Water, livelihoods and climate change adaptation in the Tonle Sap Lake area, Cambodia: learning from the past to understand the future

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ABSTRACT

The changing environment is expected to intensify the challenges that people in developing countries are facing, particularly among the groups whose livelihoods depend on natural resources. The adaptive capacity of livelihoods largely defines the extent to which people can cope with future environmental changes, whether caused by climate change or other factors such as land use changes and water resources development. This article analyses the resilience and adaptive capacity of rural livelihoods around Cambodia's Tonle Sap Lake, an exceptional lake-floodplain system dominated by flood pulse. The research findings demonstrate that despite the people's tradition of adapting to the remarkable seasonal variation of water and related resources, their capacity to adapt to unusual environmental changes is weak, with the poorest being clearly the most vulnerable group. Reasons for the weak resilience include villages' relatively homogenous livelihood structures, unjust governance practices, increasing inequality and the lack of opportunities for livelihood diversification. It is concluded that while climate change is likely to pose a remarkable challenge to people's livelihoods in the longer term, climate change adaptation activities should also take into account other environmental changes. Equally critical is the understanding of the broader socio-political context and its dynamics in increasing—and decreasing—livelihood resilience.

Key words | climate change adaptation, livelihoods, Mekong River, resilience, Tonle Sap Lake, water resources management

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ABBREVIATIONS

IPCC	Intergovernmental Panel on Climate Change
JICA	Japan International Cooperation Agency
MPWT	Ministry of Public Works and Transport, Cambodia
MRC	Mekong River Commission
MRCS	Mekong River Commission Secretariat
NAPA	National Adaptation Program of Action to Climate Change
SEA START RC	Southeast Asia START Regional Center
START	Global Change SysTem for Analysis, Research and Training network
TKK	Helsinki University of Technology (now part of Aalto University)
UNDP	United Nations Development Programme
WUP-FIN	Lower Mekong Modelling Project, under MRCS

INTRODUCTION

Unique social-ecological system of the Tonle Sap

Climate change adaptation has become one of the focal points of current development discussion. The reason for this is two-fold: developing countries have high dependence

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on climate-sensitive natural resources, and the impacts of climate change are estimated to be particularly remarkable in developing countries (IPCC 2007; Leary *et al.* 2008). Consequently, an increasing amount of resources in both rural and urban areas is allocated for enhancing the capacity to respond to the estimated impacts of climate change. Most such impacts are closely related to the hydrological cycle, including floods, droughts and storms (UNDP 2006; Ludwig & Moench 2009). While creating also new kinds of challenges, climate change impacts are likely

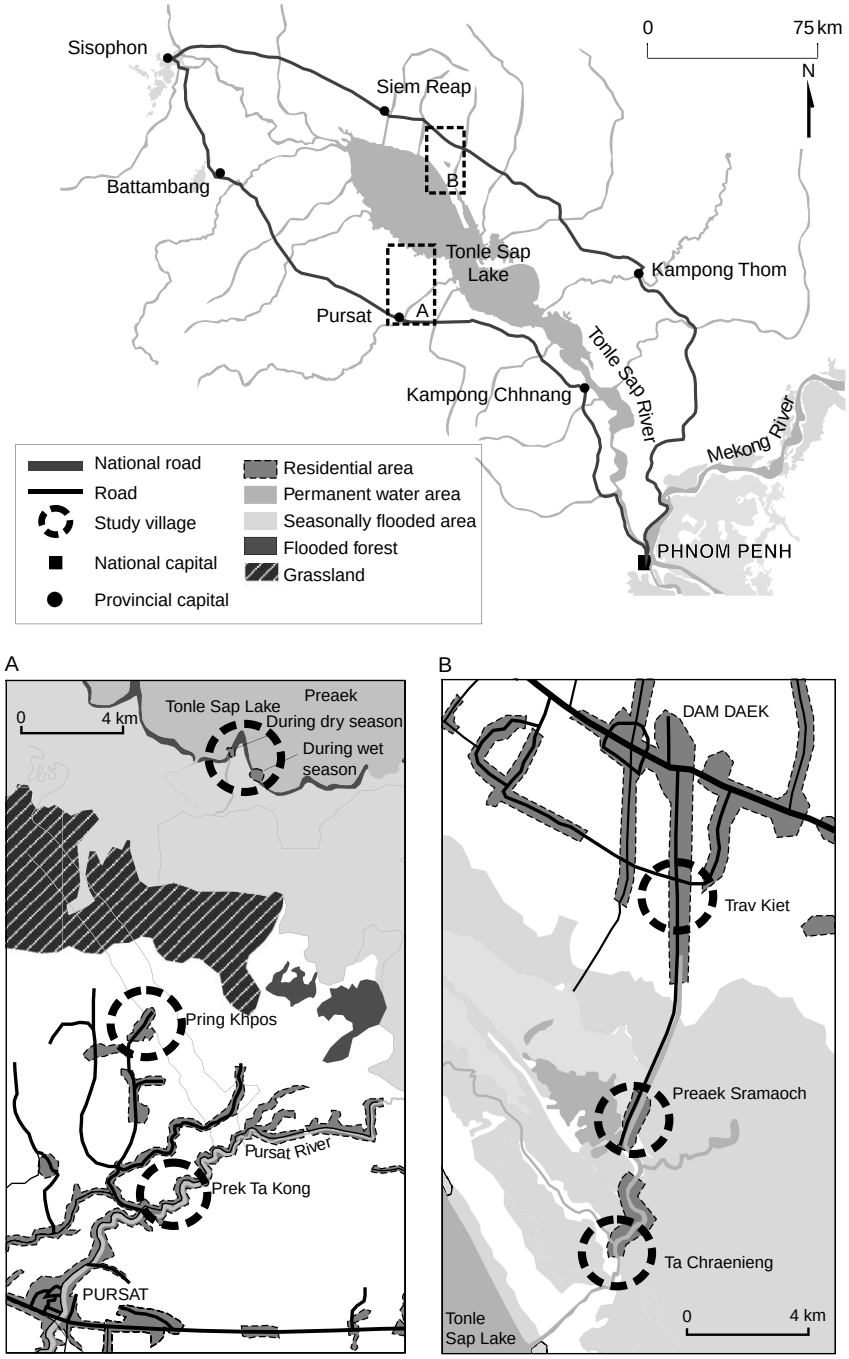

Figure 1 | Map of Tonle Sap area (upper), and the location of the study villages in Pursat (lower left: A) and Siem Reap (lower right: B) provinces, indicating the two crosscuts across the floodplain (Modified from Kummu *et al.* 2008; JICA & MPWT 1998*a*,*b*,*c*).

to be felt primarily through intensification of the challenges that people are already facing (Hultman & Bozmoski 2006). Understanding already existing challenges–whether environmental or more broadly socio-political–impacting people and their livelihoods is therefore a prerequisite also for successful climate change adaptation.

The majority of the people living in and around Cambodia's Tonle Sap Lake, the largest freshwater body in the Mekong River Basin, engage in livelihood strategies that are highly dependent on water and natural resources. The most dominant livelihoods in the area are rice cultivation and fishing, both of them influenced by the dynamic hydrology of the lake and the exceptional flood pulse system (Keskinen 2006; MRCS/WUP-FIN 2007). The flood pulse is closely related to the Mekong River: during the wet season, the floodwaters from the river flow into the Tonle Sap Lake, expanding the lake area four-fold and increasing the water depth from a mere 1 m up to 10 m (MRCS/WUP-FIN 2007). The flood pulse has a crucial role in maintaining the lake's high aquatic productivity, and it also facilitates the rice cultivation in the floodplains by bringing water and fertile silt to the fields (Figure 1). Rice and fish are the cornerstones of food security and income in the region, and fish forms the most important source of protein for a majority of the Cambodian people (Bonheur 2001; Keskinen 2006).

Both the Tonle Sap ecosystem and the people living in and around the lake are adapted to the remarkable but regular seasonal variation in the lake's water level. An epitome of this adaptation are the floating villages that allow the people and their houses to follow the remarkable seasonal changes in the lake's water level (Figure 2). Another unusual village type in the area are the floodplain villages built on high stilts, making them accessible only by boat during the floods (Figure 3). The question is, however, whether the people's livelihoods and the village infrastructures are capable of adapting to more exceptional environmental variations, expected to occur as a result of the changing climate and other factors such as land use changes, forest degradation and water development. Recent impact assessment studies indicate that the Tonle Sap area is probably most vulnerable to hydrological changes in the entire Mekong River Basin. For example, existing plans for construction of large-scale hydropower dams in the Mekong upstream are likely to have remarkable impacts in the Tonle Sap, threatening its unique ecosystem and the people dependent on them (MRCS/WUP-FIN 2007; Kummu & Sarkkula 2008).

Figure 2 | Family on a boat in the floating village of Preaek (Photo: Paula Nuorteva).

In addition to environmental and hydrological changes, other issues have an impact on the sustainability of the rural livelihoods in the Tonle Sap. The socio-political context of the area is complex, and corrupt management practices and unequal access to resources are common, particularly in the fishing villages. The fishing villages are in many ways in a more difficult situation than those closer to the national roads: the people are generally poorer, less educated, have fewer livelihood options and poorer access to markets, do not own agricultural land and depend strongly on common

Figure 3 | Stilt houses in Ta Chraenieng village in the Tonle Sap floodplains (Photo: Paula Nuorteva).

property resources. People living in the villages further away from the lake rely heavily on rice cultivation for their livelihoods, and the villagers depending on the cultivation of floating and recession rice are particularly vulnerable to the changes in floods. Although people living in the agricultural villages are generally wealthier than those living on the lake, economic disparity in the villages is greater and the challenges of land availability hinder agricultural development (Keskinen 2006; Ratner *et al.* 2007; UNDP 2007).

This article presents the findings from research conducted in 2008 in the rural villages of the Tonle Sap Lake area. The objective of the research was to assess the resilience and adaptive capacity of local livelihoods in the area towards changes in the environment and water resources. The aim was also to find ways in which the people's capacity to adapt to the impacts of climate change and other environmental changes could be increased, building on an analysis of the people's experiences with adapting to environmental changes and challenges in the past (Nuorteva 2009; TKK & SEA START RC 2009).

The research was carried out as a part of a multidisciplinary research project conducted jointly by the Water and Development Research Group of the Helsinki University of Technology (now part of Aalto University), Finland, and Southeast Asia START Regional Center at the Chulalongkorn University, Thailand. The project focused on the impacts and adaptation to climate change in the Lower Mekong Basin (TKK & SEA START RC 2009; Keskinen *et al.* 2010). More detailed information about the research presented in this article can be found in Nuorteva (2009).

METHODS

Theoretical framework: adaptive capacity and resilience

The research presented in this article builds on the concepts of adaptation, resilience and vulnerability of people and their livelihoods towards environmental changes. The concept of adaptation of humans to environmental variability was introduced to anthropology in the early 1900s (Janssen *et al.* 2006). Adaptive capacity, or adaptability, was originally defined as an ability to live and reproduce in a specific range of changes in the environment. In relation to social-ecological systems, the adaptability includes maintaining and possibly even increasing the quality of life and the viability of social and economic activities (Gallopin 2006). In the field of climate change, the term has been in use since the 1990s (Janssen *et al.* 2006). According to the definition of the Intergovernmental Panel on Climate Change (IPCC), adaptation to climate change means the adjustments in ecological, social or economic systems in response to actual or expected climatic stimuli and their effects (Smit *et al.* 2001). It includes adjustments that help to moderate the harm and potentially also to increase the benefits from the changing climate both at the present and in the future (Leary *et al.* 2008).

One way to look at the climate change adaptation is through the resilience of people towards different kinds of changes in their environment (see e.g. World Resources Institute 2008). The resilience thinking connects closely to the broader discussion about the vulnerability of people and their livelihoods. Resilience can be seen as the flip-side of vulnerability: when a social or ecological system loses resilience, it becomes more vulnerable to changes that previously could be absorbed and adapted to (Folke *et al.* 2002). Resilience is also considered as a particularly useful concept for connecting climate change-related analyses to broader social and ecological contexts, and Boyd *et al.* (2008), for example, describe it as 'climate friendly' approach.

The concept of resilience was first used in relation to ecological systems (Holling 1973). Ecological resilience describes the magnitude to which an ecosystem can withstand shocks and stresses and still remain functional (Adger 2000). The concept was extended to social systems in the late 1980s (Janssen *et al.* 2006). Compared to ecological resilience, the resilience of social systems has an additional capacity of foreseeing and adapting to possible changes, and it has therefore been defined as the degree to which a system is capable of learning and adopting new solutions (Adger 2000; Walker *et al.* 2002). Systems with good resilience are able to absorb large shocks without having to change fundamentally. To some extent, however, changes in social-ecological systems are inevitable, and they also allow resilient systems to develop their capacities as well as to reorganise themselves to match the new circumstances.

Resilience is not only about withstanding shocks and stress, resilient systems also have a potential to create opportunities for development and innovation from the occurring changes (Folke *et al.* 2002).

The resilience of social systems is linked closely to ecological resilience, particularly in the communities where the livelihoods depend strongly on natural resources (Adger 2000; Folke *et al.* 2002)–as is the case in the Tonle Sap. The capacity of social systems to adapt and to develop is highly dependent on the supporting capacity of the surrounding ecosystems, and reducing this capacity leads thus also to increasing vulnerability of the social system. Likewise, the resilience of an ecological system depends on the actions of the interlinked social systems, leading to a strong and dynamic interdependence between the two. Human activities at different geographical scales are capable of dramatically changing the surrounding environment, which may lead to negative changes in the ecological and social systems both locally and more regionally (Folke *et al.* 2002; Kummu 2008).

In terms of adaptation to climate change, it is important to note that besides increasing the occurrence of climatic hazards such as storms, the projected impacts caused by climate change are likely to add to and intensify already existing stresses on human populations (Hultman & Bozmoski 2006; Pachauri 2008). Consequently, increasing the adaptive capacity of vulnerable communities to challenges from various sources–including but not limited to climate change–is particularly important.

Field research in the Tonle Sap area

This article builds on the field research that looked at the livelihood resilience and climate change adaptation in the villages of the Tonle Sap Lake area in Cambodia. The research was conducted in autumn 2008 in two provinces, Siem Reap and Pursat, with three study villages in each province (Figure 4). The study villages were chosen so that they form a crosscut – or transect – from the lake through the floodplains to the national roads, based on the topographic zoning of the area (Keskinen 2006).

The crosscut approach was chosen to provide a means to connect the livelihood analysis to hydrological and environmental characteristics, as the availability of natural resources and the people's connection to the lake and its waters varies greatly between the villages at different parts of the crosscut (Keskinen 2006). The crosscut also allowed the comparison of the villages with various livelihood backgrounds: while the study villages highest up in the floodplain are mainly agricultural, the villages in the middle are involved in both agriculture and fishing, and the villages closest to the lake mainly fishing. These main sources of livelihoods are, however, commonly supported by diversity of secondary livelihoods (Keskinen 2003). Furthermore, as the study villages are located in the same province and even along the same road (as was the case in Siem Reap province), the crosscut approach highlights the differences between the villages due to their geographical location, and reduces the potential differences caused by other factors such as the differences between the provinces in their institutional and infrastructural settings. This kind of stationary approach has also its limitations, particularly in the Tonle Sap area that sees extensive seasonal migration of both people and the actual villages. Many floating villages in the area follow the changing lake shore, migrating several kilometres a year, and many people migrate to the lake during the best fishing season to fish or work in fish processing. While in some areas these migrants live in a kind of symbiosis with local people, e.g. by allowing local people to focus on fishing by taking responsibility for fish processing (Keskinen *et al.* 2002), the seasonal migration is also creating increasing tensions (Ratner *et al.* 2007).

Figure 4 | A local villager working in the rice field outside the agricultural village of Trav Kiet (Photo: Paula Nuorteva).

The main method used in the field research was key informant interviews. Key informant interviews are qualitative interviews with people who are particularly knowledgeable about the theme of the research (The Access Project 1999). As our research focused on general livelihoods in the Tonle Sap villages, the key informants included persons with a certain position – usually a village chief – as well as ordinary villagers with varying social and livelihood backgrounds.

Altogether 19 interviews were conducted with three or four informants from each study village. The first interview was usually conducted with the village chief or deputy chief in order to get a general understanding of the village and its livelihood patterns. The other informants were then selected so that they represented different genders, ages and livelihood sources, with an emphasis on the poorest and the most vulnerable groups[1]. The interviews were conducted in a loosely semi-structured manner following certain predetermined themes, while also allowing space for free-flowing discussions. The informants were encouraged to elaborate on their answers, and to explain the reasons and meanings behind their views.

The main issues discussed in the interviews included the informants' recollections of past environmental shocks and stresses such as floods and droughts, and the strategies they have used for adapting to them. Also other sources of challenge were discussed, including for example decline in fish catch, population pressure and increase in the price levels. Changes in the living standards during the past decades, including the reasons for these changes, were considered as well. Finally, the informants' visions and hopes for the future and possible strategies to improve their capacities to adapt to potential future challenges were discussed.

The qualitative interview method was chosen as it enables a relatively large amount of personal reflections to be included in a rather short time period. While a selection of three informants from each village cannot really be considered to represent the views of the entire village, it does allow the inclusion of various kinds of accounts, observation and opinions from different villages and livelihood backgrounds.

[1] Here the term 'poor' does not refer directly to certain economic status of a person/household, but it is defined more generally and subjectively to include those who have fewer assets and less access to them, and whose living standards are therefore lower than on average within the village.

Besides the actual field research, previous research and literature regarding the livelihoods in Tonle Sap were reviewed to get a better understanding of the overall circumstances in the area and to help to focus the field research. This research included the previous research conducted by the authors (see e.g. Keskinen *et al.* 2002, 2007; Keskinen 2003, 2006; MRCS/WUP-FIN 2007; Ratner *et al.* 2007) as well as other studies in the area (e.g. Bonheur 2001; Chea & McKenney 2003; Evans *et al.* 2004; Marschke & Berkes 2006; Resurreccion 2006; Lamberts 2008). The methodology of the field research and related literature review is discussed in more detail in Nuorteva (2009).

RESULTS

Adapting to the environmental challenges

Estimated future climate change impacts in the Tonle Sap area

The current climate change model results indicate that climate change will impact significantly on the hydrology of the Mekong River and Tonle Sap Lake, particularly in the longer term (Eastham *et al.* 2008; Västilä 2009). While there are also local climate-related changes expected in the Tonle Sap area, the most radical climate-related impacts in the area are estimated to occur through regional changes in the hydrology of the entire Mekong River Basin (TKK & SEA START RC 2009; Keskinen *et al.* 2010).

The studies indicate that with the current climate change scenarios, the wet-season water level in the Tonle Sap Lake is likely to get higher and as a result the seasonally flooded area and the height of the flood peak will increase. In addition, the timing and duration of the flood pulse is estimated to change: the flood is likely to start several days earlier and end a few days later than currently. These changes may lead to more intense flood pulses and are estimated to cause harm for agriculture, infrastructure and floodplain vegetation as well as to decrease the fertile land area. The changes may, however, also result in positive impacts, by for example boosting the ecosystem productivity and enhancing dry-season water availability (Västilä *et al.* 2010). More information on the estimated impacts of climate change in the area can be found from TKK & SEA START RC (2009) and Västilä *et al.* (2010).

The impacts of environmental changes

The impacts of climate change on local livelihoods cannot be isolated from the impacts of other changes in the environment due to the strong interconnections regarding their causes and effects. In this research, the possible future livelihood impacts of climate change and other environmental changes were investigated through the irregularities in the Tonle Sap flood pulse and more generally in the environment. The key informants were asked about unusual environmental events in the past, most importantly years with significantly higher or lower water levels than normal, as well as their impacts on people and their livelihoods.

When discussing the challenges caused by floods it is important to note, however, that flood is not generally considered to be a negative phenomenon in the Tonle Sap, although the English term often has such a connotation. For this reason the terms 'unusual flood' or 'high flood' are used in this article to indicate a flood with clearly more water and/or higher water level than normally. Furthermore, defining a 'usual' or 'normal' flood is difficult–even more so in this kind of a participatory research. In this study, normal water level was understood as an average year when the flood regime did not differ remarkably from other years. Overall, the informants were surprisingly consistent in describing 'usual'–and particularly 'unusual'–years and floods. For example, all of them recognized the year 2000 as an unusual year when the water level in the Tonle Sap was remarkably higher than normal; this is in line with other studies (O'Brien 2001; Keskinen 2003; Ministry of Environment 2005).

The findings from the interviews indicate that most of the challenges in the past were related to unusual floods and droughts and the impacts they had on infrastructure, livelihoods and food security. The most significant impacts on infrastructure were related to high floods that had led to destruction of roads and other physical structures as well as flooding of the houses. High flooding also impacted livelihoods, for example, by changing the timing for rice cultivation and making fishing more difficult as the fishing area gets larger due to greater flooded area. On the other hand, several informants also pointed out that fish was more abundant during high floods.

Intensive droughts pose another challenge for the rural livelihoods in the Tonle Sap. The problems were usually related to scarcity of available drinking water and deterioration of water quality in rivers and ponds, affecting also the villagers' health status. The droughts affected directly the livelihoods of those agricultural households that rely on irrigation during the dry season, and the unusually dry periods led to a decrease in the amount of fish in the water bodies close to the villages. The informants in all study villages mentioned serious incidences of drought during the past decade. This finding is consistent with the survey conducted for the National Adaptation Programme of Action to Climate Change in Cambodia, which found that 71% of the informants had noticed an increase in the frequency of droughts (Ministry of Environment 2005).

Other environmental changes and impacts mentioned during the field research were related, for example, to decreasing soil and water quality as well as the decline in the availability of natural resources. One significant challenge mentioned by several informants was the decrease in fish catch. This seems to be caused by the combination of several reasons, including the use of illegal fishing gear, destruction of fish habitats due to deforestation, and growing fishing pressure. Also reasons related to fisheries management were frequently highlighted in the interviews, including problems with the enforcement of laws and regulations and unequal access to fishing areas.

Also short-term environmental challenges were mentioned related particularly to extreme weather events. Heavy storms accompanied by high waves and strong winds had destroyed houses, boats and crops, prevented people from practising their livelihoods, and had even caused deaths in one study village. Overall, the impacts of such extreme weather events were felt most strongly by the poorest, as their houses are generally less solid and therefore more vulnerable to extreme weather conditions and they also have fewer assets to respond to the damage.

In addition to the direct impacts affecting people and their livelihoods, environmental changes have indirect impacts as well. Such indirect impacts go easily unnoticed, as they are being felt long-term through the complex interactions between water, ecosystem and livelihoods. In the case of reducing fish catches, for example, the reduction of fish habitats may be intensified by hydrological changes

in the flood pulse. This is so because an increase in dry-season water level, due to hydropower development, climate change or other factors, would leave large areas of seasonally flooded tall gallery forests and shrubs permanently under water, leading to their gradual destruction (Kummu & Sarkkula 2008). In addition to fishing, this would also impact other livelihood sources, as these 'flooded forests' are an important source of non-timber products and other wetland resources (Evans *et al.* 2004). However, in the longer term, forest destruction could potentially be offset by the succession of the gallery forest to the higher areas in the floodplain, presuming that such areas are not already used for example for agriculture.

Past adaptation strategies and actions

The findings related to the coping mechanisms and adaptation strategies regarding unusual environmental phenomena in the past indicate that a majority of these strategies were initiated at the level of individual households and families, rather than more formally at village, commune or district level. Most important exceptions were related to maintenance and repair of common infrastructure such as roads. At individual household level, most informants highlighted the importance of different assets and supplementary livelihood sources as the most important coping mechanisms.

The different assets mentioned in the interviews included savings as well as different kinds of physical assets that are used to support and broaden the livelihood base. While resorting to one's own savings was common among better-off villagers, the poorer villagers had borrowed money or rice from neighbours or relatives as well as from middlemen and moneylenders. Not all of them, however, were willing to take loans even during difficult times, as they were cautious of possible difficulties in repaying the loans, especially due to high interest rates. Some of the poor informants also mentioned that they had had to sell their assets (such as boats and cattle or even land) to be able to survive particularly difficult times. These kinds of 'desperation strategies' (Marschke & Berkes 2006) provide fast income in the case of emergency, but can have very harmful impacts on the long-term adaptive capacity as they reduce the long-term asset base and therefore the means for sustaining the livelihoods.

Additional livelihood sources formed another important strategy for coping and adaptation. These include relying more strongly on secondary livelihood sources not affected by the environmental changes as well as extending to altogether new livelihoods. In agricultural villages, fishing can provide additional income in times when agriculture is affected for example by floods, while for instance collecting edible aquatic plants for additional income was considered important in fishing villages. In addition, different forms of short-term paid employment were mentioned in all study villages as an important additional livelihood source. The source of employment varies according to the livelihood background and the village location: in fishing villages the employment is usually fishing-related and includes working for large-scale fishing operations, while in agricultural areas the work can be for example related to the farming activities of more affluent neighbours. In some cases the short-term paid employment also included travelling outside the village, for example to the near-by factories, or migration for certain periods to work in the provincial towns. Overall, the existing diversity of different livelihood sources was considered crucial for the villagers' capacity to respond to unexpected events and their impacts.

The villagers are also actively increasing their adaptive capacity based on their past experiences. Extraordinary environmental phenomena had led to various kinds of responses aiming to increase the villagers' possibilities to cope with similar events in the future, thus increasing their resilience. One example of this was the unusually high flood of 2000 that had flooded several houses built on stilts. While the immediate response to the flood was to transfer people and goods to other areas or at least to higher parts within the houses, the more long-term response was to increase the height of the stilts, reducing thus possibilities for the flooding of the houses in the future.

Variations in impacts and adaptive capacity across the floodplains

The crosscut approach applied in the field research enabled comparison of the villages in different parts of the floodplain in terms of the environmental changes they face as

well as their vulnerability and capacity to adapt to these changes. The specific impacts of the environmental changes were closely related to the livelihood strategies and the location of the village. Although the study villages are situated geographically relatively close to each other (distance between the villages is only 5–10 kilometres: Figure 1), the environmental changes turned out to affect the villages in very different ways.

In the case of unusually high floods, for instance, the differences between the villages were clearly visible. In agricultural villages, unusually high floods had destroyed rice harvests and caused damage to the stilt houses and other infrastructure. Besides changes in the flood patterns, other major environmental challenges in the agricultural villages were related to decreasing soil and water quality, affecting the availability of both water and land for agriculture. On the other hand, the floating houses in the villages closest to the lake remained highly unaffected by high floods, and actually benefited from them in terms of increased fish productivity. Heavy storms and related high waves, however, affected the floating villages much more. In the villages closest to the lake the biggest concerns were related to decreasing aquatic productivity of the lake and resulting reduction in fish catches.

Looking at the ways in which people in Tonle Sap area have adapted to past changes provides a means to assess their vulnerabilities and related adaptive capacity towards future changes. The current levels of resilience in the study villages were considered in two ways: as the adaptive capacity of the villages in different parts of the floodplain, and as the adaptive capacity of the social groups and households within the villages. In both of these cases, considerable differences between the levels of resilience were found.

In terms of the resilience of the villages in different parts of the floodplain, the fishing villages can be considered to have generally the lowest level of capacity to cope with unusual environmental changes and particularly the impacts that such changes are expected to have on fish and other water-related resources. We found three main reasons for this: the opportunities for diversifying the livelihood base in the fishing villages are rather limited; the livelihoods are intimately connected with water and environment; and the fishing villages are often both socially and economically less well off than the agricultural villages further up in the floodplain. This conclusion was also supported by several informants in the fishing villages, who–despite a strong interest in livelihood diversification–felt that they did not have real possibilities for this. This was mainly due to external limitations such as lack of agricultural land, challenges with fisheries management and related power inequalities as well as limited access to the markets due to long distances to provincial towns and poor transport connections. On the other hand the floating villages are most advanced in adapting to the seasonal variation of the Tonle Sap's waters, and they therefore have certain advantages over agricultural villages. This is the case particularly in terms of adaptation to floods and their direct impacts on physical infrastructure and livelihoods.

In addition to the differences in the level of resilience between the study villages, internal differences between the households and social groups within the villages were observed. Not surprisingly, the poorest households turned out to be the most vulnerable in all study villages. The poorest households often rely on one livelihood source only (usually fishing), while the better-off households typically had more possibilities for supplementary livelihood strategies. The better-off households also had more savings and other assets, while the poorest households depended on external assistance in the cases of emergency. Many of the poorest households also suffer chronically from rice shortages as well as from other aspects of poverty, such as unclean drinking water, health problems and lack of secondary education opportunities, making them particularly vulnerable to additional shocks and stresses.

The most worrying finding from the field research was that while most of the better-off informants felt that their living standards had improved during the past years, a majority of the poor informants noted that their living standards have become worse within the same period. These findings were consistent throughout the floodplain, and are in line with other recent studies (World Bank 2006; UNDP 2007). In the UNDP's Human Development Report on Cambodia (UNDP 2007), for example, it is noted that the development and economic growth in Cambodia is not spreading evenly across the different social groups, but the gap between the poor and rich is widening in many areas,

including the Tonle Sap Lake. This means that the already low level of resilience of the poorest groups is expected to worsen, making the poor even more vulnerable to future environmental changes and leading ultimately to further deprivation and increasing inequality.

DISCUSSION

Ways of increasing adaptive capacity

As an agrarian, least developed country with remarkable annual floods and a deep dependence on natural resources, Cambodia and the Tonle Sap area are highly vulnerable to negative changes in the water environment (Ministry of Environment 2006). This vulnerability is further intensified by the country's low adaptive capacity to cope with environmental shocks and stresses, as also pointed out in the National Adaptation Programme of Action to Climate Change (Ministry of Environment 2006).

Climate change adaptation in Cambodia is therefore characterized by an interesting dualism: although the people are traditionally well adapted to the variable hydrology of the Mekong system, the country's institutional and political capacity to handle unexpected changes is limited. This institutional weakness connects closely to the persistent challenges with governance; unjust practices are common especially in the management of natural resources (Le Billon 2000; Tarr 2003). Fisheries management forms a particularly challenging governance issue as it is dominated by weak implementation of policies, corrupt practices and exclusion of the local communities from access (Bonheur & Lane 2002; Ratner 2006; Tonle Sap Biosphere Reserve Secretariat 2007).

In the Tonle Sap area, people are generally well adapted to the seasonal changes caused by the flood pulse, and both the livelihood sources and the level of livelihood have a strong seasonal nature (Keskinen 2006). Our research findings indicate, however, that this adaptive capacity has its limits, and the people and their livelihoods are actually relatively vulnerable to significant changes in their environment, including the flood pulse system. The findings also show that livelihood diversity and an adequate standard of living provide the foundation for the people's capacity to adapt to these kinds of unusual environmental changes. The level of livelihood diversity in the Tonle Sap area is already now relatively high, as individual households commonly complement their main livelihood source with supplementary livelihoods strategies. However, strong dependence on just one main livelihood source, usually either fishing or rice cultivation, within each village can be seen to increase the people's overall vulnerability to sudden environmental changes. As noted by Keskinen (2006: 475): "If the primary source of livelihood fails, the secondary livelihood sources–often regarded as the safety net of the villagers–cannot sustain the sudden load created when most of the people in the village shift simultaneously to these sources".

Diversifying the livelihood base both within the households and more generally within the villages provides thus one central way to increasing resilience, as has been noted by other studies in Cambodia and elsewhere (see e.g. Folke *et al.* 2002; Marschke & Berkes 2006; Resurreccion *et al.* 2008). Several examples given by the informants show that initiating supplementary livelihood strategies and engaging in multiple livelihood sources have enabled them to increase their asset base and, overall, their standards of living. These informants were also more optimistic about their capacity to respond to environmental shocks and stress, and therefore about their possibilities to maintain their future living standards.

A number of informants had ideas about the specific supplementary livelihood strategies that they could use to broaden their current livelihood base. Most of these strategies were related to the informants' current livelihoods as well as the other livelihoods practiced in the area. In the fishing villages next to the lake, many hoped to broaden their livelihoods into fish raising, fish processing and utilisation of wetland products, while in the agricultural villages raising livestock and broadening to other crops such as vegetables were considered as possible diversification strategies. Starting small business such as shop keeping and involvement in different forms of paid labour was also mentioned by informants in all study villages.

One approach to diversifying the livelihood base is through migrating, which was recognised as a potential future adaptation strategy in all study villages (see also Rigg 2006). Examples of labour migration, both permanent and seasonal, were available in all study villages.

However, given the choice, most of the informants noted that they would rather stay in their home village, supposing that the circumstances in the village would allow this–in other words that their current livelihood strategies would be able to provide sufficient economic security in the future.

Access to credit was seen as one key factor that enable the informants to engage in supplementary livelihood sources, as noted by other studies in the area as well (O'Brien 2001; Rahut *et al.* 2007; Meinander 2009). As the credit conditions of private moneylenders and middlemen are often unreasonable and many people avoid resorting to them, the different microcredit schemes and saving groups initiated, for example, by non-governmental organisations represent particularly important forms of increasing access to credit. Low-interest microcredit enables people to acquire capital to initiate supplementary livelihood strategies (e.g. fish raising or vegetable farming) as well as for enhancing their current livelihoods (e.g. purchasing new fishing gear or a new rice variety), and it also allows people to decide for themselves in which way the additional funds would be used best.

The current dependence especially of poor households on short-term external assistance to relieve food shortage during challenging time periods suggests a low level of existing adaptive capacity. While providing short-term relief, it is not likely to increase the long-term adaptive capacity unless other actions are taken in parallel to increase resilience. As long as the existing adaptive capacity is low, however, this kind of external assistance is an important additional support mechanism.

The importance of livelihood diversity has been recognised by other studies focusing on resilience in Cambodia as well. Marschke & Berkes (2006), for example, studied the resilience of two Cambodian fishing communes, with one of them being in the Tonle Sap. They concluded that diversification is a commonly used strategy for adaptation, and also emphasised the need to analyse the resilience and livelihood dynamics at different scales, as increasing resilience on one level may have opposite effect on. Also Meinander (2009) noted in her analysis that livelihood development in the Tonle Sap would benefit from livelihood diversification, building on existing livelihoods as well as on entirely new alternative livelihoods.

To be sustainable, the supplementary livelihood strategies aiming to diversify the existing livelihood base should build on existing livelihoods and the specific characteristics of each village, and also consider the initiatives of the villagers themselves. In addition, as noted by Folke *et al.* (2002), livelihood diversity is not just an insurance against uncertainty and surprises, but it also provides a mixture of components whose history and accumulated experience help to cope with change and facilitate redevelopment and innovation. Consequently, the lessons learnt from unusual events in the past and the responses to them, either by the people themselves or someone else in the area, can help to guide the livelihood diversification in a direction that increases the existing levels of resilience.

Improved standard of living presents another key for increasing the existing levels of adaptive capacity. This is particularly important among the poorest groups who already have the weakest level of resilience, and whose living conditions are on many occasions expected to deteriorate further. An improved standard of living brings several benefits that were also visible in the interviews; it enables better housing, the acquisition of additional assets to support and diversify the existing livelihood sources, and attainment of savings that can be used during difficult times. It also has more indirect consequences, leading for example to better health conditions and improved school attendance of the children. All of these factors can be seen to build, directly or indirectly, the household's resilience to environmental shocks and stress.

CONCLUSIONS

Adaptation as an integral part of development

The impacts of climate change are likely to bring new kinds of challenges and opportunities as well as magnify the challenges that people in developing countries are already facing. The majority of the impacts to the people and their livelihoods are mediated through the alterations that changing climate causes in hydrological cycle, and consequently, in the spatial and temporal availability of water. This is likely to be the case also in Cambodia's Tonle Sap area that forms a unique lake-floodplain system with remarkable seasonal changes in its water level and an

exceptional mixture of livelihoods building on fisheries and rice cultivation.

This article looked at the existing levels of resilience and adaptive capacity of the livelihoods in the Tonle Sap area, and discussed the possibilities of improving them in order to enhance the people's ability to respond to future environmental changes. In terms of the current levels of adaptive capacity, it was concluded that despite the long tradition of adapting to the seasonal variations in water and related resources, the people's capacity to respond to unusual environmental shocks and stress is relatively weak. The adaptive capacity is also spread unevenly both between and within the villages, making the fishing villages closest to the lake and the poorest groups across the floodplain most vulnerable to environmental changes. This situation seems to be getting worse: the research findings indicate increasing inequality between the poor and the better-off, with the poorest also being the most pessimistic about the possibilities of sustaining their livelihoods in the future.

These findings are critically important for the future of the Tonle Sap, as the area is likely to see dramatic changes in its seasonal flood pulse system and the natural resources it enables. Due to the close connection that the Tonle Sap lake has with the Mekong River, such changes would be primarily due to the changes in the flows of the Mekong River, caused first and foremost by hydropower development as well as land use changes, irrigation development and, later on, climate change. Together with local developments, these regional changes are estimated to have severe impacts on the lake-floodplain system, including potentially destructive impacts to the aquatic productivity of the lake. The combination of negative impacts on fish and other aquatic resources and weak levels of resilience among the fishers and the poor is a very unpleasant scenario, and suggests that particularly these people's capacity to cope with the future environmental changes should be improved rapidly and comprehensively.

Improving the adaptive capacity of people and their livelihoods is naturally not an easy task. Our findings indicate, however, that promising starting points can be found from the local level, building on past successes (and failures) to strengthen and diversify existing livelihood strategies in these specific contexts. However, these kinds of local, 'autonomous' and largely spontaneous adaptation strategies are not enough, but need to be complemented with more macro-level, long-term policy responses. Formulating and implementing such policies is the responsibility of the government authorities, and they should to be planned so that they support, rather than replace, the efforts at more local levels. Increasing the coherence between the initiatives at local, provincial and national level is particularly important in Cambodia due to the prevalent governance challenges in many sectors, including fisheries.

Indeed, although focusing on environmental changes and their impacts, the research findings also illustrate the importance of broader political contexts in improving–and reducing–people's resilience. While the current institutional structures have a potential to strengthen the adaptive capacities at both village and household level, in many cases they seem to actually reduce it by maintaining the existing power imbalances and denying particularly the poorest and ethnic minorities equal access to common resources and more generally to the decision-making processes at the village and commune levels. The broader socio-political context related to resource use and livelihoods requires therefore much stronger attention when looking at the adaptation capacity to climate change and other environmental changes.

Overall, there is a need to realise the close linkages that climate change adaptation has with more general actions focusing on poverty reduction and fostering the development. Our research findings indicate clearly that one of the most efficient strategies for enhancing the people's adaptive capacity is to enhance their prerequisites to maintain a productive livelihood, and thus to increase their general standards of living. Climate change adaptation must thus not be considered as a new entity that would be replacing previous concerns, but rather as a complementary driving force to already existing actions aiming for livelihood development. There is no reason to reinvent the wheel, but rather to do the old things better than before–with increased momentum and resources provided by the climate change adaptation actions.

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