worker productivity (IGC, 2010), suggesting the need for raising farm worker productivity to bring parity between leading and lagging regions.

Figure 2: Contrast Between Lagging and Leading Regions of South Asia



Source: Ghani (2010).

***Small Holder Agriculture**:* Table 6 shows changes in average farm size and number of small farms (under 2 hectare) across some of the South Asian countries. With declining share of agriculture in overall GDP at a rate faster than the share of labour force in agriculture, the income gaps between the agricultural and non-agricultural sectors have widened in South Asia. Thus there are too many small farms of low viability and too many workers associated with agriculture to provide income parity with non-agricultural workforce. The exit options from agriculture at the same time are not adequate in South Asia. In this context the small farms with their inherent inability to diversify significantly into high-value farming may have little chance of making sufficient income from farming activities. At the same time, evidence of inverse relationship between farm size and productivity is a powerful rationale for land reform policies that include land redistribution for both efficiency and equity gains[3]. Thus, smallholder farming in South Asia poses challenges as well as provides opportunities for food security in the region.

Table 6: Average Farm Size and Small Farms in South Asia

Countries	Census Year	Average Farm Size (ha)	Number of Small Farms (millions)
Bangladesh	1960	1.70	
	1996	0.68	17.800
India	1971	2.30	49.114
	1995-96	1.40	92.822
Nepal	1992	1.00	2.407
	2002	0.80	3.083
Pakistan	1971-73	5.30	1.059
	2000	3.10	3.814

Note: The definition of small farms varies from country to country.
Source: Hazell (2008).

[3] See Mitra (2010) for a detailed discussion on the puzzle of inverse relationship between farm size and productivity.

2.3 Food Security Policies in South Asia

Household food insecurity arises often due to inability of the households to purchase food and/or have access to food. Recognizing this most countries of the South Asia have initiated income based or employment generating programs along with price control and distributive measures. Some countries have direct cash transfers also as part of their food security policies. A brief summary of some of the major programs across South Asian economies is given in Table 7.

Table 7: Food Security Policies in South Asia - Examples

Countries	Program	Target Population	Coverage and Implementation	Food Security Aspect
Bangladesh	Public Foodgrian Distribution System	Poorest population	Launched in 1975	Availability and Accessibility
India	Public Distribution System	Below poverty line population	To cover more than 330 million poor	Accessibility and Vulnerability
	National Food for Work Program	Rural people who are in need of wage employment	Most backward districts; launched in 2000	Accessibility
	National Rural Employment Guarantee Act	Rural semi or unskilled workers below poverty line	Launched in 2005	Accessibility and Vulnerability
	Mid-day Meal Scheme	Students of primary schools	Launched in 1995; covers students in class I to V	Utilization
	Integrated Child Development Scheme	Children and pregnant women	Launched in 1975	Utilization
Nepal	Nepal Food Corporation	People in hill and mountain areas	Launched in 1974	Accessibility and Vulnerability
Sri Lanka	Samurdhi Program	People below poverty line	Started in 1995	Accessibility
	School Mid-day Meal Program	School children	Started in2004	Utilization and Vulnerability

Note: No specific food security program in Pakistan, but many food laws.
Source: Mittal and Sethi (2009).

In addition to the above, other policy prescriptions addressing food security concerns in South Asia that target agricultural sector as well as rural sector in general include increasing productivity, development and improvement of rural infrastructure, decentralization, access to financial resources, women empowerment, good governance, and human development and capacity building. In the light of some of the emerging challenges to food security discussed in the next section many of these policy prescriptions remain relevant. The next two sections discuss the challenges and the responses in the context of food security in South Asia focusing largely on agricultural sector.

EMERGING STRESSES TO FOOD SECURITY IN SOUTH ASIA

Looking from the perspective of the agricultural sector, several potential challenges to the food systems now and in the foreseeable future have been identified in the literature (see, Pinstrup-Andersen and Watson, 2011 for a comprehensive discussion). This section discusses a few of these challenges considered relevant in the South Asian context.

Demographic Changes

Urbanization is considered as natural and inevitable consequence of economic development (Henderson, 2003). Despite significant economic growth in countries like India, the urbanization in South Asia has been fairly slow doubling in roughly sixty years from 15.6 percent in 1950 to about 30 percent in 2010. The developing countries as a whole witnessed a much sharper rise from 18 to 46 percent during the same period, propelled largely by the urbanization in the Latin American and the Caribbean countries. Table 8 shows the trends in urbanization in South Asia for the period 1950 to 2030 based on UN population projections. There are significant regional differences in South Asia, with Pakistan being the most urbanized country and Nepal, Sri Lanka and Bhutan being the least urbanized. Some studies contend that urbanization in Pakistan is even higher than the statistics reveal as the socio-economic-demographic

changes have blurred the rural-urban divide (Cheema et al., 2006). Another interesting feature of the urbanization in South Asia is that about 60 percent of the urban population growth is attributed to the natural growth and the remaining to the rural-urban migration. Ozden and Swadeh (2010) observe that despite large potential gains, the migration in South Asia is paradoxically low. Through an analysis based on India they argue that socio-cultural and policy induced barriers could be responsible for low rural-urban migration rates. While multiple languages could form part of socio-cultural barriers, the policy induced barriers could include state-specific welfare programs which are not accessible once a household migrates to different state.

One of the reasons for slow urbanization in India (and other South Asian countries) could be slow growth of agricultural productivity leading to inadequate release of agricultural laborer from rural areas. Also, India's industrialization has not been able to absorb unskilled and semi-skilled labor force resulting in too many laborers in the rural areas as mentioned in previous section.

Another feature of migration in South Asia is that the official statistics focusing on permanent migration often show higher migration rates among better off groups compared to the low income households (Deshingkar and Akter, 2009). Using National Sample Survey data from the 64th Round in India, figure 3 depicts the decile-wise incidence of short-term migrants. It can be seen that it is mainly rural male who are undertaking short term movements. Also for all the categories the incidence of migration is decreasing as decile class is increasing. This shows that persons with lower income undertake short-term migration as a livelihood strategy, as almost all short term migrants migrated for employment related reasons. The above discussion implies that there is no permanent employment option for most of these low-skilled laborers in the destination areas, which make them indulge in circular and seasonal movements. While detailed migration data from the latest

census for 2011 in India is not yet available Sainath (2011) notes that there has been a substantially high migration rate from the rural areas compared to the earlier inter-Census period attributed to a distress conditions in agriculture. The short-term as well as the distress driven migration would reflect vulnerable conditions of the food insecure people moving in search of livelihoods. Mitra (2010) points to another kind of migration that is often not discussed due to political and/or religious overtones – crossing of international borders. Indicating typical examples of such migration of Bangladeshi poor to Delhi and Jaipur in India, Mitra (2010) argues that such migration does not necessarily make them rich or food secure, but migrants perceive it to be a better situation. Of course, they also do not have return options due to difficult legal and economic conditions.

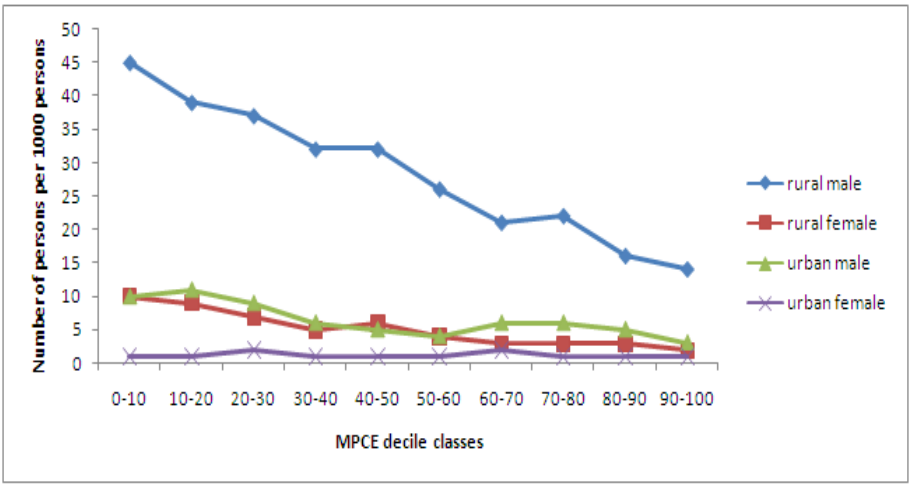
Table 8: Trends in Urbanization in South Asia, 1950-2030

(in percent of population)

Year	Bangladesh	India	Nepal	Pakistan	Sri Lanka	China	Less Developed Regions
1950	4.2	17.0	2.7	17.5	15.3	13.0	18.1
2010	27.3	30.1	18.2	37.0	15.1	44.9	45.5
2020	32.9	34.4	23.9	42.7	16.9	53.2	50.7
2030	39.9	40.7	30.6	49.8	21.4	60.3	56.1

Source: United Nations (2007).

Figure 3. Incidence of Short-term Migration by Income Decile: India, 2007-08



Source: NSS, 64th Round, 2007-08.

Returning back to the projected urban population in South Asia, table 8 shows that the region will be significantly more urbanized in the next 20 years or so with at least 30-40 percent population living in urban areas. The urban people consume high value food products in large quantities compared to their rural counterparts. Joshi et al. (2007) argued that the annual per capita cereal consumption has showed either a negative trend or marginal increase during 1990s in the South Asian countries[4], while the vegetable, fish, fruits and milk consumption have increased with a few exceptions possibly due to supply side constraints. The projections up to 2025 indicate that while the consumption of meat, eggs, fish, fruits and vegetables would increase by 90 to 100 percent, cereal consumption would increase only mildly in the South Asian countries. Given the dominance of small holder agriculture in these countries, diversification of these farmers to high value food products could be challenging without adequate policy support.

[4] In Sri Lanka, however, the per-capita cereal consumption has paradoxically increased.

Urbanization and aging of the population could also have adverse implications for the supply of agricultural labour. Labour scarcity caused by institutional and behavioral changes in rural areas is becoming a critical issue in South Asian agriculture. It emanates from various push and pull factors. The seasonal employment, irregular income, mechanization of agriculture, shrinking of agricultural activities, increasing level of education and improved quality of agricultural labourers are considered to 'push' people out of agriculture; on the other hand, increased employment opportunities in urban areas - especially in the booming construction industry, hotel industry, manufacturing, service sectors (such as, security service), engineering and motor industry and household sectors - do 'pull' the unskilled and semi-skilled labourers from rural areas to urban areas. For example, an unskilled labourer working in a construction industry in major cities like Chennai could earn an income which is four to five times greater than the income she could earn in agriculture. Unlike in agriculture, she gets regular employment throughout the year. Even though migrated labourers experience problems such as, inadequate housing and poor water supply and sanitation facilities in urban areas, they are still better-off with more savings, more resources to buy assets back in their villages and more opportunities to get their children educated well. The 'social networking' established between the non-migrated people and the already migrated ones fasten the rural to urban migration process.

The Government's 'welfare schemes' also cause increased labour scarcity in agriculture. For example, it is claimed that the free-rice scheme being implemented under the universal public distribution system in several states of India is not only ensuring food security for poor but also causing labour market distortions in rural areas. The landless households who once depended on the agricultural work for meeting their food requirement are no longer bound to do so, since the free-rice scheme helps them to meet with such requirement. In addition, rapid social changes taking place in rural areas also contribute to intensify

labour scarcity. For example, traditionally the landless and lower caste communities were instrumental in assisting land-owning communities to carry out agricultural operations successfully. While the male member of a landless/lower caste household would take care all on-farm activities, such as, ploughing, policing, harvesting, etc., the female member would take care of activities such as, cleaning the cattle shed, processing food-grains and cooking food for labourers working in the field; the male children will be responsible for maintaining cattle. In recent years, improvements in educational status and political awareness of especially the lower caste people helped them to disentangle themselves from their landlords as well as from agriculture activities. The ever increasing scarcity of labour, improvements in the bargaining power of the agricultural labourers, increased agricultural wages and reduced working hours make the agricultural situation worse-off. Rapid urbanization of rural areas and large scale rural to urban migration increase the demand for food while affecting the supply in the country side. Box 1 provides some evidence in Indian context of increasing labour scarcity.

Box 1: Tightening Rural Labour Markets in India – Causes and Concerns

Tightening rural labor markets are an indication of an incipient turning point in a classic dual sector development framework. There are several indications that rural labor markets are tightening in India. Data from NSS surveys indicates rise in rural wages for both men and women. This rise in wages is viewed positively by many for its capacity to reduce rural poverty. But there are also concerns from farmers and the industry who feel the pinch of higher labor costs. Rising wages also has the potential to affect agricultural practices, food production and prices.

There is abundant anecdotal evidence from the field confirming the tightening of the rural labor markets. But analytical evidences is scarce except for a very few studies that model the effect of the National Rural Employment Guarantee Scheme (NREGS) on labor markets. While the Employment Guarantee Scheme (EGS) undoubtedly plays a huge role in shaping the contours of labor markets, several other factors are important too. These include better functioning welfare schemes, food subsidy schemes, increased government expenditure and private investment.

An EGS program affects labor markets by increasing the bargaining strength of workers and raising reservation wages. A few analytical papers model the effects of the NREGS on labor market equilibria. Basu et al. (2009) models these effects theoretically by focusing on distributional concerns, market power, need for public works etc. Sharma (2009) used data two years before and after the initiation of the NREGS and finds that the program increased nominal wages, but aggregate price levels also rose during that time, due to which there were no real gains. Imbert and Papp (2012) use a difference-in-difference approach, exploiting the phased roll out of the program and find that NREGS has increased unskilled worker wage rate and labor force participation. The effect of an EGS could potentially be local, only affecting the market in a village where it is functional or it might affect the entire district, state or country by curtailing out-migration. States like Bihar that are typically sources of low-cost labor, supply less labor now to the rest of the country. This process is ongoing at tangible level and has mixed implications.

Recent positive economic changes in the country may also be driving many of these phenomena. States like Bihar have seen holistic development and urban growth as well as higher government and private investment in the last few years. These developments have curtailed distress driven out-migration from Bihar. A recent study by the non-governmental body, Bihar Institute of Economic Studies estimates a 26.53 per cent fall in out-migration of unskilled workers in 2006-08 as compared to that in 2001-03 (Times of India, 2011). This obviously impacts the availability of low-cost labor for the rest of the states.

Labor shortages and rising wages in the rural sector exists with different intensities in several states affecting both agricultural and non-agricultural sectors. Farmers and industry have responded to this shortage by proposing to curtail or stop NREGS during the agricultural peak season, when the demand for labor in agriculture and seasonal industries are high. They also suggest including agriculture (more extensively than what it is now) and industrial work under NREGS so that private employment is not crowded out.

There is a widespread concern that a rise in rural wages may affect food production and increase food prices. A natural response by farmers to rising wage costs may be to opt out of agriculture or diversify their occupational portfolio. This is already happening at a certain level. But interestingly, Indian agriculture is resorting to mechanization and using higher level of pesticide/weedicide to counter high wages. Again, there is no official data or any rigorous study of these changes in agriculture.

Food security concerns arise if wages increase at a rate higher than the rate of adaptation of machinery and other newer forms of agricultural practices. This adaptation rate is in turn based on the prices of these machines and equipments, their substitutability for labor and their physical accessibility. The markets for machinery, pesticides and weedicides etc. may also respond to these changes, resulting in an increase in the prices of these inputs, an improvement in their technology and an increase in their availability. The tractor industry in India is a good example to illustrate such input market dynamics. A few companies like Mahindra and Mahindra and Deere and Company have already begun to make newer investments in technology and started expansions.

In summary, the overall effect of the tightening of rural labor markets and higher wages on food production and prices are too early to predict. The landscape of Indian agriculture will certainly be affected as a consequence.

Compiled by Vidhya S. and Tanvi Rao, Columbia University

Climate Change

The global climate change and its potential impact on agriculture can perhaps be considered as a truly long-term challenge to the food security. This is a particularly important challenge for South Asia given the greater significance of agriculture in this region. Climate change could have adverse effects on crop yields and hence lead to deterioration of

food availability. Large scale changes in the food production could lead to price volatility and hence affect the access to food for the poor households. Climate change will have significant impact on the spread of diseases and thus could influence the food utilization by the households. Climate change could manifest through change in the frequency and severity of climate extreme events such as droughts, floods and cyclones. The impacts due to these events could have influence on the vulnerability aspect of food security. Thus, climate change can in principle affect all the four dimensions of food security.

Economic Impacts of Climate Change on Agriculture: Increase in carbon dioxide concentration to 550 ppm could increase yields of rice, wheat, legumes and oilseeds by 10-20 percent. However, a one degree increase in temperature may reduce yields of wheat, soybean, mustard, groundnut, and potato by 3-7 percent. The yield losses are likely to be much higher at higher temperatures. Studies assessing the economic impacts of climate change on agriculture have focused mostly on impacts on cereal crops like rice and wheat. Mall et al. (2006) indicate that the studies on the biophysical impacts on some important crops like sugarcane, cotton and sunflower are not adequate. Further, new research findings from crop-models on non-cereal and commercial crops have not been integrated yet into economic modeling. Broadly for the South Asia region, available evidence indicates that climate change results in a yield decline of approximately 14 percent, 44-49 percent, and 9-19 percent for rice, wheat, and maize respectively.

A few studies have assessed the impacts of climate change on agricultural prices. Rosenzweig and Parry (1994) were among the first to assess climate change impacts on world food supply and have incorporated the global food price effects in their analysis. Nelson et al. (2009) also analyses the food price effects and estimates that even without climate change, world food prices are projected to increase by 2050 due to factors like population increase, income growth and higher

demand for bio fuels. By 2050, world prices for important agricultural crops viz. rice, wheat, maize, and soybeans are projected to increase by 62 percent, 39 percent, 63 percent, and by 72 percent respectively. Climate change is expected to increase these prices further by a substantial amount. Accounting for climate change, these prices are projected to increase by an additional +32-37 percent, +94-111 percent, +52-55 percent, and +11-14 percent for rice, wheat, maize, and soybean respectively (Nelson et al., 2009).

Among the South Asian countries, India received by far most attention in terms of assessing economic implications of climate change impact on agriculture. Kumar and Parikh (2001a) have estimated the macro level impacts of climate change using agronomic-economic modeling approach. They show that under doubled carbon dioxide concentration levels in the latter half of the 21st century the gross domestic product would decline by 1.4 to 3 percentage points under various climate change scenarios, with adverse poverty effects. For instance, the proportion of population in bottom two expenditure classes in rural India is expected to increase by 10 to 13 percentage points by 2060s, compared to a baseline scenario for the same period without climate change (Kumar and Parikh, 2001a). The carbon fertilization effects while being positive still cannot ameliorate the adverse impacts of climate change. Kumar and Parikh (2001b) adopted a different approach that accounts for all possible farm level adaptation in its estimation and showed that a 2^{o}C temperature rise and a seven percent increase in rainfall would lead to nearly 8.4 percent loss in farm level net revenue in India. The regional differences are significant with northern and central Indian districts along with the coastal districts bearing a relatively large impact. More recently, Sanghi and Mendelsohn (2008) also estimated similar impacts due to climate change on Indian agriculture. As crops are more sensitive to temperature changes (Lobell and Burke, 2008), in all these studies the large negative effects of temperature increase outweigh slight positive effects due to rainfall increase.

Citing the presence of strong spatial autocorrelation in the agricultural output data in India, Kumar (2011) argued in favor of controlling for spatial effects in climate change impact estimation. The evidence presented in this paper suggests that, (a) accounting for spatial autocorrelation is important due to the presence of significant spatial clustering of the data; and (b) the climate change impacts are significantly lower after incorporating spatial correction either through spatial-lag or through spatial-error model specifications. The impacts of climate change on agricultural net revenue estimated in this paper are lower than the range of results obtained from other climate change agricultural impact studies in India. Under an illustrative climate change scenario of $+2^{o}C$ temperature change and +7 percent precipitation change, the results from this study estimate an annual decline of 3 percent in farm-level net revenue. The study concludes that if certain spatial effects are harnessed – for example, by promoting better dissemination of knowledge among farmers through public and private channels – then adaptation to climate change can become more feasible and less costly.

More recently, Jacoby et al. (2011) have estimated the welfare costs to Indian households of moderate warming over the next three decades and investigated the likely distribution of these costs in the population. The main conclusions from this study are:

- Fall in agricultural productivity need not translate into sharp fall in household consumption as households derive bulk of their income from wage employment as the wages are estimated to fall by only a third as much as agricultural productivity.
- Climate change impacts are regressive – falling more heavily on poor than the rich. This is true in urban as well as rural areas. Combining rural and urban areas, the impacts of climate change are estimated to be even more strongly regressive.
- Taking into account average income growth up to 2040, the national poverty rate will rise by 3-4 percentage points compared to the

counterfactual of zero warming, which, given current population projections, will result in around 50 million more poor people than there otherwise would have been in that year.

- Mendelsohn et al. (2009) assessed impact of climate change on crops, livestock and fish farms in Bangladesh. The main results from the study include:
- Climate change may not have a large flooding impact on farming in Bangladesh – this is true despite the fact that historically flooding has been one of the main causes of farm loss in Bangladesh. The agricultural damage from flooding in 2050 is estimated to be between -0.01 to -0.05 percent of the value of agriculture.
- In contrast temperature and precipitation changes are likely to have more adverse effects on farming in Bangladesh. The study estimates that when land shifts from highland to lowland, approximately 11 percent of the net revenue is lost. Given the small fraction of land that floods, the effects of flooding in very scenario but one are harmful but very small ranging from +0.03 percent to -0.21 percent. In contrast, the total climate impacts – that includes temperature and precipitation effects – range from -88 percent to +850 percent.

Seo et al. (2005) estimated the climate change impacts on Sri Lankan agriculture and argue that with warming, the already dry regions (the Northern and Eastern provinces), are likely to lose large portions of their current agriculture, but the cooler regions (the central highlands), are predicted to remain the same or increase their output. They estimate the overall impacts to range between -20 to +72 percent of agriculture output, depending on the climate change scenario considered.

Climate Change Impacts on Food Consumption and Calorie Availability: Without climate change, increasing per capita income implies reduction in cereal consumption and an increase in meat consumption (both in terms of calories consumed and also in terms of the expenditure shares) with the net change being positive, i.e. the increase in meat consumption more than offsets the decrease in cereal

consumption. Although the trend of decrease in cereal consumption and increase in meat consumption remains the same in the climate change case, here, the net change is negative, i.e. the decrease in cereal consumption is substantial and more than offsets the small increase in meat consumption (Nelson et al., 2009).

As Table 9 shows, per capita cereal consumption in South Asia decreases from 164 (kg/year) in 2000 to 157 in 2050 but meat consumption increases from 6 in 2000 to 16 in 2050. However, under climate change scenario, the decrease in cereals is very substantial which falls from 164 in 2000 to approx 124 in event of climate change. In South Asia, in the absence of climate change, the absolute number of malnourished children decreases from 77 million in 2000 to 52 million in 2050. Climate change is likely to increase the number of malnourished children to 59 million in 2050[5].

Table 9: Food and Calorie Consumption – With and Without Climate Change in SA

Details	2000	No Climate Change	Climate Change Scenarios	
			CSIRO	NCAR
Per-capita Consumption (kg/year) of Cereals and Meats				
Cereals – South Asia	164	157	124	121
Meats – South Asia	6	16	14	14
Daily Per-capita Calorie Availability (kcal/day)	2424	2660	2226	2255

Note: The CSIRO and NCAR scenarios differ in terms of irrigation water supply reliability (IWSR), with NCAR predicting an increase in IWSR while CSIRO estimates it to decline under climate change conditions.

Source: Nelson et al. (2009).

Adaptation to Climate Change: Adaptation to climate change and general socio-economic development are closely intertwined processes. This also implies that, "poor people and poor countries are less well

[5] The estimates from an earlier study by Fischer et al. (2005) indicate relatively better prospects for South Asia's food security under climate change.

prepared to deal with current climate variability than rich people and rich countries" (Parry et al., 2009, pg. 21). The same obviously holds true for the preparedness levels to deal with future climate extremes and climate variability which are projected to increase in frequency due to the anthropogenic climate change. Some studies have identified that there is a positive correlation between development indicators like literacy, income per capita and institutional capacity with reduced vulnerability to climate events (Noy, 2009). It is no surprise hence that several authors have attributed good development as one of the best adaptation response to climate change (see, Schelling, 1992; Nelson et al., 2009; Parry et al., 2009).

Adaptation as a Development 'Continuum'

Any discussion on climate change adaptation must recognize two sometimes contrasting perspectives on the nature of adaptation: (a) climate change imposes a distinct and additional burden on the society; (b) climate adaptation, is one response among many, to a host of socio-economic pressures and cannot necessarily be isolated from regular development activities.

Under some circumstances, the additional vulnerability of economic agents to climate change and specific measures to reduce this vulnerability can be clearly identified. For example, if climate change is expected to increase precipitation and flooding in certain areas, the additional economic damages from these floods and 'adaptive' investments required to reduce these damages can be established. However, climate adaptation may be rendered in-effective if policies are not designed in the context of other development concerns. For instance, a comprehensive strategy that seeks to improve food security in the context of climate change may include a set of coordinated measures related to agricultural extension, crop diversification, integrated water and pest management, and agricultural information services. Some of these measures may have to do with climatic changes and others with

regular economic development. Thus, in the broader development context building adaptive capacity is much more than developing climate-related adaptation strategies. It is thus useful to examine climate adaptation, whether it is spontaneous or policy driven, in tandem with other economic development options. For instance, in Bangladesh, increasing water salinity looms as a major problem for agricultural production. Currently, more than 170,000 hectares of agricultural land is affected by salt and this problem will only grow bigger. Development of flood- and salinity-resistant rice species is an effective measure in reducing flood- and salinity-induced relocation. Adaptation measures in the context of climate change should integrate such developmental concerns. Box 2 provides an illustration of the classification of adaptation strategies based on MSSRF (2008).

The Costs of Adaptation

The overall costs of adaptation to climate change are difficult to estimate for a variety of reasons including, (a) ambiguity associated with definition of what constitutes adaptation costs; (b) whether adaptation costs should incorporate the so called 'adaptation deficit' – which refers to lack of ability of certain regions/countries to deal with the present day climate variability and climate extremes; and (c) whether costs should include hard as well as soft adaptation options. Following some broad and simplifying assumptions World Bank (2006) estimated costs of adaptation (referred as climate proofing costs) in developing countries as 9 to 41 billion USD per year. Stern (2006) also arrived similar estimates. These estimates were subsequently modified by a number of other studies that focused on sectoral assessments (see, UNFCCC, 2007; Parry et al., 2009; EACC, 2010). In the most comprehensive study so far, EACC (2010) focusing on agriculture, fisheries, water supply and other sectors estimated the adaptation costs in the developing countries for the time period 2010-2050 to be in the range of 75 to 100 billion US dollars per year. Despite the differences all the above mentioned studies suggest that South Asia along with Sub-Saharan Africa is likely to face high

adaptation costs, and the cost of adaptation in the agriculture sector will be significantly high in both the regions.

The origins of research on adaptation costs can be traced to the climate change impact studies, where the objective was not to assess adaptation costs per se, but to refine the impact estimates with proper accounting of adaptation to climate change. In this strand of literature, adaptation costs are defined as the expected value of avoided climate damages in the future, conditional upon some future state of socio-economic vulnerability. In a recent survey of such studies Agrawala and Fankhauser (2008) argue that with the exception of coastal protection the knowledge on adaptation costs and benefits is fairly limited. Other studies, examine 'welfare' in future scenarios with and without climate change, estimate the costs of adapting to climate change and examine the 'benefits' in terms of reduced vulnerability (improved welfare) to climate change. In the agriculture sector, adaptation costs can be calculated for example through estimation of investment levels required in agricultural research, rural roads, and irrigation to restore the welfare levels to those that would exist in a future year without climate change. Nelson et al. (2009) estimate the additional annual investment needed to return the child malnutrition numbers to the no-climate change levels in 2050 to range from $7.1 to $7.3 billion under different climate change scenarios. These estimates suggest the costs to be highest in Sub-Saharan Africa, followed by South Asia and Latin America.

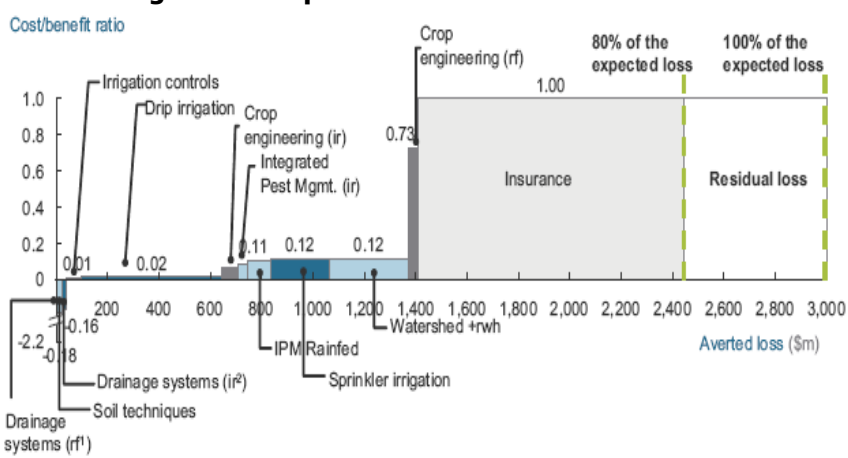
Adaptation Cost Curves

Adaptation decisions are made at the local level with an aim to identify feasible adaptation options and selecting the most effective options for implementation. A recent report by Economics of Climate Adaptation Working Group (Mckinsey, 2009) provided a methodology for constructing adaptation cost curve using cost-benefit analysis. The methodology proposed, and used in several test cases including identifying adaptation actions to protect agriculture from drought in

Maharashtra, is simple and replicable. The end point of the methodology is to develop a portfolio of adaptation responses (in the form of adaptation cost curve) that can avert the losses in a cost-effective manner. It may be noted that the methodology applies for 'hard' adaptation options and is not applicable for 'soft' options such as behavioral changes. In an effort to link the climate change concerns with the present day climate concerns, the adaptation options are identified in the context of known climate risks such as drought, flood, and cyclone.

The adaptation options with cost-benefit ratio of more than one are not attractive on purely economic efficiency perspective. Whereas, adaptation options with cost-benefit ratio of less than one are attractive as the loss averted is more than the costs involved. Further, the adaptation options with cost-benefit ratio of less than zero are worth implementing even without the climate change concerns – that is, 'no-regret' options. Figure 4 shows the adaptation cost curve generated for the Maharashtra case study. There are significant number of options with negative cost-benefit ratios – indicating that these are no-regret options that should be implemented immediately.

Figure 4: Adaptation Cost Curve – Illustrative



Source: Mckinsey (2009).

Overall, adaptation to climate change could have significant influence on the impact of climate change on agriculture and hence the food security. Technological adaptation, especially in the form of adoption of improved crop varieties that, for example can withstand greater fluctuation of temperature and precipitation, may dramatically minimize the climate change threat to agriculture and food security.

Box 2: Typology of Climate Change Adaptation Strategies

MSSRF (2008) studied potential intervention strategies in the context of climate change by focusing on two villages in Andhra Pradesh (Kothur and Srirangapur in Mehabubnagar district) and two villages in Rajasthan (Amda and Kundai in Udaipur district) in India. In all six strategies (relevant for agriculture) have been identified:

a) System of Rice Intensification (SRI) – which could enhance rice productivity especially in the areas with limited water availability. In the case study areas it has been demonstrated that water usage will reduce by 30 percent and rice production will increase by 20 percent.

b) Land management practices to conserve soil and water in sloped terrain – which controls soil erosion and increases water storage through construction of simple contour trenches, loose stone check dams, and vegetative barriers.

c) Revival of traditional irrigation management practices – through this intervention the *Harren* irrigation practice in Rajasthan has been up graded by providing lining in the canals to prevent water loss. Co-benefits of this intervention include reduced use of diesel for operating the pump-sets.

d) Pasture land management and Livestock – this community level intervention provided alternative livelihood strategy to the households and enhanced their adaptive capacity.

e) Up gradation of indigenous goat breads – similar to the previous intervention this strategy provided alternative livelihood strategy for the households to effectively deal with climate extremes.

f) Weather-based farm decision making – this intervention enabled the farmers to use weather information (generated through a simple agro-met station operated by the farmers) while making decisions. This strategy enabled formation of 'smart farmer clubs' and triggered large scale adoption of the strategy.

These strategies can be classified in two ways. Firstly they can be classified based on whether they are time-tested existing strategies, or new ones. For instance, up-gradation of *Harren* irrigation system is an example of existing strategy that if coupled with simple technological interventions can serve as effective adaptation option. On the other hand, the agro-met station is an example of new strategy borne out of the changing climatic conditions (say, increased weather fluctuations). SRI is an example of combining the traditional agricultural practices with technological advances.

The above strategies can also be classified based on their focus – that is, whether they are aimed at enhancing agricultural productivity, or increasing overall adaptive capacity by providing alternative livelihood strategies. For instance, SRI, agro-met stations, up-gradation of *Harren* irrigation practice, and improved land management practices in sloped terrain are primarily focused on enhancing agricultural productivity (either directly, or through improved water efficiency). On the other hand, adoption of efficient cook stoves, pastureland management, and up-gradation of indigenous goat breeds are examples of enhancing the overall adaptive capacity through alternative livelihoods.

Almost all these strategies can be classified as development strategies that involve significant benefits under present climatic conditions and could also enable the communities to address changes in climatic conditions effectively in future.

Input Constraints

Land Use Changes

Land use changes are often driven by multiple factors and are almost always context-specific. For instance Badiger (2010) while analyzing the factors affecting the land-use changes in the Malaprabha catchment area of the Krishna river basin in India argue that, the upstream communities faced with growing demand for food for subsistence are intensifying agriculture, whereas the downstream communities due to growing demand for commercial crops like sugarcane are shifting from rainfed and/or low-intensity irrigation farming to high-intensity irrigation practices. Thus he argues that much of the water scarcity is attributable to the farming and land-use practices, necessitating appropriate policy signals that incentivize positively affecting land-use practices and penalize negatively affecting land-use practices.

One of the important land use change that could have significant influence on food security is use of land for biofuels. Biofuels are acquiring importance due to their potential to ensure sustainable supply of green energy, besides creating rural employment through productive use of wastelands. For India, it has been estimated that by dedicating 33 mha of degraded lands at a woody biomass productivity of 4 tonnes per ha per year, 100 TWh of electricity could be produced annually, meeting most of the rural electricity needs as well as providing carbon mitigation benefit of 40 MtC annually. Actual availability of land for biofuel cultivation however would depend on a number of factors including climatic and soil conditions, access to infrastructure such as roads and electricity, as well as the ownership of the land. The available information about wasteland suitability for oilseed plantations is sketchy and a proper wasteland mapping exercise should precede any major biodiesel development program in India (Gunatilake, 2011). Similarly, ethanol production from sugarcane offers significant potential to substitute for fossil fuel. However, area under sugarcane needs to be stepped up substantially to meet the increasing ethanol demand under different

scenarios of ethanol blending with petrol. Schaldach et al. (2011) estimated that the area for sugarcane production in India increases by 46 percent (5 percent blending scenario), 79 percent (10 percent blending) and 144 percent (20 percent blending) under various blending scenarios. Expansion in sugarcane area is at the expense of the extent of natural land, which correspondingly decreases by 45 percent, 47 percent and 51 percent. However, adoption of yield increasing technologies such as drip-fertigation has huge potential to increase the existing yield levels of sugarcane and hence area expansion could be minimized if these technologies are adequtely supported through public policy.

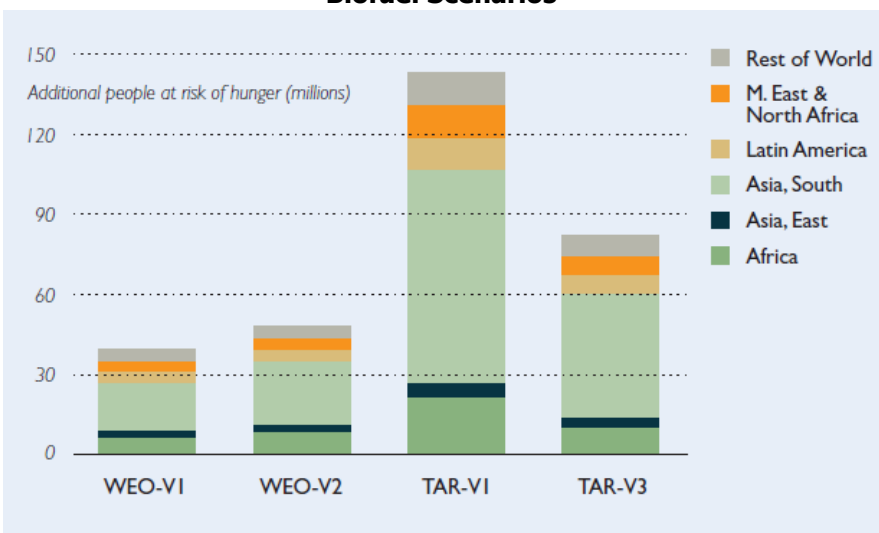
Fischer et al. (2008) in their study on biofuels and food security carry out large scale global modeling to analyze the implications of biofuel expansion on food security, transport fuel security, potential for climate change mitigation, and biodiversity. Figure 5 shows the additional people at risk of hunger relative to baseline under various biofuel expansion scenarios. The scenarios considered include: WEO-V1 – assumes transport energy demand and regional biofuel use as projected by IEA in its World Energy Outlook 2008 Reference Scenario and that second generation conversion technologies become commercially available after 2015; WEO-V2 – makes similar assumptions on transport energy demand as WEO-V1, but considers much delayed arrival of second generation conversion technologies (2030s); TAR-V1 – similar to WEO-V1, except that biofuel consumption is twice compared to WEO 2008; and TAR-V2 – similar to WEO-V2, except that biofuel consumption is twice compared to WEO 2008.

As could be seen from the figure, a large impact of biofuel expansion is on South Asia – an additional 140 to 150 million people may be at the risk of hunger by 2020 due to biofuel expansion. Fischer et al. (2008) however also argue that with the advent of second generation biofuels the impacts on food security could be minor. Such fuels may have positive impacts on greenhouse gas mitigation. However, both first

and second generation biofuels are expected to have negative impacts on biodiversity, and thus may pose threat to food security indirectly.

Msangi and Rosegrant (2011) argue that biofuel expansion will result in substantive increase in market prices and hence lead to deterioration of food security situation in developing countries. They further estimate that the developing countries (including South Asia) may have to increase their yield growth by an additional 1 percent per year up to 2030 to overcome the stress induced by the biofuel expansion. The authors project that productivity improvements and enhanced functioning of the agricultural markets could meet the challenges posed by biofuels.

Figure 5: Additional People at Risk of Hunger under various Biofuel Scenarios



Source: Fischer et al. (2008).

Water Scarcity and Degradation: Intensive use of groundwater for irrigation rapidly expanded with the adoption of tubewell and mechanical pump technology. Consequently groundwater withdrawals in India have surged from less than 20 cubic kilometers in 1950s to more than 150 km^3

now, making India by far the largest user of groundwater in the world. About 55-60 per cent of India's agricultural lands rely on groundwater for irrigation. Over-pumping has led to increased investment or operating costs as falling water tables have necessitated deeper wells and greater energy consumption for pumping. In some instances poor farmers without the capital to deepen their wells have had to revert to rainfed production. In others the necessary adjustments have been too late and desertification had set in. Small farmers with little access to expensive pumps and often insecure water rights are most affected. Water logging and salinization has affected nearly 20 m. ha in India and it is the second important cause of land degradation in India. Of particular concern are those irrigated areas in semi-arid regions that support large rural populations, such as the western Punjab and Indus valley where large areas of waterlogged saline land are spreading through the intensively irrigated plains. Surface irrigation in South Asia is prone to inefficiencies and is in need of urgent attention. For example, in Pakistan the canal irrigation network has deteriorated severely over the years. Estimates indicate that water conservation through improving the efficiency of current irrigation system alone can improve water supply by 10 to 15 percent (IGC, 2010). Significant investments are needed for improving and expanding the existing irrigation networks in almost all countries of South Asia.

Food Price Volatility

Food security in South Asia is significantly determined by access to food by the poor in the region. The recent global food crisis and the increase in world food prices have brought forward the food security concerns to the forefront in South Asia, especially because besides the urban population, a large majority of rural people in South Asia are net buyers of food. About 70 to 80 percent of the rural households in South Asia are net buyers of main food items, such as rice and wheat. Further since for most households (and especially for the poor households) the

expenditure on food is close to fifty percent of the total expenditure, food price volatility could in principle have significant adverse implications.

In a recent study, World Bank (2010) has analyzed the implications of food price increase in South Asia by looking at both first and second order effects. While the first order effects are limited to assessing the welfare implications associated with price change for the households based on their status as net buyers or net sellers of food while keeping the quantities fixed, the second order effects explore the possible implications of price changes on the consumption and production decisions. The results indicate with significant regional variation, the food price inflation had the potential to have resulted in increase in poverty levels among the South Asian economies. Despite the possibility of the second order effects neutralizing some of the adverse first order effects, the study concludes that the welfare loss is likely to persist. The study also brought out the vulnerability dimension of the food security as the households below poverty line were significantly hit by the food price inflation.

Banerjee (2010) argued that since the food price inflation in South Asia was not due to serious demand-supply mismatch in the food grains market, hoarding and speculation could have had major role especially in the persistence of high food prices in the region even after the stabilization of the global prices. Hoarding the speculation could have led to increase in retail prices and not the farm-gate prices, which are crucial for increasing the farmer income and hence have favourable implications for the food security. Given low average trade share of world output for almost all cereals, Banerjee (2010) argues in favour of increasing domestic food production – especially in the major food importing countries of South Asia, namely Afghanistan, Bangladesh and Sri Lanka – to ensure food security in future.

The stresses outlined above (especially in sections 3.2, 3.3 and 3.4) suggest that given their inter-connected nature many of the challenges to the food security should be seen in an integrated manner. Recognizing this, Ericksen et al. (2009) suggest an emerging research agenda for food security in an environmentally constrained world: (a) to go beyond narrow technological solutions of increasing yields and focus on food systems as against agriculture per se; (b) to recognize tradeoffs among food system outcomes to avoid possibility of introducing new vulnerabilities while reducing existing vulnerabilities; (c) to analyze nutritional implications of environmental change especially through the channels of changing content of food grown on degraded lands and impacts of changing disease distribution on human health; and (d) to acknowledge the importance of accounting for variability in say, food prices and climate, while assessing food security.

RESPONSES TO THE CHALLENGES TO THE FOOD SECURITY IN SOUTH ASIA

As discussed in section 2.3 above, most developing country governments in South Asia and elsewhere conventionally address food security concerns through a number of policies including direct interventions that aim at improving access to food and nutritional status[6]. In addition, the South Asian governments could consider the following agriculture related policy options to address present as well as emerging challenges to food security.

Agricultural R&D

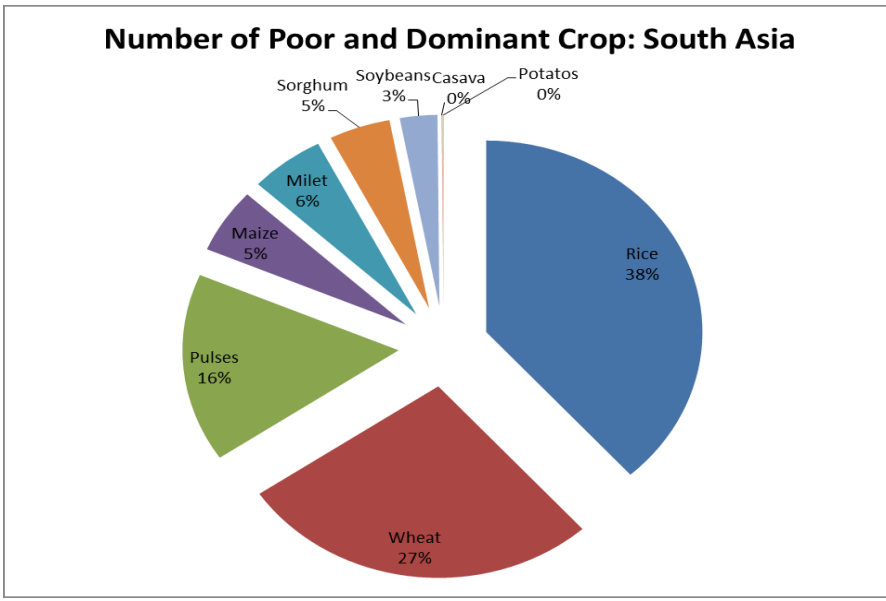
The public spending on agricultural R&D has almost tripled in South Asia between 1981 and 2002 (Beintema and Stads, 2008). Over the years, the public spending has also diversified into livestock research, horticulture, and natural resource management reflecting the growing diversification

[6] See, Pinstrup-Andersen and Watson (2011) for an in-depth discussion.

of the agriculture sector in the region. Private sector still has limited presence (with the exception of maize, where across Asia, the private sector has captured more than 89 percent of the market) in most of the South Asian countries. Hazell (2008) summarizing the evidence from various studies in India and other South Asian countries argues that public investment in agricultural research has higher rates of return than plausible discount rates. He further sites evidence from India to justify that the marginal benefits from investment in agricultural research have not declined over time. While the importance of agricultural research is well understood, it is not very obvious what research would be of greater relevance to South Asia. Given that there are serious yield gaps for various cereal and other high value crops and proven and known paths of increasing their productivity, it is imperative that the South Asian governments should ensure a steady growth rate in total factor productivity through research efforts to develop location-specific and low input use technologies with particular emphasis on regions where the present yield levels are below the national average yield. Among various crops, rice is of particular significance to South Asia. The Task Force Report on 'Sustaining Food Security in Asia' (Asia Society and IRRI, 2010) mapped the incidence of poverty and dominant crop across major world regions. The report showed (see figure 6) that the highest number of poor people in South Asia are located in areas where rice is the dominant crop[7]. Thus research focus on rice crop could have significant effects on alleviating poverty and ensuring food security in the region. While the following policy suggestions with regard to agricultural R&D are made in the context of rice crop, some of them could be applicable for other crops as well.

[7] Dominant crop is defined as crop covering more than 10 percent of the area. Since some areas have more than one dominant crop, there are overlaps in the analysis.

Figure 6: Incidence of Poverty and Dominant Crops in South Asia (2005)



Source: Adopted from Asia Society and IRRI (2010).

- The trend of recent past in declining funding for the development of new rice varieties must be reversed, with particular focus on developing varieties with higher tolerance to abiotic stresses (like drought, flooding and salinity), greater resistance to insects and diseases, and improved micro-nutrient content through precision breeding approaches. In the context of potential threats due to climate change, development of varieties that withstand greater fluctuations in the climate variables including temperature and precipitation is a research priority.

- Despite the contentions surrounding the safety issues associated with the genetically modified organisms, research on hybrid rice and biotechnology has the potential to involve private sector in the development of transgenic rice varieties. However, given considerable delays in developing new varieties and the large

financial costs involved, improving the regulatory environment is essential ensure that the research findings are not confined to few big private companies.

- The yield gaps within the South Asian region can be bridged through the exchange of knowledge on appropriate germplasm and field management practices suitable for different agro-ecological conditions. The system of rice intensification (SRI) could be a good example for such South-South cooperation.

- Bio-fortification that advances breeding of nutritionally enhanced rice varieties has great prospects in addressing food security issues of South Asia. The research on zinc-enriched rice is in the final stages of trails in Bangladesh and is scheduled for release in 2013. Similarly efforts are on to introduce iron-enriched rice.

- Micro-nutrient fortification provides another opportunity to address food security concerns of the region. However, given that rice is typically consumed in whole such fortification is often difficult compared to say wheat and maize (whose flours that go into food preparation can easily be fortified). Recent research suggests micro-nutrient fortification for rice is also feasible at small additional costs. This involves grinding rice into flour, fortifying it, and then reconstituting the flour into rice grains for regular consumption. The additional costs could increase price by 2-4 percent. Even though these additional costs are significantly higher than the fortification costs associated with say wheat, given the greater potential for rice in addressing food security concerns in South Asia micro-nutrient fortification should be given high priority.

- Other interventions include promotion of zero (or low) till agriculture to effectively address environmental externalities associated with agriculture (Erenstein et al., 2007), organic farming (Charyulu and

Biswas, 2010), and adoption of labour intensive farming practices that lower costs.

Supporting Smallholder Farmers

Given that the smallholder farming in South Asia is likely to be a reality in the foreseeable future it is important that adequate support is provided to these farmers to ensure efficient and sustainable agriculture by this majority farming community in South Asia. Some of the interventions include:

- Addressing risk and uncertainty: Farmers in general, smallholder farmers in particular, face uncertainty from multiple sources including weather and price fluctuations. Weather shocks which are spatially similar often lead to long-term impacts on poor farmers due their inability to counter the adverse implications through the geographically proximate social networks. In case of price fluctuations governments often shield the farmers through price stabilization interventions. Paradoxically however such interventions could often lead to much lower local prices than the border prices and contribute to income insecurity of the farmers.

  While moral hazard and adverse selection problems restrict implementation of crop insurance programs, index insurance is emerging as an effective alternative. Index insurance is linked to an index rather than actual loss. The index may be rainfall, crop yield, temperature or humidity. Due to the linkage with the index the payouts in index insurance are almost immediate, well before the actual crop failure and thus provide adequate safety net to the farmers. Propagation of index insurance could also facilitate access of the farmers to other financial markets.

  Despite its advantages the demand for index insurance in South Asia is still very low. Cole et al. (2011, 2012) have extensively studied

the determinants of adoption of index insurance in India. These studies based on evidence from rural India suggest that there are only few takers for the rainfall index insurance, and those who participate take a single policy, sufficient to cover only a small fraction to their income. Non-price factors including lack of trust and complete knowledge about the insurance product and liquidity constraints are affecting the adoption rate of the insurance among farmers. Besides exploring options for greater dissemination of information about benefits of insurance, one could consider the possibility of targeting a group rather than an individual farmer (Cole et al., 2012). Since the group would have more knowledge base and less liquidity constraints, there could be greater demand for the insurance.

While index insurance is also being advocated as an effective adaptation strategy in the climate change context, there could be conceptual concerns because, insurance as an instrument is amenable to fluctuations in weather around a stable climate. Its effectiveness in addressing fluctuations in weather around a changing climate is unclear. Further, Ramaswami (2010) argues that while index insurance is potentially valuable to business entities and local governments that are exposed to pooled agricultural risks, it may not be very effective for individual farmers. For individual farmers (or households) catastrophe insurance may be more valuable.

For effective functioning of the index insurance good quality weather data (or data on other indices uses) is a pre-requisite. Establishing a network of good quality weather stations is a policy priority for ensuring spread of index insurance in South Asia.

- Improving access to information: Information and communication technologies can provide information to smallholder farmers on weather, input and output prices and farming technologies in a less

costly manner and hence help in reducing the information asymmetry that these farmers typically face. The e-Choupal initiative of the Indian Tobacco Company (ITC) is often cited as a successful ICT intervention to provide market and technical information to farmers through some 6400 Internet kiosks (called e-Choupals) in nine Indian states. While ITC uses these as purchase centers of various agricultural commodities, the farmers benefit in multiple other ways including the access to information. While the benefits of ICT in reducing cost to access information is obvious, careful analysis based on randomized control group to assess the benefits of SMS based information provision to farmers in India suggests that the decisions were not entirely influenced by ICT (Fafchamps and Minten, 2011). However, the role of ICT in reaching out to smallholder farmers cannot be undermined and integration of ICT with traditional social networks could facilitate wider adoption of appropriate technologies and provision of useful information in timely manner.

- Purchase to Progress (P4P) program of the World Food Programme attempts to connect smallholder farmer to the markets to reduce the high costs typically faced by them. Among the South Asian countries, Afghanistan is participating with 20 other countries in this program over the period 2009-2013. Despite some significant challenges, the prospects appear brighter. Other examples of successful farmer/producer organizations in South Asia include, the Indian dairy cooperative and cooperative model for vegetable and fruit marketing ('Safal') in Delhi, India.
- Given the small size of individual farms 'contract farming' is considered a potentially viable option for generating more surplus in the farm sector. However, the effectiveness of this option depends on the underlying institutional arrangements governing the farming system. If contractual arrangements are complete, then a 'win-win' situation for producers, contractors and consumers can become the

reality. However, the problem is that the contracts in many cases are incomplete due to: a) problems related to availability of information at the time of contract; b) uncertainty over 'expected' information during the contractual period; c) asymmetric information between parties involved in contracts; and (d) limited ability of the contracting parties to process the available information. Rigidity in contracts that prevents accommodating information as and when it arises may also result in incomplete contracts. Incomplete contract leads to opportunistic behavior by the contracting parties, which increases the ex-post transaction costs. So, secondary level institutions to curtail the opportunistic behavior of the agents are required in the contractual arrangements.

There are many agricultural activities that are being carried out presently under 'informal' contractual agreements successfully and they can provide necessary inputs for designing formal contracts. Gherkin, cut-flowers, marigold, jasmine, wheat, sugarcane, basmati, casuarina, banana, milk and broiler are few of many items being produced under contractual arrangements in India at present. In many cases, the farmer and the contracting party operate within a 'social capital network' and this facilitates them to not only achieve non-zero sum benefits but also sustain their trading activities over a very long period of time. For example, the buyer provides necessary inputs, loans, technical know-how, equipment, labourers, insurance and transportation to the farmers, in addition to sharing any potential risks. The farmers also reciprocate in terms of delivering the supply on time at a reasonable price, and so on. While all these things happen informally, they can also happen under the formal arrangements too.

Trade Related Responses

Individual government interventions to stabilize domestic prices often lead to further volatility in the world prices which in turn will hurt poorer and small countries that rely heavily on imports. While the first best option for dealing with domestic food price volatility would be to eliminate export restrictions, it is often not feasible as the World Trade Organization rules on export barriers are much weaker than those on import barriers. Further, during a food crisis it is very unlikely that domestic political compulsions would permit the Governments not to use the export ban. Regional food reserve (with limited size) in South Asia on the other hand could provide scope for cooperation across the countries and act as buffer in the years of food grain shortfall.

Empowering Women

It is a well established fact that South Asian countries are highly patriarchal and discriminate women in several forms. While women contribute significantly to the farming activities, their participation in the production of food does not guarantee commensurate returns. It is also well established that women empowerment is critical for improving nutritional status of children. Rao (2005) argues that while land rights are crucial in empowering women, provision of land alone cannot improve the status of women and ensure household food security.

The lack of attention to 'food justice' in the mainstream notion of food security could prove detrimental in the long-run. Efforts to create a 'just' food economy are taking shape through a collective struggle of close to a quarter million women who are farming nearly 10 million acres of land in the Southern State of India, Kerala. This experiment under Kudumbashree referred as, 'Sangha Krishi' or group farming was initiated in 2007 as part of anti-poverty program. This is having palpable shift in the role of women in Kerala agriculture, enabling them for the first time to move from the traditional jobs of plantation and agricultural laborer to independent producers. It is also enabling women to salvage their

dignity. Further, Sangha Krishi is having important consequences for NREGS in Kerala as from the beginning synergies were sought between NREGS and Kudumbashree. Certain institutional mechanisms should be put in place to make this experiment sustain – firstly, lack of ownership and the associated problems in securing access to credit need immediate attention. Secondly, mechanisms to provide risk insurance should also be thought out. This experiment is worth emulating elsewhere for addressing food security problems as it also re-connects food security to livelihoods as any effective food policy must (Mukherjee, 2012).

Other Interventions

- ***Investment for Food Security***: It is well established that investment in agricultural infrastructure such as roads, irrigation systems and market systems are crucial for improving productivity of crops and also enhancing the non-farm rural economies by enabling the labour force to explore non-farm livelihood options (World Bank, 2008). It is also widely perceived that bulk of this investment will have to come from the private sector once the enabling environment is created through appropriate policy signals. FAO (2009) provided a broad assessment of investment needs in various agricultural systems over the period 2006 to 2050 in South Asia for ensuring food security. In agro processing, cold and dry storage facilities and mechanization alone it is estimated that the gross investment needs for the region would be more than 1270 billion USD. In addition to these a number of other sub-sectors have been identified for investment and these include: farmer field schools for capacity building, fertilizer inputs, creating adequate irrigation facilities, seed systems to deliver quality seeds to farmers, establishing required slaughter-houses to provide safe meat and small-scale dairies, and facilities and interventions to ensure food safety and meet nutritional requirements.

- ***Innovative Financing to Promote Private Investments in Agriculture***: Despite the developing of financial sector in South Asia, the majority of farmers still find difficulty in accessing formal markets for agricultural finance and this is particularly high in risk prone zones. This situation hinders investment capacity of farmers for sustainable food production, investments on risk mitigation options, and proper storage of agricultural produce for off-seasonal consumption and sale. Promotion of reliable rural finance systems in South Asia on lines similar to the existing success stories like Grameen Bank of Bangladesh and Sanasa in Sri Lanka is a necessary condition to enhance food security and nutrition in the region.
- ***Climate Change and Migration***: In developing countries – which are largely dependent on climate sensitive economic activities such as agriculture – climate extremes and changing climatic conditions may accelerate growing levels of rural-to-urban migration (McLeman and Hunter 2010). Further, climate related migration largely takes place at intra-national and/or intra-regional scales, and it is likely to continue under the climate change conditions (Massey et al., 2010). While people at the upper end of the socioeconomic spectrum may be tied-up with their household/business capital which would also help them resist climate change induced hardships and avoid migration, the people at the lower end of the spectrum (such as landless labourers) may easily be displaced by climate hardships. Though the mechanisms through which climate change would induce migration are not carefully studied, the likely adverse impacts of climate change on agricultural crops may necessitate rural-to-urban and rural-to-rural migration. Cyclical migration for short-duration in response to droughts may continue or even grow due to climate change (Deshingkar and Start, 2003). Feng et al. (2010) have analyzed the sensitivity of international migration (Mexico to US) resulting from climate change induced agricultural yield losses.

The methodology used in this study uses panel data analysis that facilitates estimation of (semi) elasticity of migration to crop yield. The results of Feng et al. (2010) highlighted the potential high rates of migration from Mexico to the US under the climate change scenario. Feng et al. (2012) have examined the internal migration in the US following similar approach. A series of studies are currently underway in several South Asian countries (Bangladesh, India and Pakistan) that are attempting to explore the empirical evidence for climate change induced migration and thus assess effectiveness of migration as an adaptation (or coping) strategy.

- ***Land Reforms***: With the exception of India, land reforms are needed in most of the South Asian countries. In Sri Lanka for instance, land was transferred to agricultural laborers through deed registration. Though the land holdings are equitable, this does not give ownership rights to the individuals. Hence individual farmers cannot use land as collateral and cannot explore non-farm livelihood opportunities (as quitting farming would also mean loss of land).
- ***Behavioral and Institutional Changes:*** These responses are often context and location specific as highlighted here through evidence from India and Nepal with respect to institutions that govern water use.
    - Farmer Managed Irrigation Systems (FMIS) are well known for their contribution to agricultural water management in Nepal. The community management of the FMIS is proving difficult to organize. Bhattarai (2011) studied the transaction costs involved in the creation and running of the Water User Associations (WUAs) that manage the FMIS. The results show that the transaction costs related to FMIS management are mainly linked to the time farmers spend watching, waiting and negotiating over water use. The transaction costs are not a huge burden and only amount to about one percent of

the total value of agricultural production. These costs (up to a threshold level) are shown to have positive impact on agricultural productivity. This highlights the importance of setting up and running effective WUAs for increasing agricultural productivity.

- Out of India's 2,08,000 tanks, the three southern States namely, Andhra Pradesh, Karnataka, Tamil Nadu and the Union Territory of Puducherry accounted for 60 percent (i.e.1,20,000) of them. The total area irrigated by these tanks in these states declined to 1.7 m ha in 1996–97 from 2.4 m ha in 1960–61, registering a 30 per cent decline (Narayanamoorthy, 2004). The conventional guiding principles on tank management converged towards addressing problems related to hydrology (e.g. siltation), finance (e.g. financial scarcity) and politics (e.g. encroachment) without giving much attention to behavioral issues such as, whether stakeholders are willing to participate in tank management or not. Recent policy initiatives on tank irrigation concentrate on institutional reforms, under the broader umbrella of 'participatory irrigation management'. At present, measures are initiated to improve the tank performance either by strengthening the existing 'weak' institutions or by transmitting a successful institution to those poorly performing tanks. Critical policy inputs such as, why the already prevailing institutions are weak in certain cases and why the efficient institutions do not emerge spontaneously in certain other cases, are being neglected in the present policy paradigm. In almost all current initiatives, putting WUAs to work is considered as a panacea for improving the performance of irrigation tanks. For example, the Tamil Nadu government has undertaken a large scale tank modernization programme

(under its IAMWARM project) in which creating WUAs is prescribed as a mandatory requirement. It should be noted that the WUAs created in the past in other parts of the country ran into various difficulties and in some cases, they even destroyed some of the traditional institutions managing water efficiently at village level for centuries together. Given the potential of irrigation tanks in neutralizing the impact of increased droughts and floods in future, it is imperative that innovative approaches must be identified to manage irrigation tanks. While the community management has collapsed and the WUAs run into various difficulties, the market-based instruments, with appropriate government regulations, provides immense potential for sustainable use of tanks. The payment for ecosystem services (PES) has been demonstrated to be an efficient market-based institution (see Engel *et al.* 2008) to provide necessary incentives for the local communities to manage local commons. The PES scheme brings new set of incentives for the local community to provide tank services in a better way and these incentives are dependent entirely on the underlying legal and institutional ingredients embedded in the PES framework. These legal and institutional aspects should be complemented with the 'site-specific' customary institutions and therefore, the success of the PES scheme depends on how effectively the site-specific institutions are combined with the government's guiding principles originating from the top.

- Incentives to encourage urban consumers to produce adequate vegetables and fruits for their self-consumption through innovative efforts like 'home gardens' and 'roof gardens' could provide adequate cushion against the food price volatility.

CONCLUSIONS

Notwithstanding its impressive economic growth, food insecurity in South Asia continues to be a stark reality for a large number of households. Despite several successful policy interventions by Governments, the number of mal-nourished children and adults remain alarmingly high in the region. In fact the mal-nutrition levels in the region are higher than those observed in Sub-Saharan Africa – a pattern dubbed in the literature as South Asian Enigma. Large number of people pursue agriculture as a livelihood option in South Asia, partly because of lack of other alternatives. The growing economy with a vibrant service sector has not been able to absorb surplus labor force from agriculture due to the low levels of literacy and skills they possess. The divide between farm and non-farm income levels has been increasing.

Against this backdrop, this paper examined potential long-term challenges that could aggravate the food insecurity in South Asia. Among several potential future challenges, the paper highlighted the importance of demographic changes, climate change, input constraints including land and water constraints, and food price volatility in influencing the food security in the medium to long-term.

- While the changing tastes and preferences of rapidly urbanizing population would demand high value agricultural products, the South Asian agriculture dominated by the smallholder farmers with low resource and skill set is increasingly going to find it difficult to diversify. While conventional development argument supports rural to urban migration as part of natural development process, the evidence from South Asia suggests that there is more of what could be referred as distress migration of people moving to urban areas as the livelihood opportunities are drying-up in agriculture and at the same time other sectors are unable to absorb the labor due to low skills possessed by them. This does not auger well for the food security situation in the region. Prevailing welfare schemes (such as

NREGS) while being supportive from food security perspective may paradoxically lead to agriculture labor supply shortages in the short-run in some regions.

- The climate change will aggravate food insecurity in South Asia through its effect on all the four components of food security – adverse yield changes effecting food availability, price changes influencing access to food, impact on disease distribution contributing to changes in the utilization of food, and uncertainty contributing to the vulnerability.
- Land use changes, especially for biofuel generation could have adverse effects on food security in the region. Estimates suggest that annually additional one percent increase in yield growth would be needed to overcome the stress induced by biofuel expansion. Water scarcity caused by deterioration of surface water quality and ground water over exploitation would be another cause of worry for South Asian region. The recent global food crisis highlighted the fragility of food security in the region. Food price volatility and its effect on access to food could get further aggravated by in coming years as the governments grapple with variety of responses often chosen due to domestic political compulsions.

These and other features of South Asian agriculture such as declining investment in agriculture, smallholder nature of farming in the region, declining productivity and considerable regional differences necessitate urgent policy responses to effectively address the food insecurity concerns of the region and facilitate choice of alternative livelihood options by the rural population. The policy responses outlined in the paper include:

- Given the overwhelming importance of rice crop in South Asia, agricultural research emphasis should be on developing new rice varieties with higher tolerance to abiotic stresses, greater resistance to insects and diseases, and improved micro-nutrient content through precise breeding approaches. Bio-fortification that advances

breeding of nutritionally enhanced rice varieties – such as zinc-enriched rice under trails in Bangladesh – should be promoted. Micro-nutrient fortification of rice – even though costlier than wheat and maize – should be given priority given the greater potential for rice in addressing food security in the region.

- Smallholder farmers should be supported through various interventions including promotion of index-based insurance for addressing risk and uncertainty, facilitation of ICT intervention to improve access to information, and encouraging farmer associations to increase the bargaining power of the smallholder farmers.
- Creation of regional food reserve (with limited size) in South Asia promotes cross-country cooperation and serves as buffer in the years of food grain shortfall.
- Empowering women by giving them land as well as facilitating rights to produce food would go long way in addressing food insecurity in the region. The encouraging evidence emerging from the 'Sangha Krishi' experiment in Kerala, India demonstrates how food security and rural livelihood issues can be collectively addressed through judicious policy interventions.

In addition to the above the paper highlighted the importance of other interventions such as facilitating much needed investment in agriculture and rural economies and carrying out land reforms. It also discussed the new and emerging response strategies to the 'micro' level constraints involving behavioral and institutional dimensions of South Asian agriculture.

Though the emphasis in this paper has been on the interventions that are primarily linked with agriculture, it is well recognized that for effectively tackling food security concerns the public policy must integrate responses to food access and food utilization also. It is important to

recognize relevance of integration of another kind wherein policy responses to different stresses are not viewed in isolation but to the extent possible in an integrated manner. Such an integrated approach would increase the probability of selecting response strategies that are complementary in nature.

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