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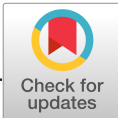
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# Adaptation to flooding in low-income urban settlements in the least developed countries: A systems approach

Anika Nasra Haque | Mike Bithell | Keith S. Richards

Department of Geography, University of Cambridge, Cambridge, UK

## Correspondence

Anika Nasra Haque  
Emails: anh31@cam.ac.uk;  
anikanasra@gmail.com

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This study aims to use a whole systems approach (1) to understand the processes of adaptation to flooding of the urban poor; (2) to identify new knowledge of how low-income settlements might better adapt to climatic risks; and (3) to begin to develop appropriate guidance on this. Low-income urban settlements in the least developed countries (LDCs) present an extreme case where catastrophic natural hazards and chronic social hazards overlap. These low-income urban populations face the greatest adaptation challenges as they often occupy informal settlements that are particularly exposed to hazards, and have multiple vulnerabilities arising from their lack of basic services. There is a dynamic complexity of issues arising from the many levels of actor involved and multiple social and physical factors. Analysing such a complex phenomenon calls for a specific conceptual framing, and a systems theory approach is suggested to provide a holistic perspective. The case study for this research is located in Dhaka East, where there is both high vulnerability to flooding, and a significant low-income population. The research has adopted a mixed methods approach involving different data collection methods governed by the different scales and actors being investigated. The research develops new systems understandings of perceptions and experiences of the local population about adaptation processes in low-income urban settlements, and how these processes may be positively influenced by integrating bottom-up and top-down approaches.

## KEYWORDS

adaptation, Dhaka, flooding, least developed countries, low-income urban settlements, systems analysis

## 1 | INTRODUCTION

Flooding is a catastrophic natural calamity causing widespread and devastating impacts on people, economy, and environment, and is the leading cause of natural disaster fatalities worldwide (Doocy et al., 2013). During this age of rapid urbanisation, flooding in urban areas is a severe and evolving development challenge with enhanced impacts. These impacts impose risks on poorer groups disproportionately: approximately one billion people in urban areas are living in slums or informal settlements which are at high risk from such climate-related shocks and stresses (Satterthwaite et al., 2007).

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The vulnerability of the least developed countries (LDCs) to the impacts of natural hazards is primarily driven by lack of economic resources, technology, infrastructure, and social safety nets; high population growth, rapid and unplanned urbanisation contribute further to this (IPCC, 2013). Low-income settlements mostly develop illegally, and households are under constant threat of eviction. The majority have limited (or no) public services (such as water supply, sanitation, education, health facility, drainage; Bicknell et al., 2010). As a result, low-income urban settlements which are most at risk lack the preconditions for successful adaptation (Satterthwaite et al., 2007). Often vulnerability of low-income settlements is associated with their poverty, but is equally linked to the inefficiency of local government, which is in turn connected to failures by national governments and international organisations involved in policy and governance (Satterthwaite et al., 2007). The widespread impacts of flooding and the growing challenges of increasing climatic variability and hazard frequency and magnitude call for better understanding and management of existing and future flood risks for disadvantaged populations.

The overall research objective here is to investigate adaptation processes in low-income urban settlements subject to flooding, identifying the factors people indicate as influencing adaptation, and understanding how they drive adaptation processes in order to help make top-down interventions more effective. The focus is on the complex web of interactions amongst the many different actors and influential factors. We seek to understand the system as a whole, evaluating the interconnections, interdependencies, and interactions amongst the physical and social factors that affect the adaptation of the urban poor, rather than just enumerating the factors involved, many of which have been discussed previously in other contexts. Such inter-sectoral and interdisciplinary knowledge may be useful to help develop policies, strategies, and interventions that can improve adaptation to flooding.

The study does not claim to generalise its findings to other LDCs, but rather takes a representative case of Dhaka to illustrate and develop a systems approach. The specifics of the individual factors identified may be context dependent, but we suggest that taking a whole systems view should be valuable as a methodology for helping to understand many different systems of this kind, and could help as a means for inter-comparison between different case studies. The approach adopted here may be transferable, rather than its specific detailed findings. It reflects the concept of evidence-based policy espoused by Cartwright and Hardie (2013). In this framework, a case study may show that a particular factor or factors underlie a successful intervention, but usually in combination with a range of additional “support factors.” Findings can only be transferable if a network of similar causal and support factors can be shown to be present in a new context. This requires that a range of potential causal and support factors is uncovered, and systems analysis drawing on evidence from multiple, mixed methods may help to produce this.

## 2 | ADAPTATION BY LOW-INCOME POPULATIONS IN THE DEVELOPING WORLD

Adaptation to hydro-climatic risk involves the alteration of an affected system (natural or human) in response to the perceived risk (observed or future) and its potential impacts (Satterthwaite et al., 2007). Although the concept of adaptation seems straightforward, simply representing an anticipatory response to a perceived risk, complexity arises when varied scales and levels are considered, involving different actors and influences ranging from local to national and international levels. Adaptation decision-making often involves interaction amongst these different levels, for example, from individual to communities to higher levels, and depends on their networks and capacities (Adger, 2001). For instance, social capital, which is based on the connections among individuals within a community, has been identified as a vital aspect of urban adaptation, specifically in the context of low-income settlements; shared informal values or norms allow people to cooperate to achieve common goals (Pelling & High, 2005).

Adaptive action often emerges from decisions based on adaptive capacity (which is the ability to adjust to climatic variabilities and their impacts; Satterthwaite et al., 2007). Where the capacity to take action is limited by other factors, even where it is clear what actions are desirable, this may represent an adaptation deficit. Pre-existing adaptation deficits in developing countries, derived from the lack of economic, institutional, and infrastructural capacity, make them much more vulnerable than developed countries to flooding, and often more severely affected. This adaptation deficit is, to a great extent, related to the “development” deficit (Satterthwaite et al., 2007). Access to safe water, sanitation, drainage, roads, garbage disposal, and health services remains a hard goal to attain for many of the urban poor in the global South (Bicknell et al., 2010). It is thus now widely accepted that vulnerability to hydro-climatic risks at the local level is inseparable from the development context of vulnerable groups (Brown et al., 2012). This adaptation deficit is perceived at different scales, from the micro-scale of the household and community, to the macro-scale of large organisations including the national government.

Observing the interrelation between development and the social, economic, and political factors defining vulnerability, poverty itself emerges as one of the most important indicators (Mitlin, 2004). This connection is especially evident in urban areas, where the poor are in a constant battle against everyday poverty (Mitlin, 2004). Along with low income and asset bases, they lack access to basic infrastructure, services, and safety nets; and have limited or no protection of their rights, poor housing quality; and are marginalised and powerless. In fact, the factors that construct and maintain poverty go beyond this to more complex social processes behind these arrangements, implying a need for a wider view of the dynamics of social and political contexts (ibid). For example, evidence from South Asia shows higher mortality rates among women during disasters, primarily resulting from the social and cultural restrictions imposed on them (Neumayer & Plümper, 2007). They may be unable to leave home without men in order to look for relief, and they may also have reduced social contact with the outside world (Neumayer & Plümper, 2007).

Studies have repeatedly stressed the importance of understanding the adaptive responses and processes that originate from within vulnerable populations (e.g., Adger et al., 2002; Forsyth & Natalie, 2013). Adaptation responses by the urban poor are not simply in response to “physical” risk, but are also a response to the social and political conditions which produce added dimensions of risk (Wynne, 1996). Hence, adaptation must be viewed in terms of the processes whereby risk perceptions are constructed and responses are delivered by particular actors, in specific contexts (Wynne, 1996). Such responses often reflect pre-existing socio-economic conditions, and the ways in which households manage resource scarcity (Adger et al., 2002). Hence, the continuing process of adaptation of the vulnerable population must be understood along with its adaptive actions, and the factors that influence and shape adaptive actions (Forsyth & Natalie, 2013).

However, there have been debates around the idea of autonomous household adaptation. It has been argued that such adaptation is inefficient and may risk the effectiveness of planned adaptation (Eisenack, 2009). Such adaptation is in most cases uncoordinated and unaided by governments, international agencies and development agencies (Eisenack, 2009). The IPCC has therefore called for more evidence to identify the processes through which this autonomous adaptation occurs, and to connect it with planned adaptation (IPCC, 2012).

Hence, adaptation debates increasingly acknowledge the complex interdependence of the physical and social elements: more recent work on urban adaptation and resilience stress the importance of the relationship between social and ecological worlds, with increasing concern for the social and political drivers behind adaptation (Bahadur & Tanner, 2014; Béné et al., 2014; Friend & Moench, 2013). This offers a way of thinking about coupled human-ecological-political systems to explain the complex interdependence of the social, physical, and political elements. This study attempts to take this forward and, acknowledging the complex interdependencies among multiple factors influencing adaptation processes, it takes a “whole systems” view to better understand the overall adaptation system. This is expressed using “causal” loop diagrams that show the overall system structure, a representation which seems not to have been considered widely within existing adaptation literature.

### 3 | CONCEPTUAL FRAMEWORK

The discussion above implies a complex system of issues relevant to the vulnerability and adaptation of the urban poor, arising from multiple levels and multiple actors; macro-level organisations range from public sector to non-state actors, while at the micro-level there are communities and households. These are linked through multiple social and physical factors (e.g., access to basic services, tenure, income) that influence adaptation. All of these system components are connected and interact in a dynamic complexity, often leading to unpredictable outcomes that are difficult to comprehend when only analysing elements in isolation (Mele et al., 2010). Such a complex system, as Jordan (1998) suggests, cannot be explained by separating it into its components: a holistic approach is required to understand its functioning. This calls for a specific conceptual framing, such as a systems theory approach (Meadows, 2008), where a “system” is an ensemble of interacting parts which exhibit behaviour not localised in its constituents. The focus is on the relationships *between* different elements: every element is characterised by its own properties, but it can acquire a different property when considered holistically as an element of the whole system, and the system may display emergent phenomena only present when all elements interact. The dynamics of such a system may depend on the non-linear behaviour of multiple interacting feedbacks; social systems, in particular, are characterised by a great variety and number of interconnected elements, and multiple levels of interconnection that feed off each other. Adaptation deficit may thus be viewed as a system-level property, for which focus on managing individual system parts may not result in expected changes, and can have unintended and even maladaptive consequences.

The focus here is therefore not so much on particular issues such as governance or service provision in isolation, but on what the complex web of interactions between the different factors looks like and what this means for understanding the

system as a whole. The aim of the study is thus to evaluate the interconnections, interdependencies, and interactions amongst the various factors influencing adaptation by the urban poor, particularly focusing on the micro-level of households and communities in the low-income urban settlements themselves. Our system includes households, government, NGOs, and community-based organisations, the physical and built environment, and those aspects of economic and social organisation considered important by the people interviewed with respect to flooding. The conceptual framework then places relationships between individual factors such as education and social capital, in terms of whether the one tends to increase or decrease the effect of the other when it comes to household adaptation to flooding. We summarise the results using “causal” loop diagrams, which express these qualitative inter-connections between different parts of the system, and whether their influences on other system aspects are positive or negative. Since this overall system is highly complex, it is summarised by several different diagrams focusing on particular issues, such as social capital. While such diagrams are frequently used in an idealised way (e.g., Sverdrup et al., 2017), here we use qualitative research methods to construct diagrams that directly reflect empirical findings. We emphasise, however, that the degree to which these may be considered causal relationships depends on the perceptions of the interviewees and focus groups, and the positionality of the interviewer(s), and reflects how the interviewees wish to express their lived experience of adaptive processes and their inter-linkages, as much as actual causation.

## 4 | CASE STUDY: DHAKA, BANGLADESH

Dhaka, the capital of Bangladesh, is one of the fastest growing mega-cities in the world. One third of its population lives in low-income settlements (Rabbani et al., 2011). Dhaka is particularly vulnerable because of its unplanned urbanisation, but it is also located in a country where storms and floods are regular events (Rabbani et al., 2011). The area at highest risk of flooding is in Dhaka East (see Supporting Information S11 for a map), which is predominantly low lying. This is not only because of topography but also because it is completely unprotected (there are no embankments or flood walls). These low-lying areas and water bodies in Dhaka East function as water retention areas to store the excess water from storm rainfall, which then drains into the adjacent river through connecting channels. However, developers have encroached on these areas to meet the growing population demand, and continue to do so (Haque et al., 2012). The natural drainage is inhibited by the presence of a large population, and the drainage infrastructure is poorly maintained, and inadequate to meet the rapid pace of urbanisation (Halcrow Group, 2006). Hence, the population of Dhaka East increasingly suffers from inundation.

During recent floods (i.e., 1987, 1988, 1998, 2004, 2007) this area has been the worst affected, being inundated for a longer period than any other part of the city (Haque & Grafakos, 2010). A significant portion of the low-income population of the city lives in this area. Thus most risk is experienced by these low-income settlements; most of these are informal (technically illegal) settlements that do not even exist in official documents.

## 5 | METHODOLOGY

### 5.1 | Data collection

Questionnaire surveys, focus group discussions (FGDs) and in-depth interviews were employed to collect the required primary data. A total of 520 low-income households (2,394 inhabitants) were surveyed, covering 99 settlements. Here the term “low-income” indicates households with a monthly income of 9,000 BDT (US\$114) or less, based on evidence from relevant reports on the population of the study area (e.g., Halcrow Group, 2006).

Fifty-one FGDs were conducted: 44 within the low-income communities and six with organisations covering representatives from government and NGOs, and community-based organisations (CBO). The purpose of FGDs with communities was to identify community perspectives on specific issues such as flooding, vulnerability and responses to flooding, barriers for adaptation, interaction patterns with others regarding flooding (including organisations), and the influence of social networks. FGDs also helped to identify not only the influencing factors believed to be important for them for their adaptations, but also the significant issues that were not addressed in the questionnaire survey and served to clarify relevant details. Two FGDs were conducted with NGOs, one with representatives from both government and NGOs, two with CBO representatives, and one with only government officials. The aim was to recognise their stance and activities regarding flooding and low-income groups; their perspective on adaptation and inclusion of low-income populations in their planning; and the interaction among government, NGOs, and CBOs.

Although we only consider government and NGOs as the relevant formal non-community organisations involved, there are other private sector organisations that may have influence (e.g., building developers). However, in the case study



context, NGOs represent the most prominent formal private sector organisations, despite being partly controlled by government. They have a major role to play in the socio-economic sector involving the urban poor, and also concerned with physical infrastructure.

Fifty-one interviews were conducted including with 17 government officials, 18 private sector officials (including representatives from NGOs, developers, journalists), six academicians, and 10 CBO heads. These interviews helped us to gain in-depth insight about specific issues relevant to the topic of inquiry and provided an opportunity to discuss any specific issues derived from the FGDs. See Supporting Information for more details on data collection (Section SI2–I4) and sampling techniques (Section SI5).

## 5.2 | Data analysis

The data collected through FGDs and in-depth interviews were analysed based on the “grounded theory” method, using a combination of open coding, axial coding, and selective coding (see Saldaña, 2015), and the questionnaire survey data were analysed using statistical techniques (e.g., cross-tabulation, chi-square, correlation).

Grounded theory was adopted as it allows the outputs to develop inductively from a corpus of data. This method allows exploration of actual relationships by the social actors in real settings (Gephart, 2004); it is particularly suitable for exploring social processes, relationships, and behaviours where these are dependent on contextual factors (Gephart, 2004). Grounded theory allows the data to speak without any bias of preconceived ideas (Strauss & Corbin, 2010), which was crucial for this study considering the lack of data and existing studies in the case-study area. This approach also enabled conceptualisation to be developed from the evidence emerging from the fieldwork.

The data emerging from the grounded theory method not only generated the overall idea of the system and its parts, but also their interrelations. Relationships established through statistical analysis of the questionnaire survey data then helped to confirm relationships identified through grounded theory. For example, survey data show a direct relationship between income and housing quality (with a Pearson correlation of 0.84 which is statistically significant at  $p = .01$ ). Also, descriptive statistical analysis of the questionnaire survey data helped in understanding the demographics of the surveyed population (see Section 6).

Following the grounded theory approach, data having common characteristics were grouped into categories in the *open coding* phase. Such categories were often formed prior to interviews and FGDs based on related preconceptions and research propositions; for example, *interaction with organisations*, *influencing factors behind adaptation*. In the next phase, data were further sub-divided and analytical categories were established integrating with the higher-level codes introduced during the open coding process. Patterns were also identified during this phase based on causal conditions, intervening conditions, context, and consequences. For instance, the influencing factors of the adaptation process are categorised into *negative* (barriers) and *positive* factors. In the final phase of coding (selective coding), relationships among different factors were established by comparing the categories and patterns identified in the earlier phases, and this helped with construction of the system. For example, during selective coding, one category was chosen as the core concept, say, *influencing factors of adaptation*, around which the other categories from the axial coding phase (i.e., *positive and negative factors*) were grouped for the purpose of explaining the observed phenomena. Then by comparing with these relevant codes, patterns were identified regarding how those factors influence the overall process. The causal relations (+/–) between different factors in the systems diagram were drawn based on participants' responses (statements) in both FGDs and interviews. For example, during the FGDs participants mentioned that they were not willing to invest in their housing to make it more resilient as they lack security of tenure and can be evicted at any time; and being given secure tenure would incentivise them to improve their housing quality. Hence, a positive connection was drawn between tenure quality and housing quality. The key factors were derived from the FGDs with communities, based on the frequency each factor was mentioned with reference to their adaptation to flooding, and on the importance assigned to factors by the participants (see Supporting Information, Section SI3). In analysing adaptation at the micro-level, only those factors identified by individuals and communities were considered.

The whole process of analysis involves a constant comparative analysis moving back and forth to identify the relationships among the emergent categories. Initially ATLAS.ti was used for coding, but there was a risk of missing certain important issues, as it was difficult to capture the nuances of meaning of a text. The coding process required a thorough understanding of the experiences, opinions, contexts, and subtle meaning of certain words. This proved only to be possible by conducting the coding process manually.

## 6 | VULNERABILITY AND ADAPTATION BARRIERS FOR LOW-INCOME POPULATIONS EXPERIENCING FLOODING: THE CASE OF DHAKA EAST

The majority (82%) of households in the study area live on a rental basis, where buildings are either developed on privately owned land by the landowner, or established illegally by influential local people on vacant public land. In both cases there is considerable risk of eviction. The government has not yet been able to produce any inclusive programme for residents' rehabilitation, or to provide them with the necessary long-term tenure security (BRAC, 2012). Interviews with government officials revealed their perception that providing basic services in these settlements would only encourage more poor people to migrate from rural areas. Such a perception, along with the lack of mandated urban policy, has incentivised government bodies to ignore low-income urban settlements. NGOs and government officials referred to this lack of an appropriate national policy for the urban poor as a prime constraint on working with low-income urban settlements. The very limited presence of the urban poor in relevant policies confirms their exclusion from development planning. The lack of basic service provision in the city reflects an authoritarian government with little accountability (BRAC, 2012). Most government initiatives were criticised by government officials themselves during FGDs and interviews for lacking significant community participation, and lacking bottom-up links from community to the higher levels of local and national authority. Corruption in every limb of the governance system contributes further to this situation (Iftekhazzaman, 2011).

Bangladesh has one of the largest NGO communities in the world (BRAC, 2012) and these NGOs provide a wide range of activities that attempt to fill the vacuum created by the absence of government, in the hope of addressing the development deficit. Although they do not have any specific activities for flood/disaster management (apart from relief activities during disaster), they mostly focus on developmental activities which increase the adaptive capacity of low-income groups. Activities include provision of basic services, micro-finance, education, grants or credit programmes, savings schemes, and vocational training. However, there are several operational barriers which restrict their effectiveness in Dhaka East. Firstly, NGOs are dependent on government for project approval, as international funds are channelled through the government. The common practice, as referred to by several high-level NGO officials, is that government never approves a project that falls outside governmental activities or contradicts its policies. For instance, it only approves projects in those low-income settlements that are recognised by the government. This results in some settlements being supported by multiple NGOs and the rest not being served at all. During interviews, several officials noted that the NGOs end up serving the government's interests rather than serving the people who actually need their support. As stated by a mid-level NGO official:

We feel that we are doing whatever the government wants us to do.... rather than serving our actual motto .... serving who needs us...who needs our service. We are more becoming a puppet for government ....

Secondly, both FGDs and interviews with NGO officials revealed that there are restrictions on the areas that can be served by donor funds allocated for urban areas. The conventional definition of *urban area* corresponds to the municipal area, and areas outside this are considered to be rural. But funds for rural projects are used for other rural areas perceived to be more vulnerable. Because growth has been so rapid, a significant part of Dhaka city (especially that occupied by informal settlement) is outside the municipal area, and is therefore out of scope for donor-funded NGO activities. There is constant renegotiation of the boundary between the urban and the rural, but large areas of low-income settlement can never receive donor and NGO support. Despite their good intentions to serve urban low-income groups, NGOs thus often fail to reach their potential because of these operational restrictions.

In the low-income settlements, the largest group (approximately 43%) of the surveyed population work as day labourers, with no permanent job; 70.4% are migrants from other cities. Half are illiterate. The condition of basic services is extremely poor, with only 21% having access to a government-provided water supply through standpipes. Typically one latrine is shared by 25–30 households; 4% of households do not have any access to sanitation services, and adopt open defecation. Medical facilities are mostly located within municipal areas and are far from the study area and low in number relative to the population. The whole study area lacks a storm sewer drainage system and only 22% of the area has surface drains. Furthermore, many of the existing surface drains do not work properly due to lack of maintenance.

The majority of people occupy temporary<sup>1</sup> (40%) and semi-permanent structures (50%). Due to lack of available land, there are settlements that have grown up on water bodies. The temporary structures on water bodies are extremely vulnerable considering their location and construction method, but FGDs revealed these communities consider their location a worthwhile trade off, occupying as they do an urban area near the central business district with good job opportunities.

Only 2.5% of the surveyed households were aware of any emergency response system, and in fact, there is no flood evacuation system in practice, and no emergency flood shelters in the city; schools and other academic institutions are

converted to shelters during severe disasters. Although there is some early warning infrastructure in the city, generally it does not work properly for multiple reasons. For instance, there is an interactive voice response system using mobile phones, but this is not yet known to most people. Only 25% of surveyed households receive some kind of early warning. The majority receive warnings through social networks (interaction with colleagues, friends, relatives, neighbours etc.), and only 6% through public announcement and 3% through the radio. Among the surveyed households, only 11% have access to government organisations, and 15% have access to NGOs (accessing services provided by organisations). In the study area, the education rate is much lower in females than in males. Approximately 60% of females from the surveyed population are illiterate. Females in the conservative society of Bangladesh are not allowed to go to school, are expected to stay at home and engage in household work, and do not have the freedom to socialise with the outside world. This also affects their access to the economic system, since people generally do not accept women working outside. These social restrictions and economic barriers largely limit their adaptive capacity. Hence, in most cases, women do not receive any sort of early warning even through social networks. Even if there are facilities for women, that is, facilities offered by NGOs, most women are not aware of them.

The above discussion illustrates that the barriers to adaptation are particularly derived from the adaptation deficit at the household level and the poor development context; lack of tenure, inadequate access to basic services, and being located outside the municipal area. Such conditions, which are derived from location and from a development deficit, mean these people are the hardest hit during disasters.

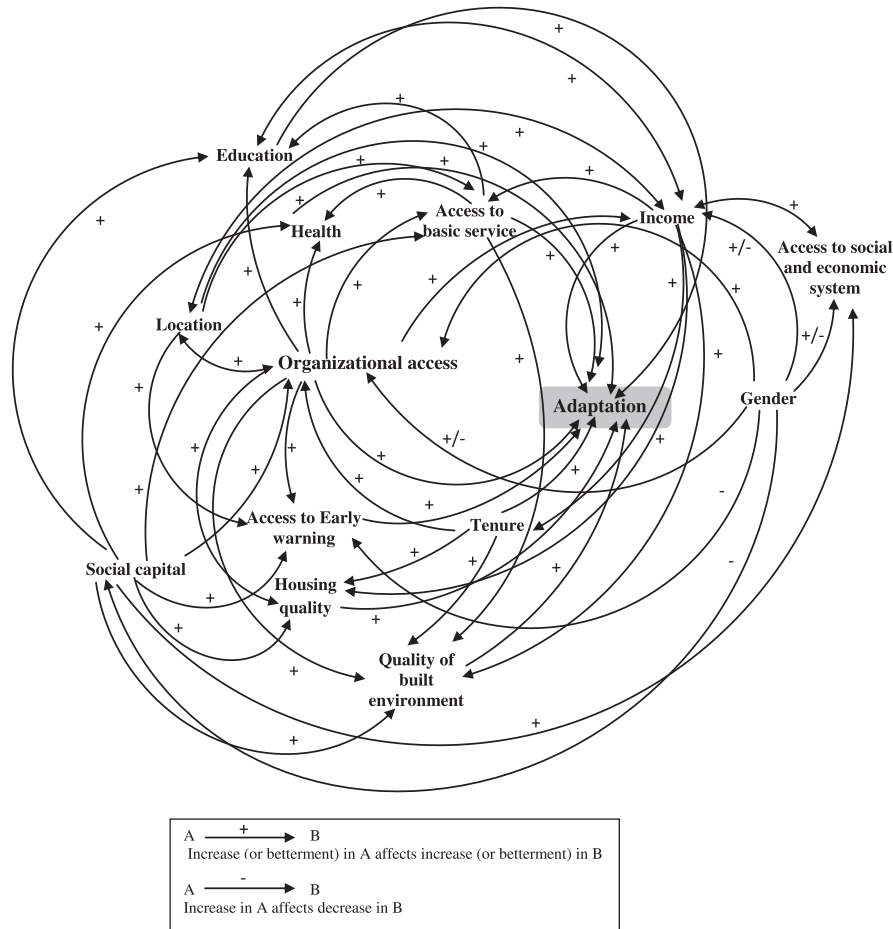
## 7 | SYSTEMS ANALYSIS OF ADAPTATION PROCESS OF LOW-INCOME URBAN POPULATION

The data show that the adaptation process in the case study area is strongly influenced by multiple interrelated factors: income, tenure, organisational access (i.e., access to government organisations and NGOs, which includes accessing the facilities offered by such organisations), gender, social capital, access to basic services, quality of built environment, location, housing, access to early warning systems, and access to the social and economic systems of support services. Figure 1 illustrates the adaptation system, including the identified influencing factors.<sup>2</sup> Only these factors are included in the system diagrams that have been mentioned by the studied population (during FGDs) to be significant for their adaptation process, and the relationships shown are those that they themselves indicated were causally connected from their own personal experiences.

The data show that people imply income drives adaptation in multiple ways: better income positively influences obtaining a better location for living, which in turn determines better access to basic services. The low-income population tends to choose lower rent housing outside the municipal area or in a highly vulnerable location. To some extent, income also determines tenure status, as most cannot afford legal tenure: land and house prices are very high and land is scarce relative to the growing population. Lack of tenure feeds hesitation to invest in housing or in the built environment for fear of eviction. This leads to *ad hoc* temporary solutions addressing immediate risks, which are impact minimising rather than preventive. Access to NGOs is, sometimes, dependent on tenure status; often, NGOs require that a household should hold legal tenure to be assisted. The primary reason, as explained by a senior NGO official, is that much of their work, for example, microcredit and other loans, is for the long term; hence they need to track the beneficiary household. This limited access to financial schemes offered by NGOs links organisational access to income. More general finance from government is also limited because of lack of recognition of settlement status. However, organisational access affects other issues: better access to early warning systems would enable them to prepare for a potential hazard in advance, and lack of such a system makes the adaptation process even harder. Improved organisational access also feeds into improved living location (and vice versa), and thus to higher incomes and a better financial situation.

Gender is another important factor (see Section 6). Females are restricted from accessing the social network (which then determines access to early warning, shelter, adaptation advice), as well as the economic system and education. Hence, females lag behind in many of the prerequisites for successful adaptation. On a positive note, as derived from the FGDs and interviews with NGO officials, gender also determines access to organisations, as many NGOs have specific services for women; for example, financial schemes or grants. These schemes influence income, and better income tends to ensure better adaptation. Social capital is vital for adaptation, influencing the adaptation process through shared communal activities serving shared objectives: the FGDs and survey data show that there is a high level of trust and interaction with neighbours, who provide the primary source of advice. This is also positively connected to many of the other influencing factors of the adaptation process; that is, access to basic services, early warning systems, access to organisational support, and access to the social and economic system through communal action. However, for women, such access may be very restricted.



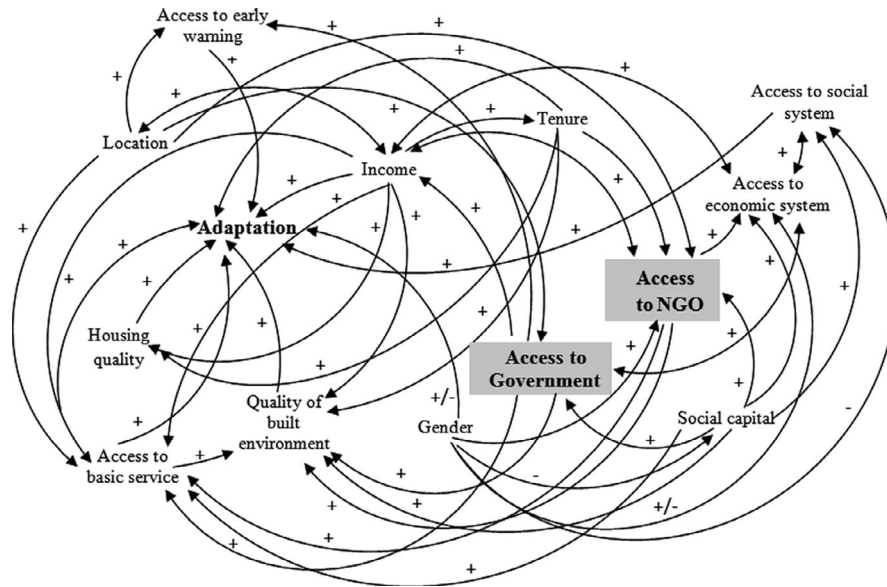


**FIGURE 1** Adaptation system in the low-income urban settlements.

Because Figure 1 shows that the majority of adaptation-influencing factors are directly or indirectly related to organisational access and to social capital, specific diagrams focusing on these two factors are helpful. Figure 2 attempts to represent the relationship between adaptation and organisations by showing the types of organisation (i.e., government and NGOs). The figure clearly shows there is a strong relationship between income and access to NGOs and government through the economic system. The relationship between income and access to the economic system is bi-directional: better access improves income, and better income ensures better access to the economic system (as the data show, many financial services require a minimum amount of income for access). Also better income influences adaptation through better housing quality and built environment (ensured through legal tenure, where possible), and also through better location of living (which again positively influences access to government and NGOs). Better access to government and NGOs influences better access to basic services (education, health facilities), which again tends to assure better adaptation. Access to government determines better access to early warning systems, with a direct positive relationship to adaptation. Gender influences access to NGOs, hence to the economic system, which ensures better income and thereby better adaptation. Social capital tends to ensure better access to both government and NGOs. Hence it is apparent that almost all the influencing factors of the adaptation system are perceived to be related to organisational access, which makes it the vital influencing factor in the whole system.

The influence of tenure security in the adaptation process is evident, primarily through low adaptation of the housing and built environment in the absence of legal tenure, and also through its extended influence on access to NGOs and access to basic services, which together influence income and thereby choice of location of living and so on. Therefore, analysis of the adaptation system further stresses the importance of tenure security in inhibiting adaptation in addition to its influence in increasing the vulnerability of the urban poor (see Section 8 and Figure 4).

Figure 3 illustrates the relationship between social capital and organisational access, and its influence on the adaptation system as a whole. To make the diagram easier to understand, factors are only shown that have a direct (positive) relation with social capital. Hence tenure, housing quality, and location have been excluded from the diagram; but note that, as is



**FIGURE 2** Adaptation system showing the influence of access to government and NGOs.

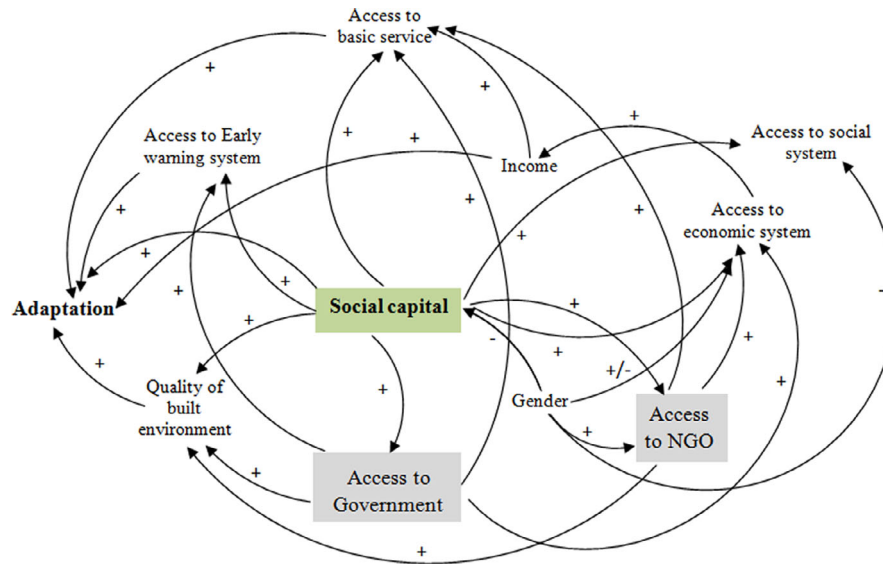
apparent from the whole system analysis shown in Figure 1, social capital indirectly (and positively) influences the excluded factors (tenure, housing quality, and location) by influencing income. Figure 3 also illustrates that social capital positively influences access to organisations (both government and NGOs) through collective action. Social capital also ensures better adaptation through enhanced quality of the built environment (not only through shared objectives but also through accessing organisations) and ensuring access to basic services. Social capital enhances access to early warning systems through the social network and also through improved governmental access, which strongly influences the adaptation process. Social capital, income, and organisational access positively influence each other. Better social capital ensures better organisational access through which income is positively influenced by improved access to the economic system provided by government and NGOs. Gender is also relevant despite the inverse relationship between being female and social capital, as a positive relationship occurs through better access of females to some NGO services.

## 8 | DISCUSSION AND RECOMMENDATIONS

This “whole system” analysis reveals that various aspects of organisational access, tenure, income, and social capital are the key influences mentioned by respondents as influencing the adaptation process in the case study context; these factors have the most connections (direct and indirect) with other system properties. All the factors are directly or indirectly related to organisational access, which has the highest number of connections with other factors in the system. Therefore, organisational access seems to be the dominating factor, playing the most important role. Social capital is also seen to play an important role in effective adaptation. It strongly and positively influences organisational access, and is also endorsed by the people themselves who accept that they can respond better to floods if they act communally. Income, as discussed in the previous section, is strongly influenced by organisational access.

Note that it is difficult (and beyond the scope of the study) to identify the strength of relationship among the factors as it can vary depending on the respondent's condition; for example, income level, gender, age, or education. Nevertheless, such a whole system view aids understanding of the holistic interrelation among the influencing factors of the system. Also, a systems analysis such as this can be an effective way of identifying intervention points to improve the system. For example, tenure insecurity creates a reinforcing loop with income and organisational access (Figure 4), so interaction among these three factors could be a focus for further investigation by identifying the ways in which this vicious circle can be broken.

As the systems analysis shows, ensuring tenure security might impact positively on the adaptation system by counteracting the reinforcing loop. Tenure regularisation (providing households with freehold or leasehold titles) might be difficult to achieve in many cities with rapid urbanisation, considering the administrative context, lack of resources and infrastructure, and most importantly, the lack of available land. Security of tenure does not necessarily require tenure regularisation (Lasserre & Lauren, 2002). Protection against forced eviction can be a first step and can solve the householder's immediate



**FIGURE 3** Adaptation system showing social capital in relation to organisational access.

problem of the fear of being evicted at any time (Lasserve & Lauren, 2002). This is an incremental process, where at an advanced stage, the provision of title can be considered.

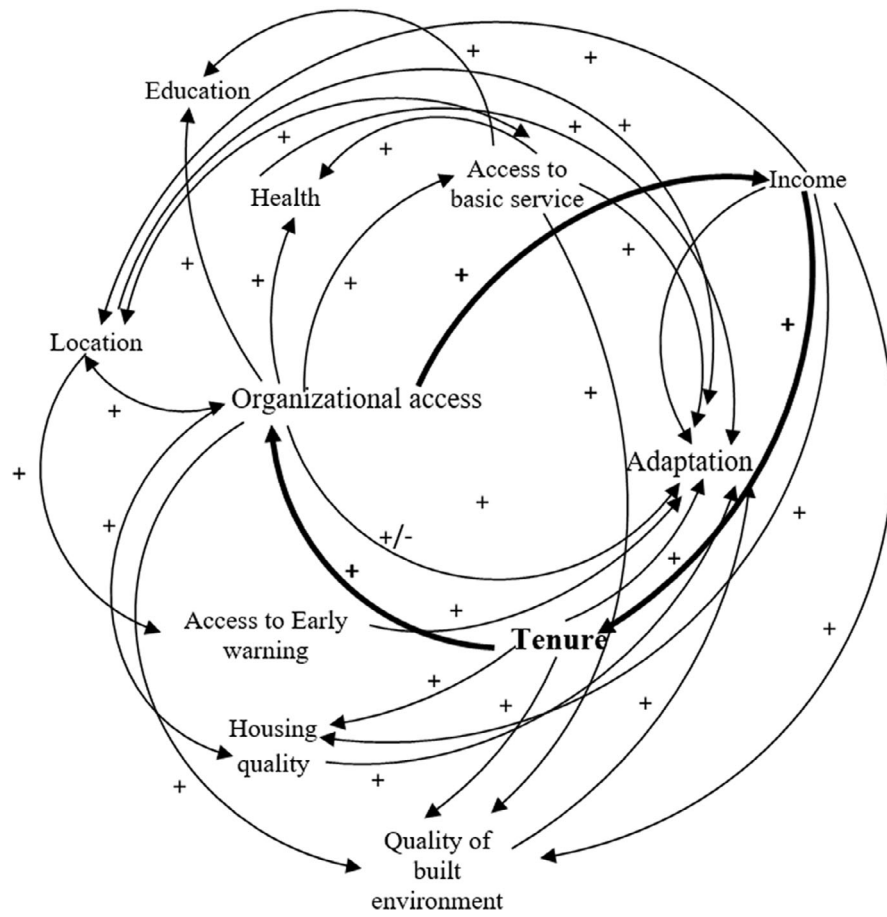
Figure 3 shows the influence of social capital on adaptation; its direct positive relationship with access to government, NGOs, basic services, early warning systems, income, and quality of built environment underlines its potential for successful adaptation by the urban poor. CBOs, which are built on the social capital within the community, can act as a positive driver for providing better access to organisations and for better enabling communities to respond to the context-specific nature of flood vulnerability (Pelling & High, 2005). Such potential can largely be explored by acknowledging and assisting people with financial and technical support. However, the importance of CBOs is relatively invisible in government policies and practices in Bangladesh (Bicknell et al., 2010), resulting in a lack of institutional support to back their activities. CBOs can potentially serve to make the vertical connection between the urban poor at the micro-level and the macro-level organisations, which is apparently missing in the study area, always provided they are not subject to elite capture (Rigon, 2014).

As mentioned in Section 6, NGO activities are largely constrained from serving their full potential because of government and donor restriction. Acknowledging the importance of NGO services in the adaptation process is crucial to ensure optimal utilisation of their potential for serving the urban poor. There is a requirement for new funding channels independent of government to ensure that funding reaches groups in need and to empower NGOs to serve these people. Again, as mentioned in Section 6, donor restrictions on serving areas outside the municipality also need to be addressed. It is urgent to revise the definition of the areas that can be served, to increase flexibility in the face of trends in urbanisation, and to enable local organisations, government, and NGOs to use funds to serve the people at risk living in urban areas rather than just within the municipal designation.

Possibly the principal outcome from this study for Dhaka is that government has the most important role to play in almost every aspect of adaptation involving the urban low-income group: from acting as an implementer (implementing its own initiatives) to an enabler (enabling NGOs and CBOs to perform efficiently), and a facilitator (facilitating NGO, CBO, or household level adaptation activities). Hence it is the government that actually holds the key for ensuring successful adaptation for and by the target group.

## 9 | SCOPE OF FURTHER RESEARCH

Our aim here has been to improve understanding of the dynamic linkages in adaptation as understood by the urban poor of Dhaka East, at least as far as the direction of influence is concerned. The method here serves this analytical purpose, showing important systems relations in the case study context. We stress, however, that these findings are indicative rather than definitive based on the data derived from the case study *sample*. The whole systems analysis, we argue, does uncover the complexity of real world systems through the discussions, information, and stories drawn from the sample participants in



**FIGURE 4** Influence of tenure in the adaptation system.

expressing their lived experiences. The whole set of connections, however, is typically not visible to any one respondent, with their own necessarily partial viewpoint. Without such a whole systems view, there may be a temptation to focus on single issues and neglect how these are related to other factors. For example, where linkages are missing (e.g., between gender and access to government), this may indicate a problem that needs to be addressed in order for adaptation to become effective for certain groups. However, there may also be indirect feedback loops through several factors (for example, access to government is linked to adaptation through income and access to services). Whether adaptive changes are indeed improved in effectiveness when these inter-linkages are taken into account then becomes a matter for continuous longitudinal observation; additionally, a willingness to adapt policy over time, and revisit people's expressions of what is working, or not, for which a partial snapshot such as the one we provide can only form a starting point. This gives scope for further in-depth systems analysis over time to understand better how individual factors influence the overall system, and what important issues may be missing.

Generalising this study in the wider LDC context will require more empirical evidence of other cases. However, we suggest that comparable systems analysis and mixed methods can be used to draw conclusions from several similar comparative case studies, and then to identify generalities and complementarities across different locations. This will also help identify which are the context-specific issues, and which are common issues irrespective of context. This can also feed into the formulation of macro-level adaptation policies by incorporating micro-level evidence.

## 10 | CONCLUDING REMARKS

It is often easy to criticise existing urban adaptation approaches, but difficult to make recommendations which are viable and practical. Nevertheless, this study has attempted to point towards some factors relevant to adaptation in one area of low-income urban settlement (e.g., tenure security, social capital, access to NGO) by indicating where a positive impact might be achieved in the adaptation process. To do this, the study looks at this research problem from a “whole systems” point of view; using “causal” loop diagrams that show stated beliefs about the influencing connections between different

adaptation factors. To the authors' knowledge this method has not been applied before for investigating adaptation processes to hydro-climatic risks experienced by the urban poor. Considering the complexity of the adaptation process and the interrelation of multiple factors in this process, the “whole systems” view provides a holistic understanding, and the influence diagrams provide a pictorial representation that may be more useful than textual descriptions or tables. The systems analysis incorporates key variables and their potentially causal relations, and not only allows visualisation of the existing system but also helps to identify how the systems can be improved; for example, by counteracting maladaptive feedback loops. The analysis also helps to identify useful intervention points. Hence it can be used as a template for interdisciplinary research and policy studies. Therefore, the conceptual basis and method of this research is adaptable to similar contexts, where it can help in unpacking the complexity of the multiple levels of interaction in the system, it can lead to understanding the relationships among its factors, and it can suggest suitable modifications of the system (adding or removing factors/elements) to support and enable adaptation.

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## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

## ORCID

Anika Nasra Haque  <https://orcid.org/0000-0002-0717-376X>

Keith S. Richards  <https://orcid.org/0000-0001-8170-6512>

## ENDNOTES

<sup>1</sup> Both temporary and semi-permanent structures use bamboo, wood, corrugated tin, and straw as roofing and walling material. The only difference is in the plinth which is mud, wood, or bamboo for temporary structures, and, brick or concrete for semi-permanent structures.

<sup>2</sup> All the interrelationships among the factors of the system are derived by analysing the collected data based on the multiple (mixed) methods mentioned in Section 5. For further details about data collection, see the Supporting Information.

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## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

**Supporting information SI1:** Location of the study area

**Supporting information SI2:** Additional details on Household questionnaire survey

**Supporting information SI3:** Additional details on questions guideline for focus group discussions

**Supporting information SI4:** Additional details on questions guideline for semi structured interviews

**Supporting information SI5:** Additional details on sampling techniques

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