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ORIGINAL PAPER

# First- and second-order adaptation to natural hazards and extreme events in the context of climate change

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**Abstract** This paper deals with coping and adaptation processes to natural hazards and (potential) climate change impacts. Selected response measures to natural hazards are critically reviewed with respect to the actual and potential consequences that these measures might imply for additional adaptation needs and changes within social-ecological systems. In this context, the author introduces the concept of first- and second-order adaptation processes in order to underline the cascade process that adaptation implies, the potentials for failure, and the limits of adaptation. Important aspects of first- and second-order adaptation processes as well as the issue of the limits of adaptation are illustrated based on observations and empirical work conducted in Vietnam. In its final part, the paper discusses the findings in light of selected theoretical approaches that might help to understand how stabilization and destabilization processes are influenced or even triggered by adaptation measures.

**Keywords** Risk management · Adaptation · Extreme events · Vulnerability · Relocation

## 1 Introduction

Climate change adaptation is a key priority within climate change negotiations at international and national level. Measures for adaptation to climate change are receiving increasing financial support (see Ad hoc Working Group on Long-Term Cooperative Action under the Convention 2009a, b). Additionally, options and limits to dealing with extreme events are being increasingly seen as a major challenge to climate change adaptation. The IPCC for example is currently developing a special report on *"Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*" which will be published by the end of the year 2011.

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Adaptation strategies have been initiated and developed, in particular for the least developed countries (LDCs), under the umbrella of the National Adaptation Programmes (NAPAs) supported by UNFCCC. Additionally, a growing number of so called developed countries in the North are implementing national adaptation strategies and programs as a response to actual and potential climate change impacts. Germany, for instance, has developed a national adaptation strategy named DAS (see German Adaptation Strategy Web site 2008), focusing on different sectors and cross-sectoral themes. Likewise, other developed countries have published and initiated national adaptation strategies, e.g., the United Kingdom (see the UK-CIP Web site 2008 for more details). The UK Adaptation Strategy formulates first principles of effective adaptation, which encompass—among other issues—the aspect of addressing risk associated with today's climate variability and extremes as well as the issue of using adaptive management strategies to cope with uncertainty (UK-CIP Web site 2008). However, issues on how to evaluate adaptation strategies as well as on how to ensure their quality, sustainability, and effectiveness are core questions that have not been sufficiently addressed yet. First, approaches have been developed by, e.g., Birkmann and von Teichman (2010), but the actual implementation of quality criteria for adaptation measures is still in its initial phase.

More recent documents and reports on adaptation to climate change such as the World Bank Report 2008 refer to the risk of more intensive floods and droughts due to climate change and call for adaptive agriculture, adaptive infrastructure, adaptive urbanization programs, and micro insurance regimes (World Bank 2008, pp. 216–218). Although the terms "adaptive agriculture", "adaptive infrastructure", and "adaptive urbanization" may point in the right direction, none of them provide sufficient information of what exactly adaptation means.

### 1.1 Objectives and main research questions addressed in this paper

Against the aforementioned background, this paper presents a new way of looking at adaptation based on a critical review of predominant views on adapting to extreme events and a differentiation between adaptation and coping. In this regard, the paper aims at underlining the need to focus in more depth on adaptation options and strategies, and, more specifically, on adaptation needs brought about by large-scale structural adaptation measures. In addition, it investigates actual and potential limits of adaptation to climate change and natural hazards. Special emphasis is given to the following key questions:

1. How is adaptation to extreme events and natural hazards defined and conceptualized?
   - How can limits of adaptation be characterized?
   - What are the differences and similarities between coping and adaptation?
2. What are key challenges and core questions when dealing with the analysis of adaptation to climate change and natural hazards?
   - How to achieve an improved understanding of adaptation processes?
3. How do people actually cope and adapt to extreme events and natural hazards?
   - What are the potential and already visible limits of adaptation of communities exposed to floods and sea level rise—using the example of the Vietnamese Mekong Delta?

4. How to further conceptualize adaptation processes and limits of adaptation with regard to the concept of first- and second-order adaptation?
5. Which theoretical approaches can shed light into different facets of the concept of first- and second-order adaptation?

Based on these questions, the paper aims to provide some new conceptual ideas that can help to improve and enhance our understanding of coping and adaptation processes to natural hazards and climate change. Apart from providing a literature review and an analysis of selected adaptation strategies and measures currently proposed, the paper empirically deals with different coping and adaptation processes based on the author's own field research undertaken in flood and sea level rise prone regions in the Mekong Delta in Vietnam. Finally, it provides a theoretical reflection on how to explain adaptation processes—particularly in terms of the concept of first- and second-order adaptation—in the context of social-ecological crisis phenomena.

## 2 Different concepts, definitions, and views of adaptation to extreme events and natural hazards

The following chapter provides an overview of different definitions, perspectives, and limits of adaptation focusing particularly on how the natural and social sciences understand the concept of *adaptation.* It also provides definitions of what first-order adaptation and second-order adaptation processes mean. Additionally, a conceptual framework focusing on the distinction between impact, coping, change, and adaptation is presented.

### 2.1 Definitions and pre-analytic views of adaptation

When examining the use of the term adaptation in the different schools of thought, for example (a) vulnerability, (b) climate change, and (c) resilience research, the terms adaptation, coping, renewal, and reorganization are frequently used to describe how communities or social-ecological systems deal with shocks and stressors. Adaptation and adaptive capacities are often seen as core characteristics of a successful strategy to deal with shocks and stressors such as natural hazards or creeping environmental changes in the long run. Building resilience is seen as a core task in this context. However, significant differences become evident when comparing the concept of adaptation from the viewpoint of the respective natural and social sciences perspectives.

Smit and Wandel (2006) analyzed different definitions and understandings of adaptation in the natural and social sciences. They conclude that for example in natural science, adaptation is often viewed as the development of genetic or behavioral characteristics, which enable organisms or systems to cope with environmental changes in order to reproduce and survive. In contrast, social science approaches examine adaptation primarily with regard to cultural practices allowing societies to survive in light of climate-induced changes. Within these approaches, behavioral and technological innovations are considered and discussed (Smit and Wandel 2006, p. 283). Furthermore, the work on adaptation in social science puts emphasis on the fact that adaptation practices and adaptive capacities are related to political and social power relations. These concepts have a close link to the concept of vulnerability and theoretical approaches like entitlement theory, conflict theories, and approaches related to political economy.

### 2.2 Characteristics of the limits of adaptation

The recognition of the need to adapt for communities as well as for coupled social-ecological systems exposed to climate change stressors and creeping environmental changes and various other developments is widely shared within the scientific community. Adaptation in contrast to coping involves changes that allow a community or a system to live with changing environmental conditions in the medium and long term. However, the ability of various social groups and different coupled social-ecological systems to adapt successfully is socially differentiated. As a consequence, actual and potential limits of adaptation for different communities and groups need to be considered when dealing with adaptation strategies.

The scientific debate about the limits of adaptation to natural hazards and climate change is relatively new (see, e.g., Arnell 2004, 2007; Adger et al. 2007, p. 719, 2009; Adger 2008). Limits of adaptation can on the one hand be an outcome of the dimension and magnitude of climate change (biophysical—impact perspective), and, on the other hand, be determined by limited physical, financial, institutional, political, cultural, and individual capacities to deal with climate-related changes, hazards, and creeping processes (human response perspective). In this context, Adger (2008) and Adger et al. (2009) underline that the limits of adaptation might be determined by certain characteristics such as individual behavior concerning, for example, the general perception within a society or community on whether adaptation—thus meaning change—itself is something to look forward to or not. That means that the limits of adaptation are characterized by tangible and intangible aspects such as opinions and perceptions about risks and knowledge of coping and adaptation options. Hence, also inner societal limits to adaptation like value systems, societal choices, and risks as well as goals of societal development have to be considered when dealing with adaptation constraints. The abilities to adapt are also influenced by social and political power relations. In addition, the complexity of climate change and the uncertainty of how climate change impacts will develop within the near future (see, e.g., Dessai et al. 2009) as well as how socio-economic trends will develop also constrain the chances of successful adaptation or require at least that adaptation strategies and measures allow for flexibility.

Based on a literature review, the following limits of adaptation to natural hazards and climate change can be outlined as:

- *Physical limits*
  Are based on the fact that physical impacts and changes due to hazards and climate change are so extreme that either the ecosystem and environmental service basis is destroyed or it is physically impossible to reduce losses and adjust communities to these levels and magnitude of stress;
- *Financial limits*
  Are important barriers when the response and adjustment to the actual and potential impacts would be too costly and would by far exceed the capacity of a household, province, country, state, or region;
- *Political, social and institutional limits*
  Are less clearly defined; however, they imply that political systems, social networks, and structures as well as institutional/organizational capacities are too limited to deal with the potential adaptation to climate change impacts effectively. Or that political will and priorities may themselves constitute a barrier of their own for setting and giving priorities to long-term adaptation goals that might be beneficial for future

generations but yield limited direct benefit to those currently in charge. Lastly, also inner societal issues, such as value systems, and behavior, as well as values set for societal development might be factors that constrain adaptation to climate change (Adger et al. 2005, p. 78, 2009; Arnell 2007).

### 2.3 Differentiation: coping, adaptation, impacts, and change

Besides the systematization of the limits of adaptation, it is important to deal with the differences and similarities between impact, change, coping, and adaptation. This differentiation is essential particularly in order to improve the understanding of what adaptation is and what it is not. That task also requires a further systematization and differentiation of the terms coping and adaptation. I argue that coping compared to adaptation is closer related to impacts, while adaptation relates to change. In some papers, the terms coping and adaptation are used synonymously. This is problematic, since it does not shed light on the fundamental differences between the two concepts. As illustrated by frameworks developed by Birkmann et al. (2009) and (2010a), the author views coping as an immediate response and reaction to hazard events that impact societies or communities such as a specific flood event or heat wave. Thus, coping mainly encompasses strategies, measures, and actions that are related directly to specific hazard impacts during or after a crisis or disaster strikes and refer primarily to capacities within existing institutional frameworks. In contrast, adaptation is characterized by medium and long-term strategies that imply or lead to change and often require changes in institutional frameworks and framework conditions. Thus, coping and adaptation do not solely differ in terms of timescale, but also in terms of the actions and strategies that are possible within current institutional settings (coping) and those who are linked to change and require changes in framing institutions. Consequently, adaptation might indicate a turning point leading to a different development path. While this change might be gradual, it is, however, different from a more short-term oriented response to hazard impacts (coping) (Birkmann 2011; Birkmann et al. 2009, 2010a). Figure 1 illustrates these differences. While coping during a drought might imply selling important assets and eating fewer meals, adaptation to drought phenomena would mean to adapt livelihoods by, for example, opting for drought-resistant crop types before the next severe drought occurs.

## 3 Key challenges and core questions when dealing with the analysis of adaptation to climate change and natural hazards

Besides advancing basic knowledge regarding the differentiation between coping and adaptation, it is important to deal with key challenges and core questions allowing a systematic analysis of practical adaptation processes to climate change and extreme events. When analyzing adaptation measures, the following questions should be considered:

- Adaptation to what? [hazard type, creeping changes, multi-hazards].
- Who has to adapt? [different adaptation needs and forced adaptation].
- Who are the actors that are responsible for the development and implementation of different adaptation strategies and measures?
- What resources do different groups and households possess in order to be able to adapt? [Who is in the position to adapt?]
- How to ensure that adaptation strategies at different scales and between different regions and communities do not conflict with each other?

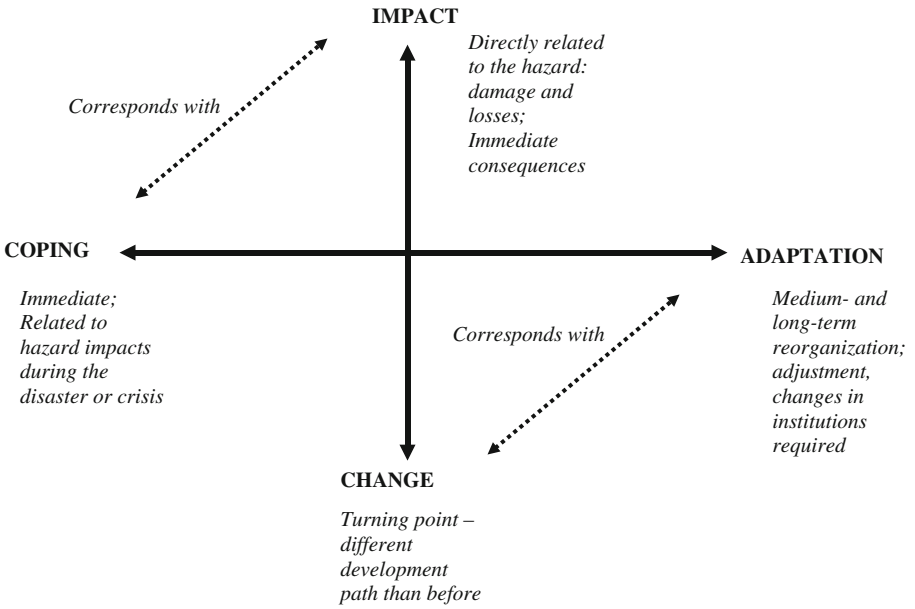


**Fig. 1** Systematizing coping and adaptation as well as impact and change. *Source:* Figure based on Birkmann (2011), Birkmann et al. (2010a) and (2009)

### 3.1 Adaptation to what

In contrast to vulnerability assessments and adaptation strategies focusing on a single hazard, the phenomenon of climate change is likely to intensify various natural hazards, such as floods, droughts, and storms. Furthermore, climate change will imply new hazards, such as sea level rise (IPCC 2007a, b; Stern 2007). In this regard, dealing with climate change means dealing with multi-hazard situations. Impact scenarios and climate-related hazard assessments are often based on projections that may occur or that are already visible to a certain degree. However, uncertainty and complexity (non-linearity) remain and have to be taken into account when developing adaptation strategies. Moreover, we also have to deal with hazard phenomena not yet experienced (e.g., sea level rise) where past experience of coping and adaptation rarely exists. Successful adaptation strategies have to enable communities and societies as well as coupled social-ecological systems to adapt to a variety of future actual and potential environmental and socio-economic changes. Uncertainty and complexity cannot be overruled but must be part of vulnerability reduction and adaptation strategies to climate change.

### 3.2 Who has to adapt?

The literature review shows that many papers and documents refer to (poor) rural communities as those most in need to adapt while encountering the greatest difficulties to do so (see, e.g., APN 2007, p. 2; Adger 1999). Although it is true that poor rural communities might be among those most impacted by climate change, the actual scenarios of sea level rise also underline the fact that various urban areas, for example in delta regions, are under enormous pressure to adapt to fundamental changes—should the projection of 1-m sea

level rise become reality (see, e.g., ICEM 2009). Generally, the need to adapt is greater in communities and groups characterized by a close coupling process of social-ecological systems. That means that communities highly dependent on environmental services are often the first to suffer from climate change impacts. Hence, the analysis of the nature and strength of the coupling process within coupled social-ecological systems is a central task when dealing with the analysis of adaptation needs.

While direct coupling processes between humans and the environment are one crucial factor, indirect coupling effects need to be considered as well. This could be, for example, the dependency of urban households and economic activities on lifelines and critical infrastructures that might not function or even collapse due to climate change and extreme events. Current projections by Carew-Reid (2007) regarding climate change-induced sea level rise for the Mekong Delta indicate that most of the rapidly growing urban areas—where about 17 million people live today—would be heavily impacted and inundated. Consequently, the ability to adapt urban areas/structures to climate change impacts is a major challenge but is presently receiving far less attention than adaptation needs in rural areas (see, e.g., Commission on Climate Change and Development 2009 and Birkmann et al. 2010b). Climate change adaptation strategies for urban areas may need to become a priority task, particularly when considering the long-lasting nature of the built environment.

Moreover, policy and governance issues, such as the role of different stakeholders regarding the decision and implementation of major adaptation measures, have to be taken into account. In the case study of the Mekong Delta, major structural adaptation measures and larger programs such as relocation have been developed and implemented by national and state-related agencies. Compared to that, most non-structural adaptation measures and livelihood changes, for example, are often the result of individual adaptation processes. Not enough attention has been devoted until now to the conflicts and mismatches arising between the strategies of state and non-state actors (Birkmann et al. 2010b).

### 3.3 What resources are needed in order to adapt?

The question of the different resources and capacities required by people and administrative and political units to promote adaptation successfully is essential. However, it is an aspect difficult to assess. As underlined by Adger et al. (2005), the effectiveness of adaptation strategies applied by one actor might be influenced by the strategies and actions of other actors (Adger et al. 2005, pp. 80–81). Thus, resources and capacities to adapt depend on the broader conditions shaped by various actors, in particular by governmental policies and public strategies. Furthermore, when focusing on a more individual household or community level—e.g. in the Mekong Delta or coastal areas impacted by the 2004 tsunami in Sri Lanka—and its ability to adapt to climate change impacts, it becomes evident that poor farmers do not have enough savings to afford new technologies and crop types that could help them to adapt. Also landless people and migrants might have severe difficulties in getting access to resources helpful to adapt (Birkmann and Fernando 2008). Moreover, the question of the resources needed for adaptation depends on the specific circumstances and demands of the different groups and economic sectors involved. While for example, seasonal migration appears to be an adaptation strategy observable in rural areas, the larger and planned migration of whole cities would require many more resources and most probably exceed the capacities of cities and communities. Hence, the role of political units and administrative levels regarding adaptation and its funding has to be addressed.

### 3.4 How to ensure that various parallel adaptation strategies and measures do not generate conflicts between each other?

It is important to examine the potential conflicts between adaptation strategies at the same and at different levels. While, for example, dyke protection systems in flood prone communities living upstream provide more security from flooding for the respective communities, it can on the other hand lead to higher floods downstreams when these structural adaptation measures are implemented on a larger scale. Therefore, the question of how to balance conflicting adaptation strategies between different communities and between different scales (household, local versus national level) is crucial. Adger et al. (2005) stress the fact, that the evaluation of the success of adaptation strategies depends on both the spatial and the temporal scales used. Consequently, the focus on the objectives of the individual stakeholders or communities is not sufficient to evaluate the overall success of adaptation (Adger et al. 2005, p. 80). The temporal axis of adaptation processes and the success of adaptation will be discussed more in depth in the next chapter in connection with the concept of first- and second-order adaptation.

## 4 Toward an improved understanding of adaptation processes: first- and second-order adaptation

The concept of first- and second-order adaptation provides a new perspective on how adaptation processes might be better understood. It underlines that purely linear thinking as well as large-scale technical interventions for adaptation to climate change and natural hazards need to be reviewed critically.

The author defines *first-order adaptation* as those strategies and measures that households, communities, or societies develop to adapt to actual or expected climate change consequences and natural hazard phenomena. That means that first-order adaptation is adaptation to changes and thresholds in physical and ecological systems. These adaptation measures and processes can happen at a more formal level, i.e., be planned and organized by official organizations and institutions or be more informal in terms of adjustments of individuals and households. However, the author has observed that in most regions, structural and large-scale adaptation measures and programs are processed by national governments or national agencies, while adaptation strategies at individual or household level often encompass less structural measures but rather changes in livelihood patterns.

*Second-order adaptation* encompasses processes, strategies, and measures that can and most likely need to be executed by households, communities, and societies to adjust to the direct and indirect consequences of the measures and structures implemented within the scope of first-order measures. Particularly when adaptation measures and actions include major structural and technological measures, such as dykes, uplifting of land, or early warning systems, there is a huge need for additional individual and behavioral changes or changes within coupled social-ecological systems. Adaptation measures currently discussed such as the relocation of people do not merely imply a spatial relocation of households, but often the need for additional adaptation processes regarding livelihoods, social networks, and mobility patterns. These processes are subsumed under what I call *secondary adaptation.*

Until now, scientific research has been paying only little attention to the differentiation of adaptation phases, particularly to the needs for second-order adaptation processes

triggered by first-order adaptation measures. The term second-order adaptation has been used also within the framework for the discussion of the German Adaptation Strategy (for more details, see UFZ 2008). However, their meaning and interpretation differ from what is being discussed in this paper. Within the context of the German Adaptation Strategy, second-order adaptation is defined as processes that deal with the adjustment to societal and economic developments, while first-order adaptation is defined as a response to the direct impacts of climate change. In contrast, I use the term second-order adaptation to capture processes and adjustments to the impacts triggered by first-order adaptation strategies and measures. Thus, first- and second-order adaptation processes in this paper are linked to different cascades of adaptation in the context of natural hazards and climate change.

A key hypothesis that lays behind the concept of first- and second-order adaptation is that many adaptation measures discussed today (see Table 1), such as dyke systems for protection against more severe floods, early warning systems for storms, and heat waves as well as relocation of people out of areas highly exposed to natural hazards—to name just a few—(see, e.g., World Bank 2008; IPCC 2007c) require second-order adaptation processes. Second-order adaptation processes can thwart the intention of first-order adaptation. Secondly, second-order adaptation processes might be essential in order to be able to live with the consequences of changes introduced by first-order adaptation processes. Thirdly, second-order adaptation might be required in order to make first-order adaptation measures effective and useful for the people and communities exposed. For example, technical adaptation measures—such as early warning systems–need to be facilitated by collective and individual behavior ensuring that these technical or structural measures really contribute to an improved adaptation level of societies facing natural hazards and climate change. Thus, dealing with adaptation to climate change and natural hazards requires a more comprehensive focus on the potential implications of first-order adaptation measures for the people affected as well as on second-order adaptation processes in these communities. Lastly, it should be mentioned that first- and second-order adaptation processes are not necessarily limited to one scale or entity. For example in the case of flood protection through dyke systems, households and communities downstream might be adversely affected thus having to engage in second-order adaptation, even though they may not benefit from the first-order adaptation process.

In order to contribute to an improved understanding of adaptation as well as to a better understanding of its limits, this paper provides some selected examples of coping and adaptation processes based on the author's own research in the Vietnamese Mekong Delta. Thereafter, the operability of the concept of first- and second-order adaptation will be dealt with in more depth.

## 5 Actual coping and adaptation strategies of people exposed to flood risk: case study Mekong Delta Vietnam

The function of this case study is to provide some illustrations of the challenges when dealing with coping and adaptation to natural hazards. The case study also gives an insight into different hazards (floods and sea level rise), coping and adaptation measures, as well as the institutions and organizations seen as key when dealing with the impacts of natural hazards. The chapter constitutes an important basis to further conceptualize the concept of first- and second-order adaptation processes. The examples, however, are structured primarily according to the assessment carried out in the Mekong Delta focusing on the

**Table 1** Overview of selected adaptation measures proposed for different sectors

| Sector/area | Climate change stimuli/ influence, (particularly shocks and trends) | Adaptation strategy/measures (first-order adaptation) | Potential limits of adaptation |
|---|---|---|---|
| Urban/spatial planning | Storm surges, sea level rise | Relocation Dyke system, Storm barriers | Financial limits, physical barriers |
| Agriculture | Heat waves, floods, droughts | New crop varieties: fast-growing crops or hazard-resistant crops (drought-resistant crop) | Technological (new varieties) and financial limits) |
| Water and sewage management | Drought, floods | Modification of water–sewage infrastructures to deal with very low water and high water levels in, e.g., canal systems, reduce water leakage, etc. | Financial limits, physical barriers |
| Energy and power supply | Heat waves, floods, extreme low water levels in rivers | Mix of different energy and power plants, changes in the consumption behavior of energy/electric power during weather extremes, such as heat waves | Limited access to viable alternatives; financial and technological barriers |
| Infrastructure/ transport | Low water levels in rivers, damages to and flooding of roads/rails of roads (heat waves, heavy precipitation events | Modifications of infrastructure, e.g., canals, water retention, relocation of critical infrastructure | Financial limits, technological barriers, availability of relocation space |
| Tourism | Reduced snow, heat waves, storm surges, Seasonal shift | Modification of tourist industry/profile: diversification, artificial snow making | Marketing uncertainties, artificial snow making needs more energy, not applicable if too warm |
| Health | More extreme weather events, heat waves, spread of diseases and pests | Changes in medical services (care of the elderly), disease surveillance, migration | Limits in human tolerance, knowledge limitations, limits of financial capacity |

(*Source*: IPCC 2007a, b, c)

differentiation between coping and adaptation measures. The differentiation is important in order to understand key characteristics and qualities of adaptation compared to coping.

The case study concentrates on the Mekong Delta in Vietnam, in particular its northern part. It deals with coping and adaptation to floods (frequent hazard phenomena in the region), while the southern and central parts of the Vietnamese Mekong Delta are exposed to potential sea level rise. The discussion of coping and adaptation strategies in this chapter is based on two focus group discussions: one within a rural and flood prone community in the Dong Thap province—conducted with farmers as well as official organizations of the Local People's Committee and a second with planning institutions in the city of Can Tho. Additionally, literature review findings and expert interviews have been considered in order to better understand the implications of the response actions of governments and other organizations, for example in the aftermath of the major Mekong Delta flooding in 2001 and the overall consequences of the economic liberalization policy in Vietnam (Doi Moi).

### 5.1 Introduction: Vietnam—Mekong Delta

Just 150 years ago, the Mekong Delta had a very low population density and was characterized by poor agricultural output and a high prevalence of human diseases. Due to drainage programs and massive settlement development during the French period between 1886 and 1930, the Delta rapidly changed its character and was transformed from a sparsely populated area with little agricultural activities to an area with high population density becoming one of the major Vietnamese rice producers (Luttrell 2001, p. 65). Today, more than 17 million people live in the Delta, encompassing major cities such as Can Tho with about 350,000 inhabitants. More than 90% of the national rice export and 60% of the total export turnover from fishery products comes from the Mekong Delta (see, e.g., Nguyen 2007, p. 2; Edmonds 2004). The Mekong Delta is characterized by major floods that occur and influence the northern provinces of Dong Thap and An Giang, while the southern provinces on the coast line like Tra Vinh are confronted with salinization problems due to salt water intrusion from the sea (Vo 2009). Additionally, the southern and central provinces of the Mekong Delta are prone to sea level rise according to a study conducted by Carew-Reid (2007). Another type of hazard likely to occur in the Delta is typhoons such as the typhoon No. 5 that hit the area in 1997.

### 5.2 Strategies and measures to face floods

The analysis of coping and adaptation strategies is based on qualitative data gathered through a focus group discussion (FGD) in Dong Thap (in the village of Phu Hiep) as well as on secondary literature and data reviews. Particular attention was given to response measures conducted after the flood disaster in the year 2000. The discussion of the sea level rise scenario is based on a literature review and recent studies as well as a discussion within the Expert Working Group on Measuring Vulnerability conducted in 2008 in Vietnam with experts from Can Tho University, UNDP in Vietnam, and other stakeholders from within and from outside the region. The focus group discussions, which are the major source for the analysis of coping and adaptation, were conducted with representatives of the Local People's Committee in the Phu Hiep Commune and with local farmers of the same commune.[1] The assessment in Dong Thap was aimed at getting a better understanding of what local people perceive and learn more about actions and strategies that might reduce loss and harm in case of a flood event. The case study provides an overview of different coping and adaptation strategies implemented by local farmers or governmental agencies. It also illustrates aspects of first- and second-order adaptation using the example of dyke construction and relocation. Finally, it shows that some first-order adaptation measures might also diminish capacities to cope.

[1] The FGD—conducted in September 2008–mainly encompassed eight steps—particularly regarding the discussion with local farmers. Firstly, the method of an FGD and its goals was presented; secondly, a timeline of major events was developed with the participants, and thereafter a risk hierarchy and hazard mapping was conducted. In a fourth step, the impacts and consequences of major hazard events were discussed, followed by the compilation of coping mechanisms and actions for the case of floods. Additionally, adaptive actions were discussed in contrast to short-term coping. Thereafter, these adaptation measures listed were evaluated and brought into a hierarchy.

### 5.3 Coping: strategies and measures

The focused group discussion (FGD) showed that the farmer households in Phu Hiep were fully aware of various coping strategies to deal with floods. Most of the farmers had applied them personally during major flood events in the past. Lifting the ground floor level (a); moving important items to upper floors (b); sending the children to day care centers (c); and selling livestock in case of very large floods (d) were measures and strategies that had been conducted by local farmers during past major flood events such as those in 1978, 1996, and 2000 (see Fig. 2).

However, it is interesting to note that particularly elderly persons mentioned that their coping strategy would be to simply stay at home and wait for the flood to retreat. In addition, evacuation, relief and reconstruction issues were mentioned such as getting support from a kind person far away from the commune or registering for help at the village leader/local government to get support.

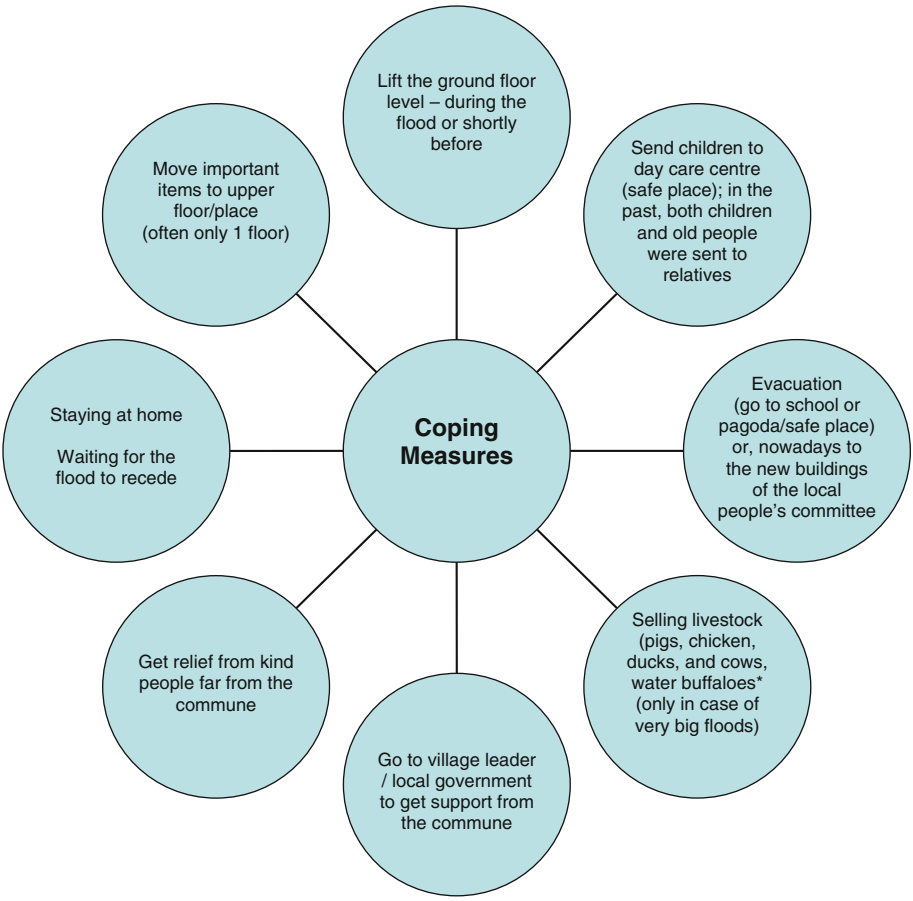


**Fig. 2** Coping measures to floods—Vietnam, FGD Phu Hiep Commune Dong Thab (*Source:* own figure, based on Focused Group Discussion in Phu Hiep Commune). Acknowledgements: The research in Dong Thab was undertaken in the context of the WISDOM project funded by the German Science Ministry 'BMBF'. In this regard the author would like to express his very special thanks to Mr. Tuan Vo Van who supported the Focused Group Discussion and particularly the translation

### 5.4 Coping strategies and limits of coping

Most of the coping strategies relating to floods at the Mekong Delta indicate that flood events are characterized by a relatively slow process, which allows various courses of action—such as lifting the ground of the floor level, sending children to day care centers, and selling livestock. Nevertheless, these strategies show severe constraints in light of major floods. For example, damage and fatality reports from the major floods in the year 2000 reveal that children had been severely impacted and were among the groups that suffered the most in terms of fatalities. A larger report for the Vietnam Red Cross (VNRC) and the International Federation of Red Cross and Red Crescent Societies (IFRC) developed by Neefjes (2002) concludes that the flood in 2000 had impacted children more than any other age group since out of 501 casualties, 374 were children (Neefjes 2002, p. 1). The same was true during the floods in the year 2001, where out of the 407 people dead, 321 were children (Neefjes 2002, p. 1). These figures underline that children have very limited abilities to apply coping measures to this hazard phenomena. The numbers also show that vulnerability to slow-onset floods is socially differentiated (e.g., in terms of child mortality).

### 5.5 Institutions and organizations crucial within the coping process

The institutions assessed as the most important and accessible to help in coping with floods (see Fig. 3)—using the Venn diagram technique (for detailed description of the methodology see, e.g., Chambers 1994; Kumar 2002; IFRC 2008)—were the Local People's Committee and the Search and Rescue Team (SAR). They were ranked first and second, respectively. This result might have been influenced by the substantial power of the Socialist Party and the Local People's Committee.[2] Family and relatives as well as neighbors were ranked in the third place in terms of their importance in providing help during the coping phase. These findings reflect the fact that the relatively poor rural communities depend on external or governmental support when major floods exert a severe impact on the community members as a whole. Interestingly—in contrast to post-disaster processes in other regions (e.g., Indonesia and Sri Lanka after the Indian Ocean Tsunami)—religious organizations and kind people far away from the community—who might donate funds for reconstruction—were classified as less important compared to governmental organizations such as the Local People's Committee and SAR as well as social networks such as family and neighbors.

In terms of institutions, organizations, and networks that provide aid and support in the aftermath of a disaster, the Local People's Committee and the SAR were viewed as the most important (see size of the circle around these organizations in Fig. 3); however, the majority qualified the access to these organizations and their support as rather limited compared to the access to support from family members and relatives as well as neighbors. Overall, formal organizations in Vietnam (particularly in Phu Hiep) like the local authority represented by the Local People's Committee and the SAR team were generally ascribed a more significant role and judged to be more important than informal organizations.

[2] However, during the FGD none of the observers from the Local People's Committee (governmental body) attempted to restrict any comments or critical remarks expressed by the participants/farmers during the meeting.

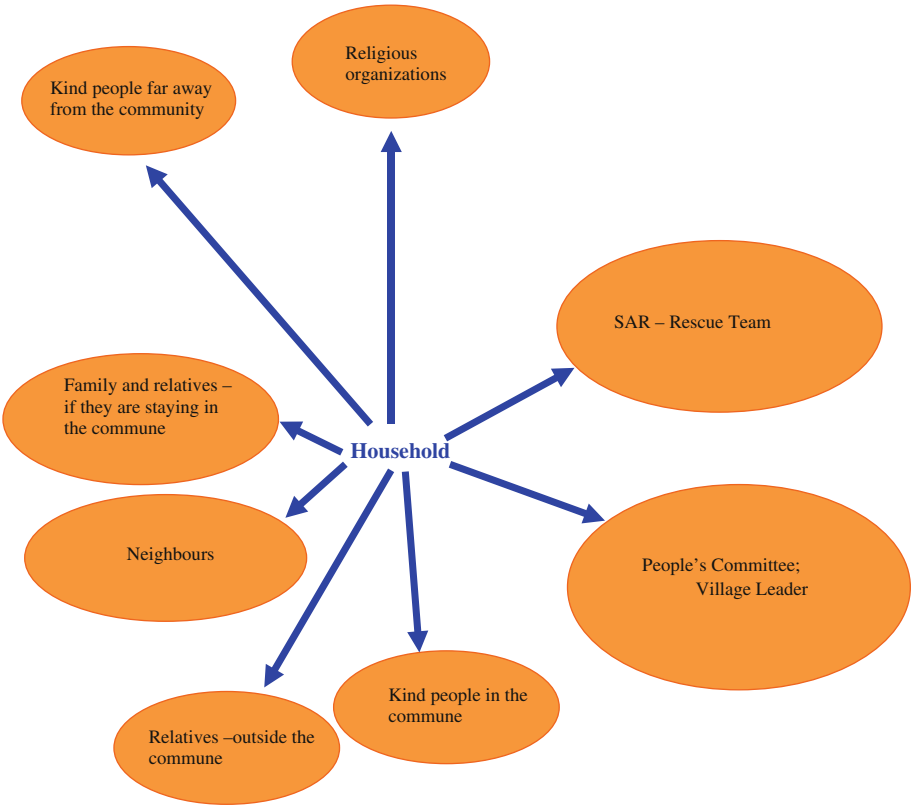


**Fig. 3** Venn diagram: institutional and social network analysis—coping with floods Mekong Delta (*Source:* own figure, based on Focused Group Discussion in Phu Hiep Commune). Remark: the size of the *circle* indicates the importance regarding coping; the length of the *arrow* indicates the perceived distance (accessibility) to institutional and social networks

### 5.6 Adaptation: strategies and measures

Besides the analysis of coping strategies, the FGD also examined the different adaptation strategies and measures local people undertake to adjust their houses and livelihood activities to floods. Most participants saw a clear difference between those actions that help to deal with (immediate) flood impacts (coping), and those that can help to adjust activities to prevent harm and losses before and after a major flood. The results also underline that structural measures, such as the construction of dyke systems and local roads as well as shifts in occupational and livelihood strategies like changes in crop cultivation and diversification as well as engagement in non-farming activities (see Fig. 4) imply a cascade of adaptation measures and phases that can be systematized into first- and second-order adaptation processes.

Most of the adaptation measures and strategies reflect on past response strategies to major floods such as the development of residential clusters and relocation of people in the aftermath of the flood in the year 2000. For example, the relocation strategy of people in rural areas—under the name "new residential clusters" particularly in Dong Thap and An Giang—was a governmental response strategy after the major floods in 1996 and especially

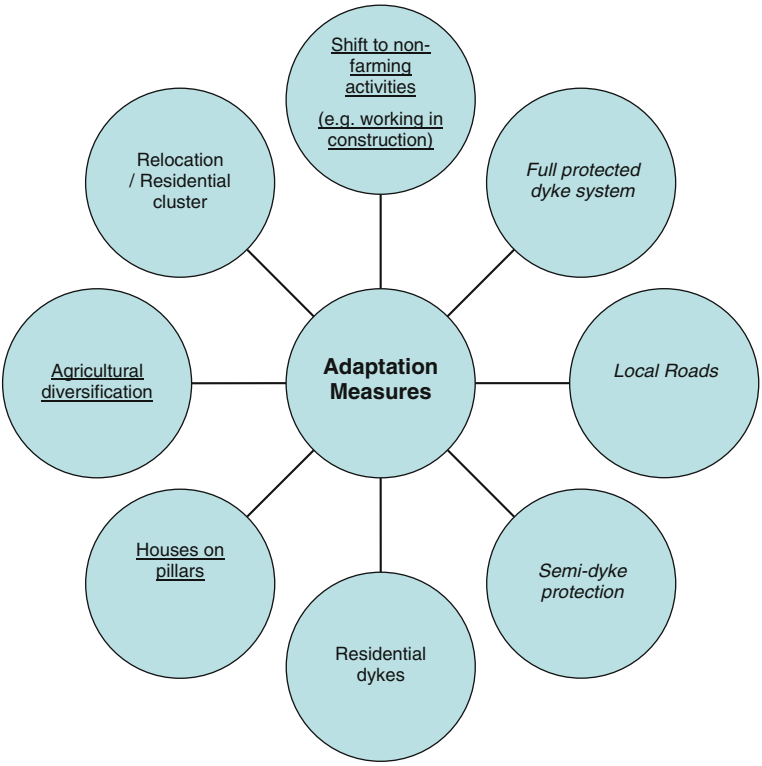


**Fig. 4** Adaptation strategies and measures outlined in the FGD in Phu Hiep, Vietnam (*Source:* own figure, based on Focused Group Discussion in Phu Hiep Commune). Remark: *Underlined* adaptation measures can be undertaken by the household themselves; Measures written in *italics* can be undertaken by the household in cooperation with the local government/commune; The other measures can be undertaken only by the local/national government or commune

those in 2000. This strategy and program encompassed the relocation of about 200,000 households (Vo 2009; Neefjes 2002, p. 12). Relocation was one of the most visible and influential formal responses to floods, with positive and negative implications for those relocated. Compared to the coping measures outlined before, adaptation measures such as relocation have fundamentally changed the institutional and spatial context of farmer households. Even if the relocation place was only few kilometers away from the former place of residence, the measure of relocation has severely changed livelihood activities and required additional adaptation processes (here defined as second-order adaptation).

The assessment of the different adaptation measures revealed that the responsibility for dyke construction—particularly residential dyke systems—and the development of new residential clusters (relocation) rests within the government. In contrast, semi-structured dykes and local roads are often implemented by the government and local people jointly, while changes in crop patterns and crop diversification as well as the engagement in non-farming activities are seen as individual responses. Hence, governmental adaptation measures against future floods concentrate mainly on structural measures (dykes, roads) and relocation projects.

Although structural measures such as residential dykes and local roads also entail potential negative effects, they were ranked among the top priorities. Fully protected dyke

systems and houses on pillars were seen as important on a kind of second rank. Crop diversification and shifting to non-farming activities were also seen as important adaptation strategies. However, some participants clearly underlined the prerequisites for being able to shift to non-farming activities, such as the need to acquire additional skills and the necessity to migrate (temporarily but frequently) to other places. Crop diversification was another strategy to reduce potential losses caused by floods. Nevertheless, this strategy requires access to land, which constitutes a major problem for some farmer households in Vietnam.

Interestingly, in the Socialist Republic of Vietnam, a large number of farmers do not have access to land or have lost their land cultivation rights. The pressure to sell these land cultivation rights to another farmer was often a result of the failure to surmount the difficulties posed by the transition toward export-oriented and intensive agricultural rice farming under the economic liberalization program (Doi Moi). About 15–20% of farmers failed to successfully undertake these changes being thus confronted with serious income difficulties. One way out of these difficulties was to sell their land cultivation rights to other farmers and engage as wage laborers. Another option for these farmers was to migrate to larger towns and cities (see, e.g., Van Ni et al. 2001).

The examples outlined above hint toward limits of adaptation in terms of the different adaptive resources of various groups and households. For example, in the case of landless farmers with limited access to land, the dependency on wage labor restricts the option to diversify agricultural production on their own. Furthermore, the limited job skills of some households imply that these people are locally bound to a specific occupation for whom moving to non-farming activities is a risky strategy.

The case study examples from the Mekong Delta, Vietnam, reveal various coping and adaptation strategies. Capacities to cope and adapt are clearly socially differentiated—even in a so called socialist country like Vietnam. Capacities to cope and adapt are influenced by internal as well as external factors and drivers, such as the impacts of the Doi Moi reform. While coping processes are often operating in the framework of existing structures and institutions, adaptation as outlined in this paper implies change and also modifications of existing structures and institutions. These adaptation measures—in form of technological, social-organizational, or cultural processes—often create new context situations that require further adjustment processes by households in order to be able to live with the changes introduced by the first-order adaptation measures. In this regard, it is important to improve the understanding of the role of different institutions and organizations in the context of climate change adaptation (see Agrawal 2008). These issues will be illustrated in the following paragraphs using examples of dyke construction and resettlement processes.

#### *5.6.1 Building dykes*

It is interesting to note that the development of dykes is perceived by local farmers and governmental officials as an important adaptation strategy to floods. Although dykes do contribute in part to increase human security, a major reason for developing a differentiated system of residential fully protected and semi-protected dykes[3] stems from economic

[3] The semi-protected dykes are just preventing floods in August, thus the first floods of the flooding season. These dykes do not deter high floods from causing major losses on residential areas. Fully protected dykes protect a whole area mainly to include sheltering the agricultural production inside the dyke system. Residential dykes are just a variety of those dykes also used for housing. Many local roads are built on these dykes and houses have been constructed along their left and right-hand sides. Therefore, they are classified as residential dykes.

motives. The semi-protected dykes—that prevent areas from flooding in August—as well as the fully protected dykes are linked to the economic interest to continue to produce agricultural crops during the first part of the flood season (semi-protected dyke) or, in the case of the fully protected dyke, throughout the whole flooding season. Hence, dyke structures cannot be solely explained by the aspiration to improve human security but are rather linked to different strategies to increase the agricultural production in the Mekong Delta.

In addition, the dyke system has and had severe consequences for local and regional environment and ecosystems. Since the year 2000, a recognizable decline of fish resources has been observed due to the development and implementation of the dyke system and the intensification of the use of agrochemicals in farming. Consequently, such structural measures often entail severe consequences for the coupling effects of social-ecological systems and the environmental services the communities depend on. Putting in place, dyke systems implies major changes that require and force people to develop additional capacities to adapt (second-order adaptation) to come to terms with the consequences of such a structural measure (first-order adaptation).

#### *5.6.2 Relocation and new residential clusters*

Large relocation programs and the development of new residential clusters after the floods in 1996 and, in particular, in 2000 were a major strategy for the national government involving more than 600 communes and the relocation of about 200,000 households living in the most affected and flood-prone areas in Dong Thap and An Giang (Neefjes 2002, p. 12; Vo 2009). Also in other regions in Vietnam, resettlement due to floods is a governmental strategy that often generates trade-offs and conflicts (Beckman 2006, p. 166). The national goal of this relocation strategy was to ensure that evacuation and temporal displacement would become unnecessary in times of major floods. Since 2004, about 170 farmer households in the Phu Hiep community have been resettled into the new residential cluster built in their commune.

The new residential clusters are often located in relatively close distance to the former place of residence; in the case of Phu Hiep, most farmers reported that their former places of living were located 2–6 km away from the new place. The new houses were built on subsidized land in the center of the commune. Before, they had lived in the unprotected flood-prone area. The landless farmers interviewed perceived the relocation to the new residential cluster as an option to improve their general social and economic situation. However, the more in-depth evaluation of their today's situation in the relocation site and the comparison with their former situation showed in more detail both the positive but also the negative consequences of relocation. Table 2 outlines these positive and negative aspects of relocation discussed during the FGD and the visit of this relocation site in the Phu Hiep commune. The table does not intend to be comprehensive; it rather means to hint at the positive and negative implications of relocation as an adaptation strategy.

Particularly, landless farmers viewed the relocation process as a positive development due to the fact that they had received a plot of land and a new house subsidized by the government. Nevertheless, the situation of chronic poverty and unemployment had not changed. Additionally, none of the households interviewed in the relocation cluster has so far been able to pay back the interest-free loan granted by the government when they moved into that relocation cluster. These findings can be supported by other studies conducted in selected relocation sites in the An Giang province. Vo (2009) concludes that in the An Giang province the chances of resettled households to be able to pay back that

**Table 2** Positive and negative aspects of relocation outlined by farmers relocated in Phu Hiep/Mekong Delta

| Positive aspects | Negative aspects |
|---|---|
| Children can go to school even during flood season | Farmers are not allowed to grow small livestock such as chicken, ducks, or pigs (important coping option) |
| Access to electricity | Lack of income earning activities |
| Access to piped water | Have to pay back the loan received by the government (additional burden) |
| Improved housing material | Most relocated people (mainly poor and landless) are clustered together, which might create a ghetto situation due to the lack of access to jobs |
| Full-protected area | Many farmers have still to work in flood-prone areas as wage labor |
| Access to local roads that are accessible also during the flood season | |

*Source:* Own table

loan are very limited. Hence, although relocation did accomplish to provide better physical living conditions—after a certain phase—it failed to improve the socioeconomic and employment situation of these households.

While growing small livestock such as chicken and pigs was allowed in the former location, it was forbidden in the new and more densely structured urban relocation cluster. This was seen as a negative development; since particularly for relatively poor farmers, the growing of own livestock was an important coping strategy to buffer potential shocks or food insecurities. Hence, some adaptation strategies—such as relocation—reduced the coping capacity of households although the new place of residence was less exposed to floods than before. However, still many of those households resettled had their place of work inside the flood-prone area.

It must also be noted that people who had been selected for relocation were given no choice but were rather forced to move to the new site. This means that the decision of who had to adapt to which location had been pre-determined top down by the local and national government and the people's committee.

### *5.6.3 Resettlement in light of sea level rise*

Although migration and resettlement are controversial adaptation measures often leading to tension, the prognosis of climate change impacts such as sea level rise for the Mekong Delta indicates that planned migration might become unavoidable. Carew-Reid (2007) and ICEM (2009) show that a 1-m sea level rise would mean that about 12,000 sq km would be inundated, which amounts to 85% of the total land area of the Vietnamese Mekong Delta. Such a dimension of inundation goes beyond what has been experienced during previous floods or typhoon disasters. As described before, the Mekong Delta today is heavily urbanized and the place of living of more than 17 million people. This means that planned migration would require a different approach than was the case in previous relocation programs observed after disasters (residential clusters). In addition to the construction of physical buildings in new sites, particular emphasis needs to be given to the establishment of social relationships with the new site before the relocation is implemented. That means that second-order adaptation has to be supported before or during the implementation of

the first-order adaptation process. Preliminary social and cultural relationships with "high-land" communities would be required years before such a migration may become necessary. City partnerships between low-lying and high-land communities or other forms of networks should be established in order to promote the feasibility of secondary adaptation processes—such as the adjustment to a new environment and social networks. Additionally, it has to be considered that about 1.5 million people likely to be affected by the sea level rise would need governmental support in order to be able to adapt in one way or another. Even if relocation is not feasible, the strengthening of housing structures will need to be financially supported to prevent the failure of adaptation processes to sea level rise.

Taking into account the important work on the potential adverse effects of relocation in the context of natural hazards and development projects (e.g., Oliver-Smith 1986; Cernea 1996; de Wet 2006) and the need to improve the participation in planning and management (Ghai and Vivian 1995; Sanoff 2000), climate change implies new challenges, such as the uncertainty of whether people will have to be relocated or not. The support, however, for second-order adaptation processes would require that these support regimes (e.g., social networks with high-land communities) are developed long before the relocation actually takes place. These issues are new facets that have to be considered when dealing with the design of climate change adaptation strategies such as relocation.

The Vietnam case study illustrates the various implications that first-order adaptation measures—such as relocation—have on local people. While the measures successfully reduce the exposure of these households to floods, they might generate second-order adaptation needs that to go beyond the existing capacities of people exposed to the impacts of the first-order adaptation. Thus, adaptation processes linked to structural measures such as dyke construction and relocation (first-order adaptation measures) increase the necessity of additional social-organizational adjustments that are often not sufficiently considered and addressed within the process of the planning and implementation of the first-order adaptation measure.

The negative consequences of large-scale interventions in the environment—particularly related to the mitigation of risks to natural hazards—have been discussed before by different researchers, with Bogard (1988) figuring among the most prominent. Bogard's work gives emphasis to the unacknowledged conditions and unanticipated consequences of mitigation strategies. However, he discusses these issues primarily on a theoretical–conceptual level. In contrast, this paper examines processes of first- and second-order adaptation linked to specific measures and strategies applied in the context of climate change adaptation and natural hazards in Vietnam. Additionally, the concept of first- and second-order adaptation is also linked to the differentiation of coping and adaptation and the notion of change. Coping processes are primarily a direct response to hazard impacts and therefore rather short term. They often operate within existing institutions and framework conditions. Adaptation, in contrast to coping, often goes along with fundamental changes that require—particularly in the context of large-scale structural measures and fundamental changes in societal organization (at local level)—additional adjustments to the changes introduced by the first-order adaptation process. Hence, adaptation involves and at the same time requires changes within existing structures and institutions. Constraints and potential failures of adaptation measures to reduce disaster risk are, on the one hand, linked to the lack of capacities and abilities of people to adapt to changing environmental conditions (first-order adaptation). However, on the other hand, many adaptation measures require further adjustments that go beyond the capacities of people exposed to the consequences of the first-order adaptation measure. In this context, I view first- and second-order adaptation as strongly interwoven processes not merely dealing with the negative

unacknowledged and unanticipated consequences of adaptation measures, but also with the impacts and transformation processes within coupled social-ecological systems and with limits of adaptation at multiple levels (see also Fig. 5).

## 6 Potential and actual limits of adaptation to floods in the Mekong Delta, Vietnam

The expert interviews and the literature analysis as well as the results of the coping and adaptation analysis of local farmers in the flood-prone commune Phu Hiep in Dong Thap province clearly hint at several limits of adaptation.

The first results of the FGD, for example, identify landless farmers as particularly vulnerable due to their lack of access to land, their dependence on wage labor, but also due to their limited ability to conduct adaptation measures. While the dyke policy increased the protection of some communes against major floods, it had severe consequences for the environmental resources and services communities depend on. The fish stock and the fertilization brought about by floods were significantly reduced. Additionally, the large-scale construction of dyke systems in the provinces of the northern Vietnamese Mekong Delta has increased—and will continue to increase—the likelihood of stronger floods in the middle and southern provinces. This might become a specific problem, for example, for the city of Can Tho, which already today is flooded when high tide and high water levels in the Mekong Delta coincide. Overall, the main limits and constraints of adaptation can be summarized as follows:

- Newly built dykes in the flood prone province of Dong Thap can lead to the increased flood risk of downstream communities and cities such as Can Tho. These secondary consequences of adaptation measures for other areas have to be taken into account.
- The dyke system has influenced the coupling of the social-ecological systems of local farmers to their environment in the Dong Thap province. The semi-protected and fully protected dykes allow people to grow rice and other agricultural products even in times of the flood season. At the same time, however, dyke systems reduce the fish stock and increase the tendency to use agrochemical fertilizers since the natural fertilization brought about by floods is significantly decreased.
- Relocation to new residential clusters was mainly seen in the first place as positive (based on the FGD). However, the more in-depth discussion showed that the new place and location did not change the structural problems of unemployment, lack of sources of income, and the consequent chronic poverty of landless farmers.
- Shifting to new income earning opportunities in the non-farming sector requires new or additional skills which many rural farmers—particularly landless farmers—often do not have. Although the pressure to adapt and even to change the livelihood patterns is likely to increase under the impact of climate change, the options and abilities of local farmers to change to a new occupational sector is limited.
- In some cases, field research revealed that households have adapted to the protection of the dyke system by reducing the height of their houses behind the dyke. This might lead to complications in the future, particularly if a dyke failure occurs. The local knowledge regarding housing standards on pillars as well as the ability to lift the ground floor might be hampered if after a certain period of time people start to build houses on a lower level.

- The projections of the impacts of a 1-m sea level rise for the Mekong Delta show that nearly all communities and cities would be affected. It is most likely that this phenomenon would exceed the adaptive capacity of communities and cities exposed.
- Integrated strategies for the whole Mekong Delta—such as a master plan for the Mekong Delta—are being confronted with a lack of institutional and organizational structures. There is yet no institution in place that would be responsible for the planning of integrated strategies for the whole Mekong Delta. Rather, the Vietnamese Mekong Delta is structured in 12 provinces that would need to be coordinated and brought together when aiming to develop more integrated and comprehensive strategies.

## 7 Further conceptualization of processes and limits of adaptation in the light of the concept of first- and second-order adaptation

The analysis of coping and adaptation strategies in the case study has shown that actual adaptation strategies—such as relocation and dykes—should not be viewed in isolation but need to be embedded in a broader concept of adaptation including the analysis of the abilities of people to adapt to the intended changes. Additionally, the limits of adaptation and the externalities that first- and second-order adaptation processes might imply for other regions and scales have to be taken into account.

The author argues that the issue of adaptation to natural hazards and climate change has to be regarded as a cascade of processes. Thus, a distinction between first- and second-order adaptation processes is important. Although the adaptive cycles developed earlier within the framework of social-ecological systems point already in the direction of a cascade of adaptation processes, the concept of first- and second-order adaptation emphasizes the potential failure of adaptation. Moreover, it underlines that the ability of communities or regions to undertake second-order adaptation measures is crucial. Consequently, the development of adaptation strategies and respective funding regimes needs to be based on detailed studies perusing the potential implications of any measures. Furthermore, due to the unavoidable uncertainty in relation to climate change impacts and the effects of adaptation measures, a constant evaluation and monitoring of these strategies must accompany the whole adaptation process. This enables different stakeholders to react to potential failures and unforeseen implications of these measures.

Relocation, for example, is still a strategy frequently implemented by national governments after mega disasters such as the major floods in Vietnam in 2000 or the Indian Ocean Tsunami in 2004 in Sri Lanka. However, this strategy requires more than just the construction of new physical structures (new houses). Aspects such as securing social networks and fostering place-based jobs and skills need to be considered when dealing with the social, political, financial, and institutional limits of adaptation and the necessity of second-order adaptation. Resettlement and planned migration might be unavoidable for some delta regions if the scenarios of sea level rise brought about by climate change (see, e.g., Carew-Reid 2007, p. 25) should become reality. Therefore, new concepts and strategies for planned migration including the support of second-order adaptation processes are needed.

Additionally, dyke systems are seen as an important tool to adapt to flood risks (see FGD in Phu Hiep commune and World Bank 2008). While dykes in the northern Mekong Delta were helpful to ensure the continued production of agricultural products during the flood season, they had severe consequences for the fish stock and most likely also increased the dependence of local farmers on agrochemicals due to the reduction in flood-based

fertilization. The first-order adaptation measures also had severe implications for downstream communities. In the medium and long run, they will be dealing with more severe flood risks due to the larger development of flood-defence structures and dyke systems upstream. That means that adaptation measures might generate externalities that induce second-order adaptation needs in a different region at the same scale or even at different scales. Hence, the evaluation of appropriate adaptation should also account for various spatial and temporal consequences and conflicts that these measures and strategies might trigger.

Overall, the examples underline that a more phase-related view on adaptation processes is essential. This phase-related view on adaptation also has to consider the potential of the failure of adaptation processes and the externalities in terms of space and time scales. Figure 5 provides an illustration of the first- and second-order adaptation processes linked to three different cases. The figure shows that failures of adaptation processes to natural hazards and climate change can also be caused by the changes triggered by the first-order adaptation measures. Thus, the consequence of the first-order adaptation might exceed the capacities of communities or social-ecological systems to adapt to these changes (see Fig. 5: phase II, case II).

Figure 5 outlines that even if first-order adaptation measures are implemented successfully, this does not necessarily mean that the entire adaptation process will be

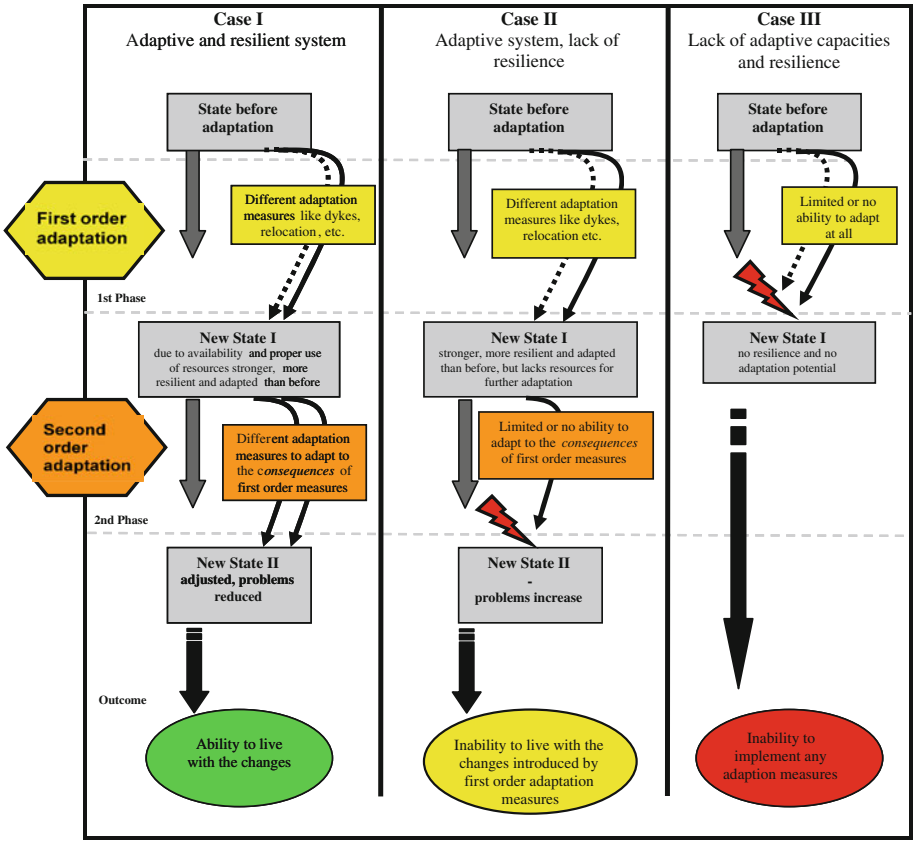


**Fig. 5** First- and second-order adaptation phases exemplified by three cases. *Source:* own figure

successful. Most of the structural adaptation measures or fundamental changes—such as relocation—go hand in hand with positive and negative consequences, which coupled social-ecological systems or social entities need to deal with and adapt to. The differentiation between first- and second-order adaptation underlines that the potential consequences of first-order adaptation measures as well as the resources and abilities of communities and households to adapt to changes have to be examined in more depth prior to their planning and implementation on such a large scale. Moreover, the limits of adaptation should be discussed and acknowledged transparently (see Fig. 5: phase I, case III).

Lower income groups and people who have a place-based occupation have very limited abilities to adjust to a new environment that is very different from their original place of living (framework conditions). Consequently, close coupling processes between livelihood activities and specific environmental resources or landscapes (e.g., coastal zone) limit the ability to undertake second-order adaptation processes in the context of relocation. As a consequence, local people have to be integrated in each step of potential adaptation strategies. It is highly important to make them aware of the difference between coping and adaptation strategies in order to justify measures of adaptation that will require and imply changes—in some cases even without showing immediate positive effects.

## 8 Discussion of different theoretical approaches that can shed light into various facets of the concept of first- and second-order adaptation

The question of appropriate theoretical approaches that could help to explain the complex nature of adaptation, stabilization, and destabilization is not easy to answer. Many key terms such as coupling, coupled social-ecological systems, disaster risk, or livelihoods refer to specific theoretical approaches. Consequently, it might even be impossible to develop an overarching theoretical framework. Nevertheless, the author views the theoretical approaches of (a) resilience and the adaptive cycle, (b) social ecology and regulation as well as, (c) political ecology as most appropriate to explain some features of the phenomena discussed in this paper. Additional approaches such as the structuration theory of Giddens could have been considered as well; however, the author focuses intentionally on theoretical concepts that have a closer link to the adaptation of social-ecological systems. Most of the challenges outlined before—using the case study of Vietnam—are not solely determined by inner societal structures or by purely environmental factors. Therefore, the discussion of concepts that have a closer link to the notion of social-ecological systems seems to be most fruitful.

### 8.1 Resilience and the adaptive cycle

The first theoretical background that might help to understand and explain first- and second-order adaptation needs is the theoretical and conceptual discussion of resilience, collapse, reorganization, and adaptability in the context of coupled social-ecological systems (see, e.g., Berkes et al. 2003; Folke 2006; Abel et al. 2006; Walker et al. 2004, 2006). Particularly, the "adaptive cycle" developed by Holling (2001) and Holling and Gunderson (2001) explains transformations and adaptation processes within four phases encompassing "exploitation", "conservation or consolidation", "collapse or release", and "reorganization". It therefore describes the four phases of any complex system that undergoes

1. times of unorganized search for the right combination of elements and functions necessary for its own establishment under the prevailing conditions and availability of a wide range of resources;
2. times in which this search has led to a result, growth slows and structures are consolidated making the whole system more effective but at the same time more rigid and inflexible toward changes and new developments, hence more vulnerable to external disturbances;
3. phases in which this rigidity leads to a breakdown of the established structures under changed conditions or external disturbances and to the release of the stored resources, energy, and creativity; and finally,
4. phases in which these resources, energy, and creativity are used to reorganize the system into a different state or even a new system adapted to the new prevailing conditions.

Most relevant are the so called "backloops" and feedback processes embedded in collapse or release and reorganization phases. Abel et al. (2006) underline that these phases can either lead to a bouncing back to the same state and regime, to a shift into a different regime with the same set of state variables, or to a complete transformation resulting in a new regime characterized by entirely different scales, state variables, and feedbacks. Although the notion of these regime shifts is still strongly related to an environmental perspective, some processes observed in the case studies can be systematized according to this classification. Adaptation through relocation implying major shifts in livelihood activities—and in the environmental conditions households are embedded—can be linked to the "transformation" of the social-ecological system, while the development of improved housing standards would rather be characterized as a shift to a different regime since feedback processes change while the state "variables" remain the same. Both processes, however, require the prior rupture of existing structures due to changed conditions or unforeseen disturbances and the subsequent reorganization of resources and relations. For a sustainable adaptation process, this reorganization should put emphasis on the development of flexible structures and strategies that allow for future adaptation to changing conditions.

Apart from the adaptive cycle, the concept of "adaptability" within the resilience discourse is also useful for this study. It underlines the thesis that second-order adaptation processes depend heavily on the resources and all forms of capital available to the people as well as on institutions and governance (see, e.g., Walker et al. 2006). The acknowledgment that people and communities have to have access to the resources and capacities in order to adapt to changes implies a different approach than viewing adaptation as a concept that could be implemented through structural measures coming from external entities. Thus, forms of social and institutional adaptation are essential. In the same context, transformability not only includes forced transformation, but also awareness, experimentation, reserves, and governance, and can thus be seen as a potential self-organized and intended transformation that needs to consider the anxieties, needs, and abilities of the affected population.

The concept of complex adaptive systems as the basis for resilience thinking involves the idea of dynamics that are characterized by connectivity and feedbacks across and within scales as well as through additional processes of self-organization (Abel et al. 2006). This theoretical understanding helps to explain the various impacts and consequences adaptation might have within such a dynamic and connected social-ecological system. For example, in terms of the dyke construction exemplified in the case study of the Vietnam Mekong Delta, the various effects and the connectivity across scales as well as

processes of self-organization and complexity become evident. Here, interventions and adaptation measures not only influence "local social-ecological systems" but also other communes or even regions downstream due to the connectivity across and within scales. Viewing adaptation processes or failures of adaptation as a cascade—including first- and second-order adaptation phases—corresponds to the notion of a self-organized system and its intrinsic "cyclicity" modeled by the adaptive cycle of Holling.

Lastly, resilience theory is useful to understand that future stability concepts have to shift from the normative to maintain structures to the normative of resilience, which emphasizes that shocks and stressors will continue to destabilize social-ecological systems especially under the influence of climate change. Therefore, it is essential that these systems constantly learn to adapt to permanent change or to reorganize and transform while enhancing adaptive capacities and the level of self-organization. These aspects are not sufficiently addressed in governmental programs on climate change adaptation.

### 8.2 Social ecology and regulation of society–nature relationship

The second type of theoretical approaches that can help to understand adaptation processes and measures are subsumed under the theoretical concepts of social ecology, regulation, and political ecology (Becker and Jahn 2006; Goerg 2003; Walker 2005, 2006; Collings 2008; Krings 2007; Bak 1997). These theoretical approaches can help to focus on the dynamic relationships between society and nature and the different interests that are inherent in different adaptation strategies and measures. Furthermore, social ecology and the theoretical concept of regulation of societal relationships with nature by Goerg (2003) might help to view adaptation in terms of a more phase-specific stabilization of certain processes for a certain time.

The concept of social ecology focuses around the dynamic interrelationship between society and nature. Becker and Jahn (2006) emphasize that complex social-ecological interactions can neither be explained solely by natural science concepts alone nor by mere social science approaches. Instead of focusing on the conflict of naturalism versus constructivism, social ecology aims to understand the dynamic interactions between societal and ecological relationships (Becker and Jahn 2006, p. 31). The "science of social ecology" as Becker and Jahn (2006) call it can particularly sharpen the focus regarding the fact that adaptation intervenes and interacts in a problem context in which social and natural phenomena are closely interrelated. Consequently, not the focus on the natural event alone, but rather on the broader human relation to nature and its responses to the phenomena have to be critically reviewed and considered when developing adaptation strategies.

Also the concept of Goerg (2003) regarding the regulation of society–nature relationship emphasizes that "ecological crisis phenomena" have to be examined in the broader context of stabilization and destabilization factors, focusing particularly on the regulation and stabilization of conflicting patterns in the utilization of nature. Brand and Goerg (2008) stress the fact that contradictions inherent to social development or between the utilization of nature and human reproduction are often not solved, but solely institutionally secured. Following this view, stabilization of specific patterns of human–environmental interactions or specific patterns of the utilization of natural resources are characterized through a contingent stabilization based on power relationship and structural forms of reproduction. Although regulation theory and the specific theoretical approach of the regulation of societal relationships with nature (Goerg 2003) focuses on major system changes, the idea of a temporal stabilization of society–nature relationships—while major contradictions remain—can also be applied to certain adaptation strategies to climate change and natural

hazards. In many cases, adaptation measures solely contribute to stabilize current utilization patterns of environmental resources, while major contradictions between the economic development approach and environmental change are not taken into consideration. For example, regarding the case study in Vietnam, one could question the suitability of further urbanization and agricultural intensification in the Delta region that is prone to floods and sea level rise. However, these fundamental questions are often not addressed when dealing with adaptation. Additionally, the approach might also help to underline that not only environmental facts and processes, but also their scientific description and political contestation and acknowledgment as a societal problem constitute environmental problems and create the context for adaptation strategies. Lastly, the concept of societal relationships with nature after Goerg stresses the fact that large crises lead to change and transformation, while smaller crises do not since they can be managed within the current settings of institutions and organizations. This observation is also true in the context of disasters caused by hazards of natural origin. In the case of Vietnam, large interventions and changes were implemented particularly after major disasters had occurred (flood disaster Vietnam in 2000). Interestingly, these responses allowed for a stabilization of the societal development for a certain time. However, the further destabilization of coupled social-ecological systems in the Mekong Delta has already become evident, since the adaptation measures implemented, particularly dykes and relocation, have not solved the conflict and social-ecological crises in the long run but contributed to a certain extent to a new destabilization of social-ecological systems. Considering these constant changes in phases of stability and instability of social-ecological systems, Bohle (2008) argues that the perception that social-ecological systems are stable and robust is misleading since most of the social-ecological systems are characterized by different degrees of destabilization and often tend to develop within a destabilized form without collapsing. He underlines that a social-ecological system could develop even during a crisis situation. This theoretical perspective of "relative stability" (Bohle 2008) supports the argument that adaptation measures should not aim to create robust or stable systems per se.

### 8.3 Political ecology

This leads to the last theoretical concept discussed in this section to explain adaptation processes, namely political ecology (see, e.g., Walker 2006; Krings 2007, pp. 949–958; Collings 2008), and theoretical concepts linked to the vulnerability research field (see, e.g., Bohle 2008, p. 74, Bohle 2007, pp. 805–815). These approaches can be useful to explain and examine the different abilities of people to cope and adapt to changes introduced by adaptation measures. Despite the diversity of approaches summarized under the headline of political ecology (see, e.g., Walker 2005, pp. 74–75, 2006; Krings 2007), it is important to note that political ecology helps to underline that adaptation measures are embedded in a politicized environment and are not solely derivable from natural hazard or climate change scenarios. Particularly, the early work of Blaikie and Brookfield (1987) under the perspective of political ecology already dealt with the influence of political economy as a force of maladaptation and instability. In this context, this paper also contributes to the debate about maladaptation, cascade processes of adaptation, and failures of adaptation. In this regard, political ecology provides a historical background and a theoretical basis for this study, without taking a specific concept or methodology into account. Rather, the paper uses the perspective of political ecology to focus particularly on potential impacts of these measures on marginalized groups and the impact for the re-configuration of assets and resources (e.g., in terms of resettlement processes).

The discussion of different theoretical approaches to explain adaptation processes as well as the limits of adaptation showed the existing variety of conceptual and theoretical approaches. The critical review underlined that the various theories explain parts of the processes discussed; however, no theory alone can capture the diversity of the observed and discussed processes of first- and second-order adaptation. Consequently, further research and practical work are needed to better understand specific patterns of coping and adaptation to natural hazards and climate change. While there is a fast growing literature on adaptation to climate change (see, e.g., Schipper and Burton 2009), there is a gap in better understanding adaptation processes and constraints to natural hazards and climate change—particularly in multiple interacting systems. In this context, the paper is one contribution to the further enhancement of the understanding of adaptation to natural hazards and climate change, conveying a strong emphasis on linking practical experiences and observations with conceptual and theoretical approaches.

## 9 Conclusions

At present, most countries and national governments seem to prioritize structural and technological adaptation measures such as technical early warning systems or dykes to prevent floods or to deal with actual and potential consequences of natural hazards and climate change-related trends. This dominant focus on technological modernization might be misleading, particularly, if a critical review of the deficits existing in societal structures and institutions is not undertaken as well.

The concept of first- and second-order adaptation readdresses the attention also to the consequences of these adaptation measures for social and social-ecological systems. It underlines that the adaptation measures are selected within the larger context of power relationships. The ability of people to adapt to these measures and strategies proposed has to be taken into consideration when planning such measures. The concept of first- and second-order adaptation might help to differentiate between various adaptation phases and to acknowledge the importance of focusing on the capacities of societies and communities to adapt to large-scale structural measures. The examples also have shown that adaptation processes are often interwoven; consequently, failures of adaptation might not solely depend on the successful implementation of one specific measure, but are rather the outcome of the interaction of various processes. In this regard, the constraints and limits of adaptation are linked to multiple levels as outlined in Fig. 5.

This paper has shown that the issue of adaptation to climate change and to an increasing number of natural hazards has to be scrutinized much more critically than it has been done so far. In this respect, especially the discussion of the preconditions and implications of adaptation strategies and measures proposed to increase human security with regard to natural hazards and climate change have to be considered as key topics when promoting adaptation. Additionally, the case study has underlined that some adaptation measures—such as relocation—might also severely reduce coping capacities of people to other shocks and stressors.

While many reports and scholars, such as for example the "Global Monitoring Report" (World Bank 2008, p. 216), view adaptation mainly as a strategy to develop robust systems and to reduce the exposure and sensitivity of systems to natural hazards and expected changes in natural and social systems, the author argues that not every social group or community possesses the same resources and abilities to implement such strategies. The concept of first- and second-order adaptation warns that adaptation is often not a single,

linear process but might imply and consist of several unforeseen consequences that require additional and integrated adaptation efforts. In this regard also, the limits of adaptation have to be taken into consideration.

Overall, a broader understanding of adaptation is needed that takes into account the various changes introduced by first-order adaptation measures and the implications for second-order adaptation needs. Additionally, the term adaptation should be further qualified regarding its differences to coping processes. This paper argues that coping and adaptation are linked but imply different sets of measures and processes. Finally, the paper also stresses the need to better understand adaptation in terms of the entities responsible for the development of the adaptation measures, the right time for the implementation of respective measures, and the evaluation of the changes introduced by these measures and strategies. In particular, the enhancement of monitoring systems that continuously evaluate the consequences of adaptation measures (and processes of first- and second-order adaptation) are needed in order to avoid that local communities exposed to these changes fail to adapt.

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