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ORIGINAL ARTICLE

Autonomous adaptation to riverine flooding in Satkhira District, Bangladesh: implications for adaptation planning

Adrian Fenton[1,2,3] · **Jouni Paavola**[1,2] · **Anne Tallontire**[1]

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Abstract Systematic understanding of adaptation measures utilised by households in developing countries is needed to identify the constraints they face, and the external interventions or adaptation planning needed to overcome them. Understanding of autonomous household adaptation patterns remains underdeveloped. In particular, little is known regarding whether households are implementing incremental or transformational adaptation measures as well as the implications of this for adaptation planning. We demonstrate the suitability of the risk hazard approach for understanding autonomous household adaptation patterns and discuss the implications for planned adaptation. To achieve this, we use an in-depth village case study from an area of Bangladesh particularly vulnerable to climate change, using qualitative semi-structured household interviews as primary material. We find that the risk hazard approach is ideal for exploring autonomous adaptations because of its capacity for understanding how households respond to livelihood risk, and what resources are required for it to be most effective. However, the risk hazard approach overlooks equity and fairness considerations need to be integrated due to the insufficient emphasis on these concerns.

Editor: Jamie Pittock

✉ Adrian Fenton
adrianfenton@hotmail.co.uk

[1] School of Earth and Environment, University of Leeds, Leeds, UK

[2] ESRC Centre for Climate Change Economics and Policy, University of Leeds, Leeds, UK

[3] International Centre for Climate Change and Development, Dhaka, Bangladesh

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Introduction

Adaptation to climate change (henceforth 'adaptation') has become a critical issue in developing countries. It is generally accepted that external intervention or adaptation planning is required to help communities within developing countries meet adaptation challenges. External support should be predicated upon knowledge of what autonomous adaptation is taking place, by whom and how in order to accommodate and influence community needs and priorities which may not be sufficiently informed by long-term considerations (Stern 2006; Smit et al. 2000; Scoones 2009; Eriksen et al. 2011; Wise et al. 2016). Autonomous adaptation consists of household perceptions and responses to climate change. It is a continuous process occurring outside of top-down policy support, intervention and constraints, and it typically occurs in response to multiple stimuli rather than to climate stimuli alone (Smit et al. 2000).

Our understanding of autonomous adaptation at the local-level remains weak (Thorn et al. 2015), with much of the local adaptation unnoticed, uncoordinated and unaided by development actors (Christoplos et al. 2009). It is also poorly understood to what extent adaptations remain incremental or are transformational, resulting in something fundamentally new. This distinction is important, as it is increasingly likely that transformational rather than incremental adaptations will be needed. Consequently, adaptation planning will need to identify priority issues and which strategies are most effective (Smith et al. 2011).

This article examines autonomous household adaptation in Satkhira District, Southwest Bangladesh. Bangladesh

provides an opportunity for examining household livelihood responses to climate change (Lewis 2011). It is one of the least developed and among the most vulnerable countries to climate change. A large proportion of its territory is comprised of flat alluvial plains, with 80% of land less than 10 m above sea level (CCC 2009). Bangladesh has one of the world's largest river systems, transporting the highest sediment load in the world. This contributes to its particularly high exposure to flooding. A quarter of the land area is flooded annually with attendant livelihood and asset losses. Severe floods have affected over half the country around every 5 years, destroying important household assets, such as agricultural land, and severely disrupt everyday lives (Tutu 2005; MoEF 2008). In the changing climate, heavy precipitation events are projected to increase and flooding to become more intense and frequent (Kundzewicz et al. 2014).

Our article has four aims. Firstly, we aim to conduct an in-depth qualitative empirical examination of autonomous household adaptation to deem whether adaptations are incremental or transformational. Secondly, we aim to empirically demonstrate the appropriateness of the risk hazard approach for understanding autonomous household adaptation. Thirdly, we aim to demonstrate the benefits to adaptation planning of using the risk hazard approach for systematically understanding autonomous household adaptation, a requirement for successful external intervention. Finally, we aim to empirically demonstrate that unless power and equity concerns are incorporated into the risk hazard approach, there is a danger of exacerbating social inequities.

The article contributes to existing literature by demonstrating why the risk hazard approach is the most suitable one for assessing autonomous household adaptation. By employing this approach, we show how households use a combination of incremental and transformational measures to adapt to flooding. The results highlight how socioeconomic status is linked to patterns of transformative adaptation; households with low socioeconomic status do not have equal access to adaptation measures and existing government extension programmes often accentuate inequalities. We conclude that while the risk hazard approach is well-suited to understanding autonomous adaptation, equity and long-term considerations need to be given additional attention.

Conceptualising adaptation and transformation

The need for individual, household, or community adaptation arises due to vulnerability which has different meanings across the three key strands of adaptation research (for an overview, see Janssen and Ostrom 2006, Eakin et al. 2009 and Eakin and Luers 2006). The socioecological resilience approach focuses on systems and thresholds, and the ability of a system to adjust and respond over the long term (Folke 2006). The political ecology approach focuses on power, equity and capabilities. It is mainly concerned with immediate needs caused by vulnerability, causes of vulnerability and how vulnerability differs across societal groups (Adger 2006). The risk hazard approach focuses on exposure and sensitivity to hazards. It has been primarily concerned with practical implementation of adaptations at the sectoral and community levels (Smit and Wandel 2006). It focuses on enabling environments and creating decision-support tools to facilitate bottom-up adaptation by private sector, civil society and local government actors (Eakin and Lemos 2006).

The three strands of vulnerability research ask different questions, highlight different characteristics as central to vulnerability and thus have their own strengths and weaknesses. For instance, the risk hazard approach privileges efficiency and effectiveness over equity, whereas the reverse is true for the political ecology approach (Eakin et al. 2009). The approaches have also somewhat different scales of application. The political ecology and risk hazard approaches are well suited to focus on household and community-scales, while the ecological resilience approach is more suited to studying larger socioecological systems (Eakin and Luers 2006). Both the risk hazard and political ecology approaches are compatible with participatory processes involving low capacity stakeholders; however, the ecological resilience approach is somewhat incompatible with these processes (Butler et al. 2016; Butler et al. 2014; Butler et al. 2017).

We adopt the risk hazard approach because it is best placed to ask questions relating to cost, risk and uncertainty. It is particularly well suited to household level livelihood studies as local responses to climate change are driven by how they impact on livelihoods and assets (Ayers and Forsyth 2009). Consequently, by the term adaptation, we refer to the processes through which households adjust to changing conditions, stresses, hazards, risks or opportunities (Smit and Wandel 2006). Adaptation is distinct from 'coping' which refers to immediate responses to events: in contrast, adaptation prepares households for expected future events (Berman et al. 2012). Adaptive capacity is a measure of the ability to adapt (for overview see Smit and Wandel 2006). Adaptations are often described by their function: adaptations which retreat from hazards can lead to the abandoning of exposed areas; others accommodate hazards enabling continued occupancy and use of vulnerable areas; lastly, adaptations can seek to protect against hazards and thus defend exposed areas, economic activities and natural resources (Dronkers et al. 1990). Within this approach, adaptation measures that inadvertently increase vulnerability are considered as maladaptive (Barnett and O'Neill 2010).

Transformation is becoming an increasingly important adaptation concept as worsening climate change impacts are likely to demand more substantial responses. Small-island and other

low-lying states threatened by sea level rise provide an example: transformational changes such as loss of land and statehood may not only occur, but will likely result in subsequent transformational changes such as mass relocations of populations.

The risk hazard approach has only recently started using the term transformation (Klein et al. 2014) but earlier statements such as the need for 'non-marginal change' already suggested it (Rickards and Howden 2012 citing Stern 2006). Transformation is emerging as an important topic particularly in research on agriculture (Rickards and Howden 2012). Here, transformation refers instrumentally to the depth or extent of change needed (Leclere et al. 2014; Klein et al. 2014). Three observed types of transformations are actions adopted at greater scales or intensities, actions that are original to a particular region or resource system and actions that transform places and shift locations (Kates et al. 2012). But deeming what is transformational and what is not remains often difficult to do in practice in all approaches. Rickards and Howden (2012) suggest that this is due to the multiple dimensions through which change can be assessed. Determining whether something is a transformation is therefore somewhat subjective and relative.

The risk hazard approach has an instrumental take on transformation: it may be needed because of extreme vulnerability or severe climate change impacts, which threaten socially negotiated norms and inhibit the ability to fulfil objectives. Without transformation, losses would occur (Dow et al. 2013; Kates et al. 2012). Thus, limits and barriers are central to transformation. 'Barriers' can frustrate adaptation but they can be overcome (Barnett et al. 2015). They are distinct from 'limits' that prevent objectives from being realised (Dow et al. 2013; Marshall et al. 2012). 'Hard limits' prevail when nothing can be done to avoid intolerable risk. Transformations can occur in the face of hard limits but they would entail drastic changes in objectives and associated values (Barnett et al. 2015). In the presence of 'soft limits', intolerable risks can be overcome with new strategies and measures (IPCC 2013). Transformation can therefore be seen as a way of overcoming soft limits, for instance when efforts to tackle climate change are new to a location (see Kates et al. 2012).

Consequently, we consider transformational adaptations to include those novel livelihood changes that enable households to overcome adaptation limits posed by hazards, and which respond to what is perceived an untenable situation. Incremental adaptations in turn include those household livelihood changes, which manage changing risks posed by hazards. While this creates a simple dichotomy, the linkages between incremental and transformational changes remain an underexplored topic. In practice, it is sometimes not easy to make a distinction between the two. For instance, it is becoming clear that incremental change can both facilitate and inhibit transformational change (Rickards and Howden 2012; Kates et al. 2012; Butler et al. 2016).

Materials and methods

A single village case study was chosen to enable the in-depth examination of the context specific nature of vulnerability and adaptation. This required the use of qualitative research methods as part of a wider mixed-methods approach, which in turn required a prolonged presence in the field in order to gain familiarity and trust of research participants. This approach is consistent with state of art in the adaptation literature (Janssen and Ostrom 2006; Ford et al. 2010; Smit and Wandel 2006).

The research was carried out in the Satkhira District, Khulna Division; one of the poorest areas in Bangladesh where flooding is a common problem (Azam and Imai 2009; Tutu 2005). We selected this district in light of key informant interviews with national civil society organisations. Noapara village was selected after key informant interviews with local civil society, government and community representatives. Both methodological and pragmatic considerations informed the selection process. Methodological concerns included the need for the village to be typical for the district, exposed to a prominent hazard for a number of years and exhibit evidence of adaptation. Pragmatic considerations included accessibility, safety and absence of research fatigue (Fig. 1).

In March 2014, 30 participants (11% of the total households in Noapara village) engaged in focus group discussions involving tools such as seasonal calendars and Venn diagrams to explore village life, confirm the appropriateness of the village for the study and to plan future research in more detail. Between May and June 2014, 266 households (99%) were surveyed on demography, assets, access to weather and climate information, support networks, innovations, access to improved seed varieties and exposure and sensitivity to environmental hazards. Between March and April 2015, semi-structured interviews were conducted with heads of 38 households (14%) to explore household responses to environmental changes. Selection of households for interview was informed by livelihood profiles, constructed from survey data, purposefully sampled for socioeconomic status by considering land ownership and education, as well as considering homestead status, and credit usage. Also, 13 short interviews were conducted with market stall owners. Personal observation and informal conversations complemented the above data collection methods.

Focus group findings were interpreted in situ with participants. Survey data was analysed using SPSS and interpreted using literature themes. Semi-structured interviews were coded according to coping mechanisms and household adaptations. Analytical categorisation was undertaken using an iterative process that builds on the initial descriptive coding, drawing themes from the literature to interpret the material.

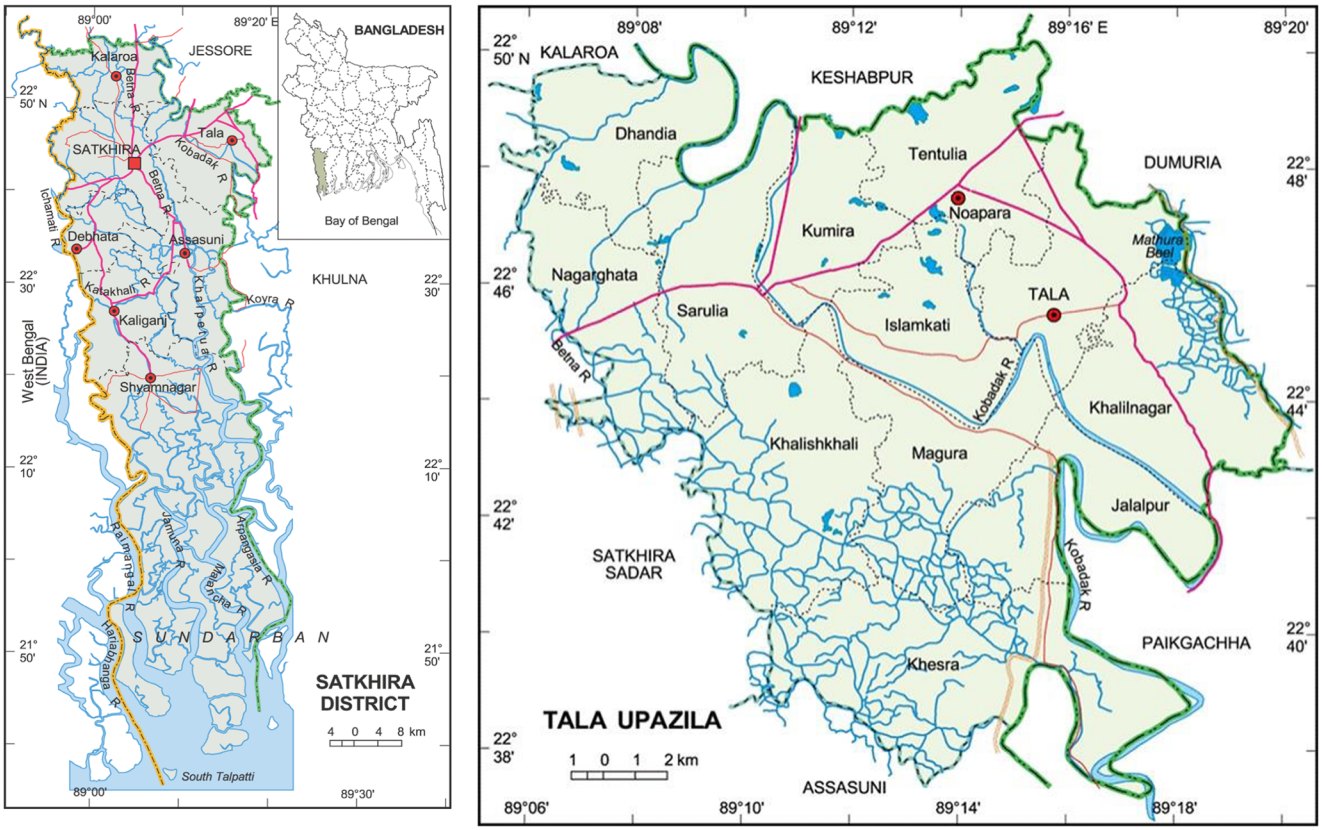

Fig. 1 Location of case study. *Left*: map of Satkhira District which is in the south west of Bangladesh. *Right*: Tala Upazila (*right*) which is situated in the north of Satkhira district. Noapara is represented with a *red mark* and is situated in Tentulia Union Parishad. The Kobadak River flows through the middle with a connected canal in close proximity to Noapara

Case-study

Noapara is surrounded by the Ganges Floodplain in the north and the Sundarban Mangrove tidal forest in the south. It is surrounded by agricultural land and dissected by a major road connecting Satkhira and Khulna and acts as a market village for other villages further away from the road. The nearby towns of Tala, Patkhelgata and Paikgachha have larger markets and more economic activity. Noapara is home to 267 households, 74% of which have 3–5 members (median = 4), and most are male-headed (94%). Agriculture is central to livelihoods, one respondent commenting that 'no job means no farming'. Agriculture has historically followed a pattern of cash crop cultivation during summer and high-yield rice cultivation in winter. Cash crops provide income, while rice provides food security. Summer cultivation of jute has been vital to livelihoods in recent years: one participant remarked 'Oh jute, it had a huge impact on my livelihood, I paid [off land mortgage] with that money… I built this house using that money… I bought cattle and goats selling jute'. Small-scale livestock (cattle and goats) and poultry (chicken and ducks) rearing are also common, typically serving household consumption but also serving as investment. Aquaculture of fresh water prawn and fish is practised in ponds, with a few households engaged in larger-scale production for wider markets. Seasonal migration for agricultural labour to nearby Jessore, Khulna and Satkhira is common. Less common livelihood activities include non-agricultural salaried work, international migration and business in temporary or permanent premises.

Focus group discussion yielded farmland ownership and educational attainment as key indicators of socioeconomic status. Households of low socioeconomic status (57.7%) are both functionally landless and have illiterate household members. Households of medium socioeconomic status (28.1%) have mostly educated members (with potential to apply for salaried employment) and they are typically small landholders. Households of high socioeconomic status (14.2%) own substantial amount of land or had at least secondary school education. Farmland ownership is an important indicator of wealth in a rural economy. It is highly positively skewed in the village as well as in the Satkhira District as a whole (Government of Bangladesh 2010). Most households are either functionally landless (64%) or small landholders (27%). Some households (8.6%) own moderate amounts of land and small number of households (0.4%) own most of the land.

Education is highly regarded; assets such as animals and credit are used to pay school fees. One villager stated: 'we

need education…without education you cannot do anything'. Education is closely linked with poverty reduction. Jute cultivation was brought to the village by a school teacher. Over half of households have at least some illiterate members (55.8%). Only 6.7% of households have members that had at least secondary education. The proliferation of homestead adaptations has reduced the significance of homestead type as an indicator of socioeconomic status. Households either live in basic (earthen), semi-improved (kiln-fired brick) or improved (kiln-fired brick with plaster coating) homesteads. Many households live in semi-improved homesteads (56%), and most homesteads (82%) are on plinths of differing heights and reinforcement status.

All households are exposed to multiple hazards but particularly to riverine flooding. Flooding typically occurs between July and August but it can have adverse impacts for much longer because of poor drainage from flat land of low elevation. Flooding occurs almost every year when water overflows the banks of the Kobodak River, which is elevated above surrounding land (BWDB 2011). Flooding is a major concern in the area which is less than 3 m above sea level (Ahmed 2010). The main cause of flooding is considered to be the Coastal Embankment Project completed in the 1960s. Construction of polders and lack of dredging has restricted tidal flow and prevented sedimentation on surrounding floodplains, leading to sedimentation in rivers and reducing their drainage capacity (ADB 2007; Tutu 2005).

Participants indicated that the intensity of flooding has increased dramatically over the last 10 years, with major events occurring in 2008 and 2011. Flooding typically lasts for 2–3 months but can continue longer. A local councillor commented that in 2011, flooding lasted for 8 months. The survey indicated that most households have been affected by flooding 3–5 times in the past decade depending on homestead and agricultural land elevation, as well as implemented adaptation measures. Conventional homesteads were not designed for extended flooding and plinths were too low to keep buildings dry: they collapse when unreinforced plinths and walls dissolve in flood water. Only improved homesteads survived flooding in 2011. According to a local councillor, 'no one stayed in their homestead… [they all] took shelter on the roads'.

Many assets such as trees, livestock and poultry have been lost, with one participant reporting that 'Nothing is left, nothing is left, I have nothing left. There were big trees over there. There were coconut trees, mango trees and other fruit trees. Trees died because of the flood'. Households cope by selling affected assets at nearby markets, but they often obtain lower prices and returns on their investments. Participants reported higher incidence of disease and snake-bites during floods. Summer cultivation of cash crops often fails during floods. Many households have ceased summer cultivation because flooding which is perceived to be too big risk even with flood-resistant seed varieties. As most agricultural inputs are purchased with credit, debt levels increase when harvests fail. Demand for agricultural labourers also declines when harvests fail or land is left uncultivated. Some households have to sell rice to repay debts, which reduces their food security. Businesses are negatively affected by flood damage to premises and stock, but also due to lower demand for goods and services. Some of them close for the summer for this reason.

Results

Household interviews brought up numerous and often interlinked adaptations to flooding such as changing composition of poultry stocks, homestead and plinth improvements, domestic and international migration, conversion of agricultural land for aquaculture, halting of summer cultivation and salaried labour. These adaptations are all autonomous, despite the multitude of non-governmental organisations and government extension officers in the area. Some government extension services such as the provision of training and financial services have facilitated adaptation, but only serendipitously. Interviews with the local government representatives indicated a lack of formal support for household adaptation to flooding and that engineering solutions such as the dredging of the river were deemed the only solution to address the flooding.

Autonomous adaptations consisted of a mixture of incremental and transformative measures. Increasing duck rearing is an example of incremental adaptation to accommodate flooding. The chicken are vulnerable to snakes and diseases during flooding and need higher ground. Rearing ducks reduces asset loss risk and need for animal housing investments. One interviewee said that 'ducks float on water and become less infected by diseases, but chicken face problems as they stay on the ground'. Duck rearing is widespread in all socioeconomic groups. Survey results indicate that ducks now outnumber chicken, reversing the historical pattern.

Homestead and plinth improvements can be considered transformational adaptations which accommodate flooding. These improvements involve using bricks and mortar to construct homesteads and plinths to prevent collapse during flooding. This adaptation attests the importance of a safe living place and has been made possible by the availability of credit. Interviews and survey data suggest that the proportion of households with improved homesteads has increased from 1 to 78% since flooding started. Homestead and plinth reconstruction is a transformational adaptation for households as it meets both the untenable and originality criteria. Most participants considered the risk of building collapse and costs of reconstruction untenable. Improved homesteads help

overcome soft limits associated with basic homesteads and flooding.

Moreover, homestead and plinth improvements also enable male members of households to migrate without fear of homestead collapse. One participant living in a traditional homestead explained why he cannot migrate for extended periods: 'My father is sick and anything can happen to him anytime. My brothers live [outside the village] and I feel anxiety about the house falling down. I feel afraid to stay outside [of the village]'. The originality criterion is met because for most households, constructing buildings of bricks and mortar is a new technology. Previously, only the wealthiest households had improved homesteads and plinths as they are much more costly and need the skills of hired labour.

Domestic migration can be considered transformational adaptation and represents a retreat from flooding. Male members of households of low socioeconomic status typically migrate to elsewhere in Khulna Division to harness agricultural labour opportunities. Migration is increasing as summer cultivation of cash crops has decreased dramatically due to flooding, resulting in loss of income and lower demand for agricultural labourers. One participant commented that 'earlier I cultivated both rice and jute, now I have leased the land for fish culture. The rent is very small'. Migration does not fully compensate for the loss of income, however. One interviewee complained that income earned while migrating was 'not a handsome amount. Many people go to Jessore to get job and the daily wage decreases. I bring back a small amount of money'. Migration is particularly widespread among households of low socioeconomic status. It meets the untenable criterion of transformation because households cannot withstand the loss of income and still fulfil livelihood needs. Domestic migration enables overcoming the hard limits imposed by flooding on crop cultivation. It also meets the originality criterion, as planned migration as a substitute for summer crop cultivation and local agricultural wage labour is a new livelihood strategy.

International migration can be also considered a transformational adaptation and represents a retreat from flooding. Male members of some households migrate overseas to find non-agricultural labour opportunities because they consider that flooding has suppressed the local economy to such an extent that livelihood diversification out of agriculture is not possible. One participant commented: 'Yes, I can start a business. However, the interest charged would be more than the profit. If I go [abroad], that amount of money I would be able to make will be sufficient to repay loans'. Another participant believed suitable jobs simply were not available for their son: 'What he used to earn here was not enough. He has master's degree. We thought that if he could go to abroad he would be able to earn more…it was absolutely the right decision'. This adaptation only occurs among households of high socioeconomic status. It passes the untenable criterion as the adaptation occurred in response to declining economic activity, which limits livelihood opportunities that are considered viable by households of high socioeconomic status. International migration is thus a way to overcome the hard limits imposed on the economy by flooding. It passes the originality criterion, as it is a new livelihood activity for the households involved.

Conversion of agricultural land for aquaculture can be considered a transformational adaptation accommodating flooding. It involves the cultivation of fresh-water prawn and fish on land previously used for agriculture. This land is usually particularly low-lying and located close to a canal. Thus, it often remains flooded for much of the year, which prevents agriculture. Some households have seized the opportunity by renting and combining adjacent plots of land and enclosing them with embankments. Aquaculture is mainly adopted by households of high socioeconomic status, due to its resource requirements. It meets the untenable criterion because the height, duration, and consistency of flooding prevent agricultural activity on the land. The hard limit flooding poses to crop production is overcome by using the land for aquaculture.

Although a reliable source of fresh water is needed for aquaculture, flooding poses a risk for aquaculture as well. One interviewee noted that 'during the flood the embankments get damages and the fish flows with the water… I am very worried [there will be a big flood]'. Some households have ceased aquaculture due to the financial losses caused by the breaching of embankments. One over-indebted fish farmer said that: 'for three years I tried to cultivate fish but I made loss… After that, I have never tried to do it anymore'. Aquaculture also passes the originality criterion although it is not entirely new in the area. Small-scale aquaculture in household ponds for household consumption is common. Some households also operate fish farms in wetland areas. However, the conversion of agricultural land for aquaculture is a new practice.

Discussion

Our findings contribute to risk hazard literature by demonstrating the suitability of the approach for assessing autonomous household adaptations in a developing country context, focusing on the characteristics of transformational adaptations and their likely adopters. In contrast, earlier risk hazard literature typically adopted a regional or sectoral approach and a developed country focus when exploring transformation (e.g. Rickards and Howden 2012). The identified autonomous adaptations demonstrate that households devise ways for reducing livelihood risk, corroborating arguments that local responses to climate change are driven by its impacts on livelihoods and assets (Ayers and Forsyth 2009).

The findings also corroborate existing literature, which suggests that the risk hazard approach leads to somewhat ambiguous categorisation of adaptations as transformational (e.g.

Kates et al. 2012). The scale of assessment determines whether adaptation measures are novel or part of wider incremental change. For instance, the increasing number of households improving homesteads and plinths can be interpreted as an incremental increase in the uptake of an existing practice at the village or wider scales, but for the households, it is a step-change. Similarly, the consideration of the wider livelihood context within which adaptations take place can determine whether they are complex transformations or incremental changes. For instance, domestic migration is incremental when considered in isolation from wider livelihood changes. Our study also contributes to the existing literature by highlighting how perceptions partly determine whether adaptations are incremental or transformational. For instance, household income aspirations determine whether the situation that gave rise to international migration was considered untenable.

Implications for adaptation planning

We now turn to demonstrating how the use of the risk hazard approach for understanding autonomous adaptation is important for adaptation planning. The findings indicate that households cannot reduce their exposure to flooding, highlighting that providing protection from hazards is an important issue for planning. Many households have modified livelihood assets, such as homesteads and poultry; they have also altered their income-generating activities, especially during flooding months. Many households have partially retreated away from flooding through seasonal migration in the absence of protection measures.

From a risk hazard perspective, autonomous adaptations comprised a mixture of incremental and transformational adaptations. Incremental adaptations accommodated hazards and demanded little resources; for instance, rearing ducks instead of chickens at subsistence level. Transformational adaptations in turn accommodated or helped to retreat from flooding. Two distinct forms of transformational adaptations can be identified. Low-cost transformations were often involuntary, uncontrolled and negative in terms of their outcomes; for instance, substituting cash crop cultivation for agricultural labouring. High-cost transformations were typically voluntary, planned and involved taking advantage of emerging opportunities; for instance, converting agricultural land for aquaculture. Patterns of transformational adaptation were clearly related to household socioeconomic status. Low-cost transformations, such as domestic migration, were adopted by households of low socioeconomic status. Transformations requiring more resources such as international migration and aquaculture are only adopted by households of high socioeconomic status with the necessary resources. Homestead adaptation was an exception: all households adopted it because they had to, and could do so by using credit, mortgaging land and by building very small homesteads to keep costs sufficiently low (Fenton et al. 2016).

In our research, most autonomous adaptations could be considered as transformational when viewed through the risk hazard lens. This contrasts with other studies of planned adaptation, which have found that mostly incremental strategies were derived through participatory, multi-stakeholder processes (Butler et al. 2016). One explanation may be that flooding in our study site was so severe that existing livelihood strategies became impossible, forcing transformational responses. This raises the question whether planned adaptation can facilitate transformational or incremental strategies, when households will autonomously decide on either form as they see fit. Adaptation planning should be concerned with patterns of incremental autonomous adaptation. Incremental adaptations can build the necessary capacity for future transformational adaptation; however, they may also represent short-term measures that can potentially create hidden and latent systemic risks (Kates et al. 2012; Matyas and Pelling 2015). 'Instead, adaptation planning must facilitate positive transformations, and incentivise households to take advantage of emerging opportunities (see Rickards and Howden 2012; Howden et al. 2007; Park et al. 2012), and thus avoid or adopt certain adaptation pathways (Butler et al. 2014, Wise et al. 2016, Butler et al. 2017).

By encouraging cross-scale social networks, trust and innovation, multi-stakeholder adaptation planning provides an opportunity to build the capacity of communities to anticipate and navigate future change (Butler et al. 2015), but it must provide the right incentives and knowledge for autonomous adaptation to occur (Fankhauser et al. 1999). This may be particularly important for transformational adaptation strategies to occur in developing countries. For instance, in our case study, all households needed to modify their homesteads to cope with flooding. Without alternative knowledge, households simply copied their peers' designs. But it is possible that the adopted design is not the most efficient or cost-effective. NGOs have promoted a different design across Bangladesh, in which homestead walls are made of matted bamboo rather than brick and mortar. In another example, households of lower socioeconomic status were unable to successfully convert agricultural land to aquaculture due to poor embankment construction. Government extension services could provide households with relevant training and resources to achieve this.

Understanding which transformational strategies to facilitate is likely to be complicated. In the risk hazard approach, transformations do not necessarily result in positive outcomes, unlike political ecology (cf. Pelling et al. 2015; Rickards and Howden 2012). In the risk hazard approach, transformation merely refers to technical aspects of change rather than the qualities of the change. In our case study, most households of low socioeconomic status now migrate because they are

unable to cultivate summer cash crops. Migration is a transformational adaptation, reducing vulnerability to flooding, and providing income during the summer months. However, household income still declines due to low agricultural wages in migration hotspots, a common outcome across Bangladesh (Banerjee 2007). Therefore, whether migration is a positive transformative autonomous adaptation which should be promoted is still debated in academic literature (e.g. Tacoli 2009; Black et al. 2011; Paul 2005).

Facilitating transformational adaptation can also pose difficulties because supporting one may negatively impact another group. Climate change may result in winners and losers (O'Brien and Leichenko 2003). This was also the case in our case study. There was a link between the transformative choice of poorer households to migrate and of wealthier households to convert agricultural land for aquaculture. Land converted for aquaculture is often owned by poorer households. Instead, they rent their land to wealthier households who are able obtain the resources required for conversion. Unable to cultivate their land, poorer households migrate to work as agricultural labourers, earning less income than before. Thus, households of high socioeconomic status that have enjoyed increased incomes have mainly been able to do so by using the land of the households of low socioeconomic status. Aquaculture also reduces local employment opportunities as it requires less labour than agriculture (Paul and Vogl 2011). Consequently, adaptation planning will need to decide whether such outcomes are socially acceptable or not. The risk hazard approach provide limited utility for adaptation planning as it does not give sufficient consideration and emphasis to equity and fairness, because of its focus on risks and risk mitigation measures (Eakin and Luers 2006; Eakin et al. 2009).

Furthermore, adaptation planning will need to understand how government extension programmes can inadvertently contribute to unequal outcomes. In our case study, households who transitioned into aquaculture did so in part because they obtained free training and large amounts of inexpensive credit from government extension programmes. According to our survey, the average loan from banks was significantly larger than that from NGOs. Only 13.5% of households obtained credit from banks. Poorer households are typically unable to access credit from government banks which require formal documentation that they do not possess and thus cannot access the credit required to transition into aquaculture (Fenton et al. 2016).

Conclusions

Our study contributes to debates on autonomous and transformative adaptation by demonstrating the utility of the risk hazard approach in understanding the phenomena, as well as by drawing lessons for adaptation planning in developing countries.

Considering that local responses to climate change are driven by the impacts of those changes on livelihoods and assets, the risk hazard approach is best suited for investigating how households are adapting autonomously. In this approach, transformation refers to a depth of change: untenable situations call for novel solutions, which overcome limits to adaptation. Our results indicate that a considerable amount of autonomous adaptation to flooding in Bangladesh is occurring. Observable adaptations include both incremental and transformative measures, although the categorisation of measures is influenced by the scale or unit of assessment and the wider context within which adaptation occurs. The results also indicate that household perceptions can partly determine whether adaptations are incremental or transformative.

Our results identified two distinct forms of transformational adaptations. Low-cost transformations were often involuntary, uncontrolled and negative in their consequences. High-cost transformations were in turn voluntary, planned and helped to take advantage of emerging opportunities. Each type of transformational adaptation was closely associated with the socioeconomic status of households. Poorer households adopt low-cost transformations such as domestic migration while wealthier households adopt costlier transformations such as international migration and aquaculture. Adaptation planning needs to mitigate the causes of negative transformations whenever possible, facilitate positive transformations and incentivise households to take advantage of emerging opportunities.

While the article demonstrates the value of the risk hazard approach in understanding autonomous adaptation and its patterns, it also highlights its limitations such as omission of equity and fairness considerations. It contributes to the risk hazard literature by highlighting how there is a need to give equity considerations additional attention to ensure fair adaptation plans and outcomes are generated. Some progress has been made in this regard (e.g. Reed et al. 2013; Butler et al. 2017); however, a widely accepted and unified approach has not yet been applied into adaptation planning.

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