

# Floods in megacity environments: vulnerability and coping strategies of slum dwellers in Dhaka/Bangladesh

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**Abstract** In many megacities of the global south, the combination of rapid population growth and high pressure on space for housing, results in urban growth taking place in areas particularly prone to natural hazards. Dhaka, the capital of Bangladesh, is no exception to this rule. Many marginal settlements or slums are located on low-lying land at high risk of flooding. This paper analyzes the vulnerability of slum dwellers in Dhaka and highlights the major factors behind their sensitivity to floods and their ability to adapt to the related changes. The empirical findings presented are based on a questionnaire survey covering 625 households in five slum areas of Dhaka. Our data suggests that social capital plays an important role with regard to the ability of slum dwellers to find ways to live with the floods. Regardless of how strongly people are affected, mutual help and support are dominant features in times of crises. While poorly educated and resourced slum dwellers are highly vulnerable to external shocks, they still show a surprising capacity to cope with natural calamities.

**Keywords** Flood · Vulnerability · Coping · Adaptation · Slums · Megacities · Dhaka

## 1 Introduction

Rapid urbanization—especially the growth of megacities—does not only pose a tremendous challenge for urban planners regarding the provision of urban infrastructure systems, such as water supply, sanitation and transport, it also puts an increasing number of people at risk of falling victims to natural hazards. Megacities in developing countries do not only suffer from insufficient financial means and a lack of infrastructure, they also bear a substantial share of the global growth of urban population (Kraas 2007; Uitto 1998). Due to lack of housing space people are forced to settle in high risk areas. Especially poor people, migrants, refugees, and people in search for work will be driven to those areas and forced to settle in newly evolving, informal, marginal settlements (termed “slums” in South

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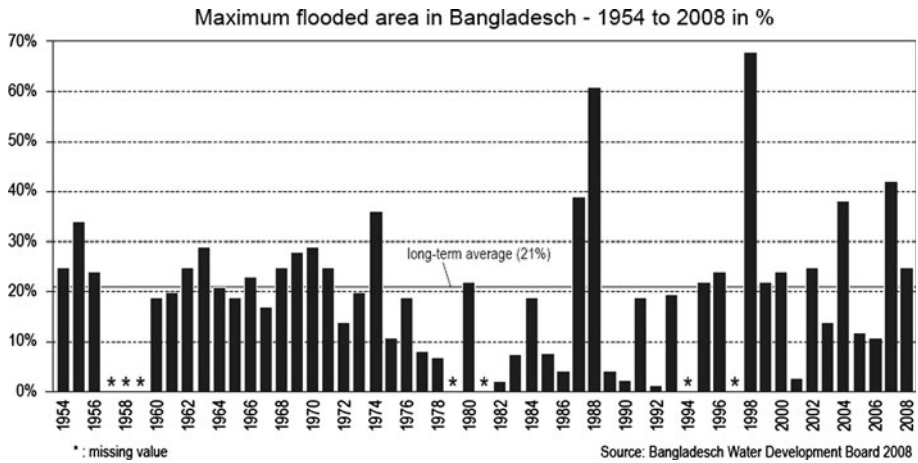
Asia). Overpopulation associated with weak infrastructure and low livelihoods make poor slum dwellers highly vulnerable to the consequences of natural hazards. However, many slum dwellers also show a surprisingly high capacity to cope with disaster and to recover relatively quickly when hit by a natural extreme event.

One prominent example for a disaster-prone megacity is Dhaka, the capital of Bangladesh. Dhaka is situated in the delta of the Ganges–Brahmaputra–Meghna system and is regularly subjected to flooding (Ahmed and Falk 2008; Gain et al. 1998; Huq 1999; Nizamuddin 2001). More than one-third of Greater Dhaka's population of about 14 million lives in marginal settlements (Centre for Urban Studies et al. 2006). The situation of slum dwellers is likely to deteriorate not only by effects of climate change and widespread land-use changes that might lead to more frequent, higher and longer lasting floods (IPCC 2007), but also because Dhaka is still one of the fastest growing megacities in the world (Islam 2005a). Most of the urban poor are forced to live in marginal settlements in extremely flood-prone areas.

The aim of this paper is to analyze the hardship residents of Dhaka's slums are facing as a result of floods and to highlight the key factors influencing their vulnerability. In this context vulnerability is conceptualized in accordance with Turner et al.'s definition of vulnerability. According to Turner et al. (2003), the vulnerability of an individual or a system depends on three main factors: the level of exposure, the sensitivity of an individual or system and the ability to cope with an event. All three factors are closely related to socio-economic conditions. As slum dwellers in Dhaka are subject to frequent floods and their livelihoods are often exceptionally weak, their socio-economic conditions are poor and consecutively their vulnerability is rather high. However, as our research demonstrates, Dhaka's slum dwellers were still able to cope with the effects of the extreme flood events of 1998 and 2004 despite their vulnerable situation. Against this background, our paper aims to explore the crucial factors that determine vulnerability and resilience on the household level.

## 2 Flood hazards and booming urbanization

Floods in Bangladesh are both a blessing and a curse. "Normal" floods—when water inundates up to one-fifth of the countries' surface area—are essential for replenishing groundwater levels, to fertilize fields by depositing fine sediments and to kill pests. These effects are crucial for the country's agriculture. However, if more than 20% of the land surface is inundated, the water destroys the harvest, damages houses and creates huge social and economic hardship (Braun and Shoeb 2008). The most memorable incidents of severe flooding in the recent past occurred in 1988 and 1998 when 61 and 68%, respectively, of the land surface were under water (Fig. 1). As a response to the disastrous event of 1988 a Flood Action Plan (FAP) was implemented in Dhaka, so that the capital city is now much better protected than most other parts of the country. The building of a new embankment in particular has significantly improved the situation for the western parts of the city. However, despite these measures, Dhaka remains at risk of flooding. Each of the more recent floods in Bangladesh (1987, 1988, 1998, 2004, 2007, 2008) also had severe effects on Dhaka (Alam and Rabbani 2007; Islam 2005b, 2006; Stalenberg and Vrijling 2009). Rashid (2000), for instance, reports that in 1998 many streets and market places were completely flooded. Continuous precipitation fell on already over-saturated grounds. The sewage systems were blocked and stagnating water created health hazards, stench and



**Fig. 1** Maximum flooded area in Bangladesh from 1954 to 2008 (in percent). *Source* Bangladesh Water Development Board 2008

breeding places for mosquitoes. The drinking water was severely contaminated, making it difficult to prepare meals or to continue work.

Rapid population growth forces more and more people to settle in areas susceptible to natural hazards, e.g. in unprotected wetlands or areas close to rivers and water bodies (Burkart et al. 2008). Analyses by Dewan and Yamaguchi (2008) show that between 1975 and 2005, water bodies as well as low-lying agricultural lands have been transformed into built-up areas at a substantial rate. The latter grew by 270% between 1975 and 2005, while water bodies, wetlands, lowlands and agricultural lands are constantly shrinking. Especially poor people, with limited financial means, tend to settle in high-risk areas. Due to many evictions of slum dwellers by the government since 2002 most slums in Dhaka are now on private land, very often on land that is destined for further development (mostly multi-storey apartment buildings). Slum dwellers in those areas are dependent on mostly informal arrangements with their landlords and have no security of tenure.

In the future, two factors might further increase the hardship caused by recurrent floods in Dhaka. Firstly, due to climate change, floods could occur more often and with a higher magnitude (IPCC 2007). Secondly, if Dhaka's annual growth rate continues to remain above the 2.5% mark until 2025 as predicted by the United Nations (United Nations 2008), then Greater Dhaka's population would increase by about 500,000 people per year and reach a total population of about 22 million by 2025. A recent study on urban slums in Bangladesh concluded that the population in slums and informal settlements in Dhaka will continue to increase significantly (Centre for Urban Studies et al. 2006). This creates a rather gloomy scenario for the future, given the high likelihood of the new slums to be located in high-risk areas and the particular vulnerability of the poor to cope with disturbances and external shocks such as extreme flood events due to their limited financial, physical and human capital (Rashid 2000; Wood 1998). However, the capacities of slum dwellers to cope with these calamities must not be overlooked. In order to understand the assets and skills that enable vulnerable slum dwellers to cope with floods, a standardized questionnaire survey with 625 participating households in slum areas was conducted.

### 3 Methodology

The household survey was conducted in November and December 2009 by researchers of the University of Cologne in cooperation with the Universities of Rajshahi and Dhaka in five potentially flood-affected slum settlements (Fig. 2). Seven student assistants conducted the interviews in Bengali. The reference units of the survey were households defined as economic entities, not individuals.

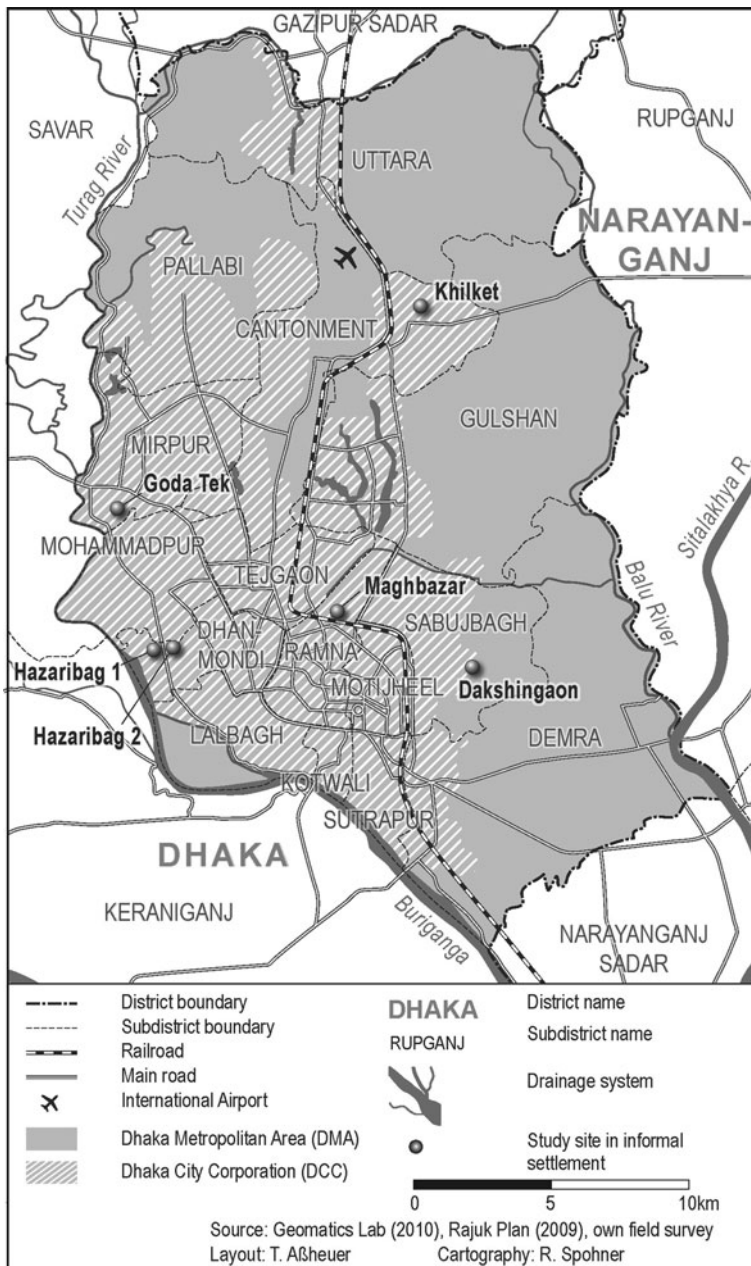
The settlements were selected on the basis of a two-day workshop with local experts, extensive on-site inspections in many locations throughout Dhaka and a series of preparatory qualitative interviews with slum dwellers. The definition of “marginal settlements” (slums) was taken from the most recent slum survey of the Centre of Urban Studies (Centre of Urban Studies et al. 2006). The five study sites were selected to be spatially evenly distributed over Dhaka and to represent different types of slums with respect to flood affectedness. Hazaribag 2 and Goda Tek are protected by the western embankment. Hazaribag 1 is located in the immediate floodplain of the Buriganga River just outside the western embankment. Maghbazar is located in the centre of Dhaka. It is protected by embankments and rather consolidated in its social and physical structure. Khilket and Dakshingaon are located in the East of Dhaka and are not protected by any dykes or embankments.

About 2000 households live in the five study sites; out of these 625 have been interviewed during the questionnaire survey. Those households not interviewed were absent at the time of the survey or did not personally observe any flood that matched with our definition (water level at least two feet in the house and/or at least 1 week in front of the house). Many of the households had simply not been living in the area for long enough to have experienced a major flood. Thus, our survey represents a complete sample of all households that experienced at least one severe flood in the five study areas. From a second (representative) slum survey which was conducted in cooperation with Alexander Krämer and Mobarak Hossain Khan (University of Bielefeld) and which was not selectively concentrating on flood affected areas, we can estimate that about two million slum dwellers currently living in Dhaka have already experienced at least one major flood in and around their dwelling according to our definition.

### 4 Impacts of floods on dwellers in marginal settlements

There is no doubt that floods are a major threat for the inhabitants of marginal settlements. Most people in slums fear them because the floods limit the access to fundamental needs, like food, drinking water, clothes and shelter. When floodwater enters a slum area, finding dry places to sleep, drying clothes, getting drinking water, earning money, and cooking food gets difficult if not impossible.

Floods are a common feature in Dhaka's slums. On average a major flood hits the study sites every 4 years. About half of the respondents stated that the flood that hit them worst reached a level of more than 2.5 feet in their living room, that their dwelling remained under water for more than 15 days, and that the flood had covered the areas in front of and surrounding their home for more than 30 days. The impacts of these floods on the livelihoods of the households interviewed are presented in Table 1. The data reveal that half of the responding households had to leave their accommodation and take shelter either in public schools, relatives' houses or on elevated streets or embankments. Due to the disastrous hygienic conditions during the floods, especially due to contaminated drinking



**Fig. 2** Location of study sites. *Source* Geomatics Lab 2010; Rajuk Plan 2009, own survey

water, 57% of the respondents stated that at least one of their family members fell ill during the flood. Flood-related diseases—in most cases diarrhea, fever and/or skin diseases—were often severe and considerably hampered the daily routines of the households.

**Table 1** Affectedness of households in Dhaka slums during major flood events

Characteristics during or immediately after the flood	Results of the survey
House/dwelling has been damaged	70% of the households
People had to leave the house	51% of the households
Cutback in nutrition	90% of the households were forced to eat less or far less than during normal times
Preparation of food	85% had difficulties to prepare food
Diseases	At least one family member got severely ill in 57% of the households
Ability to continue work	75% of the households were not able to continue work (out of these 70% did not work for 14 days or longer)
Reasons for not being able to work	Not able to reach the workplace: 48% Working area flooded: 35% Severe diseases: 11% Necessity to take care of household/children: 5%
Family income	70% of the households faced a significant decrease of the family income
Loss of savings	74% lost all their savings
Loss of valuables	70% of the households lost valuable assets

*Source* Own survey of 625 households 2009

Consequently, water-borne diseases, flooded working areas or the inability to reach their workplaces due to inundated roads, were the major reasons for not being able to continue work during the times of flooding. This in turn led to a significant loss of income for most households. As more than half of the responding households had no savings or food storage, many families faced extreme hardship and were not able to buy any food or medicine.

In order to systematically analyze differences in the flood-affectedness of slum households two “groups of affectedness” can be distinguished. The group of “strongly affected” households fulfilled the following criteria, with all others falling into the category of “less affected households”:

- members of the household were forced to eat less during the flood,
- at least one member got severely ill, so that he or she was not able to continue work,
- the income of the household decreased significantly,
- recovery from the effects of the flood and “getting back to normal” took at least 2 months,
- at least one of the members of the household was forced to leave the house during the flood event.

The differences between the two groups are presented in Table 2. The different levels of affectedness observed, correspond to different levels of vulnerability.

## 5 Reasons for different levels of vulnerability

Cutter’s (1996) “hazards of place” indicates that vulnerability exists when a biophysical risk affects people who are not able to fully cope with that risk. The model of

**Table 2** Major characteristics of “highly affected” and “less affected” households

Selected Characteristics	Highly affected households	Less affected households
Number of households	160 (25%)	465 (75%)
Head of household was able to continue work during flood	2%	32%
Loss of valuables during flood	90%	62%
Ability to cook and prepare food during flood without difficulties	3%	19%

Source Own survey of 625 households 2009

Turner et al. (2003) defines the basic elements of vulnerability as “exposure”, “sensitivity” and “resilience”. While exposure describes the physical aspect of being prone to be hit by a natural event, sensitivity covers the socio-economic status of the household and resilience is understood as the ability to cope with an event. Resilience corresponds thus directly to the systems’ ability to cope with, to adjust to and to adapt to the event (ibid, Adger 2006). Whereas the concept of (social) vulnerability refers to the exposure of groups or individuals to stress as a result of the impact of environmental change, resilience can be defined as the ability of groups or communities to cope with external disturbances as a result of environmental but also of social or political change (Adger 2000). Resilience in general means the capacity to adjust to threats and to mitigate or avoid harm. As resilience increases the capacity to cope with stress and external shocks, it can be seen as a loose antonym for vulnerability. However, because of its institutional context, social resilience is mostly defined on the community level rather than being a phenomenon related to individuals.

In order to understand the coping abilities and the socio-economic conditions of the slum dwellers of Dhaka, it is necessary to analyze their livelihood assets in more detail.

### 5.1 Livelihoods of slum dwellers in Dhaka

Livelihood assets are those assets that are essential for living (Khan and Seeley 2005). In order to survive people need access to at least one or two of the five basic livelihood assets: physical capital, financial capital, human capital, social capital, and natural capital. The most direct and flexible asset is financial capital, because with money it is possible to buy many crucial items such as food, medicine, shelter, land, etc. However, if access to financial assets is limited, other livelihood assets become more important in order to access the items necessary for survival.

#### 5.1.1 Physical capital

The physical capital of a household consists of its basic infrastructure and other material goods (Krantz 2001). In the case of slum dwellers in Dhaka the most relevant forms of physical capital are housing, shelter, sanitation, and water supply. Flood-related physical capital is rather limited in the urban slums of Dhaka. This is not only true with regard to housing materials (tin, bamboo, plastic), which do not offer much protection against flood water, but also with regard to collective technical infrastructure and structural protection devices against floods (Table 3). Individual protection measures like a raised plinth or elevated door entries are very rare. Often public schools provide the only flood shelter in slum areas. Being well organized and built structurally sound, public schools offer a dry



**Table 3** Selected characteristics of physical capital among slum households

Characteristics of physical capital	Percent of households
Main building material of house	Bamboo and/or plastic: 38% Tin: 37% Brick and/or concrete: 25%
Raised plinth or door entry	18%
House built on stilts	35%
Supply of drinking water	Shared tap: 64% Shared tube wells: 25% Other (tap in house, buying water, ponds): 11%
Mud oven for cooking	53%
Shared kitchen with gas supply	37%
Electricity supply	73%
More than two people sharing one room	80%

Source Own survey of 625 households 2009

**Table 4** Selected characteristics of financial capital and material possessions among slum households

Characteristics of financial capital	Percent of households
Income per capita per day	<67 BDT (i.e. 1 USD): 75% <30 BDT (i.e. 0.4 USD): 25%
Households with savings	30% of households have savings, half of them less than 25 USD
Own house	46%
Own land at home village	34%
Own television set	41%
Own mobile phone	46%

Source Own survey of 625 households 2009

place and a certain level of protection against robbery and unfavorable weather conditions. In many cases the Government of Bangladesh and non-governmental organizations (NGOs) provide food free of cost in public flood shelters.

### 5.1.2 Financial capital

The financial capital of a household consists, firstly, of the regularly incoming returns or salaries and secondly of the household's savings. However, the income of slum households in Dhaka is very low (Table 4). Only one-fourth of all households earn more than one US Dollar per day per capita. According to the definition of the World Bank, this means that three quarter of all households belong to the group of the extremely poor. 25% even earn less than 40 US Cent per day. Not surprisingly, the amount of savings is also low. Neither income flows nor savings are sufficient to rely on during times of crisis.

Material possessions (e.g. television sets, mobile phones, land) of slum dwellers can, nevertheless, be quite substantial. Many people still possess land and own a house at their birthplace or home village.



**Table 5** Selected characteristics of human capital among slum households

Characteristics of human capital	Percent of households/individuals
Literacy rate (people can read and write at the age of 15 and above)	49% (male household heads), 32% (female household heads)
Occupation (jobs where no formal education required)	64% (household heads)
Regular school attendance of children	70% (children, age 6–10)
Regular child labor	20% (children, age 6–15)

Source Own survey of 625 households 2009

### 5.1.3 Human capital

The human capital of a household is based on individual skills, knowledge and the ability to work. For the ability to work it is important that people are healthy and have the necessary experience and education. However, our empirical findings suggest that conventional human capital is rather weakly developed in Dhaka's slums (Table 5). The level of formal education of slum dwellers in Dhaka is even lower than the Bangladeshi national average (national literacy rates: men 58%, women 48%; United Nations Development Programme 2009). The pattern of employment and occupations mirrors the residents' low level of education. Many of the heads of households hold jobs that require no formal education and hardly any training (e.g. rickshaw puller, day laborer, beggar, waste collector, etc.). Most of these jobs are manual and take place on the streets, alleys and market places of Dhaka. Although these occupations do not rely on any sophisticated form of infrastructure, they are vulnerable to weather impacts, because work ceases to be possible during periods of inundations. Floods thus often immediately interrupt the flow of income, yet, as soon as the flood water recedes, work can also be continued quite easily.

As a result of several campaigns organized by NGOs and the Government most parents are now well aware of the importance of education. Still, one-third of all children aged 6–10 years, are not attending school regularly. Despite the fact that primary education is free in Bangladesh, some families still cannot afford to purchase clothes, books or writing materials for their children.

The relatively low endowment with human capital in slum communities suggests that individual sensitivity to flood events is high. The prevailing lack of human capital makes people in slums highly vulnerable to external shocks and changes.

### 5.1.4 Social capital

In contrast to other forms of capital, some aspects of social capital are strongly developed in informal settlements. Even though the concept of social capital is a rather contested one (see e.g. Castiglione 2008), social capital can be understood as social resources that enable an individual to claim access to resources which he or she would not be able to afford or access without the help of others (Portes 1998). Basic components of social capital are social networks and shared norms and values (Halpern 2005). In the case of Dhaka slums, social capital plays a dual role: Firstly, it influences the creation or provision of social resources in the community and, secondly, it affects the ways in which these resources are claimed and/or utilized during times of crisis (Wood 2005).

Our findings suggest that social resources can be strong in slums (Table 6). Relations to relatives and neighbors are often close. In slums, where privacy is almost impossible and

**Table 6** Selected characteristics of social capital among slum households

Characteristics of social capital	Percent of households/ respondents
Good/very good relation to neighbors	85%
Neighbors help each other in critical situations	53%
Head of households' place of origin	82% outside of Dhaka
Borrow money from relatives or neighbors	55%
Feeling safe in the neighborhood	87%
Trust neighbors in terms of lending and borrowing money	96%
Landlord would intervene in conflicts between neighbors	35%
The landlord helped to repair damaged house	62%
Mutual support	83% of the respondents think that they will get support from a person they helped before
Community support	77% of the respondents think that the community will support them because they provided help to the community at an earlier occasion

Source Own survey of 625 households 2009

life takes place outside the house and in public view, everybody knows each other. Neighborhood networks are thus an important social resource. Most of the slum dwellers regularly interact with their neighbors; they support and help each other. Relatives are another important source of support. The majority of slum dwellers do not originate from Dhaka and strong ties exist to their places of origin, where many slum residents still own land.

Neighbors and relatives can play an important role during times of crisis. They are providers of food, clothes, and money. Moreover, they often are a source of emotional support, which might be even more important in order to overcome bad times. The very positive responses to questions regarding mutual support networks suggest that trust, reliability and reciprocity are essentials of social life in Dhaka's slums.

Despite the poor housing conditions and often desperate socio-economic situations, robbery and theft are not prevalent in the slum areas—at least not amongst neighbors. Almost all interviewees stated that they would lend money to their neighbors. Mutual trust and an understanding of reciprocity can be crucial in order to respond to calamities. Even the poorest households can be sure that they will receive help—and they also know that they will be obliged to help others in return. These results support earlier findings by Mozumder et al. (2008) who studied the role of private transfers during the massive flood 1998.

Landlords also play an important role in the social fabric of Dhaka's slums. They are usually people of authority, respected by all residents of the compound and responsible for mediating in case of disputes between neighbors. They often also help with the repairs of damaged houses after a flooding.

From the findings of our study it becomes clear that social resources are strong and important for slum communities. In Sect. 5.2 it will be shown that these resources can actually be utilized during flood events.

#### 5.1.5 Natural capital

The fifth form of capital within the livelihood framework is natural capital, comprising all natural resources people are able to utilize in order to improve their living conditions (Krantz 2001). Private goods and resources (e.g. private ownership of fertile land) as well as common goods (clean air and water) belong to this category. In the case of Dhaka's slums individual ownership of natural capital plays a very minor role, because space for agricultural production is extremely limited and rivers and ponds are too heavily contaminated to be utilized for fishing or any other income-generating activity. Within the confines of the slums natural capital is thus not an available asset to slum dwellers—neither during periods of floods nor otherwise. However, some families can utilize the natural capital (i.e. land) they possess at their place of origin.

### 5.2 Coping of households in marginal settlements

The findings of the household survey revealed that the livelihoods of slum dwellers make them extraordinarily vulnerable to flood events. Slum dwellers are not only more exposed to floods due to the mere location of their settlements, their socio-economic situation also makes them particularly sensitive to external shocks. However, our survey also shows that in some aspects—e.g. social resources—slum households have considerable capacities that enable them to overcome the negative effects of extreme floods. This third aspect of vulnerability in the model of Turner et al. (2003)—referring to the ability to cope—will be analyzed in this section.

Slum dwellers often have to deal with stagnant water in or around their homes. During the rainy season flood water is almost omnipresent in Bangladesh, Dhaka included. Under normal flood conditions simple strategies like blocking the entry of the house with sand-bags, positioning one's personal belongings on stilts of bricks or hanging them under the roof are sufficient to prevent any severe flood damage. In case of extreme floods, however, these strategies are not adequate and further adaptation and coping strategies are required. Adaptive measures are being conducted *before* an event takes place and should be understood as an intentional action in order to minimize the potential negative impact of an event (Nelson et al. 2007; Smit and Wandel 2006). Coping measures are practices which people apply *after* the event started in order to combat the negative effects that accompany the event (Davies 1993; Nelson et al. 2007). "Adaptation" refers predominantly to long-term strategies while "coping" to short- or mid-term adjustments.

During a major flood, the strategy of "wait and see", i.e. hoping for the water to recede eventually, is hardly adequate. The results of the survey indicate that one of the most common coping strategies is to take out a loan to be able to buy food (Table 7). Although many households relied on this strategy, only a minority had to address local money-lenders, who demand exorbitant interest rates. The majority was able to borrow money from neighbors or relatives. Interestingly, Khandker's (2007) study on rural Bangladesh confirms the important role of neighbors and relatives as money lenders during flood events, but reports slightly lower percentages.

The importance of personal networks is further emphasized by the fact that almost half of the interviewed households either received money, food or clothes or were offered

**Table 7** Coping with major floods among slum dwellers

Coping measure	Percent of households
Taking loan	67%
Partners from whom the households obtained the loan	49% from neighbors or relatives 25% from NGOs 16% from local moneylenders
Repayment of loans within 1 year	60%
Households that received food, money or cloths from people they personally knew	45%
Households that were provided shelter in a relative's house	30%
Households that received relief from the Government and/or NGOs	49%
Organizations that distributed relief	54% government 21% private individuals (e.g. local politicians) 17% NGOs
Households that had some savings before the onset of the flood	44%
Households that stored dry food before the onset of the flood	32%
Households that organized building materials (mainly bricks, sand) before the onset of the flood	40%

Source Own survey of 625 households 2009

shelter by people they personally knew (mostly relatives or neighbors). Given that neighbors and relatives have, in most cases, also been affected by the flood, the significance of these personal networks for mutual help is surprising. People help each other regardless of how much they are affected themselves. Despite the difficult circumstances, average repayment times of loans are short, which indicates that borrowing does not necessarily lead to a vicious circle of indebtedness. It is rightly stressed by Davies (1993) that some short-term coping measures may have negative long-term effects because savings are used for immediate recovery and cannot be invested in productive, income-generating activities. Our survey data, however, show that coping strategies applied by the households do not affect their financial resources to a great extent. Consequently, long-term livelihoods are not severely undermined by short-term coping measures for most of the cases.

Other important sources of support are landlords and providers of “official” relief such as the Government and NGOs. Many landlords offer food, lend money or repair damaged houses. 49% of the households reported that they received “official” relief and half of those stated that this help was more or less sufficient.

While different (reactive) coping strategies were commonly used by Dhaka's slum residents, this was not the case for genuine (proactive) adaptation strategies. Physical protection of houses or compounds is almost non-existent (see also physical capital). In contrast to this, individual preventive measures (e.g. savings, storing food or medicine, or organizing building materials in advance) are commonly used. Our empirical results, however, show no clear correlation between these preventive practices and the actual affectedness of individual households. Many residents reported, for instance, that most of their stored food was destroyed by the flood water, that it was impossible to organize enough building material and that they were unable to accumulate sufficient savings to be better prepared for future flood events.

## 6 Relevant factors influencing vulnerability

The analysis of livelihoods and coping strategies of slum dwellers draws a rather bleak picture of the vulnerability of residents of slums. This generates the question whether any resources—or the absence thereof—are particularly determining people’s vulnerability regarding flood events. Therefore, we carried out cross tabulations of various characteristics of livelihoods and household affectedness, which shall be discussed in the next section of the paper. It is important to keep in mind that affectedness is not identical with vulnerability. Vulnerability is the prerequisite of a disaster and affectedness the outcome of a disaster. However, a quantitative comparison of differently affected households (for definition of the two groups see Sect. 4) allows an indication of the underlying factors of vulnerability.

The exposure to flood is part of the vulnerability of an individual or a social system, such as a household (Turner et al. 2003). While “exposure” is characterized by the location of the affected entity and its protective measures, “exposure” also depends on the specific characteristics of the flood event itself. Per definition our case study sites had been affected by severe floods in the past and we already stated that protective measures were almost non-existent in the slums we studied. To better understand the impact of floods we will therefore analyze the interrelation between the severity of the flood and the affectedness of the households.

### 6.1 Natural characteristics and flood affectedness

Our correlation analysis of the affectedness of households and the severity of the flood (duration of flooding and height of water levels) reveals that the specific characteristics of a flood event have significant impacts on the affectedness of slum dwellers. In strongly affected households the peak level of the floodwater was higher, and the water stayed significantly longer than in less affected households (Table 8). As described before, many people try to protect furniture, valuables, food or livestock from the flood water by piling bricks. If the water levels reach too high, however, brick stilts are not sufficient and after a threshold of about four feet people have to retreat from their living rooms. They either stay on the top of the roof or even have to abandon the house and take shelter somewhere else. Another crucial aspect related to the height of the water level is the flooding of the water supply (tube wells or water pipes). The higher the flood water levels the greater the risk of drinking water contaminations and the higher the number of diarrhea cases. To obtain clean and safe drinking water from uncontaminated sources, residents are forced to cover large distances and to spend significant amounts of time wading through muddy floodwater, which increases their risk of injuries and skin diseases.

**Table 8** Flood characteristics and flood affectedness of households—comparison of means

	Strongly affected households (arithmetic mean)	Less affected households (arithmetic mean)
Height of water in house	3.1 feet	2.5 feet
Duration of water in house	29 days	18 days

*T* tests proved the differences of means to be highly significant ( $p < 0.000$ )

Source Own survey of 625 households 2009

However, the suffering of people is not only influenced by the water levels, but also by the length of time they have to cope with the inundation. The duration of a flood is hence strongly related to the hardship experienced by the slum residents. The quality of the stagnant water deteriorates with each day the flood continues and the period of time people have to survive with little or no income increases.

Of course, it is not only the characteristics of the natural event itself that trigger social disasters. Therefore, we should also focus on the socio-economic factors that lead to an increase in vulnerability.

## 6.2 Socio-economic determinants for vulnerability

Human capital, especially education, and financial capital, especially regular income generation, have been proven to impact directly on households' vulnerability. Table 9 shows that higher education and lower flood affectedness are related to a significant degree. Thus, education may be regarded as a crucial factor for reducing vulnerability in slums. Better education allows access to better paid jobs and thus to the generation of higher salaries.

In the group of the less affected households the income of the head of household was significantly higher compared to the group of strongly affected households (Table 9). The important role of income levels with regard to vulnerability can be explained by the fact that a household's income is closely linked to other relevant forms of capital. For example, families with a high income might also be able to build up greater savings. While the survey data did not reveal any clear correlation between flood affectedness and savings, it did show a significant correlation between the income of the head of household and the physical capital available (superior building materials, water and electricity supply, etc.). Families living in houses made of bricks or concrete were far less affected by floods than families living in sheds built of bamboo and sheets of plastic. Bricks and concrete are more expensive but provide a much better protection against flood water. Moreover, more expensive houses made of bricks and concrete tend to be located in better and less flood-prone areas within the slums, and they are usually more thoroughly planned. Typically, high risk areas in unprotected floodplains or close to rivers and channels are used for the cheapest and effectively non-permanent forms of housing. This leads to the conclusion that the basic constituents of vulnerability—exposure, sensitivity and resilience—are interrelated to a high degree and dynamically interact with each other. The socio-economic condition of a household influences its sensitivity, but it also its resilience and exposure.

From the analysis it can be concluded that the major factors that profoundly increase the vulnerability of slum dwellers with regard to floods are firstly the exposure to intensive

**Table 9** Socio-economic characteristics of flood affectedness—cross tabulation and comparison of means

	Strongly affected households	Less affected households
Head of household has higher education (visited at least high school)	9%	20%
Monthly income of head of household (arithmetic mean)	4260 BDT (64 USD)	5200 BDT (78 USD)

Chi-square ( $p = 0.004$ ) and  $t$  test proved to be highly significant ( $p = 0.001$ )

Source Own survey of 625 households 2009

flooding (height and duration) and secondly low levels of education and income. Of course, these factors are closely interrelated with each other. Because of poor income, people cannot afford to move to elevated ground or to areas with better infrastructure (see Brouwer et al. 2007 for quite similar interrelations in rural Bangladesh). Consequently they are suffering from flooding which in turn causes further economic drawbacks that hamper the building-up of stable financial and human assets.

It must not be neglected, however, that despite the high level of vulnerability prevalent in marginal settlements, slum dwellers often show a surprising ability to overcome the negative effects of floods: 70% of the respondents stated that they were able to clean the area from the dirt, repair the houses and continue their daily routine within a period of only 2 months after the water receded. Most of the assets lost during the flood were replaced quickly: in 29% of the cases within 1 month and in almost all the other cases within 6 months (87%). Almost two-third of the responding households were able to repay their loan within 1 year.

If we take into account the low level of livelihoods of the slum dwellers, their ability to recover relatively quickly from floods is impressive. The “secret” behind their resilience (i.e. their capability to cope with floods) seems to lie in social resources and their high levels of social capital.

## 7 Conclusions

The results of the survey conducted in five selected slums in Dhaka, can certainly be applied to Dhaka as a whole and to many other megacities in the global south. Undoubtedly, poor people living in slums are always affected if hit by major flood events and they suffer severe hardship when water enters their homes. Their low livelihoods make them vulnerable to floods and other natural extreme events. Low levels of education and, closely related, low levels of regular income are factors that have been demonstrated to significantly increase the slum dwellers’ sensitivity against floods. However, our analysis also reveals that even during times of suffering poor people are able to react and adapt, because they can rely on their social resources. Slum dwellers seem to dispose of a relatively strong base of social resources, which they are able to convert into social capital when in need. Thus, social capital comprises an important asset that increases resilience and improves the coping capacities of slum households and their ability to respond to external shocks. People do not only live and work in slums because they have no other options, but rather because the big cities and even the slum environments offer them opportunities. This is true despite all disadvantages and problems that are typical of slums. People live in slums mainly because they want to work and earn money (Begum 1999). Extreme flood events interrupt income generation for a while, but as soon as the water recedes work can be continued. These relatively stable income flows enable slum households to repay loans and to replace assets they had to sell during the flood. Employment of slum dwellers does, for the most part, not depend on sophisticated equipment or machines. The system as a whole is thus relatively flexible, open and redundant. The main base of income generation and the key factors that attract further growth, i.e. the opportunity to earn a living, can hardly be completely destroyed by flooding. Floods may be dangerous and have the potential to affect people’s livelihoods to a considerable degree, but they rarely do cause any long-lasting harm or damage to the slum and its economy. The economic basis of slums might be weak in terms of welfare generation, but it is a surprisingly resilient system that continues to foster further population growth.



Dhaka is particularly vulnerable to many kinds of natural hazards because of its specific location in one of the largest coastal deltas of the world, its exceptionally high rates of urban growth and poor planning. In the future, the effects of climate change will create new and substantial challenges for the city. However, Dhaka is also characterized by highly flexible and complex informal structures that increase rather than decrease the city's ability to cope with extreme natural events and other external shocks. As a result, Dhaka will continue to grow. And despite all problems and calamities it will continue to be a place of hope for many more migrants arriving from rural areas.

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