Soilless Cultivation for Landless People: An Alternative Livelihood Practice through Indigenous Hydroponic Agriculture in Flood-prone Bangladesh

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Abstract

Due to multidimensional manifestations of climate change, along with different social and economic problems, Bangladesh is facing many challenges in achieving sustainable development. Since some parts of Bangladesh remain flooded for a prolonged period of the year, agriculture is the hardest hit and this in turn has a serious impact upon the lives of the farming population, which also leads to the loss of farming hands who have been the mainstay of a largely agricultural economy. In this scenario, alternative farming practices like hydroponics agriculture hold great promise. Farmers can use their submerged lands for crop production by adopting scientific methods like hydroponic agricultural practice, or floating agriculture, where plants can be grown on the water in a bio-land or floating bed of water-hyacinth, algae and other plant residues. Moreover, this is not a new practice in Bangladesh, and has origins in the traditional practices of our forebears, though the scientific component is a later addition. The awareness of possible benefits and suitability of this practice, however, is still very low among Bangladeshi farmers.

Keywords: adaptation, alternative farming practices, hydroponics, sustainable development.

Introduction

Today, the world is facing many threats arising from human-induced changes in nature's systems. Global warming, which is probably the most widely known of these changes, causes the sea level to rise as a result of ice melting at the poles, and a subsequent increase in the volume of sea water. There is widespread debate on exactly how far the sea level will rise in the near future, but it is clear that there are some places in the world where the sea level has already risen and affected people's lifestyles. Further, a warming planet will most probably have more frequent flash floods, intensive tropical storms, and rainfall (Lynas 2008). Bangladesh, with a population of roughly 150 million people (Central Intelligence Agency 2009), is one country that is these days witnessing large-scale natural disasters. It is situated on low land, to the east of the Indian Peninsula, and it is criss-crossed by more than 230 rivers and their tributaries (Islam and Sultan-Ul-Islam 2006: 589). The Ganges, the Brahmaputra, and the Meghna are Bangladesh's three major rivers, which “drain a combined catchment of some 1.55 million square kilometers, 11 times greater than the area of Bangladesh itself” (Thompson and Sultana 1996: 1).

The southern part of the country consists of coastal lowland and mangrove areas, formed by the delta of large river systems. Bangladesh is an agriculture-based developing country where the poor people depend on agriculture for their livelihood. This country today faces the multidimensional effects of climate change in the forms of flood, cyclone, rising sea levels, drainage congestion, salinity in freshwater systems, and so on. Burdened by socioeconomic problems such as a high rate of unemployment, low income per capita, and low levels of literacy, it also faces many challenges in achieving sustainable development, so that natural disasters have significant impacts. First, such events lead to the collapse of standard agricultural practices in vast areas, thereby depriving people of their livelihood. Second, because the country is poor, the government has little ability to provide relief to all the people who are affected. Therefore, the people are not only affected temporarily, but also for years afterwards following a single disaster. It is easy to see that if this country is regularly threatened by natural disasters caused by human impacts on nature, it will create a huge worldwide problem.

Statement of the Problem

Recently, devastating cyclones arriving from the Bay of Bengal and torrential rains – often continuing for days at a stretch and flooding vast areas as a consequence – are just some of the calamities that have ravaged Bangladesh. Flooding is a recurrent problem in Bangladesh, and has been a constant feature of this country’s natural phenomena over the years. However, recent floods have had a much more catastrophic effect on the population than in past years. A rise in the frequency of flood occurrence has been attributed to global warming, and the large-scale climate change that is being wrought as a result (IPCC 2001; IFRC 1999 cited in Uyigue and Agho 2007; Pender 2008). With the increasing frequency of flooding in Bangladesh, a greater proportion of the population is being affected each year, with a sizeable number of them being poor. There have been flood mitigation measures, but most have been ineffective, due to the socioeconomic conditions that prevail in the country. Since some parts of Bangladesh remain flooded for a prolonged period of the year, agriculture is the hardest hit, which has a serious impact on the lives of the farming population. Farming families often end up migrating closer to urban areas, which results in overcrowding of those areas, and gives rise to social instability and other problems (Integrated Regional Information Networks [IRIN] 2007). At the same time, Bangladesh is steadily losing the farmers who have been the mainstay of what is a largely agricultural economy. In this scenario, alternative farming practices, such as indigenous hydroponics, hold great promise.

This article explores the benefits and suitability of the indigenous practice of hydroponics, and how it can be a means of sustainable development if it is implemented correctly in areas where people are landless. In addition, it tries to lay some guiding markers indicating how this practice can be expanded for the benefit of those landless farmers affected by global-scale catastrophes.

Analyzing the Flood Phenomenon of Bangladesh

In Bangladesh people generally use two terminologies to explain the extent of flooding and its consequences on their socio-economic lives. The first one is *borsha*, a normal flood equating with the monsoon rains occurring between *ashar* (June) and *kartik* (October). In Bangladesh, a normal flood is considered a part of daily life, even though it may cause damage to crops and properties (Brammer 1990b: 164, cited in Paul and Rashid 1993). It is also considered a blessing for agriculture, given the fact that floodwater provides moisture and nutrients which eventually make the land more fertile for cultivation (Brammer 1990b: 164, cited in Paul and Rashid 1993).

The second one is *bonna*, an abnormal flood, which occurs once every few years and is considered undesirable as it causes massive loss of life and property (Islam 1980; Alam 1990, cited in Paul and Rashid 1993). Paul and Rashid (1993) find that "although the people of Bangladesh have evolved numerous adaptive strategies to benefit from normal flooding, an abnormal one surpasses their ability to adjust therefore the flood has some effects on environment, economy and on both individual and social levels".

In Bangladesh generally four main types of floods occur: flash floods, riverine floods, rain floods and storm-surge floods (MPO 1987; FEC 1989; Mirza 1997, cited in Mirza 2002). Many scholars have also classified the floods in Bangladesh in terms of the extent of inundation, respective return periods, and the level of physical damage (ibid).

Flash floods generally occur in the eastern and northern rivers along the borders, whereas riverine floods generally rise and fall slowly over 10–20 days or more from the overflow of major rivers and their tributaries and distributaries (MPO 1987; FEC 1989; Mirza 1997 cited in Mirza 2002). Rain floods, on the other hand are the result of high intensity local rainfall of long duration in the monsoon season, and storm surge floods are generated by tropical cyclones and mainly occur in the coastal area of Bangladesh (ibid). Storm surge floods are responsible for extensive damage to property and loss of life in coastal areas (ibid).

Impact of Floods on Bangladesh

Bangladesh suffers from flooding almost every year to a small or large extent, and in the case of the years with small-scale flooding, the losses have not been assessed properly, but for those years with large-scale flooding, different institutes try to assess the loss from their perspective (Mirza and Ahmad 2005). Monetary losses from floods are constant realities in Bangladesh. Flood damages physical structures such as dwellings, roads, bridges, embankments, and on the other hand it also has an impact on livestock as well as on the agriculture and fishery sectors. These losses have a direct impact on the national economy and on capital stock, which restricts the growth potential of the country. However, the government also needs to invest money to recover these losses. An overall estimation of flood loss can be seen in Table 1 below.

Table 1: Adverse Impacts of Major Floods during the last 50 years

Event	**Impact**
1954 floods	Affected 55% of country
1974 flood	Moderately severe, over 2,000 deaths, affected 58% of country, followed by famine with over 30,000 deaths
1984 flood	Inundated 52,520 sq. km, estimated damage US$378 million
1987 floods	Inundated over 50,000 sq. km, estimated damage US$1.0 billion, 2,055 deaths
1988 floods	Inundated 61% of the country, estimated damage US$1.2 billion, rendered more than 45 million homeless, between 2,000 and 6,500 deaths
1998 floods	Inundated nearly 100,000 sq. km, estimated damage US$2.8 billion, rendered 30 million people homeless, damaged 500,000 homes, heavy loss of infrastructure, 1,100 deaths
2004 floods	Inundated 38% of country, estimated damage US$6.6 billion, affected nearly 3.8 million people, 700 deaths
2007 floods	Inundated 32,000 sq. km, estimated damage over US$1 billion, over 85,000 houses destroyed and almost 1 million damaged, approximately 1.2 million acres of crops destroyed or partially damaged, 649 deaths

Source: Bangladesh Ministry of Environment and Forests 2005; cited in Rahman et al. 2007.

Flood has a great effect on the agricultural sector, because it inflicts huge damage to the production of food grain in Bangladesh. The extent to which floods affect the agricultural sector is demonstrated in Table 2, which shows the damage to food grains caused by flooding.

Table 2: Damage to Food Grains in Bangladesh Due to Floods (selected recent years)

Year	**Damage (thousands of metric tons)**	**Year**	**Damage (thousands of metric tons)**
1963	62	1974	2000
1964	640	1976	1050
1968	1400	1980	500
1970	1900	1984	925
1971	1150	1987	800
1972	335	1988	2500
1973	1500	1998	3400

Source: Hofer and Messerli 1994 (for floods 1963–1988 inclusive). The 1998 flood's figure is the author's estimate based on relevant data obtained from the Local Government Engineering Department (LGED) and other sources, cited in Ahmad and Ahmed 2003.

Flood also has a severe impact on the environment in Bangladesh, affecting both the rural and urban environment. In rural Bangladesh floods cause riverbank and soil erosion, waterlogging, and destruction of trees, as well as causing water contamination, leading to associated health risks. Following a flood, everything is submerged beneath muddy floodwaters, with the mud covering all the paddies and vegetable fields, and inundating many tubewells. Health risks arise as a result of damage to sanitary latrines and a scarcity of safe drinking water, and a number of waterborne diseases, such as diarrhea, cholera, and various skin diseases, spread rapidly among the affected population, with nutrition scientists fearful that maternal and child malnutrition may develop as an immediate after-effect of the floods.

The ultimate threat, however, is to urban structure, because each day a stream of migrants from flood-affected areas arrive in their nearest urban area. There are no exact figures on the number of flood-affected people migrating to Dhaka (the capital of Bangladesh), which is already over-populated with 11 million inhabitants, but current estimates place their numbers at around 3,000 per day (IRIN 2007).

Current Steps Being Taken against Floods

In Bangladesh, floods are managed using both structural and nonstructural strategies. Different hydraulic structures, such as building embankments, reservoirs, dams, groynes, spurs, etc., are the most common structural strategies. On the other hand, nonstructural strategies involve land-use management, flood forecasting and early warning systems, public information and education, identification of evacuation and relocation sites, flood risk mapping, and so forth.

But in a world of more frequent natural disaster, mitigation and adaptation is required in the food and agriculture sector (Food Agriculture Organization [FAO] 2008). In this regard, multiple pathways comprised of both short-term and long-term adaptive measures is needed to improve adaptive responses (Baas and Ramasamy 2008). From the historic past, people involved in the agriculture sector are showing different autonomous adaptation techniques to cope with the inconsistency of climate change (FAO 2008). For example, the Aztecs of Central America, when banished to marshy lands, created floating beds on rafts by tying them with reeds and placing dredged nutrient-rich soil on top that was acquired from the lakebed. They had to innovate this new method as they could not farm with their existing techniques (Werner 1992). In many ways, the situation in Bangladesh today is similar. Due to poor socioeconomic conditions prevailing in the country, the government's flood mitigation steps have proved inadequate to fight against natural disasters. To cope with this situation the people of Bangladesh have developed different adaptation techniques, and floating cultivation is one of them.

Floating Cultivation in Bangladesh

In some parts of Bangladesh most affected by flood and where water remains for a prolonged period of time, farmers are using their submerged lands for crop production by adopting scientific methods which are similar to hydroponic agriculture practices, i.e. floating agriculture, whereby plants can be grown on the water in a bio-land or floating bed of water hyacinth, algae or other plant residues.

Around the 1920s and 1930s, Dr. W. E. Gericke of California University coined the term "hydroponics", which usually means the technique of cultivating plants without the use of soil, employing an inert medium, for example gravel, sand, perlite, vermiculite, clay pebbles, etc., and adding a nutrient solution comprising the essential elements needed by a plant in order to grow and develop (Winterborne 2005: 179). However, the concept of growing plants without soil started with the mythical Hanging Gardens of Babylon, followed by the Aztecs' *chinampas* in Mexico, and the raised or drained fields of the pre-Columbian civilizations of the Americas (Winterborne 2005; Islam and Atkins 2007). The commercial use of hydroponics started after 1945 in the US, and from 1950 the practice expanded throughout the world to countries such as Italy, Spain, France, England, Germany, Sweden, the former Soviet Union, and Israel (Winterborne 2005). In Asia, this practice is used in Lake Inle in south-eastern Burma, the Tonle Sap in Cambodia, Kashmir in India, and some parts of Bangladesh, but in different, traditional ways (Haq et al. 2002).

Moreover, this is not a new practice in Bangladesh; it has traditional roots in practices dating back to the country's forbearers, although the scientific component is a recent addition. According to their needs, people in different parts of Bangladesh have adopted, modified and named this practice differently (Asia-Pacific Environmental Innovation Strategies [APEIS] 2004; Islam and Atkins 2007; Irfanullah et al. 2007), such as *baira*, *boor*, *dhap*, *gathua*, *gatoni*, *geto*, *kandi* and *vasoman chash* and floating agriculture; all these names represent this same traditional cultivation practice that can be scientifically referred to as hydroponics. Actually, this practice is most successful in the coastal areas that are adjacent to the sea-bank areas, which remain submerged for long periods, especially in the monsoon season, as well as the wetland Haor Areas (flat lowland spreading across the middle of the Meghna River basin) (Yoshitani et al. 2007), which also remain flooded for long periods. A selection of hydroponics projects being run by various internal and external organizations are listed in Table 3 below.

Table 3: Hydroponics Projects in Bangladesh

Project	Location
Research on Innovative and Strategic Policy Options (RIPSO) by APEIS	Gopalgonj (Southern Region)
Baira project under Strengthening Household Abilities for Responding to Development Opportunities (SHOUHARDO) program of CARE Bangladesh, funded by USAID	Habigang District (Northeast Region)
Wetland Resource Development Society (WRDS) program under the project of Reducing Vulnerability to Climate Change (CARE-RVCC), funded by Canadian International Development Agency (CIDA).	Chandra (Southwest Region)
Adaptation to Climate Change in Bangladesh by Practical Action	Gaibandha (Northwest Region)

Source: Author

Floating cultivation procedures in Bangladesh

In Bangladesh when most of the lands become flooded during monsoons, farmers practice floating cultivation in their submerged lands. The procedure of making the floating bed is usually the same, however the size, shape and local materials vary from region to region (Islam and Atkins 2007; APEIS 2004). Various local materials are used to build the floating layers. The most commonly used material is water hyacinth (*Eichhornia crassipes*), but topapana (*Pista stratiotes*), son ghash (*Imperata cylindrica*), noll ghash (*Hamerthria protensa*), wood ash, and dissected coconut fibers are also used (Islam and Atkins 2007: 131). In May and July, water hyacinth is gathered from rivers nearby, known as *khals* (canals) and from other water bodies where it can be found (APEIS 2004: 2). The collection of the water hyacinth probably starts four or five weeks before the platform preparation (Irfanullah et al. 2007).

After collecting water hyacinth, bamboo is laid on a dense layer of water hyacinth to enable people to stand on it, and then more water hyacinth is piled on top to make it compact. The bed must then be left for several days to decompose before it is ready for cultivation. The eventual thickness depends on the duration of waterlogging, for it must be able to float during that time. To accelerate the process, the previous year's decomposed bed or raft can be used. "The average length of the freshly prepared platforms was 4.6m, width 1.4m and height 1.1m. The height decreased significantly to about 0.5m after 2–3 weeks, when the platform had rotted and was ready to cultivate" (Irfanullah et al. 2007). The structure of the floating raft is strengthened with bamboo, and bamboo poles are used to fix it in position to avoid damage due to wave action or drifting. Sometimes, taro is planted along the edge, as it has a dense root system (Irfanullah et al. 2007).

The farmers also practice floating cultivation during winter times as well as the monsoon season (mainly during June to August). The list below outlines those crops and vegetables suitable for floating bed cultivation.

Table 4: Monsoon and Winter Crops

Monsoon Crops	Winter Crops
cucumber	bottle gourd
ridged gourd	yard long bean
bitter gourd	bean
snake gourd	tomato
wax gourd	potato
amaranth	cauliflower
red amaranth	cabbage
lady's fingers (okra)	kohlrabi
eggplant (brinjal)	turnip
pumpkin	radish
Indian spinach	carrot
taro	ginger
turmeric	onion
	chilli
	garlic

The benefits of floating cultivation

Being an overpopulated country, Bangladesh can ill afford to remain dependent on its ever-shrinking areas of arable land to feed the population. Floating cultivation can help to mitigate this situation and reduce the pressure on arable lands by turning the flooded and waterlogged areas into productive ones (Haq et al. 2004).

Further, floating cultivation does not need any additional water, nutrients, or chemical fertilizers, and the beds can be recycled as organic fertilizer in the newly prepared floating bed and also in the agricultural fields, which is economical as well as environmentally friendly.

As floating beds are mostly made of water hyacinth, a very invasive weed that doubles in area every week or two, they provide a means of using it in a beneficial way, reducing breeding grounds for mosquitoes, lessening the reduction in the carrying capacity of the water body that occurs when the weed breaks down the drainage system, and also having a positive impact on open-water fishing (Haq et al. 2004). Because it allows better control over this plant, some researchers have noted the greater productivity of floating bed practices compared with traditional land-based agriculture (Haq et al. 2004).

This cultivation practice helps to supplement people's income, which contributes towards the alleviation of poverty, and provides greater food security by increasing the landholding capacity of poor as well as landless people by allowing them to grow vegetables and crops with lower input costs, due to the minimal infrastructure required (Irfanullah et al. 2007).

The floating-bed technique also has some positive social impacts. It involves both men and women, thereby improving the gender balance, as well as people's perception of particular areas as suitable places to live. People who are practicing floating-bed cultivation are enjoying a better life economically, than those in other flood-affected areas who have not yet adopted this practice.

Drawbacks
Every approach has some drawbacks, and floating-bed cultivation is no exception. Insect and rodent infestation, as well as ducks and other animals, can cause damage to the crops grown on floating beds (APEIS 2004; "Floating Gardens in Bangladesh" 2006; Irfanullah et al. 2007). Further, large waves can cause the beds to drift, increasing the possibility of damage to both the seed as well as the raft. Scarcity of the materials required for the construction of the floating beds sometimes creates problems. Wherever floating-bed cultivation is practiced in common property areas, there is the possibility of conflict, because "the local elites and politically powerful people will try to capture those areas" (Islam and Atkins 2007: 134).

A Background to Sustainable Development

Development can be measured in many ways, from economic indicators and scientific and technological progress through to improved lifestyle, literacy, and social stability. For a long time, development that saw the countryside being transformed into cities was the most popular measure of economic development, but as we have seen in recent times, this form of growth has led to numerous significant problems; the environment is in deep trouble, people in many parts of the world still fight for two meals a day, and war and diseases continue to claim millions of lives. Environmental hazards in the developing world are essentially unresolved development problems, and hazard reduction has become an important dimension of development within sustainable limits (Chan and Parker 1996: 313). As cited by Chan and Parker (1996: 313), according to the United Nations (1994) and Burton et al. (1993), "[t]he increasing occurrence of disasters throughout the world is a commonly identified indicator of non-sustainable development." Therefore, many scholars say there is a need to view development in an alternative way, a need to seek a more holistic approach to the concept, rather than concentrating on economic indicators alone. For example, the World Development Report of 2008 bears the title *Agriculture for Development*. This does not mean a journey back to the primitive ages, but rather, acknowledges that billions of people are still mainly dependent on agriculture for survival, especially those in developing countries, mainly on the two continents of Asia and Africa. Without societies achieving a better standard of living, development loses much of its significance.

Though sustainable development is an elusive concept, it is achievable; otherwise the enormous amount of study on sustainable development would not be happening. There seems to be no general agreement regarding a definition of the concept of sustainable development (Yeh 1999). To achieve sustainable development, there must be integration of the concept of sustainable development from different sectors, enterprises, and organizational units, at all levels. Sustainable development can be subdivided into "sustainable agriculture," "sustainable forestry," "sustainable fishing," "sustainable community," and so on. If we consider the agriculture sector, sustainable agriculture, according to the United States Department of Agriculture (USDA) (2008), is "an integrated system of plant and animal production practices having a site-specific application that will, over the long-term: (a) satisfy human food and fiber needs; (b) enhance environmental quality and the natural resource base upon which the agricultural economy depends; (c) make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls; (d) sustain the economic viability of farm operations; and (e) enhance the quality of life for farmers and society as a whole."

Although the poor may develop hazard-adaptation practices to limit their vulnerability to disasters, poverty is generally believed to heighten such vulnerability. Poverty reduction and policies designed to nurture hazard resistance amongst the poor are, therefore, important for sustainable development. As the Bruntland Commission reports: "The essential needs of vast numbers of people in developing countries…are not being met…A world in which poverty and inequity are endemic will always be prone to ecological and other crises" (World Commission on Environment and Development [WCED] 1987).

The Link of Floating Cultivation with Sustainable Development

How is this indigenous hydroponic agriculture i.e. floating cultivation of Bangladesh sustainable? This article, by analyzing the structural factors, necessities, and processes related to hydroponic agriculture, argues that in the context of present day Bangladesh, it can be utilized as a sustainable farming practice in flooded and waterlogged areas, having reached the following conclusions. Hydroponic agriculture:

- Generates income for the rural poor, and stability in their lives.
- Requires minimal infrastructure and very little capital.
- Needs much less water and nutrients than conventional soil-based agriculture.
- Involves the participation of administrative, policy-making, and local bodies.
- Encourages multilateral dialogue on governance by putting local people first.

In a broad consensus, the incorporation of environmental, social, and economic factors should be the vision or practice of any sustainable concept though a comprehensive list of factors or indicators are available to assess the sustainability (vanLoon et al. 2005). According to McGlade (2007: xx), the objectives of sustainable development are "economic prosperity, social well-being, and environmental recovery and protection." The dimensions of floating cultivation can also be explored using the sustainability tripod, i.e. environmental, social, and economic dimensions which are given below:

Table 5: Sustainability Tripod

Environment	Society	Economic
- No chemical fertilizer - Needs less water and nutrients - Nutrients are recycled - Weed control - Use of local resources	- Food security - Empowerment - Female employment - Capacity building	- Income generation - Lower Input Cost - Minimum infrastructure

Concluding Remarks

Over the flat, deltaic country of Bangladesh, monsoon-generated flooding covers an estimated 20 per cent of the total land area, and very severe floods may cover as much as half of the country (Rogers et al. 1989; cited in Smith 2001: 262). Significant changes in the extent and depth of this inundation may occur in future. Greater changes in inundation are further expected with small temperature increases. Alterations to land inundation patterns may introduce substantial changes in agricultural activities (Mirza 2002). Hence, adaptation as well as capacity building is required in the agricultural sector to strengthen flood management policies and adaptation measures in Bangladesh (Mirza 2002). Therefore, indigenous hydroponics is a viable practice in a flood-prone country like Bangladesh, which will most probably have less and less land available to feed its people from now on as sea levels rise. It is a very low-impact practice, using minimal infrastructure. It is pro-environment, suitable for use by poor people, and its practice can be expanded in cases of extreme climatic events. However, more research is needed to discover the specific parameters of sustainability in this practice. At present, popular acceptance of this practice is still at a very low level, due to the low environmental awareness and low literacy levels of the Bangladeshi population. There are also governance-related issues. The government is probably unable to bring in sweeping changes alone, therefore increased government–society or government–NGO cooperation, along with community-based development measures, need to be employed that are focused on this concept. The key to sustainable development is providing access to all in an equitable manner. Unless social equity is achieved, implementing this practice in a sustainable manner will remain a distant dream.

With such attributes, the practice of indigenous hydroponics in a flood-prone country like Bangladesh stands to deliver significant benefits in extremely vulnerable areas which is also an effort towards strengthening understanding of indigenous knowledge along the lines of the Institute for Global Environmental Strategies (IGES) white paper (2008), that suggested that developing countries should emphasize their indigenous knowledge and local coping strategies and use them in local adaptation plans (IGES 2008). In future, it could become an effective agricultural practice in the face of the increasing incidence of catastrophic flooding as a result of global warming, and could provide a model for other regions with similar problems. It could also lead to more sustainable use of natural materials, not only in flood-prone areas, thereby proving that people can sustain an economically viable society in collaboration with nature.

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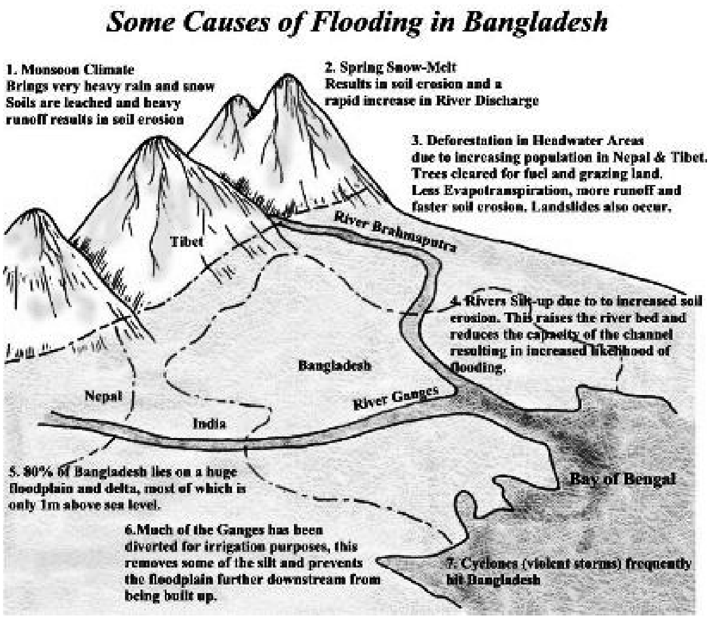
Appendix

Figure 1: Causes of flooding in Bangladesh



Source: http://www.geobytesgcse.blogspot.com (accessed 11 November 2007)