

Climate change, flooding and food security in south Asia

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Abstract The most vulnerable groups in terms of food security during floods in south Asia under climate change will be the poor, women and children. Current procedures for the transfer of climate adaptation funds tend to marginalize these groups. Food production is being disrupted by flooding more frequently and more severely than before, due to climate change. By 2080 the situation is likely to be much worse than at present. Adaptation has to encourage management of all stages of food security, from the farm to the consumer, both urban and rural. Measures have to be participatory, from the community to the international level. While many individual initiatives offer hope and demonstrate good practice, institutional, economic and environmental factors may all impede the maintenance and enhancement of food security in south Asia. Innovative forms of food production, distribution and storage will have to be developed.

Keywords Climate change · Flooding · Food security · Poverty · Women · Children

Introduction

This paper sets out to examine interrelated issues of food security in the face of climate change in south Asia, with special reference to Bangladesh. It endeavours to find the answers to six questions:

1. How will climate change influence future flooding?
2. How will climate change influence food production?

3. How will future flooding affect food security?
4. Are current responses to flooding adequate?
5. What changes are needed now?
6. What changes will be needed in the future?

The underlying hypothesis is that the most vulnerable groups in terms of food security during floods will be the poor, women and children. It will be argued that current procedures for the transfer of climate adaptation funds will marginalize these groups, further aggravating social crises in south Asia.

Food security is influenced by a wide variety of biophysical, political, social, economic, cultural, psychological and behavioural factors. This discussion concentrates on the factors that are most likely to be influenced by climate change, and particularly on increased flooding caused by climate-change. Figure 1 shows the key relationships between climate change, flooding, crop production and rural and urban communities.

Future climate change impacts on flooding

Climate change (Box 1 in Fig. 1) appears to be influencing both the monsoon and tropical cyclones, the two prime drivers of flood events in South Asia. Floods will be affected by changes in temperature and in rainfall. Rising temperatures will accelerate the rate of melting of snow and glacier ice, increasing seasonal peak flows of Himalayan headwaters. This in turn may lead to an increased frequency of flooding (Box 2 in Fig. 1), particularly along rivers whose channel capacity had been reduced by sedimentation (Aggarwal et al. 2004). In the longer term, however, reduced snow cover will result in reduced water flow to rivers.

Elsewhere the probable increase in storm precipitation will mean that severe flooding will happen more often, as it

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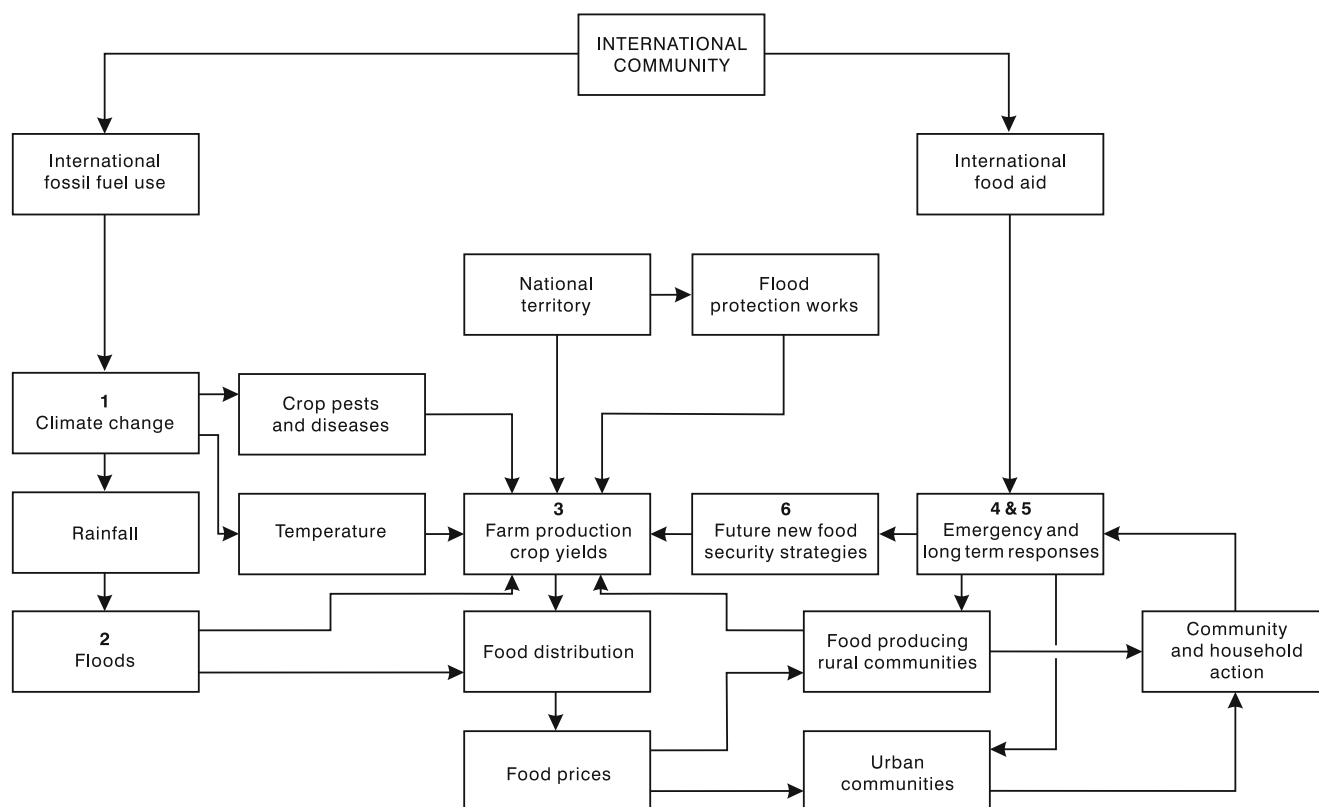


Fig. 1 Schematic diagram showing the interrelationships between climate change, flooding and food security in the South Asian context

did in Gujarat in 2005, 2006 and 2007. Productive deltaic agricultural land will become more vulnerable to floods, to the impacts of possibly more severe tropical cyclones and to rising sea levels. A possible sea-level rise of 15 to 38 cm by the 2050s (Ravi 2008) would cause saline water to penetrate further inland and ultimately displace some 35 million people around the Bay of Bengal and change conditions in other deltas and coastal plains on a similar scale.

Future changes in precipitation regime have four distinct implications: (1) the timing of occurrence of floods may change, with a possible change in the seasonality of the hydrological cycle; (2) an increase in monsoon precipitation in the Ganges, Brahmaputra and Meghna basins may increase the magnitude, frequency, depth, extent and duration of floods; (3) changes in the timing of peak flood flows descending the major rivers may alter the likelihood of synchronization of flood peaks of the major rivers; (4) increases in the magnitude, depth and duration of floods will lead to dramatic modifications of land-use patterns in all the major deltas of the sub-continent (Fig. 2).

Future climate change impacts on food production (Box 3 in Fig. 1)

South Asian people, food yields and economies have always been affected by variations in the monsoon

(Vasudeva 2002). However climate change is likely to bring greater variability (Whetton 1994) and pose problems for national food supplies because agriculture is so dependent on the monsoon (Shukla 2003). It could also raise temperatures by 0.1–0.3°C by 2010, 0.4–2.0°C by 2070 (Whetton 1994), and 3.5–5°C by 2100 (Ravi 2008). These higher temperatures will affect water availability for food crops by their impacts on evapo-transpiration. Monsoon season (*kharif*) crops may be little affected by moderate temperature and CO₂ rises, but winter (*rabi*) crops could suffer decreased yields, due to large temperature increases and greater uncertainty of rainfall (Mall et al. 2006). Many of the gains in yield that would be caused by a doubling of atmospheric CO₂ would be more than offset by reduction in yield resulting from temperature and moisture changes (Vasudeva 2002; Attri and Rathore 2003).

During both seasons, crops could be increasingly disrupted by more frequent weather extremes, such as variations in monsoon onset, duration and frequency of drought and floods, and pest infestations. Although monsoon precipitation is likely to increase in many regions, winter rainfalls are likely to decrease in northern India (Ravi 2008) affecting the output of winter wheat and mustard crops which could impact on food security. Lower rainfall in drier areas will make marginal agricultural areas less productive.

Fig. 2 Map to show the key places and rivers mentioned in the text



Differences in seasonal conditions most probably will affect the presence and impact of crop pests and crop diseases (Aggarwal et al. 2004). However, the net effects of the region-wide changes are uncertain because of variation in the growing season and crop management, the lack of understanding of possible changes in plant and animal diseases and pests, and the vulnerability of agricultural areas to episodic floods, droughts, and cyclones.

A warmer climate scenario, with more uncertain onset of summer monsoons is likely to affect not only rain-fed crops, but also water supplies for irrigation. Increasing demand for water by industry and urban areas will further reduce water available for agriculture (Aggarwal et al. 2004). Food crop production in most parts of South Asia will be at greater risk in a warmer climate than under present-day conditions (Mizra 2002). Poor rural people dependent upon traditional agricultural practices or using marginal lands will be particularly at risk (Vasudeva 2002).

Impact of future flooding on food security (Box 3 on Fig. 1)

Losses of food crops during floods have always had severe impacts in South Asia. Crop damage by floods and food security is closely inter-linked. In 1974 when a flood

damaged about 0.6 million tonnes of crops and generated a severe unemployment crisis for farm workers, a famine broke out in Bangladesh due to lack of food security. It cost the lives of 1.0–1.5 million people (Alamgir 1980). Future flooding will increase the dimensions of such crises.

Although, during the floods of 1988 and 1998 the Bangladesh government managed to balance food demand and supply, this did not necessarily ensure food security at the household level. This serious problem of getting the food to the people who need it, which exists even in normal years, will affect increasing numbers of people living below the poverty line when bigger floods occur in future.

Croplands presently liable to flooding are likely to become wetter for longer and additional land will be inundated in the worst floods due to increased river heights and rising sea levels. Crop damage and unemployment caused by floods will make an even larger section of population extremely vulnerable to starvation, malnutrition and even death (Shahabuddin 2000).

Unless action is taken in time, the higher future floods will disrupt existing transport and communications for longer periods and over a wider area. This will make the movement of food supplies more difficult. Longer wet periods could also affect the quality of food in storage, unless particular care is taken. Seasonal food shortages (monga) are already a persistent problem in Bangladesh

(Zug 2006). Increased flooding is only likely to make them worse.

Adequacy of current responses to flooding (Box 4 in Fig. 1)

Adaptation to climate change can be based on uncoordinated choices and actions of individuals, firms and organisations or on collective action and choice at local, national, international as well as intermediate and multiple levels (Table 1). While national food distribution policies and regional and local flood relief measures alleviate conditions for the poor, many have to rely on their own household strategies. At present, action on climate change adaptation is overwhelmingly focused on proactive responses by the international community and national governments. There is little international recognition of and provision for local and individual adaptive responses (Paavola and Adger 2002).

South Asian governments and communities are accustomed to floods and have emergency relief systems that aim to bring food supplies to those worst affected by flooding. However, at the local level the government distribution systems are not always effective. Within communities, households and families, there are local responses to flood-related food shortages. Immediate responses follow well-established patterns. They begin with households responding to warnings or the imminent ingress of water into their dwellings or across their fields. Livestock are moved to higher ground. Chickens are put into baskets and loaded on to boats or rafts along with children and key household possessions. People and belongings are carried to higher ground and to refuges such as roofs, school buildings and even trees.

Within communities self-help begins on an informal basis between individuals, helping each other to get out of the way of the flood, sharing food, and minding children and the old and infirm. When the first phase of the onset of disaster has passed, community committees and self-help becomes more organised, particularly in obtaining external assistance and in sharing out what is supplied. When community organisation fails and supplies are not delivered, protest and conflict may follow.

Inadequate responses have long-term implications, particularly for health and nutrition. After the 1998 floods in Bangladesh, real household incomes and living standards fell. Although many households managed to buy enough food, by relying partly on small government transfers and heavy borrowing from private individuals, others suffered inadequate calorie consumption. Lower food intakes, alongside deteriorating human health conditions, caused the nutritional status of children in households most severely exposed to floods to worsen (Del Ninno and Lundberg 2005). Post-1998 flood assistance programmes designed to deal with this were ineffective, especially when compared to those designed to maintain children's health over the long term, perhaps because the small government programmes did not target children affected by the flood sufficiently. Despite immediate Government intervention providing small emergency rice rations to disaster victims in poor households selected by local committees, in the following 4 months, a shortage of public stocks and uncertainties about food aid deliveries hampered the distribution of food grains, especially wheat (Del Ninno and Dorosh 2002).

Evacuation is a common response to flooding in South Asia. In Bangladesh, people move to higher ground, to levees or anchor boats or rafts to trees to ride out the flood. Although schools, or other government buildings, act as

Table 1 A typology of adaptive responses to climate change impacts with examples of responses in terms of agricultural productivity and food security (after Paavola and Adger 2002)

Response	Proactive	Reactive	Inaction
International	Guidelines for national adaptation strategies, support for development of new crop varieties	Food aid measures	No responses are taken to instigate context-specific behavioural responses
National	Grain storage, investments and changes in agricultural policies to adapt crop mix and agricultural practices to changing climate	Changes in tariffs and fiscal policy to augment food imports; disaster relief and food aid	No small-scale proactive investments in infrastructure that confer only local adaptive benefits
Local	Small-scale infrastructure investments for groundwater recharge, irrigation and flood protection, local seed banks, and coordination of adaptive responses	Collective action and reciprocity in overcoming obstacles in agricultural production and mitigating shortages of food and water	Migration ignored as an adaptive response
Individual	Diversification of livelihood, investment in human capital, physical capital and alteration of agricultural practices	Migration	Adjustment of increased vulnerability and/or reduced welfare

evacuation centres, there is often insufficient shelter for all the local people. To alleviate the problem, some NGOs have built community shelters able to accommodate 100 people, on artificially raised ground. Even though they have clean water and medical supplies, they depend on food aid deliveries and are only able to assist a fraction of the people in need.

Raised earthen platforms can provide temporary shelter to people and livestock of the affected villages, which get marooned frequently and suffer from acute hardship due to disruption of basic civic amenities and communication links. Such a scheme in the villages of North Bihar, which are frequently flooded, involves platforms built and maintained with local participation near or in the villages 60 cm above the 1 in 25-year flood level. They are provided with food, fodder, drinking water and public conveniences. Connections either to all-weather roads or to service roads on embankments provide emergency access for additional food supplies. A motor boat or raft is made for clusters of platforms where road communication is not possible or viable.

Large parts of cities can be inundated for long periods, but local mobility is usually maintained. Nevertheless, floods have major impacts on food access in large cities, especially those with large numbers of people living in poverty. The 1998 floods affected people in Dhaka from all levels of society, from slum dwellers to the country's elite. Diarrhoea epidemics broke out in many parts of the city (Kunii et al. 2002). Although most basic services, food markets and transport were all disrupted, many people, particularly the poor, devised ingenious methods to cope with terrible conditions (Rashid 2000). Prices of basic food items generally rose, imposing severe stress on the poor. To save money, most family members reduce their food intake. For example, many women interviewed after the 1998

floods admitted that they reduced their consumption of rice from twice a day to once a day or even less frequently (Rashid 2000). Most relied on the roti (flat bread) distributed by the relief agencies to fill their stomachs. Many poorer families relied on dry foods, such as *muri* (puffed rice), molasses and others ate rice with dry chilis or salt (Rashid 2000). Some excellent reactive responses by local communities occurred, many groups organising flood committees to help people to cope (Table 2).

Similar food shortages and price rises occurred in later floods. In the 2004 floods, rice prices rose by 30 per cent in Dhaka and vegetable prices more than doubled. Urban slum dwellers and the landless rural poor were hardest hit, neither group having the ability to produce their own food. Following the 2008 Bangladesh floods, the Government made emergency food distributions and also endeavoured to prevent sharp rises in the cost of rice. An Open Market Sale (OMS) of rice from government stocks influenced the market positively, causing the price of rice to fall by one taka per kg. This is a typical governmental reactive response to flooding (Table 2).

While rural adaptations are evident, the problems in towns and cities are more complex, because efforts to protect one part of town readily lead to floodwaters being re-directed to another. An Asian Development Bank project to reduce flood losses in smaller towns has four components: flood protection facilities, such as earthen flood embankments, reinforced concrete flood walls and drainage regulators; improved drainage works; improved solid waste management and sanitation; and building the capacities of the participating towns to manage the newly created assets. Such integrated actions to help to move floodwaters away from the areas involved, but have to be carefully planned and maintained to avoid causing flood elsewhere.

Table 2 Examples of current adaptive responses to climate change impacts with examples of responses in terms of agricultural productivity and food security (after Paavola and Adger 2002)

Response	Proactive	Reactive	Inaction
International	International aid for flood mitigation and flood defence works	Emergency food and medical supplies	Increased migration and destitution leading to greater global insecurity
National	Government inter-agency co-ordination of disaster; management; maintenance of emergency food stocks; improved drainage	Bangladesh open market rice sales to stabilise prices; emergency repair to embankments and drainage channels	Economic disruption and rural to urban migration; increased poverty and unemployment
Local	Village schools as refuges; flood and cyclone relief shelters; local flood warning schemes	Formation of flood committees; mutual assistance and self-help groups	Disruption of communities; in worst cases on chars: loss of land, crops and homes through erosion
Individual	Household plans for removing family members and valuables to high ground, using boats or evacuating to safer places	Emergency evacuation to higher ground, roof-tops or in boats anchored to trees; assistance from relatives and neighbours; reliance on hand-outs	Increased ill-health; loss of employment and educational opportunities; damage to livelihoods

In terms of food security, rapid responses to floods can be hampered because the complexity of food supply chains makes them highly vulnerable when communications and transport are disrupted by floods. The Indian food supply chain is disjointed. One series of processes and flows is involved in the production of crops by the farmer. A second series relates to the transfer of produce from the farmer to the market or food processor. A third series is the delivery of food to retail outlets, consumers or food distribution agencies (Acharyulu and Mathew 2006). Industry experts estimate that more than 30% of all fresh produce is lost or spoiled before it reaches the market. On average, goods pass through six or seven middlemen before a consumer can buy them, resulting in tortuous journeys, big mark-ups and poor quality.

The Indian Food Corporation has its own warehouses, but there are now many private warehousing and distribution businesses. The impact of disruptions in delivery from producers to warehouses will depend on the stocks held by the warehouses and effectively those in difficulties can be reached by the distribution system. The perishable food supply chain is fragmented and particularly vulnerable to disruption. International corporations, such as Wal-Mart and Carrefour, are attempting to enter this business. International relief organisations have their own supply chains, but high levels of coordination are required. While these emergency distributions can reach hundreds of thousands, if not millions of people, increasing resilience and improving adaptation to future floods and increasing food security at the village or urban slum level reaches far fewer. While countless examples of good practice and successful schemes exist, their implementation and diffusion is slower than the rate of growth of the population. Despite the increasing severity of the risk, adaptation of food supplies and food security to climate change has not been fast enough.

What changes are needed now? (Box 5 in Fig. 1)

Strategies to reduce the vulnerability of the region's food systems to climate change need to be based on a combination of technical and policy options. Their development should take account of the concurrent changes in socio-economic stresses. Selection of new adaptation techniques and practices requires not only assessment of social acceptability and economic efficiency, but also deep understanding of how the region's food systems operate in practice and how they interact with climate change (Aggarwal et al. 2004).

There has long been discussion of the viability of building major embankments and dykes in South Asia deltas. The existing structural features protect large areas of

cropland. Further protection of human settlements and croplands could increase food security. However, traditionally major engineering works have been designed to cope with a particular magnitude of flood, such as that with a probability of occurring once in 100 years or once in 50 years. The estimation of the height of that flood, and thus of the required height of the embankment was based on the sizes of floods that had occurred in past decades. The assumption was that past events were the key to future probabilities. Climate change is making such forecasting extremely unreliable. Now computer models of future floods are based on a series of assumptions on future monsoon regimes, storm magnitudes, typhoon occurrence, land cover and riverine structures. On the coast and in deltaic areas sea level rise has to be considered as well. The many uncertainties suggest that other forms of reducing flood losses and adaptation to changed flood regimes caused by climate change have to be considered, either as alternatives or to be used in conjunction with appropriate strengthening and enlargement of embankments.

Softer, local engineering and social awareness-raising measures, such as high ground refuges, flood warning systems and flood proofing of key buildings, especially food stores, could be considerably more cost-effective in reducing river flood damages than huge earth moving works. Large embankments can trap local runoff when heavy localized rain occurs, flooding crops and water-logging the soil. Embankments can change flow patterns within channels and alter the movement of sediments. Such processes would greatly increase the vulnerability of the landless people who live and grow food on unstable sandbars (known as "chars") within the huge channels of the Ganges-Brahmaputra delta. The chars get flooded in most years, but the people have nowhere else to go. Ideally, they would not have been allowed to occupy such hazardous places, but now they have to be helped to adapt to a worsening flood situation.

What changes will be needed in the future? (Box 6 in Fig. 1)

Future changes have to improve the immediate reactive responses (Table 3) through emergency relief and have to instigate wide programmes of proactive long term responses that will help communities adapt to the altered flooding situation under climate change. In disasters and emergency situations, effective management of supply chains and delivery systems is central to relief operations. Good logistics are usually the key. First, it is crucial to the effectiveness and speed of response for major humanitarian programmes, such as health, food, shelter, water, and sanitation. Second, the logistics of procurement and

Table 3 Possible future adaptive responses to climate change impacts with examples of responses in terms of agricultural productivity and food security (table format after Paavola and Adger 2002)

Response	Proactive	Reactive	Inaction
International	Full implementation of funding for adaptation to climate change; specific orientation to the poor and to women; Assistance in improving emergency relief logistics and in capacity building for the maintenance and operation of drainage and flood control works	Improve efficiency of collaboration and food delivery. Ensure that donor government promises of assistance are met and that the benefits of aid and emergency relief reach the needy. Build long-term resilience into relief strategies	Failure to prepare for climate change will lead to bigger humanitarian disasters in the future
National	Ensure national disaster management authorities have the capacity to cope with climate change as well as present risk levels. Integrate rural and urban flood relief strategies, changing flows of food and biomass to ensure greater food security. Adequate numbers of boats for distribution of food relief; involvement of women in distribution decisions. Link all villages to raised embankments and shelters	Collect information on where marooned and evacuated flood victims are. Ensure rapid distribution of food supplies and medical assistance to affected groups	Lack of attention to flood resilience and to emergency and long-term nutritional problems will affect national educational attainment and health levels
Local	Increased height of raised gardens, food stores and shelters; encourage development of flood-resistant food production, such as floating gardens and hydroponics. Set up emergency foods stores at safe locations. Find alternative locations for people living on the most vulnerable and unstable chars. Involve women in distribution decisions	Maintain flood warnings. Assist people to evacuate. Have systems for accessing emergency food supplies and communicating to regional offices about needs. Ensure equity in food distribution	Lack of community common purpose decreases resilience to future disasters aggravated by climate change
Individual	Strengthen household strategies for flood survival; ensure household level preparedness, especially among the urban poor; ensure evacuation procedures are both effective and understood	Redevelop food production and restore shelters in rural areas. Re-establish livelihoods and dwellings in urban areas	Increasing poverty, ill-health and malnutrition. Possible family breakdown and loss of children

transportation can be one of the most expensive parts of a relief effort. Third, logistics involves the tracking of goods through the supply chain, thereby collecting data that can be analysed to provide post-disaster re-organisation (Thomas and Kopzack 2005). Often such ideals cannot be met during floods that disrupt communications and isolate many communities.

One of the best ways to adapt to climate change is to involve people at the grass-roots level. South Asian people are enterprising and innovative and those on floodplains and deltas have lived with disasters for a long time. It is important to help them understand the likely new dangers of changed flood regimes and peak river heights. This will enable them to develop new forms of adaptation and to modify existing practices.

As indicated earlier, many structural measures, particularly the embankment and associated weirs and sluice gates will have to be changed to avoid excessive waterlogging. Quick drainage facilities to relieve drainage congestion can efficiently alleviate hardship in chronically flood-prone areas. A North

Bihar scheme, involving the local community, includes restoration of existing sluice gates and connected works, provision of additional drainage openings and improvement of approach and outfall channels in the sluices. It is also important to flood-proof civic amenities to minimize the adverse effects of floods in the daily life of their victims (Ghani 2002). Future climate change and sea level rise will alter the situation, requiring a national level response (Table 3), in collaboration with local communities to revise the number of raised platforms and emergency shelters required (Ali 1999).

In terms of food security, future responses to disaster should not only ensure that food reaches the vulnerable at times of disaster, but also attend to the nutritional needs of the victims on a long-term basis. Usually the immediate response is effective, despite many victims complaining of delays in receiving assistance. However, undernourishment and malnutrition prevail long after the disasters occur. Victims need help to acquire adequate and balanced diets. In this context the role of women is particularly important, both for themselves and for their children (Singh 2002).

To enjoy sustained health and strong recovery children need to be in better health prior to the crisis. They have to enjoy both regular and post-disaster food security. Intervention intended to reduce the prevalence of malnutrition in general also provides resources for individuals to overcome temporary food shortages. While large government programmes helping flood exposed households with small children might help children cope better with the crisis, it is better to recognize that small children need to be healthy and strong in order to be able to cope with the stresses that flooding brings. Future responses (Table 3) have to increase resilience, reliability of emergency relief systems, and the effectiveness of communications about needs and life-threatening situations. Apparently intractable problems, such as helping people occupying highly vulnerable chars, have to be solved. Managing emergency food supplies and ensuring long-term food security and nutrition have to go hand in hand.

Other longer-term local proactive responses include changing the way food is grown (Table 3). Adapting to changing situations is a familiar traditional practice in Bangladesh. At Deara, a village in the coastal area of southern Bangladesh, one of the poorest and most vulnerable places on Earth, people grow tomatoes, peppers and other vegetables hydroponically. The plants grow out of balls of organic matter floating in 13 by 1.3 metre flooded plots amongst tangles of water hyacinth. This project is part of efforts by the Bangladesh and UK governments to prepare communities for climate change and both present and future disasters.

Major contrasts exist in responses between urban and rural areas. The greatest difference between solutions to food and nutrition insecurity in rural and urban areas is probably that in rural areas development can often be addressed through broad-brush interventions affecting agriculture, which drives the rural economy. While agricultural growth may also help to reduce urban food insecurity, the income sources in urban areas are more diverse, as are underlying causes and actors in the urban environment. Urban people rely largely on food from sources outside their towns and cities. Urban and peri-urban agriculture can help alleviate food shortages, if suitable land is available. Future town planning and land use regulation may seek to have key areas for urban food growing. Urban industries may enable food from foreign sources to be purchased and stored to help the reliability of supplies during and immediately after floods. Effective policies and programmes need holistic responses (Table 3) coordinating actions across actors and levels: from the household (raising incomes, for example), to the community (encouraging local food gardens), to far beyond (to government promotion of strategic food stocks and export industries to facilitate food imports). The most effective, relevant

policies will emerge from good governance linking the needs of the poor to a politically responsive local government that has the technical and institutional capacity to act. Programmes should improve the ability of the poor to organize, make demands, and influence local authorities and also strengthen local government's understanding of its responsibility to respond (Garrett 2000).

Conclusions

Climate change is likely to aggravate the existing severe flood problems in South Asia. The onset and intensity of the monsoon is highly likely to become more variable. The timing of peak flows in major rivers may change, affecting the way in which they combine to create flood peaks in deltaic areas. Sea level rise will increase flood heights in deltas and cause saline water to penetrate further inland.

Temperature rises and increased greenhouse gases in the atmosphere will affect crop growth and yields. Higher temperatures and changed water regimes are likely to more than offset any increased yield due to higher atmospheric CO₂ levels. Food crops probably will be increasingly disrupted by variation in the onset of the monsoon, the duration and frequency of floods and droughts and vector-borne diseases and pest infestations.

Croplands in presently flooded areas are likely to remain wetter for longer and additional land will be inundated in the worst floods due to increased river heights and rising sea levels. Crop damage and unemployment caused by floods are likely to make many people highly vulnerable to starvation or malnutrition.

Present emergency responses are sound, in that international organisations and NGOs, governments and communities have emergency relief systems that aim to bring food supplies to flood-affected people. However, in both rural and urban areas there are groups and localities that do not get the help they need. In many cases rural communities suffer through lack of boats and emergency shelters. In the towns, food price rises leave the poorest families eating only once a day and buying only the cheapest food, with consequent child malnutrition, which affects long-term growth and health.

The low nutritional levels of poor people in Bangladesh and some other parts of South Asia influence their ability to recover from floods and the survival and growth prospects of their children. At the same time, weaknesses in the food distribution system create difficulties for the poor that at times seem avoidable. The weaknesses can be institutional, such as gender bias in local food allocation; structural, in terms of the loss of food through wastage between farm, market and domestic consumer; or economic, in terms of price increases at times of disaster. The many instances of

lack of coordination between agencies, between government departments, between urban and rural strategies and plans, and probably between official and non-governmental emergency relief, tend to further aggravate the difficulties of achieving a high level of food security.

Immediate changes to responses should aim to meet the needs of people more locally and to ensure parity of distribution among the needy. Governments have begun to act to keep food prices stable, but the problem of malnutrition during and after floods remains. Strengthening the resilience of local communities through local emergency food stocks, local shelter and evacuation plans by supporting local community groups and ensuring good local government is important.

Just as future floods cannot be predicted on the basis of past flood events, neither can the provision of future food security rely solely on refinement of past practices. Novel means of food production, processing, storage and delivery are required. Confronting the problem of a growing population on less and less arable land, in the face of greater and longer flooding, coastal erosion, increased salinity and urban expansion will pose real challenges for innovation, not only in achieving higher yields from existing crops, but in finding alternative crops, perhaps using horticulture, hydroponics and aquatic plants.

Longer term responses involve better flood preparedness and preparation, including changes to and strengthening of structural works, but also, and, in some cases, preferably more localized provision of raised shelters, flood proofing of buildings and better warning and emergency evacuation procedures. Care has to be taken to ensure that any structural flood protection works do not have adverse effects on farmland by impeding local drainage. New ways of growing crops and storing food are required. Plans have to be integrated at all levels from national government to local communities. International aid has not only to be a rapid disaster response, but also a long-term capacity building and strengthening of flood preparedness, not just through government strategic plans, but by giving communities the resilience to adapt to and cope with the challenge to deal with climate changes that are not of their own making. The international community, particularly in the countries with highest per capita greenhouse gas emissions, has to acknowledge its contribution to climate change-driven flood-induced hunger in South Asian deltas: a consequence of high past and present rates of fossil fuel consumption.

The many present examples of good practice, of community mutual support, of effective emergency food delivery, of efficient infrastructure establishment and operation, and of household and community level emergency adaptation strategies, reassure any observer that food security can be enhanced and adapted to climate change. What is less certain is that the international partners, the

national decision-makers, the local politicians, officials and community leaders, as well as those who control the flows and prices of food will have sufficient altruism, generosity and concern for others, to make things work to alleviate the plight of both the urban and the rural poor. Women are still suffering more than men during floods. Positive steps have to be taken to lessen their suffering and improve their health for both their own sakes and for their children. Failure to meet the needs of the women and the poor may lead to increasing social disruption and conflict.

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