Chapter 17
The Water-Development Nexus: Importance of Knowledge, Information and Cooperation in the Mekong Delta

Fabrice G. Renaud and Claudia Kuenzer

Abstract As most world deltas, the Mekong Delta [or the "delta" hereafter (in this chapter we exclusively concentrate of the Vietnamese portion of the delta which covers roughly four-fifths of the Mekong Delta)] is highly dynamic both from environmental and socio-economic perspectives. The delta plays a crucial role for the Vietnamese economy in terms of agricultural and aquaculture production, is rapidly urbanising, and has seen an important development of its infrastructures, particularly those related to water resources management. Water plays a central role with respect to the development of the region but, as described throughout this book, water resources are also threatened by anthropogenic processes such as pollution, infrastructure development, and over-abstraction, as well as by global environmental change including the impacts of climate change. Knowledge generation, knowledge sharing and stakeholder cooperation with respect to water resources management are still limited in the region and this should be addressed rapidly in order to allow for efficient decision-making in the face of rapid societal, economic, climate and environmental change.

F.G. Renaud (✉)
United Nations University - Institute for Environment and Human Security (UNU-EHS), UN Campus, Hermann-Ehlers-Str. 10, Bonn 53113, Germany
e-mail: renaud@ehs.unu.edu

C. Kuenzer
German Aerospace Center (DLR), Earth Observation Center (EOC), German Remote Sensing Data Center, Oberpfaffenhofen, 82234 Wessling, Germany
e-mail: claudia.kuenzer@dlr.de

F.G. Renaud and C. Kuenzer (eds.), *The Mekong Delta System: Interdisciplinary Analyses of a River Delta,* Springer Environmental Science and Engineering,
DOI 10.1007/978-94-007-3962-8_17,

17.1 Water at the Centre of the Delta's Development

The development of the Mekong Delta relies to a very large extent on its water resources and infrastructure, whether we talk of the construction of navigable waterways for transport of goods, the excavation of canals for drainage and irrigation of agricultural land, the supply of freshwater to communities, or the protection measures against floods and salinity intrusion. Despite the abundance of water, the development of the delta is often hindered by too much water during the flood season, too little during the low flow season, or too polluted water. The impacts vary depending on the geographical location in the delta but also on the socio-economic circumstances of individual households, as the delta is far from being homogeneous from both physical and societal perspectives. This chapter synthesizes some of the key points made in previous chapters of the book, linking water resources management, knowledge management, and development.

17.1.1 Water Infrastructure, Rural Development and Poverty

In the last few decades, agricultural development in the delta has proceeded rapidly principally through the impact of the Green Revolution, infrastructure development and improved agricultural practices (Nguyen Duy Can et al. 2007; Chap. 3). Three main periods of policy-driven changes with respect to the delta's agricultural systems can be identified (see Nguyen Duy Can et al. (2007: 78–79) and Garschagen et al. – Chap. 4). A first shift was from extensive rice production systems in the pre-*Doi Moi* period to rice expansion and intensification in the 1990s which was partly promoted thanks to infrastructure development (e.g. dikes, irrigation canals and sluice gates). The second shift was triggered in the 2000s through "effective land use" policies which encouraged the farmers to diversify their agricultural systems (e.g. integrated rice-fish production systems, shrimp farming – see also Ngo Thi Phuong Lan 2011). The third shift was induced by taking stock of the lessons learnt from previous agricultural intensification practices, forcing the government to reconsider giving priority to rice production in some areas of the delta and to look further at alternative land uses. These relatively rapid transformations have not been uniform in the delta, and there are large disparities in terms of development at the provincial level.

Infrastructure developments had both negative and positive effects in terms of management of water resources and land use changes (Dang Kieu Nhan et al. 2007, Chap. 6). Economic benefits included possibilities for rice monoculture intensification, agriculture diversification, rural road improvement providing among others, better access to markets, the development of aquaculture production zones, and the reduction of flood damages. Negative impacts encompassed the destruction of natural wetlands, the deforestation of protective mangrove belts along the coastline (Chap. 12), degradation of river ecology and natural fish stocks, soil fertility reduction, soil erosion, and conflicts between upstream-downstream users, as well as within or between

agricultural, urban, and industrial activities (see e.g. Biggs et al. 2009). In addition to internal transformation processes, the delta, as the most downstream region of the Mekong River Basin, has to face the consequences of all activities taking place at the scale of the basin without having the political power to substantially influence decision-making in the other riparian sovereign nations. The region is therefore facing many uncertainties linked to internal transformations, development activities within Vietnam and in upstream riparian areas (Chap. 5), and global economic and environmental changes, including climate change (see also Biggs et al. 2009).

One of the main objectives of infrastructure development in the delta was (and remains to be) the social and economic development of the region and the country as a whole and, linked to this, the reduction of poverty. The Mekong Delta has seen rapid development which led to an impressive reduction in overall poverty (Chap. 4), but a part of its rural population remains poor. Recognizing the problem, the Government of Vietnam has recently set ambitious targets in terms of national food security for the period 2020 (GoV 2009) which also addresses rural poverty. These targets include increases or stabilisation in production of rice, of other crops, of fisheries, and of aquaculture; they address the nutritional needs of the population and children in particular and, perhaps more critically, aim to improve the profitability of agriculture, particularly for rice farmers. Although rice production plays a central role in the delta, many rice farmers remain in precarious situations (Biggs et al. 2009). Coclanis and Stewart (2011) illustrated this fact by discussing "precarious paddies", highlighting the uncertainty, instability, insecurity, and risk burden characterising rice farming in the delta. They reviewed various historical, environmental, and developmental factors affecting rice farming in the region and showed that political reforms and scientific innovations (e.g. more productive rice varieties) have not drastically reduced the uncertainties under which rice farmers operate.

Garschagen et al. (Chap. 4) showed that a consequence of poverty in the region is a net negative migration flow of people, principally due to out-migration towards more economically dynamic regions. As noted by Huynh Truong Huy and Le Nguyen Doan Khoi (2011), migration and development complement each other as development induces migration and migration contributes to development. Contemporary migration is from rural to urban areas with nearby Ho Chi Minh City being one of the main receiving cities with ca. 50% of migrants moving there, but also Can Tho City. According to Huynh Truong Huy and Le Nguyen Doan Khoi (2011), this migration is mainly driven by poverty, natural disasters, failures in production and the markets, socio-economic background, and ethnicity in the commune of departure.

Through the enactment of various policies, the Government of Vietnam has favored agricultural diversification. In various provinces of the delta, aquaculture, including shrimp farming, is replacing the traditional rice crops as farmers see higher income opportunities even if production risks are also higher. For some farmers, this represents one strategy to step out of chronic poverty although here again, inequality can prevail as the poorest farmers have difficulties in meeting the high investment costs required to shift from a rice to a purely aquaculture production system. Ngo Thi Phuong Lan (2011) and various ongoing research in the coastal

provinces of the delta indicate that the shift from a freshwater rice production system to saltwater shrimp cultivation systems contributes to long-term changes in the social (e.g. power relations, shifts in main activities), economic (possibilities for higher returns on investment, but also of financial failure as has been experienced by many farmers already), and of course ecological (shift from a freshwater to a saline water environment) systems. These changes are directly linked to and impacting water resources in the delta as the ultimate choice of farming system has consequences both in terms of water use and water pollution. Rice and aquaculture systems require relatively large amounts of water albeit of different qualities (freshwater vs. saline water) and will also have different pollution impacts. These impacts are not just in terms of further agricultural water use but also on freshwater availability for human consumption, and other domestic uses. Policies to encourage shifts in agricultural systems therefore need to consider the related environmental, social and economic consequences thoroughly as failure (e.g. of intensive shrimp farming) will have long term repercussions on farmers' direct livelihoods and on the ecosystems and their services. Some researchers now suggest that in terms of aquaculture, rice-shrimp and extensive shrimp systems are more sustainable in terms of soil and water quality impacts when compared to intensive shrimp systems (Chap. 14) and therefore offer fewer risks to farmers' livelihoods. Agricultural production systems in the delta will have to adapt to the effects of climate change and in particular with increased salinisation of coastal areas induced by a combination of lower river flows during the dry season and of sea-level rise. Various development pathways are possible including (but certainly not limited to) considering shrimp farming systems as an adequate adaptation strategy and/or the building of additional infrastructures such as sluice gates at river mouths to preserve rice production in regions not yet affected by salinity (Marchand et al. 2011; see also Chap. 2 where other adaptation strategies are discussed). Each development pathway will lead to different economic and social development outcomes and carries different levels of risk.

17.1.2 Pressure on Water Resources

With intensification and diversification of land use, new pressures have started to be exerted on water resources in the delta. The Ministry for Agriculture and Rural Development (MARD) is officially responsible for irrigation infrastructure development and for hydro-climatic disaster prevention (Decree 01/2008/ND-CP, GoV 2008), and for climate change adaptation in agriculture (Decision 2730/QD-BNN-KHCN, MARD 2008), among others. Yet, it is the Ministry of Natural Resources and Environment (MoNRE) which is responsible for organising and directing the National Water Resources Strategy towards the year 2020 (GoV 2006) and is the focal point for coordinating climate change adaptation activities. In this context, MoNRE noted that water resources with respect to sustainable development and health in Vietnam were under-appreciated and not well protected. MoNRE recognised that adding infrastructures to reduce, for

example, drought occurrences (which negatively impact agricultural production and livelihoods during the low-flow season) is only part of the solution, and that more integrated approaches are required to solve the dry-season water deficits, or general variations in flood pulses. The Ministry also recognised that giving access to sufficient clean water is of absolute necessity to achieve sustainable development and that water resources management activities are dispersed, poorly coordinated, and overlapping responsibilities exist between various stakeholders. There is a lack of cross-sectoral cooperation and a lack of applied sub-basin management (MoNRE 2006; GoV 2006; Chap. 6).

The rapid development of the delta has brought about many environmental changes and disruptions (Fabres 2011), and ecosystem services are negatively affected in many ways (Vo Quoc et al. 2012). Historically, from an environmental perspective, the main challenges for the delta are seasonal floods[1] during the rainy season, as well as drought and salinity intrusion during the dry, low-flow season. Frequency and extent of floods and salinisation are reviewed by Le Anh Tuan et al. (2007). All these hazards are now predicted to be aggravated by the consequences of climate change (Chap. 2) and infrastructure development upstream of the delta and within the delta can either reduce or worsen flood impacts (Chap. 5). The region is also experiencing rapid urbanization with insufficient urban planning (Garschagen et al. 2011) as well as industrialization. All these developments have increased the pressure on water and land resources in many ways:

- Surface and groundwater pollution (Chaps. 7, 13, 14): Pollution of water resources has many origins, some driven by the (i) intensification of agriculture and aquaculture production – e.g. pollution by pesticides, antibiotics, nutrients, acidity (the latter originating from the management of acid-sulphate soils), (ii) urban development – e.g. high concentrations of untreated urban wastewater released in river and canal systems or surface runoff from sealed and polluted surfaces, and (iii) industrial development – e.g. industrial chemicals, some of which releasing compounds which can affect the endocrine system. As a portion of the delta population still relies on untreated surface water and on groundwater, risks linked to polluted water on population health could be significant. Furthermore, the same pollution poses an increasing threat to aquatic ecosystems (Chap. 11).
- Rapid land use changes with the removal of most of the native vegetation, particularly in coastal areas but also, through the development of hydraulic infrastructures (Chaps. 2, 3, 12). This threatens the biodiversity of the delta's ecosystems (Chap. 11; Fabres 2011), whereby large regions of the delta are being converted from freshwater systems to saltwater systems because of shifts from rice production to shrimp production. For example, Binh et al. (2005) have illustrated the rapid changes in land use in the Cai Nuoc District of Ca Mau Peninsula in the delta: whereas rice-based farming systems covered more than 50,000 ha in

[1]Floods are also beneficial in many ways for the delta. We refer here only to large flood events which affect people and their livelihoods negatively.

the region in 1968, they had completely disappeared by 2003; in parallel, shrimp monoculture, which was non-existent in 1968, represented ca. 73% of the land cover in 2003. In fact, in 1998, shrimp cultivation systems only represented ca. 15% of the land cover and the rapid increase in shrimp monoculture was a direct result of agricultural diversification policies issued at the national level.[2] The region also suffered from extensive loss of forest cover and diversity with most conversion taking place because of the extension of the rice cultivation area in the 1970s–1990s and the development of shrimp cultivation (Binh et al. 2005; Chap. 12).

- Water over-abstraction, in particular in the case of groundwater. Groundwater is seen by farmers, industries and urban dwellers as a reasonably accessible resource but its management is not optimized (Chap. 7; Reis 2012). Excessive groundwater withdrawal can also lead to slow but steady land subsidence, which would aggravate the effects of sea level rise in coastal provinces (Chap. 2)
- Agricultural land degradation resulting in declining soil fertility induced by intensification of the cropping systems, in particular rice production (Nguyen Duy Can et al. 2007).

Degraded water quality can impact human health directly (consumption of untreated or partially treated surface water) or indirectly (consumption of aquatic products). Large numbers of the delta population relies on surface water for their domestic uses and treatments applied at the household level do not allow eliminating all sources of pollution (for pesticides, see Pham Van Toan 2012). Rural and peri-urban populations are the most exposed to this lack of connection to clean piped water systems, and although many communities harvest rainwater during the rainy season or access groundwater resources, others still rely on surface water for their daily freshwater supplies.

17.1.3 Differentiated Impacts from Water-Related Hazards

In addition to water access and water pollution problems, the delta will have to deal with increased frequency and magnitude of hydro-climatic hazards such as floods (in terms of variability, see Chap. 9) typhoons, salinity intrusion or droughts (Chap. 2). The region has already suffered greatly from some of these hazards (e.g. the flood of the year 2000 or typhoon Linda in 1997), and at the time of writing, the 2011 flood has already caused human losses and important damages to agriculture and infrastructures in the region. The research of Birkmann et al. (Chap. 10) dealing with the assessment of vulnerability of households exposed to various hydro-climatic hazards in the delta clearly showed that vulnerability in the delta is socially differentiated and is not only limited to a problem of exposure. Some of the vulnerabilities are shaped by factors that are hazard independent (e.g. land tenure, access to loans, presence of

[2]Principally resolution 09/NQ-CP passed in 2000.

social networks), while others are more hazard specific (e.g. type of housing). The mechanisms available to cope with the hazards vary greatly depending on the actual impact and wellbeing of the affected households. One way of coping, frequently undertaken by the poorer households, is temporary or permanent migration of family members (see Dun 2011 in the context of floods; Chap. 10). Another alternative is resettlement (Birkmann et al. in press; Dun 2011). With respect to resettlement, in an attempt to reduce the impacts of the most severe floods, the Government of Vietnam introduced the "living with floods" programme, which consists of the relocation of exposed households into new settlements which are protected from flood impacts. This is in a way a forced migration situation which has both benefits and disadvantages for the concerned population. Vo Thanh Danh and Mushtaq (2011) reviewed some of these and, for a case study in An Giang Province, identified changes in land use/ownership, a decrease in animal husbandry activities, changes in employment (e.g. less engagement in agricultural activities, increase in unemployment) with changes in income sources, and improvement in social conditions (such as greater access to public services including education, particularly during the flooded periods of the year). Furthermore, forced relocation often goes along with a financial burden for the people affected in case they want to maintain their standard of living with respect to their previous living place. Changes are felt differently depending on each household's circumstances prior to relocation, implying that relocation is not necessarily the most appropriate solution for everyone.

The above concerns and additional discussions by Fabres (2011) and in several chapters of this book indicate that the Government of Vietnam is a main actor when it comes to addressing water-related threats and considering the links between water and development in the country in general, and in the delta in particular. Yet, public investments to reduce these threats remain relatively low. Many laws and decrees are in place (see e.g. Chaps. 2 and 6), but progress towards good environmental and integrated water management is still a challenge, particularly in terms of clarifying responsibilities and cooperation at various governance levels and in terms of enforcement. Furthermore, water resources planning in the Mekong Delta is still "top-down". Villagers and farmers play a very minor role in water planning (Le Anh Tuan et al. 2007). This can lead to poor planning or mismanagement of water-related infrastructures, both in terms of water supply for irrigation and domestic use, but also in terms of protection against environmental hazards. The top down approach does not allow capturing and addressing adequately the socially differentiated needs of the population at the local level, as indicated in Chap. 10 in the context of hydro-climatic hazards.

Future management of water resources will determine whether or not it will continue to be an agent of development for the region as a whole or whether its continued unsustainable use and pollution will increase the pressure on agricultural and industrial development and on the livelihoods of the poorest segments of the delta population. There are many opportunities for a sound management of water resources in the region, and we focus the rest of the discussion on two particular aspects: knowledge generation and sharing and increased cooperation between the many stakeholders influencing/involved in water resources management in the delta.

17.2 Knowledge and the Need for Increased Cooperation

17.2.1 Knowledge Generation and Sharing

Given the context of agricultural intensification, burgeoning industrialisation, and environmental and climate change, access to information will be crucial for planning purposes in the Mekong Delta. Le Anh Tuan and Chinvanno (2011) noted that, among other factors, the development of policies for information sharing is very important. However, knowledge generation and sharing is a necessary but certainly not sufficient condition for good policy-making. Many factors are at play in the policy-making process that do not necessarily follow rational processes regardless of the amount of knowledge policy-makers have at hand. We nevertheless argue here that policy-making and the development of IWRM in the delta and upstream can certainly be better informed through the generation of additional, pertinent knowledge and the sharing of this knowledge between various stakeholders.

The amount of research and studies that has recently been conducted in the delta and those that are ongoing is considerable. Of critical importance is the knowledge generation by Vietnamese universities and organizations and, according to the work of Gerke et al. (Chap. 15), local-level knowledge generation is on the increase. This trend needs to be further enhanced and additional funds made available so that Vietnamese scientists are able to conduct independent research that could be published in international peer-reviewed publications and that would complement donor-driven collaboration. Knowledge clusters, which are defined as areas of a high density of knowledge producing institutions and high-level manpower, have developed in Ho Chi Minh City and Can Tho (Chap. 15; Bauer 2011). While Can Tho University and neighbouring institutes such as the Mekong Delta Rice Research Institute are clusters of knowledge production in the delta, other delta provinces host smaller universities whose student numbers are on the rise. However there continues to be a lack of knowledge-sharing within and between institutions, limiting the transfer of knowledge to policy-implementing agencies. Gerke et al. (Chap. 15) showed that this is problematic at various spatial scales, from the very local (e.g. farmers not sharing knowledge with other farmers to keep a productivity advantage) to the national (e.g. central- and local-level governments performing their tasks with little coordination). One of the implications of the latter is that national policies are implemented differently at the sub-national level, and in particular, each province insists on its autonomy which can have negative implications with respect to the implementation of Integrated Water Resources Management - IWRM (Chap. 6). Knowledge-sharing between international organisations working either in research or development activities in the delta is also relatively poor: there usually are very little exchanges, and actions are often driven by agencies interests and funding opportunities rather than strategically, in an attempt to build synergies between projects. Finally, data and knowledge exchange and transboundary cooperation between the riparian countries could also be significantly improved (Le

Anh Tuan et al. 2007; Le Anh Tuan and Chinvanno 2011) if a true IWRM strategy at the basin-scale is to ever materialise (Chap. 5).

As noted by Fabres (2011), taking advantage of and contributing to international information systems is critical. Several agencies and initiatives are trying to actively promote the sharing of information. These are the Mekong River Commission (MRC) which is supplying general knowledge of the Mekong Basin as well as water level and geodata via its website; programmes like M-Power or Mekong Basin related knowledge expansion initiatives of the World Wildlife Fund, the International Union for the Conservation of Nature, and other Non Governmental Organisations. However, the difficulty remains that much of this knowledge will not arrive at the stakeholder level, or will even be observed with scepticism, as it is assumed that the mentioned – often non political – organizations actually have their own political agenda. For the MRC the future pathway is currently unclear, as the leadership has been handed back to the riparian countries, and staff policies for external experts, future fields of focus, funding and strategic redirection remain unclear. However, openly available scientific knowledge of high – reviewed – quality is urgently needed, and the biggest challenge will be to produce, present and communicate this knowledge in a manner that it reaches stakeholders at all levels so that crucial information for the basin or the delta can be incorporated into decision making.

An example of knowledge sharing is the water-related information system developed through the WISDOM project[3] for the region of the Vietnamese Mekong Delta. A major focus of the project is to establish a comprehensive, web-based information portal on the water resources in the delta. This bilingual (English and Vietnamese) water related information system for the sustainable development of the Mekong Delta (Chap. 16) does not only contain a broad range of geo-data, ranging from geophysical information on soil moisture, inundation, water quality, or land use to socio-economic data on demographic patterns, or economic production, but also contains an extensive literature database, a comprehensive database with relevant legal documents, as well as a database containing all stakeholders and decision-making organizations involved in water resources management (Kuenzer 2010). The system is designed as a web-based platform, which can be accessed by all project partners and decision makers involved in the project, as well as by external scientists, stakeholders and interested experts requesting a login. The current phase of the project is focussing on the improved adaptation of the system to the user's needs in the delta, which are especially the provincial offices of MoNRE and MARD. The biggest challenge with information systems in general is to ensure local ownership in a way that they are used, maintained, and that relevant data on natural resources, as well as socio-economic information are being updated in the future (Kuenzer 2010). Therefore, the project, which is now running in its second phase until the end of 2013, is undertaking large efforts in terms of capacity development

[3] Water-related information system for the sustainable development of the Mekong Delta in Vietnam (see Chap. 1 and http://www.wisdom.caf.dlr.de)

in the Mekong Delta provinces through 'trainings of trainers' to ensure the long term sustainability of the system. Furthermore, financial resources need to be mobilized to fund personnel, hardware and software to operate the information system after the end of the WISDOM project.

17.2.2 Cooperation Between All Stakeholders

At the international level, there is a great need, among other factors, to share data and information to improve risk preparedness with respect to floods and droughts and there needs to be further consultation when it comes to the development of the Mekong River (see e.g. Grumbine and Xu 2011). This would allow joint co-development of the basin for the benefit of most. Examples of tensions arising from poor cooperation are the development of dams in upstream countries which have been blamed (perhaps wrongly, see Chap. 5) for droughts in the lower reaches of the Mekong River or the recent controversies linked to the development of the Xayaburi Hydroelectric Power Project in Laos, where consultations seemed to go in the right direction until they fell apart in 2011 with Cambodia deciding to go ahead with construction plans (Stone 2011). However, should a compromise be found on the development of this dam, Grumbine and Xu (2011) suggest that this would then become a prime example of successful integrated, transboundary river basin management. It is clear that each of the Mekong Basin riparian countries have their own development needs and objectives and that the Mekong River can be the backbone for such development. However, as in all transboundary basins, individual countries will only truly reap benefits from the development of the water resources if an international strategy is put in place, not sector by sector as still being emphasised by many, but in an integrated way from the beginning. This applies to the Mekong Delta which is often seen as the region that has to suffer the consequences of development processes in upstream countries. However, Vietnam also develops infrastructures on the tributaries of the river and is interested in purchasing electricity generated from the Mekong River in upstream countries (Methonen 2008). Vietnam is therefore both driver and recipient of changes taking place in the Mekong Basin and needs to implement a coherent approach to its own development projects, in collaboration with the other riparian countries.

As mentioned above, one available platform for this is of course the MRC which could be strengthened in its ability to deal with and negotiate complex matters such as the development of hydropower on the Mekong River and its tributaries (Grumbine and Xu 2011). This would constitute a shift with respect to the MRC's current limited ability to influence national-level processes and gaining access to non-member, upstream countries – this might change with shifts in the organisation's working structure (Ha 2011). Another exchange platform between the riparian Mekong countries – as driven by economic interests – is the Asian Development Bank funded Greater Mekong Subregion Initiative (GMS). This initiative includes the four member countries of the MRC, as well as China and Myanmar, and aims at regional and

sub-regional economic cooperation mainly via investment into the development of infrastructure (Nikula 2008). These activities are backed up by the Association of Southeast Asian Nations (ASEAN), which in 2002 agreed jointly with China to create the world's biggest free trade zone. Here investment and development of the Mekong River Basin are key priorities for cooperation in the region. The very strong engagement of China with the GMS and ASEAN is spurred by important financial incentives.

As reviewed in the previous section and in Chap. 6, improved cooperation is also required at the national level. Most national-level policies and directives identify multiple actors for their implementation, particularly at the ministerial level. However, horizontal cooperation among ministries or other organisations remains weak (e.g. Chap. 15). This is particularly the case for all the directives related directly or indirectly to water resources management. This lack of cooperation at the Ministerial level is not specific to Vietnam and is observed worldwide. But it is at least openly acknowledged in Vietnam whereby MoNRE recognises that when it comes to the current national water resources strategy, the management, protection, and development of water resources must reflect the integrated nature of river basins and not be separated by administrative boundaries (MoNRE 2006). This is unfortunately easier said than done although mechanisms have already been put in place in Vietnam, such as the River Basin Organisations, which have representatives from provinces and national-level ministries but which, by and large do not fulfil their role adequately as discussed by Waibel et al. (Chap. 6). Collaboration at the national level but also with sub-national governance levels is essential to ensure that decision-making considers not only the national targets, but also the needs of local populations and the trickle-down-effects of policy decisions. Lack of joint ownership of project development can be detrimental not only locally but also have off-site consequences. For example, Birkmann et al. (Chap. 10) show that dyke construction in the province of Dong Thap to protect populations against flooding can actually generate serious flood problems further downstream. This can be avoided with the implementation of IWRM principles.

Many actors are also directly or indirectly involved in water resources management and protection at the sub-national level. As previously discussed though, there is competition at these governance levels, in particular at the level of provinces. At the sub-provincial level, the People's Committees also exert great power on decision making and implementation of national-level policies can vary greatly from one locality to another. As one of the last group of stakeholders in this hierarchal governance chain, farmers actually have little to no voice when it comes to conflicts pertaining to national initiatives (Biggs et al. 2009). More participatory decision-making is therefore required within and at the interface between governance levels and stakeholder groups so that the needs of all can be considered when it comes to water resources management. As indicated by numerous national newspaper articles in 2011 alone, despite policies and legislation, people and industries excessively withdraw or pollute water resources in the delta and elsewhere with few if any legal consequences. The impacts are felt by different stakeholders in terms of freshwater provisioning for domestic and production uses. It should therefore be a

priority for the Government to ensure that legislation is properly enforced as, if the status quo remains, defiance will prevail between various stakeholders, making it impossible to apply IWRM principles. The new water law which is currently being drafted may be a good step in the right direction.

17.3 Conclusions

In order to benefit further from its extensive water resources, generation of (local) knowledge related to water resources and their management in the Mekong Delta needs to be further enhanced and this knowledge needs to be shared more widely than it currently is. In addition, a nested institutional approach is required to understand all social and ecological implications of water resources management in the region: one covering the basin scale whereby decision-making on water and land resources management needs to be more integrative and participatory; one at the national and regional (or better, local basin) levels where directives and decisions need to be more integrated with each other and where responsibilities are streamlined to ensure greater effectiveness in addressing all developmental-related issues of water resources (e.g. at the basin level by providing a stronger mandate and resources to RBOs); and one at the provincial and local levels where cooperation instead of competition should be encouraged.

Water resources in the delta are complex both in their bio-physical characteristics and in their social representation and many research gaps need to be addressed in order to implement a true IWRM strategy in the longer run. These cover the resource base *per se*, such as understanding better extreme water and sediment flows (see Chap. 8) as affected by climate change and infrastructure development; developing decision support systems to find solutions (technical, environmental, social and economic) for more effective water resources management and disaster risk reduction; characterizing the multiple pollution sources generated within the delta but also transferred from riparian countries and identifying and enforce adequate technical and political solutions to reduce and remediate these pollution; improved understanding and valuation of the ecosystem services provided by the extensive freshwater system which dominates the region. Research gaps also need to be addressed, in parallel and/or conjointly with the above, on the social and institutional side of the equation. These include, for example, the development of quality criteria for climate change adaptation; scenario-planning for the delta which incorporates not only projections from the perspective of the physical environment but which also address future social and economic changes; and integrated vulnerability and hazard mapping.

Enhanced cooperation and generation and sharing of knowledge are crucial to ensure equitable use of water resources in the region, protection of individuals and ecosystems against environmental (including climate change related) and anthropogenic pollutions and hazards, and ensuring the sustainable development of the region and its increased resilience to external shocks. As the Mekong Delta is highly

vulnerable to the consequences of climate and environmental change it is urgent to put in place a mechanism were politicians, decision-makers, scientists, and the many development actors can meet and discuss on a regular basis the broad issue of the water-knowledge-development nexus of the region.

References

Bauer T (2011) The challenge of knowledge sharing. Practices of the Vietnamese Science Community in Ho Chi Minh City and the Mekong Delta. LiT Verlag, Berlin

Biggs D, Miller F, Hoanh CT, Molle F (2009) The delta machine: water management in the Vietnamese Mekong delta in historical and contemporary perspectives. In: Molle F, Foran T, Käkönen M (eds) Contested waterscapes in the Mekong Region: hydropower, livelihoods and governance. Earthscan, London, pp 203–225

Binh TNKD, Vromant N, Hung NT, Hens L, Boon EK (2005) Land cover changes between 1968 and 2033 in Cai Nuoc, Ca Mau Peninsula, Vietnam. Environ Dev Sustain 7:519–536

Birkmann J, Garschagen M, Fernando N, Hettige S, Tuan VV, Oliver-Smith A (2012) Relocation: reduction in exposure – increase in susceptibility? Measuring dynamics of vulnerability before, during and after relocation processes in the context of disasters and natural hazards. In: Birkmann J (ed) Measuring vulnerability to natural hazards. Towards disaster resilient societies, 2nd edn. UNU Press

Coclanis PA, Stewart MA (2011) Precarious paddies: the uncertain, unstable, and insecure lives of rice farmers in the Mekong Delta. In: Stewart MA, Coclanis PA (eds) Environmental change and agricultural sustainability in the Mekong Delta, vol 45, Advances in global change research. Springer, Dordrecht, pp 103–114

Dang Kieu Nhan, Nguyen Van Be, Nguyen Hieu Trung (2007) Water use and competition in the Mekong Delta. In: Tran Thanh Be, Bach Tan Sinh, Miller F (eds) Challenges to sustainable development in the Mekong Delta: regional and national policy issues and research needs. The Sustainable Mekong Research Network, Bangkok, pp 143–188

Dun O (2011) Migration and displacement triggered by floods in the Mekong Delta. Int Migr 49(S1):e200–e223

Fabres B (2011) Think global, act global in the Mekong delta? Environmental change, civil society, and NGOs. In: Stewart MA, Coclanis PA (eds) Environmental change and agricultural sustainability in the Mekong Delta, vol 45, Advances in global change research. Springer, Dordrecht, pp 7–34

Garschagen M, Renaud FG, Birkmann J (2011) Dynamic resilience of peri-urban agriculturalists in the Mekong Delta under pressures of socio-economic transformation and climate change. In: Stewart MA, Coclanis PA (eds) Environmental change and agricultural sustainability in the Mekong Delta, vol 45, Advances in global change research. Springer, Dordrecht, pp 141–163

GoV (2006) Decision 81/2006/QD-TTg: approving the national strategy on water resources to 2020. Socialist Republic of Viet Nam, Hanoi, 13 p

GoV (2008) Decree 01/2008/ND-CP defining the functions, tasks, powers and organisational structures of the Ministry of Agriculture and Rural Development. Socialist Republic of Viet Nam, Hanoi

GoV (2009) Resolution 63/NQ-CP on National Food Security. Socialist Republic of Viet Nam, Hanoi. Unofficial English translation accessed on 02/09/2011 at http://asemconnectvietnam.gov.vn/lawdetail.aspx?lawid=1735

Grumbine RE, Xu J (2011) Mekong hydropower development. Science 332:178–179

Ha M-L (2011) The role of regional institutions in sustainable development: a review of the Mekong river commission's first 15 years. Cons J Sustain Dev 5:125–140

Huynh Truong Huy, Le Nguyen Doan Khoi (2011) Analysis of labour migration flows in the Mekong Delta of Vietnam. In: Stewart MA, Coclanis PA (eds) Environmental change and agricultural sustainability in the Mekong Delta, vol 45, Advances in global change research. Springer, Dordrecht, pp 115–140

Kuenzer C (2010) WISDOM: Water related Information System for the Sustainable Development of the Mekong Delta – thoughts on sustainability and long term implementation. In: Proceedings of the 3rd Indo-German conference on research for sustainability: water and waste management, New Delhi, India, 3–4 Feb 2010

Le Anh Tuan, Chinvanno S (2011) Climate change in the Mekong River Delta and key concerns on future climate threats. In: Stewart MA, Coclanis PA (eds) Environmental change and agricultural sustainability in the Mekong Delta, vol 45, Advances in global change research. Springer, Dordrecht, pp 207–217

Le Anh Tuan, Chu Thai Hoanh, Miller F, Bach Tan Sinh (2007) Flood and salinity management in the Mekong Delta, Vietnam. In: Tran Thanh Be, Bach Tan Sinh, Miller F (eds) Challenges to sustainable development in the Mekong Delta: regional and national policy issues and research needs. The Sustainable Mekong Research Network, Bangkok, pp 15–68

Marchand M, Dam R, Bucx T (2011) Towards a Mekong Delta plan. Synthesis of water sector assessment. Prepared by Deltares in commission of the Delta Coordinator of Directorate General Water in the framework of the Mekong Delta programme. http://www.partnersvoorwater.nl/wp-content/uploads/2011/09/Annex5_mekongdelta-assesments_synthesis.pdf. Accessed 14 Nov 2011

MARD (2008) Action plan framework on climate change adaptation of the agriculture and rural development sector in period 2008–2020 (Decision No. 2730/QD-BNN-KHCN), 30 p

Methonen K (2008) Do the downstream countries oppose the upstream dams? In: Kummu M, Keskinen M, Vairs O (eds) Modern myths of the Mekong. A critical review of water and development concepts, principles and policies. Helsinki University of Technology: Water & Development Publications, Espoo, 187 pp

MoNRE (2006) National water resources strategy towards the year 2020. Ministry of Natural Resources and Environment, Hanoi, 26 p

Ngo Thi Phuong Lan (2011) From rice to shrimp: ecological change and human adaptation in the Mekong Delta of Vietnam. In: Stewart MA, Coclanis PA (eds) Environmental change and agricultural sustainability in the Mekong Delta, vol 45, Advances in global change research. Springer, Dordrecht, pp 271–285

Nguyen Duy Can, Le Thanh Duong, Nguyen Van Sanh, Miller F (2007) Livelihoods and resource use strategies of farmers in the Mekong Delta. In: Tran Thanh Be, Bach Tan Sinh, Miller F (eds) Challenges to sustainable development in the Mekong delta: regional and national policy issues and research needs. The Sustainable Mekong Research Network, Bangkok, pp 69–98

Nikula J (2008) Is harm and destructions all that floods bring? In: Kummu M, Keskinen M, Vairs O (eds) Modern myths of the Mekong. A critical review of water and development concepts, principles and policies. Helsinki University of Technology: Water & Development Publications, Espoo, 187 pp

Pham Van Toan (2011) Pesticide use and management in the Mekong Delta and their residues in surface and drinking water. Unpublished PhD dissertation, Faculty of Agriculture, University of Bonn

Reis N (2012) Tracing and making the state. Policy practices and domestic water supply in the Mekong Delta. ZEF Development Series. Lit Verlag, Berlin

Stone R (2011) Mayhem on the Mekong. Science 333:814–818

Vo Quoc T, Kuenzer C, Vo Quang M, Oppelt N (2012). The concept of ecosystem services – a review. J Ecol Indic (accepted for publication)

Vo Thanh Danh, Mushtaq S (2011) Living with floods: an evaluation of the resettlement program of the Mekong Delta of Vietnam. In: Stewart MA, Coclanis PA (eds) Environmental change and agricultural sustainability in the Mekong Delta, vol 45, Advances in global change research. Springer, Dordrecht, pp 181–204