



## Research papers

## Governance conditions for adaptive freshwater management in the Vietnamese Mekong Delta

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## ABSTRACT

The Vietnamese Mekong Delta (VMD) is a region of utmost importance to Vietnam's national food security. However, the availability of required freshwater resources (from both surface and groundwater sources) is currently under great threats due to dry season salinity intrusion, surface water pollution, and over-exploitation of groundwater. Global climate change, sea level rise, and upstream and in situ development activities may worsen the situation. Assuming that adaptive management could be a promising strategy to address the increasingly complex and unpredictable water-related problems in the VMD, we design and apply a framework to identify the extent to which the governance regime in this region exhibits conditions that are likely to promote adaptive freshwater management. Using both primary and secondary data, our analysis reveals that the prospects for adaptive water management in the study area are limited since several conditions were not present. We observe among others limitations in vertical and horizontal integration and public participation, restraints in knowledge and information sharing, inadequate policy development and implementation, and insufficient diversification of financial resources. Following our findings, we conclude the paper with recommendations both for national, regional and local policy interventions and for future research.

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## 1. Introduction

The Vietnamese Mekong Delta (VMD) (12% of Vietnam's total area) is of utmost importance to Vietnam's national food security (Cosslett and Cosslett, 2014; Anthony et al., 2015; Smajgl et al., 2015). The Delta, home to approximately 17.6 million people, representing one-fifth of the Vietnamese population (GSOV, 2015), is characterized by a tropical monsoon climate with a wet season from June to November and a dry season from December to May (Cosslett and Cosslett, 2014).

Paddy rice production and aquaculture are dominant economic activities in the VMD. Approximately 65% of the land (2.6 million ha) in the Delta is used for agriculture, of which 2 million ha is used for rice paddies. Between 1995 and 2014, the VMD contributed more than 50% annually to Vietnam's total outputs in rice and fishery production (GSOV, 2015). In 2013, Vietnam's rice export accounted for 8.7% of the global rice market, positioning the country as one of the major global rice exporters (FAO,

2016). According to Hoanh et al. (2014), the Delta's contribution in rice production was even more significant (about 70%) in recent years.

Agriculture in the VMD has been sustained by an abundant availability of freshwater and riverine sediment from the Mekong River. Rice-based farming systems account for more than 65% of total freshwater demands in the Delta (Cosslett and Cosslett, 2014). However, freshwater availability in the VMD is increasingly threatened by global climate change, rising sea level, and upstream and in situ development activities (Smajgl et al., 2015). Problems affecting freshwater resources in coastal areas of the VMD are interrelated. They include dry season salinity intrusion (Cosslett and Cosslett, 2014; Trung and Tri, 2014; Smajgl et al., 2015), which may negatively impact rice production (Kotera et al., 2008; Chen et al., 2012), surface water pollution (Moglia et al., 2012; Wilbers et al., 2014; Chau et al., 2015; Giang et al., 2015), and over-exploitation of groundwater (Erban et al., 2014; Dang et al., 2016).

Groundwater resources in the middle and lower VMD are already systematically depleted (Governments of Vietnam and the Netherlands, 2013; Ha et al., 2015). An average decline of 26 cm/y was detected (Erban et al., 2014), and reductions will

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continue (Shrestha et al., 2016) unless sufficient strategies to restrict groundwater use are implemented (IUCN, 2011). Declines in groundwater levels introduce another significant challenge since accelerated groundwater extraction has also been linked to compaction-based land subsidence averaged at 1.6 cm/y (Hak et al. 2016). In the next decades, land subsidence may increase the risks associated with sea level rise (Hak et al. 2016) with greater magnitudes (Ingebritsen and Galloway, 2014). Moreover, pump-induced land subsidence has also been connected to the release and spread of arsenic to deep aquifers (Erban et al., 2013; Erban and Gorelick, 2016; Huang et al., 2016).

Considering the growing complexities and unpredictability of freshwater problems in the VMD, adaptive management may be a promising strategy for sustaining the region's freshwater resources. Traditionally, water management has been a top-down state-led process characterized by a "command-and-control" approach, which mainly resorts to technical and engineering solutions (Folke, 2006; Ostrom, 2009; Biswas and Tortajada, 2010) and neglects the complexities of the human dimension (Pahl-Wostl et al., 2010; Engle et al., 2011). In the past decades, adaptive management has emerged as a new paradigm (Castro, 2007; Pahl-Wostl et al., 2012) and has been strongly advocated as an appropriate approach to address water issues (Pahl-Wostl, 2007, 2008; Bogardi et al., 2012). The ability to deal with uncertainties is an essential requirement for sustainable water management in times of global climate change (Pahl-Wostl et al., 2007b). An adaptive management strategy, however, must be embedded in and supported by the existing water governance regime.

So far, studies exploring water governance issues in the VMD are limited. Existing research has shed light on the legal framework for water management (Nguyen, 2012), institutional structures and prominent actors (Evers and Benedikter, 2015; Sajor and Thu, 2009), irrigation policy development (Hoanh et al., 2014), and river basin management (Molle and Hoanh, 2009). None of these studies has comprehensively investigated the prospects for adaptive water management in this region. Our study, therefore, addresses this knowledge gap by identifying the extent to which the freshwater governance regime in the VMD exhibits conditions that are likely to promote adaptive management for coping with growing future uncertainties. By doing this, our study also provides a comprehensive overview of this region's water governance regime that can guide more in-depth future research.

## 2. Promoting adaptive management, an assessment framework

Adaptive management, which originated in Holling's resilience theory (as mentioned by Folke et al., 2005) can be defined as "a systematic process for continually improving management policies and practices by learning from the outcomes of implemented management strategies" (Pahl-Wostl, 2007). Adaptive management explicitly acknowledges the inherently complex, non-linear, and unpredictable nature of ecosystems (Folke et al., 2004; Folke, 2006), and emphasizes learning, experimentation, and flexibility as means of developing the capacity for managing uncertainties and changes (Folke et al., 2005; Huitema et al., 2009). Central to adaptive management is the concept of social learning, a multi-scale process in which diverse stakeholder groups are involved to generate and communicate knowledge and to share values and perspectives in order to collectively improve their situations (Bouwen and Taillieu, 2004; Pahl-Wostl et al., 2007a).

An adaptive governance regime refers to the broader social and institutional contexts that enable adaptive management of ecosystems (Dietz et al., 2003), specifically to the structures and processes by which actors in societies share power, deliberate,

coordinate, and make decisions (Lebel et al., 2006). In order to support successful adaptive management a governance regime must: (i) promote multi-party interaction to enable collaboration and social learning (Bouwen and Taillieu, 2004; Folke et al., 2005; Pahl-Wostl et al., 2007a); (ii) facilitate the involvement of various actors in knowledge production to improve the diversity of knowledge and perspectives (Folke et al., 2005; Lebel et al., 2006); (iii) allow for the integration of learning and knowledge into policy and management processes to continually improve them (Folke et al., 2005); and, (iv) support measures to spread risks to tackle uncertainties (Folke et al., 2005; Huntjens et al., 2010). Based on the works of Pahl-Wostl (2008) and Huntjens et al. (2010), we have developed an assessment framework (Table 1) that consists of conditions that are grouped under five dimensions: (i) governance and structure; (ii) leadership; (iii) knowledge and information management; (iv) policy development and implementation; and, (v) financial management.

According to Pahl-Wostl (2008), the *governance structure* of an adaptive water governance regime must be polycentric and horizontal with broad stakeholder participation. Polycentric governance arrangements are best understood as structures consisting of many (nested or sometimes partly overlapping) semi-autonomous decision-making centres (Ostrom, 1996; McGinnis, 1999). They are assumed to have a high adaptive capacity due to their potential to self-organize and to change like complex adaptive systems (i.e., organisms or nervous and immune systems) (Pahl-Wostl, 2009). Furthermore, the multiple relatively independent decision-making centres within a polycentric structure allow the development of context-appropriate institutions that may enable the implementation of adaptive measures at suitable levels (Lebel et al., 2006). However, coordination and collaboration can be challenging in polycentric systems (Huitema et al., 2009); thus the multiple decision-making centres in these systems must be well integrated (both vertically and horizontally) to ensure a good flow of information and good social collaboration (Ostrom, 2005; Pahl-Wostl, 2008, 2009). Public participation and informal networks also contribute to building social capital for social learning and collaboration (Folke et al., 2005; Olsson et al., 2006; Pahl-Wostl, 2008).

*Vertical integration* refers to the interplay and cooperation between different hierarchical levels of administration involved in water management (i.e., local, regional, national, and international levels), and the distribution of authorities among these hierarchies (Pahl-Wostl, 2009). A lack of vertical integration tends to result in policy failures. If different management levels are disconnected, gaps between policy development and implementation are most likely to arise (Ostrom, 2005; Pahl-Wostl, 2009). Examples of failures resulting from a lack of vertical integration include the failed attempts to reform water institutions in South Africa (Varady et al., 2013) and the ineffectiveness of many Groundwater User Associations in Spain (Lopez-Gunn, 2003; Lopez-Gunn and Cortina, 2006).

*Horizontal integration* refers to the integration between water-related sectors like agriculture, transportation, and environmental management (Knüppe and Pahl-Wostl, 2011, 2013). Adaptive water management requires a high level of sectoral integration to identify inconsistencies and emerging issues and to ensure unified adaptive responses to changes (Pahl-Wostl, 2008; Pahl-Wostl et al., 2010). Horizontal integration can be achieved through processes of network governance, rather than through bureaucratic hierarchies and centralized policy development and implementation (Pahl-Wostl et al., 2007a). Horizontal integration was found to be crucial in resolving land subsidence problems in Taiwan (Tang and Tang, 2006) and in reducing groundwater extraction in Gujarat, India (Shah et al., 2008).

**Table 1**

Assessment framework for adaptive management.

Dimension	Variable	Condition	Reference
Governance Structure	Vertical integration	Well-balanced distribution of responsibilities and authorities between levels of administration Involvement of actors at lower levels in decision-making at higher levels Frequent interaction and collaboration among actors from different levels	Ostrom (1996), Pahl-Wostl (2009), Huntjens et al. (2010), Knüppe and Pahl-Wostl (2011, 2013), Pahl-Wostl et al. (2012)
	Horizontal integration	Full integration of freshwater issues into water-related planning Frequent interaction and collaboration among sectoral actors on water-related issues Consensus resolution to cross-sectoral conflicts	Pahl-Wostl et al. (2007b), Huitema et al. (2009), Huntjens et al. (2010), Knüppe and Pahl-Wostl (2011, 2013), Pahl-Wostl et al. (2012)
	Public participation	Legal provisions supporting public participation in rule-formulation Involvement of non-state actors in formulation of rules that directly affect them Initiatives by non-state actors for solving freshwater problems	Stringer et al. (2006), Pahl-Wostl et al. (2007b), Huntjens et al. (2010), Pahl-Wostl et al. (2010); van Rijswick et al. (2014)
	Informal policy network	Formation of a policy network beyond the formal bureaucratic structure	Folke et al. (2005), Olsson et al. (2006), Rijke et al. (2012)
Leadership	Visionary leadership	Presence of leadership that sets long-term goals and visions	Olsson and Folke (2004), Folke et al. (2005), Gupta et al. (2010)
	Entrepreneurial leadership	Presence of leadership that stimulates actions and undertakings	Gupta et al. (2010)
	Collaborative leadership	Presence of leadership that initiates collaboration between actors/actor groups	Olsson and Folke (2004), Folke et al. (2005), Gupta et al. (2010)
Knowledge & Information Management	Collaborative knowledge production	Involvement of diverse actors in defining and executing research	Pahl-Wostl et al. (2007b), Huntjens et al. (2010), Pahl-Wostl et al. (2010)
	Diversity of knowledge	Inclusion of both expert and local knowledge Implementation of research in multiple disciplines	Folke et al. (2005), Pahl-Wostl et al. (2012)
	Knowledge and information sharing	Public awareness programs that actively communicate water problems to state and non-state actors Information and knowledge are accessible and actively shared between state actors Information and knowledge are accessible to the public and actively disseminated to the public by the government	Pahl-Wostl et al. (2007b), Huntjens et al. (2010), Pahl-Wostl et al. (2010, 2012), Bettini et al. (2015)
	Knowledge and information utilization	Knowledge and information systematically influence decision-making and policy formulation or adjustment	Pahl-Wostl et al. (2007b), Huntjens et al. (2010), Pahl-Wostl et al. (2010)
Policy Development & Implementation	Tackling uncertainties	Systematic application of alternative scenarios in planning and policies Systematic integration of climate change issues into planning and policies Planning and implementation of diverse solutions to each specific problem Preference for flexible and reversible solutions that do not limit the range of possible measures in the future	Folke et al. (2005), Bohensky et al. (2006), Pahl-Wostl et al. (2007b), Huntjens et al. (2010), Pahl-Wostl et al. (2012)
	Experimentation	Systematic support for small-scale experiments	Folke et al. (2005), Huntjens et al. (2010)
	Policy implementation	Implementation and enforcement of existing policies and plans	Huntjens et al. (2010)
	Monitoring, evaluation, and feedback	Development and execution of policy evaluation programs that incorporate feedbacks and support policy improvements	Pahl-Wostl et al. (2007b), Huntjens et al. (2010)
Financial management	Cost recovery	Mechanisms exist and are enforced for recovering the costs of solving water-related problems	Huntjens et al. (2010)
	Diversified financing	Inclusion of diverse sources of funding to finance water infrastructures and solutions to water-related problems	Pahl-Wostl (2008), Pahl-Wostl et al. (2007b), Huntjens et al. (2010)
	Emergency funding mobilization	Easy mobilization of funds to deal with contingencies and emergency situations	

*Public participation* may contribute to a better use of available information and enhance the quality of decision-making (Huitema et al., 2009). By opening up access to different types of knowledge and perspectives, public participation facilitates information exchange (Lebel et al., 2006; Knüppe and Pahl-Wostl, 2013). Moreover, repeated interactions among stakeholders can

contribute to building trust, improving shared understanding of management issues at stake, and enabling social learning (Lebel et al., 2006; Huitema et al., 2009). Although in reality, public participation is not without drawbacks (i.e., stakeholders with more resources can exert more influence) (Huitema et al., 2009), its benefits, or the management failures due to the lack thereof, are well

documented in numerous case studies. These include the rezoning of marine conservation areas in the Great Barrier Reef (Australia) (Lédée et al., 2012), the Water Sharing Plan for the Namoi Basin (Australia) (Ross and Martinez-Santos, 2010), and the water reuse projects in California, Georgia, and Texas (USA) (Lebel et al., 2006).

*Informal or shadow policy networks* refer to “informal governance systems across organizational levels with an interest in influencing and implementing policies in a given resource area” (Folke et al., 2005, p. 450). Informal networks can help stimulate information exchange and collaboration, build trust and consensus and provide novelty and innovation to deal with changes. These networks operate within, rather than replace the formal bureaucratic structures (Folke et al., 2005). Whether informal networks contribute to adaptive management ultimately depends on the dominant interest they represent. Informal networks may also be counterproductive. However, in the case of noble crayfish conservation in Sweden, informal networks played a crucial role in the realization of successful outcomes (Olsson et al., 2006).

*Leadership* is another important dimension of an adaptive governance regime (Olsson and Folke, 2004; Folke et al., 2005). Leadership is key to establishing links within and between organizations, to facilitate information flows and help build social capital and social linkages that nurture collaboration and social learning (Folke et al., 2005). Leadership is also essential for interpreting and making sense of information and knowledge in order to act on it (Olsson and Folke, 2004; Folke et al., 2005). Gupta et al. (2010) make a distinction between: (i) visionary leadership to set long-term visions and objectives; (ii) entrepreneurial leadership to stimulate actions and undertaking; and, (iii) collaborative leadership to bring various stakeholders together. In the cases of the Coulburn-Broken catchment and the Kristianstad Water Realm, leadership appeared crucial for overcoming institutional, scale, and other barriers and establishing social links that enabled the formation of ideas, skills and other capitals for adaptive management (Lebel et al., 2006).

*Knowledge and information management* is critical to achieving adaptive management. Since social learning – knowledge exchange and value sharing – is at the heart of adaptive management, an adaptive water governance regime must actively support: (i) collaborative knowledge production; (ii) diversity in knowledge; (iii) knowledge and information sharing; and, (iv) knowledge and information utilization. The inclusion of diverse actor groups in knowledge generation and incorporation of different kinds of knowledge may aid in finding innovative solutions that are widely supported by the stakeholders (Berkes and Folke, 2002; Olsson and Folke, 2004). Similarly, active sharing of knowledge and information help empower different social groups (Pahl-Wostl et al., 2012). Furthermore, knowledge and information must be utilized to continually improve policies and management practices (Huntjens et al., 2010).

In adaptive management *policy development and implementation* is considered a process of on-going experimentation, reflection, and adjustment in which: (i) uncertainties are tackled to prepare for change (Folke et al., 2005); (ii) small-scale experiments are systematically supported to explore alternatives (Folke et al., 2005; Huntjens et al., 2010); (iii) existing policies and plans are fully implemented (Huntjens et al., 2010); and, (iv) policy evaluation programs and feedback mechanisms are executed to continually fine-tune and improve future policies (Pahl-Wostl et al., 2007b; Huntjens et al., 2010).

Finally, financial management is critical since the availability of *financial resources* is required for any management actions. An adaptive governance regime should, therefore: (i) contain mechanisms for recovering the costs of solving problems (i.e., users' taxes); (ii) diversify its financial resources using various private

and public financial instruments to lower risks should one or more instruments fail (Pahl-Wostl, 2008; Pahl-Wostl et al., 2007b; Huntjens et al., 2010); and, (iii) set up efficient protocols for mobilizing funding for emergency situations.

Drawing from water management and adaptive water governance literature, we have operationalized all variables into more specific conditions for adaptive management as shown in Table 1. In the next section, we clarify how we use this framework to assess the governance conditions for adaptive freshwater management in a coastal province of the Vietnamese Mekong Delta. However, the applicability of the assessment framework is not necessarily restricted to this area.

### 3. Research methods

#### 3.1. Case selection

To analyse the prospects for adaptive management in the VMD, we have conducted an in-depth study of the presence of the conditions discussed in Section 2 in Soc Trang province (Fig. 1), where we can find typical natural and socio-economic characteristics of the VMD's Southeastern coastal region. Of the five provinces in this region, Soc Trang has a medium landmass (331,165 ha) and population density (395 persons/km<sup>2</sup>). Agricultural and aquaculture production remain the primary economic activities that demand most land (83%) and freshwater use (Soc Trang Statistics Office, 2014). Due to its relatively low land surface elevation, its extensive coastlines and expansive networks of rivers and canals, surface water resources in Soc Trang are vulnerable to saltwater intrusion (Cosslett and Cosslett, 2014). Surface water sources also suffer from domestic and industrial waste discharges and the run-off of chemical residues from agricultural and aquaculture activities (Soc Trang DONRE, 2010). Groundwater is currently the primary source for drinking water and other domestic consumptions in the province, but groundwater tables have been detected to steadily decrease at average rates of 10–50 cm/y since the 1990s (An et al., 2014).

#### 3.2. Data collection

We utilized a combination of primary and secondary data from different sources, including document analysis, in-depth interviews, and surveys. We first studied over 100 legal and policy documents (including laws, decrees, circulars, resolutions, decisions, plans, and reports) pertaining to salinity intrusion, surface water pollution, groundwater and environmental protection, and climate change issued by Vietnamese state agencies at the national, provincial and district levels. In the Vietnamese – top-down hierarchical system – legal documents issued at lower levels cannot deviate from those issued at higher levels. Thus, we selected a combination of nationally and locally issued documents based on their relevancy and applicability to the area under study with regards to each specific condition outlined in the assessment framework. We also analysed reports, brochures, policy briefs, and websites on water-related projects implemented in Soc Trang, as well as publications of research conducted in the province to evaluate the conditions relating to informal networks, knowledge and information management, and finance management. In addition to the document analysis, in April 2016, the first author of this paper conducted 18 in-depth face-to-face and 3 email and telephone interviews, which were semi-structured according to the conditions mentioned in Table 1. Interviewees were asked questions on topics that are relevant to the functions and authorities of their agencies. Each interview took about 45 min. Interviewees included representatives from government agencies, education



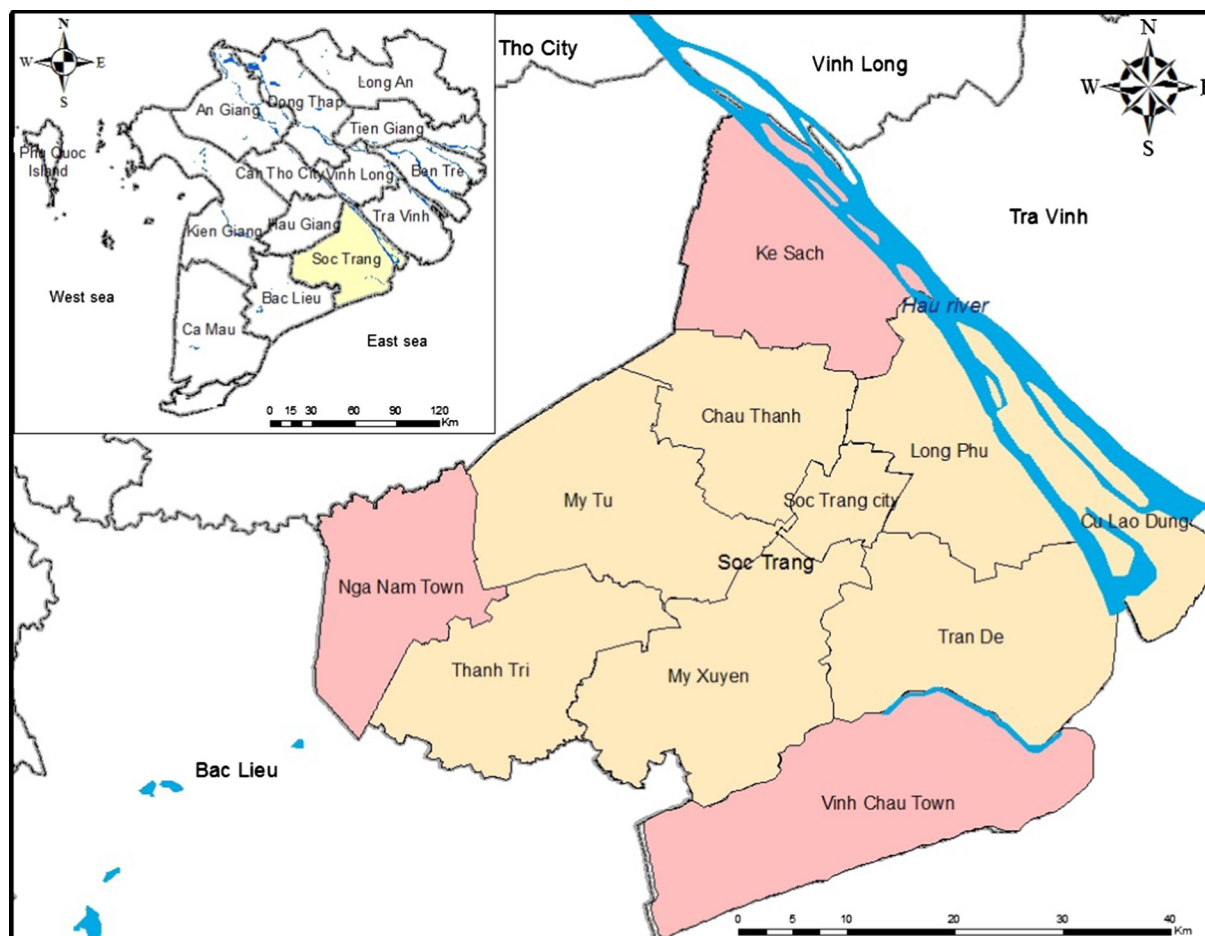


Fig. 1. Soc Trang Province and the locations of study.

and research institutes, and a state-owned water supply company (Table 2) that were pre-selected by their superiors. Summaries of the interviews were sent to the interviewees for validation.

For the assessment of the conditions relating to public participation, knowledge and information sharing between state and non-state actors, policy implementation, and cost recovery, we used a survey involving sixty local resource users (paddy rice, aquaculture, vegetable and fruit farmers). The users were members of households<sup>1</sup> that were randomly selected from different communes in Ke Sach, Nga Nam, and Vinh Chau Districts (Fig. 1) with the help of local guides. These districts represent different levels of susceptibility to salinity intrusion in Soc Trang. Ke Sach, located in the Northern-most part of the province, next to the Bassac River, has abundant freshwater availability and three seasons of rice crops per year. Nga Nam is a part of the central depression where rice crop is only cultivated in two seasons due to seasonal salinity intrusion from the neighbouring Bac Lieu Province. Vinh Chau directly faces the East Sea and suffers from saline water intrusion almost year-round. Due to a limited access to freshwater, the main economic activity in this area is saline-based aquaculture, complemented by one rain-fed paddy rice crop in the wet season and vegetable farming utilizing groundwater during the dry season.

To the extent possible, data on most of the conditions were triangulated using multiple sources of information (i.e., different interviewees or combination of interviews and document analy-

Table 2  
Overview of interviewees.

Actor Group	Number of Interviews
State-owned water companies	1
Public universities	2
Government research institutes	2
People's Committee of provincial government	1
Department of Natural Resources & Environment of provincial government	1
Department of Agriculture & Rural Development of provincial government	1
Department of Planning & Investment of provincial government	1
Department of Finance of provincial government	1
People's Committee of district government	1
Office of Natural Resources & Environment of district government	3
Office of Agriculture & Rural Development of district government	3
People's Committee of commune government	4

sis). Discrepancies among different sources of data are explicitly mentioned under the result section.

### 3.3. Data analysis

Data from the reviewed documents and in-depth interviews are coded into categories corresponding to the conditions specified in

<sup>1</sup> The people that participated in the survey were either the heads of, or the persons available in the households that the first author randomly entered.

**Table 3**

Presence of the conditions related to the governance structure.

Variable	Condition	Assessment Result
Vertical integration	Well-balanced distribution of responsibilities and authorities between levels of administration	(–)
	Involvement of actors at lower levels in decision-making at higher levels	(0)
	Frequent interaction and collaboration among actors from different levels	(0)
Horizontal integration	Full integration of freshwater issues into water-related planning	(–)
	Frequent interaction and collaboration among sectoral actors on water-related issues	(0)
	Consensus resolution to cross-sectoral conflicts	(?)
Public participation	Legal provisions supporting public participation in rule-formulation	(0)
	Involvement of non-state actors in formulation of rules that directly affect them	(–)
	Initiatives by non-state actors for solving freshwater problems	(–)
Informal policy network	Formation of a policy network beyond the formal bureaucratic structure	(?)

Table 1 and analysed using the Nvivo v.10 software. The Microsoft Excel program is used to analyse the data from the survey with local resource users. For each condition, the analysis results are compared to the prescribed conditions in the assessment framework to determine whether a condition is: (i) absent (–); (ii) partially or moderately present (0); or, (iii) fully present (+).

## 4. Results

### 4.1. Governance structure

Overall, Soc Trang Province has a top-down governance structure with limited vertical and horizontal integration and little public participation (Table 3).

Regarding vertical integration, analysis of relevant policy documents<sup>2</sup> shows that most responsibilities and authorities concerning freshwater management, including policy formulation, planning, research and international cooperation, are concentrated at the national and provincial levels; few are transferred to the district and commune levels. District and commune governments are mainly responsible for specific implementation tasks such as observing groundwater licensing and pollution prevention regulations, sealing idle groundwater wells and managing small water infrastructures (i.e., tertiary canals, sluices and pumping stations). While all government representatives (at the provincial, district and commune levels) confirmed in the interviews that they had access to decision-making processes at higher levels, they could provide little evidence supporting their contributions to those processes. Most respondents also stated that actors from different administrative levels often met and interacted to work on specific projects or issues such as land use planning or agricultural restructuring.

Concerning horizontal integration, freshwater issues were not integrated into either Soc Trang's land use plans or economic development plans such as the Social and Economic Development Master Plan (Decision 423/2012/QĐ-TTg). In fact, per Decree 92/2006/ND-CP, social and economic development master plans and sectoral master plans form the foundation for developing land use plans. Considerations for water conservation were partly reflected in the Restructuring Plan on Rice Paddy Land program of the Ministry of Agriculture & Rural Development (MARD) (Decision 3367/2014/QĐ-BNN-TT) and the Agricultural Restructuring Scheme of Nga Nam District, which promoted the planting of more salt-tolerant and less water-intensive varieties. However, our respondents from DARD and OARDs commented that the funds

for these programs were too limited to incentivize large-scale implementation. All respondents from the environmental and agricultural agencies also acknowledged that actors from these sectors did not meet regularly, but only interacted and collaborated for specific tasks such as land use planning or environmental audits.

The People's Committees are in charge of solving potential cross-sectoral conflicts at the provincial, district and local levels. In some cases, they can keep the balance between the water needs for both freshwater-based agriculture and saline water based aquaculture (Cosslett and Cosslett, 2014), but in other cases, water conflicts between different sectors still exist (Eucker, 2011). We, however, lack the data for a more elaborate assessment of the presence of this condition.

The Laws on the issuance of legal documents (Law 17/2008/QH12 and Law 80/2015/QH13) contain several provisions supporting public participation in policy-making. However, neither these laws nor other associated legal documents include any mechanisms or guidelines for enforcing these provisions. Indeed, all local water users participating in our study confirmed that they were never asked by the local governments to provide inputs for any policies or regulations that apply to their localities. While 85 per cent of the participants were aware of the freshwater problems in their neighbourhoods, few were proactive in planning adaptive measures or long-term solutions. As confirmed both by local resource users and representatives from different government agencies, the Agricultural Cooperatives, the only form of civic organizations in Soc Trang, are mainly platforms for joint investments for reducing irrigation costs; they do not promote innovative solutions to freshwater problems.

It is difficult to identify the presence of an informal policy network from the available data. Some freshwater and climate change partnerships are present in Soc Trang. Key actors in these partnerships include Can Tho University (CTU), the Southern Institute of Water Resources Research (SIWRR), the Division for Water Resources Planning and Investigation for the South of Vietnam (DWRPI), Soc Trang People's Committee (Soc Trang PC), Soc Trang Department of Agriculture and Rural Development (DARD), Soc Trang Department of Natural Resources and Environment (DONRE) and the World Bank. A few other international organizations such as Gesellschaft für Internationale Zusammenarbeit (GIZ), German Federal Ministry for Economic Development and Cooperation (BGR) and Japan International Cooperation Agency (JICA), are also active on the periphery. It is however not clear whether those entities form a stable network and if so, which role this network plays, especially in improving water management locally.

### 4.2. Leadership

Table 4 shows the assessment results of the conditions related to leadership. Water management in Vietnam involves various ministries and agencies, but the Ministries of Natural Resources

<sup>2</sup> Decree 36/2012/ND-CP, Decree 21/2013/ND-CP, Decree 199/2013/ND-CP, Circular 27/2014/TT-BTNMT, Circular 50/2014/TTLT-BTNMT-BNV, Circular 14/2015/TTLT-BNNPTNT-BNV, Decision 11/2008/QĐ-UBND, Decision 06/2014/QĐ-UBND, Decision 20/2014/QĐ-UBND, Decision 22/2014/QĐ-UBND, Decision 30/2015/QĐ-UBND, Decision 37/2015/QĐ-UBND, Decision 41/2015/QĐ-UBND, Decision 412/2015/QĐ-UBND, Decision 03/2016/QĐ-UBND.

and Environment (MONRE) and Agriculture and Rural Development (MARD) are the most dominant players (Fig. 2). Both Ministries play leadership roles in water resources management. While MONRE is responsible for the overall planning and management of water resources and is solely in charge of managing groundwater resources, MARD is responsible for the overall planning, implementation, and management of hydraulic structures for irrigation, flood control, and salinity intrusion prevention. Both MONRE and MARD have subsidiary agencies (resp. DONRE and DARD) at the provincial and district levels.

The Government of Vietnam has instituted a planning system that starts with the elaboration of visions into the future. Based on a vision for 2030, an Integrated Socio-Economic Development Plan for the Mekong Delta (2014–2020) was developed. Additionally, an informal Mekong Delta Plan (MDP) containing a long-

term vision and strategy for a safe, prosperous and sustainable delta has been elaborated in cooperation with the Dutch government. The time horizon of the MDP (until 2050) is longer than the average timespan of 20 years in the Vietnamese planning system. Most water-related plans (of the Vietnamese system) however contain only short-term visions (until 2020).

The positive score for entrepreneurial leadership is based on the observation that M(D)ONRE and M(D)ARD are formally in charge of taking the lead to stimulate actions related water issues (i.e., Decree 36/2017/ND-CP and Decree 15/2017/ND-CP). Moreover, the presence of entrepreneurial leadership can also be motivated by observations regarding the economic domain in which the Vietnamese government has realized high growth rates by raising awareness, brokering specific conditions and engaging the market. Moreover, independent shrimp and rice farmer cooperatives have shown that they are able to take actions to bring different actors together to address problems (Tinmientay, 2016a,b).

Although governmental documents call for collaboration between relevant ministries and departments (i.e., Law on Water Resources 17/2012/QH13) our interview results reveal that actual collaboration between water-related agencies seems to be limited.

#### 4.3. Knowledge and information management

The presence of the conditions related to knowledge and information management is assessed in Table 5.

**Table 4**  
Presence of the conditions related to leadership.

Variable	Condition	Assessment Result
Visionary leadership	Presence of leadership that sets long-term goals and visions	(0)
Entrepreneurial leadership	Presence of leadership that stimulates actions and undertakings	(+)/(0)
Collaborative leadership	Presence of leadership that initiates collaboration between actors/actor groups	(0)/(-)

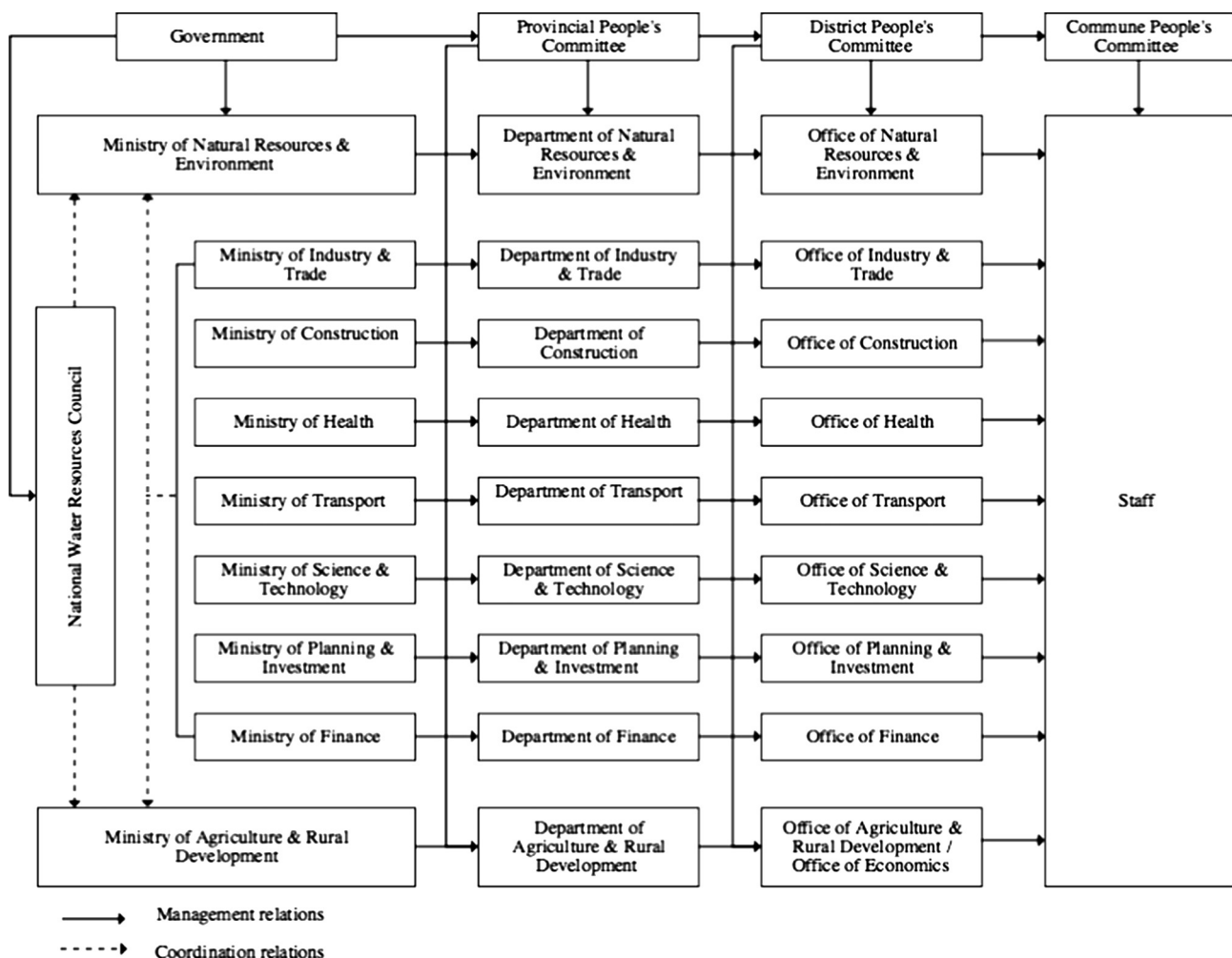


Fig. 2. The institutional structure for water management in Vietnam.

A total of thirty-seven studies concerning natural resources and environmental management conducted in Soc Trang were analysed. Sixteen of these studies deal with water; eight address agro systems; five concern soil; two examine natural ecosystems; and the remaining investigate resource ownership, climate change, livelihood, and adaptation. These studies are published in national journals and international peer-reviewed journals. Our review of these studies indicates that various actors including Vietnamese universities and state research institutes, government agencies, international research institutes and universities, and foreign private companies are involved in collaborative knowledge production. However, no local civic organizations are identified to produce or co-produce any of these studies. Local knowledge on ecosystem dynamics is hardly mentioned in these studies.

Knowledge and information sharing in Soc Trang appear to be limited. Although various respondents at different levels of administration confirmed that during the last five years public awareness programs on water resources and the environment had been implemented annually in Soc Trang, our survey results, however, indicate that only 13.3 per cent of the local users have heard of these programs on television and radio. Also, the outreach of project-specific public disclosures seems to be limited. Public consultation workshops are often organized in a later phase of a project, mainly for meeting donor's requirements. Interviews with government representatives at all levels showed that while new policy documents, data on salinity intrusion, and data serving aquaculture activities were proactively shared among state actors, data on water resources in particular, and the environment in general, was mainly accessible on request. Information concerning salinity intrusion was proactively and effectively shared with the public, but the dissemination of other information, including contents of water resource policies and data on water and environmental qualities, was rather poor. Only 5% of local users were aware of the requirement that they have to register the groundwater they extract for household consumption (as specified in Decision 11/2008/QĐ-UBND). None was knowledgeable about the requirements of Decision 33/2010/QĐ-UBND to pay surface water or groundwater taxes. On the contrary, our survey data showed that all aqua-farmers were aware of the regulations against dis-

**Table 6**

Presence of the conditions concerning policy development and implementation.

Variable	Condition	Assessment Result
Tackling uncertainties	Systematic application of alternative scenarios in planning and policies	(0)
	Systematic integration of climate change issues in planning and policies	(0)
	Planning and implementation of diverse solutions to each specific problem	(0)
	Preference for flexible and reversible solutions that do not limit the range of possible measures in the future	(0)
Experimentation	Systematic support for small-scale experiments	(-)/(0)
Policy implementation	Implementation and enforcement of existing policies and plans	(-)/(0)
Monitoring, evaluation, and feedback	Development and execution of policy evaluation programs that incorporate feedbacks and support policy improvements	(-)

charging sludge from shrimp ponds into water sources (Decision 09/2012/QĐ-UBND and Decision 46/2015/QĐ-UBND).

While evidence corroborating systematic utilization of new knowledge and information could not be detected, available data indicated that existing policies and plans have to some extent incorporated available knowledge. Specifically, climate change issues have been taken into consideration in several national programs and master plans (i.e., Decision 158/2008/QĐ-TTg, Decision 1824/2014/QĐ-TTg, and Decision 120/2015/QĐ-TTg). In Soc Trang, data from groundwater resource investigations conducted by the *Division of Water Resources Planning and Investment for the South of Viet Nam* has formed the basis for the provincial groundwater resource planning. Furthermore, the design of the seasonal planting calendars and the operations of water control structures depended entirely on salinity intrusion forecasts and daily salinity intrusion records (which were manually collected).

#### 4.4. Policy development and implementation

Uncertainties were somewhat tackled in the policy development process, but not in a systematic manner as shown in Table 6. Although alternative scenarios were outlined for climate change and rising sea level, they were not developed into specific pathways to systematically navigate an uncertain future. In particular, these scenarios only included preliminary assessments of impacts on different sectors and regions in Soc Trang. Long-term mitigation and adaptive measures were not consistently integrated into existing policies or spatial and economic development planning. Moreover, most projects and programs designed to address climate change issues have not been implemented during the period of our research.

Although several solutions to freshwater problems were executed and planned, structural solutions remain predominant. Dikes and sluice gates are primary solutions to address salinity intrusion (Soc Trang has a total of 93.8 km of sea dikes, 301.2 km of river dikes, and 136 sluice gates). To reduce pressures on groundwater resources, a surface water plant<sup>3</sup> was constructed in Soc Trang, and larger facilities for the entire VMD are currently being planned (Decision 2140/QĐ-TTg, issued in 2016). Non-structural measures such as early warning systems and seasonal planting calendars only complement the use of the structural solutions. On paper, two pro-

**Table 5**

Presence of the conditions related to knowledge and information management.

Variable	Condition	Assessment Result
Collaborative knowledge production	Involvement of diverse actors in defining and executing research	(0)/(+)
Diversity of knowledge	Inclusion of both expert and local knowledge	(0)
	Implementation of research in multiple disciplines	(0)
Knowledge and information sharing	Public awareness programs that actively communicate water problems to state and non-state actors	(0)
	Information and knowledge are accessible and actively shared between state actors	(0)
	Information and knowledge are accessible to the public and actively disseminated to the public by the government	(0)
Knowledge and information utilization	Knowledge and information systematically influence decision-making, and policy formulation or adjustment	(0)

<sup>3</sup> An Nghiep Water Plant in Chau Thanh District.



jects were planned for developing salt-tolerant and drought-resistant crop varieties, but respondents from DARD (at both provincial and district levels) confirmed that such adaptive varieties were not yet developed. A respondent from Can Tho University (CTU), however, shared that Bac Lieu, the neighbouring province of Soc Trang, has contracted the College of Agriculture and Applied Biology at CTU to carry out experiments with salt-tolerant rice varieties. Only a few integrated solutions combining small-scale infrastructure with adaptive measures were commissioned by international organizations and foreign government agencies; the mangrove reforestation project by GIZ<sup>4</sup> is a typical example. Analysis of future plans and interviews with government representatives indicated that irreversible solutions such as large-scale structural installations remained the dominant choice for preventing salinity intrusion and groundwater overexploitation. Some interviewees, including the representatives of environmental agencies at provincial and district levels, however, acknowledged that regulatory measures are also necessary.

Small-scale experiments were not systematically supported in Soc Trang. Various respondents reported that several small-scale experiments were carried out throughout the province, including the planting of salt-tolerant soursoy trees in Nga Nam and water-saving upland crops in Long Phu, Cu Lao Dung and My Xuyen (the others districts in Soc Trang) and installations of water-saving irrigation models in Vinh Chau, but the funds allocated to these experiments were highly limited.

Except for regulations against discharges of sludge directly from shrimp ponds into water sources, most policies were poorly enforced. Only 16.7 per cent of the local users confirmed that their domestic wells were registered. All respondents indicated that the local authorities did not inspect their groundwater extraction activities. They also reported that they did not pay any surface water or groundwater taxes. Similarly, all respondents, who were not connected to the municipal water networks, shared that they did not pay any wastewater discharge fee. The remaining respondents were not sure whether the fee was included in their monthly water bills. In contrast, all aqua-farmers reported compliance with the sludge discharge policy, as they had witnessed or heard of their neighbours being fined for violations of the regulation.

Most interviewees from environmental agencies claimed that many challenges stood in the way of implementing and enforcing groundwater policies. First, local users were accustomed to obtaining groundwater resources freely. Secondly, the district and commune governments did not have sufficient manpower to inspect all the drilling sites, and so they mostly relied on the leaders of hamlets to monitor and report instances of violations. However, information flow from the hamlets to commune and district governments was said to be poor. The new Law on water resources (Law 17/2012/QH13) came into force in 2012, but some current provincial policies have not been fully updated and were still based on the old Law (Law 08/1998/QH10). Two representatives also stated that implementation and enforcement of water policies were also challenging because many local households were too poor to pay water taxes.

Evidence of the presence of mechanisms for a systematic evaluation of the effectiveness of existing policies and plans could not be found.

#### 4.5. Financial management

The assessment of the conditions pertaining to financial management in the study area is presented in Table 7.

**Table 7**

Presence of the financial management conditions.

Variable	Condition	Assessment Result
Cost recovery	Mechanisms exist and are enforced for recovering the costs of solving water-related problems	(0)
Diversified financing	Inclusion of diverse sources of funding to finance water infrastructures and solutions to water-related problems	(0)
Emergency funding mobilization	Easy mobilization of funds to deal with contingencies and emergency situations	(0)

Several mechanisms are officially in place to recover costs of investing in water infrastructures and solutions, including irrigation and water fees (Decision 33/2007/QD-UBND and Decision 15/2015/QD-UBND), wastewater discharge fees (Decision 06/2014/QD-UBND), surface water and groundwater taxes (Decision 33/2010/QD-UBND), and administrative fees relating to water resources (Decision 20/2014/QD-UBND). However, both interviews and survey data showed that most of these fees and taxes were not collected.

Data obtained from the interviews with relevant agencies and reports, brochures, and websites pertaining to water and climate change-related projects<sup>5</sup> implemented in Soc Trang after 2008 showed that the primary sources of capital for freshwater management and climate change adaptation mainly came from the state budgets (approximately 20%) and World Bank loans (approximately 78%). Non-refundable international development aids only contributed a limited amount (2%).

Contingency funds were included in the annual budgets allocated to the provincial, district, and commune governments. They could be mobilized at the full disposal of the governments at these levels. According to the Law on state budgets (Law 01/2002/QH11 and Law 83/2015/QH13) and related regulations (Decree 60/2003/ND-CP and Circular 59/2003/TT-BTC), these funds were capped at small amounts (2–5% of the total annual budget). Procedures for mobilizing funds for emergencies beyond these capped amounts were not clearly instituted.

## 5. Discussion

Our study indicates that the freshwater governance regime in the VMD only partially exhibits the conditions that are likely to promote adaptive management. Especially, vertical and horizontal integration are limited while public participation is almost non-existent. Except for salinity intrusion data, most knowledge and information are not proactively shared among actors; and knowledge and information are not systematically fed into policy development. Moreover, the policy development and implementation process neither thoroughly tackle uncertainties nor contain mechanisms for evaluating policy effectiveness and incorporating feedbacks for future improvement. Most policies are also poorly implemented, financial resources are not strongly diversified, and cost recovery mechanisms are rarely implemented. We, therefore, argue that the prospects for adaptive water management in this

<sup>5</sup> Management of Natural Resources in the Coastal Zone of Soc Trang Province by GIZ; Building Resilience to Climate Change Impacts in Southeast Asia Project by European Union; Saline Intrusion Prevention for the Left Bank of the Saintard River Project by MARD; Scaling up Community-based Adaptation in Nga Nam District by Australian Aid; Coastal Ecosystem Research & Water Quality Integration & Analysis by Yeosun Foundation; Climate Change & Water Supply in the Mekong Delta Project by Vitis Evides International; and Mekong Delta Integrated Climate Change Resilience & Sustainable Livelihood Project by MARD.

<sup>4</sup> For details see <https://www.giz.de/en/worldwide/18,661.html>.

region are still limited. Several factors, however, might have biased above-mentioned results.

First, due to the highly compartmentalized nature of the administrative bureaucracy in Vietnam, the officials who took part in the interviews might not have been familiar with all the aspects of the organizations. Additionally, since most of the interviews took place in non-private settings, our respondents might have been deterred from discussing certain issues openly.

Second, since agriculture (including aquaculture) is the main economic activity in Soc Trang, we have not included perceptions of other non-state stakeholder groups such as commercial businesses or urban-dwellers. Our findings concerning the implementation of surface water and groundwater taxes might change if perceptions from commercial businesses were also included in the survey. Urban dwellers may have different perceptions on the collection of wastewater discharge fees.

Third, the low rate of exposure to public awareness programs may be explained by the fact that most respondents resided in rural areas, and are between 30 and 69 years of age, whereas the programs are only hosted in the centre of districts, and mostly targeted younger populations (i.e., high school and middle school students).

Fourth, our analysis involves interpretation that might result in biases since undisputable benchmarks for each of the conditions so far are not available in existing literature.

Notwithstanding these possible biases, some of our findings are supported by existing research. In particular, the lack of public participation we found is consistent with the conclusions by Biggs et al. (2009), Sajor and Thu (2009), and Hoanh et al. (2014). The lack of proactive resolution or adaptation effort among the local users is supported by Dang et al. (2014).

## 6. Conclusions

Based on our analysis we conclude that the prospects for adaptive management in the VMD so far are limited since its freshwater governance regime only partially exhibits the conditions that are likely to promote adaptive management. We have identified several challenges and accordingly, would like to make the following recommendations:

First, the national government should institute principles or mechanisms through regulations so that water issues steer economic and spatial development planning, rather than the other way around. The national government should also develop frameworks for systematically monitoring policy implementation and effectiveness.

Second, the provincial government should enhance the involvement of local actors, in particular, the officials of district and commune governments and local resource users, in the policy formulation and management processes. Delegating more responsibilities and authority to these actors can help instil a sense of resources ownership, encourage social learning and invoke incentives for actions. The provincial government should also allocate more funds for small-scale experiments to support the development of potential adaptive measures such as adaptive and water-saving crop varieties to diversify solutions and spread risks.

Third, both provincial, district and commune governments should invest more financial resources and institute mechanisms to enhance policy implementation. Specifically, they must strengthen information sharing across bureaucratic levels and sectors, as well as between the government and the public. Improvement of public awareness of freshwater issues and pertinent regulations can enhance resource stewardship, support public participation and bolster policy implementation.

Fourth, the science-policy interface can be improved by establishing communities of practice and research. National research institutes and universities like Can Tho University (CTU) are well connected to many international and domestic actors. These organizations can play a critical role in generating long-term visions, influencing values, producing knowledge, fostering collaboration and social learning among different actors, and brokering solutions to specific issues. They should continue to capitalize on their position as important players in the (fresh)water policy arena.

Fifth, to further understand the freshwater governance regime of the VMD, and facilitate the transition to adaptive management, we recommend to conduct additional in-depth and large n-studies to determine: (i) the factors preventing local actors from participating in decision-making at higher levels; (ii) the institutional barriers to integrated planning; (iii) the effectiveness of each type of communication channel (i.e. television, radio, and word of mouth); (iv) the existing mechanisms and processes of information exchange between scientists and policymakers; (vi) the elements enabling and impeding social learning; and, (v) the factors influencing innovation and the application of innovation.

Sixth, next research steps are needed to further elaborate on the assessment framework. Our assessment framework consists of conditions that do have impact on the adaptive water management as studies in Australia (Lebel et al., 2006), India, (Shah et al., 2008), South Africa (Varady et al. 2013), Sweden (Olsson et al. 2006), Spain (Lopez-Gunn, 2003; Lopez-Gunn and Cortina, 2006; Knüppe and Pahl-Wostl, 2011, 2013), Taiwan (Tang and Tang, 2006), Hungary, Netherlands, Portugal and Ukraine (see Huntjens et al., 2010) have shown. We, therefore, believe that our framework can be used to study a range of political systems and capture meaningful variations in governance conditions that are relevant to adaptive management. The framework has shown its usefulness in our case study but can still be improved by conducting more case studies. Vietnam's political system is characterized by a state-led market economy. It may be an option to further tailor our framework and define more specific benchmarks by incorporating features of the political system. Our general operationalization of the conditions may be refined by studying water governance regimes in other parts of the VMD or in countries like Cambodia, China, Laos, and Thailand that also have a state-led market economy. Moreover, the practicality of our approach can be further tested by applying it to cases with other political systems as well. In theory this would allow us to further discuss which of the conditions of our framework really matter in promoting adaptive management. We believe that our framework allows us to capture relevant variations in governance conditions, but further applications must clarify what the limitations of our approach are.

Since recent projections of groundwater use and related land subsidence indicate that further depletion of the groundwater resources will occur and that cities are also likely to experience more frequent and prolonged inundation periods (Minderhoud et al., 2017) we think that the political momentum for effectuating our suggestions has arrived. The changes we propose do match with the contents of the dominant strategic plans for the area, the Mekong Development Plan and the Master Plan on the Socio-Economic development of focal areas in the Mekong Delta (Decision 1005/QD-TTg and Decision 245/QD-TTg).

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## Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.jhydrol.2017.12.024>.

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