2030 Water Resources Group

VIETNAM

Hydro-Economic Framework for Assessing Water Sector Challenges

AUGUST 2017

About 2030 Water Resources Group

The 2030 Water Resources Group is a unique public-private-civil society partnership that helps governments to accelerate reforms that will ensure sustainable water resource management for the long-term development and economic growth of their country. It does so by helping to change the “political economy” for water reform in the country through convening a wide range of actors and providing water resource analysis in ways that are digestible for politicians and business leaders. The 2030 WRG was launched in 2008 at the World Economic Forum and has been hosted by the International Finance Corporation (IFC) since 2012.

Acknowledgments

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Cover photo: Boats parked in the Hàn river passing through Da Nang, Vietnam (Jan 23, 2015).

Photo credit: Crhistopher Crouzet Source: http://ow.ly/eBUb30eB7CG

Foreword

Vietnam is experiencing increasing variability in water availability across regions and seasons. Mitigating against the impacts of such changes requires a thorough assessment of the water challenges and the design of multi-stakeholder solutions, grounded in sound analytics.

Commissioned by the 2030 Water Resources Group, this analysis provides a high-level assessment of the Vietnam water sector, aimed at assessing the water demand-supply gap, mapping ongoing stakeholder initiatives, and identifying key private sector driven solutions for priority areas.

With the intent of fostering greater collaboration between the public, private and civil society on water resources management, this report aims to deepen the dialogue on collective action within the country. It has been developed through extensive stakeholder interviews and has been guided by a multi-stakeholder Advisory Group.

2030 Water Resources Group (2030 WRG), hosted by International Finance Corporation, facilitates open, trust-based dialogue processes to drive action on water resources reform, with the aim of closing the gap between water demand and supply by the year 2030.

We hope this document triggers an active dialogue between the stakeholders leading to concrete action on water security solutions in Vietnam. We wish to acknowledge the inputs of all the peer reviewers and contributors to this report.

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Executive Summary

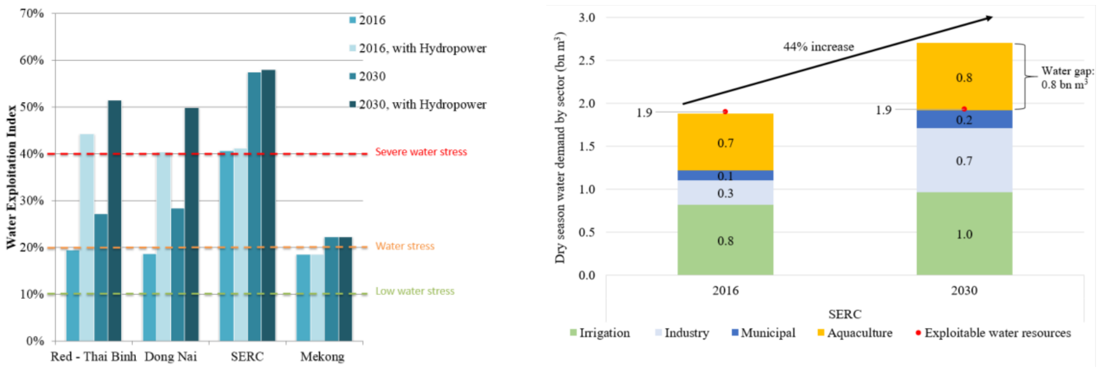
Viet Nam's economic growth and social transformation over the past decades has lifted large portions of the society out of poverty. However, it has also put pressure on sustainable resource use and environmental protection, which is expected to put limits on future economic growth.

Building on Integrated Water Resource Management Framework (IWRM), this assignment presents a high-level overview assessment of Viet Nam's water sector with the aim of identifying water demand reduction solutions to accelerate water sector transformation in Viet Nam regarding water security for long-term economic growth, meeting environmental and domestic needs and enabling shared prosperity. The analysis focuses on four river basins, which jointly generate approximately 80% of Viet Nam's GDP, namely, the Red Thai Binh, Mekong, SERC and Dong Nai river basins.

Key identified challenges include:

1. The river basins generating 80% of Viet Nam's GDP are all expected to face 'water stress' in the dry season by 2030. SERC river basin, a severely water stressed basin, it is even expected to not be able to meet 28% of water demand in the dry season by 2030 (See Figure 1)

Figure 1. Left: Water exploitation index (WEI) for Viet Nam's four key economic river basins; Right: SERC river basin dry season water supply-demand gap



2. Over-exploitation of Viet Nam's unmonitored groundwater resources, results in falling groundwater levels, which caused land subsidence in Hanoi, Ho Chi Minh City and Da Nang, and localised water shortages in the dry season, e.g. the Mekong, where 50% of Vietnam's rice is produced, and in the Central Highlands, where 88% of Viet Nam's coffee is grown. Saline intrusion to aquifers further reduces agricultural productivity in the Mekong and Red River.

3. Viet Nam's surface waters face serious pollution, with only 10% of the municipal and industrial wastewater treated. Rivers in and around major cities are considered 'dead rivers' – increasing groundwater dependence and over-extraction. Untreated wastewater is used for irrigation downstream, with unforeseen public health implications.

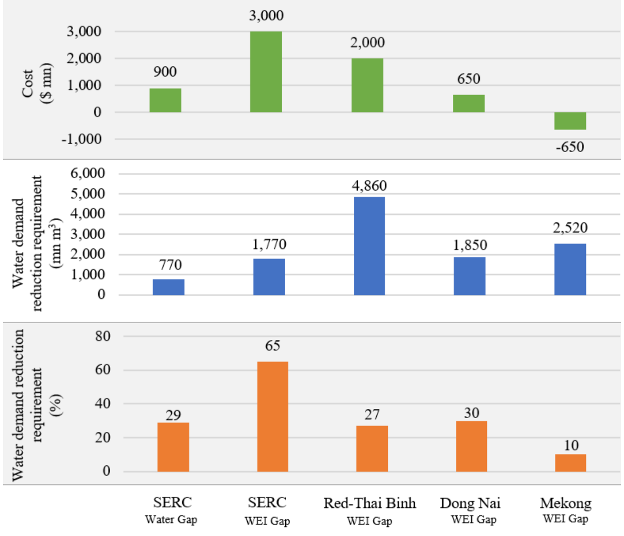
4. Aging water supply infrastructure and illegal connections reduces the availability of potable water in cities.

5. Rapid expansion of hydropower in Viet Nam causes water sharing conflicts and issues related to dam safety of small dams, potentially worsening water stress in the dry season. Further, reduced sediment loads in rivers endangering Viet Nam's agricultural productivity.

6. Drought events are increasing in frequency and severity impacting livelihoods and agricultural production. The recent El Nino event between 2014 and 2016 caused the most severe drought Viet Nam experienced in 90 years, severely impacting livelihoods and the economy.

To identify the most cost-effective solutions to close the identified water supply-demand gap in SERC and to move the Red Thai Binh, Mekong, SERC and Dong Nai river basins to a low water stress status and to receive a high level estimate on overall costs, 24 measures (agricultural, municipal and industrial) were reviewed for each river basin (refer to Figure 2). The analysis focuses on water efficiency measures; water supply augmentation solutions were not assessed.

Figure 2: Overview of water demand reduction requirements in key economic river basins and associated high level costs



In the Mekong river basin, agricultural measures alone, such as Alternative Wet and Dry (AWD) rice management and use of quotas, were required to achieve the targeted reducing in water stress. It was found that a combination of agricultural, such as AWD rice management, municipal, such as leakage reduction, and industrial measures, such as industrial wastewater treatment, were the most cost-effective combination for Dong Nai and Red-Thai Binh river basins. The situation in SERC river basin, however, is so grave that all analyzed 24 measures were insufficient to achieve the targeted water stress level. It is suggested that potential water supply augmentation measures are investigated.

Further, four deep dives were made for measures which, based on stakeholder consultations, were deemed to have the highest impact, with following findings:

- **Irrigation scheduling**, which causes 'induced water stress' for coffee has the potential to reduce total coffee water demand in the groundwater stressed Central Highlands by up to 25% or 577 mn m^3/yr. Coordination of already active stakeholders to support in overcoming challenges to a widespread adoption is recommended.
- **Alternate wet and dry (AWD) rice management practices** reduce water demand for Viet Nam's most water intensive crop by 30% (up to 20 billion m^3) while offering a business case for farmers in increasing profits. Avenues to support the government in achieving and surpassing its goal to apply AWD on an area of 1 mn ha can be explored.
- **Reusing treated municipal wastewater** has the potential to reduce Ho Chi Minh City's water stress to 'low stress' level by 2030. The potential of effluent reuse for non-potable water use is up to 3.7 mn m^3/d. The additional cost of upgrading the planned wastewater treatment works to meet suitable non potable water standards is estimated at \$0.25/m^3. Areas on supporting the government in drafting required regulation and in enabling investments from public and private organisations as PPP arrangements can be explored.
- **Treating wastewater from industrial clusters** along the Nhue-Day River close to Hanoi can considerably improve surface water quality. This would involve the treatment of 22 mn m^3/yr of industrial wastewater; the associated cost of the CETPs has been previously estimated at \$97 mn (2010). Opportunities with MONRE, MARD, MOC and MOIT to improve the legal framework and

enforcement can be explored, as well as with infrastructure development companies on commercialising CETPs and industrial water reuse systems.

The implementation of the recommended solutions, requires an integrated response by MARD, MoNRE, MoST, People's Committees, the Farmers Unions, as well as Private Enterprises and International Organisations. An ad-hoc implementation of solutions may result in structural inefficiencies as well as conflicting outcomes. The backbone of Viet Nam's water sector transformation lies in addressing key governance challenges to incentivise and enforce fundamental requirements for sustainable water resource management, including:

1. Strengthening of IWRM by creating and implementing IWRM plans at river basin level;
2. Revision of economic and regulatory instruments, such as water prices, pollution charges and fines to incentivise sustainable water resource management;
3. Amendment of existing laws and regulations to close loopholes for water users and polluters and to allow for new solutions, such as treated wastewater reuse.
4. Enforcement of laws and regulations by demonstrating political will, building provincial governments' capacity and delivering the Government's initiative of monitoring discharges online;
5. Coordination of roles and responsibilities across Ministries and Departments to avoid conflicting roles, to enable management at river basin level and to facilitate data sharing within government agencies and with the public to allow for informed decision making; and
6. Provision of technical support and capacity building locally to ensure sustainable and long-term implementation of solutions.

Following IWRM principles, a strong coordination between the private and public sector, as well as civil society is required. While the public sector will take the lead in institutional changes, such as amending laws, regulations and economic and regulatory instruments, input from the private sector and civil society should be considered. Private sector and civil society can play a leading role in providing technical support and building capacity at the local level, e.g. via sustainable supply chain initiatives. Further, the private sector is critical in contributing to innovative financing mechanisms, infrastructure provision and information technology.

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Abbreviations

2030WRG	2030 Water Resources Group
ADB	Asian Development Bank
ADM	Archer Daniels Midland
AFD	French Development Agency
ANCP	Australian NGO Cooperation Program
AusAID	Australian Agency for International Development
AWD	Alternate Wetting and Drying
BOD	Biochemical Oxygen Demand
BTC	Belgian Development Agency
CECR	Centre for Environment and Community Research
CEFACOM	Center for Health Research and Development
CERETAD	Centre for Research, Training and Development of Health Human Resource
CETP	Centralised Effluent Treatment Plant
CIRAD	French International Agricultural Research Centre for Development
COD	Chemical Oxygen Demand
DANIDA	Danish International Development Agency
DARD	Department of Agriculture and Rural Development
DoC	Department of Construction
DoF	Department of Finance
DoH	Department of Health
DoIT	Department of Industry and Trade
DONRE	Department of Natural Resources and Environment
DoST	Department of Science and Technology
DoT	Department of Transport
DPI	Department of Planning and Investment
FAO	Food and Agriculture Organization
FDC	Finland Development Cooperation
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GIZ	German International Development Agency
GoV	Government of Viet Nam

HCMC	Ho Chi Minh City
HueWACO	Thua Thien Hue Water Supply Company
HUNRE	Hanoi University of Natural Resources and Environment
IBRD	International Bank for Reconstruction and Development
IDA	International Development Association
IDC	Infrastructure Development Companies
IFC	International Finance Corporation
IRRI	International Rice Research Institute
IUCN	International Union for Conservation of Nature
IWMI	International Water Management Institute
JICA	Japan International Cooperation Agency
MACC	Marginal Abatement Cost Curve
MARD	Ministry of Agriculture and Rural Development
MCD	Centre for Marine life Conservation and Community Development
MLD	Megalitres per day
MONRE	Ministry of Natural Resources and Environment
MoC	Ministry of Construction
MoF	Ministry of Finance
MoH	Ministry of Heath
MOIT	Ministry of Industry and Trade
MONRE	Ministry of Natural Resources and Environment
MoST	Ministry of Science and Technology
MoT	Ministry of Transport
MPI	Ministry of Planning and Investment
MOPS	Ministry of Public Security
MW	Megawatt
NAWASCO	Nghe An Water Supply Company
NOMAFSI	Northern Mountainous Agricultural and Forestry Science Institute
NRW	Non Revenue Water
NGO	Non Governmental Organisation
OECD	Organisation for Economic Co-operation and Development
OEPIW	Order on exploiting and protecting irrigation work

ODA	Official Development Assistance
PPC	Provincial People's Committee
PPP	Public Private Partnership
SAWACO	Saigon Water Corporations
SDC	Swiss Development Agency
SECO	State Secretariat for Economic Affairs, Switzerland
SERC	South East River Cluster
SIDA	Swedish International Development Cooperation Agency
SNV	Netherlands Development Organisation
SOE	State Owned Enterprises
SRI	System of Rice Intensification
TSS	Total Suspended Solids
WEI	Water Exploitation Index
WEPA	Water Environment Partnership in Asia
WRL	Water Resources Law
WWTW	Wastewater Treatment Works
UNDP	United Nations Development Programme
UNHABITAT	United Nations Human Settlements Programme
USAID	United States Agency for International Development
VEPA	Viet Nam Environment Protection Agency
WB	World Bank
VIUP	Viet Nam Institute of Urban and Rural Planning
VND	Vietnamese Dong
VNMC	Viet Nam National Mekong Committee

1 Introduction

2030WRG (www.2030wrg.org) is a public-private-civil society partnership that supports governments to accelerate reforms with the aim to ensure sustainable water resources management for the long-term development and economic growth of partner countries. 2030WRG supports the water sector transformation through convening a wide range of actors and providing comprehensive water resources analysis in ways that are digestible for politicians and business leaders.

Viet Nam is a country, which faces diverse water-related challenges whilst experiencing strong economic growth. To respond to these challenges, a partnership between the Government of Viet Nam, 2030WRG and the private sector is currently being explored.

In order to support all interested parties in identifying and aligning joint initiatives to work towards sustainable water resource management which enable long-term economic growth, an “Analysis of the water sector in Viet Nam” was commissioned to an international team comprising of Arup, the Institute of Social and Environmental Transition – International (ISET) and local Vietnamese specialists.

1.1 Objectives of the assignment

The objective of the assignment is to conduct a high-level overview assessment of Viet Nam’s water sector, with the aim of identifying water demand reduction solutions to drive economic growth (across sectors including agriculture, industry, urban development).

2030 WRG aims to accelerate water sector transformation in Viet Nam with regard to water security for long-term economic growth, meeting environmental and domestic needs and enabling shared prosperity. With this objective, a multi-stakeholder Advisory Board was established to guide the current analysis, in order to identify the water demand-supply gap, on-going initiatives, and cost-effective and technically feasible solutions to close the gap.

1.2 Approach

The assignment approach comprises three main activities:

- Technical analysis based on recent robust scientific data to assess the overall water resources situation and identify interventions to optimise water use;
- Extensive stakeholder consultations with the public and private sectors, non-governmental organisations, development agencies and academia to obtain information on the water sector challenges in Viet Nam and on-going water initiatives;
- Workshop to communicate findings, identify common issues and possible joint opportunities.

1.3 Multi-stakeholder consultations

Extensive field work was conducted including interviews and discussions with approximately 30 key stakeholders. The stakeholders included government ministries and organisations, the private sector, non-governmental organisations (NGOs), international organisations and academia. Stakeholders were identified based on their influence on the water sector in Viet Nam and their vulnerability with respect to future water resource challenges.

The interviews focused on exploring:

- Stakeholders’ roles and responsibilities related to water resource management
- On-going and recent water initiatives and programmes

- Risks, barriers and opportunities related to water resource and water demand management in Viet Nam
- Stakeholders' views on possible solutions to identified risks

The list of stakeholders consulted is included in Appendix A.

Following the completion of this report, a high-level conference will be organised with key decision makers from the public and private sectors and the civil society, in order to map the potential next steps of 2030WRG's involvement in Viet Nam.

2 Viet Nam: In context

The Socialist Republic of Viet Nam, home to 92 mn people, had a GDP of $159.2 bn in 2015, which equates to $1,735 GDP per capita, and an estimated GDP growth rate of 10.6%.[1]

In 1986 the Government of Viet Nam (GoV) enacted 'Doi Moi' (renovation), which embraced economic liberalisation policies including structural reforms to develop more competitive trade and export-driven industries.[2] Since then, the country has made huge strides in alleviating poverty and is now a middle-income country. The central government still holds tight control over the economy with 40% of GDP coming from State Owned Enterprises (SOE), though 500 SOEs were equitised by the end of 2015.[3] Viet Nam has been a member of the World Trade Organization since 2007 and joined the Trans-Pacific Partnership free trade negotiations in 2010.[4]

Viet Nam's geographic position near global supply chains, the growing consumer market, the pro-business economic reforms and expected benefits from the completion of the Trans Pacific Partnership combined with foreign investors' desire to diversify manufacturing away from China has led to a steady level of $17 bn/yr of Foreign Direct Investment (FDI) for the last five years. Korean and Japanese firms have led the foreign investment pack. Investment and economic development challenges remain significant, including weak legal infrastructure, low technical capacities, shortage of skilled labour, land use limitations, unclear and bureaucratic decision-making, infrastructure needs, and uncertainties about access to reliable and affordable energy in the future.

Foreign investment trends are dominated by manufacturing with an emphasis on high technological content. Investment in infrastructure has also seen increases, including power generation, roads, railways, and water treatment. Nonetheless, Viet Nam's rapid growth in recent years has outpaced its infrastructure, leading to major constraints to continued growth and investment. An estimated $200 bn investment in new roads, bridges, ports, water sanitation, power, and other infrastructure is required to sustain growth between now and 2020.[5] While the population is shifting from rural to urban living and FDI is leading to industrial growth, 48% of the labour force is still engaged in agriculture, 21% in industry and 31% in services (2012).[6]

The impressive economic growth and dramatic changes in society have resulted in significant challenges and growing disparities, which if left unchecked, could severely compromise the country's sustainable development. The Socio-Economic Development Strategy 2011-2020 calls for 'breakthroughs' in structural reforms, environmental sustainability, social equity and macroeconomic stability to allow Viet Nam to lay the foundations for a modern, industrialised society by 2020.[7]

With regard to water management Viet Nam is divided in 16 main river basins. Four river basins account for approximately 80% of Viet Nam's GDP – the Red -Thai Binh (25%), the Mekong Delta (17%), the Dong Nai (28%) and the South East River Cluster SERC (10%).[8] A location map of all basins is included in Appendix B.

3 Setting the scene: Water management in Viet Nam

3.1 Institutions and governance

Viet Nam is a single-party socialist republic country officially established in 1945. The country administratively comprises of 63 provinces and cities, with Hanoi being the capital. The National Assembly, "the highest organ of state power" according to the country's Constitution, is elected once every five years.

3.1.1 Institutional setting

Viet Nam has shifted its approach towards Integrated Water Resource Management (IWRM) when the Law on Water Resources was enacted in 1998. As this law revealed many weaknesses, and for example, did not regulate key aspects of water resource management, such as the protection of water resources, it was revised in 2012 to meet Viet Nam's new development policies and to be in line with the global development context.[i]

A dedication towards IWRM is also reflected in the Approval of the National Strategy on Water Resources to 2020 (Decision 81/2006/QD-TTg) which states that 'water resource management must be implemented in an integrated manner on a river basin basis'.

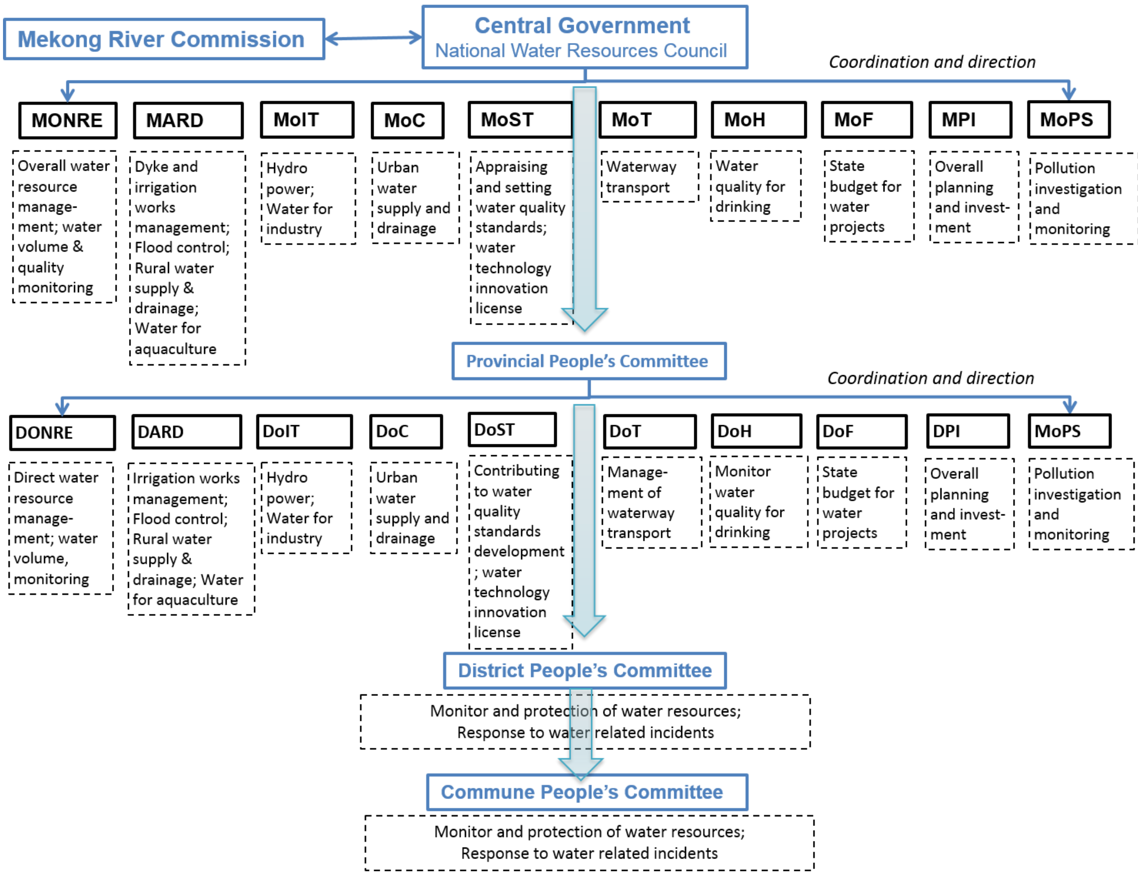
However, water resources are still mostly managed within the boundary of individual sectors and provinces; as opposed to an integrated river basin management system. Viet Nam has – as part of the Mekong River Commission – officially established the Mekong River Basin Committee.[9] Since 2016, the government and relevant ministries have discussed the establishment of another six major river basin management committees. None has been officially launched to date, however, a committee in Sesan Srepok River Basin, has been piloted by MONRE. Recently, the Da Nang city and the Quang Nam province also established a joint committee to initiate dialogue on Vu Gia – Thu Bon river basin.

[i] DWR (2015) IWRM and National Water Resources Protection Policy. Accessible under: http://dwrm.gov.vn/index.php?language=vi&nv=news&op=Hoat-dong-cua-Cuc-Tin-lien-quan/QUAN-LY-TONG-HOP-TAI-NGUYEN-NUOC-VA-CHINH-SACH-BAO-VE-NGUON-NUOC-QUOC-GIA-4172

3.1.2 Organisational structure of Viet Nam's water management

Water resources management in Viet Nam is organised at four administrative levels of national, provincial/city, district and commune. The basic institutional and organisational structure of water resource management in Viet Nam is shown in Figure 3 with further details on each entity in Appendix C.

Figure 3. Organisational and Institutional structure of Viet Nam's water and wastewater sector



In summary, ministries, ministerial-level agencies and other agencies attached to the Government are responsible for water resources management at national level and for the water management in large river basins, reservoirs, industrial zones and factories.

People's Committees at provincial/city and district levels and their attached agencies/divisions are responsible for water resources management within localities, water management in medium-size industrial zones and enterprises and the response to water-related incidents.

Clean water supply, irrigation and drainage companies, water professional associations and groups of water users are also stakeholders in water and wastewater management.

3.1.3 Relevant laws and regulations, licenses and permits

Viet Nam's key water policies and legal framework and their development over time are introduced in Table 1. The first law on water resources, the most important legal document on water resources, was issued in 1998, brought into force in 1999 and revised in 2012/13. Over 300 regulations have been used to establish water policy at the national and subnational level.[10]

Table 1. Viet Nam's key legal and regulatory framework related to water

Milestone	Description
1999	Law on Water Resources
2000	Rural Water Supply and Sanitation Strategy to 2020
2001	Law on use and protection of irrigation systems
2004	Decree on licensing for exploitation of water resources
2005	Law on Environmental Protection
2006	National strategy on water resources to 2020
	Establishment of Environmental Police
2009	Partial privatisation of water supply (socialisation or equitisation)
2011	Third revision of Water Resources and Sanitation Strategy to 2020 and Vision to 2050
2012	Principles and methods for calculating water supply fee
2013	Revised Law on Water Resources
2014	Policies and measures for mobilising funding to invest in water supply, waste water sewage
	Revised Law on Environmental Protection
	Decree on drainage, sewage and waste water treatment
2015	Decree on waste and materials management
2016	Adjusted decree on payment for environmental service: increased fee of PES for hydropower and water supply
2017	Law on Hydraulic / Irrigation Works (drafted and shared for comments since March 2015)[11]
	Irrigation Law (approved 19 June 2017)

Source: Authors and adopted from Nella Canales Trujillo et al (2015).[12]

Waste discharge activities and irrigation work systems (IWS) must be licensed by an authorised government office (Article 37 WRL, Article 26 OEPIW), and are regulated by the Water Resources Law (WRL), the Order on Exploiting and Protecting Irrigation Work (OEPIW), and the Decrees on drainage, sewage and wastewater management and on waste and materials management. The latter, states that 'wastewater must be collected, treated, re-used or transferred to functional units suitable for re-use or treatment up to environmental technical standards before being discharged into the environment' (Article 4). Industrial zones are obliged to have wastewater treatment systems to treat the entire wastewater generated from operations. Companies outside of industrial zones must also have wastewater collection and treatment systems (Article 37).

Up to 2011 water resource planning in Viet Nam focused on surface water resources with relatively minor consideration of groundwater and groundwater resource protection. According to the 1999 Law on Water Resources, permits are required for groundwater supply units and industrial wells. Recognition of dwindling supplies and deteriorating quality has led the Prime Minister to issue Decision 1251/QD-TTg in September 2008 and Decision 2065/QD-TTg in November 2010.[13] Decision 1251 approves water supply planning in key economic zones[14] in three Northern, Central and Southern ecological regions, calling for reasonable use of groundwater. Decision 2065 also approves water supply planning in the key economic zones in the Mekong region including step-by-step reductions in groundwater use, with cessation of groundwater exploitation in key economic zones by 2020.

The Government of Viet Nam grants the following types of water resources licenses and permits: 1) Licence for underground water exploration; 2) Permit for surface water exploitation and use; 3) Licence for exploitation and use of underground water; 4) Licence for sea water exploitation and use; and 5) Licence for discharge of wastewater into water sources (Article 15, Decree 201/2013/ND-CP).

3.1.4 Economic and regulatory instruments

Viet Nam's economic instruments for charging organisations and individuals that use water and water surface area, discharge wastewater into water sources, and violate water-related regulations are described below. Applications of those instruments vary at different scales (national, subnational) and water uses.

Fee for domestic clean water: Circular 88/2012/TT-BTC of Ministry of Finance stipulates that organisations and individuals using clean water for domestic purposes supplied by a water supply company are charged based on the volume of water used measured by a water meter. The fee is paid directly to the company.

Fee for industrial water uses: Organisations and industries can – depending on their location - receive water from the water supply company or from the irrigation works. If they receive water from the water supply company, the Provincial People's Committee will – after consultation with the company - decide the level of the fee (Circular 75/2012/TTLT-BTC-BXD-BNNPTNT). If water is supplied from the irrigation works, the fees are described in Decree No. 67/2012/ND-CP.

Fee for water use from irrigation works: Water from the irrigation works is used for agricultural activities, including aquaculture, as well as for non-food production or industrial purposes. Fee related to this source of water includes fee / tariff for water resources use and costs for the operation and management of the irrigation works.

Those using water from the irrigation works for agricultural activities pay the irrigation and drainage management company based on irrigated area of crops; those using water from the irrigation works for non-food production or industrial purposes pay based on volume of water consumed. These are stipulated in Decree 67/2012/ND-CP of the Government.

However, in 2013 the Ministry of Finance issued Circular 41/2013/TT-BTC[15], which exempted basically all users from the irrigation fee, i.e. making irrigation water free to use.[16] Farmers only had to manage and pay for connecting their fields to the irrigation system.

Following discussions among scientists and relevant ministries on the inefficiency of the recent irrigation fee policy (corruption issues and the heavy burden on the state budget)[ii,17], a new Irrigation Law was passed by the National Assembly on June 19, 2017.[iii]

The law introduced that irrigation services now need to be paid for by the users. Irrigation prices will comply with the provisions stated in the Law of Price and shall include management costs, operation and maintenance expenses, depreciation charges, and other reasonable actual expenses and allow for profits which are deemed suitable to the marketplace. The affordability if the users to pay for irrigation products and services will be considered when setting the price level. The state shall determine the price of irrigation services and products and the roadmap for adjusting these is already approved by the competent state agencies (Article 34).

Fee for wastewater discharge and environmental protection: Organisations and individuals, aside from identified exempt cases[18], pay for the treatment of discharged wastewater. The payment, besides an annual fixed amount, is calculated based on volume of water used (for domestic consumption) and pollution content of their discharge, in particular, for industrial, agricultural and service activities. Water

[ii] Operation costs—including personnel salary, management fees, irrigation (and discharge) system maintenance fee, pumping costs, etc.—of irrigation service companies are largely covered by the state budget. The costs for each company are calculated based on agricultural areas the company can provide sufficient water for cropping. But in fact the companies do not provide enough water as planned and/or the quality of service is lower than the budget allocated to them. The ask-and-give mechanism, poor/weak monitoring system and collusion (between budget provider and the irrigation companies) allow the companies to claim more than what they provide. Cases have been exposed in Hanoi, Thanh Hoa, Gia Lai and Quang Ngai.

[iii] The reference number of the Irrigation Water Law is 08/2017/QH14.

supply and drainage companies, together with provincial, district and commune people's committees, are responsible for collecting the charges. These are then submitted to the state treasury and used for environmental protection activities. This is promulgated in Decree 154/2016/ND-CP of the Government.

Fines on water pollution: MONRE/ DONRE in cooperation with the Environmental Police, which is established under the Ministry of Public Security, are responsible for monitoring water quality and identifying violations to regulations. Once a violation is identified, the Provincial People's Committee is informed and takes action. Fines are applied to organisations and individuals who violate water resources and/or environmental protection regulations. Depending on nature of the violation, warning, compensation, request for restoration, licence/permit stripping, or a combination of those measures, are enforced by provincial and district people's committees. This is stipulated in Decree 155/2016/ND-CP.

3.2 Viet Nam: National overview

3.2.1 Water resources

Highlights:

- Total renewable water resources amount to 884 bn m^3/yr, while only 42% is sustainably exploitable
- 63% of water resources originate outside of Viet Nam
- Hydropower, national and international, poses challenges to reliable supply
- Urban water treatment plants only meet 55-70% of potable water demand

Viet Nam has a dense and complex river network, with most of the large river systems linked. The river system comprises approximately 2,360 rivers which exceed a length of 10 km. Viet Nam has sixteen main river basins, of which nine river basins contribute 90% of the total river basin area in the country.[19] These river basins are as follows: Red, Thai Binh, Bang Giang-Ky Cung, Ma, Ca La, Thu Bon, Ba, Dong Nai, and Mekong River Basins. The average annual rainfall in Viet Nam is about 1940-1960mm.[20] Viet Nam's total annual surface water runoff is estimated at 830-840 bn m^3, approximately 59% of which is available in the Mekong Basin and 17% in the Red-Thai Binh Basin.

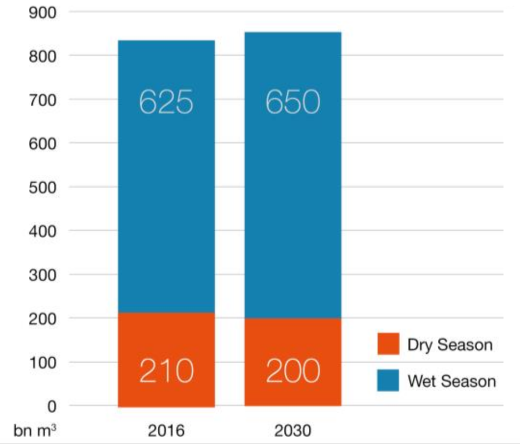
According to FAO estimates, 43% of the surface water nationally can be sustainably exploited. In the dry season which ranges (depending on location) from six to nine months (typically January to June), the total natural discharge and rainfall is only 20-30% of total annual volumes.

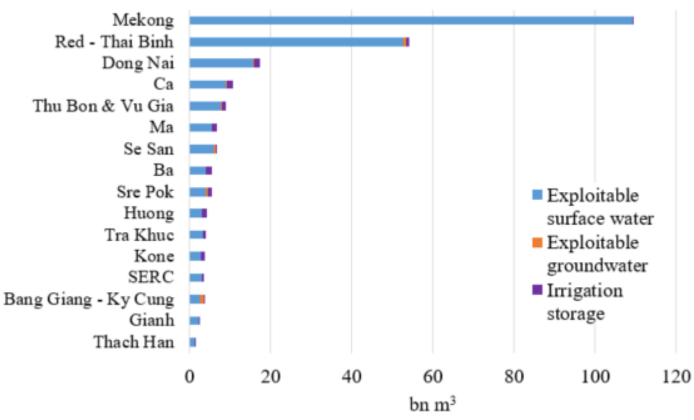
Viet Nam has an irrigation water storage capacity of 12.48 bn m^3, with 80% of these reservoirs functioning as multi-purpose reservoirs.[21] The bulk of the storage capacity (57%) is located in the North and Central Coast. In addition, reservoir storage for hydropower purposes is estimated at 56.8 bn m^3. Hydropower is discussed further as a components of water demand in section 3.2.2.5.

Viet Nam's total groundwater potential amounts to 63 bn m^3/yr, i.e. 8.4% of the total annual water availability.[22] According to FAO estimates, only 7% of the groundwater is sustainably exploitable. Groundwater in Viet Nam is assessed at a regional rather than a river basin level. For the purpose of this study, an estimate of the groundwater allocation per river basin is used.

Climate change is expected to increase the total annual water run off by 15 bn m^3, i.e. 1.5% of the current annual water run off, by 2030.[23] However, the seasonal distribution is predicted to change with dry season run off reducing by10 bn m^3/yr, while wet season run off increasing by 25 bn m^3/yr. An overview of the total water resources for Vie Nam's main basins is shown in Figure 4.

Figure 4. Left: National water run off in dry and wet seasons, 2016-2030; Right: Overview of exploitable water resources in the dry season, per river basin (2016)

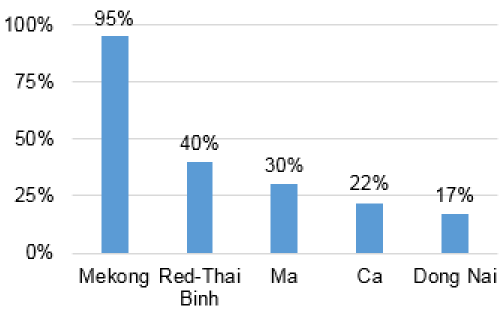




Source: Institute of Water Resource Planning (left); Current study (right)

High trans-boundary water dependency increases the uncertainty of future economic output in Viet Nam's key economic regions. With 63% of total surface water originating from upstream countries such as Cambodia, China and Lao PDR, Viet Nam is highly dependent on its neighbours.[24] For example, the Mekong and Red River Basins, contributing jointly approximately 42% of Viet Nam's GDP, receive 95% and 40% of the annual flows respectively from outside of Viet Nam (refer to Figure 5). As economic activities in these basins, i.e. mostly industry and rice production, are highly water intensive, this poses a significant risk to Viet Nam's future.

Figure 5. Percentage of average annual surface water flows in river basins originating outside Viet Nam



Source: ADB Water sector review (2009)

Upstream hydropower dam construction, particularly in the Mekong and Red-Thai Binh river basins, is considered to pose a significant risk on future surface water flows. The 11 hydropower dams, which are planned to be constructed in Lao PDR and Cambodia, in addition to those planned by China, are considered to have potentially adverse impacts on river flows and sediment loads.

A recent breach of a Mekong River Commission procedure by Lao PDR, in which it did not consult on the construction of the new hydropower dam Don Sahong, along with a growing influence on China financing hydropower projects in Lao PDR are observed with increasing concern by the downstream countries.[25]

3.2.2 Water demand

Water demand estimates, current and projected, differ across studies. As such, the ADB estimated the total water demand to be 80.2 bn m^3/yr in 2009.[26] A report by the Institute of Water Resource Planning (2015)[27] estimated current water demand at 80.6 bn m^3/yr and at 95 bn m^3/yr in 2030. A study by the

Agriculture and Forestry University (2013) estimated water demand in 2013 at 115.4 bn m^3/yr.[28] To understand the magnitude of water demand in 2016 and 2030 per river basin, this study uses the data from the ADB study to project water demand in 2016 and 2030 based on assumptions specified below. The information was complemented with current information on reservoir storage for hydropower generation. Further details on the assumptions made are included in Appendix D.

3.2.2.1 Agriculture

While the agricultural sector only contributes 18% to the GDP, it comprises of 48% of the labour force and uses 80% of total water resources - and continues to grow as a sector.[29] Viet Nam is the top global producer of pepper, the second largest global producer of coffee after Brazil, the third largest global producer of aquaculture products and the fifth largest global producer of tea. Viet Nam is also the second largest exporter of rice, a highly water intensive crop.[30]

In Viet Nam, 35% of the land is used for agriculture; 20.6% (11.8 mn ha) is arable land, 12% is used for permanent crops and 2.1% for permanent pasture. Some 55% of the arable land (3.9 mn ha) is equipped with irrigation infrastructure. The Mekong and the Red-Thai Binh river basins are Viet Nam's key agricultural areas, with 56% and 15% of the irrigation works installed respectively.

Rice is the dominant crop grown and irrigated in Viet Nam; 58% of the irrigated area is used for rice production and 96% of the rice area is irrigated. Rice production is dominated in three regions: the Southern Delta, which includes the Mekong Delta and accounts for approximately 50% of total rice production, with the remaining share mostly produced in the Northern Delta and the Northern Highlands.[31]

In Viet Nam, rice can be produced in four growing seasons and up to three times a year in the Mekong Delta. The total production volume of rice amounted to 45 mn tonnes in 2014. Other key crops include maize (1.2 mn ha, 5 mn tonnes), vegetables (0.89 mn ha, 16 mn tonnes), coffee (0.65 mn ha, 1.4 mn tonnes), rubber (0.6 mn ha, 1 mn tonnes), cassava (0.6 mn ha, 10 mn tonnes) and sugar cane (0.3 mn ha, 20 mn tonnes).[32]

Water requirements for rice in Viet Nam range between 10,000-12,000 m^3/ha in the winter-spring (dry) growing season and approximately 5,000 m^3/ha in the summer-autumn (wet) growing season.[33] Almost 45% of Viet Nam's irrigation water is used in the Mekong River Basin, almost exclusively for paddy rice.[34] According to the Agricultural Master Plan 2020, the rice production area shall not be expanded beyond 3.8 mn ha. The target is to produce 41 to 43 mn tonnes/yr in 2020 and 44 mn tonnes/yr in 2030 in order to ensure food security and export the balance.[35]

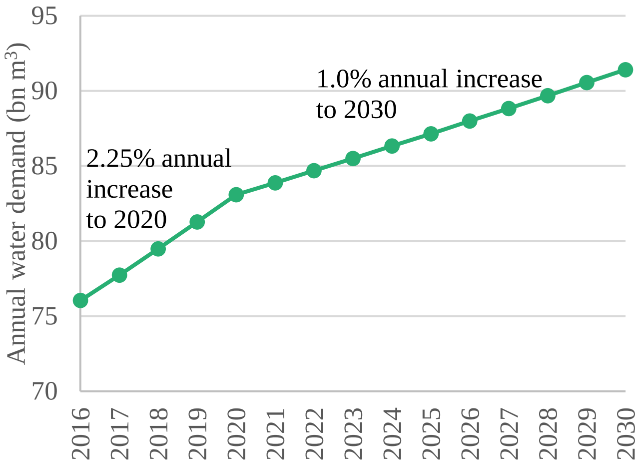
Coffee is predominantly grown in the Central Highlands (90%), with the Dak Lak province accounting for about one third of the coffee growing area. Supplementary irrigation from either surface water or groundwater is required during the dry season (Jan-April). Average water demand amounts to 4,000 m^3/ha.

A university study from 2013 stated that 'the irrigation system in Viet Nam is seriously degraded, meeting only 50-60% of the design capacity'. It also found that the cost of irrigation in Viet Nam was the highest across Southeast Asia.[36]

Total annual agricultural water use in 2016 is estimated at 76 bn m^3 and is projected to increase to 91 bn m^3 by 2030 (refer to Figure 6). The increase in irrigation water demand is expected to level out after 2020 as the area of paddy rice production will be capped.

Figure 6. Left: Agricultural water demand highlights; Right: Assumed agricultural water demand to 2030

Highlights:
- Water demand (2016): 76 bn m^3/yr
- Water demand (2030): 91 bn m^3/yr
- Main crops: Rice, maize, coffee, sugarcane
- 58% of irrigated area is used for rice production
- 96% of rice area is irrigated
- Main rice growing regions are Mekong (50% of all production), Red River Delta and Northern Highlands



3.2.2.2 Aquaculture

Aquaculture contributes 2.5% to 3.5% to Viet Nam's GDP, and forms 65% of Viet Nam's total fisheries export value. The sector is increasing in importance with an average annual growth rate of 12%. However, while fisheries are a large source of foreign exchange, food safety is an increasing concern with shipments being rejected by importing countries due to antibiotic residues and other contaminants.[37]

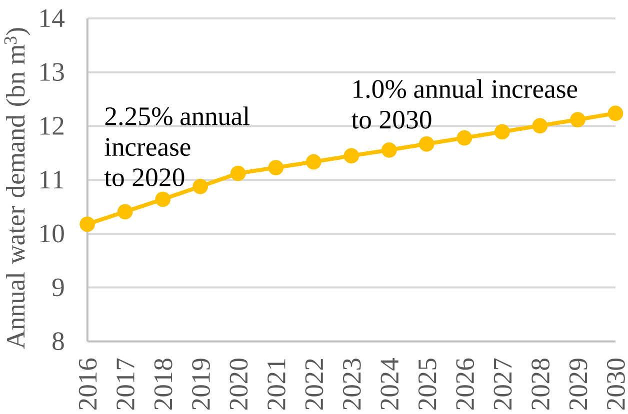
Aquaculture is seen as a viable alternative to rice production in areas, which have become too saline for rice – a factor explaining the rapid annual increase in production. However, according to MARD, the area for brackish water shrimp farming had to be temporarily reduced by 50%, due to too high saline levels during the recent drought.[38] Similarly, an increase in consumptive water use in the basin will lead to reduced freshwater flows and have a detrimental impact on the aquaculture industry.

Aquaculture production is concentrated in the Mekong River Basin, requiring 65% of the national aquaculture water demand. Other river basins with fish farms include Red-Thai Binh (9%), SERC (8%), Ma (4%) and Ca (3%).

Total freshwater use for aquaculture is estimated at 10 bn m^3/yr in 2016 and is projected to increase to 12 bn m^3/ yr by 2030 (refer to Figure 7).

Figure 7. Left: Aquaculture water demand highlights; Right: Assumed aquaculture water demand to 2030

Highlights:
- Water demand (2016): 10 bn m^3/yr
- Water demand (2030): 12 bn m^3/yr
- Aquaculture forms 65% of Viet Nam's total fisheries export value
- Current annual growth rate of 12%



3.2.2.3 Industry

Viet Nam has developed competitive manufacturing sectors with intensive low-cost labour and assembly industries, which require extensive water use. Industry contributes 39% of the GDP and is growing fast (at an estimated 7% in 2016). Main industrial activities include food processing (9% of GDP), chemical industry (2%), textile and dyeing (6%), leather, paper and pulp production and automobile repair and mechanics (6%).

Industries are concentrated around three key river basins, namely Red-Thai Binh, South East River Cluster (SERC) and Dong Nai, and account for 80% of the industrial output. Some 65% of the craft villages are located in the Red-Thai Binh River Basin. The Red-Thai Binh basin accounts for nearly half of the total industrial water use nationwide, while the Dong Nai, Mekong and SERC basins account for 25%, 10% and 7% respectively.

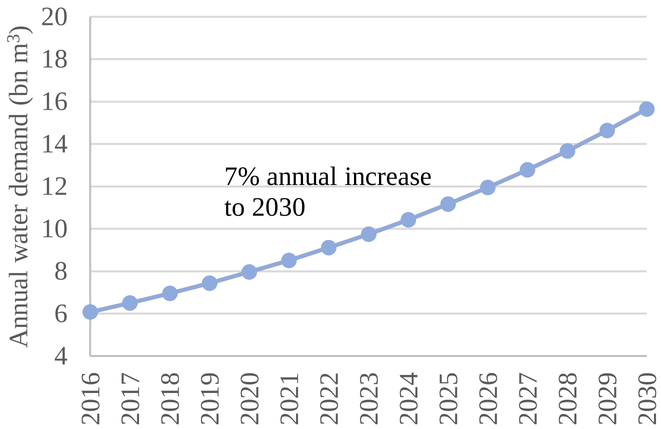
Although industrial water demand is not disclosed or reported, Viet Nam's standards for construction No33:2006 (TCXDVN33:2006) indicates that industrial sectors such as liquid, milk, food processing and paper have an estimated water demand of 45 m^3/hectare/day. Published data indicates that industrial park water demand can be significantly higher at 75 m^3/hectare/day.

The total annual industrial water usage is estimated at 6 bn m^3 in 2016 and is projected to increase to 15.6 bn m^3 by 2030 (refer to Figure 8).

Figure 8. Left: Industrial water demand highlights; Right: Assumed industrial water demand to 2030

Highlights:

- Water demand (2016): 6 bn m^3/yr
- Water demand (2030): 15.6 bn m^3/yr
- GDP contribution of 39%; average growth rate 7%
- 80% of industrial output come from Red Thai Binh, SERC and Dong Nai River Basins



3.2.2.4 Municipal

Although Viet Nam's population growth rate has stabilised at 1.03% (2017) from a high of 3% (1960), there has been a rapid growth in urban population due to inward migration. This is the result of employment opportunities in the growing industrial sector in cities and reduced employment in agriculture due to mechanisation. Viet Nam has one of the fastest rates of urbanisation in the world, with almost 43% of the country's population expected to be living in cities by 2030.[39] While more than two-thirds of the population still live and work in provincial towns and villages, the cities of Hanoi, Ho Chi Minh, Da Nang and Haiphong are growing rapidly.

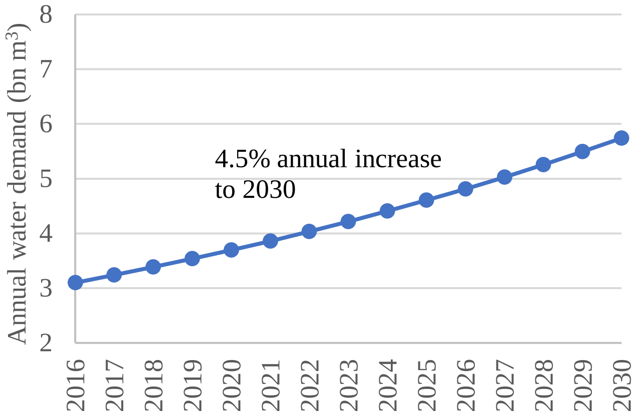
Viet Nam as an emerging economy could grow at 5% or more per annum until 2030.[40] This is likely to result in an improvement of living standards and water supply and sanitation. Currently approximately 300 out of 635 towns and cities are planning projects to construct new water supply systems. The current water demand of 30 mn people living in urban areas for drinking, sanitation, business and services are estimated at 8 to 10 mn m^3 per day. The total designed capacity of water treatment plants in urban areas is about 5.4 mn m^3/day i.e. it meets less than 70% of the urban water demand.

Up to 62% of rural population is supplied with sanitary water and up to 30% with drinking water. Water supply for domestic uses and sanitation activities of people in many urban areas and rural areas is largely from groundwater.[41]

Data from over 90 water utilities in Viet Nam indicate an average water use of 110-120 l/capita/day. The total annual municipal water usage is estimated at 3.1 bn m^3 in 2016 and is projected to increase to 5.7 bn m^3 by 2030 (see Figure 9).

Figure 9. Left: Municipal water demand highlights; Right: Assumed municipal water demand to 2030

Highlights:
- Water demand (2016): 3 bn m^3/yr
- Water demand (2030): 5.7 bn m^3/yr
- One of the fasted urbanisation rates in the world
- Currently water treatment meets less than 70% of the urban water demand



3.2.2.5 Hydropower generation

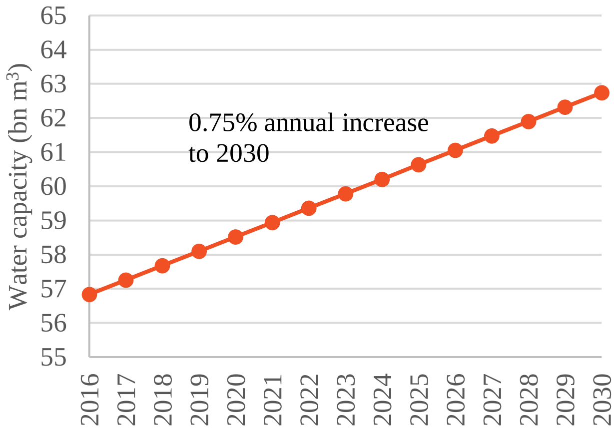
Hydropower generation has been a key enabler of economic growth and has particularly promoted the industrialisation and modernisation of Viet Nam since 1990s. Viet Nam's hydropower capacity in 2016 amounts to 16,982 MW. The bulk of the hydroelectric plant capacity is located in the Red -Thai Binh basin (47%), followed by the Dong Nai (16%) and Se San (12%) basins. The total disclosed water reservoir capacity amounts to 57 bn m^3, but in reality it is likely to be higher.

According to the Power Development Plan 2011-2020, the total hydropower capacity will increase to 21,600 MW by 2020 and 27,800 MW by 2030.[42] While the Open Mekong Database lists 29 hydroelectric plants that are currently under construction (814 MW), the water storage capacity for the remaining 10 GW of planned expansion is not available yet. Future water capacity is, therefore, expected to be significantly higher than illustrated in the 2030 scenario.

For the purpose of our assessment, the total hydropower demand is estimated at 57 bn m^3 in 2016 and assumed to be 63 bn m^3 by 2030 (refer to Figure 10). A detailed overview per region, river basin and plant scale is available in Appendix D.

Figure 10. Left: Hydropower capacity highlights; Right: Assumed hydropower water capacity to 2030

Highlights:
- Water storage capacity (2016): 56.8 bn m^3/yr
- Water storage capacity (2030): 62.7 bn m^3/yr
- Hydropower is a key enabler to economic development and industrialisation
- Capacity is expected to increase significantly by 2030



4 Main challenges and implications

This section sets out the key water management challenges in Viet Nam, including water stress, water pollution, climate change as well as institutional issues. It then summarises the implications and impacts of these challenges both nationally and at river basin level.

4.1 Water stress and water shortages

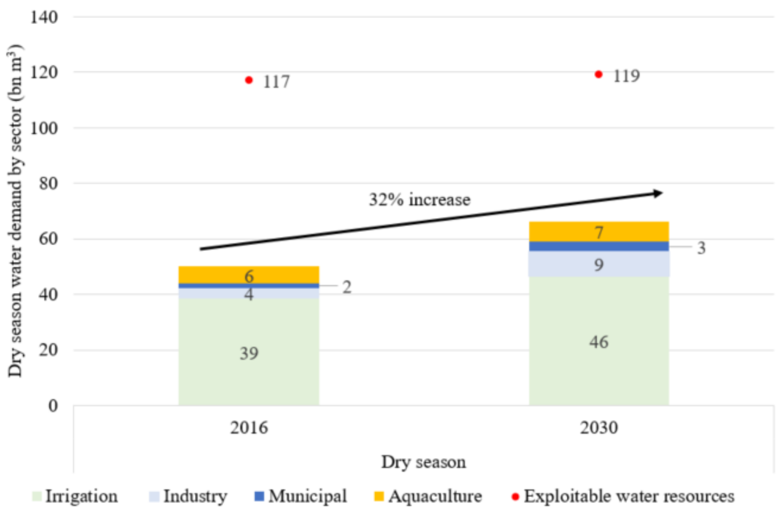
It is well documented that water scarcity results in significant environmental, social and economic impacts. The analysis focuses predominantly on the four river basins which account for approx. 80% of Viet Nam's GDP, namely the Red-Thai Binh (25%), Dong Nai (28%), Mekong Delta (17%) and SERC (10%). The Mekong and Red Thai Binh river basins are also key in achieving Viet Nam's food security, as most rice is produced in these deltas.

4.1.1 Current and future water availability and demand

4.1.1.1 National level

On a national level, Viet Nam does not face an annual water supply and demand gap in 2016 or 2030. The comparison of exploitable water resources[iv] and water demand for the dry season also reveals that Viet Nam has sufficient resources to meet the current and future water demands (refer to Figure 11).

Figure 11. Dry season water demand by sector in Viet Nam



Source: Current study

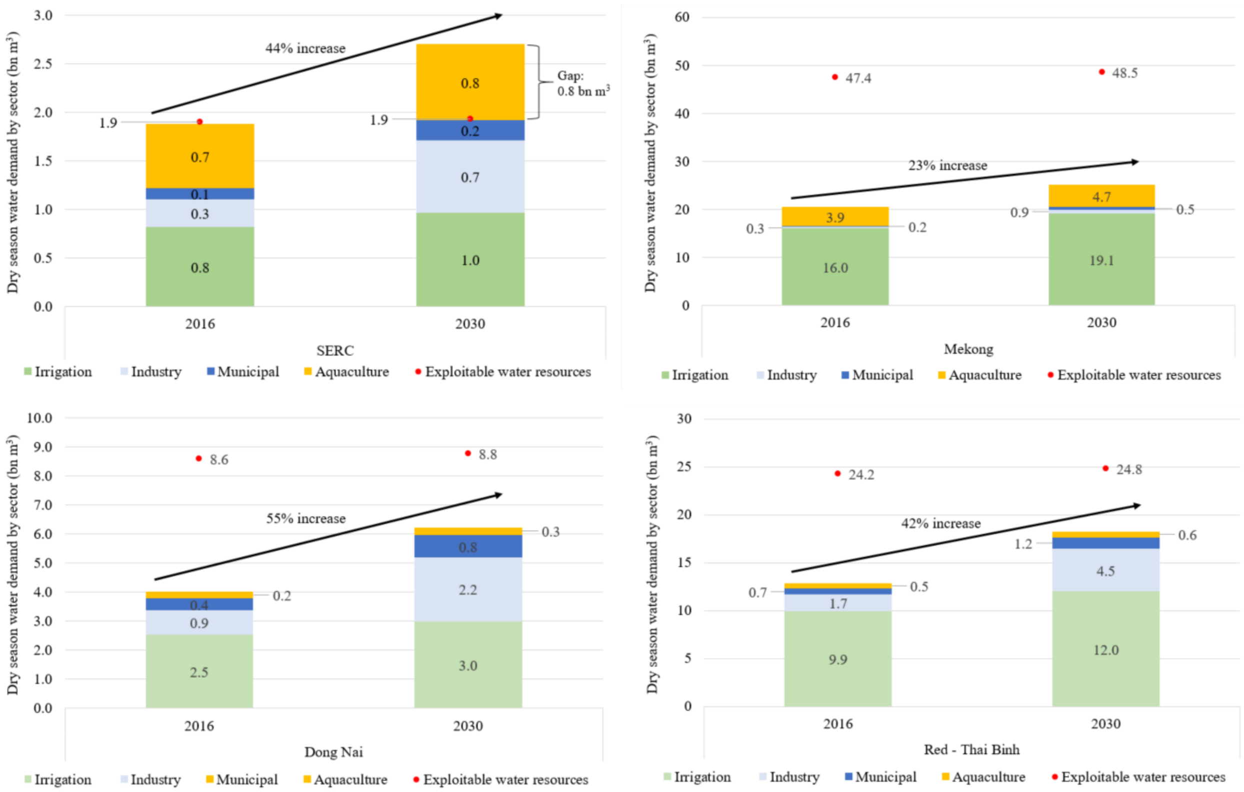
4.1.1.2 River basin level

The water supply and demand assessment is more meaningful, though, at river basin level. The water supply-demand gap indicates the difference between water demands from all sectors and the total available water supply for a river basin, either at an annual or seasonal basis, such as dry-season assessment undertaken in this study.

[iv] For the purposed of this analysis, exploitable water resources are defined as the sum of renewable surface water resources, groundwater potential and irrigation reservoirs

The analysis shows that the Red-Thai Binh, Dong Nai and Mekong basins are not expected to face a dry season water supply-demand gap by 2030. The SERC basin, however, is projected to face a water shortage of approximately 770 mn m^3/yr (28% of total demand) by 2030 (refer to Figure 12). Water demand in SERC is not typical for Viet Nam as it is balanced across three sectors, namely, agriculture (36%), aquaculture (29%) and industry (27%) rather than dominated by agriculture.[v]

Figure 12. Water demand projections (dry season only) for Mekong, Red-Thai Binh, Dong Nai and SERC river basins



Source: Current study

4.1.2 Water Exploitation Index

The water exploitation index (WEI), or withdrawal ratio, is defined as the mean annual total abstraction of fresh water divided by the long-term average 'renewable' freshwater resource availability and it allows the assessment of the water stress in each river basin.[vi] These renewable resources are rivers and recharging freshwater groundwater, and WEI helps to indicate whether the water abstraction rates balance the needs of water by the people, industry and agriculture with the needs of water by the environment.

While the water supply-demand gap assessment is a good indicator of the river basins facing water shortages, the WEI provides a more granular picture of how the total water demand puts pressure on the available water resource and whether rates of abstraction are sustainable over the long term. The thresholds are based on the view that freshwater ecosystems cannot remain healthy in water stressed conditions.

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[v] Please note that besides SERC, Ma river basin is also expected to face a water shortage of 310 mn m^3 (8% of water demand). However, as the Ma river basin – mainly agricultural – is comparatively not as economically significant as the four river basins mentioned above, it is not further analysed in the main report. Details can be found in Appendix I.

[vi] Please note that the original methodology suggests to consider abstractions minus return flows. However, as this information is not available, total water abstractions are considered.

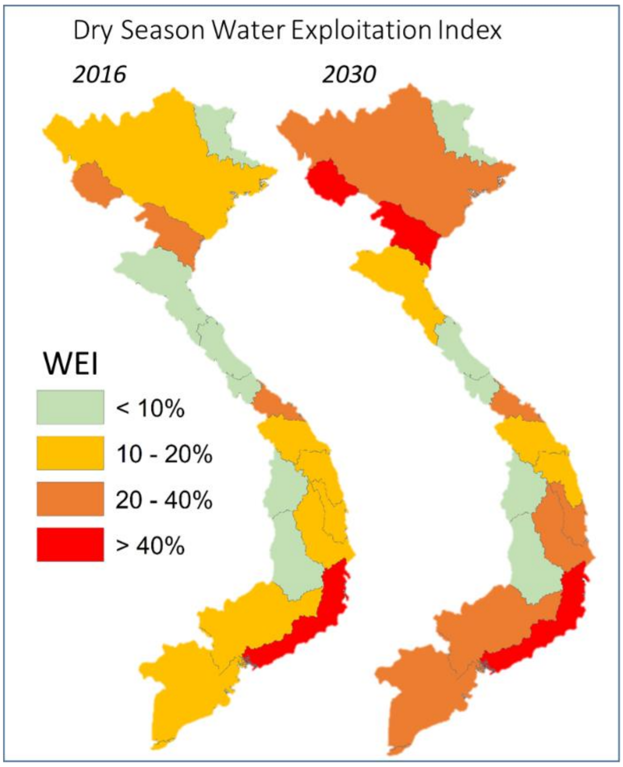
For this assessment, the following threshold values / ranges for the water exploitation index have been used to indicate levels of water stress:[vii]

(a) non-stressed river basins < 10%; **Green**
(b) low stress 10 to < 20%; **Amber**
(c) stressed 20% to < 40%; and **Brown**
(d) severe water stress ≥ 40%. **Red**

Table 2 illustrates the water stress levels for river basins in the dry season, assuming that water from hydroelectric reservoirs will be made available to downstream water users as required.

Table 2. Water stress levels in the dry season in 2016 and 2030, excluding hydropower storage

Basin	2016	2030
Bang Giang - Ky Cung	1%	2%
Red - Thai Binh	19%	27%
Ma	35%	44%
Ca	9%	12%
Gianh	2%	3%
Thach Han	5%	6%
Huong	23%	28%
Thu Bon & Vu Gia	11%	15%
Tra Khuc	13%	16%
Kone	19%	23%
Ba	19%	24%
Dong Nai	19%	28%
SERC	41%	58%
Se San	<1%	1%
Sre Pok	5%	6%
Mekong	19%	22%



Source: Current study

The SERC river basin is assessed as 'water severely stressed' both in 2016 and 2030. By 2030, all but five river basins are expected to face some level of water stress. Three basins are expected to face 'low stress', six basins face 'stress' and two 'severe water stress'.

The river basins, which generate approximately 80% of GDP in Viet Nam, are expected to experience 'severe water stress' (SERC) or 'water stress' (Red-Thai Binh, Dong Nai and Mekong).

While agriculture remains the dominant water user in the Red-Thai Binh, Dong Nai and SERC river basins, industrial water usage is also significant (25%, 35% und 28% in 2030, respectively) and projected to increase on a national scale by 160% between 2016 and 2030. Thus, industrial water demand, with an approximate increase of 160% and municipal water demand, with an approximate increase of 85%, are the key drivers of increased water demand by 2030 across all river basins.

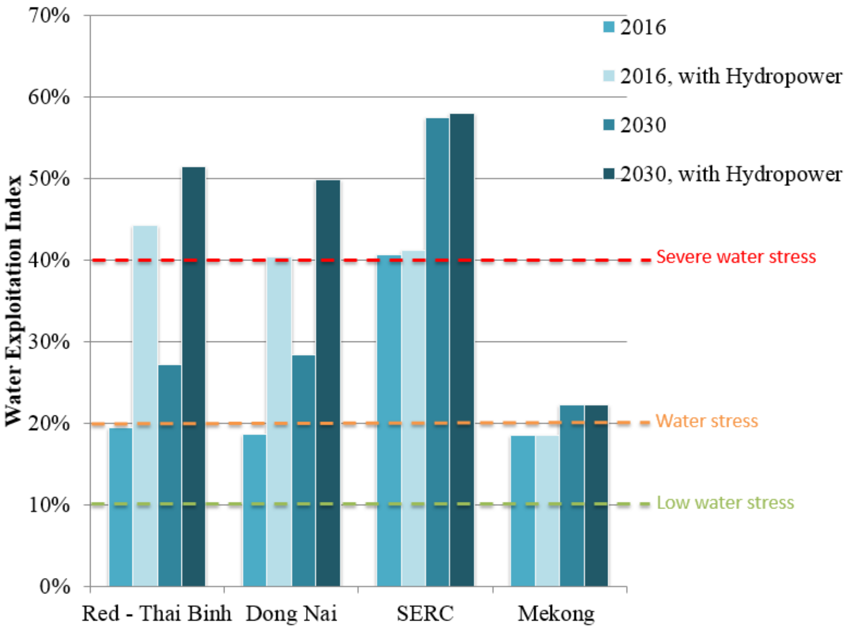
[vii] The threshold values/ranges above are averages and it would be expected that areas for which the water exploitation index is above 20% would also be expected to experience severe water stress during drought or low river-flow periods.

As discussed previously, the Mekong basin produces 50% of Viet Nam's rice and water stress could pose a national threat to food security and export revenues.

Water allocation conflicts between water for hydropower generation and other water uses during the dry season could increase water stress levels further. Figure 13 shows that the Red – Thai Binh and Dong Nai River Basins, which account for over 50% of Viet Nam's GDP, are sensitive to hydropower storage. The Red-Thai Binh River Basin is highly vulnerable, despite not showing a water supply-demand gap by 2030.

A detailed breakdown of the river basin specific stress levels, as well as the water demand per sector (agricultural, industrial, municipal) is available in Appendix E.

Figure 13. Water Exploitation Index for key basins - with and without hydropower storage, 2016-2030



Source: Current study

4.2 Water pollution

In general, the quality of surface water, along with biodiversity, in the upstream end of Viet Nam's river basins is relatively good. However, the water quality of river reaches flowing through urban areas, industrial zones and crafts villages further downstream deteriorates, in some cases seriously, as most municipal and industrial wastewater is discharged untreated into water bodies. Agricultural run-off from an increased (over-) application of fertilisers and pesticides further reduces surface and groundwater quality.

By the end of 2015, the total capacity of 35 centralised municipal wastewater treatment plants in Hanoi, Ho Chi Minh City, Da Nang and other large cities was about 850,000 m^3/day, which equates to 12-13% of Viet Nam's municipal wastewater treatment requirements.[43] In addition, it has been estimated that several thousands of decentralised wastewater treatment plants have been constructed and installed across the country[44] for the purpose of treating domestic wastewater from residential areas, hospitals, hotels and office buildings. Despite this, only 50% of the hospitals and 7% of the 23,500 livestock farms in Viet Nam have wastewater treatment systems as of 2014.[45]

Wastewater discharged from industrial factories and industrial zones also exert great pressure on the surface water environment in the country. While it is mandatory by law for industries to treat their wastewater, in effect only 10% volume of the industrial wastewater is treated.[46]

Figure 14. Status of industrial wastewater management in Viet Nam[47]

Industrial wastewater discharges

- **Industrial zones:** Total effluent discharges of 450,000 m^3/day.
- **Industrial complexes:** 610 operating complexes. No data of discharging.
- **Craft villages:** 5,000 villages; no data of wastewater discharging.

Industrial wastewater treatment

- **Industrial zones:** 60% of the effluent from 212 out of 283 operating industrial zones is treated for some pollutants. Only 35% is treated to required standards.
- **Industrial complexes:** 5% of operating industrial complexes have effluent treatment systems
- **Craft villages:** No treatment; direct discharges to environment.

Automatic monitoring system

- **Industrial zones:** **A**lmost 40% of the 212 industrial zones have automatic monitoring system.
- **Industrial complexes:** Non automatic monitoring system.
- **Craft villages:** Non automatic monitoring system.

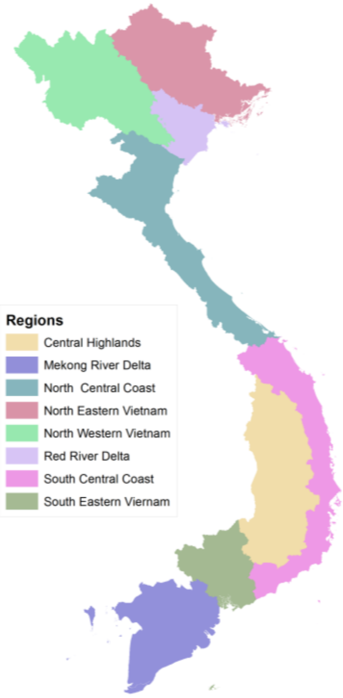
A detailed assessment of the industrial sector in 2008 indicated that the top 3 polluting industries in Viet Nam were paper and wood production, chemical production and processing and metal. Since then, the food and drink and textile industries have grown rapidly and are responsible for large portions of the industrial pollution load.

In addition, there are 5,000 craft villages in Viet Nam with over 65% of them located in the Red-Thai Binh basin. These villages usually discharge untreated wastewater directly into water bodies without any treatment.[48]

An overview of Viet Nam's water pollution challenges can be seen in Table 3. More detailed information on water pollution hotspots and the status of the municipal and industrial wastewater treatment in Viet Nam is available in Appendix F.

Table 3. Status of water quality in Viet Nam

Region	Rivers		Groundwater	Pollution			
	Upstream	Downstream		Urban	Industrial	Agriculture	Saline
Northwest Region	5	4	5	X			
Northeast Region	5	2	4	X	X		X
Red River Delta	4	2	3	X	X	X	X
North Central Coast	4	3	4	X		X	
South Central Coast	5	2	4	X	X		
Central Highlands	5	4	5		X		
North East of Mekong	4	1	3	X	X		X
Mekong River Delta	4	2	3	X	X	X	X



Notes:

- 5: good quality → 1: very poor quality
- The assessment and scoring are based on the detailed information provided in Appendix F.

4.3 Climate change

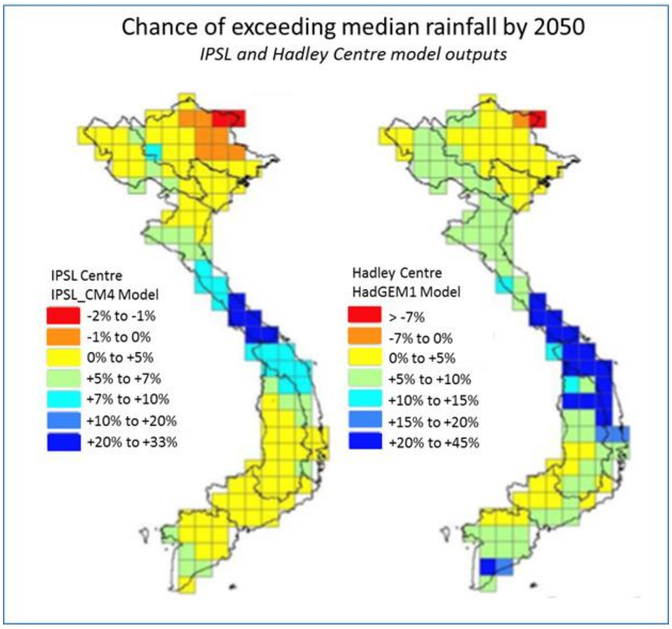
Viet Nam is expected to be one of the five most affected countries by climate change.[49] ADB estimates that costs due to climate change could amount annually up to 7% of Viet Nam's GDP by 2100, which is significantly higher than the global average.[50] The Central Highlands Region will be hardest hit because of decline agricultural value of up to 30% [51], according to World Bank report on economics of adaptation to climate change.

Precipitation will be affected by the changing climate, with increased rainfall in the central part of the country and reduced rainfall in the northern and southern parts. The coastal river basins are small and more susceptible to rainfall changes (refer to Figure 15).

The Mekong Delta, Viet Nam's rice bowl, is expected to receive on average 20% less rainfall than in the 1980s and experience delayed rainy seasons. In addition to the changes in rainfall, the climate models predict that by 2070, the temperatures are likely to increase by 1.5°C and 2.0°C in coastal and inland areas respectively resulting in increased evaporation by 7.7% - 8.4%. Together with the high irrigation demands, there is an increased likelihood of declining surface water runoff and flows into the rivers.

Climate change is also expected to intensify climatic extremes, such as an increase in number and intensity of storms leading to more frequent and more intense floods, as well as a greater variability and intensity of droughts.[52] The UN-REDD programme estimates that land use changes related to the reduction of diversified production systems and native forests for agricultural production have made Viet Nam even more susceptible to droughts and other impacts of climate change.

Figure 15. Outputs of two climate models on predicted change in rainfall by 2050



Regions, which suffered from the El Nino-driven drought in 2014-2016, i.e. the Central Highlands, the Southern Coast and the Mekong Delta, are expected to be more frequently and longer exposed to drought conditions, as well as to more frequent flood conditions. It is expected that low-lying lands, such as the Mekong Delta and the coastal areas will be affected by a sea level rise of 30 cm by 2050.[53] In this scenario, 13% of rice production area in the Mekong would be lost due to inundation and salinity increase.[54] Sea level rise would is also expected to have significant impacts on water supply, drainage and water degradation.[55]

According to ADB estimates, a one-meter sea level rise would inundate a quarter of Ho Chi Minh City, home to 6 mn people, and would submerge 11,000 km of roads.[56] In a worst case scenario assessed by WEPA, a five-meter sea level rise would result in a loss of 16% land area, reduce 35% GDP and affect 35% of the population.[57]

4.4 Institutional issues

Despite an elaborate policy framework comprising over 300 regulations, water sector management in Viet Nam is challenged by unsustainable exploitation and use of water resources, water pollution, disconnect between the national policies and practice at local level, and overall lack of policy and institutional coordination within the water sector.[58]

While economic instruments exist (see 3.1.4), the current state of the environment shows that these are not designed and enforced or incentivise sustainable water usage and optimal water allocation. With agricultural water use constituting 80% of total water demand, and over-exploitation of groundwater resulting in falling groundwater tables, e.g. in the Mekong Delta and Central Highlands, incentives for sustainable agricultural water usage are imperative.

While a new Irrigation Law was passed in June 2017, which re-introduced payment for irrigation services, the water price shall only be determined on the financial cost of irrigation water, i.e. operation and maintenance cost, depreciation, management costs, other expenses and allowance for some profits for the service provider. The water price, in this case, would not differentiate between water scarce and abundant areas, thus lacking an incentive function for water savings and a potential re-allocation to more productive uses. While the re-introduction of irrigation payments is a big step forward, it will lack the full incentive function which is required for sustainable agricultural water usage.

Overlap and inconsistency in water resource management functions at the central government level (MONRE, MARD, MOIT, MOC, MOT, and MOH) also exist.[59] MONRE is responsible for overall water resources management, but rural water and water-related disasters (flood and drought) are under MARD management and urban water is under the management of the Ministry of Construction.[60] For example, Decree 91/2002/ND-CP[61] states that MONRE is the government agency responsible for the State management of water resources. However, Decree 86/2002/ND-CP[62] reassigns river basin management to MARD. More recently, the Government Office has announced a decision of the Prime Minister to transfer the task of river basin management from MARD back to MONRE again.[63]

Overlapping responsibilities between MONRE, MARD and province-level People's Committees create challenges in terms of managing licences and supervising activities. For example, irrigation divisions in each province are responsible for licensing wastewater discharge permits into irrigation systems but they do not have the capacity to monitor water quality at the discharge point.

Some provinces still prioritise the goal of economic growth and underestimate environmental protection.[64] MONRE inspection findings reveal that many industrial zones and industrial parks have their own wastewater treatment systems but most of them are not functioning. According to MONRE's Minister Tran Hong Ha, in 2016, environmental incidents occurred in every type of water resources, including the sea, rivers and lakes. Along with the process of economic development, the environment has reached the '*threshold of tolerance'*.[65]

Monitoring, inspection, control and management of discharges is not transparent and lacks consistency. Lack of resources, technology and coordination, result in weak enforcement of environmental standards. Taking measures against environmental crime is challenging, as the authority and rights of the Environmental Crime Prevention Police are stipulated dispersedly in a number of legal documents.[66] Organisations and individuals take advantage of the loopholes or they are willing to pay fines for violations rather than complying with the law.[67] Recent environmental disasters, such as the Formosa case, have revealed the weaknesses in the current system.[68]

4.5 Implications of Viet Nam's water challenges

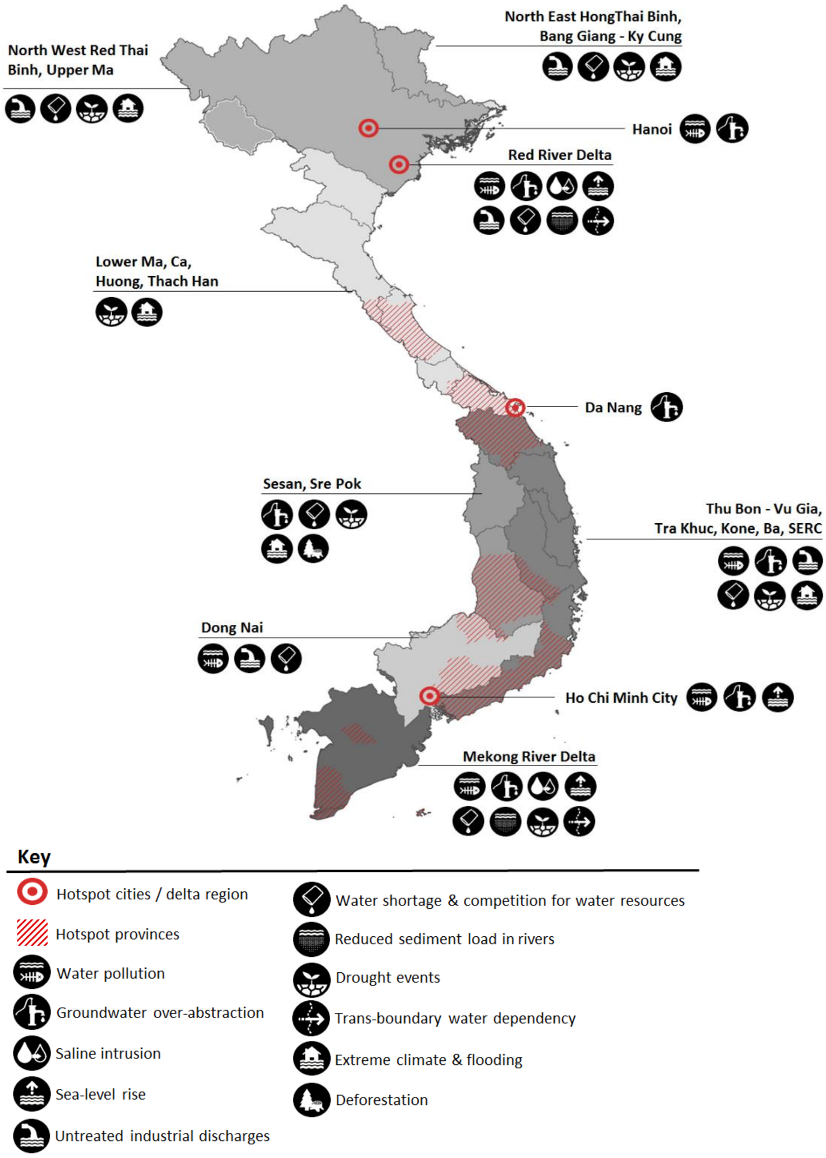
Drought events are increasing in frequency and severity impacting livelihoods and agricultural production.

Viet Nam is affected by El Nino and La Nina events approximately every two to seven years with varying intensity. Past El Nino events with severe impacts on environmental and socio-economic sectors in Viet Nam occurred in 1982-82, 1997-98 and 2003. In 2003 coffee production was reduced by 25%.[69] The recent El Nino event between 2014 and 2016 was the most severe drought Viet Nam experienced in 90 years.[70] Areas most affected include the Central Highlands and Central Coast, especially the provinces of Ninh Thuan and Binh Thuan, which experienced serious water shortages and the Mekong Delta experiencing saltwater intrusion.[71] The Ministry of Planning and Investment estimated the economic impact of the 2016 drought at VND15 trillion ($660 mn).

CGIAR (2016) reported that in the Central Highlands by early April 2016, discharges of main rivers were reduced by 20-90%, water volumes in most reservoirs declined to 10-50% of the design capacity, 70% of the cultivation areas (rained and irrigated) experienced severe drought affecting approximately 170,000 ha of crops. In Dak Lak alone the reduction of crops on 42,400 ha was estimated to be equivalent to a $60 mn loss. Freshwater was lacking for about 2 mn people, 1.75 mn people were reported to have a compromised livelihood, with 1.1 mn people depending on food aid.[72] Today, water reservoirs are again filled to 70% design capacity. It can be expected that the impact of the drought in the Central Highlands will be felt even after its end, as it has affected the perennial drought-sensitive coffee crops.

The drought hit the Mekong Delta in the critical growing season of the paddy rice, requiring farmers to supplement irrigation with groundwater to save their crops. The reduced surface water flows allowed saltwater to intrude up to 70-90 km upstream, 20-30 km further than usual, making the water unfit for irrigation. 13 provinces with approximately 180,000 ha irrigated area in the Mekong Delta (10% of total irrigated area) were seriously affected by the drought and salinisation.[73] According to FAO, rice production fell by 1.1 mn tonnes (2.2% of national production) as a consequence. The longer term effects from salinisation are currently assessed by the government.

Figure 16. Main challenges in the river basins of Viet Nam



Groundwater over-extraction poses threat to Viet Nam's future water security and is expected to substantially increase infrastructure costs due to land subsidence

Dependence on groundwater during the dry season for agriculture and uncontrolled industrial and urban groundwater abstractions pose a severe pressure on Viet Nam's groundwater resources. Adverse impacts of groundwater over-exploitation manifest themselves already:

- Key urban areas, such as Hanoi, Ho Chi Minh City and Da Nang are experiencing **land subsidence**. In Hanoi, for example, groundwater levels experienced a maximum drop from 18 to 32 meters since 2008 in central districts and an average land subsidence of 30-90 cm with the maximum subsidence of 104 cm being registered at the water supply station Phap Van. Increasingly buildings have to be removed and rebuilt as a consequence. With business as usual, parts of Hanoi are expected to sink up to 120 cm in between now and 2030, especially around vulnerable water supply stations.[74] The groundwater table in Ho Chi Minh City, Viet Nam's economic powerhouse, reportedly decreased annually by 1.5-2 meters between 2000 and 2006.[75]

- In the Mekong Delta, Viet Nam's rice bowl, groundwater over-extraction is a serious concern, which is believed to have caused **increased saline intrusion** and land subsidence in rural areas of 10 mm/yr to 20 mm/yr and in urban and industrial areas of around 25 mm/yr.[76]
- In the central highlands, Viet Nam's key coffee and horticulture producing area, groundwater tables in Dak Lak and Dak Nong have dropped by 20% in the past 10 years. In the dry season, average groundwater tables are 4-5 meters lower than in the 1980s, leaving farms and even domestic users with **inadequate water resources**. Dense coffee irrigation and related land use change from forest area to coffee plantation are assumed to be the cause of this issue.[77]

Rapid expansion of hydropower in Viet Nam causes water sharing conflicts and issues related to dam safety of small dams.

The reservoirs of small hydropower dams are constructed mostly for hydropower generation, i.e. they are not used for irrigation or flood control, while medium and large size hydropower plants often use multi-purpose dams. The Institute of Energy has found that approved designs for storage reservoirs were amended during construction and the reduced reservoir capacity leads to increased water discharges during the wet season which **aggravates downstream flooding.** Water is also maintained in the dry season, leading to water usage conflicts between hydropower, agriculture and urban areas.[78] In 2013 the Central Coast, including the Da Nang city, faced a severe water shortage affecting 1.7 mn people and 10,000 ha of agricultural land. The dam operator of Dak Mi 4 Hydropower Joint Stock Co **refused to release water to alleviate the impacts of the drought** as this would impact their electricity operation, despite the Prime Minister issuing a directive requesting the operators to release water.[79]

According to the Report of Committee on Science, Technology and Environment of the National Assembly, 30% of small hydro dams are not technically verified. In 2016, **66% of small and medium dams lacked safety plans, while 55% lacked flood prevention plans**. While large and medium sized hydropower projects (installed capacity >31 MW) require approval from MoIT, small dams (installed capacity <30 MW) are under the responsibility of the Provincial People's Committee, who frequently lack the capacity to assess the technical proposals.[80] The lack of compliance has led to **multiple dam failures**, such as the dam break of Dak Mek 3 in 2012, which killed one person and injured several others. The Dam Failure of Ian Krel 2 destroyed 200 ha of cropland.[81]

Reduced sediment loads in rivers may endanger productivity in key agricultural regions

Over centuries, the Red River and Mekong deltas were formed by sediments transported downstream from its rivers. Recent hydropower development, in addition to legal and illegal sand mining activities in Viet Nam and in upstream countries, are drastically reducing sediment loads and impacting soil fertility.

WWF estimated 50 mn tonnes of sand were extracted from the Lower Mekong mainstream in 2011 alone, much more than the river produces in a year. These drastic disruptions of the sediment regime are already reshaping landscapes downstream.[82]

The river bed in Mekong delta's two main channels fell by more than a meter between 1998 and 2008, resulting in salt water intruding even further inland and impacting fertile arable land. On average **12 meters of coastal land is lost annually** and the reduced sediment load is also expected to contribute to land subsidence.[83]

Rapid deforestation and land use change worsen natural disasters

To increase the cultivation of coffee, a rapid deforestation was observed since 1997, with forest cover being reduced from 65% to 42% in the Central Highlands over the past 10 years alone.[84]

The reduced soil infiltration capacity has contributed to the frequency and severity of floods from rainfall and have increased the severity of drought events.[85]

Severe water pollution reduces surface water availability

Poor surface water quality reduces water availability to downstream users and increases water treatment costs. As a result, groundwater is over-exploited (particularly in large cities) leading to issues analysed earlier.

Agriculture in many cases uses the polluted river water for irrigation, which reduces yields[86] and poses a significant public health risk.

The financial impact of irrigating with untreated industrial wastewater

Industrial effluents discharged untreated to agricultural areas considerably impact crop yields. Kai and Yabe (2013) assessed paddy rice areas which are impacted by untreated industrial effluent in Can Tho, one of the biggest rice producing areas in Mekong. They found that yields decrease by 0.67 tonnes/ha (12%) and additional costs increase by 0.97 mn VND/ha (9%) resulting in 3.2 mn VND/ha (26%) loss in profits. In addition, farmers are reported to have suffered from skin disease and only 1-2 rice crops are planted each year (instead of three crops). The assessment did not include the impact on rice quality and health implications which could be serious, especially in the long term.

Aging water supply infrastructure and illegal connections reduces the availability of potable water in cities.

Non-revenue water (NRW) ranges between 11.8-28.1% on a national level, while large cities typically have NRW percentages of 22-28%. GoV has recognised the need to address this issue and has embarked on an ambitious non-revenue water reduction programme to reduce average NRW to 15% by 2025.[87] [88]

Non-revenue water programme in Viet Nam

The programme includes: public awareness improvement activities; capacity building for local authorities and water supply companies; establishment and improvement of NRW policy framework and; technical improvements for network monitoring and maintenance. The methodology adopted for the NRW reduction programme is in line with the Asian Development Bank's Knowledge Product "The Issues and Challenges of Reducing Non-Revenue Water".

The programme cost is estimated to be around $500mn is largely funded by official development assistance (98% ODA, 2% state budget). By addressing NRW, the government aims to dramatically reduce investment requirements. It is estimated that reducing NRW to 15% will increase annual revenues by $800mn and provide 1.3 mn m^3/day additional water capacity.

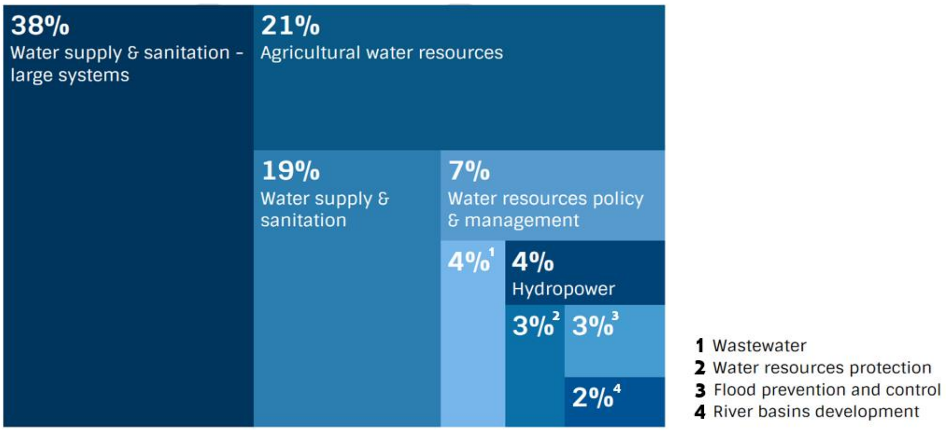
5 On-going water initiatives

More than 140 completed and ongoing water-related initiatives, programmes and projects, which have commenced since 2006, were identified through secondary literature review and stakeholder interviews. According to OECD, over $6.4 bn have been distributed as Official Development Assistance to water-related sectors in Viet Nam since 2006. Of these, over 55% have been invested into the improvement of water supply and sanitation systems in the country, 21% on agricultural water resource management, and a further 7% on institutional and governmental capacity building (refer to Figure 17 and Appendix G).

Water initiatives and programmes are predominantly funded by state development agencies and international multilaterals. In the last decade, Development Assistance Committee (DAC) countries have funded $3.4 bn of water related initiatives, with the JICA providing funding of over $1.8 bn. The World Bank Group, including World Bank, IDA, and IFC, is another primary source of funding, with investment amounting to $2.3 bn since 2006.

Various NGOs, such as IRRI, IUCN, WWF, and the Global Green Growth Institute, have extensive programmes of technical and financial assistance to agricultural, micro-industries and civic sectors. A number of private sector firms, many from the beverage industry, are also actively involved in developing sustainable water-related projects, working in collaboration with NGOs, and international multilaterals.

Figure 17. Overview of funding distribution to water sector initiatives in Viet Nam from 2006 to 2015



Source: OECD

5.1 Focus area: water supply

12 of the 16 river basins in Viet Nam, including Mekong, DERC, Dong Nai and Red-Thai Binh, are facing challenges from water shortage, groundwater over-abstraction, and competition for water resources. These prevailing challenges are reflected in a strong focus of initiatives on water supply (refer to Figure 18).

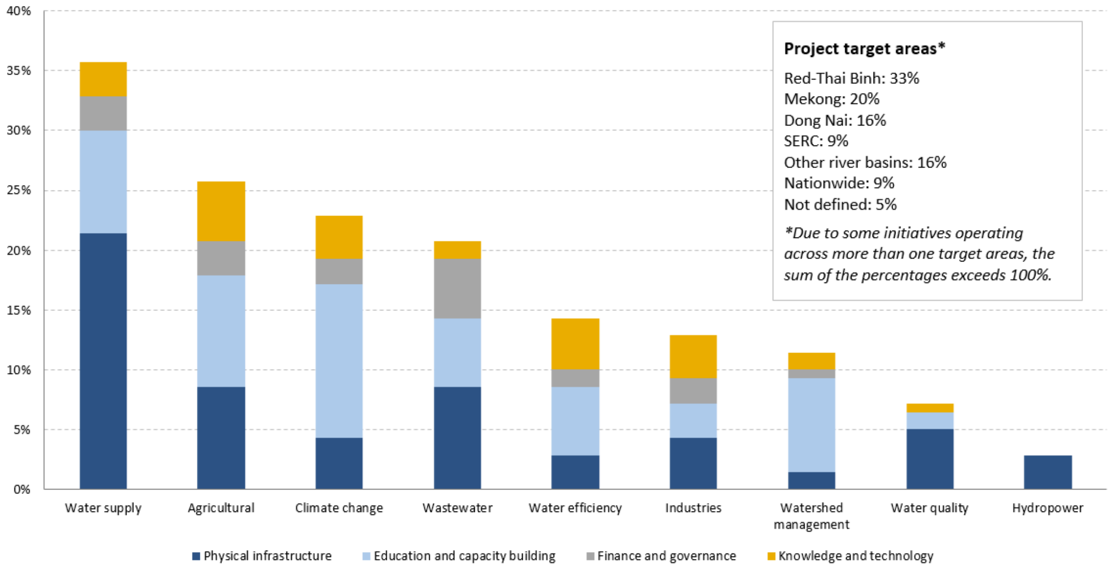
More than half of the water supply initiatives are delivered through infrastructure improvement. The World Bank and IFC's Urban Water Supply and Wastewater Project (2012-2019) is increasing access to sustainable water services and environmental sanitation in selected urban areas in Red-Thai Binh. ADB is delivering a joint venture with the State General Reserve Fund of Oman, State Capital Investment Corporation of Vietnam, state-owned technology enterprise Newtatco, VietinBank Capital, and the Hanoi Water Limited Company, to expand a water treatment plant on the Da River to supply Hanoi with drinking water. JICA is delivering a project to improve An Duong Water Treatment Plant in Hai Phong City. In Mekong, the French Development Agency (AFD) delivered the Phuoc Hoa and Saigon River project (2003-2012), including the construction of Phuoc Hoa dam and associated transfer canals, to provide better distribution of water between the provinces and amongst competing activities from agriculture, industries, hydropower and civic demand.

In addition to infrastructure delivery, 15% of the water supply initiatives reviewed are focused on capacity building, improving national governance structure and technology advancement. For instance, ADB is helping increase access to clean water in Viet Nam by improving the efficiency of water supply companies (2013-onging), with the first tranche covered Ho Chi Minh City. The programme is now in tranche four and has been extended to four more provinces in Red-Thai Binh.

5.1.1 Private sector and civil society initiatives

Coca Cola is working with UN-Habitat and Research Center for Family Health & Community Development (CEFACOM) to increase the coverage of clean water provision through the delivery of water provision facilities in Dong Nai (2004-ongoing). Grundfos's Water2Life programme (2013-2016) delivered over 80,000 metres of pipelines to bring safe water to ten communities in Mekong. The Viet Nam Water Partnership, a non-profit network facilitated by the Global Water Partnership (GWP), was established in 2002 to promote integrated water resource management with a focus on governance and capacity building. UNDP collaborated with CEO Water Mandate and a number of private firms in the manufacturing sector to improve water management, mitigate water-related risks and water stress on communities (2011-2012).

Figure 18. Sectorial and geographical distribution of water initiatives in Viet Nam



5.2 Focus area: wastewater treatment

ADB is working with Ho Chi Minh City People's Committee and their government to finance sound wastewater and drainage system to future-proof the city's infrastructure for socio-economic growth (2016-ongoing). The Swiss Development Agency (SDC), in collaboration with KfW banking group and BUSADCO, delivers sanitation improvement projects in four provincial centres in Red-Thai Binh (2010-2018) and SERC (2009-2016) through the construction of wastewater treatment facilities, and the rehabilitation and extension of sewer systems. A proportion of the wastewater treatment initiatives also focus on capacity building and governance. For instance, the World Bank and IFC are improving the compliance with industrial wastewater treatment regulations in four provinces in Red-Thai Binh and Dong Nai, through the development of a rating methodology and public disclosure for industrial wastewater treatment (2013-2019).

5.2.1 Private sector and civil society initiatives

The Global Green Growth Institute (GGGI) is working with Ministry of Planning and Investment (MPI), Ministry of Construction (MOC), UNDP, Provincial and City People's Committees (PPCs and CPCs), UN-Habitat and Viet Nam National Mekong Committee (VNMC) to promote green growth in the Mekong Delta through supporting the implementation of water-sector green growth policies, with a focus on wastewater management.

5.3 Focus area: agriculture

Infrastructure improvement and rehabilitation is a key focus of water initiatives in the agriculture sector. A number of AFD-led projects, delivered with partners such as the Northern Mountainous Agricultural and Forestry Science Institute (NOMAFSI) and the French International Agricultural Research Centre for Development (CIRAD), focused on agricultural water resource rehabilitation and capacity building in Dong Nai (2006), SERC (2008), and Red-Thai Binh (2010-2016). These projects aimed to improve drainage, irrigation system and crop yield through the construction and rehabilitation of hydraulic structures such as dykes, pumping stations and canals. The World Bank and ADB are also active in the rehabilitation of irrigated agricultural production systems in Red-Thai Binh and Dong Nai through projects such as the Viet Nam Irrigated Agriculture Improvement Project, Sustainable Rural Infrastructure Development Project, and Productive Rural Infrastructure Sector Project. In Mekong, the World Bank and IFC are working to improve rice and coffee farming practices and support the implementation of the agricultural restructuring plan through improving market linkages, technology access and finance facilitation (2015-2020).

5.3.1 Private sector and civil society initiatives

Food and drink company Nestlé is working with SDC and the Vietnamese authorities to encourage local coffee growers to optimise their water use through the assessment of water footprint of coffee production and providing training on seasonal water consumption optimisation (2014-2017). In Mekong, the International Union for Conservation of Nature (IUCN) is working with SDC, AFD and local NGOs on integrated water resource management for agriculture. Coca Cola and WWF have been involved in a wetland restoration project in Mekong (2007-2010) to improve water resource management in fishery and agriculture.

One of the key NGOs is IRRI, which has been providing assistance in Viet Nam since 1963 in a wide range of collaboration in the fields of rice breeding material exchange, rice varietal improvement, resource management, and capacity building. Most recently it has been providing assistance in The Alternate Wetting and Drying (AWD) Rice Management Practice and System of Rice Intensification (SRI) to increase productivity and yield of crops.

5.4 Focus area: climate change

Climate change related water initiatives largely focus on education and capacity building to improve resilience to climate risks and disasters. The Belgian Development Agency (BTC) is promoting integrated water management and urban development in relation to climate change in a number of provinces in SERC, through the development of appropriate operational climate change modelling and institutional capacity to apply the national strategy on climate change at regional level. USAID is working with Pacific Disaster Centre and Ministry of Agriculture and Rural Development (MARD) to develop and implement an initial VinAWARE early warning and decision support system for central-level officials in Hanoi and flood management offices at provincial level in central Viet Nam (2012-2015).

5.4.1 Private sector and civil society initiatives

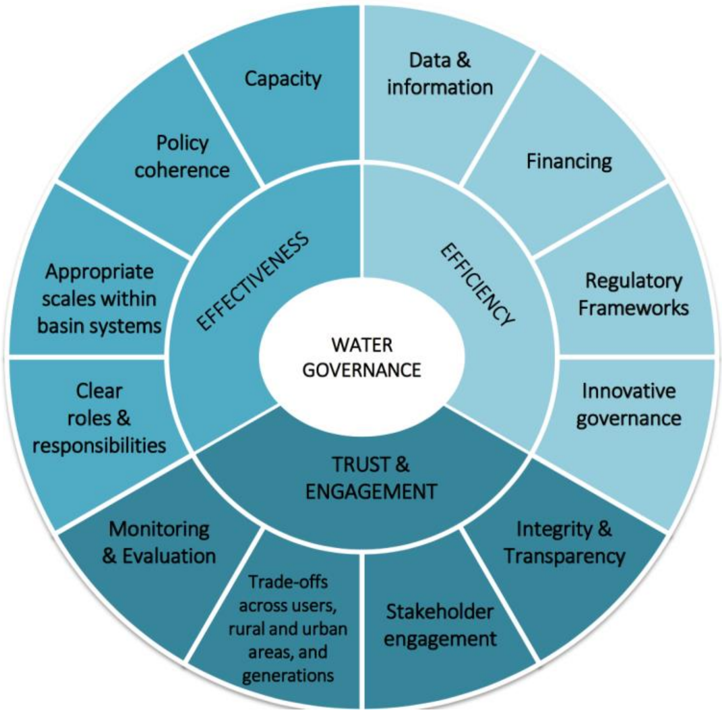
A small number of infrastructure improvement projects have been identified, all of which focus on improving infrastructure resilience to flooding. Examples include UNDP’s flood proofing programme in Mekong river delta and climate resilience of coastal communities in Red-Thai Binh. In terms of capacity building, UNDP is leading on a number of climate change related projects in Red-Thai Binh, including building community resilience to climate-related disasters through training (2007-2008), and addressing climate risk to critical infrastructure assets through policy integration and knowledge sharing (2012-2017). No private sector initiatives have been identified relating to climate change.

6 Key solution areas

6.1 Good governance and institutional solutions

The foundation of Viet Nam's water sector transformation lies in good water governance and adherence to Integrated Water Resource Management principles. Figure 19 illustrates the OECD Principles on Water Governance. The principles are divided into three categories: Effectiveness, Efficiency, and Trust and Engagement. To implement solutions, clear sustainable water policy goals and targets at all levels of government need to be determined, implemented and meet expected targets (effectiveness). Further, benefits of sustainable water management and welfare need to be maximized at the least cost to society (efficiency). Finally, public confidence needs to be built, while inclusiveness of stakeholders through democratic legitimacy and fairness for society at large needs to be ensured.

Figure 19 OECD Principles on Water Governance (Source: OECD) [89]



In Viet Nam, water governance does not as yet meet the standards required to enable implementation of sustainable and integrated water resource management.

While IWRM is mentioned in policy documents, currently there is no assessment of groundwater availability at a river basin level, nor the presence of integrated water resource management (IWRM) plans, thus providing no basis for sustainable water resource management. Policy-makers and industry groups should collaborate with government departments, donors, NGOs and the community to collaboratively **move towards delivering IWRM plans at river basin level**.

In order to allow informed decision making by all stakeholders, an open-access, solid and verified database of water resource related information is required. Currently even the government departments have **difficulties in accessing relevant data** as, e.g. MONRE's Centre for Water Resources Inventory and Planning collects data on groundwater; MONRE's Department of Hydro-metrology collects data of surface water and river basins; while MARD's Department of Water Resources manages data on irrigation system/works.[90]

During the stakeholder interviews it was stated that **publically available data may have been adjusted to reflect certain standpoints rather than reality**. With the Law on Access to Information issued in late 2016, and the implementation guidance Circular released in March 2017, there is an opportunity to address this issue and build trust and to increase confidence amongst stakeholders.

As a reaction to nation-wide protests on the Formosa incident, in which the Taiwanese steel company is made responsible for leaking toxic discharges to the environment which killed approximately 70 tonnes of fish and impacted numerous livelihood in 2016,[91] the Prime Minister led a meeting across Ministries in which the seriousness of enforcing wastewater regulation was stressed. As an immediate reaction, a publicly accessible **online monitoring system of companies' discharges** will be launched.

A Memorandum of Understanding was signed between the Department of Science, Technology and Environment (MONRE) and Microsoft to support the development of an e-government and national database architecture for natural resources and environment.[92] While this monitoring system, once implemented, can be seen as a **strong tool to make polluters accountable** for their actions, clarity on which governmental body can provide discharge permits and under which conditions and minimum requirements, as well as how the enforcement of penalizing offenders will be realised are equally important questions which need to be addressed.

A **lack of a clear regulatory framework and its enforcement**, a **lack of capacity at provincial government departments**[viii] [93] and **missing incentives for sustainable water resource management** are key challenges, which need to be addressed.

Considering that less than 10% of the water resources are available from groundwater, the **unmanaged abstraction across all sectors is causing serious concerns**. To address this, Viet Nam's water resource planning has to be adapted to include groundwater as a key resource. While Decision 2065[94] seeks to reduce groundwater abstraction in industrial zones and stop it in key zones by 2020, measures need to be put in place to also sustainably manage groundwater in agriculture and urban areas.

The new Irrigation Law (2017), provides an o**pportunity for revising the incentives for agricultural groundwater.** While the price levels are yet to be determined, it seems as if these should be set with the objective of cost recovery, rather than setting incentives for sustainable water abstraction.

One key challenge will be on **how the law will deal with rice irrigation**, the primary water user in Viet Nam. The preceding discussions seem to suggest that rice farmers will be exempted from paying an irrigation levy. Furthermore, the on-going agricultural reforms have the potential to relax the land use requirements determined by the government, allowing farmers to maximise crop per drop. It is crucial that these two on-going policy changes consider the importance of sustainable water resource management.

There is also a **lack of technical capacity at local levels**, where large majority of operational decisions are made. **Increased training and support at local level** can improve the management of the water resources and pollution in local river basins. The on-going discussion on the establishment of river basin management committees therefore needs to be accelerated and implemented.

At the meeting of the central government in April 2017, a number of solutions have been proposed by the Ministry of Natural Resources and Environment to address environmental issues such as promoting environmental planning, promulgating criteria for screening and publicising polluting and disgruntled industries. In particular, the urgent issues are **to review and adjust financial mechanisms, mobilise resources for environmental protection**, especially the mobilisation mechanism on the principle that polluters pay correctly.

6.2 Technical solutions on river basin level

Following the principles of Integrated Water Resources Management (IWRM), key solutions within a river basin are assessed, considering agricultural, industrial and municipal solution areas.

There are opportunities to address Viet Nam's water resource management issues through the identification and implementation of cost-effective water demand reduction measures at the four key river basins which generate 80% of the country's GDP. This section assesses:

- Measures to close the identified water supply-demand gap for SERC basin
- Measures to move the Red Thai Binh, Mekong, SERC and Dong Nai basins to a low water stress status (WEI<20%) by 2030.

The implementation of 24 measures targeting the agricultural, industrial and municipal sectors were reviewed for each river basin. In order to allow the prioritisation of measures, the cost-effectiveness (i.e. the cost of making one unit of water available) as well as the overall impact (i.e. the quantity of water this measure could make available in each river basin), of each measure was assessed. The list of measures, as well as an overview on the assumptions made related to scale, impact and costs of each measure can be found in Appendix H.

As the focus of the analysis is on **water efficiency measures**, water supply augmentation options (such as reservoir storage, additional groundwater aquifer recharge and desalination) were not included in the methodology. It is recognised, though, that could be part of the solution in certain river basins.

Agriculture water demand accounts for majority of the water use. This is reflected in the solutions presented in the following sub-sections.

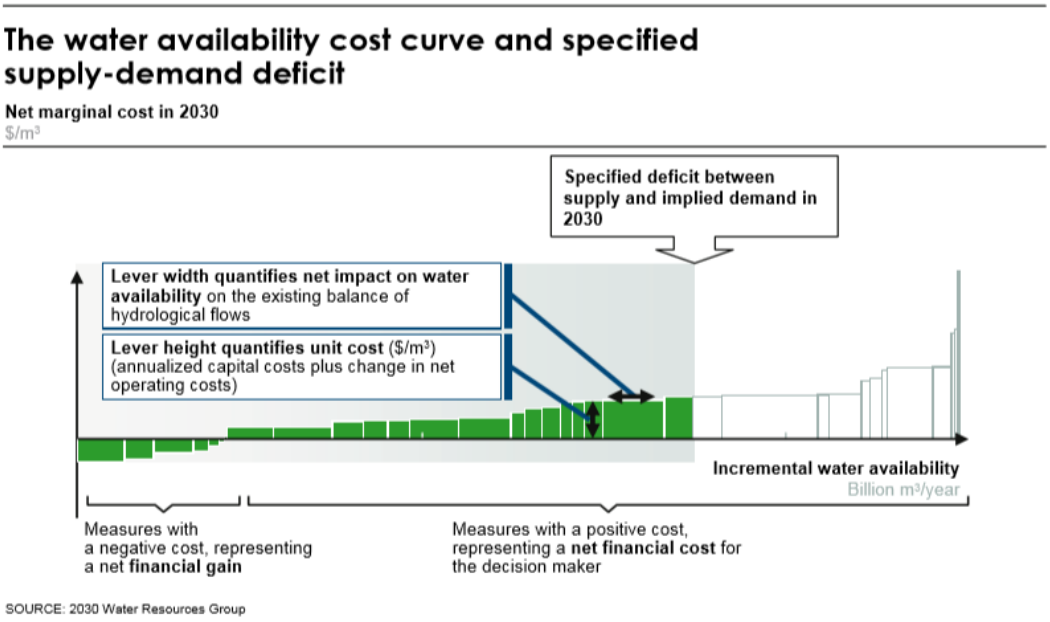
6.2.1 Methodology

A cost curve was used to assess the various interventions and the demand and availability gap. This process is not a substitute for other economic tools and analyses, nor is it a substitute for basin-level planning. It provides, though, a relatively simple picture of the primary solution sets available and any major trade-offs. The measures identified were compiled with local experts and describe the highest potential opportunities to reduce water demand. As the Viet Nam water demand is dominated by agriculture, the study predominantly considered solutions in this sector.

Figure 17 provides an overview of the methodology used for the assessment. The cost curve's horizontal axis measures the amount of water made available by each measure. The vertical axis of the cost curve measures the cost per unit of water required by each measure in the year of the cost curve. This is the annualised capital cost, plus the net operating cost compared to business as usual.

The wider a measure on the horizontal axis, the larger its net impact is on water availability to close the supply-demand gap. The height of the measure's height on the vertical axis, indicates its financial cost.

Figure 20. Water availability cost curve methodology



While the cost curves are estimated specifically for the four key river basins based on available information, further analyses are required to assess their implementation and exact costs and impact. In any case, the cost curves provide very useful insights on the magnitude of potential measures in terms of impact and costs.

6.3 Assessment of cost effective solutions at key river basins

This section presents cost-effective measures to close the water supply demand gap for SERC river basin, and to further move key analysed river basins from (severe) water stress to low water stress, i.e. water abstractions amount to 10-20% of available freshwater resources.

6.3.1 SERC basin

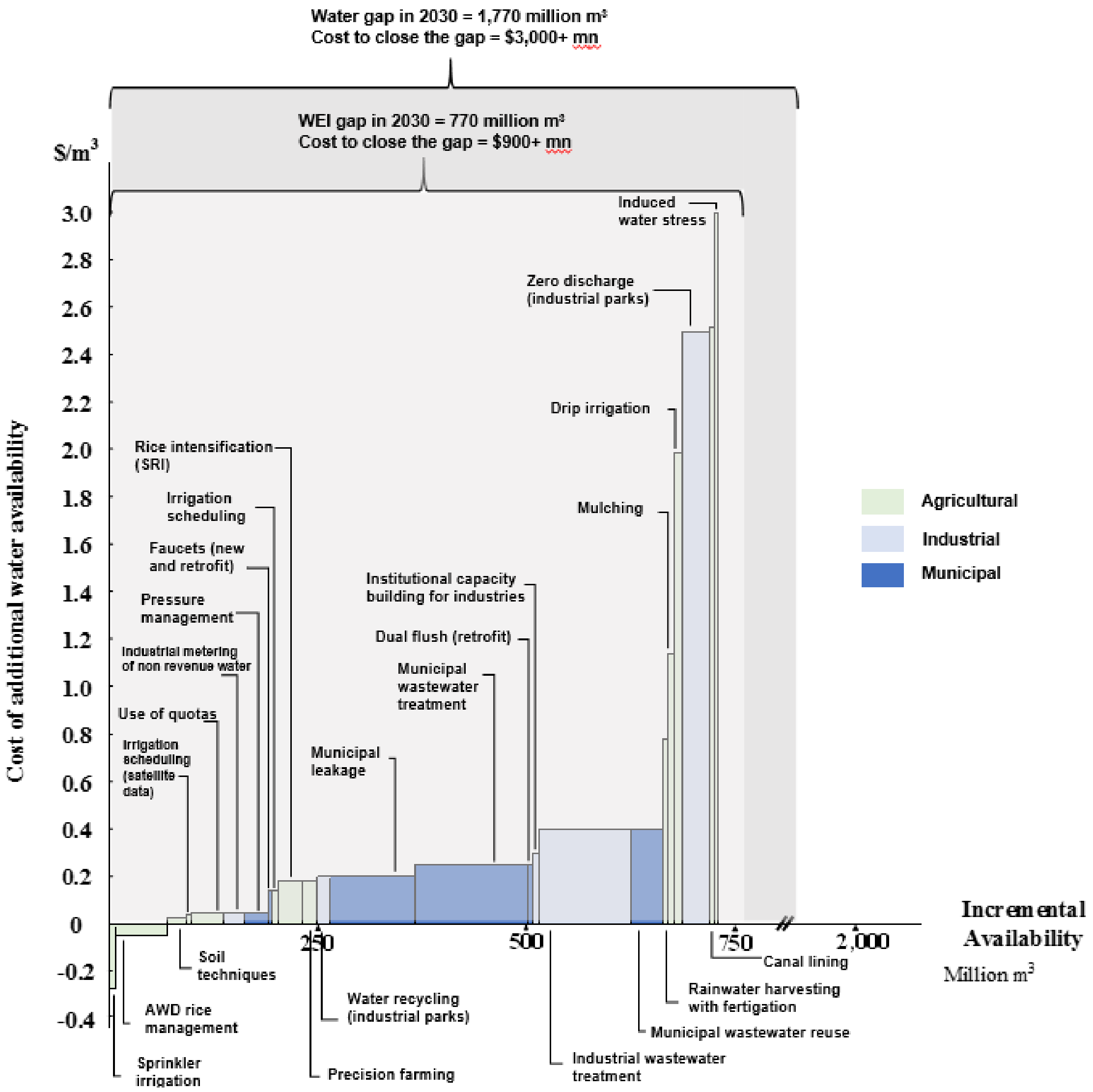
By 2030, in the dry season, the SERC basin could have water demand exceeding total available water supply by 28% or 770 mn m^3/yr (‘water gap’). The water demands will need to be reduced by this volume to meet the needs of all users.

In addition, as the SERC basin is assessed as ‘severely water stressed’ (WEI = 58%) during the dry season, a total water demand reduction of 1.76 bn m^3/yr will be required to move the basin to a more sustainable ‘low water stress’ state (‘WEI gap’). This represents 65% of the total water demand in 2030. The options analyses are focussed on closing the gaps for both these targets.

The SERC basin has about 1% of Viet Nam’s water but produces about 10% of GDP and has over 2% of total irrigation water use. The water use in the SERC basin is also not typical in Viet Nam as aquaculture and industry are projected to have significant portion of the water demand.

As Figure 21 shows, the limited water availability and high water demand have an implication on the solution mix and a wide array of measures across different sectors are required to move towards closing the water gaps. Municipal and industrial interventions could have a significant volumetric impact at a relatively high unit cost. However, the situation in SERC river basin is so grave that all assessed 24 measures are not sufficient to close the targeted water gaps by 2030.

Figure 21. SERC River Basin – cost curve of solutions to close the dry season water gap and reduce water stress to 'low water stress' in 2030



While the analysis only focuses on water efficiency measures, it becomes clear that water supply augmentation measures will need to be assessed in future to understand whether these are sufficient to ensure water security for SERC river basin. For example, aquifer recharge with an estimated unit cost of $0.5-1/m^3$ is likely to be a cost-effective solution, while increasing reservoir storage capacity at an estimated cost $2-5/m^3$ could also be explored. Seawater desalination is another potential source of supply augmentation, however the costs[95] are greater than identified options, has a higher energy use, and a greater environmental impact. The feasibility of any water supply augmentation interventions will require detailed technical assessment.

Assuming that water supply augmentation measures are feasible, the implementation cost to close the water supply-demand gap in 2030 is estimated at least $900 mn. Reducing the basin's water stress level to low will require an estimated total cost of at least $3 bn.

6.3.2 Red-Thai Binh basin

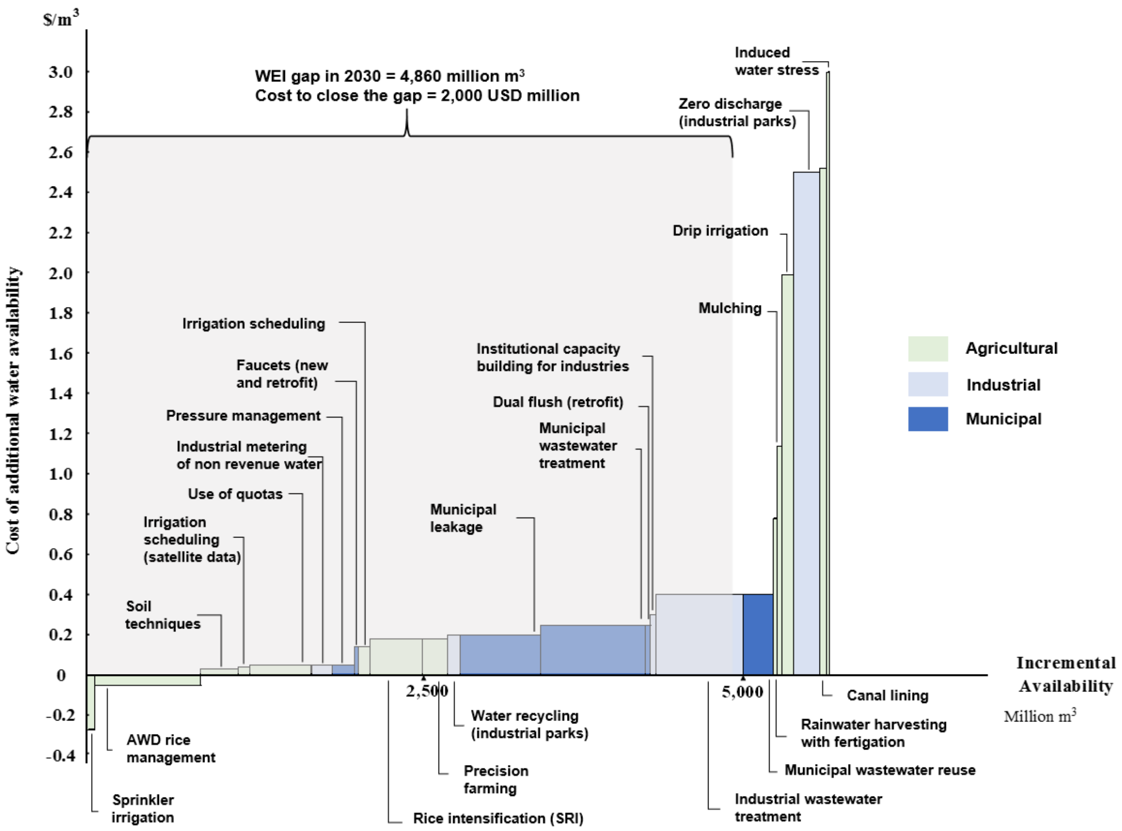
The Red-Thai Binh basin is assessed as ‘water stressed’ (WEI=27%) during the dry season by 2030 and a total water demand reduction of 4.9 bn m^3/yr will be required to move to a ‘low water stress’ state. This is the target ‘WEI gap’ for options analysis in Red Thai Basin.

It is a diverse basin with significant rice production (15% of Viet Nam’s rice irrigation) and home to booming industrial areas and craft villages and large urban conurbations such as the capital Hanoi.

Figure 22 shows that agricultural interventions, including sprinkler irrigation, alternate wet and dry (AWD) rice management practice, no till agricultural and irrigation scheduling, managing evapotranspiration using quotas and system of rice intensification (SRI) are the most cost effective and could close approximately 50% of the water gap. Less cost effective municipal and industrial interventions at an estimated \$0.2-0.4/m^3 are required to fully close the 4.9 bn m^3/yr water gap.

A deep dive into industrial wastewater treatment and reuse in the Hanoi area is available in Chapter 7.

Figure 22. Red-Thai Binh River Basin – cost curve of solutions to reduce water stress in the dry season in 2030



It is estimated that reducing the basin’s water stress level to ‘low’ will require a total cost of \$2 bn.

6.3.3 Dong Nai Basin

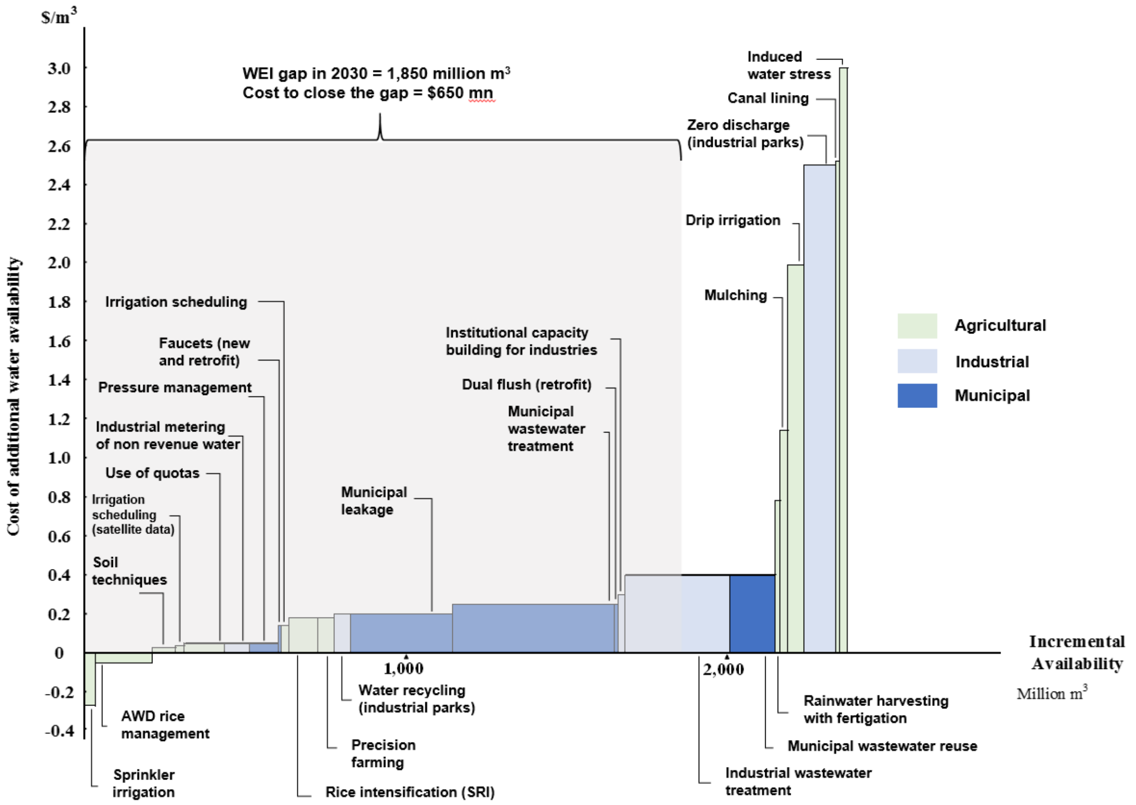
The Dong Nai River Basin is assessed as 'water stressed' (WEI=28%) during the dry season by 2030 and a total water demand reduction of 1.85 bn m^3/yr will be required to move to a 'low water stress' state. This is the target 'WEI gap' for options analysis in Dong Nai Basin.

Dong Nai is home to HCMC and significant industrial development. The basin has about 4% of the nation's water and produces 28% of the GDP.

As Figure 23 illustrates, that whilst agricultural measures are cost effective, they can only close approximately 30% of the 1.8 bn m^3/yr water gap. Municipal and industrial interventions, including leakage reduction and wastewater treatment should be part of the solution basket. Due to the clustering of factories in industrial parks and zones in the basin, the implementation cost of industrial measures may benefit from economies of scale.

A deep dive on reusing treated municipal wastewater in Ho Chi Minh City is available in Chapter 7.

Figure 23. Dong Nai River Basin – cost curve of solutions to reduce water stress in the dry season in 2030



It is estimated that reducing the basin's water stress level to 'low' will require a total cost of $650 mn.

6.3.4 Mekong Basin

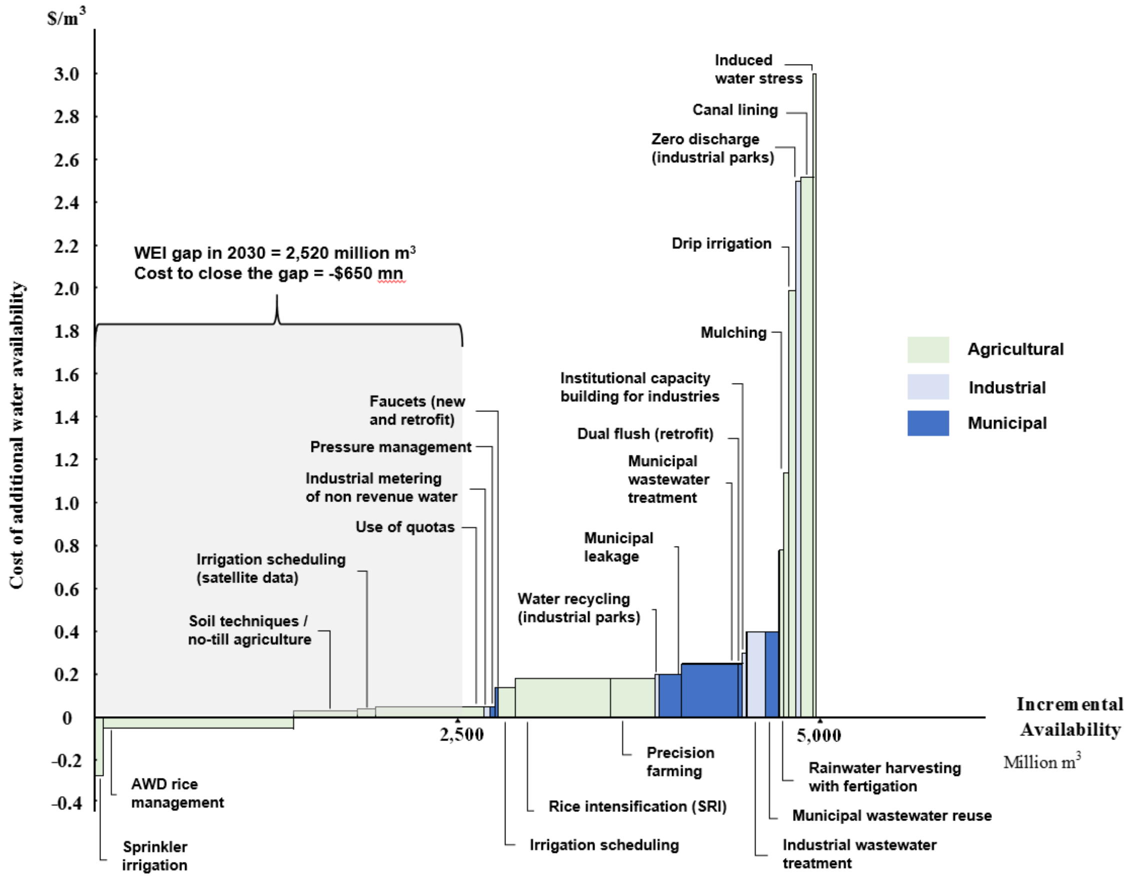
The Mekong River Basin is assessed as 'water stressed' (WEI = 22%) during the dry season by 2030 and a total water demand reduction of 2.5 bn m^3/yr will be required to move to a 'low water stress' classification, the basis of the 'water gap' analysis for Mekong Basin.

The Mekong basin has about 60% of Viet Nam's water and produces 17% of the GDP and 50% of the country' rice. Approximately 75% of the basin's water demand is for agriculture.

Given the large area of rice cultivation, agricultural water efficiency interventions such as alternate dry and wet rice management (AWD) could unlock significant reduction in water demand. Figure 24 shows that the implementation of a handful of cost-effective agricultural interventions would suffice to close the targeted water gap.

A deep dive on AWD is available in Chapter 7.

Figure 24. Mekong River Basin - cost curve of solutions to reduce water stress in the dry season in 2030



Due to the low cost and potential financial benefits of the assessed interventions (such as increased yield), it is estimated that reducing the basin's water stress level to 'low' could result in a cost saving of $650 mn.

6.4 Solution delivery

While section 6.3 illustrated the most cost-effective solutions to reduce water stress in the analysed river basins to the target value, it needs to be understood what is required to deliver these solutions within the framework of Integrative Water Resource Management (IWRM).

The successful implementation of the identified solutions depends on one or a combination of the following:

- Incentives: The water user (farmer, industry, public service or citizen) requires an incentive to change their behaviour towards sustainable water resource management
- Regulation (enforcement): Existing regulation needs to be stronger and more consistently enforced so that water users frame their decisions within the regulatory context
- Regulation (new): A new regulation needs to be implemented to allow for the delivery of the solution

- Finance: Financial support is required to implement the solution
- Technical support/ Capacity building: If technologies are part of the solution, support needs to be provided in how to select and operate these. If no technologies are required, changes in practices require capacity building.

Table 4 Requirements for successful solution delivery across all 24 measures

ID	Category	Identified solutions	Responsible Institution	Incentive	Regulation (enforcement)	Regulation (new)	Finance	Technical support / Capacity building
1	Agricultural	Managing evapotranspiration using quotas	MARD, Provincial People's Committee (PPC), and irrigation companies	x	x			x
2	Agricultural	Agricultural rainwater harvesting with fertigation	MARD, PPC, irrigation companies, and farm communities	x	x		x	x
3	Agricultural	Canal lining	MARD, PPC, irrigation companies, and farm communities	x	x		x	
4	Agricultural	Drip irrigation	MARD, PPC, irrigation companies, and farm households	x	x		x	x
5	Agricultural	Irrigation scheduling	MARD, PPC, irrigation companies, and farm households	x	x			x
6	Agricultural	Irrigation scheduling using satellite information	MARD, PPC, irrigation companies	x	x			x
7	Agricultural	Mulching	MARD, PPC, farm households	x				
8	Agricultural	Precision farming	MARD, MOST, PPC, farm households	x	x			x
9	Agricultural	Soil techniques/no-till agriculture	MARD, MOST, PPC, farm households	x				x
10	Agricultural	Sprinkler irrigation	MARD, PPC, irrigation companies, and farm households	x	x		x	x
11	Agricultural	System of rice intensification (SRI)	MARD (extensional services), PPC, farm households	x	x			x
12	Agricultural	Alternate Wet And Dry Rice Management Practice (AWD)	MARD (extensional services), PPC, farm households	x	x			x
13	Agricultural	Change in irrigation practice (induced water stress)	MARD (extensional services), PPC, farm households	x	x			x
14	Industrial	Industrial metering of non-revenue water	MARD, MOIT, MONRE, MOPS (Environment police), PPC	x	x		x	x
15	Industrial	Institutional capacity building to manage industrial water use	MOIT, MOH, MOST, MONRE, PPC					x
16	Industrial	Water recycling from industrial parks	MOIT, MOH, MOST, MONRE, PPC	x	x	(x)	x	x
17	Industrial	Zero discharge from industrial parks	MOIT, MOH, MOST, MONRE, PPC	x	x	(x)	x	x
18	Industrial	Industrial wastewater treatment	MOIT, MOH, MOST, MONRE, PPC	x	x		x	x
19	Municipal	Dual-flush toilets (retrofit)	MOC, city developers (investors), PPC, City People's Committee, city inhabitants	x	x	(x)	x	x
20	Municipal	Faucets (new and retrofit)	MOC, city developers (investors), businesses, PPC, City People's Committee, city inhabitants	x	x	(x)	x	x
21	Municipal	Municipal leakage	MOC, water suppliers, city developers (investors), businesses, PPC, City People's Committee, city inhabitants	x	x		x	x
22	Municipal	Pressure management (in water supply networks)	MOIT, MOH, MOST, MONRE, PPC, City People's Committee	x	x		x	x

23	Municipal	Municipal wastewater treatment	MOIT, MOH, MOST, MONRE, MOPS (environment police), PPC, City People's Committee	x	x		x	x
24	Municipal	Wastewater reuse	MOIT, MOH, MOST, MONRE, PPC, City People's Committee	x	x	x	x	x

As Table 4 shows, incentives and enforced regulation are key in the implementation of all solutions. Users need to be incentivized to adopt sustainable water management measures, such as AWD, industrial water recycling, installation of water saving appliances in households, as this either requires additional effort, a change in habit, an investment or a combination of these.

As was touched upon in Section 6.1, economic instruments, such as water prices, effluent charges and payments for ecosystem services, need to be designed such that the user is incentivized to act in a sustainable manner. For example, water efficiency measures will only be adopted (if not forced upon) when the cost of saving water from these measures exceeds the cost of the investment of the measure.

Further, regulatory instruments, such as pollution fines, need to be designed such that the fine for polluting is higher than the cost of treating wastewater. In both instances, the enforcement of these instruments is paramount. Currently, pollution fines are considered too low to follow suit with regulatory requirements, while capacity of provincial government bodies is too low to even assess violations. Institutional enforcement is so low that only 7% of industries registered at DONRE for discharge permits. The current water price for industries of between $0.2-0.26/m^3 is also lower than the costs of reusing treated effluent. It is suggested to explore opportunities with MONRE, MARD, MOC and MOIT to improve the legal framework and create incentives for sustainable water resource management.

In some cases, it is required to design a new regulation to allow for solution delivery. This is the case for wastewater reuse. The design of regulations and standards around treated wastewater usage is required before the solution can be implemented. For other solutions, such as water recycling from technical parks, zero discharge from industrial plants, dual flush toilets and faucets an amendment in existing regulation may be beneficial in the speed of the update of solutions.

The implementation of agricultural measures, particularly, may benefit from being integrated in MARD's strategies. Currently, for example, MARD's target for AWD adoption is 1 mn ha by 2020, while IRRI estimates that AWD could be adopted on 4.08 mn ha. Revision of this target may facilitate grater adoption rates of AWD.

Depending on the solution, financing may be required. For large scale municipal solutions, such as municipal leakage reduction or wastewater treatment, either PPP arrangements or international donors may be sought. Currently, the required clear regulatory framework and support for interested private and public sector organizations are lacking, reducing the potential for PPPs. For smaller investments, such as those in agriculture, financing challenges due to the upfront capital costs can be overcome by cooperating with market intermediaries, such as coffee mills, to provide guarantees for farmers. It is recommended to explore cooperation opportunities with organizations already working in this field, as well as with the local governmental bodies (DONRE, DARD, PPCs), irrigation solution suppliers, agricultural banks and coffee or farmer associations.

A key barrier to implementation is the inadequate guidance in appropriate technologies and capacity building across all sectors. There are opportunities for the public sector to cooperate with the private sector and civil society to provide this know-how and build required capacities. As such, (international/ national) companies with agricultural supply chains could engage with their suppliers and support them with the required know how. Further, they may offer them financing schemes to purchase required equipment (if any) to allow farmers to reap benefits of this subsequently.

6.4.1 Private sector:

The OECD Water at a Glance data shows that most developing countries, including Viet Nam, have sought to involve the private sector to varying degrees, as a source of financing, but also to improve efficiency in service delivery, reduce costs, contribute to long-term sustainability and favour technology transfer.

The private sector operating in water and sanitation in Viet Nam is diverse with varied interests and background. It includes international investors, water operators, industries and industrial parks, agricultural operators, large users (such as the beverage and mining companies) and the finance community, as well as joint ventures between public and private companies.

Private actors, in the form of small-scale providers, have also helped alleviate the deficiencies of service provision where it has failed to keep pace with rapid population growth and urban migration, e.g. the involvement of international companies under Build-Operate-Transfer (BOT) model to support the state owned Water Service Companies.

There is opportunity to expand private sector involvement in water supply sanitation provision. However, there is little private sector participation in publicly financed infrastructure projects. Primarily the private sector has been involved where funding has been provided by international financial institutes, such as ADB, or industrial units associated with international corporations. The recent municipal wastewater treatment plant for Ho Chi Minh City being funded by Japanese Government and awarded to consortium of Veolia, Hitachi, and POSCO E&C (of South Korea) is such an example.

Although foreign exchange controls have been removed which has improved the scene for foreign direct investment, factors such as lack of minimum returns guarantees, inadequate loan security, and lack of common procedures and standardized contracts still act as hindrance for international private sector involvement where they are likely to face competition with local SOEs.[96]

Actions by the private sector, both local and international, is critical in delivering the identified solutions identified in previous sections of this report. Some examples of their involvement are listed below (the list is not exhaustive):

- Infrastructure provision in municipal, agricultural and industrial sectors for water supply and efficient water use. (e.g. canal lining, drip irrigation, municipal leakage, metering, pressure management)
- Infrastructure provision in municipal, agricultural and industrial sectors for effluent treatment and water reuse. (e.g. industrial wastewater treatment and recycling, municipal wastewater treatment,
- Training and capacity building for better and more sustainable water management practices. (e.g., improved irrigation practices incl. SRI and AWD, capacity building for industries on water efficiency and pollution prevention).
- Information technology and information provision. (e.g., satellite data for irrigation scheduling and precision farming.)

The institutional assessment has highlighted that there is unclear allocation of responsibilities across different the government tiers and agencies and the multiplicity of government agencies responsible for implementation and oversight has led lack of clarity for private sector. In addition, the lack of enforcement of existing regulations as well as lack of financial incentives has led to lack of compliance by private sector, e.g. fines for pollution at times are lower than instituting effluent treatment and discharge compliance.

There is likely to be greater potential involvement of international water sector in industrial wastewater treatment of the industrial parks, which are required under existing regulations to treat industrial effluent before discharge. The enforcement of current laws, which are likely require institutional capacity building, can act as financial incentives to these industries to improve their wastewater treatment and thus water quality of the receiving bodies.

The new Irrigation Law, which commoditises the water, may, despite seemingly only to aim at cost recovery rather than setting incentives, enhance the economic incentives for the local private sector (both industrial and agricultural) in implementing measures to increase water efficiency and reducing pollution from their operations.

The international private sector also has a role to play through capacity building of their local partners, financial support, or through procurement contracts aligned with sustainable water management in corporate social and environmental policies. A number of international corporations already have implemented such measures in both industrial and agricultural sectors, e.g. requiring local suppliers to meet environmental and water efficiency standards in their operations and providing technical and financial support. These exemplars operations could be promoted and replicated.

7 Deep dives

Building on the previous chapter on solutions to close the water gap and move water stressed river basins towards experiencing only 'low water stress', three solutions areas were selected for a deeper analysis. Following stakeholder consultations, the solution areas were selected based on their potential impact, regional relevance and feasibility of implementation. Selected deep dives include:

- Alternate wet and dry (AWD) rice management practice;
- Municipal wastewater treatment and reuse in Ho Chi Minh City; and
- Industrial wastewater treatment around Hanoi.

A fourth solution area was investigated as a response to declines in groundwater levels in the Central Highlands:

- Enabling water efficiency for coffee production in the Central Highlands;

As agricultural water usage amounts to 80% in Viet Nam, two deep dives were selected in this area. The deep dives provide an improved understanding on the impact, cost and barriers of implementation of analysed measures. They also provide an indicative roadmap on implementation and relevant stakeholders.

7.1 Alternate wet and dry rice management practice

7.1.1 The challenge

Rice is the dominant crop grown in Viet Nam and accounts for 58% of the total irrigated area. Majority of the rice is grown in three regions: The Southern Delta (including the Mekong Delta) accounts for approximately 50% of total rice production, followed by the Northern Delta and the Northern Highlands.[97] The climate in Viet Nam allows almost year round rice production, with up to three crops a year grown in the Mekong Delta.

With an approximate 10,000 -12,000 m^3/ ha water demand, rice requires very high volumes of water. This issue is exacerbated due to old and inefficient irrigation systems and practices leading to high water inefficiencies in rice production. Uncontrolled over-abstraction of groundwater in the key rice producing areas of Mekong and Red Rivers is causing increased rate of depreciation in groundwater table. This not only is leading to saline intrusion but also reduced irrigation efficiency in rice growth.

7.1.2 The solution

The Alternate Wetting and Drying (AWD) Rice Management Practice has the potential to reduce water usage by 30% compared to continuous flooding. Research by Ha (2014) has found that the application of AWD in Viet Nam can reduce water usage by 40-50%.

Using AWD practices can increase yield by up to 12% (or 0.7 t/ha) while simultaneously reducing the costs for farmers ($38/ha) and thus increasing the profits for farmers by 25 to 37%. It also has added benefit of reducing methane (CH_4) emissions by an average of 48%.[98]

The AWD practice has been developed by International Rice Research Institute (IRRI) in cooperation with national research institutions and has been piloted a number of countries including Viet Nam. It is based on the research finding that rice plants can tolerate up to 30% reduction in water supply during the main growing period when compared to conventional irrigation without affecting yields. The objective of the practice is to manage soil moisture within the top layer of the soil medium to enable plant growth. The fields are flooded and then allowed to dry up in two week cycles, which are repeated during all stages of crop growth except flowering stage during which plants are sensitive to dry conditions.[99]

The Government of Viet Nam has already incorporated AWD into farmers' programmes, such as the 1 Must Do, 6 Reduction (1M6R) which was adopted in 2012 by MARD for the Mekong River Delta.[100] As stated by MARD, AWD is already practiced fully on 60,000 ha and partially on an additional 300,000 ha of rice fields in the Mekong and Red River Basins. MARD set the target to cover at least 1,000,000 ha of paddy fields with AWD by 2020.[101] According to IRRI, there is potential to increase rice fields under AWD even to 1.14 mn ha in the Red River Delta and to 4.08 mn ha in the Mekong Delta.[102] WWF Viet Nam has applied the 1M6R model, which included AWD in one of their Climate Smart Agriculture Projects in Lang Sen Wetland Reserve (Long An province).

7.1.3 Impact and cost of the solution

The estimates of impacts of AWD adoption on water usage, crop yields, profitability, and Greenhouse Gas emissions are presented in Table 6. The estimates are for the MARD target of 1 mn ha (an increase of 0.94 mn ha) and the potential as estimated by IRRI of 4.08 mn ha. Data on unit impacts of AWD adaption were taken from the case study illustrated by Basak (2016), while the more conservative estimate on water demand reduction of 30% (instead of 40-50%) was taken based on IRRI's experience across countries, including Viet Nam.

The estimates assume that AWD would be applied to the summer and winter rice crops. The water irrigation requirements for conventional paddy rice production are estimated at 10,000 m^3/ha - 12,000 m^3/ha in the winter-spring (dry) season and 5,000 m^3/ha in the summer-autumn (wet) season.[103] In most areas farmers can crop rice twice a year while in the Mekong Delta, farmers are able to produce three rice crops a year.

Table 5. Overview of impacts of AWD adoption

	Changes due to AWD adoption	MARD Target ('000s)		Potential ('000s)	
		Min	Max	Min	Max
Variable production costs ($/ha)	(-38) $/ha	(35,720)		(152,760)	
Yield (t/ha)	0-0.7 (t/ha)	0	658	0	2,814
Profit ($/ha)	170-391 $/ha	159,800	367,540	683,400	1,571,820
GHG emissions (CO_2/ha)	1.8-4 CO_2/ha	1,692	3,760	7,236	16,080
Water usage (m^3)	(-30%)	4,230,000	4,794,000	18,090,000	20,502,000

These estimates highlight that application of AWD practices can yield increase in profits and, therefore, should be highly attractive proposition for the farmers.

7.1.4 Barriers

According to the study carried out by Basak (2016)[104] in Viet Nam and according to MARD, the key challenges to rolling out AWD are the following:

- Farmers do not see clear economic benefits of AWD, mostly as irrigation water is not paid on volumetric basis
- Unlevelled fields make it more difficult to control water level and soil moisture
- Inadequate irrigation and drainage systems
- Fragmented and unconsolidated farm land make adoption more difficult

- Lack of capacity of farmers to implement AWD correctly (and lack of understanding to trust this approach)
- Lack of policies to encourage farmers in application of AWD.

7.1.5 Roadmap

Currently the Law on Water Resources is under revision and is expected to come into effect in May 2017. Following this, MARD will have the technical lead on setting the water price for irrigation as well as guiding its implementation. In stakeholder discussions, MARD has expressed interest in receiving external support for revising the irrigation water price to incentivise farmers to adopt water efficient practices, e.g. AWD.

MARD has also expressed interest in getting technical support for other measures required to expand AWD, such as levelling rice fields (e.g. laser land levelling technologies), creating awareness and capacity (e.g. with farmers' trainings), as well as infrastructure investments to improve the irrigation systems.

There is potential for additional measures to support these activities, such as development of a stakeholder platform in which all organisations working towards AWD, such as farmers' organisations, local NGOs, international NGOs, (sub-) governmental units have the opportunity to connect and scale ideas and implementation. Detailed directions for up-scaling AWD is required from national level to province, district and commune level. The governmental institutions could particularly benefit in cooperating with local NGOs in creating awareness and capacity among the farmers.

As 50% of the rice is produced in the Mekong Delta, it is our recommendation that it should be the initial focus for rolling out of any AWD programme. Once it has been successfully implemented there it can be followed on in Northern Delta and Northern Highlands. The small average farm size in the North and Centre of Viet Nam (0.13 ha/household) created a challenge to the adoption of AWD and will require greater level of support for outreach and adoption (IRRI et al).[105]

Alternatively, the full 1 Must Do, 6 Reduction (1M6R) Approach can be adopted. This approach requires farmers to use quality seeds (1 MUST) and to reduce seed density, fertilizer, herbicide, water, post-harvest loss and GHG emissions (6 Reductions). This approach is more holistic than just applying AWD and thus results in wider beneficial environmental effects, beyond water savings. Stakeholders should be engaged to understand the optimal solution.

A targeted analysis can further refine identification of areas in the Mekong Delta that should be prioritised, taking into account criteria such as existing infrastructure, adequate farm level size and levelled fields.

7.1.6 Key Stakeholders and enablers

- MARD and MONRE
- Central Agricultural Extension Services (MARD): Provide technical support at provincial, district and commune level
- DONRE and DARD
- International Rice Research Institute (IRRI)
- Water User Associations
- Irrigation and Drainage Management Companies
- Farmer's organisations
- Sustainable Rural Development:[106] An NGO that follows a participatory approach towards sustainable rural development, incl. farmer field classes, focus groups, community based

organizations, and training of trainer (ToT) courses around cropping, water management, irrigation etc.

7.2 Enabling water efficiency for coffee production in the Central Highlands

7.2.1 The challenge

Groundwater tables have been falling by 20% in the past 10 years in the Central Highlands, particularly in Viet Nam's key coffee producing areas of Dak Lak and Dak Nong. In the dry season, average groundwater tables are on average 4-5 meters lower than in the 1980s, resulting in increased cost of abstraction and reduced water availability not only for agriculture and domestic use. Groundwater withdrawals for coffee irrigation are assumed to be the key driver, as the groundwater tables are comparatively lower around dense coffee plantation areas.[107] Land use changes, i.e. the conversion from forests to coffee plantations, are assumed to have aggravated the situation, due to the higher water requirements of coffee plantations as compared to the forest and due to the reduced infiltration rats of run-off to the aquifers.

The Central Highlands were particularly hard hit during the recent drought between 2014 and 2015. This is of high significance as 88% of the coffee is produced in these areas, with Dak Lak (32%), Lam Dong (24%) and Dak Nong (19%) accounting for majority of the coffee production.[108] During the dry season between January and April, coffee requires supplementary irrigation,[109] which in these areas is usually sourced from groundwater sources.[110]

Further, D'haeze [111]found that due to the rapid expansion, the 'coffee area in Dak Lak province exceeds the spatial extents in terms of sustainability' and that there was a 'mismatch between the present land use pattern and the natural resource base'. This issue has also been identified by MARD, which set a target to reduce overall coffee production area in the Central Highlands from 577,121 ha to 542,500 ha – a 6% decrease. This reduction could impact the majority of the 600,000 coffee farmers in Viet Nam.

Only a few large farms were found to use drip irrigation for coffee production, offering potential scope for increasing the water use efficiency.[112] However, as 75% of the farmers are smallholders, there are challenges around awareness raising, high upfront capital costs and barriers to access credit.

7.2.2 The solution

Water stress conditions for plants, where the water supply to their roots becomes limiting, has an effect on their growth and development. For coffee plants, Amarasinghe et al[113] have identified that changing the irrigation patterns to artificially 'induce plant water stress' between January and April could result in reduced water use, but also increase green bean yields. The achievement of this targeted irrigation scheduling can be supported by the usage of precision irrigation systems.

MARD recommends an irrigation application of 650 litres/plant/round in three rounds.[114] However, due to insufficient information, many smallholder famers were found to irrigate twice this recommended level.[115] Amarasinghe et al also found that further reducing water application to 150-300 litres/ plant/ round could save 500 to 1000 m^3/ha / year of irrigation water, while even increasing yields.

In addition to the above measure, achieving the target set by MARD for sustainable levels of coffee productions will also aid in reducing the abstraction of groundwater.

7.2.3 The Impact

According to ADB (2009), 20% of Viet Nam's groundwater resources are located in the Central Highlands (12.6 mn m^3/yr). However, according to FAO, only 7% (or 0.824 mn m^3/yr) of these groundwater resources can be sustainably abstracted across Viet Nam.

While a location specific assessment would be required, this can be used as an estimate to understand the magnitude of the challenge. Current average water demand for coffee production is estimated at 4,000 m^3/ha, which amounts to an annual water demand of 2.3 bn m^3/yr – of which less than 1% can be met by sustainable groundwater abstraction.

Depending on the percentage of coffee area adopting the induced water stress production method, the following water savings can be potentially realised (see Table 6**Error! Reference source not found.** b elow):

Table 6. Water saving scenarios for adoption of 'induced water stress' method for coffee irrigation

Water savings if % area adopts method		
% area adopting induced water stress method	Minimum (mn m^3)	Maximum (mn m^3)
10%	29	58
30%	87	173
50%	144	289
70%	202	404
90%	260	520
100%	289	577

Assuming the best case of 100% adaption rate and maximum water savings, 25% of water demand can be saved. Assuming a more likely 50% adaption rate and a conservative estimated on water savings, 6% could be saved.

Further, a yield increase to a minimum of 4,000 kg/ha has been observed for areas applying the induced water stress method. Average yield of green coffee beans vary between 2,161 kg/ha (in 2009) to 3,458 kg/ha (2006). This can also be explained that farmers participating in this method pay greater attention also to other inputs, such as fertilisers. Given that coffee production currently isn't very profitable for farmers, and farmers are switching to other cash crops, the change in irrigation methodology can be expected to result in higher profits from increased yield and reduced inputs.[116]

Table 10 illustrates that the reduction of the coffee plantation area to meet the MARD target can save 6% (138 mn m^3/yr) of total coffee water demand in the Central Highlands.

Table 7. Water savings for MARD targeted reduction of coffee area

Current area (ha)	577,121
Target area (ha)	542,500
Water usage 2014 (mn m^3/yr)	2,308
Target water usage (mn m^3/yr)	2,170
Water reduction (mn m^3/yr)	138
% reduction	6%

The above demonstrates that a greater scale of water saving can be achieved by expanding the adoption rate of the induced water stress method.

7.2.4 Barriers

As 75% of the coffee growers are smallholding farmers, increasing the transaction costs of implementing any programme is a major barrier to any initiative where up-front capital costs are required. Furthermore, it can be assumed that smallholders are more reserved in adopting new methods, fearing the risk of losing their livelihood. These fears can be alleviated by starting pilot projects in which positive results are demonstrated and adequate training and capacity building of the farmers to ensure that these methods are properly applied.

A targeted irrigation system is necessary to implement the induced water stress methods. This will also require stakeholder consultations and site assessments to identify whether drip irrigation is required, or whether the same results can be achieved by less efficient irrigation schemes, such as sprinkler irrigations.

If drip irrigation should be required, the initial capital costs of approx. $2,200 to $2,450/ha were found to be prohibitive for smallholders.[117] Even where cost benefit assessment can show that the costs can be recovered through increased level of profits, smallholders can face challenges in accessing credit due to lack of collateral.[118]

The latter challenge can be overcome by establishing a collaborative scheme involving government, key agricultural banks and coffee mills, where the mills can offer to pay the bank in the event of farmer default. The coffee farmer needs to bring his harvest to the mill for processing, thus, offering an indirect collateral to the bank. A similar financial model is being adopted in Karnataka (India) and had enabled sugarcane farmers to access finance for drip irrigation.

7.2.5 Roadmap

The following steps are recommended to assess the potential impact of suggested projects:

- Stakeholder engagement, including researchers of identified case studies, private sector implementation teams, farmer organisations etc. to gain deeper insights into project requirements and options for scaling up
- Discussion with irrigation supply companies, banks, Viet Nam coffee and cocoa association, and Farmers Union on potential credit schemes for drip irrigation
- Launch of a pilot project/ illustration of already implemented projects by Nestlé.
- Focus on presenting the switch to induced water stress irrigation as business case to the farmers, as yields can increase and inputs, such as fertilizers, decrease, resulting in higher profits.
- Design and implement capacity building programmes for farmers to correctly adopt irrigation method
- Raise awareness via Provincial People's Party Committee and or radio/ TV broadcast and social media.

7.2.6 Key Stakeholders and enablers

- Researchers including IWMI, Embden Drishaus and Epping (EDE) Consulting, Western Highlands Agriculture and Forestry Science Institute (WASI), Viet Nam
- Nestlé / Nestlé Farmer Connect network in Viet Nam
- Swiss Agency for Development and Cooperation
- Farmers Union
- Agricultural Banks
- Viet Nam Coffee and Cocoa Association
- Irrigation system supplier
- DONRE and DARD
- Provincial People's Committee

7.3 Municipal wastewater treatment and reuse in Ho Chi Minh City

7.3.1 The challenge

Ho Chi Minh City is a delta city and the largest conurbation in Viet Nam. The city has a population of approximately 8.5 mn projected to increase to 10 mn by 2025 and is the economic hub of Viet Nam with an estimated gross domestic product (GDP) of $43.7 bn.

The current domestic and industrial water demand is estimated at approximately 3,500,000m^3/d. Although the majority of the water is abstracted from surface water sources, groundwater overexploitation has led to declines in groundwater levels, deteriorating water quality due to saline intrusion and land subsidence. Surface water quality is impacted by agricultural and aquaculture activities upstream and untreated wastewater discharges.

At present, all industrial zones in HCMC are reported to have central wastewater treatment plants which generate approximately 240 000 m^3/d of treated wastewater.[119]

Less than 10% of the total municipal wastewater discharges are currently treated and the government is actively exploring opportunities to expand the existing network and wastewater treatment capacity to 70% by 2020 and 100% by 2030. The current plans for municipal wastewater treatment investment is summarised in Table 8.

Table 8. Existing and planned wastewater treatment capacity in Ho Chi Minh City

Wastewater Treatment Plants	Capacity (m^3/d)	Status	Project value ($m)
Bing Hung	Phase 1: 141,000 Phase 2: upgrade to 469,000	Completed Ongoing	- 131.5
Bing Hung Hoa	30,000	Completed	-
Nhieu Loc-Thi Nghe	Phase 1: 480,000 (2020) Phase 2: upgrade to 600,000 (2025) Phase 3: upgrade to 830,000 (2040)	Ongoing Planned Planned	495 (WB loan) N/A N/A
Tham Luong-Ben Cat	Phase 1: 131,000 Phase 2: upgrade to 250,000	Planned Planned	85 N/A
Tay (West) Sai Gon WwTW	150,000	Planned	80
Bac Sai Gon 1	170,000	Planned	N/A
Tan Hoa – Lo Gom	300,000	Planned	N/A
Binh Tan	180,000	Planned	N/A
Other (6 no)	850,000	Planned	N/A

7.3.2 The solution

The anticipated growth in wastewater treatment provides an opportunity to reuse effluent for non-potable water uses and reduce the dependency on freshwater sources.

The typical wastewater effluent standards in Viet Nam can be achieved by secondary treatment and are presented in Table 9. If the process is designed appropriately, the anticipated plant performance should be significantly better than these effluent standards.

Table 9. Wastewater effluent standards in Viet Nam

Parameters	Units	Effluent Standard (QCVN 14-2008 Class A)
pH		5-9
BOD (20oC)	mg/l	30
TSS	mg/l	50
Total Diluted Solids	mg/l	500
Sulphur	mg/l	1
Ammonia	mg/l	5
Nitrate (NO3)	mg/l	30
Oil	mg/l	10
Total surface active agent	mg/l	5
Phosphate (PO4)	mg/l	6
Total Coliform	MPN/100 ml	3,000

The US EPA's guidelines for water reuse (2012)[120] provide guidance on the use of treated effluent for different uses (refer to Table 10). Although irrigation of food crops with treated effluent is common globally, WHO guidelines provide procedures to minimise risks of microbial contamination of crops, especially those grown for raw consumption such as certain vegetables and fruits.

Table 10. Suggested effluent reuse treatment and uses

Primary treatment Sedimentation	Secondary treatment Biological oxidation and disinfection	Tertiary/advanced treatment Chemical coagulation, filtration and disinfection
• No uses recommended at this level	• Surface irrigation of orchards and vineyards • Non-food crop irrigation • Restricted landscape impoundments • Groundwater recharge of non-potable aquifer • Wetlands, wildlife habitat, stream augmentation • Industrial cooling processes	• Landscape and golf course irrigation • Toilet flushing • Vehicle washing • Food crop irrigation • Unrestricted recreational impoundment

7.3.3 Impact and cost of the solution

The use of secondary treatment with disinfection should enable the limited use of treated effluent for industrial and urban uses. Additional tertiary treatment and disinfection would allow the extensive use of treated effluent. The non-potable water demand in Ho Chi Minh City in 2025 is estimated at over 4,000,000m^3/d.[121] Effluent reuse could meet between 500,000 and 3,700,000m^3/day of this demand.

Table 11. Potential of effluent reuse for non-potable water use in Ho Chi Minh City (2025 estimates)

Users	Description	Demand (m^3/day)	Option 1- Secondary treatment and disinfection	Option 2 -Tertiary treatment and disinfection
Urban	Road washing and fire extinguishing	340,000	No	Yes
	Garden & park watering	199,000	No	Yes
	Toilet flushing and cloth washing	1,020,000	No	Yes
	Watering golf courses and sport facilities	19,000	No	Yes
	Greening belt	58,000	Yes	Yes
Industry	Industrial use:	623,000	No	Depends on use*
	Cooling water	160,000	Yes	Yes
	Others	249,000	No	Depends on use*
Agriculture	Irrigation and aquaculture	1,391,000	Non-food crops only**	Yes
Landscape and recreation	Ponds and water parks	46,000	No	Yes
Total		4,105,000	496,200	3,669,000

* Assumed that 50% of the use could be met through effluent reuse

** Assumed that 20% of the use could be met through effluent reuse

The cost of the planned wastewater treatment works is likely to be in the region of $0.25/$m^3$ of water treated. The additional costs to meet the Options 1 and 2 effluent treatment requirements are estimated at $0.1/$m^3$ and $0.25/$m^3$ of water treated respectively.[122] Therefore, the total costs for Options 1 and 2 are $0.35/$m^3$ and $0.45/$m^3$ of water treated respectively.

The cost for the treated effluent distribution system has been excluded as the layout will be governed by a number of factors, including the locations of planned water reuse facilities in relation to potential users, topography, soil and geological conditions, land use, right-of-ways and existing and planned roads.

7.3.4 Barriers to implementation

The total cost for treating and reusing treated effluent ($0.35-0.45/$m^3$) compares unfavourably to the water tariff for potable water which is up to $0.4/$m^3$. In addition, the treated effluent volumes currently available are low and it is unlikely they will increase significantly before 2020. They should be sufficient, though, to commence a small scale pilot trial on the feasibility of this solution.

Retrofitting water reuse collection and transmission networks is costly and can cause severe disruption to a megacity like Ho Chi Minh City. Therefore, the greatest opportunities for water reuse projects are likely to be in serving new urban and industrial areas and agricultural/green areas near the city.

Decision No 1930/QD-TTg (20 November 2009) describes the development of urban drainage and wastewater up to 2025 and the vision to 2050. It includes the extensive 20-30% of treated wastewater from domestic properties in Viet Nam and reuse for water planning, road cleaning and other urban water uses. This is supported by other Vietnamese legislation which endorse resource recovery and reuse including wastewater treatment and reuse. Although there are some contradictions in legislation,[123] the most important issues are inadequate guidance in appropriate wastewater treatment technologies and insufficient funding mechanisms. This leads to lack of implementation and support for projects and programmes which could assist interested public and private sector organisations.[124]

7.3.5 Roadmap

There are opportunities to support potential municipal water reuse opportunities by:

- Working with ministries such as MONRE, MARD and the MoC to improve the legal framework, provide technical guidance on water quality standards and finance advice.
- Engaging with HCMC Department of Planning and Investment to confirm the current wastewater treatment programme and aspirations.
- Reviewing the HCMC planning standards to promote the installation of dual distribution systems for new developments.
- Explore opportunities with the private sector and developers with regards to the construction, operation and commercialisation of non-potable networks.

7.3.6 Key stakeholders and enablers

- JICA and the World Bank as key stakeholders in wastewater treatment projects in Ho Chi Minh City
- HCMC Department of Planning and Investment
- MONRE
- MARD (if treated effluent is used for agriculture)
- MoC
- Local authorities
- Developers of commercial and residential buildings and sites
- Farmers' organisations

7.4 Industrial wastewater treatment around Hanoi

7.4.1 The challenge

Hanoi is Viet Nam's second city with a population of 7.6 mn in 2016, expected to increase to 9 mn by 2030.[125] 28% of the country's industrial production (by value) was generated in Red River Delta, large portion of it produced in and around Hanoi.

Hanoi's six key industries, namely textile; food processing; chemicals; mechanical manufacturing; electronics; and information technology, have been critical to the city's industrial development and contribute 60 percent of the city's total industrial production value and employ for 50% of the industrial workforce (Viet Nam Chamber of Commerce and Industry).[126] In addition to the industries in Hanoi, there are numerous craft villages in adjoining provinces of Hay Tay and Bac Ninh. These include high water use industries, such as food processing, metalwork, paper, and textiles.

The primary source of pollution is untreated domestic wastewater from North and South Tu Liem Districts and Ha Dong District, followed by industrial wastewater from production facilities and Tu Liem industrial cluster, and Phu Do craft village. Of the 550,000 mn m^3 of wastewater discharged into the river, both treated and untreated, industries accounts for 24% of the wastewater effluent and the craft villages accounting for 4% of the wastewater effluent discharged into the Nhue-Day River.[127]

Though there are legislative requirements for all government and privately operated Industrial Zones to treat industrial effluent prior to discharge, there is a lax enforcement of these regulations. Table 12 below presents the lack of appropriate treatment in most industrial facilities in Nhue-Day sub-basin.[128]

Table 12. Presence of industrial water treatment in Nhue-Day basin in 2010

City	Industrial Parks		Industrial Clusters		Industrial points		Craft villages
	Total	Without CETP	Total	Without CETP	Total	Without CETP	Without WW treatment
Hanoi	13	12	37	35	43	43	257
Ha Nam	11	10	6	6	5	5	14
Nam Dinh	11	10	16	16	-	-	75

Source: World Bank 2010

This heavily polluted water from Nhue River is used to water more than 80,000 ha of cultivation land. A considerable amount of the river water is infiltrates into groundwater and used as the water supply for millions of inhabitants along Nhue River (IWRP, 2010). Pollution levels in water supplied from My Dinh II plant prompted its closure in 2014 by VEA[129], and similar incidences are likely to increase unless water quality in the basin improves.

7.4.2 The solution

7.4.2.1 Municipal effluent treatment

Most industries and industrial estates are located in suburban districts where neither municipal sewers nor centralized municipal wastewater treatment is available in most areas. However, the expansion of drainage and new Municipal ETPs can also capture and treat the industrial effluents. Hanoi has four ETPs in operation with design capacity of 248,000 m^3/d, but according to MONRE currently operating at 133,300 m^3/d due to lack of drainage infrastructure.[130]

Expanded drainage network and at least an additional 650,000 m^3/day treatment capacity will be required by 2030 to capture and treat all the wastewater effluent in Hanoi. There is a stated intention of Municipal Government to invest VND 42 Trillion ($2 bn) by 2020 to upgrade both drainage and effluent treatment capacity.[131]

7.4.2.2 Industrial zone CETP and wastewater reuse

The state owned and private Industrial Zones (IZ), as well as Industrial Clusters and industrial units in craft villages in Hanoi, Ha Nam, and Bac Ninh, discharge 60,000 m^3 of untreated effluent into the Nhue-Day Basin every day. There is opportunity to implement CETP in these clusters and craft villages, along with training for better wastewater management practices. Currently, the World Bank and IFC are working in four industrialised provinces, including three IZs in Nam Dinh and four IZs in Ha Nam, to improve compliance with industrial wastewater treatment regulations. Work carried out include the development of environmental monitoring infrastructure and the improvement in environmental enforcement activities.

Table 13. Cost of CETP for treatment of industrial effluents

City	Industrial Parks		Industrial Clusters		Industrial points	
	Flow (m^3/d)	Capital Cost ($ mn)	Flow (m^3/d)	Capital Cost ($ mn)	Flow (m^3/d)	Capital Cost ($ mn)
Hanoi	63,900	33.0	37,900	18.8	6,200	3.3
Ha Nam	17,530	9.5	1,670	0.93	580	0.32
Nam Dinh	3,170	22.8	9,600	8.4	-	-
Total		**65.3**		**28.13**		**3.62**

Source: World Bank 2010

The industrial water use tariff in Hanoi of 4,500 to 6,000 VND/m^3 (or $0.2 to $0.26) is significantly lower when compared to the additional cost of treating industrial effluent for reuse. To incentivise wastewater reuse at Industrial Zone level, the costs for effluent discharge will need to be raised to provide appropriate financial incentives.

In the absence of such incentives, the most suitable outcome will be to ensure that the treated effluent meets the water quality guidelines by WHO and FAO for crop irrigation purposes.

7.4.2.3 Craft villages – on site treatment

For the industries that lie outside of the Industrial Clusters onsite treatment is not feasible in majority of the circumstances. However, there may be an opportunity to implement decentralised ETP to treat both effluents from industrial and domestic premises.

7.4.3 Impact of the solution

MONRE estimates the industrial effluent accounts for 61 tonnes of BOD/day in the Nhue-Day basin and municipal wastewater accounts for 162 tonnes of BOD/day, accounting for 27% and 73% of the total BOD load.[132]

Treatment of the wastewater effluent will improve the state of water bodies in Nhue-Day sub-basin, increase the utility of the water for irrigation and aquaculture, and reduce the health risks and hazards for residents living in proximity of the polluted water bodies.

In addition, recent research has indicated that improvement of water quality can enable 10-12% reduction in water use to grow the same yield of crop.[132] Therefore, treating the wastewater effluents can reduce the water gap in the sub-basin by 10% if adequate abstraction management controls are put in place.

7.4.4 Barriers

As of 2010, only 7% of industries that would need a Wastewater Discharge Permit (WWDP) were registered with DONRE with regards to their wastewater discharge permits.[133] Without adequate incentives, such as enforcement by DONRE or DARD, this number will stay low and the information about pollution levels will not be captured.

Decree 67 on Environmental Protection Charges for Wastewater instituted tariffs for pollution of the environment based on three organic indicators (BOD, COD, TSS) and four heavy metal indicators (Mercury, Lead, Arsenic, Cadmium). However, these sampling measurements are costly and there is limited capacity at local level for this.

Decree 81 allows for sanctions for violation of environmental regulations. Unfortunately the low level of fines does not provide a strong enough disincentive to environmental violations. Industries often prefer to pay fines than to solve the environmental problem.

Under the regulation, a CETP does not need to be built before the start of operations of a new Industrial Park. This can result in a period where untreated effluent is discharged into the environment.

The regulation do not require an industry in an Industrial Zone to be connected to an existing or proposed CETP and the industrial unit can choose to treat its wastewater and obtain a discharge license. For Infrastructure Development Companies (IDC), that provide, own and operate CETP, this is a problem as it is difficult to design CETP without knowledge of flow and loading. It also is a financial risk for IDC if some industries do not use the CETP.

The tariffs (VND 4000/m^2 and 3,000 to 5000 VND/m^3 of wastewater) are too low for full cost recovery and do not provide financial incentives for IDC to invest in CETPs. Provinces are reluctant to increase fees for fear of losing investors. Even with low rates, industries are often reluctant to pay these tariffs.

Craft villages currently have almost no environmental management and control.

7.4.5 Roadmap

There are opportunities to support potential industrial water treatment and reuse opportunities by:

- Working with ministries such as MONRE, MARD and MOIT to improve the legal framework regarding connection requirements to industrial zone CETP.
- Working with MONRE, MOIT and VEPA to improve legal framework and sanction structure on breach of environmental regulations, linking to the current World Bank / IFC initiatives in industrial pollution management.
- Engaging with Hanoi DOIT, DONRE and DARD to review industrial water and wastewater tariff structure.
- Assisting Infrastructure Development Companies on financing of CETP and Industrial Water Reuse systems.

In addition, opportunities can be explored with the private sector and developers with regards to the construction, operation and commercialisation of CETP and non-potable networks within Industrial Zones and Industrial Clusters.

7.4.6 Key Stakeholders and enablers

The key stakeholders for industrial water management in Viet Nam are listed in Table 14.

Table 14. List of key stakeholders and enablers for waste water management at industrial units in Viet Nam

Stakeholders	Industrial Estate	Standalone industries	Craft Villages (Hanoi & Ha Tay)	Craft Villages (Ha Nam & Nam Dinh)
MONRE	✓	✓		
DPI	✓			
DOIT		✓	✓	
DONRE		✓		
DARD				✓
Industrial Management Boards	✓			
District Authorities			✓	✓
Provincial Industrial Zones Authorities	✓			
River Basin Committees	✓	✓	✓	✓
Provincial People's Committees	✓		✓	✓
Infrastructure Development Companies (IDC)	✓			
VEPA	✓	✓	✓	✓

8 Conclusions and recommendations

The analysis shows that by 2030 all but five river basins in Viet Nam are expected to face some level of water stress in the dry season. Key river basins for the Vietnamese economy will face ‘water stress’ or even ‘severe water stress’ at the same timescale. The situation may deteriorate further as hydroelectric power generation – the engine of Viet Nam’s past industrialisation and modernisation – has reached such large proportions that water sharing conflicts between electricity generation, agriculture, industry and municipalities have already occurred in critical dry periods.

Falling groundwater tables due to groundwater over-exploitation are causing challenges in meeting demand in the dry season, with implications in the Mekong, where 50% of Vietnam’s rice is produced, and in the Central Highlands, where 88% of Vietnam’s coffee is grown. Falling groundwater tables are also linked to land subsidence in Hanoi, Ho Chi Minh City and Da Nang. With only 10% of the municipal and industrial wastewater treated, Viet Nam’s surface waters face serious pollution issues. Many rivers in and around major cities are considered ‘dead rivers’ resulting in an increase in groundwater dependence. Due to lack of clean water resource, polluted water is used for irrigation downstream with unforeseen public health implications.

The report recommends prioritisation of cost-effective interventions to address water stress and water pollution issues in the key basins:

- **South East River Corridor (SERC)**: A water demand reduction of 770 mn m^3/yr is required to close the water gap by 2030, while 1.8 bn m^3 are required to reduce the water stress level from ‘severely water stressed’ to ‘low water stress’. This is a significant challenge, as this accounts for as much as 65% of the total basin water demand. Together with the implementation of selective cost effective demand management interventions, consideration of water supply augmentation measures (such as aquifer recharge and increased reservoir storage) is necessary to close the water gaps. The cost to eliminate the water gap is estimated at $900 m, while achieving a ‘low water stress’ status will require an estimated total cost of at least $3 bn.
- **Red-Thai Bin basin:** To move the basin from ‘water stressed’ to ‘low stress’ status during the dry season by 2030, a total water demand reduction of 4.9 bn m^3/yr is required. A mix of agricultural, municipal and industrial interventions could achieve the required target at a cost of $2 bn.
- **Dong Nai basin:** To move the basin from ‘water stressed’ to ‘low water stress’ status during the dry season by 2030, a total water demand reduction of 1.85 bn m^3/yr is required. A suite of agricultural, municipal and industrial interventions could achieve the required target at an estimated cost of $650 mn.
- **Mekong basin:** To move the basin from ‘water stressed’ to ‘low water stress’ status during the dry season by 2030, a total water demand reduction of 2.5 bn m^3/yr is required. Given that 76% of the basin’s water demand is from agriculture, a handful of cost effective agricultural interventions are sufficient to achieve the target. Adoption of the optimum measures could result in a total saving of $650 mn.

Deep dives were conducted to provide a more detailed insight into selected interventions which were identified as ‘high impact’ areas for a future work plan in Viet Nam. These are as follow:

- **Alternate Wet and Dry (AWD) Rice Management Practice:** Water efficiency measures in rice production can have a great impact on reducing agricultural water demand. AWD has the potential to reduce demand by 30% and is endorsed by the Government of Vietnam. The MARD target for AWD adoption is 1 mn ha by 2020, while IRRI estimates that AWD could be adopted on 4.08 mn ha. Achievement of the MARD target could reduce water demand by up to 4.79 bn m^3/yr. AWD also results in yield increases which could present a business case for farmers. Engagement with MARD is recommended to revise irrigation incentives as part of the decree development for the new law on Hydraulic/ Irrigation infrastructure. In addition, there may be collaboration opportunities to convene leading NGOs in the area of AWD already operating in the Mekong Delta, such as IRRI and farmers' associations, water user associations and Irrigation and Drainage Management Companies.

- **Municipal wastewater treatment and reuse in Ho Chi Minh City (HCMC):** HCMC is projected to be 'water stressed' by 2030. Currently only 10% of HCMC's municipal wastewater is being treated. However, the government plans to increase the treatment capacity to 100% by 2030. It is estimated that between 0.18 bn m^3/yr and 1.35 bn m^3/yr of HCMC's estimated non-potable water demand of 1.46 bn m^3/yr (2025) can be met with wastewater treated to appropriate standards. This could reduce HCMC's water stress level to 'low water stress'. A key barrier to implementation is the inadequate guidance in appropriate wastewater treatment technologies, treated wastewater standards for reuse and an insufficient funding mechanism. The lack of support for interested private and public sector organisations also reduces the potential for PPPs. It is recommended to explore areas to support the Government of Viet Nam in designing regulation around treated wastewater reuse and identify means in which PPPs could be enabled. JICA should be consulted given their relevant project expertise in Viet Nam, while potential private and public investors could be consulted to understand barriers to PPPs in this area.
- **Industrial wastewater treatment and reuse around Hanoi (Nhue-Day Basin):** Despite legislative requirements, most facilities do not have wastewater treatment plants. Central effluent treatment plants (CETPs) can be implemented in state owned and private industrial zones, clusters and units in craft villages in Hanoi, Ha Nam and Bac Nimh. A key challenge is the lack of institutional enforcement, with only 7% of industries registered at DONRE for discharge permits. Fines are considered too low to follow suit with regulatory requirements, while capacity of provincial government bodies is too low to even assess violations. The current water price of between 0.2 – 0.26 $/m^3$ is also lower than the costs of reusing treated effluent. It is suggested to explore opportunities with MONRE, MARD, MOC and MOIT to improve the legal framework and create incentives for sustainable water resource management. Opportunities can also be explored with infrastructure development companies around financing arrangements and commercialisation of CETPs and industrial water reuse systems.
- **Enabling water efficiency for coffee production in the Central Highlands:** Excessive groundwater abstraction for coffee production is reducing groundwater tables and causes water shortages. Total water demand for coffee in the Central Highlands amounts to 2.3 bn m^3/yr. Applying irrigation schedules, which cause 'induced water stress' to crops, could result in up to 25% (577 mn m^3/yr) reduction in water demand, while potentially increasing yields and reducing input costs. As the government plans to reduce area for coffee production, this measure would only reduce overall coffee water demand by 6% (138.5 mn m^3/yr). As most (75%) farmers are smallholders, transaction costs could be quite high to reach out to them. It is also not certain if drip irrigation is required for this technique. If so, financing challenges due to the high upfront capital costs (approx. 2,200 $/ha) can be overcome by cooperating with coffee mills to provide guarantees for farmers. It is recommended to explore cooperation opportunities with organisations already working in this field, as well as with the local governmental bodies (DONRE, DARD, PPCs), irrigation solution suppliers, agricultural banks and coffee associations.

To implement these solutions, incentives structures need to be created with economic and regulatory instruments and an increased enforcement of regulations. Further, for some solutions, new regulations are required, e.g. for reuse of treated wastewater. Financial support for large scale municipal solutions, such as municipal leakage reduction, can be mobilized via PPP or with the support from international donors. Financial support for smaller projects, such as drip irrigation, can be provided through innovative partnerships between the private sector and banks to farmers. Technical support and/or capacity building can be provided in partnership between civil society, the public and private sector.

Given Viet Nam's political system, close engagement and collaboration with the government is paramount in facilitating the implementation of project ideas.

Appendix A

List of stakeholders consulted

A1 List of stakeholders consulted

Organisation	Name	Position
Centre for Environment and Community Research (CECR)	Mr Nguyen Tien Dung	Project Coordinator
Centre for Environment and Community Research (CECR)	Ms Dinh Thu Hang	Project officer
Centre for Environment and Community Research (CECR)	Ms Lo Thanh Hoa	Team leader
Coca Cola	Ms Nguyen Thi Y Nhu	Government Relation Manager
Embassy of Canada	Ms Le Thi Mai Huong	Development Officer
Embassy of Canada	Mr Robert Foote	Project Director
Embassy of Israel	Ms Nguyen Thi Bao An	Mashav Officer
General Department of Water resources, MARD	Mr Nguyen Viet Anh	Vice Head
General Department of Water resources, MARD	Mr Nguyen Van Hung	Specialist
Hanoi University of Natural Resources and Environment (HUNRE)	Ms Hoang Thi Nguyet Minh	Vice Head
JICA	Mr Hiroshi Anzo	Advisor
JICA	Mr Nguyen Vu Tiep	Programme Officer
Khang Thinh group (Netafim partner)	Mr Vo Trung	Director
MARD	Mr Truong Duc Toan	Technical staff
MASAN group	Mr Phan Nhat Long	Director
Ministry of Construction	Mr Tran Bien Trung	Technical staff
MONRE	Mr Thuận	Deputy Director
MONRE	Ms Le Thi Viet Hoa	Head
MONRE	Ms Vu Hoai Thu	Chief of office cum Head
MONRE	Ms Nguyen Thu Phuong	Specialist
MONRE	Mr Hoang Minh Tuyen	Director
Nestlé Viet Nam Ltd	Ms Huynh Thi Thanh Truc	Government Relation Manager
Netafim	Ms Vu Ha	Country representative

Organisation	Name	Position
State Secretariat for Economic Affairs SECO	Mr Roman Windisch	Deputy Country director
The Asia Foundation	Mr Michael DiGregorio	Viet Nam Country Representative
UNDP	Ms Bui Viet Hien	DRR officer
Viet Nam Institute of Urban and Rural Planning (VIUP), MOC	Mr Luu Duc Minh	Director
Viet Nam Institute of Urban and Rural Planning (VIUP), MOC	Mr Nguyen Viet Dung	Vice Director
Viet Nam Institute of Urban and Rural Planning (VIUP), MOC	Mr Vu Tuan Vinh	Vice head
VietAn Enviro Group	Mr Nguyen Hoai Thi	CEO

Appendix B

Map of river basins

Table 15. Map of key river basins in Viet Nam

Appendix C

Institutions and governance

C1 Institutions and governance

Table 16. Organisational and Institutional structure of Viet Nam's water sector

Administrative level	Institution	Responsibility
Central	National Water Resources Council	Supporting the Prime Minister making measures to water resources protection, exploitation and sustainable use; Preventing, combating and overcoming water harmful effects[134]
	Ministry of Natural Resources and Environment - MONRE	Overall state management of water resources Develop strategies, plans Water volume, water quality monitoring Develop models of economical and efficient use of water; Wastewater discharge control (to rivers, lakes, etc.)
	Ministry of Agriculture and Rural Development - MARD	Dyke and irrigation works management; flood control; rural water supply/drainage; water used for aquaculture
	Ministry of Industry and Trade - MOIT	Hydropower, water for industries
	Ministry of Construction - MOC	Urban and industrial water supply and sewerage/drainage
	Ministry of Science and Technology - MOST	Water quality standards appraisal and issuance; and water-related technology invention licensing
	Ministry of Transport - MOT	Waterway transport
	Ministry of Heath - MOH	Drinking water quality
	Ministry of Finance - MOF	Unified financial management of ODA capital sources for investment in water supply development; State budget management for water projects; Coordinates methods for determining clean water consumption prices, price brackets and their implementation Water resources related environmental tax/fee/charges
	Ministry of Planning and Investment - MPI	Encourage and mobilise domestic and foreign investment capital sources for water supply, waste water works; Coordinates mobilisation of ODA capital sources for investment in water supply development
	Ministry of Public Security - MOPS (public security)	Water pollution investigation and monitoring
Regional	Mekong River Basin Committee of Viet Nam	Support the Prime Minister making measures to water resources development, management and use of Mekong basin in Viet Nam[135]
Provincial	Provincial People's Committee (PPC)	State investor in irrigation system and water quality at provincial level; Water supply at provincial and district level, Response to water related incidents
	Department of Natural Resources and Environment -DONRE	Direct water quality control/management at provincial and district levels, water volume and monitoring
	Department of Agriculture and Rural Development - DARD	State management role over agricultural irrigation system within provincial responsibility. Rural water supply;

Administrative level	Institution	Responsibility
		Irrigation canals, reservoirs for watering within province and dykes; Food processing
	Department of Industry and Trade - DOIT	Hydro power; Water for industries
	Department of Construction - DOC	Urban water supply and drainage within the province
	Department of Science and Technology - DOST	Contribution to water quality standards development; Guidance to application of water quality standards
	Department of Transport - DOT	Waterway transport
	Department of Health - DOH	Drinking water quality standards and monitoring
	Department of Finance - DOF	ODA/State budget for water projects
	Department of Planning and Investment - DPI	Encouragement and mobilisation of domestic and foreign investment, and ODA capital sources for water supply development
	Department of Natural Resources and Environment - DONRE	Water pollution investigation and monitoring within province
District	District People's Committee[136]	Monitor and protection of water resources; Response to water related incidents
Commune	Commune People's Committee	Monitor and protection of water resources; Response to water related incidents
Service providers and Associations	Water Supply Company	Utility at urban level for water supply, sometimes they include water treatment
	Drainage and sewerage company	Public utility enterprise
	Viet Nam Water and Sewerage Association	Professional association, predominantly focus on urban water companies
	Irrigation Management Company	Irrigation providers
	Urban Environmental Company	Waste water collection, treatment in urban areas
	Water User Association	Group of farmers taking care of inner field irrigation system

Appendix D

Data used in the water demand assessment

D1 Water demand

D1.1 Water demand estimation and forecast

Table 17. Assumptions used to project water demand to 2030

Sector	Growth assumptions	Assumed increase in water demand (abstraction) by 2030
Irrigation	• Agriculture growth (including forest and fisheries) since 2009 is estimated at 3.5%.[137] A third of the growth is attributed to the forest and fisheries. After 2020 rice plant area is not to increase further. Move towards cash and plantation crops is likely. • 2009-2020: 3.5% annual GDP increase for agriculture, forest and fisheries • 2020-2030: 3% annual GDP increase for agriculture, forest and fisheries	• 2009-2020: 2.25% annual increase in water demand • 2020-2030: 1% annual increase in water demand. Increase halved due to steady rice plant area which is the largest water user. Cash and plantation crops are less water intensive in terms of water use (m^3/ha).
Industry	• 7% average annual increase	• 7% average annual increase in water demand
Municipal	2030 assumptions: • Viet Nam population reaches 105 mn; • Daily water use of 150 l/person/day	• Equivalent to 4.5% annual increase in water demand
Aquaculture	• Assume increases in line with irrigation sector	• Assume increases in line with irrigation sector
Hydropower generation	• Additional reservoirs under construction estimated at 5.9 bn m^3	• Equivalent to a cumulative increase of 10% in water demand. This assumption is likely to be underestimating the increase in reservoir storage for hydropower generation.

D1.2 Hydropower

Table 18. Overview of hydropower capacity and respective reservoir capacity, per scale and region and river basin, for operating plants (2016)

	Total Capacity MW	% capacity of total	Reservoir (mn m^3)	% reservoir of total
Hydropower				
Operation	16,981.47		56,836.44	
Small	1,365.97	8%	2,796.51	5%
Medium	2,204.50	13%	5,914.54	10%
Large	13,389.00	79%	48,125.39	85%
Unknown	22.00	0%	-	0%
Region				
Northeast	525.49	3%	2,669.91	5%
Northwest	7,536.50	44%	25,245.27	44%
North Central Coast	1,121.30	7%	11,171.36	20%
South Central Coast	2,320.55	14%	5,310.16	9%
Central Highlands	4,775.23	28%	8,022.26	14%

	Total Capacity MW	% capacity of total	Reservoir (mn m³)	% reservoir of total
Southeast	702.40	4%	4,417.48	8%
River Basin				
Ba	712.93	4%	1,512.30	3%
Bang Giang - Ky Cung	35.90	0%	0.37	0%
Ca	440.30	3%	2,223.16	4%
Dong Nai	2,722.30	16%	8,091.07	14%
Red Thai Binh	7,992.79	47%	27,904.98	49%
Huong	316.00	2%	1,949.20	3%
Kone	141.90	1%	310.00	1%
Ma	377.00	2%	6,950.83	12%
Se San	1,980.20	12%	3,371.43	6%
SERC	126.00	1%	42.89	0%
Sre Pok	869.20	5%	1,222.94	2%
Thach Han	6.00	0%	58.00	0%
Thu Bon & Vu Gia	1,059.60	6%	2,661.65	5%
Tra Khuc	186.05	1%	537.63	1%
Mekong	15.30			

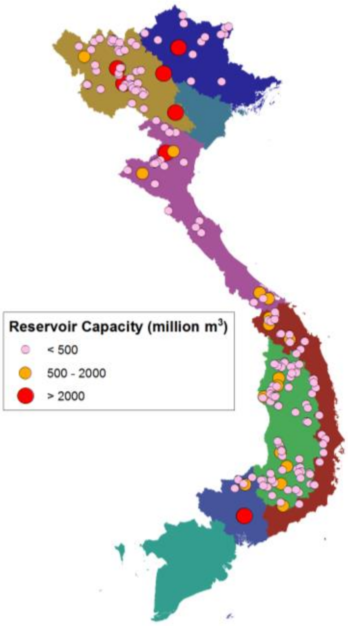
Table 19. Overview of hydropower capacity and respective reservoir capacity, per scale and region and river basin, for selected future hydropower plants (2030)

Hydropower	Total Capacity MW	% capacity of total	Reservoir (mn m³)	% reservoir of total
Under construction	549.4		971.55	
Ma	422	77%	412.15	42%
SERC	5.5	1%	0.4	0%
Sesan	49.9	9%	1.7	0%
Sre Pok, Ia Lop, Ia H'leo	30	5%	9.3	1%
Tra Khuc, Ve, Tra Bong	42	8%	548	56%

Source: Open Development Mekong Database[138]

Note: Reservoir capacity was not available for all hydroelectric plants; it is likely that the actual reservoir capacity is higher.

Figure 25. Reservoir capacity for hydroelectric plants in Viet Nam

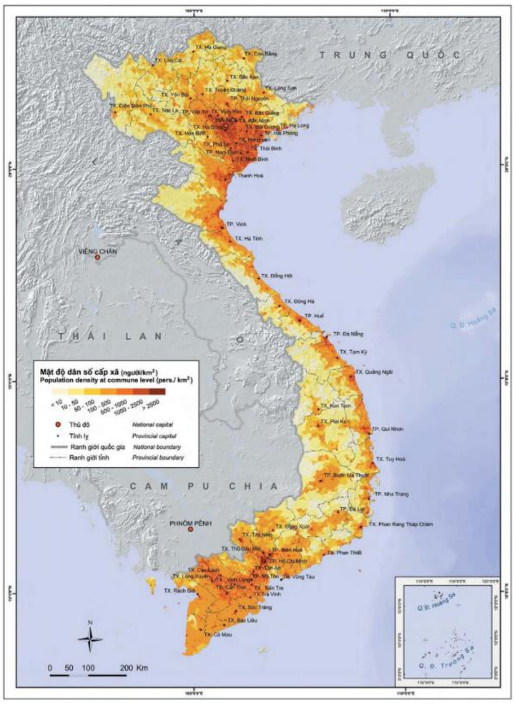


D2 Population

Viet Nam has one of the fastest rates of urbanisation in the world, with almost 43% of the country’s population expected to be living in cities by 2030.[139] While more than two-thirds of the population still live and work in provincial towns and villages, the cities of Hanoi, Ho Chi Minh, Danang and Haiphong are growing rapidly, as can be seen in Figure 26.

This rapid urbanisation without adequate infrastructure provision, such as water supply and sanitation, has led to negative impacts on the water environment from discharges of untreated municipal and industrial waste.

Figure 26. Population Density in Viet Nam (source: Agroviet)



D3 Agriculture and aquaculture

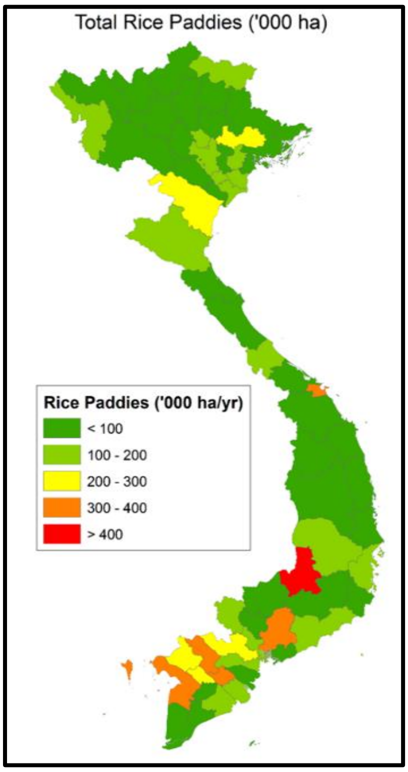
Although agriculture is fading as the most important economic sector in Viet Nam, it is still the main source of raw materials for the processing industries and a major contributor to exports. Rice production, in particular, plays an important role in Viet Nam's food security and rural economy. Other key crops include maize and sugarcane. The primary agricultural areas are the Mekong Delta and the Red River Delta; these two basins account for 70% of the water uses in the country.[140]

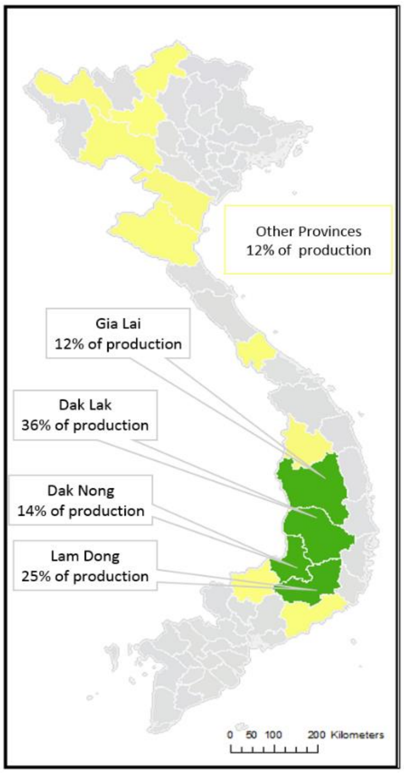
Aquaculture has grown significantly in recent years averaging over 12% annual growth since 1990.[141] The river basins with the highest water demand for aquaculture are the Mekong, Red – Thai Binh, Dong Nai and Ma.

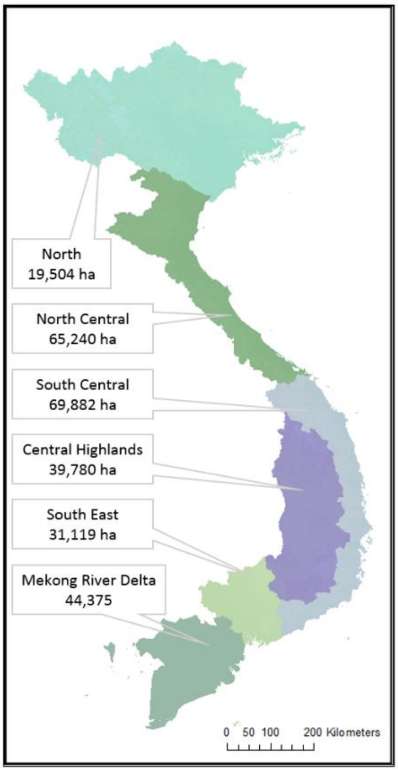
Figure 27. Distribution of rice growing area in Viet Nam [142]

Figure 28. Distribution of coffee growing area in Viet Nam[143]

Figure 29. Distribution of Sugarcane growing areas in Viet Nam.



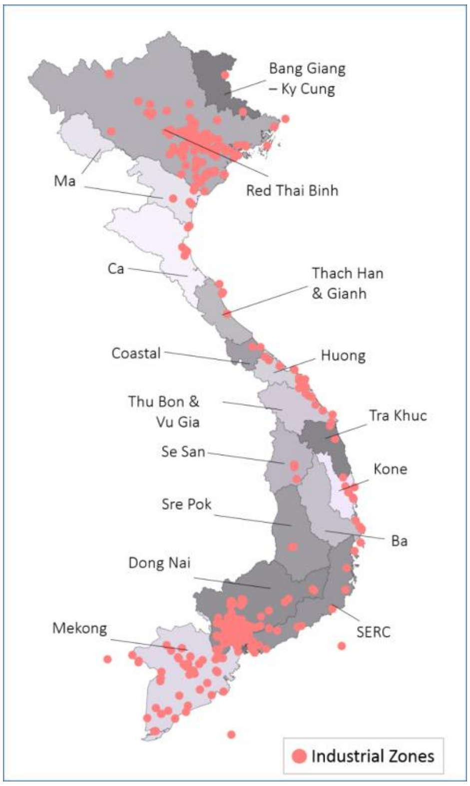




D4 Industry

Large portion of the industrial production occurs in designated Industrial Zones and Industrial Parks, locations of which are shown in Figure 30.

Figure 30. Map of industrial zones/parks



D5 Other data

Viet Nam Export data (2015). Available at: http://wits.worldbank.org/detailed-country-analysis-visualization.html [8 May 2017]

Open Aid Data database (2015). Available at: http://www.openaiddata.org/ [8 May 2017]

Open Development Mekong. (2017). [online] Available at: https://opendevelopmentmekong.net/ [Accessed 10 April 2017].

Appendix E

Water demand, water gap and
Water Exploitation Index

E1 Water supply-demand gap

The tables below illustrate exploitable available water resources and water demand by sector in the dry season in 2016 and 2030. A water gap occurs when exploitable water availability is insufficient to meet water demand, i.e. the value in the water gap column is negative (highlighted in red). Positive values indicate that there is no water gap.

E1.1 2016 Dry season (excluding storage for hydroelectric power generation)

Table 20. Water use and water gap during dry season (2016)

Basin	2016 Dry Season						
	Exploitable Water Availability	Water Demand (in mn m^3)					
		Irrigation	Industry	Municipal	Aquaculture	Hydropower	Water Gap
Bang Giang - Ky Cung	2,157	178	15	8	19	-	1,937
Red - Thai Binh	24,240	9,947	1,730	652	504	-	11,408
Ma	3,701	2,792	89	76	279	-	464
Ca	5,642	1,048	19	82	219	-	4,275
Gianh	1,075	38	12	7	7	-	1,011
Thach Han	703	62	12	6	15	-	609
Huong	2,555	1,005	16	54	87	-	1,393
Thu Bon & Vu Gia	4,662	1,040	128	46	112	-	3,335
Tra Khuc	2,139	630	9	8	28	-	1,464
Kone	2,129	804	35	20	18	-	1,251
Ba	3,341	1,270	18	31	27	-	1,995
Dong Nai	8,606	2,522	854	414	229	-	4,587
SERC	1,903	818	288	111	665	-	22
Se San	3,253	35	11	6	3	-	3,199
Sre Pok	3,276	432	14	29	38	-	2,763
Mekong	47,416	15,995	285	241	3,937	-	26,957
Total	**116,795**	**38,614**	**3,535**	**1,790**	**6,187**	-	

Source: Current study

E1.2 2030 Dry season (excluding hydroelectric power generation)

Table 21. Water use and water gap during dry season (2030)

Basin	2030 Dry Season						
	Exploitable Water Availability	Water Demand (in mn m^3)					
		Irrigation	Industry	Municipal	Aquaculture	Hydropower	Water Gap
Bang Giang - Ky Cung	2,182	213	39	14	22	-	1,892
Red - Thai Binh	24,783	11,984	4,461	1,207	607	-	6,525
Ma	3,756	3,359	231	140	336	-	-310
Ca	5,735	1,263	50	152	264	-	4,006
Gianh	1,098	49	27	11	10	-	1,000
Thach Han	717	77	27	9	19	-	585
Huong	2,585	1,225	36	87	106	-	1,131
Thu Bon & Vu Gia	4,741	1,336	256	67	144	-	2,937
Tra Khuc	2,172	771	18	11	34	-	1,338
Kone	2,157	995	71	29	22	-	1,041
Ba	3,382	1,541	42	51	33	-	1,716
Dong Nai	8,766	2,998	2,202	766	273	-	2,527
SERC	1,933	969	742	205	787	-	-770
Se San	3,315	55	28	11	4	-	3,217
Sre Pok	3,317	505	42	64	44	-	2,662
Mekong	48,542	19,068	856	521	4,694	-	23,403
Total	**119,181**	**46,409**	**9,127**	**3,346**	**7,399**	-	

Source: Current study

E2 Water Exploitation Index

The calculation of WEI figures is presented below without the inclusion of storage for hydroelectric power generation.

E2.1 WEI excluding the impact of hydropower storage

Table 22. Water Exploitation Index for river basins

Basin	2016			2030		
	Dry Season (in mn m^3)		WEI	Dry Season (in mn m^3)		WEI
	Water demand	Water Availability	Dry season	Water demand	Water Availability	Dry season
Bang Giang - Ky Cung	220	18,117	1%	289	18,175	2%
Red - Thai Binh	12,832	65,740	20%	18,258	66,993	27%
Ma	3,236	9,226	35%	4,066	9,355	43%
Ca	1,368	13,905	10%	1,729	14,117	12%
Gianh	64	3,345	2%	98	3,397	3%
Thach Han	94	2,035	5%	132	2,067	6%
Huong	1,162	5,144	23%	1,454	5,214	28%
Thu Bon & Vu Gia	1,327	11,777	11%	1,803	11,960	15%
Tra Khuc	675	5,243	13%	834	5,320	16%
Kone	877	4,754	18%	1,117	4,821	23%
Ba	1,346	6,915	19%	1,666	7,009	24%
Dong Nai	4,019	21,603	19%	6,239	21,972	28%
SERC	1,881	4,628	41%	2,703	4,699	58%
Se San	54	12,344	0%	98	12,486	1%
Sre Pok	513	11,502	4%	655	11,598	6%
Mekong	20,458	110,510	19%	25,139	113,111	22%

Source: Current study

Note: Water demand refers to water abstraction, not consumption

Appendix F

Water pollution challenges and regional water quality

F1 Wastewater treatment

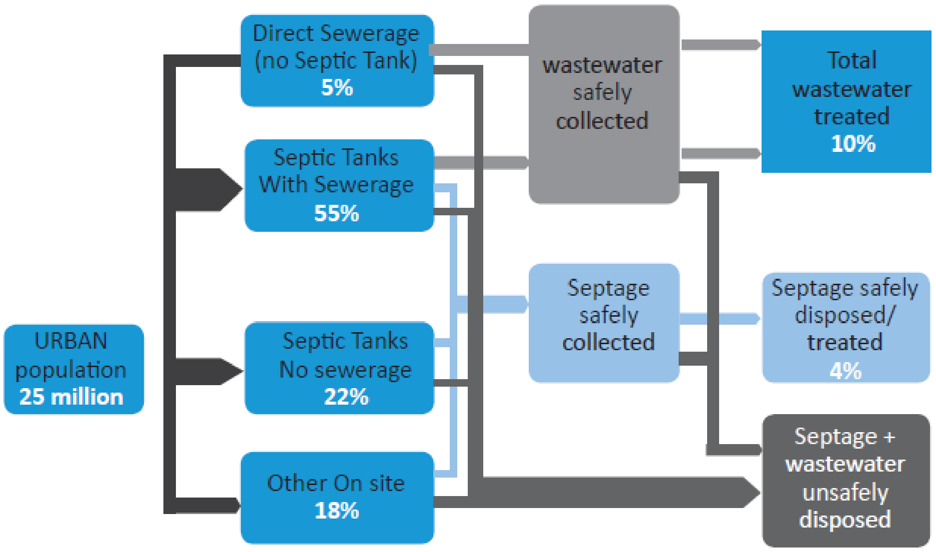
F1.1 Municipal wastewater management

Highlight:
- Only 12-13% of municipal wastewater is treated

Most drainage and sewerage systems in large cities of Viet Nam are combined sewer systems, primarily serving as stormwater drainage, with only a few newly developed urban areas employing separate sewer and drainage systems. Although 60% of households dispose wastewater to a public system, much of this is directed informally to the drainage system and only 10% is treated.[144] While 90% of households dispose wastewater to septic tanks, only 4% of septage is treated. Sludge management is generally poor in most cities (see Figure 31).

By the end of 2015, the total capacity of 35 centralised wastewater treatment plants in Hanoi, Ho Chi Minh City, Da Nang and other large cities was about 850,000 m^3/day, which equates to 12-13% of Viet Nam's requirements.[145] The focus of wastewater expenditure to date has been in constructing treatment facilities, but this has not always been accompanied by appropriate collection systems.

Figure 31. Status of urban wastewater management in Viet Nam[146]



In addition, it has been estimated that several thousands of decentralised wastewater treatment plants have been constructed and installed across the country[147] for the purpose of treating domestic wastewater from residential areas, hospitals, hotels and office buildings. Despite this, only 50% of the hospitals and 7% of the 23,500 livestock farms in Viet Nam have wastewater treatment systems as of 2014.[148]

F1.2 Industrial wastewater management

Highlight:
- Only 10% of industrial wastewater is treated

Viet Nam has more than 500,000 manufacturing facilities generated more than 630,000 tonnes of hazardous industrial waste and 17,000 tonnes of hazardous medical waste. In addition, every year more than 100,000 tonnes of pesticides are consumed while the Ministry of Natural Resources and Environment (MONRE) inspects more than 100 small-scale domestic waste incinerators that are likely to emit dioxin, furan, and air pollution.[149]

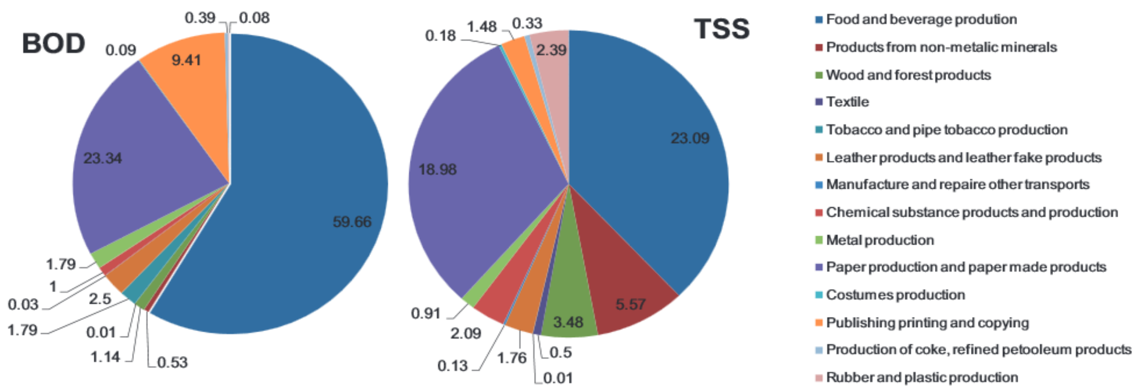
Wastewater discharged from industrial factories and industrial zones exert great pressure on the surface water environment in the country.

A detailed assessment of the industrial sector in 2008 indicated that the top 3 polluting industries in Viet Nam were paper and wood production, chemical production and processing and metal. Since then, the food and drink and textile industries have grown rapidly and are responsible for large portions of the industrial pollution load. Each sector discharges specific pollutants. For example, wastewater from:

- Mechanical and metallurgical industries contain heavy metals and mineral oil;
- Textile, dye and paper industries contain solids and organic pollution;
- Food industry contains solids and particularly impacts on biochemical oxygen demand (BOD) as well as discharging nutritive substances such as nitrogen and phosphorus compounds and others.[150]

While it is mandatory by law for industries to treat their wastewater, in effect only 10% of industrial wastewater is treated.[151] According to the Ministry of Natural Resources and Environment, of the 283 industrial parks, about 70% have invested in wastewater collection and treatment system. However, during recent inspections 137 polluting facilities with a discharge capacity of more than 200 cubic meters a day were identified.

Figure 32. Estimated BOD_5 and Total Suspended Solids (TSS) contribution by industries[152]



Note: Industrial Pollution Projection System was used with pollution co-efficient adjusted for Vietnam

Finally, there are 5,000 craft villages in Viet Nam with over 65% of them located in the Red-Thai Binh River Basin. These villages usually discharge untreated wastewater directly into water bodies without any treatment.[153]

F2 Water pollution

F2.1 Groundwater pollution

Groundwater pollution is increasingly becoming a problem in Viet Nam, particularly in industrial and craft villages, as well as agricultural areas. In addition, groundwater faces major challenges associated with organic and coliform contamination that is hundreds or thousands of times over the current standards and increasing phosphate pollution. In Dong Nai River Basin, polluting land use activities and discharge of untreated wastewater and industrial effluent has impacted groundwater quality and is posing a significant risk to users.[154]

F2.2 River pollution

Pollution from organic matter, exceeding standards, is most common. Heavy metal pollution is mostly concentrated in the tributaries near mining and industrial production facilities. Likewise, oil pollution mainly occurs in reaches with navigation activities and in those receiving industrial wastewater from production facilities and ports. Effluent from the textile and pulp and paper industries, in particular, has cyanide and ammonia concentrations that can be up to 84 times higher than the discharge standards.

The heaviest polluted rivers include those passing through dense industrial and municipal areas and crafts villages. According to policy brief (2016) from the Center for Environment and Community Research, three rivers passing through Hanoi can be classified as 'drainage systems', namely To Lich (Hanoi), Set river (Hanoi), Kim Nguu (Hanoi), while on a national scale the following rivers can be considered to be 'dead rivers': Ngu Huyen Khue (Bac Ninh), Buoi (Thanh Hoa), Nhue-Day (Hanoi and Ha Nam), Thi Vai (Dong Nai), Da Do (Hai Phong), Gam (Cao Bang), Nam Cat (Bac Can).[155]

Further, water quality is of serious concern for economically significant rives including the Cau River and Nhue River in the Red-Thai Binh River Basin, which pass close to/ through Hanoi, the Sai Gon River and the wider Dong Nai River Basin, passing through Ho Chi Minh City, and the Hau River in the Mekong River Basin. 65% of craft villages, which typically do not have wastewater treatment plants, are located in the Red-Thai Binh River. Pollution levels in these rivers are considered 'serious' and become even more critical in the dry season.

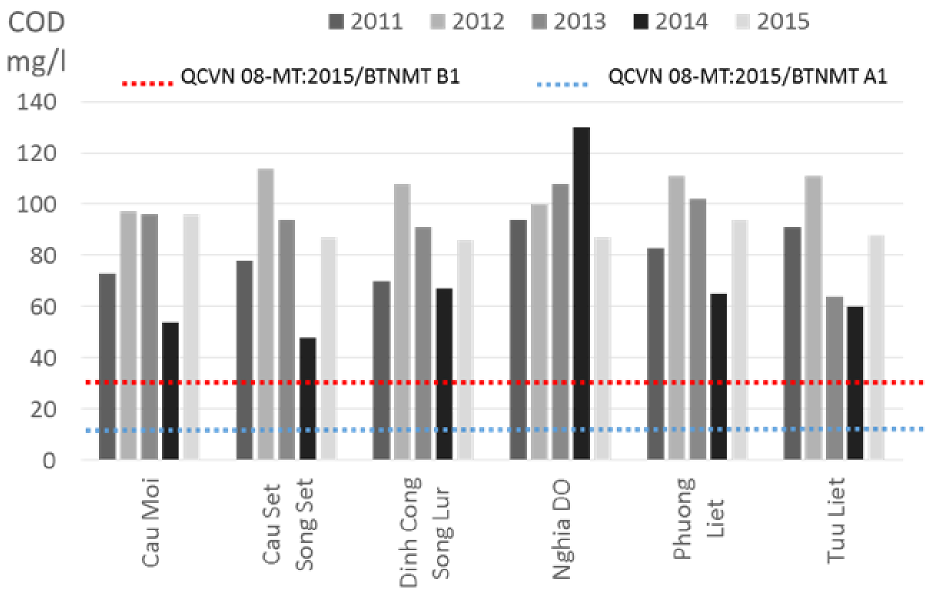
Besides, salinity intrusion in downstream estuaries is becoming increasingly common in the South West, South East and Central Coast.

F2.3 Urban surface water pollution

While there have been measures to improve urban surface water quality, surface water bodies within big cities like Ho Chi Minh City, Da Nang and Hanoi still face a pitiful state.

Taking Hanoi as an example, Figure 33 demonstrates that water bodies consistently show COD levels beyond 80mg/l in 2015, which by far exceed the standard required to use it for domestic or even agricultural use.

Figure 33. COD content in selected urban surface water areas in Hanoi, 2011-2015



F3 Regional water quality

F3.1 Northwest Region

The primary economic activities in this region are agriculture, forestry and mining. The water quality is generally considered as good, there is some localized deterioration near the few urbanized locations in the region. Ground water quality is reportedly good and well within the national standards.

F3.2 North East Region

The rivers of this region generally have good water quality.

The upstream reaches of the Red River in the Lao Cai province, and some of the larger tributaries in Lo, Gam, Cau, Thuong and Luc Nam have good water quality. (Class A and B of the National Standards).

The water quality in the tributaries passing through dense urban and industrial areas do not meet national water quality standards, with a hot spot near the town of Viet Tri.

The **Cau River** originates in Bac Kan province, and flows through Bac Kan, Thai Nguyen, Bac Giang, Bac Ninh, Vinh Phuc and Hai Duong. As Figure 35 shows, the water quality decreases starting in Thai Nguyen due to discharge of industrial and municipal wastewater. It further deteriorates to the worst water quality index levels as it passes Bac Giang and Bac Ninh due to industrial water and discharges from craft villages. Most serious pollution challenges come from the craft villages located between Dong Anh (Hanoi) to Van An Ninh in Ngu District and Khe District. This downstream surface water can only be used for navigation.

Figure 34. Water Quality of the Cau River based on the Water Quality Index (2014)

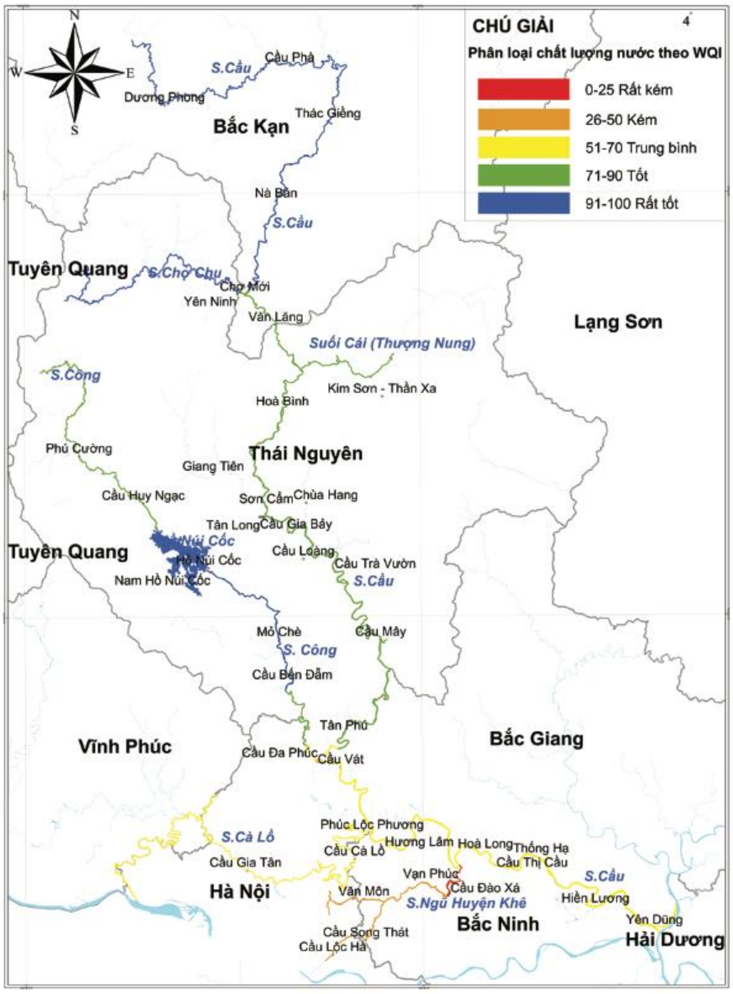
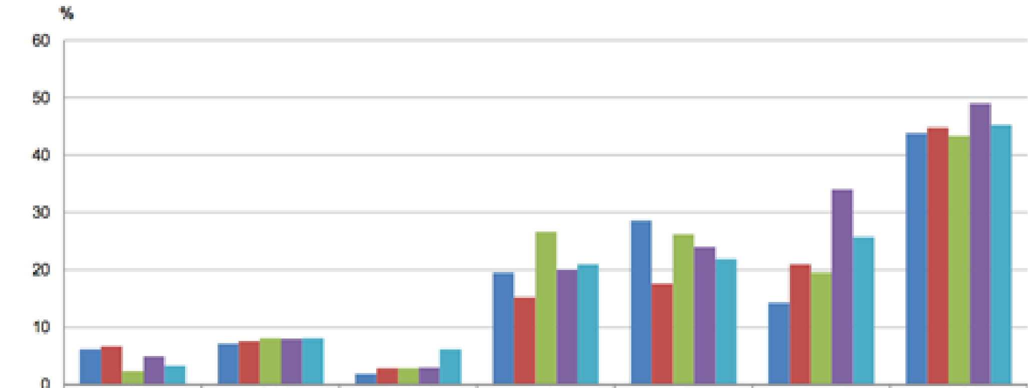


Figure 35. Evolution of excess rate of selected water quality parameters in surface water in Cau River, 2011-2015



	DO	COD	BOD5	TSS	Fe	Amoni	Nitrit
2011	6,19	7,14	1,90	19,52	28,57	14,29	43,81
2012	6,67	7,62	2,86	15,24	17,62	20,95	44,76
2013	2,38	8,10	2,86	26,67	26,19	19,52	43,33
2014	5,00	8,00	3,00	20,00	24,00	34,00	49,00
2015	3,33	8,10	6,19	20,95	21,90	25,71	45,24

Source: Viet Nam 5-year Environmental Report 2011-2015

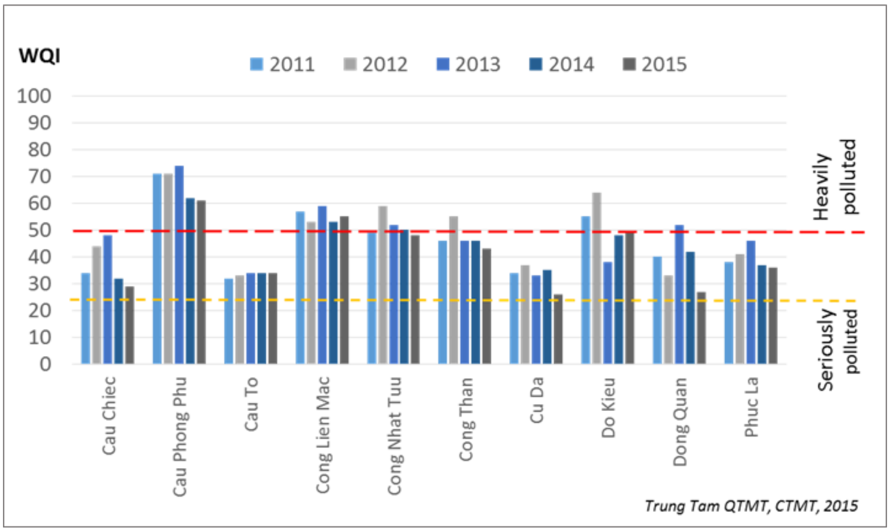
The ground water quality is generally good, however is likely to be affected by ingress of polluted freshwater from the riverine system. The groundwater in coastal zone suffers from saline intrusion, which is likely to worsen due to climate change linked sea level rise.

F4 Red River Delta

The upstream water quality meets the standards in most parts and is suitable for industrial and domestic use. However, there are pollution hotspots near effluent discharge outlets from industrial areas.

Nhue-Day River flows through Hoa Binh, Hanoi, Ha Nam, Nam Dinh and Ninh Binh. Water quality deteriorates rapidly as it passes Ha Dong, Thanh Tri and Thanh Oai (Ha Noi) due to industrial, municipal and craft village wastewater discharges. As Figure 36 shows, the water quality index is mostly below 50, i.e. the water quality is so bad that river can only be used for navigation and for stretches below 25 not even for that.

Figure 36. Annual average water quality index of the Nhue River, 2011-2015



Similar to other regions, groundwater is generally acceptable levels but at an increasing risk from pollution ingress from water bodies as well as saline intrusion in the coastal zones.

F4.1 North Central Coastal Region

Agriculture and tourism are primary economic activity in the area. The upstream water quality is generally within acceptable standards.

The quality of water in rivers passing through urban centres and industrialised areas is in poor state, with levels of BOD5, COD, NH4 and PO4 above acceptable levels in National Water Quality Standards.

The groundwater is generally to acceptable standards for consumption, however subject to complex chemical composition in the plains and subject to saline intrusion in the low lying coastal areas.

Increase in industrial development and increased urbanisation will further degrade the water quality in the areas, unless adequate municipal and industrial effluents are put through appropriate treatment before discharge.

F4.2 South Central Coastal Region

The primary economic activity include tourism, fisheries and aquaculture, mining and industry.

Upstream water quality is to acceptable national standards. However, high level of pollution is present in water bodies in coastal cities like Da Nang, Quy Nhon and Nha Trang.

There are high level of heavy metals and other toxic substances in water bodies passing through mining zones.

Groundwater has not been affected by pollution in the water bodies and is generally to acceptable standards. However, there is a long term risk due to ingress of pollution from untreated discharges from mines, municipalities and industry into surface water bodies.

F4.3 Central Highlands Region

This region is predominantly used for agriculture and forestry, and growing cash crops such as coffee. There is high level of seasonality in rainfall, with long dry season and high risk of droughts in period from January to May.

There is limited monitoring water quality information for this region. However as its primarily agricultural, the level of pollution are low compared to other regions.

There is potential for increased pollution from agricultural sources, e.g. from fertiliser use, in future if sustainable practices are not employed.

F4.4 Northeast Mekong

This region has high level of industrial activity and a high level of urbanisation, with large volumes of untreated or minimally treated effluent being discharged into the water bodies.

Pollution hotspots are present in Dong Nai, Thi Vai and Sai Gon rivers, whereas Thi Vai River is heavily polluted with industrial effluent from Bien Hoa and Phu My industrial zones. Sources of pollution include, coliforms, nitrogen, phosphorus, and heavy metals (chromium, lead, mercury and arsenic)

The **Dong Nai River Basin**, includes some large rivers such as Dong Nai, La Nga, Be, Sai Gon and Vam Co rivers. Dong Nai, Binh Duong, Ho Chi Minh, Lam Dong, Binh Phuoc, Dak Nong, Binh Thuan, Ninh Thuan, Long An, Tay Ninh and Ba Ria - Vung Tau. Many areas across the entire river basin were seriously polluted from industrial, municipal, agriculture and aquaculture wastewater discharges.

While the situation has been found to have improved between 2006 and 2010, there are still several pollution hotspots. The water quality of the Dong Nai River and Sai Gon River deteriorates when passing through Ho Chi Minh City due to industrial and municipal discharges. There are many river stretches in which the water quality is unfit for domestic and agricultural uses according to water quality standards QCVN 08-MT: 2015 / BTNMT A1 and QCVN 08-MT: 2015 / BTNMT B1. Further downstream, Thu Dau Mot Town and Tan Uyen District pose a further pollution hotspot due to industrial and municipal wastewater discharges.

The superficial aquifers in seashore band (between Mekong and Dong Nai River) have high level of salinity. Deeper aquifers have lower level of contamination and can be used for consumption.

Figure 37. COD content in surface waters across Dong Nai River, 2011-2015

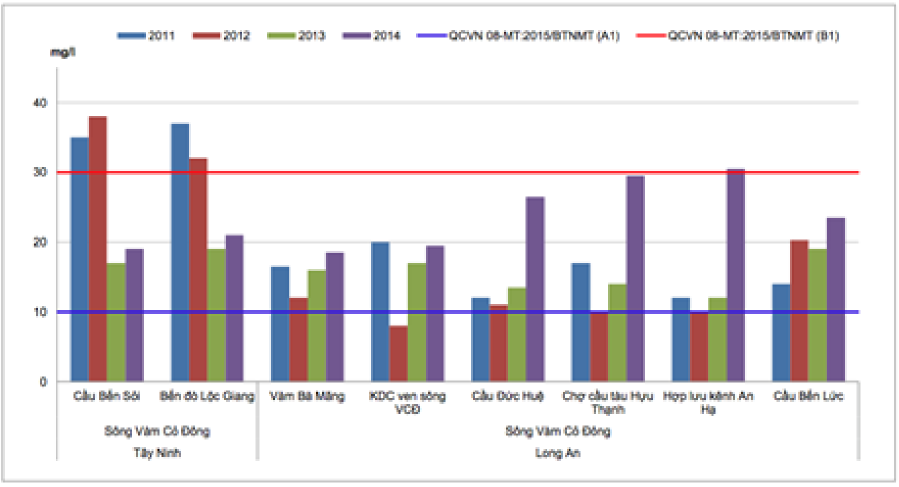
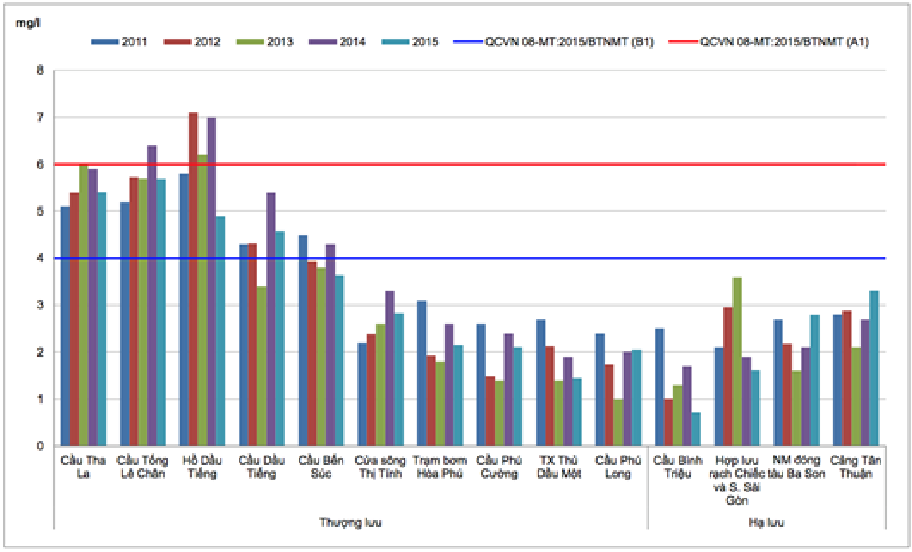


Figure 38. COD content across the Saigon River, 2011-2015



F4.5 Mekong River Delta Region

Mekong River Delta is one of the most densely populated regions in the world, with agriculture, aquaculture and food processing industry dominating the local economy.

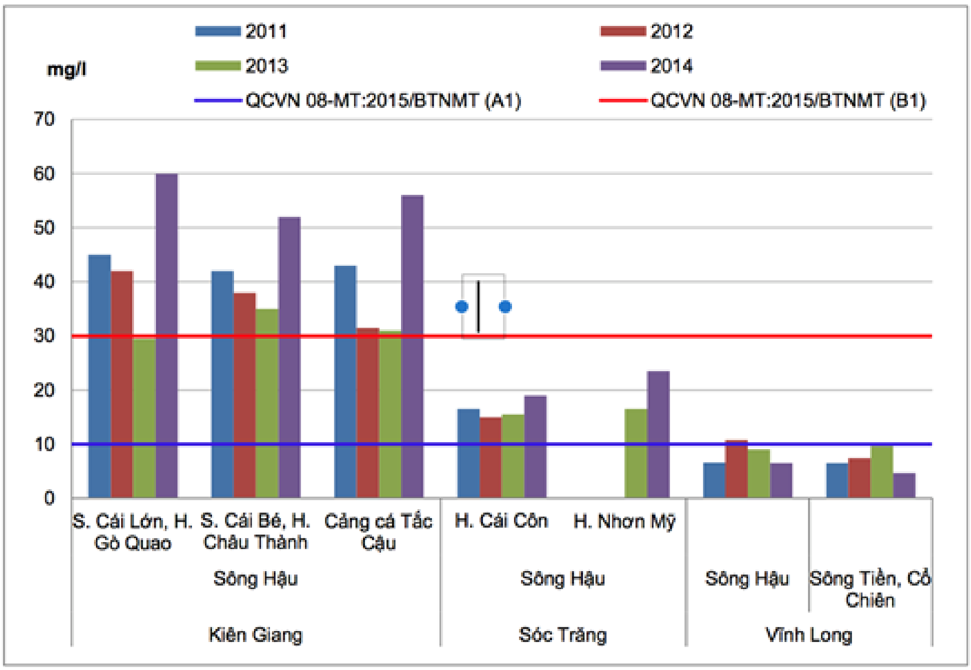
While the water quality of the Mekong River Basin can be considered as good at large, the water quality of the two largest rivers, namely the Hau and the Tien River, deteriorates in industrial zones and urban areas, such as the My Tho fishing port and My Tho industrial zone. The level of pollution, mainly from organic matter, nutrients, micro-organisms and alumn, has been increasing over the years, has led in Kien Giang to water quality levels unfit for domestic or agricultural water usage. Pollution intensity is increasing over the years, a particularly worrying trend as 50% of Viet Nam’s rice is produced in the Mekong Delta.

Besides, salinity intrusion in downstream estuaries is becoming increasingly common in the South West, South East and Central Coast.

The groundwater in coastal areas of the delta suffers from saline intrusion, and superficial aquifers in many other parts have been registered with high nitrogen levels.

The coastal waters are in poor state due to the high levels of untreated effluents being discharged into these coastal waters.

Figure 39. COD levels across the Mekong River Basin, 2011-2015



Appendix G

List of ongoing initiatives

Ref	Project	Lead	Partners	Water supply	Wastewater	Watershed management	Water efficiency	Water quality	Climate change	Hydropower	Transportation	Municipal	Agricultural	Industries	Physical infrastructure	Education and capacity building	Finance and governance	Knowledge and technology	Status
1	Mekong Safe Water Project	HSBC	Save the Children		X							X			X				completed
2	Southeast Asia Apparel Water Action	CEO Water Mandate, UNEP	Levi, Nike, H&M, and Nautica	X										X		X			completed
3	Can Tho & Danang Urban Projects Funds	AFD																	live
4	Ho Chi Minh City Investment and Finance Company (HFIC) Projects	AFD			X							X			X				completed
5	Clean Water Project in Mekong Delta Cities	AFD		X								X			X				completed
6	Central Region Urban Environment Improvement Project (CRUEIP)	AFD		X	X							X			X				completed
7	Capacity- building in Water Resources Management and Water System Rehabilitation in Bac Hung Hai	AFD	NOMAFSI, CIRAD						X			X	X		X				completed
8	Northern Mountainous Area-ecological Project (ADAM project)	AFD				X							X					X	completed
9	Saigon River Project	AFD		X								X	X	X	X				completed
10	Phuoc Hoa Water Resources Project	AFD		X								X	X	X	X				
11	Harnessing water resources in Ninh Thuan Province	AFD		X									X		X				
12	Hydraulic Infrastructure Project of Son La Province	AFD		X						X		X	X		X				
13	Huoi Quang Hydroelectric Power Station Project	AFD								X		X		X	X				completed
14	Technical Support Unit (TSU) for Water Management and Urban Development in Relation to Climate Change	BTC	MPI						X			X				X			live
15	Integrated Water Management and Urban Development in Relation to Climate Change in Ha Tinh Province	BTC							X			X				X			live
16	Integrated Water Management and Urban Development in relation to Climate Change in Binh Thuan Province	BTC							X			X				X			live
17	Green Growth Strategy Facility (GGSF)	BTC							X			X	X				X		live
18	Integrated Water Management and Urban Development in relation to Climate Change in Ninh Thuan Province	BTC							X			X				X			live
19	Growing more coffee with less water in Vietnam	SDC	Nestlé				X						X			X			live
20	Mekong River Commission (MRC) – Strategic Plan 2016-2020	SDC	MRC Development Partners Consultative Group (Several countries, WB, UNDP; IUCN and WWF)			X						X				X			live
21	RECOFTC: Center for People and Forests	SDC				X						X	X			X			live
22	Core Contribution to RECOFTC (Regional Community Forestry Training Center for Asia and the Pacific)	SDC				X						X	X			X			completed
23	Integrated Water Management of the Lower Mekong Basin	SDC	DANIDA, SIDA, AFD, AusAID, IUCN and local NGOs			X							X			X			live
24	Water Footprint Development	SDC					X						X					X	completed
25	IFC Green Building EDGE Program	SDC	IFC				X					X					X		live
26	Can Tho Urban Development and Resilience Project	SDC	WB, IBRD						X			X				X			live
27	Public Private Infrastructure Facility (PPIAF) Phase IV	SDC	WB, IBRD	X	X							X					X		live
28	Cities Development Initiative for Asia	SDC	ADB	X	X							X					X		live
29	Wastewater and Solid Waste Management Vietnam	SDC	KfW banking group		X				X			X			X				live
30	Ba Ria Wastewater Collection and Treatment	SDC	BUSADCO, State Wastewater Entity, Ba Ria, Vietnam		X							X			X				completed
31	Vietnam forest and deltas program	USAID	Winrock International						X				X				X		live
32	Red River Delta Adaptation and Youth	USAID	UNDP	X					X			X	X					X	live
33	Strengthening Capacity and Institutional Reform for Green Growth and Sustainable Development in Vietnam	USAID	UNDP						X			X				X			live
34	USAID Green Annamites Project	USAID	ECODIT			X						X	X			X			live
35	Ha Long – Cat Ba Alliance	USAID	IUCN, MCD					X				X				X			live
36	Building Disaster Resilient Communities in Coastal Vietnam	USAID	HelpAge International						X			X				X			completed
37	Vietnam Flood Modelling and Early Warning Capacity Development – Phase II	USAID	Pacific Disaster Center, MARD						X			X				X		X	completed
38	Community-based Disaster Risk Management in the Central Highlands	USAID	Plan International, Department of Education and Training						X			X				X			completed
39	Sister Cities Disaster Preparedness Program	USAID	Hai Phong Department of Foreign Affairs, the Vietnam Chamber of Commerce						X			X		X		X			completed
40	Rural Sanitation Demand Creation and Supply Chain Development	SNV	WB	X								X						X	completed
41	Supply Chains Development and Capacity Building on Sanitation	SNV	WB	X								X				X			live
42	AgResults Vietnam Emissions Reduction Pilot	SNV					X						X					X	live
43	Learning to live with climate change	SIDA	MCD					X						X				X	completed
44	Community-centered intervention to increase the access to high quality water supplies among ethnic minority groups in Lao Cai	FDC	WaterFinns, Center for Research, CERETAD-Health	X				X				X			X				live
45	Developing Water Supply and Sanitation Sector in Vietnam through New Partnerships	FDC	Finnish Water Forum, Vietnam Water Supply and Sewerage Association		X							X						X	live
46	Dien Bien Phu Drainage, Wastewater Collection and Treatment Project	FDC			X				X			X			X				live
47	Upgrading the Rainfall, Storm and Lightening Detection Capabilities of National Hydro-Meteorological Service	FDC							X			X	X	X				X	completed
48	Water and Sanitation Sustainability Programme for Small Towns, Sustainability Phase (WSPST III)	FDC	Konsultit, Kehitysmaan julkinen sektori	X	X							X			X				live
49	Scaling up hand washing with soap in ethnic minorities in Lao Cai	FDC	WaterFinns	X								X				X			completed
50	Mekong Transport Infrastructure Development Project	AusAID									X	X			X				completed
51	Improving household environments for children in Quang Uyen District	ANCP	Childfund Australia	X								X			X				live
52	Bright Futures Program - scaling up community based adaptation	ANCP	Australian Foundation for the Peoples of Asia and the Pacific	X								X			X				completed
53	Building healthy homes and strong communities in Phu Tho province	ANCP	Habitat for Humanity Australia	X	X				X			X				X			completed
54	Green Breweries	Heineken					X					X						X	live
55	Towards Water Security	Heineken				X						X		X				X	live
56	Clean water project for community	Heineken		X								X			X				completed
57	Clean water project for local people	SAB Miller	Binh Duong Provincial Youth Union	X								X			X				completed
58	2017 Mizuiku – I love clean water	Pepsico		X								X				X			live
59	Project for Improving An Duong Water Treatment Plant in Hai Phong City	JICA		X								X			X				live
60	North Nghe An irrigation system upgrading	JICA					X						X		X				live
61	Hue city water environment improvement	JICA						X				X			X				live
62	Water Quality Improvement for Japanese Bridge Area in Hoi An	JICA						X				X			X				live
63	Thac Mo Hydropower Station Extension Project	JICA								X		X		X	X				live
64	Southern Binh Duong province water environment improvement (Phase 2)	JICA						X				X			X				live
65	Ben Tre Water Management Project	JICA				X						X			X				live
66	Project for Green Growth Promotion in Halong Bay area, Quang Ninh province	JICA					X					X				X			live
67	Ha Long city water environment improvement	JICA						X				X			X				live
68	Da Nhim hydropower plant expansion	JICA								X		X		X	X				live
69	Agriculture Development in Phan Ri - Phan Thiet Phase II	JICA					X						X			X			live
70	Dong Nai province water infrastructure construction	JICA		X								X			X				live

Ref	Project	Lead	Partners	Water supply	Wastewater	Watershed management	Water efficiency	Water quality	Climate change	Hydropower	Transportation	Municipal	Agricultural	Industries	Physical infrastructure	Education and capacity building	Finance and governance	Knowledge and technology	Status
71	Second Ho Chi Minh City Water Environment Improvement Project	JICA						X				X			X				live
72	Vietnam REF Industrial Zone Project	WB/IFC			X							X		X			X		live
73	Vietnam Agri	WB/IFC					X						X					X	live
74	Vietnam Green Building Regulation	WB/IFC			X		X					X				X			live
75	FIG Clients	WB/IFC		X	X									X			X		
76	Industrial Pollution Management Project	WB/IFC			X							X				X			live
77	Mekong Delta: Advancing Climate-Resilient Development	WB/IFC							X				X					X	live
78	Vietnam Irrigated Agriculture Improvement Project	WB/IFC					X						X		X				live
79	Vietnam Dam Rehabilitation and Safety Improvement Project	WB/IFC		X								X			X				live
80	Urban Water Supply and Wastewater Project	WB/IFC		X	X							X				X			live
81	Coastal Cities Sustainable Environment	WB/IFC			X							X					X		live
82	Vietnam Sustainable Agriculture Transformation Project	WB/IFC					X						X				X		live
83	Da River water treatment plant	ADB	JV of State General Reserve Fund of Oman, State Capital Investment Corporation of Vietnam, state-owned technology enterprise Newtatco, VietinBank Capital, and the Hanoi Water Limited Company (Hawacom)	X								X			X				live
84	Thua Thien Hue water supply	ADB		X								X			X				
85	Bac Hung Hai irrigation and drainage system	ADB		X									X		X				
86	Ho Chi Minh City Wastewater and Drainage System Improvement Project	ADB			X			X				X			X				
87	Water Efficiency Improvement in Drought Affected Provinces	ADB					X						X			X			
88	Water Sector Investment Program - Tranche 3	ADB		X	X							X			X	X			
89	Productive Rural Infrastructure Sector Project in the Central Highlands	ADB					X						X		X				
90	Improving Operational Performance of the Water Supply Sector Project	ADB		X										X	X				
91	Water Sector Investment Program - Tranche 2	ADB												X		X			live
92	Ho Chi Minh City Wastewater and Drainage System Improvement Project	ADB			X		X					X			X				live
93	Water Sector Investment Program PFR4	ADB		X								X			X				live
94	Sustainable Rural Infrastructure Development Project in Northern Mountain Provinces	ADB		X									X		X				live
95	Urban Environment and Climate Change Adaptation Project	ADB		X								X			X				live
96	Investing in Irrigation Improves Agricultural Yields in North Viet Nam	ADB	AFD						X				X		X				completed
97	Assessing the Applicability of Nanotechnologies in Viet Nam's Water and Sanitation	ADB	Viet Nam National University		X							X						X	live
98	Piloting Integrated Non Revenue Water (NRW) and Asset Management (ASM) Software for Nghe An Water Supply Company in Viet Nam	ADB	NAWASCO	X								X						X	completed
99	Country Water Action: Ho Chi Minh's Helping Hands	ADB	Saigon Water Corporation (SAWACO)	X	X							X					X		
100	Country Water Action: From Interim to Permanent	ADB		X								X			X				completed
101	Developing and Demonstrating a Mechanism for Sustainable Supply of Purified Water in Remote Communities	ADB	HueWACO	X								X						X	completed
102	Development of Pro-Poor Rural Water Actions in Collaboration with an NGO — CARE	ADB	Care International, MARD	X	X							X				X			completed
103	Development of Pro-Poor Rural Water Actions in Collaboration with an NGO - World Vision	ADB	MARD and World Vision	X	X							X				X			completed
104	Initiating Integrated Water Resources Planning in the Vu Gia Basin	ADB	Quang Nam People's Committee			X						X				X			completed
105	Country Water Action: Binh Duong Water Gets Strength from Phnom Penh Twin	ADB		X								X				X			completed
106	Evaluation Capacity Development Through Project Completion Report (PCR) Preparation (Self-Evaluation Training)	ADB										X				X			
107	Supporting Evaluation Capacity Development and Networking	ADB		X								X				X			
108	Central Region Small and Medium Towns Development Project	ADB		X	X							X			X				
109	Support to the Disaster Management System in Viet Nam	UNDP							X			X				X			completed
110	Strengthening Institutional Capacity for Disaster Risk Management in Viet Nam, including Climate Change related Disasters	UNDP							X			X				X			completed
111	Flood Proofing of Poor Coastal and Inland Households in the Mekong River Delta of Viet Nam	UNDP							X			X			X				completed
112	Vietnam/UNDP/UNEP Partnership initiative for the integration of sound management of chemicals in development planning and processes	UNDP						X				X				X			completed
113	Building Resilience of Communities to Recurrent Natural Disasters, particularly Flash Floods in the Upland Areas of Viet Nam	UNDP							X			X				X			completed
114	UN-REDD Vietnam Programme (United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries)	UNDP				X							X			X			completed
115	Strengthening National Capacities to Respond to Climate Change in Viet Nam, Reducing Vulnerability and Controlling Green House Gases (GHG) Emissions	UNDP							X							X			completed
116	Strengthening capacity on climate change initiatives in the Industry and Trade sectors	UNDP							X					X			X		completed
117	Strengthening Sustainable Development and Climate Planning	UNDP							X			X				X			completed
118	Strengthening Institutional Capacity For Disaster Risk Management In Viet Nam Including Climate Change Related Risks (SCDM Phase II)	UNDP							X			X						X	completed
119	Promoting Climate Resilient Infrastructure in Northern Mountain Provinces of Viet Nam	UNDP							X			X				X			live
120	Improving the resilience of vulnerable coastal communities to climate change related impacts in Viet Nam (will be signed with the VN Gov)	UNDP							X			X			X				live
121	UN-REDD Vietnam Programme (United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries) Phase II	UNDP				X							X			X			live
122	Strengthening Capacity and Institutional Reform for Green Growth and Sustainable Development in Viet Nam	UNDP							X			X				X			live
123	Vietnam textile industry sustainability	IFC					X							X		X			live
124	Strengthening Capacity of Water Environmental Management in River basin	JICA				X						X				X			live
125	Water Footprint of Coffee Production in Vietnam	Nestle / SDC	Western Highlands Agriculture and Forestry Science Institute, IWMI				X						X			X			
126	Efficient water management at Tri An factory	Nestle					X							X				X	completed
127	Nestle Water Recycling	Nestle					X							X				X	live
128	Conserving the Mekong	Coca Cola	WWF			X							X		X				completed
129	Clean Water for Communities in Thuong Tin and Thu Duc districts	Coca Cola		X								X			X				live
130	Coca Cola Water for Asian Cities programme	Coca Cola	UN-Habitat, CEFACOM	X	X							X			X				completed

Ref	Project	Lead	Partners	Water supply	Wastewater	Watershed management	Water efficiency	Water quality	Climate change	Hydropower	Transportation	Municipal	Agricultural	Industries	Physical infrastructure	Education and capacity building	Finance and governance	Knowledge and technology	Status
131	The Public Private Task Force on Sustainable Agricultural Growth in Vietnam	MARD, Nestle	ADM, BASF, Bayer CropScience, Bunge, Cargill, Cisco Vietnam, DuPont Vietnam, Kraft Foods , METRO Cash and Carry Vietnam, Monsanto Vietnam, Nestlé Vietnam, PepsiCo Vietnam, Sara Lee, Syngenta Asia Pacific, Swiss Reinsurance, Unilever Vietnam, Yara International				X						X			X			live
132	Clean water for communities in Hatay	Coca Cola		X								X			X				completed
133	Water2Life in Vietnam	Grundfos		X								X			X				completed
134	Water purification system for Nguyen Thi Dinh school	Dow Chemical Company		X								X			X				live
135	Green Growth Planning and Implementation	GGGI	MPI, MOC, UNDP, Provincial and City People's Committees, UNHABITAT		X							X					X		live
136	Water and Green Growth in the Mekong Delta	GGGI	VNMC		X							X				X			live
137	Vietnam Water Partnership	GWP		X								X	X			X			live
138	Mangroves for the Future	IUCN				X						X				X			live
139	Project of Restoration of wetlands in Plain of Reeds phase 2	WWF				X						X	X			X			completed
140	Guidance on Ecosystem-based adaptation (EBA) approach to climate change	WWF	Institute of Strategy and Policy on Natural Resources and Environment, Biodiversity Conservation Agency			X							X				X		live

Appendix H

Interventions

H1 List of interventions

The interventions in the Table below were investigated and their high level impact at basin level was modelled. Several key assumptions were made in the selection and assessment of possible technical options. These are presented in detail in H2.

Table 23. Interventions investigated for the Viet Nam study

Type of measure	Measure	Description
Agricultural	Managing evapotranspiration using quotas	Use of quotas to reduce consumptive water use
Agricultural	Agricultural rainwater harvesting with fertigation	Boost productivity of currently rain-fed crops by applying water during dry spells; requires construction of small reservoirs for rainwater collection
Agricultural	Canal lining	Line on-farm canals with cement/plastic to reduce seepage
Agricultural	Drip irrigation	Applying water through low pressure tubing requires less water than flooding
Agricultural	Irrigation scheduling	Prevent farmers from over-irrigating
Agricultural	Irrigation scheduling using satellite information	Prevent farmers from over-irrigating
Agricultural	Mulching	Cover soil with protective plastics to prevent water evaporation and keep temperature constant
Agricultural	Precision farming	Use of GPS to optimize sowing density, fertilizer and other input needs
Agricultural	Soil techniques/no-till agriculture	Techniques to reduce tillage; laser land leveling to reduce runoff and better drain lands
Agricultural	Sprinkler irrigation	Increase yield and irrigation efficiency (e.g. through reduced evaporation)
Agricultural	System of rice intensification (SRI)	Improve rice planting, irrigation and production practices
Agricultural	Alternate Wet And Dry Rice Management Practice	Alternate wet and dry cycles during all stages of crop growth, except during the flowering stage.
Agricultural	Change in irrigation practice (induced water stress)	Induced water stress during January to April can provide higher green bean yield.
Industrial	Industrial metering of non-revenue water	Water audit programme and meter retrofitting
Industrial	Institutional capacity building to manage industrial water use	Aggregated potential of industrial measures (water and energy optimisation)
Industrial	Water recycling from industrial parks	Install wastewater treatment system and recycle wastewater
Industrial	Zero discharge from industrial parks	Install wastewater treatment system and recycle wastewater to achieve zero discharge
Industrial	Industrial wastewater treatment	Install wastewater treatment systems to factories located outside industrial parks
Municipal	Dual-flush toilets (retrofit)	Installation of water saving dual-flush toilets
Municipal	Faucets (new and retrofit)	Installation of water efficient faucets with aerators and pressure controllers to keep the water flow at desired levels

Type of measure	Measure	Description
Municipal	Municipal leakage	Reduction of water lost through leak detection and repair in water distribution networks
Municipal	Pressure management (municipal)	Improved pressure management in water distribution system
Municipal	Municipal wastewater treatment	Treatment of domestic effluent discharges
Municipal	Wastewater reuse	Treatment and reuse of domestic effluent discharges

H2 Key volume and cost assumptions

The key volume and cost assumptions used in the study along with the data sources are summarised below.

Table 24. Volume and cost assumptions used in the Viet Nam study

ID	Type of measure	Key volume assumptions	Key cost assumptions	Source(s)
1	Managing evapotranspiration using quotas	20% of all irrigation areas. Reduced water use by 20-40%.	$0.05/m^3$	2030WRG Managing Water Use in Scarce Environments Catalogue (Hai Basin case study)
2	Agricultural rainwater harvesting with fertigation	Applicable to all crops (predominantly in mountain areas). Yield improvement 25% i.e. 20% water use reduction per unit yield. Potential: 10% increase by 2030.	CapEx 240-280 $/ha 10-20 $/ha OpEx increase, mainly additional repairs	2030WRG Charting our Water Future
3	Canal lining	Applicable crops: oil crops, vegetables, roots and tubers, sugarcane, fruits, cotton. No yield improvement; Gross water savings 3%. Potential area: From 26% to 40% of total crop area (mostly dry areas)	Fertilizer, fuel and electricity savings OpEx savings 6 $/ha Upfront CapEx/ha: $1,200	World Bank, Project in Viet Nam
4	Drip irrigation	Applicable to all crops, vegetables, roots and tubers, sugarcane, fruits, cotton, coffee; excluding rice Gross water savings 35% Yield improvement 15%, assumes fertigation as part of system; Potential 20% of total crop area	Reduced cost for fertilizer, labor, fuel, electricity and pest control; increases for repairs, and interest on capital ~150-250 $/ha ~2,200 $/ha CapEx	2030WRG Charting our Water Future Local data
5	Irrigation scheduling	Yield improvement 5-20% Gross water savings 12% Applied to additional 5% grain area and 10% commercial crop areas	Fertiliser, fuel and electricity savings; cost for informative device on soil moisture level. CapEx: 100 $/ha	2030WRG Charting our Water Future 2030WRG Managing Water Use in Scarce Environments

ID	Type of measure	Key volume assumptions	Key cost assumptions	Source(s)
				Catalogue (several case studies)
6	Irrigation scheduling using satellite information	Yield improvement 5-20% Gross water savings 13% Applied to additional 5% grain area and 10% commercial crop areas.	2 $/ha setup 2 $/ha per annum	2030WRG Managing Water Use in Scarce Environments Catalogue (Western Cape case study)
7	Mulching	Applicable to all types of crops, excluding rice Yield improvement 10% Gross water savings: 11% Applied to additional 30% crop cover area by 2030	Equipment to apply film on the field 300 $/ha every 3 seasons	2030WRG Charting our Water Future
8	Precision farming	Applicable to all annuals crops Yield improvement 10-15% Gross water savings: 11% Potential: Apply to additional 15% of the land by 2030	Fertilizer costs increase by half of projected yield increase, and labor costs increase due to skill required. CapEx of 310 $/ha, 600 $/ha for tractor and spreader.	2030WRG Charting our Water Future
9	Soil techniques/ no-till agriculture	Applicable to annuals, i.e. all crops. Yield increase 5%. Gross water savings 12%. Potential on 20% for rice and commercial crops.	Reduced cost for fertilizer, labor, fuel; increases for pest control, weed control Operational savings of 40-60 $/ha Assumes laser levelers are purchased by a centralized group and has full utilization over year (45 $/ha)	2030WRG Charting our Water Future
10	Sprinkler irrigation	Applicable to 40% of the crops (excluding rice fields) Yield increase 5-10% Gross water savings 12-15%	CapEx of ~200 $/ha for a small mobile sprinkler unit. Operational savings of 50-100 $/ha in fertilizer, fuel, electricity and labour	2030WRG Charting our Water Future
11	System of rice intensification (SRI)	Applicable to rice Yield increase 5% Gross water savings 15% Potential: From 5% to 30% of total crop area by 2030	Savings of 11% on overall rice cultivation costs; reduces seed, fertilizer, pesticide costs and in some cases energy cost Opex: 70 $/ha	2030WRG Charting our Water Future USAID, Ghana trial
12	Alternate Wet And Dry Rice Management Practice	Applicable to rice Yield increase 0-12% Gross water savings 30% Potential: 25% of total rice area	Operational savings of 38 $/ha	International Rice Research Institute
13	Change in irrigation practice (induced water stress)	Applicable to coffee Gross water savings 12.5% Potential: adaptation by 50% of the coffee area	Reduced cost for fertilizer, labor, fuel, electricity and pest control; increases for	2030WRG Charting our Water Future Amarasinghe et al (2015) Toward sustainable coffee

ID	Type of measure	Key volume assumptions	Key cost assumptions	Source(s)
			repairs, and interest on capital ~150-250 $/ha ~2,200 $/ha CapEx	production in Viet Nam: More coffee with less water
14	Industrial metering of non-revenue water	Target 50% of industry outside industrial parks Assumed 10% reduction	0.05 $/m^3; this includes an allowance for increased revenue	2030WRG Managing Water Use in Scarce Environments Catalogue (Ekurhuleni case study)
15	Institutional capacity building to manage industrial water use	Target 20% of industry outside industrial parks Average of 6.5% water use reduction	0.05-0.60 $/m^3 water saved (depending on industry sector and existing infrastructure). This study uses 0.3 $/m^3 water.	2030WRG Managing Water Use in Scarce Environments Catalogue (Jordan case study)
16	Water recycling from industrial parks	Assumes wastewater reuse measures will achieve 25% water saving Applied at industrial park level (CETP) 30% penetration by 2030	0.1-0.25 $/m^3 water saved	2030WRG Managing Water Use in Scarce Environments Catalogue (Jeddah and Udaipur case studies)
17	Zero discharge from industrial parks	Assumes wastewater reuse measures will achieve zero-discharge 75% of savings). Applied at industrial park level (CETP) 20% penetration by 2030	Water savings partially offset by higher energy cost 2.5 $/m^3 water saved	2030WRG Managing Water Use in Scarce Environments Catalogue (several case studies) 2030WRG Industrial Water Use in Bangladesh
18	Industrial wastewater treatment	Target 50% of industry outside industrial parks Action will result in more available water	Treatment cost of 0.4 $/m^3	As per municipal wastewater treatment
19	Dual-flush toilets (retrofit)	Target 4,000,000 households (15% of total households) by 2030 Retrofit converting mechanism. Dual-flush toilets use 18 l/c/d less than conventional toilets	Average cost of 50 $/unit	2030WRG Charting our Water Future
20	Faucets (new and retrofit)	Target 4,000,000 households (15% of total households) by 2030 Retrofit converting mechanism. Reduced water use by 20 l/c/d	Average cost of 30 $/unit	2030WRG Charting our Water Future
21	Municipal leakage	Municipal leakage 24%-31% Reduce 40% of total leakage by 2030	0.05-0.2 $/m^3 water saved	2030WRG Charting our Water Future 2030WRG Managing Water Use in Scarce Environments Catalogue (several case studies)
22	Pressure management (municipal)	3% water demand savings via pressure reduction	0.05 $/m^3 water saved	2030WRG Managing Water Use in Scarce Environments Catalogue (Cape Town case study)

ID	Type of measure	Key volume assumptions	Key cost assumptions	Source(s)
23	Municipal wastewater treatment	Applicable to domestic effluent discharges Action will result in more available water Potential: Up to 70% by 2030.	Treatment cost of 0.25 $\$/m^3$	Waste-water treatment technologies: a general review, UN World Bank Wastewater project in HCMC (adjusted for inflation)
24	Wastewater reuse	Applicable to domestic effluent discharges; In addition to municipal wastewater treatment intervention. Potential: Up to 20% by 2030.	Treatment cost of 0.4 $\$/m^3$	2030WRG Charting our Water Future

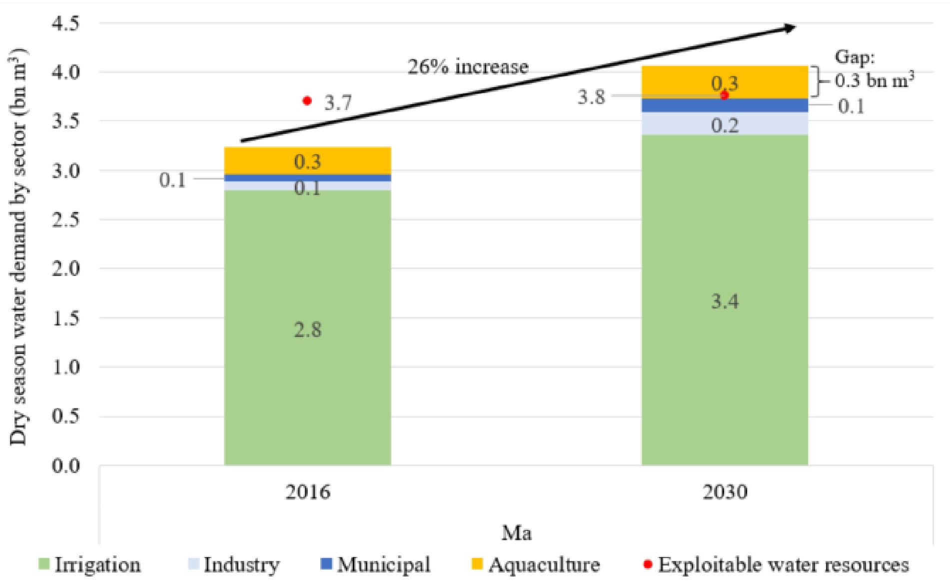
Appendix I

Ma River Basin - Water gap

I1 Closing the water supply´-demand gap: Ma basin

By 2030 the Ma basin could face a dry season water shortage of 310 mn m^3, or 8% of the total water demand (refer to Figure 40).

Figure 40. Water demand projections for Ma river basin

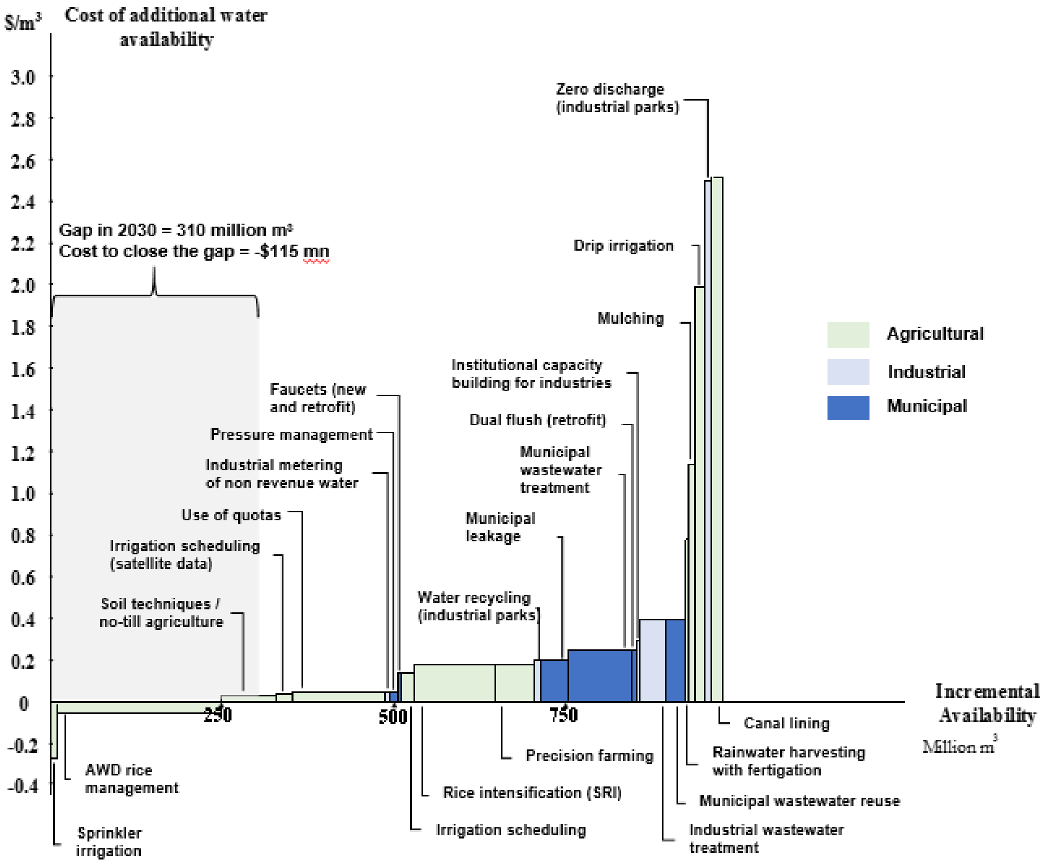


Agriculture is the predominant water user in the Ma basin accounting for 83% of the total water demand and therefore this is the sector with the greatest potential for improved water management and the implementation of water efficiency measures.

As Figure 41 shows, the adoption of sprinkler irrigation systems and alternate wet and dry (AWD) rice management practice and change in soil techniques (no-till agriculture) are estimated to be sufficient to reduce agricultural water demand and close the predicted gap. More information on applying AWD in Viet Nam can be found in the deep dives in Section 7.

Due to the low cost and potential financial benefits of the assessed interventions (such as increased yield), it is estimated that the gap could close resulting in a total cost saving of $115 mn.

Figure 41. Ma River Basin – cost curve of solutions to close the dry season water gap in 2030



Appendix J

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