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Groundwater governance reforms to address land subsidence and saline intrusion in the Vietnamese Mekong Delta

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Abstract

Groundwater governance in the Vietnamese Mekong Delta (VMD) faces multiple challenges, ranging from technical constraints to organizational inefficiencies and behavioral impediments, that contribute to resource degradation. Improved groundwater governance is urgently needed, particularly amidst climate change and escalating impacts such as land subsidence and saltwater intrusion. This study analyses groundwater governance at the regional scale and examines how different stakeholders shape policy implementation regarding groundwater governance in the VMD, with a specific focus on Decree 167/2018, a key regulatory



milestone. A qualitative case study approach was employed, combining in-depth interviews, focus group discussions, and provincial and regional workshops. Using the OECD Water Governance Principles as an analytical framework, regional governance gaps and enabling factors were identified, followed by an in-depth analysis of Decree 167 implementation across four VMD provinces. The findings reveal that fragmented institutional mandates, uneven stakeholder engagement, limited monitoring and data systems, and divergent interests of influential actors jointly constrain effective groundwater governance and exacerbate land subsidence risks. These results highlight how governance challenges evolve across administrative boundaries and hydrological scales, underscoring the need for regionally coordinated and adaptive governance arrangements. By linking empirical evidence from the VMD to broader groundwater governance debates, the study provides insights into the importance of policy coherence, multi-level coordination, and actor alignment in managing common-pool groundwater resources. Policy implications include strengthening monitoring and evaluation systems, enhancing vertical and horizontal coordination, building institutional capacity, exploring alternative water sources, and promoting stakeholder awareness and participation to support effective groundwater governance in delta regions.

Keywords: Groundwater Governance, Vietnamese Mekong Delta (VMD), Land Subsidence, Decree 167/2018, Climate Change

1. Introduction

The Vietnamese Mekong Delta (VMD) is home to 18 million residents and a key region for agriculture and aquaculture production (GSO, 2023). However, the area faces multiple ecological challenges, including floods, droughts, saltwater intrusion, and land subsidence. These challenges are further exacerbated by climate change (Luu et al. 2022; Triet et al. 2020). Especially in this context, groundwater serves as a crucial source of water supply, accounting for about 60% of domestic water consumption and supporting socio-economic activities in the coastal areas. The estimated volume of fresh groundwater reserves in the VMD ranges from 830 to 900 billion cubic meters (Gunnink et al., 2021).

The relationship between groundwater overexploitation and declining water levels is globally well recognized (Galloway & Burbey, 2011; Gambolati & Teatini, 2015) and has been extensively documented in the relation to the VMD (Erban et al., 2014; Karlsrud et al., 2017; Minderhoud et al., 2017, 2020a). Groundwater depletion in the region results from multiple factors including climate change, sea level rise, and human activities (Ha et al., 2019). Additionally, reduced streamflow from the upstream Mekong River and increased salinization have heightened the demand for groundwater extraction (Bui et al., 2015; Ha et al., 2024). Modeling results suggest that the groundwater withdrawal rates are nearly double the natural recharge rates, and that reducing extraction by 75% could restore groundwater levels by half of the depleted amount (Minderhoud et al., 2020a). Furthermore, excessive groundwater pumping facilitates the infiltration and mixing of existing saline (paleo)groundwater, contributing to the salinization of the remaining freshwater reserves (van Pham et al., 2019).

Another issue associated with groundwater overexploitation in the VMD is extraction-induced, accelerated land subsidence (Minderhoud et al., 2017; Karlsrud et al., 2017; Nguyen et al., 2023; Erban et al., 2014; Minderhoud et al., 2020b; Dörr et al., 2024). Although the relative contribution of groundwater extraction compared with natural compaction (Zoccarato et al., 2018), land-use change (Minderhoud et al., 2018) or infrastructure loading (de Wit et al., 2021) remains debated (Dörr et al., 2024), pumping may account for more than two-thirds of observed subsidence (Neussner, 2019). These dynamics pose an existential threat to the long-term stability and habitability of the delta, reinforcing calls for urgent mitigation of human-induced subsidence (Kondolf et al., 2022).

Despite the extensive hydrogeological understanding of groundwater depletion, salinity intrusion, and subsidence, governance responses in the VMD remain fragmented and inadequate. Weak vertical and horizontal integration among institutions, overlapping mandates, and limited stakeholder participation constrain effective groundwater governance (Ha et al., 2018; Powlen et al, 2023). Technical and regulatory interventions have been introduced to curb groundwater extraction, yet multiple barriers persist (Hamer et

al, 2020; Phan et al., 2016; Preeyaporn & Nguyen, 2022; Phan et al., 2023), including inadequate policy guidance for local implementation, unclear institutional responsibilities, restricted access to information, and limited public awareness of groundwater risks. Addressing these intertwined socio-environmental challenges, therefore, requires governance systems capable of adaptive management, cross-sectoral coordination and social learning rather than purely technical control (Ha et al, 2018).

In response to these governance lacunae, the Vietnamese government enacted Decree 167/2018/ND-CP (hereafter Decree 167), a regulatory milestone designed to strengthen groundwater governance through licensing, monitoring, and enforcement mechanisms. This policy marks a shift from predominantly technical groundwater management toward greater attention to institutional and behavioral dimensions of the resource use. Evaluating the emergence and implementation of Decree 167 provides an opportunity to assess whether groundwater governance in the VMD is evolving toward more integrated and adaptive forms.

Groundwater governance in this study refers to the administrative and institutional systems, both formal and informal, through which authority over groundwater allocation, use, and protection is exercised, as well as the processes shaping collective decision-making (Stoker, 1998; OECD, 2011). This concept is distinct from groundwater management, which concerns operational and technical practices. Although governance challenges in the VMD have been explored in previous research, most studies focus on individual provinces or specific sectors, limiting insight into regional-scale, multi-level governance dynamics and their broader theoretical implications (Phan et al., 2016; Nguyen et al., 2024; van Pham et al., 2019). Consequently, it remains unclear how recent institutional reforms, such as the Decree 167, reshape governance interactions across administrative boundaries or contribute to a generalizable understanding of groundwater governance transformation in deltaic regions.

To address this gap, the present study examines groundwater governance in the VMD through the analytical lens of the OECD Water Governance Principles, drawing on in-depth interviews and regional stakeholder workshops. Focusing on the implementation of Decree 167 across four provinces, we investigate: (1) the evolution of groundwater policy and stakeholder involvement in the VMD; (2) key enablers and barriers to effective groundwater governance; and (3) governance dynamics shaping the implementation of Decree 167.

By linking regional empirical evidence to international groundwater governance scholarship and operationalizing the OECD framework to diagnose institutional performance, this study moves beyond a purely descriptive case analysis. It provides new insights into how governance systems respond to groundwater depletion, land subsidence, and salinity intrusion under conditions of environmental stress, thereby contributing to cumulative scientific understanding of groundwater governance transformation in vulnerable delta regions.

2. Analytical Framework for Groundwater Governance

Groundwater governance has increasingly emerged as a critical dimension of water security, particularly in regions experiencing rapid abstraction, subsidence, and salinization. A growing body of international scholarship highlights that groundwater crises are rarely caused solely by hydrogeological scarcity, but more commonly by institutional fragmentation, weak regulatory enforcement, limited stakeholder participation, insufficient monitoring systems, weak or unclear property rights and misaligned policy incentives (Villholth et al., 2017; Narain, 1998). Comparative analyses further emphasize opportunities for improving governance through clearer allocation of roles and responsibilities, stronger multi-level coordination, transparent information and data-sharing mechanisms, adaptive regulatory frameworks, and inclusive stakeholder engagement (Villholth et al., 2017; OECD, 2015).

Building on this body of knowledge, recent groundwater governance research has operationalized governance performance using structured analytical frameworks. Among these, the OECD Water Governance Principles constitute one of the most widely applied diagnostic approaches, having been used across dozens of international case studies, including applications in Southeast Asia (Akhmouch et al., 2018; OECD, 2015; Phan et al., 2016; Nguyen et al., 2024). The OECD framework conceptualizes governance quality across three

interrelated dimensions: (1) Effectiveness, referring to the capacity of institutions at multiple levels to define and implement coherent and sustainable water policies; (2) Efficiency, referring to the ability to maximize social and environmental benefits of water management relative to costs, supported by sound regulation, financing, and data systems; and (3) Trust and engagement, referring to the extent to which governance arrangements ensure transparency, accountability, and inclusive stakeholder participation (OECD, 2015; Akhmouch et al., 2018).

Previous groundwater-focused applications of this framework demonstrate its usefulness for identifying governance deficiencies and reform opportunities, while also enabling structured comparison across institutional contexts. In particular, prior studies have shown how OECD indicators can be adapted to groundwater-specific challenges such as abstraction control, monitoring, compliance, and cross-sectoral coordination.

Guided by this scholarship, the present study applies the OECD principles as an analytical lens rather than as a data-collection template, enabling systematic interpretation of qualitative evidence on groundwater governance in the VMD. Selected principles most directly relevant to groundwater governance in the region include: regulatory frameworks, data and information, and financing (efficiency); roles and responsibilities, scales, policy coherence, and capacity (effectiveness); and stakeholder engagement, integrity & transparency, and monitoring & evaluation (trust & engagement). These principles structure both the analysis and presentation of findings, allowing the empirical case to be interpreted in relation to broader theoretical insights on groundwater governance and institutional coordination for common-pool resources (Villholth et al., 2017; OECD, 2015).

3. Methodology

3.1 Research Methods

This study employed multiple qualitative methods to examine groundwater governance in the VMD, including a document analysis, semi-structured interviews, focus group discussions (FGDs), and stakeholder workshops. First, a targeted document analysis was conducted to identify formal regulations, policy instruments, and reported governance challenges related to groundwater in the VMD. Policy documents, legal regulations (e.g., Decree 167), provincial reports, and relevant academic and grey literature were purposively selected based on their relevance to groundwater governance and land subsidence issues in the region. These materials were reviewed and coded thematically to identify key governance dimensions, which subsequently informed the design of interview protocols and the selection of case-study provinces.

Based on this document analysis, four provinces, namely Can Tho, Soc Trang, Ben Tre, and Kien Giang (Figure 1), were selected as illustrative cases experiencing significant challenges related to groundwater extraction, land subsidence, and salinity intrusion. Semi-structured interviews were then conducted with 37 officials from provincial and sectoral government agencies involved in water and land management from October to November 2020 (Appendix B).

The interviews explored stakeholder roles, existing policies, governance challenges, implementation progress, and potential solutions related to groundwater governance, with particular attention to the implementation of Decree 167 (see Appendix C for interview guidelines).

Subsequently, three provincial workshops were organized in Can Tho, Ben Tre, and Soc Trang in March 2021, within which FGDs were conducted to further explore emerging themes and validate preliminary findings. Kien Giang could not host an FGD due to COVID-19 restrictions. The FGDs and workshops enabled the identification of additional themes not fully captured in the interviews, particularly regarding inter-provincial coordination, data-sharing constraints, and stakeholder perceptions of policy trade-offs. Following the workshops, the interview data were revisited and iteratively re-analysed to incorporate these additional insights. An online regional workshop organised in October 2021, involving approximately 50 participants from ministries, provincial departments, academia, and media, further facilitated cross-provincial comparison and triangulation of findings. Notes from workshops and FGDs were systematically integrated

into the qualitative analysis.

To examine actor dynamics, stakeholder analysis was conducted after the initial round of interviews and refined following the workshops. A stakeholder analysis is a method to understand governance systems by identifying key actors and assessing their interests and influence (MacArthur, 1997). Using a scoring approach adapted from MacArthur (1997) and ODA (1995), stakeholders were assigned scores from 0 to 10 for both interest and influence. Highest-influence actors in each province were first identified based on interview evidence; other actors were then comparatively scored by the researchers using information provided by interviewees. The scores were not assigned directly by interviewees; instead, qualitative assessments provided during interviews were interpreted and translated into numerical scores (0–10) by the research team following the adapted framework. These preliminary scores were subsequently cross-checked and adjusted through evidence from workshops and FGDs to ensure consistency, reliability and triangulation. The resulting stakeholder maps informed the application of the OECD Water Governance Principles by clarifying actor roles, coordination patterns, and engagement dynamics across governance levels.

The interview dataset is dominated by government stakeholders, with limited representation from industrial zones and no direct interviews with Provincial People’s Committees (PPC) or civil society organizations due to pandemic/logistical limitations, thus access constraints. Nevertheless, triangulation with workshops involving academia, media, and cross-sectoral participants helped partially mitigate this limitation, although the findings should still be interpreted with caution. Overall, combining document analysis, interviews, FGDs, and workshops enabled an iterative and triangulated assessment of groundwater governance challenges and policy implementation processes across the selected provinces.

3.2 Research Areas

While this study adopts a regional governance perspective for the VMD, the analysis is operationalized through an embedded multiple-case study design focusing on four provinces (Can Tho, Soc Trang, Ben Tre, and Kien Giang). These provinces are not treated as isolated analytical units, but rather as representative governance arenas through which regional-scale dynamics of groundwater governance, policy implementation, and institutional interactions can be examined. This design allows the study to capture both cross-provincial variations and shared structural governance challenges that characterize the VMD as a whole (Appendix A).

While the study focuses on four provinces as analytical cases, these were selected using a “maximum variation” logic to capture the diversity of climate-related challenges, policy responses, and governance arrangements across the Mekong Delta. They therefore function as indicative rather than statistically representative cases of regional dynamics.

It should also be noted that recent administrative restructuring in Vietnam (effective July 2025) has altered provincial boundaries; for instance, Ben Tre Province has been administratively merged into Vinh Long Province. This study retains the pre-restructuring provincial delineations for analytical consistency with the study period (2020–2024).

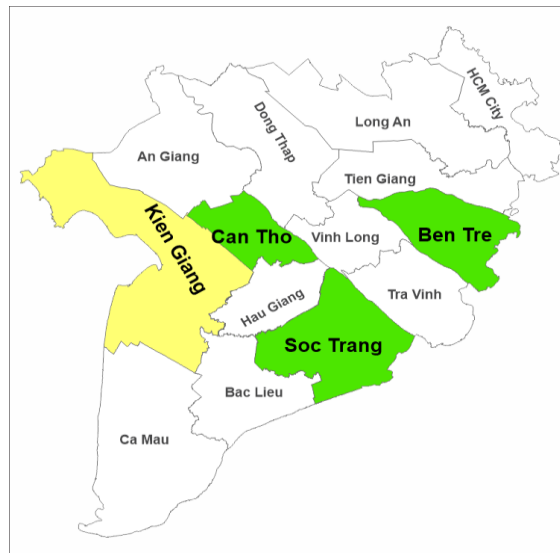


Figure 1. Four studied provinces. Provincial workshops were organized in three provinces (green color) and cancelled in one province (yellow) (Note: Vietnam has recently revised its provincial/cities boundaries, which differ from those shown in this figure)

Can Tho and Soc Trang are located on the southern bank of the Bassac River, one of the two biggest distributaries of the Mekong River in Vietnamese territory (Monglia et al, 2012). Ben Tre is situated at the mouth of the Mekong River whereas Kien Giang is partly situated in Ca Mau peninsula. While Can Tho is located in an inland area, the other three provinces are coastal provinces and are therefore especially vulnerable to salinization due to sea level rise and limited or decreased freshwater resources (RVO, 2021). A decrease of groundwater level has been observed in Can Tho and Soc Trang. Especially, land subsidence has caused flooding in urban areas in Can Tho (RVO, 2021).

4. Key findings

4.1 Multiple aspects of groundwater governance under the perspectives of OECD principles

4.1.1 Efficiency

Regulatory frameworks: the intertwining and development of groundwater and land subsidence policies

The overall institutional and governance framework for water resources including groundwater was first established in 1998 and then amended in 2012 in the Law on Water Resources (LWR) (No. 17/2012/QH13) (RVO, 2020). Groundwater exploitation is generally considered as one of the main causes of land subsidence in regulations. Land subsidence governance thus has been integrated into groundwater governance policies. A number of Decrees, Decisions, and Circulars further elaborate and instruct the management of groundwater and land subsidence (Figure 2).

During the period from 1998 to 2008, groundwater governance mostly involved taking permissions for the exploitation and the use of groundwater resources from the agencies responsible for this purpose, through groundwater use permits and licenses. Groundwater was first governed by the law on water resources in 1998. However, only a decade later the relation between groundwater abstraction and land subsidence was acknowledged in the Decision 15/2008/QĐ-BTNMT issued by MONRE (Neussner, 2019). Decision 15/2008/QĐ-BTNMT in 2008 is considered as a milestone marking the shift of the central government to protect the groundwater resources.

Since then, a change took place in the perceived relation between groundwater abstraction and land subsidence. It came to be recognized that reducing groundwater abstraction was required to avoid land subsidence and this thrust has been intensified over time in the central policies (Figure 2). For the first time, the policy on the prohibition of new groundwater abstractions in areas affected by land subsidence came to be regulated in Decision 15/2008/QĐ-BTNMT and the step-by-step reduction in groundwater use is governed by Decision 2065/2010/QĐ-TTg. A new groundwater abstraction is prohibited if it causes land subsidence, as regulated in the Law on Water Resources (17/2012/QH13) and Circular 40/2014/TT-BTNMT.

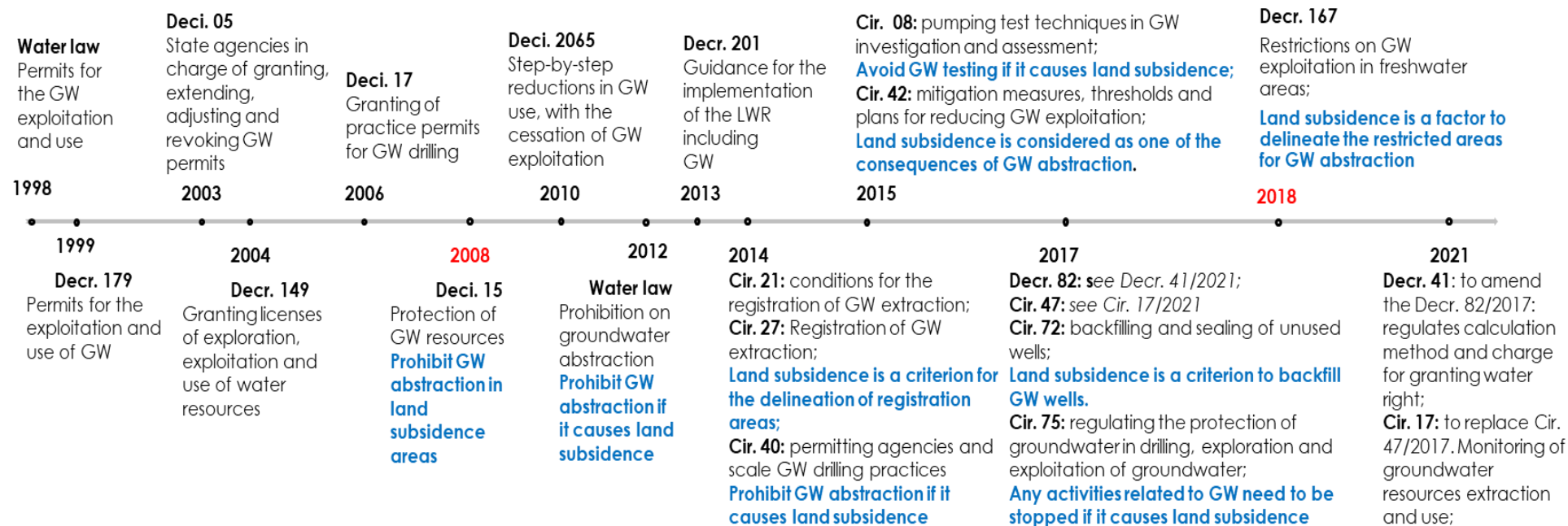


Figure 2. Policy evolution in groundwater management (Source: authors compile based on Neussner (2019) and RVO (2020)). Note: Deci.: Decision; Decr.: Decree; Cir.: Circular; Dark blue texts show that the governance of land subsidence is included in the regulations; Red texts show the milestones in groundwater governance.

It is recognized that land subsidence could be caused by groundwater abstraction (Circular 42/2015/TT-BTNMT). Since 2014, various circulars have been issued to regulate relevant aspects to support the abovementioned policies on the reduction of groundwater exploitation. These Circulars govern the conditions for groundwater registration and extraction (Cir.21, 27), permitting agencies, and scale drilling practices (Cir. 40), as well as mitigation measures, thresholds, and plans for groundwater use reduction (Cir. 42). Land subsidence is a criterion for the delineation of registration areas for groundwater abstraction (Circular 27/2014/TT-BTNMT) and all testing activities, e.g., pumping velocities/volumes, need to be avoided if they cause land subsidence (Circular 08/2015/TT-BTNMT).

A step further to reduce the groundwater abstraction is the regulation on the sealing of groundwater wells starting in 2017. Land subsidence came to be considered a criterion to backfill the abandoned or production wells (Circular 72/2017/TT-BTNMT). Any activities related to groundwater need to be suspended if they cause land subsidence (Circular 75/2017/TT-BTNMT). Most recently, the central government has issued a restriction on groundwater abstraction in freshwater areas. Land subsidence is a factor to delineate the restricted areas for groundwater abstraction (Decree 167/2018) (Neussner, 2019).

The intertwining and linkage of the issues on groundwater abstraction and land subsidence are observed in the policy dynamics (Figure 2). We, therefore, argue that the change in the policies and governance of the central government toward the use, protection, reduction, and prohibition of groundwater resources is partly accounted for by the increased attention and seriousness paid to land subsidence related issues, especially after a series of papers on land subsidence in the VMD were published (e.g. Minderhoud et al, 2017, 2018). More important perhaps, this is due to the greater dynamics falling upon the whole VMD in the new climate change context where improved groundwater governance is the easiest option for Vietnam to delay the submergence of the delta caused by both internal and external causes in which the central government has limited power over the latter (Kondolf et al., 2022). Another factor could be the increase of more reliant scientific evidence from recent studies on the relationship between land subsidence and groundwater abstraction (Ha et al, 2024).

Regulatory frameworks: inappropriate groundwater pricing regulations

Imposing a groundwater tariff or taxation is proven to be a highly effective tool to reduce groundwater use and stimulate the use of alternative water sources. For example, the land subsidence crisis caused by groundwater overexploitation in Bangkok was overcome by imposing a steadily increasing groundwater tariff per cubic metre (m³) volume unit (Lorphensri et al. 2011). Currently, the indirect negative environmental effects of groundwater extraction such as damages caused by land subsidence and salinization are not factored into the price of groundwater in the VMD. There is no groundwater tax or charge leading to underpriced groundwater. Many rivers and canals in the research areas are polluted leading to high wastewater treatment cost. Furthermore, access to fresh water in the coastal provinces is challenging due to saltwater intrusion, especially during the dry season. Meanwhile, groundwater is higher in quality, easier to access, and cheaper due to no tax. Users mostly only pay for the installation and the energy costs for pumping. There are approximately 500.000 private wells with a total extraction rate varying from 500.000 m³/day to the use of a million m³/day (Bui et al., 2015; Minderhoud et al, 2017; Tran et al, 2022). Replacing groundwater with surface water will increase the costs for households, which will be unaffordable for some domestic users and economically less attractive for investors who depend on water for production.

A lack of scientific data and information

To govern a natural resource effectively, it is foremost important to understand its status quo. Available data and scientific knowledge on land subsidence and groundwater extraction are, however, insufficient to support effective management strategies at both delta and provincial scales. Detailed information in terms of amount, direction, and how the aquifers are naturally recharged is limited (Regional workshop, 2021). This is mostly due to an inadequate and insufficient monitoring network, e.g., in relation to the number of wells, the volume of groundwater withdrawn, the groundwater levels in different aquifers, the rate of depletion or recharge, the land subsidence rate, and the extent of saltwater intrusion in surface watercourses and aquifer systems. The lack of monitoring data, in turn, is the main factor inducing uncertainty into modeling and

projections of land subsidence in the VMD.

At the FGDs, several concerns were raised about the monitoring data. The actors stated that a structural monitoring network for land subsidence did not exist in the delta, which is in line with the literature (Bui et al, 2015; Khai et al, 2022). In 2020, there were only about 58 stations, with 245 monitoring wells for the whole VMD covering an area of 40500 km² (0.006 well/km² on average) (Ha et al., 2022). Few wetland sites in the delta are equipped with relative Surface Elevation Tables measuring shallow subsidence in the top 20 meters managed by Ho Chi Minh University of Technology (Vietnam National University) and other universities (Lovelock et al., 2015), and two subsidence stations were installed in Ca Mau (the third station malfunctioned) by the Norwegian Geotechnical Institute in collaboration with the Vietnam Institute of Geosciences and Mineral Resources (VIGMR) under MONRE (Karlsrud et al., 2020).

At the national level, the benchmark surveys done by MONRE provide data measured within a 10-year time interval. They provide the movement of unprotected benchmarks with long-term trends characterized by high uncertainty. These point measurements are inadequate to be sufficiently accurately interpolated into a map. Similarly, benchmarks at the provincial level are insufficient and inaccurate. MONRE has a rather extensive monitoring network at the provincial level to monitor hydraulic head (i.e., water pressure) evolution in different aquifers, with measurement time series going back to 1991. This network has been updated and densified in recent years.

Insufficient financing resources

The governing system is considered to be insufficient in terms of financial resources. At the FGDs, local officials stated that the central government issued regulations on groundwater management but did not allocate a budget for implementation. The local governments have to mobilize the resources themselves. Since groundwater is not the most urgent issue, local governments prioritize the finance for other short-term issues such as irrigation infrastructure or transportation that are perceived to be more important (Interview Ben Tre actors in 2020) (RVO, 2021). This partly results in a lack of a monitoring system to collect groundwater-related data leading to an insufficient and fragmented database which in turn challenges appropriate groundwater management practices.

4.1.2 Effectiveness

Roles and responsibilities: institutional fragmentation and overlaps

In Vietnam, the water sector is governed by a hierarchical system where three national bodies including the Central Party, National Assembly, and Central Government, assert directions and supervisions by framing laws, resolutions, decisions, decree, and circulars to guide the implementation of the legislative regulations at the provincial level (Nguyen et al. 2020). The national bodies are supported by ministries of corresponding sectors (Nguyen et al. 2020).

The water sector in general and groundwater specifically have gone through a considerable shift in this new millennium in terms of responsible actors. Before 2002, the governance of water resources fell under the responsibilities of the Ministry of Agriculture and Rural Development (MARD). Since 2002, responsibility for groundwater, which is considered a natural resource, has rested primarily with the Ministry of Natural Resources and Environment (MONRE). MONRE is responsible for the overall management and coordination of the use of groundwater. However, MARD continues to be an influential actor since it is in charge of agriculture and rural water supply, to which extracted groundwater contributes considerably. Other ministries are responsible for specific water use in their sectors (Regional workshop, 2021).

It appears that both MONRE and MARD are responsible for managing land subsidence events related to groundwater. However, their responsibilities are unclear and do not cover all aspects of land subsidence (Neussner, 2019). Specifically, measuring and understanding the causes of land subsidence are not covered in any legally binding documents. Understanding the impacts of land subsidence related to water falls under the responsibility of MONRE, while mitigation of the impacts of subsidence is the responsibility of both MONRE and MARD (through Vietnam Disaster Management Authority) (Neussner, 2019; RVO, 2020).

Multiple scaling issues

Current groundwater policies, e.g., Decree 167/2018, focus on horizontal instead of vertical zoning. Below the delta surface a thick multi-aquifer system with up to seven main aquifers reaches depths of more than 500 m at some locations (Ha et al. 2019a). Extractions occur at different depths, with larger and industrial extractions reaching deeper aquifers through wells up to several hundred meters deep. Only focusing on horizontal zoning omits the complexity of the aquifer system and the various layers that users use to exploit groundwater. Additionally, it could negatively affect different groundwater layers regarding recharge and exploitation rates and inhibit effective groundwater resource management.

Even the horizontal zoning poses serious scaling problems. The physical borders of aquifer systems seldomly coincide with the provincial administrative boundaries. However, this scale level is insufficiently covered in the policies. The scale mismatch could lead to inequality and ineffectiveness in policy implementation. Currently, groundwater exploitation and land subsidence have occurred at the whole delta scale (Minderhoud et al., 2020b; Dörr et al., 2024), meaning that groundwater extraction must stop at the delta scale. However, article 6 of Decree 167 classifies only certain subsiding areas as 'Restricted Area 1' which are obligated to terminate all existing groundwater extraction. The implementation, unfortunately, differs across provinces, causing investors to move to areas where they are still allowed to withdraw groundwater. The abstraction in non-restricted areas may cause new land subsidence in these areas and adversely impact the groundwater resources in the nearby 'Restricted Area 1' zones, as extraction in one place can lead to a larger area of depletion (Regional workshop, 2021). Similarly, this is problematic as extraction-induced subsidence is a local process with a high dependency on regional and local settings and activities.

The scaling challenges are not only shown in the issued policies, but also on the collaboration at different levels of the governing system. An example raised by the regional actor concerns the licensing. Licensing of groundwater has internationally been proven to be effective in avoiding overexploitation and thereby mitigating extraction-induced subsidence (Elshall et al., 2020). However, implementation of effective licensing in the VMD is complicated. At the regional level, transboundary licensing and responsibilities are unclear. Collaboration between provincial and governmental levels to implement licensing regulations is limited. For example, MONRE is responsible for all licenses of wells above 3000 m³/day and provinces are responsible for licenses lesser than that. Some businesses take advantage of this regulation to ask for licenses with 3001 m³/day to receive a license issued by MONRE so that provinces cannot revoke the licenses, as reported in the case of Can Tho province. Within provinces, districts regulate groundwater extraction, for example, registration with a capacity beneath 10 m³/day. Small wells are, however, not registered nor considered in important policies such as Decree 167, while their influence in large abundance can be substantial.

Policy coherence: Lack of enforcement and overlapping of the policies

There is a lack of enforcement of groundwater regulations for checking land subsidence. Sanctions for misconducted activities in groundwater use are insufficient to ensure implementation. For example, no sanctions or restrictions are imposed when violating the rules of the Decree 167. The example is made for Can Tho city, after enforcing groundwater exploitation limits, it was difficult to control groundwater use for industrial activities (Le et al, 2017). The overlaps of the policies, roles, and responsibilities, coupled with the lack of enforcement, create room for free-riders and heterogeneous implementation. For example, Can Tho has not officially started the procedure because it wants to wait for a general strategic plan from MONRE before implementing Decree 167 (Interview Can Tho actors in 2020) (RVO, 2021).

A lack of capacity and human resources

Regarding human resources, all four provinces shared a common challenge that the number of specialists who are trained in water management in general and groundwater is insufficient. They thus have to concurrently be in charge of various responsibilities that sometimes do not align with their specialization. In addition, provinces are highly dependent on the technical capacity of consultancy agencies that differ per province, leading to inconsistencies in the quality of zoning plans. Finally, the awareness of policy makers and implementers regarding small wells is inadequate leading to the inability to manage the extraction from groundwater wells (Regional workshop, 2021).

4.1.3 Trust and Engagement

Stakeholder engagement

At the local scale, several provinces have initiated awareness-raising efforts on groundwater use. For example, Soc Trang has promoted measures to limit groundwater abstraction through increased use of surface water and rainwater, water-saving practices, improved efficiency, and water recycling in industry. Similarly, Kien Giang has strengthened communication campaigns on groundwater extraction and use. Nevertheless, available evidence suggests that many users remain insufficiently aware of the long-term importance of groundwater protection for the VMD (Regional workshop, 2021).

At the regional scale, governance practices remain largely top-down and non-participatory, with strong expectations of compliance with centrally defined mechanisms. Responsibilities are formally distributed across governmental levels, yet they are often not clearly operationalised, and lower-level authorities are frequently excluded from strategic decision-making (Tran & Rodela, 2019). Moreover, groundwater management is shaped by differing provincial interests and constrained administrative capacities, resulting in weak inter-provincial collaboration and fragmented implementation (Tran et al., 2019). Consequently, heterogeneous provincial strategies persist even though aquifers transcend administrative boundaries, creating collective-action challenges and potential free-riding in the shared use of groundwater resources.

Integrity & transparency and monitoring & evaluation

Beyond participation issues, document analysis and prior studies also point to structural factors affecting trust and engagement. Regarding transparency and integrity, regulatory frameworks for groundwater licensing and abstraction control are formally established, yet access to updated extraction data and enforcement outcomes is uneven across provinces, which may limit public oversight and stakeholder confidence in policy implementation (OECD, 2015; Tran et al., 2019). Concerning policy trade-offs, several regional and provincial strategies implicitly prioritise short-term agricultural production and urban water supply over long-term aquifer recovery, reflecting enduring tensions between economic development and groundwater sustainability objectives. In terms of monitoring and evaluation, technical monitoring networks and periodic reporting requirements are in place, but systematic evaluation of policy effectiveness, particularly with respect to subsidence mitigation and abstraction reduction, remains limited and fragmented across jurisdictions (OECD, 2015). These governance features suggest that challenges to trust and engagement are embedded not only in participatory processes but also in institutional transparency, unresolved policy trade-offs, and weak monitoring and evaluation arrangements.

Furthermore, Kien Giang, An Giang, Dong Thap, and Long An share transboundary aquifers with Cambodia. Apart from several ongoing initiatives, such as NexView Project (USA) and the FAO-supported “Enhancing Sustainability of the Transboundary Cambodia–Mekong River Delta Aquifer” project, there is currently no fully institutionalised cross-border coordination mechanism or joint monitoring network between these provinces and Cambodia (Regional workshop, 2021). Divergent understandings of transboundary aquifers' dynamics and differing management approaches between the two countries may therefore hinder the development of effective bilateral governance arrangements, further constraining trust-building and collaborative engagement at the regional scale.

4.2 A case study of the implementation of the Decree 167

The implementation of a specific regulation, Decree 167, is described in the four provinces to illustrate the complexity of groundwater governance in the VMD with a focus on stakeholder analysis.

4.2.1 The Decree 167 explanation

Decree 167/2018/ ND-CP requires provinces to develop zoning plans to regulate groundwater extraction. These zoning plans will guide policy implementation to control groundwater withdrawal and avoid aquifer over-extraction problems such as contamination, saltwater intrusion, and land subsidence. Multiple zones with corresponding restrictions should be identified for different groundwater-related issues. The delineation must be suitable to the scale and properties of the areas affected by land subsidence, pollution, salt-water intrusion and exhaustion of freshwater, and the characteristics of the aquifers. The Decree also encourages the use of surface water and available water supply for saving groundwater. For example, the

areas where land subsidence has been observed will be listed as restriction zone 1. In this zone, all existing groundwater extraction activities shall be terminated and the wells shall be filled in accordance with the regulations. Groundwater exploitation is restricted in wells that show a water level decline for more than three consecutive months. Groundwater exploitation in the VMD is also restricted for wells where the hydraulic head is 30m, 35m and 40m below the land surface in rural areas, big cities, and Can Tho, respectively. If the residential and concentrated industrial areas are connected with the concentrated water supply or adjacent connection points of the water supply system and the clean water is ready to supply, they shall be delineated as restricted areas. Detailed guidance with different steps to implement is regulated in the Decree 167 (Figure 3).

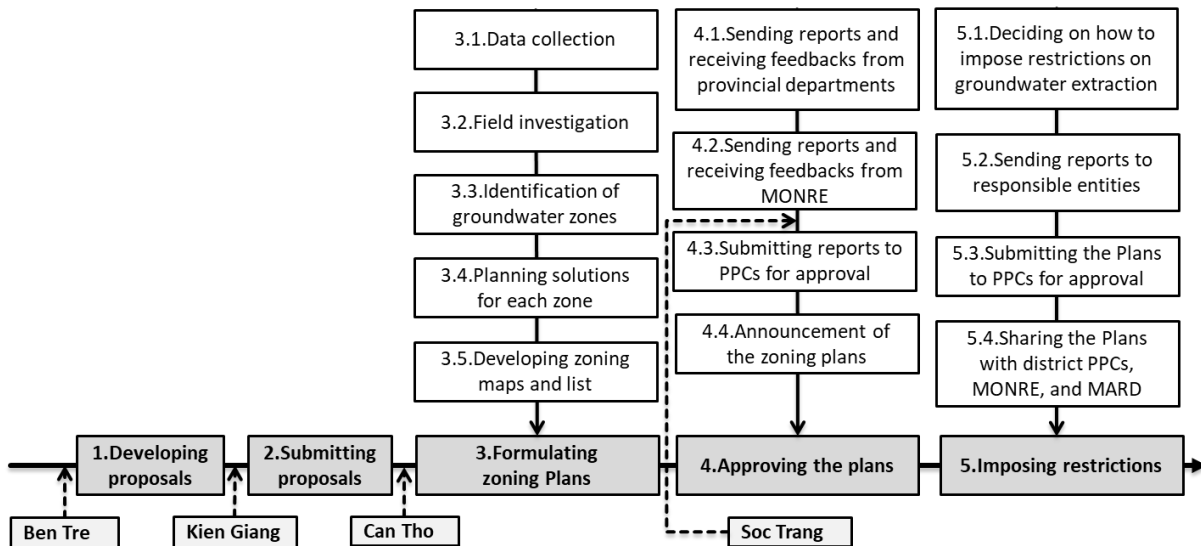


Figure 3. The progress of the implementation of Decree 167 by 2021 (source: adapted from RVO, 2021).

In regulation, the provinces are required to follow five main steps: (1) developing a proposal on how the Decree would be implemented; (2) submitting this proposal to obtain the approval from the Provincial People’s Committees (PPC); (3) with approval from the PPC, formulating zoning plans through five standard steps; (4) sending zonal plans to relevant provincial departments and MONRE for feedback, which then again need to be approved by the PPC; (5) deciding on how to impose the restrictions on groundwater extraction and reporting the implementation to the PPC for the last approval, and finally, sharing the plans with MARD and MONRE (Figure 3). During this process, the local government normally asks for consulting services to support the provinces at these phases.

However, there is a gap between the intended approach and the actual implementation. In reality, most of the provinces rely on consultants to suggest a suitable approach to specific contexts in each province. Under the common policy, interestingly, different provinces take different approaches and thus are at various stages of the implementation process (Figure 3). Ben Tre is currently in the very first phase of the implementation. Kien Giang has just started the implementation and is looking for a consultancy to advise them on the implementation process. The province is waiting for permission from the PPC. Can Tho has developed a plan to set up the zoning plans and has received approval from the PPC, but they have not officially started the procedure yet. At the time that this research was carried out, (i.e., beginning of 2021), Can Tho was waiting for a general strategic plan from MONRE before implementing Decree 167. The next steps in developing the zoning plan will most likely have to wait for the water resources plan, which in turn has to wait for the Mekong Delta Regional Integrated Planning under Resolution 120 that the (new) Prime Minister approved by the 2022 (Decision 287/2022/QĐ-Ttg). Compared to the other three provinces, Soc Trang is the furthest in implementing the zoning plan.

4.2.2 The interests and influence of different actors

Generally, the Provincial People’s Committee (PPC) formally holds the final decision-making authority and therefore theoretically has the strongest influence. However, PPC decisions are shaped by inputs and consultations from other actors, and its influence is therefore rated 9. The Department of Natural Resources and Environment (DONRE) demonstrates both high interest and influence in groundwater governance, as it holds primary responsibility for water management and directly advises the PPC in making final decisions. The Department of Agriculture and Rural Development (DARD) shows medium to high interest and influence, given its role in irrigation and rural water use, which are closely linked to groundwater abstraction. The Department of Planning and Investment (DPI) advises the PPC on sectoral financial allocations across sectors, and thus can exert substantial influence where groundwater issues are integrated into socio-economic planning. However, its relevance varies across provinces depending on whether groundwater management is prioritized within investment and development agendas. The Department of Construction (DOC), primarily concerned with urban water supply, has limited relevance to groundwater governance and land subsidence. Although DOC participates in the Appraisal Board during the approval process of the Decree 167, it does not play a significant role overall.

The level of interest and influence assigned to each actor differs by province, reflecting the local groundwater conditions and institutional roles. These ratings were established based on stakeholder interviews in each province (Figure 4). Detailed scores and responsibilities are provided in Table B1, Appendix B.

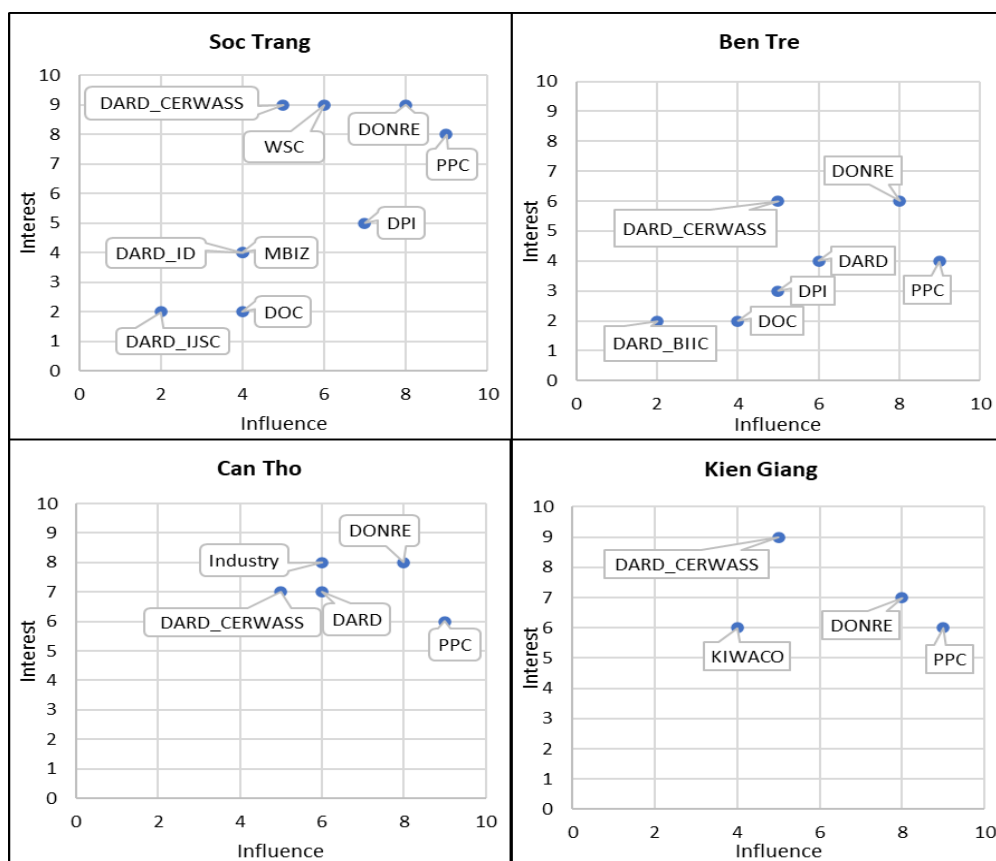


Figure 4. Stakeholders’ interest and influence toward groundwater in the four provinces

In Soc Trang, groundwater is the primary water source for domestic, industrial, and agricultural activities. Stakeholders widely acknowledge its unsustainability and envisage a gradual shift toward alternative freshwater sources. This recognition has motivated Soc Trang to implement groundwater-related policies, including Decree 167/2018/ND-CP (Soc Trang workshop, 2021). Because groundwater use spans multiple socio-economic sectors, both PPC and DONRE demonstrate high interest. Within DARD, interest and influence vary by unit: The Irrigation Department (DARD_ID) shows medium interest and influence as groundwater is not its main source, whereas the Center of Environment Rural Water and Sanitation Supply (DARD_CERWASS) has high interest due to its responsibility for rural water supply but limited influence since

proposals must pass through DONRE before PPC approval. The Irrigation Joint Stock Company (DARD_IJSC) reports limited involvement with groundwater. The Water Supply Company (WSC), which supplies treated groundwater to urban users, has high interest and informal influence based on its technical expertise. The Managing Board of Industrial Zone (MBIZ), which oversees companies in An Nghiep Industrial Zone, shows medium interest and influence, as its operations depend on groundwater supplied by the Soc Trang WSC, but focus mainly on administrative procedures.

In Can Tho, industrial activities are among the largest groundwater consumers, while rural areas also rely on groundwater due to poor surface water quality. Aquaculture processing industries require large water volumes and costly surface water treatment reinforces dependence on groundwater. DONRE and DARD Can Tho therefore, display medium-high to high interest. Industrial zones also have high interest but only formal low influence; however, their economic leverage enables informal influence through lobbying or political mobilisation for groundwater permits. They are thus assigned a medium-high influence score.

“The total amount of groundwater abstraction in the rural areas is not that much, but enough for several hundreds of households. Local people mainly use the water for cooking and bathing for women. It is impossible not to use groundwater, for example, during the dry season when the water level is very low, local people need to use groundwater for livestock like pigs or for fish ponds” (Interview DARD Can Tho in Oct. 2020) (RVO, 2021).

In Kien Giang, land subsidence is not yet a political priority, but the province is highly vulnerable to sea level rise due to low elevation and heavy groundwater reliance (Regional workshop, 2021). DONRE Kien Giang has high influence but medium-high interest, as it hosts multiple groundwater projects with limited direct benefits. DARD_CERWASS shows high interest because groundwater remains an important rural water source. The Kien Giang Water Supply and Sewerage Limited Company (KIWACO) has low influence and medium interest, currently using groundwater at several sites but planning to reduce future reliance.

In Ben Tre, groundwater levels reached record lows in 2020, with some aquifers containing only saline groundwater (Ben Tre workshop, 2021). Extraction far exceeds recharge, and saline groundwater remains the last available source for many residents. The shift toward intensive shrimp farming has further increased demand for both fresh and saline groundwater (Ben Tre group discussion, 2020). Nevertheless, increasing salinity reduces groundwater’s overall role in Ben Tre’s water supply. Consequently, PPC, DONRE, and DARD show low to medium interest and instead prioritise surface water and irrigation investments over implementing Decree 167. CERWASS Ben Tre displays similar institutional influence to that in Soc Trang, but lower interest due to limited usable groundwater. Ben Tre Irrigation Infrastructure Company (DARD-BIIC) does not utilize groundwater, and other departments, including DPI and DOC, exhibit very low interest, as groundwater is not integrated into the City’s Planning agenda.

The observed differences in actor interest and influence reveal key governance dynamics across the VMD. While the PPC consistently holds the highest formal authority, its interest in groundwater governance varies depending on the severity of groundwater-related risks. In provinces such as Soc Trang, where depletion and subsidence threaten livelihoods and economic activities, PPC engagement is stronger. In contrast, in Ben Tre, where surface water and irrigation infrastructure receive higher priority, PPC interest remains comparatively limited. Similarly, DARD’s role varies across provinces. Although it is a key stakeholder in agricultural water management, its influence over groundwater governance is constrained because licensing and regulation fall under DONRE’s jurisdiction. DARD’s interest, therefore, depends on the relative importance of groundwater for local agricultural systems in each province.

Overall, these variations contribute to fragmented policy implementation and uneven prioritization of groundwater management across provinces. Where influential actors such as PPC and DONRE align their interests, implementation of measures such as zoning plans under Decree 167 is more likely to progress. In provinces where key actors lack interest or face competing priorities, governance efforts lag behind. This highlights the need for stronger inter-sectoral coordination, clearer delineation of responsibilities, and mechanisms to align the interests of powerful actors with long-term sustainable groundwater management

objectives.

4.2.3 The implementation of the Decree 167 in the provinces: defining their own ways, arriving at their own pace

There is a huge gap between the intended approach and the actual implementation of the Decree. Under the common policy, interestingly, different provinces may take different approaches and thus are at various stages of the implementation process (Figure 3). Ben Tre is currently in the very first phase of the implementation. Kien Giang has just started the implementation and is looking for a consultancy and is waiting for permission from its PPC. Can Tho has developed a plan to set up the zoning plans and has received approval from the PPC, but it has not officially started the procedure yet because it wants to wait for a general strategic plan from MONRE before implementing Decree 167. Soc Trang is the furthest in implementing the zoning plan.

It seems that the interests of decisive stakeholders, e.g., PPC, are among the most important factors for the implementation of the Decree 167. This is shown especially in the case of Soc Trang and Can Tho where powerful actors such as PPC, DONRE, and DARD are interested in the groundwater use, thus promoting for the implementation of the Decree. The drivers behind these interests seem to be the usability of and thus the demand for groundwater. Here, we see a clear difference in water strategies between the provinces. Specifically, Soc Trang and Can Tho are highly dependent on groundwater for different purposes.

By contrast, groundwater is not considered for supply and thus left out of the policy agenda in Ben Tre:

“The City’s financial ability is low. Ben Tre puts surface water and irrigation projects as the first priorities in using financial resources. Therefore, there is not enough funding for implementing the zoning plan” (Interview Ben Tre DONRE in 2020) (RVO, 2021).

“We heard about Decree 167, but since DONRE did not implement any and we care only about surface water, so we did not involve in Decree 167” (Interview Ben Tre DARD in 2020) (RVO, 2021).

In summary, the analysis identifies common challenges in groundwater governance, with Decree 167/2018 emerging as a pivotal focus point. Despite its significance, the effective implementation of this Decree faces 9 following obstacles: (1) Monitoring and managing groundwater-related land subsidence faces limited and inaccurate benchmark surveys, insufficient monitoring networks, and complexities in delineating subsidence zones; (2) Limitation of data availability and scientific research at both delta and provincial scales coupled with inadequate monitoring networks hinders the understanding and limits information on groundwater extraction as well as land subsidence dynamics; (3) Current policies primarily focus on horizontal zoning, neglecting the complexity of aquifer systems and various exploitation depths, thus potentially impacting the recharge and exploitation rates and hindering effective integrated groundwater resource management. In addition, the policy coverage at the whole delta scale leads to a mismatch between policy implementation and groundwater management needs at the local level, resulting in inequality and inefficiency; (4) Top-down management approaches and a lack of collaboration between jurisdictional boundaries result in heterogeneous approaches, fragmentation, and ineffective policy implementation; (5) Complications in implementing effective licensing arise due to unclear responsibilities, limited collaboration between departments, and regulatory loopholes exploited by businesses; (6) Inappropriate pricing of groundwater use, coupled with unaccounted negative environmental effects, leads to underpricing, potentially exacerbating extraction and land subsidence issues; (7) Weak enforcement of groundwater regulations and insufficient sanctions for misconducted activities hinder policy implementation effectiveness; (8) Financial and human resource constraints, along with competing priorities, which limit the capacity for effective groundwater management and monitoring; (9) Inadequate awareness among policymakers and implementers, particularly regarding small wells, undermines management efforts, while insufficient user awareness exacerbates groundwater depletion issues. These challenges highlight the complex nature of groundwater governance in the region and the imperative for tailored interventions.

4.3 Discussion and policy implications

This study showed that groundwater regulations in Vietnam, particularly in the VMD, remain only partially aligned with a comprehensive groundwater governance perspective. Improving groundwater governance requires both technological and institutional reform. Groundwater, as a common pool resource, characterized by subtractability and non-excludability, requires coordinated institutional arrangements that regulate access, allocation, and collective use (Narain, 1998, 2000). Comparative experiences from countries such as India, Bangladesh, Thailand, and Japan further demonstrate that effective groundwater governance depends on integrated institutional and technological reforms rather than regulatory instruments alone (Hermans & Narain et al., 2022; Lorphensri et al., 2011; Kaneko & Toyota, 2011). Consistent with the gaps identified through the OECD Water Governance Principles, particularly regarding policy coherence, multi-level coordination, and stakeholder engagement, our findings highlight the need for more integrated and regionally coordinated governance arrangements (OECD, 2015).

Fragmented provincial zoning and limited coordination across administrative boundaries emerged as a key governance challenge. The independence of provinces in developing groundwater zoning plans complicates understanding the cumulative cause-and-effect relationship between groundwater abstraction and land subsidence across shared aquifers. This reflects weaknesses in policy coherence and multi-level governance identified in the OECD-based analysis. Spatial planning at appropriate hydrological scales is essential to address groundwater governance challenges in the VMD. An inter-regional planning framework that transcends provincial and sectoral boundaries, supported by a dedicated coordinating mechanism, would enable more coherent allocation of water resources across sectors and territories. Within the current hierarchical governance system, stronger vertical coordination between ministries and provincial departments, combined with horizontal alignment across sectors, is crucial to ensure consistent policy implementation (Tran et al., 2020) and reduce transaction procedures. Regular inter-provincial dialogues, shared information platforms, and joint planning exercises could further facilitate collaboration, including for transboundary aquifer management between Vietnam and Cambodia, thereby directly addressing coordination gaps highlighted in the OECD-based assessment (OECD, 2015). To effectively develop regional coordination, actors such as local universities or the Regional Coordination Council could play a bridging role in coordinating initiatives from different projects to promoting trust and mutual understanding among stakeholders.

Recent administrative restructuring in Vietnam (effective July 2025) introduces additional implications for groundwater governance across the Mekong Delta. The consolidation of provincial units (e.g., the integration of Ben Tre Province into Vinh Long Province) may strengthen vertical coordination and resource pooling, yet it can also create transitional challenges related to institutional continuity, policy alignment, and long-term data comparability. Such dynamics illustrate how evolving administrative boundaries interact with the governance of shared aquifers, which inherently operate at hydrological rather than political scales. These developments reinforce the argument for regional-level governance analysis introduced earlier in the paper, as aquifer dynamics, subsidence risks, and management responses increasingly transcend administrative jurisdictions. Similar challenges have been documented in global groundwater governance research, which emphasizes that fragmented mandates and multi-level institutional complexity often hinder coherent aquifer management (Villholth et al., 2017). Therefore, analysing governance at the regional scale is not only empirically justified in the Mekong Delta context but also consistent with broader theoretical insights stressing the need for cross-boundary coordination, adaptive institutional arrangements, and polycentric governance structures in managing common-pool groundwater resources. Insufficient data availability and weak monitoring and evaluation systems constitute another major constraint on effective governance. The analysis revealed limited empirical evidence linking groundwater extraction to land subsidence, hindering informed decision-making and policy evaluation. This aligns with OECD principles emphasizing the importance of data, information sharing, and adaptive governance. Because decision-makers operate under conditions of uncertainty, flexible and adaptive policy approaches are required (Bijlsma et al., 2011; Tran et al, 2025). Reliable data generated through an effective monitoring network would allow models to be (re)calibrated and provide governments with crucial information to support evidence-based policymaking. However, our results indicate that current knowledge and data on the groundwater dynamics and subsidence in the VMD remain insufficient to support effective management strategies. It is thus crucial to expand

monitoring networks, conduct targeted studies, and integrate multiple data sources to fill existing knowledge gaps. Multiple technical strategies, such as, reducing groundwater extraction rates, monitoring groundwater levels and quality, and measuring land subsidence are recommended to address these challenges (Appendix D).

Variations in actor interests and institutional capacities across provinces also contribute to inconsistent policy implementation, reflecting gaps in capacity and stakeholder alignment identified in the OECD analysis. Differences in perceptions of groundwater regulation among departments, as well as uneven technical expertise, limit effective coordination and enforcement of national policies in the VMD (Minkman et al., 2022). Strengthening public sector capacity through targeted training, technical assistance, and improved access to analytical tools such as Geographic Information Systems (GIS) would enhance more consistent implementation across provinces. Moreover, understanding groundwater mechanisms at the delta scale, including the cumulative impacts of abstraction on specific aquifers and associated subsidence, is essential for fostering inter-provincial collaboration. Encouraging further education and professional training for officials through workshops, short courses, and partnerships with academic institutions would help address existing knowledge gaps and strengthen their management skills. Improved administrative procedures, including simplified well registration processes and strengthened enforcement of violations, could further increase regulatory compliance. Economic instruments such as groundwater taxation may also help correct price imbalances between groundwater and surface water, while ensuring that basic domestic water needs are prioritised over industrial and agricultural uses in licensing decisions.

Finally, limited stakeholder awareness and participation, identified in the trust and engagement analysis, further constrain behavioural change and compliance. Effective groundwater governance, therefore, requires transdisciplinary collaboration among social and natural scientists, policymakers, and communities to support collective monitoring and co-management of groundwater resources. Awareness-raising strategies should be tailored to different user groups, such as urban households, rural communities, and industrial users, to improve understanding of groundwater sustainability and regulatory obligations. For example, for urban households, raising awareness on the use of treated water and proof of good quality is needed to encourage them to switch to water supply options other than groundwater. Meanwhile, rural users or industries might need a better understanding of the regulations and sanctions for illegal groundwater exploitation. Further research is needed to identify appropriate engagement strategies for different user groups. One promising approach is “citizen science” a form of collective learning in which non-professional citizens participate in data collection and monitoring, thereby raising awareness and contributing to closing data gaps (RVO, 2021). Examples of such collective learning initiatives include the International Fund for Agricultural Development project (Neefjes et al., 2018) implemented in Ben Tre and Tra Vinh (Neefjes et al., 2018).

5. Conclusions

This study examined the challenges of groundwater governance in the VMD, using the OECD principles as an analytical framework and identified pathways to improve groundwater governance. The findings reveal a complex interplay between groundwater regulation, land subsidence, and saltwater intrusion, highlighting that groundwater governance cannot be addressed in isolation from broader socio-hydrological dynamics. By applying the OECD principles, the study demonstrates that key governance gaps in the VMD relate to weak policy coherence, limited multi-level coordination, insufficient data and monitoring systems, and uneven stakeholder engagement.

A central empirical insight concerns the varying interest and influence of key actors, particularly the Provincial People’s Committee (PPC), DONRE, and DARD, across provinces. These differences, shaped by local socio-economic conditions and water use patterns, significantly influence the implementation of groundwater policies such as Decree 167. The results, therefore, illustrate how fragmented institutional mandates and competing political and economic priorities among influential actors constrain effective policy enforcement and compliance, reinforcing the fragmented nature of groundwater governance.

Beyond the specific case of the VMD, this study contributes to the broader groundwater governance literature by empirically demonstrating how governance effectiveness depends not only on formal regulatory frameworks but also on actor alignment, inter-sectoral coordination, and adaptive knowledge systems. These findings resonate with challenges observed in other deltaic and coastal regions worldwide, where shared aquifers transcend administrative boundaries and require coordinated, polycentric governance arrangements (Langridge & Ansell, 2024).

Political and economic interests of powerful actors emerged as primary factors in effective groundwater governance. These factors pose significant challenges to the enforcement and compliance with groundwater regulations, thereby hindering progress towards effective resource governance. Achieving effective groundwater governance in the VMD requires an integrated approach that combines technical innovation, institutional reform, community empowerment, and environmental stewardship. Several key strategies are recommended, including the establishment of robust groundwater monitoring systems to better understand resource dynamics; fostering collaboration among various sectors to develop integrated water management approaches; exploring alternative water sources to alleviate pressure on groundwater reserves; and promoting awareness among stakeholders regarding responsible groundwater use practices.

Overall, the study underscores that effective groundwater governance in delta regions demands governance systems capable of managing common-pool resources across administrative boundaries, addressing scientific uncertainty through adaptive management, and aligning the interests of powerful actors with long-term sustainability goals. By linking empirical findings from the VMD to broader governance debates, this research provides transferable insights for improving groundwater governance in other rapidly urbanizing and climate-vulnerable coastal regions.

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Contributor Statement

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Use of AI

During the preparation of this work, the author(s) did not use any AI tools. During the revision stage, the AI tool Perplexity was used to improve clarity and conciseness by refining wording and enhancing readability. All AI-generated suggestions were carefully reviewed, and full responsibility for the final content rests solely with the authors.

Conflict of Interest

There is no conflict of interest.

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Appendices

Appendix A. The four studied provinces

Table A1. Area and population of the four studied provinces in comparison to the Mekong Delta. (Source: Authors compile based on website: https://en.wikipedia.org/wiki/Mekong_Delta, retrieved on 25/05/2025).

	Area (thousand km ²)	Population (million)	Year
Mekong Delta (MD)	43	19	2022
Can Tho	1.046	1.507187	2024
Soc Trang	3.2982	1.2043	2024
Ben Tre	2.3797	1.799328	2023
Kien Giang	6.35202	2.4621	2024
TOTAL four provinces	13.07592	6.972915	
% compared to MD	30.40911628	36.69955263	

1 **Appendix B. The interviewees' local agencies and their scores**

2 *Table B1. Scores of interests and influences of actors in different local agencies in the four provinces*

Agency	General responsibilities	Can Tho			Soc Trang			Ben Tre			Kien Giang		
		No. Int*	Interest	Influence	No. Int	Interest	Influence	No. Int	Interest	Influence	No. Int	Interest	Influence
PPC (Provincial People's Committee)	Final decision-making authority; Approving proposals related to water use in the province	0	6	9	0	8	9	0	4	9	0	6	9
DONRE (The Department of Natural Resources and Environment)	Primary responsibility for water management and directly advises the PPC in making final decisions; Reviewing proposals related to water resources use, submitted from other sectors	2	9	8	1	9	8	2	6	8	1	8	8
DARD_CERWASS (Center of Environment Rural Water and Sanitation Supply)	In charge of water supply in the rural areas	1	7	5	2	9	5	1	6	5	2	9	5
DARD_General (The Department of Agriculture and Rural Development)		2	7	6	NA	NA	NA	2	6	6	NA	NA	NA
DARD_ID (Irrigation Department)	Water supply for agriculture	NA	NA	NA	2	4	4	NA	NA	NA	NA	NA	NA
DARD_IJSC (Irrigation Joint Stock Company)	Water supply	NA	NA	NA	1	2	2	NA	NA	NA	NA	NA	NA
DARD_BIIC (Ben Tre Irrigation Infrastructure Company)	Water supply and infrastructure	NA	NA	NA	NA	NA	NA	1	2	2	NA	NA	NA
KIWACO (Kien Giang Water Supply and Sewerage Limited Company)	Provide water supply and sewerage services	NA	NA	NA	NA	NA	NA	NA	NA	NA	2	6	4

DPI (The Department of Planning and Investment)	Consults the PPC on financial allocations across sectors	NA	NA	NA	1	5	7	3	3	5	NA	NA	NA
DOC (The Department of Construction)	Provides urban water supply	NA	NA	NA	2	2	4	3	2	4	NA	NA	NA
MBIZ (Managing Board of Industrial Zone)	Managing the activities of the companies in the An Nghiep Industrial zone	NA	NA	NA	2	4	4	NA	NA	NA	NA	NA	NA
Industrial zones	Consumer	2	8	6	NA	NA	NA	NA	NA	NA	NA	NA	NA
WSC (Water Supply Company)	Supplying water for the population and industry in Soc Trang city	NA	NA	NA	2	9	6	NA	NA	NA	NA	NA	NA
Total interviews		7			13			12			5		

(*): "No. Int.": "Number of interviewees"

3

Appendix C. The open-ended interview questionnaires

Introduction

Currently (Oct. 2020), the factsheets are about 80% finished. The focus is now on filling the last information gaps regarding certain governance aspects. For example, there is missing information on several important stakeholders for the four provinces regarding their governance structures and their perception on governance and policy measures to tackle land subsidence and groundwater management (such as the zoning plans). This information contributes to a thorough understanding of the existing governance structures and decision-making power of the involved stakeholders as well as the status of policy development and regulations.

Additionally, information from involved stakeholders on the development of Decree No. 167/2018/ND-CP will be gathered. In particular information on the zoning plans (zones where groundwater extraction is restricted according to the guidelines given in Decree No. 167/2018) can support in determining the bottlenecks and enablers regarding the implementation of the zoning plans in Can Tho city and the three provinces Ben Tre, Soc Trang and Kien Giang.

The material will be collected by means of interviews in each province, conducted by Vietnamese team members.

In summary, the interviews have **two objectives**:

- 1) Gathering the missing data to finalize the planned factsheets per province
- 2) Determining the current status of the zoning plans per province and gathering province specific needs for strategic advice from the Consortium

General questions to finalize the factsheets

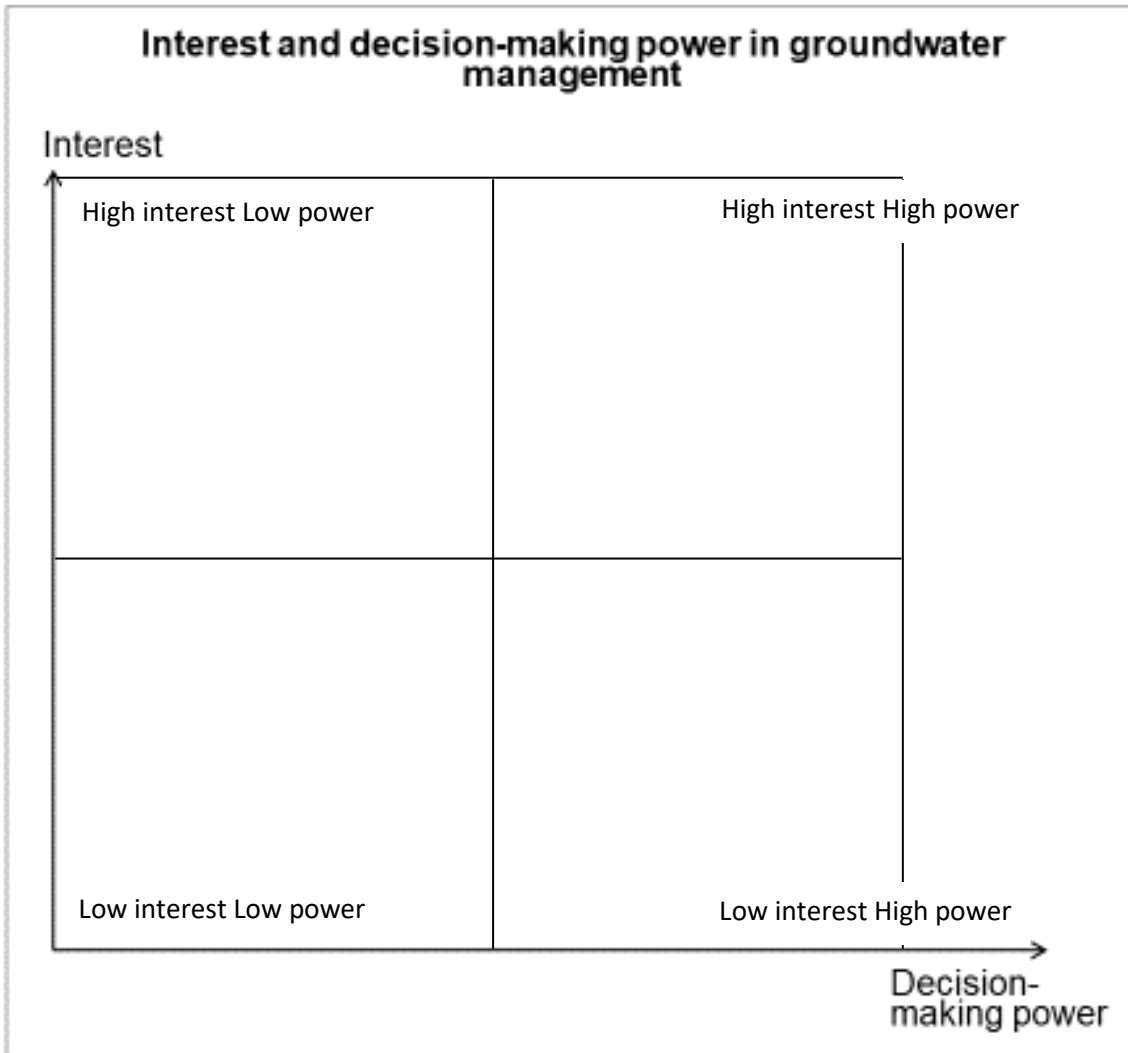
Understand governance and power structures of involved stakeholders:

- 1) What stakeholders make the decisions related to groundwater management and land subsidence? And how does the decision-making process go? Who are the most important stakeholders that can influence the decision-making process (*both gov. & non gov.*)?
- 2) Are there any province specific policies, or regulations, related to groundwater management and/or land subsidence in place?
- 3) What governance challenges related to groundwater management and land subsidence is your province facing? (e.g., within your province, but also possibly with neighboring provinces)
- 4) What potential governance measures (no hard infrastructure) related to groundwater management are mentioned by stakeholders? And which stakeholders would mainly be involved in these potential government measures? In what role and with what responsibility?
- 5) Please fill out the following figure. *We will combine the answers of the different interviews per province and create an averaged figure for the province.*

Explanation: You can see a list of suggested stakeholders involved with groundwater extraction and/or land subsidence. We would like you to write each stakeholder in one of the four boxes in the figure below. The four boxes are based on whether the stakeholder has high/low interest and high/low decision-power. Interest means that the topic is very relevant to the stakeholder. Decision-power means how much the stakeholder is able to influence the decisions related to groundwater extraction. For example: a stakeholder with high interest & low power means that the stakeholder is very much involved with groundwater extraction and finds it important what is happening with groundwater extraction, but is not able to influence decisions that affect groundwater extraction.

Please make sure the reasoning behind placing a stakeholder in a certain quadrant is

explained.



Suggestions: DONRE, DARD, DPI, DOC, Industries, Water supply companies, DWRM, CERWASS, Unions, Farmers, *Other...*

Clarification:

Interest: The level of interest that a stakeholder has with regards to this topic

Decision-making power: The amount of influence a stakeholder has with regards to this topic

Please explain the reasoning behind placing a stakeholder in a certain quadrant.

General questions related to the zoning plans

Understand the perception on the zoning plans:

Zoning plans: The plan to outline zones (areas) where groundwater extraction is restricted into 4 classes according to the guidelines given in Decree No. 167/2018/ND-CP on restriction on groundwater extraction.

- 1) Is your province already working on a zoning plan for ground water management? (Decree No. 167/2018/ND-CP) Can you tell us more about the decree?
- 2) Who or which organization/department is responsible for developing the zoning plan in the province?
- 3) Which (other) departments or stakeholders are involved in the development of the zoning plan? How is this organized and how do they collaborate?
- 4) What steps do you take to develop the plan and what is the timeframe to do so?
 - a. What are the procedural steps to take towards implementation of the plan?
 - b. What are the milestones and dates in this administrative process for your province?
- 5) What are the steps that still need to be taken to finalize the zoning plans?
 - a. Do you have a list of areas with restricted groundwater exploitation?
 - b. Do you have list of areas which need to register for groundwater extraction?
 - c. Are all regions already included in the two lists?
 - d. How are you planning to implement the zoning plans?
- 6) Do you foresee or experience any challenges or difficulties in developing the zoning plan?
 - a. If the zoning plan is almost finished, does the stakeholder expect there to be issues when implementing the zoning plans?

Interviewer notes to stimulate answers: For example, with assessing which region belongs to which area for the list of regions that need to register? Or for example for regions where wells need to be filled? Or for example explaining the importance of the zoning plans and the need to implement?

- 7) Land subsidence was mentioned as one of the criteria for the zoning plans, what is according to you the importance of land subsidence as a criterion.
 - a. To what extent is land subsidence influencing the delineation of the zones?
- 8) How can the Consortium contribute to the development of the zoning plans? Is there any assistance required/helpful?

- a. On what topics or aspects would you like the consortium to provide strategic advice to your province? In other words, what would be the best way to support you in case you wish some advice?

Interviewer notes to stimulate answers: For example, on (regional) coordination between provinces, with working groups or workshops, training sessions or the creation of informative/educational materials for stakeholders

9) Does the province work together with other provinces on the zoning plans?

- a. What is going well in this collaboration?
- b. What are difficulties regarding this collaboration?
- c. What are future opportunities in regional coordination and collaboration on this?

10) Would the province be interested in sharing lessons learned with other provinces, related to the development of the zoning plans? *On both, successes and advice on improvements of methods, analysis and implementation.*

11) As a last question we would like to know if you are willing to participate in a workshop on the relationship between land subsidence and Decree No. 167/2018

Results of the interviews

- At the start of each interview, agree who will be the lead reporting and who will support and review the report of the interview.
- It is suggested to share a draft version of the Vietnamese report to the counterpart for approval, to make sure we understood all well and to prevent any misinterpretations.
- For the English version of the report, please use the format in Annex A of these guidelines.

Appendix D. Strategies to cope with multiple issues related to groundwater

Regarding the groundwater extraction rates, it is suggested to improve the techniques, e.g., installation of measurement meters on the large extraction pumps, and the development of a jurisdiction system to report actual pumped volumes of registered wells and the registration of currently unknown illegal wells.

In terms of the groundwater levels, the National Center for Water Resources Planning and Investigation subdivision in the south is monitoring groundwater at the national scale. Provinces can support this process to improve spatial coverage of the data on water levels by using potentially available data sources such as the one-time measurement of existing production wells or data from water companies and industries.

Regarding groundwater quality, salinity monitoring can help identify saltwater intrusion hotspots to improve zoning plans. Information and advanced techniques such as the 3D model of total dissolved solids using geostatistical analyses (Gunnink et al., 2021) can be useful to further modeling processes, e.g., groundwater flow, salt transport, or aquifer recharge and storage. When these models are based on a reliable amount of input and calibration data (e.g., hydrogeological and geo-mechanical subsurface data and depth-dependent subsidence observations), they can provide powerful tools that can also be employed to make estimates on safe groundwater extraction limits, as when groundwater exploitation matches recharge rates, the resource can be used sustainably. However, the current level of sparse data availability impedes building models accurate enough to make reliable estimates at a local level.

Besides groundwater, monitoring of in-situ land subsidence rates is important. A network of extensometers measuring soil compaction at different depths and depth intervals in the delta will be essential to reduce uncertainty regarding at what depth land subsidence is mainly occurring and help to disentangle the different causes of land subsidence. Advanced techniques such as satellite-based PS-InSAR (Persistent Scatterer Interferometric Synthetic Aperture Radar) could be applied to assess subsidence as done in the case of Can Tho, Ca Mau, and Long Xuyen in a recent study (de Wit et al., 2021). This study provides information on the vertical movement of the shallow subsurface but not on any compaction occurring below the foundation depth of large buildings. Measurements of surface elevation done through continuous monitoring, for example by permanent GNSS stations, will provide reliable ground data needed to calibrate the PS-InSAR solutions. However, as these stations are currently unavailable, PS-InSAR observations suffer from larger uncertainties in absolute values.

Physical solutions: alternative freshwater sources

Alternative freshwater sources are important to save groundwater. Provinces recognize the benefits of prioritizing the use of other available water sources over groundwater. Alternative water sources for those provinces which do not have large and clean surface water quantities during the dry season such as the downstream provinces are therefore important.

Improve the surface water quality

One of the main causes of water pollution is the current intensive agriculture. Transforming agriculture will need integrated solutions which involve multiple actors and sectors. International collaborative efforts such as the Agricultural Transformation Program (ATP) is an example. ATP is part of the New Rural Development program funded by the World Bank. The next phase from 2021-2025 will focus on creating a sustainable nexus and food supply chain in which the implementing actor MARD will be supported by The Netherlands and other international agencies. One of the goals

is to reduce agricultural pollution by decreasing runoff which would prevent surface water pollution and increase surface water usability for other users. Feasibility studies to support actors implementing surface water projects for water supply and treatment are needed.

Storage of freshwater

Various techniques for storing freshwater have been applied such as dyke, gate, and even reservoirs are constructed in the Mekong Delta for managing freshwater to minimize the drought and salinization impacts. However, technical solutions like freshwater storage using excess water collected from treated wastewater or rain water to recharge wells or aquifers could be considered. One of the potential concepts is Aquifer Storage and Recovery (ASR) which stores freshwater during the wet season in the subsurface to use in the dry season. This method is claimed to have multiple benefits such as reducing evaporation losses, storing excess water to reserve for shortage periods, increasing buffer capacity and groundwater levels, reducing saltwater intrusion, limiting the loss of aquifer storability by sustaining the piezometric head, and managing land subsidence. It could serve a variety of water users including water supply companies, farmers, and the industry. Different methods used to store freshwater in the ASR include reversed drainage, infiltration ponds, and wells, and recharge weirs, each acting differently and suitable depending on the local hydrogeological situation, e.g. (in)ability for water to infiltrate, pressure difference, and desired depth of infiltration. Some AR pilot tests are also conducted in several provinces in the Mekong Delta such as Tra Vinh, Hau Giang and Ho Chi Minh City (Ha et al., 2022). The artificial recharge is also mentioned in the water law of Vietnam in 2012 and 2023. However, the government does not have technical guidelines for implementation of such projects.

The concept has been implemented at a pilot scale in Tra Vinh province, exploring the potential for shallow infiltration in sandy dune deposits. Different criteria to identify suitable locations for applying the concept include a good permeable aquifer, absence of very low permeable layers, availability of good-quality surface water to reduce aquifer clogging, and available storage capacity at the end of the wet season. For the coastal provinces of Ben Tre and Tra Vinh, maps showing potential areas to upscale and apply ASR have been developed (FAME project workshop, 27.08.2021).