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Challenges for Water and Food Security in the APEC Region: Water Governance in a Context of Climate Change

APEC Policy Partnership on Food Security

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Produced by:

Chris Wood and Sean Chappell
Washington CORE, L.L.C.
Address: 4340 East-West Highway, Suite 1110, Bethesda, Maryland 20814 United States
Tel: (1) 301-654-2915 Ext. 127 Fax: (1) 301-654-4054
Email: chris@wcore.com
Website: www.wcore.com

General Department of Agricultural Policies
Ministry of Agriculture and Irrigation of Peru
Address: Alameda del Corregidor, 155 - La Molina, Lima 12
Tel: (0051) (01)209-8800
Email: jcastro@minagri.gob.pe/vgavidia@minagri.gob.pe
Website: http://minagri.gob.pe/portal/

For
Asia-Pacific Economic Cooperation Secretariat
35 Heng Mui Keng Terrace
Singapore 119616
Tel: (65) 68919 600
Fax: (65) 68919 690
Email: info@apec.org
Website: www.apec.org

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1 Executive summary

1.1 Introduction

The APEC Policy-Partnership on Food Security study "Challenges for Water and Food Security in the APEC Region: Water Governance in a context of Climate Change (PPFS 02 2016) was conducted with the support of the Ministry of Agriculture and Irrigation of Peru (MINAGRI) as a regional effort to explore solutions to the impacts of climate change and other stresses on water supply and food security, namely the potential for Integrated Water Resource Management (IWRM) to address these issues. IWRM "promotes the coordinated development and management of water, land and related resources to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems," and thus can contribute to a more holistic approach to addressing the highly interconnected issues of water, food security and climate change.

1.2 Key issues

1.2.1 Challenges to food security

APEC economies are facing significant and growing pressure on water and food security due to climate change and increased food demand from growing populations. This is accompanied by rapid urbanization and rising living standards, leading to higher energy demands and industrial development, which compete with the agricultural sector for water and land. Food production must increase despite decreasing availability of arable land, while also needing to adapt to a rapidly changing climate.

The economic importance of food and agriculture to most APEC economies and the geographic exposure to high climate change risks makes them highly economically vulnerable to this pressure. World population growth combined with the expected rise of living standards and growing demands for animal feed and energy from crops (bio-fuels), require a substantial increase in cereal production to ensure sustainable food security. Various organizations estimate that a 70 - 100 percent increase in cereal production is required over the next 25 - 30 years. There is also a common understanding that 80 - 90 percent of this increase will have to come from existing cultivated land and only 10 - 20 percent from land reclamation.

However, due to climate change, urbanization, desertification, salinization, etc. the size of the available cultivated area is in fact decreasing. In the Asia-Pacific region, observed temperature increases are between 0.4°C–1°C, with projections of an increase of 1.5°C–2°C by 2046–2065. The greatest warming is expected to occur in lower-middle income economies with limited capacity for adaptation - Thailand, Myanmar, Lao PDR, Cambodia and Viet Nam,[1] It is estimated that in a scenario without strong climate-oriented development, the repercussions of this warming could eliminate the poverty reduction gains achieved in the region in recent decades.[2]

Furthermore, sea levels in the region are expected to rise by 3-16 centimeters (cm) by 2030 and 7-50 cm by 2070, threatening low-lying coastal areas and increasing salinity intrusion into freshwater systems.[3] Small increases in temperature also lead to disproportionally severe increases in the prevalence of extreme weather events, compounding the already high disaster

[1] Sawhney, Perkins 2015, p. 1
[2] United Nations ESCAP (UNESCAP) 2016, p. iv
[3] IFAD, The Global Mechanism 2009

risks in the Asia-Pacific region, which accounts for 90 percent of total deaths and 50 percent of total damage caused globally by natural disasters.[4]

These changes in climate will lead to dramatic shifts in seasonal conditions that will negatively impact the ability to cultivate agricultural products in certain areas. It is predicted that rainfall will become more highly concentrated in wet seasons, with dry seasons becoming increasingly severe, increasing flood risks and reducing agricultural productivity.[5]

1.2.2 Water resource scarcity in APEC economies

Water resource availability varies significantly by APEC economy, but most face significant challenges in terms of total size of the water endowment or spatio-temporal availability of water. In many economies freshwater resources are abundant in certain regions but scarce in others, or abundant during a rainy season and scarce during a dry season. The spatial distribution of water often doesn't align with the distribution of the population, such as in Peru and Indonesia, where population is concentrated in some of the most water-stressed regions. This can lead to reliance on groundwater resources, which can potentially become depleted and cause ground subsidence, as recently observed in parts of Malaysia, Mexico, the western US, and Viet Nam.

In terms of the temporal distribution, over time rainfall is expected to concentrate further in wet seasons due to climate change, leading to increased floods, and more severe dry seasons leading to more droughts. Economies such as Viet Nam that are downstream on major river systems face unique challenges related to their water endowment, as a large portion of their water flows through other economies before it reaches them. Upstream development activities can impact water timing, access, scarcity, quality and sediment load, fisheries and pollution.

As discussed, competition for water resources between the agricultural sector and other sectors is increasing as population grows, global temperatures rise and urbanization progresses.[6] In the present day, agriculture accounts for about 70 percent of global water consumption, and the agricultural sector in some APEC economies is plagued by low productivity, outdated techniques and technologies and inefficiencies that lead to wasted water resources and lower yields. Further, there are urgent needs to evaluate watershed condition and promote appropriate rehabilitation where economic activities have negatively impacted watershed headwaters. Furthermore, rehabilitation and careful management of watershed headwaters can promote resilience to extreme events, like droughts or floods.

This is a concerning trend as agriculture is a significant contributor to total GDP, exports, and household income in the APEC region. For example, in Peru, agriculture accounts for 11 percent of exports,[7] and over a third of Peruvian households rely on agriculture as their primary source of income. Peru is also one of the most vulnerable economies to climate change, meaning that food security and economic well-being in the future will depend largely on innovative water resource management, new agricultural practices and technology, and prudent planning.

In addition to agriculture, demand for water is increasing from industrial sectors as economies develop and urbanization advances. Urbanization is also accompanied by increased consumption of energy, which depending on the resource, can be water intensive when the entire supply chain is considered. For example, increasing urban populations in Australia require more water, which

[4] Hanna et. al 2011, p. 18
[5] IFAD, The Global Mechanism 2009
[6] OECD(b), n.d.
[7] INEI 2016, p. 2

requires electricity to transfer. Australia's energy mix is dominated by coal (65 percent), which is water intensive across its supply chain, and a contributor to climate change. This means that for Australia, simply delivering the water to users is a water intensive activity in itself. This reveals the high level of interconnectedness between water, energy resources and the economy in the region.

1.2.3 Water governance limitations in APEC region

Water governance refers to the political, economic, social and administrative systems that influence water use and management. The effectiveness of water governance depends on cooperation among all stakeholders involved in managing water resources such as different levels of government and administrative bodies, citizens, the private sector, international organizations and non-governmental organizations (NGOs). Clear legal frameworks, comprehensive water policies, enforceable regulations, functional institutions and mechanisms of accountability are required to ensure actors in and outside the government fulfill their responsibilities. Each APEC economy has a unique water governance arrangement, reflecting the widely varying political, social and economic situations of APEC members.

Highly capable institutions are necessary to achieve effective water governance and management policies, which must consider numerous political, social and environmental issues, and are highly complex from administrative and technical standpoints. The levels of institutional development, communication and coordination, and stakeholder engagement required for IWRM are high and expensive, creating implementation difficulties for economies lacking in financial resources and expertise. IWRM initiatives in some APEC economies have made slow progress as a result, for example limiting efforts to monitor water use and to develop river basin management plans. In 2016, the Network of Asian River Basin Organizations (NARBO), determined that IWRM implementation is hindered across Asian APEC economies due to deficiencies in institutional capacity at the basin level.

Institutional coordination is a common challenge in APEC economies, especially in the context of implementing IWRM. When responsibilities for water resource management are not clearly and explicitly assigned to government authorities or assigned across multiple jurisdictions, the prospects of the institutional arrangement for water functioning in an integrated manner across sectors are especially challenging, as jurisdictional disputes create uncertainty and hinder implementation. This was an issue in Viet Nam, where uncertainty regarding the mandates for water resource management at the basin-level led to some confusion amongst agencies.

Furthermore, implementing an integrated approach is impractical without effective coordination among levels of government and institutions that manage certain sectors, as each sector's development carries significant water-related risks for others, and increasingly local authorities are needed to implement IWRM. This was commonly recognized as an issue across many APEC economies and within international organizations. In examples from some economies, the respective authorities responsible for water supply, agriculture and other sectors were described as communicating very little, if at all, leading to uncoordinated policy and planning for their water resources.

Absent a well-defined mechanism to engage stakeholders, water resource management decisions can lead to unintended consequences for the environment, food production and other economic activities, as well as resistance from populations. Inclusivity, education and capacity building and transparency and accountability are essential to generate demand for IWRM reforms and secure the participation of communities, the private sector, and government in initiatives.

Stakeholder engagement is important to consider in the context of the water benefits and costs and significant trade-offs stemming from water resource decisions among communities, government bodies and economic sectors with differing interests. For example, in Indonesia, participation in water resource management is limited due to a lack of outreach by water resource authorities, meaning the tradeoffs between sectors, administrative authorities and upstream/downstream concerns cannot be properly discussed or managed. Without broad stakeholder engagement, water resource management can become narrowly focused on technical matters, to the exclusion of socioeconomic factors.

APEC economies have employed a number of tools to address these governance challenges, as well as technical measures and technologies to improve efficiencies, improve water quality and distribution and help increase agricultural productivity. Reform through legislation can create and rearrange institutions to help increase coordination, communication and coherence, as well as reassign responsibilities to reflect institutional capacities and integrate activities.

1.3 Takeaways

Many economies in the APEC region have formulated ambitious and forward-looking plans and goals for IWRM, but at the same time face a variety of water governance and management capability gaps and challenges in making concrete progress toward IWRM. The high level of institutional capacity required for IWRM is an obstacle for many economies due to limitations in staffing and technical and administrative expertise, especially when enforcement of existing water policies is already a challenge.

APEC economies typically have limited coordination and communication between government bodies with different water-related responsibilities. A lack of finances to support water resource development, water infrastructure operations and maintenance, water reforms and IWRM initiatives is also a common challenge, making it difficult to recover costs for water service and infrastructure improvements. Limited technology, infrastructure and information resources further hamper the achievement of water and food security related goals. Lastly, it is challenging to achieve regular engagement with the wide range of stakeholders that are affected by water resource management decision-making and should therefore be included in IWRM planning.

The strains on water resources, food security and ecosystem integrity from climate change, urban/industrial development and population growth are clear, necessitating an approach that properly addresses these interdependencies in an integrated manner. The interconnectedness between water, agriculture, climate change and human livelihoods necessitates an approach such as IWRM, although the discourse surrounding this topic doesn’t need to be prescriptive. It is evident that the way these water stresses are experienced by populations and the way in which they are managed vary significantly across economies.

Given this, the dialogue surrounding IWRM as a strategy to address interrelated water, food security and climate change related issues should focus on principles that can be pursued universally and, as appropriate, adapted locally, and which are compatible with place-based initiatives that address practical water and food challenges and also clearly promote economic development in the food and agriculture sector of APEC economies. The research and conversations initiated as part of this project and the First APEC Water Resource Authorities Meeting can help to share vital knowledge amongst APEC economies about their water and food security goals and water governance efforts. Continuation of such dialogue is essential to promote faster adoption of effective IWRM practices and ensure that water usage and agriculture production in the APEC region remain sustainable for generations to come.

2 Methodology

This study conducted a preliminary research report informed by extensive literature and interview research; surveyed economies' water resource authorities; and held "The First APEC Water Resource Authorities Meeting" workshop of government, industry and academic stakeholders. The survey was distributed to representatives in all 21 APEC economies, with 14 economies responding or partially responding.[8] While not all APEC economies were fully represented by their respective water authorities at the workshop, the workshop facilitated diverse well-informed perspectives and constructive dialogue about economy, regional and local experiences with initiatives to improve water governance, address specific water-related issues, enhance food security and deploy essential infrastructure and technology; with the aim of gathering recommendations and best practices for addressing water scarcity issues caused by climate change and other factors.

Based on analysis of these research inputs, the Final Report and Guidelines for "Climate Change in the APEC Region: Challenges for Water and Food Security" reviews regulations, institutional arrangements and best practices on water resource management for food security and climate change adaptation.

A list of Principles for Effective Water Resource Management and Implementation of IWRM are proposed to address the gaps identified in Section 1.2. These principles are a set of fundamental concepts and policy suggestions intended to help guide APEC economies with enhancing and reforming their water governance and management systems. The principles were determined through analysis of research findings to identify effective responses to the identified gaps. Attention was paid to make the principles sufficiently general, avoiding very specific and prescriptive policy actions that may not currently be feasible in many economies. Although APEC economies share many common challenges related to water resource management, the way these challenges are experienced and dealt with vary widely due to differing political, economic, social and geographic contexts.

Having established these general principles, the report reviews related experiences of APEC economies adopting similar strategies, initiatives and tools to progress towards IWRM and achieving fundamental water, food security and climate change adaptation goals. The report then concludes with a list of potential actions and resources that could contribute to solutions of the APEC region's common challenges.

[8] Survey responses were provided by Australia; Canada; Chile; Hong Kong-China; Malaysia; New Zealand; Papua New Guinea; Peru; the Philippines; Singapore; Chinese Taipei; Thailand; the United States; and Viet Nam. Note that some economies' responses did not address all components of the survey.

3 Research findings[9]

This chapter contains the research findings regarding "Climate Change in the APEC Region: Challenges for Water and Food Security".

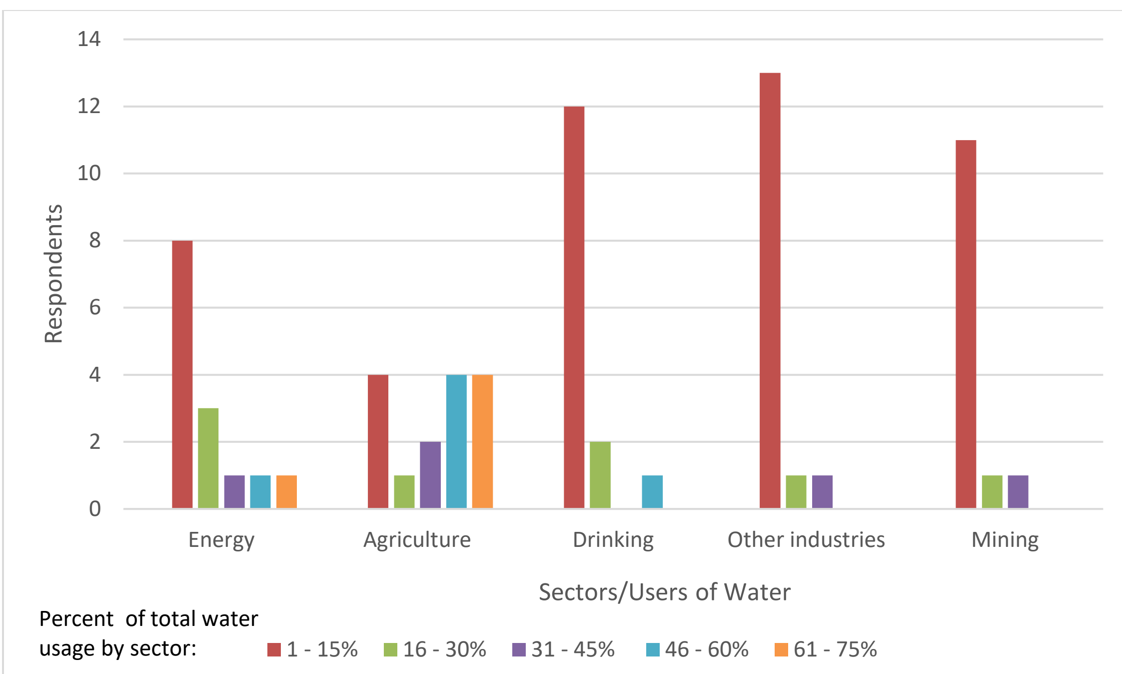
3.1 Water, food security and climate change related issues in APEC

Common challenges related to water resources, food security and climate change adaptation in APEC include issues such as rising demand for food and water resources due to population growth, difficulty balancing agriculture and urban development and various consequences of a changing climate for the region.

This section explores the situation in APEC regarding these themes through the lens of the endowment of water resources, water-related concerns for agriculture and food security, and water-related concerns in other economic sectors and households in certain APEC economies. This creates the foundation for discussion of how economies deal with various issues surrounding the supply, demand, different sectors, stakeholders, climate-change-related risks and other concerns through their water governance institutional arrangements and management practices, and the potential for IWRM to mitigate common challenges.

In the survey, economies were asked to estimate what percentage of water resources is allocated to agriculture, energy generation, drinking water, other industries and the mining sector.

Figure 1: Allocation of water resources by sector in APEC economies[10]



[9] Note: Research findings refers to the insights derived from literature research, expert interviews and survey results. Preliminary research results were distributed to economies for review and presented at the First APEC Water Authorities Meeting. A draft of the Final Report was also distributed to economies, although only the US, Peru and Singapore submitted comments.
[10] Washington CORE 2017

Note that agriculture is the largest water using sector in many APEC economies (8 respondents indicating usage exceeding 46 percent of total water resource usage). Energy generation, mining, and other industries consume much less, with most of the responding economies indicating that they consume 1 -15 percent, likely due to the non-consumptive nature of many uses of water in these sectors. However, as urbanization and economic development occur in developing economies, competition for water from these other sectors will likely increase, necessitating changes in agricultural practices.

3.1.1 Water endowment

In order to understand how water resource management philosophies like IWRM can contribute to improved water governance practices, enhanced food security and adaptation/mitigation to climate change; it is necessary to understand the current situation of water resources and availability based on physical geography and hydrology and anticipated future changes as a consequence of human activities. In this section, the water resource situations in various APEC economies will be presented.

Spatio-temporal issues in water availability are common in the APEC region; water simply isn't necessarily available when and where it is needed due to geography and hydrology, climate and weather, complicating management. In certain areas, most precipitation falls during a defined "wet season", and water resources are scarce other times. Furthermore, precipitation may only occur in certain regions of the economy, and these areas often don't match up with the population centers and agricultural areas. The availability of surface and groundwater is also highly variable geographically, meaning different areas must rely more on one or the other. Overexploitation of aquifers can lead to long-term water depletion and land subsidence, which can make affected areas unsuitable for agriculture and habitation.

In special cases, the water available to a certain economy may be "used", meaning that the economy is downstream from other users of that water resource. Economies that are downstream from others must make due with less and often contaminated water, as upstream economies withdraw, consume and discharge surface water. Upstream economies can also alter the entire flow regime of the river system with large infrastructure projects.

All APEC economies have common concerns regarding the effects of climate on their respective hydrological systems and water resources. Increased variability of weather, sea-level, and associated extreme weather events threaten both peoples' lives, livelihoods and ecosystem integrity. There is heterogeneity among APEC economies with respect to policies, best practices, technologies and capacities to research, assess and manage water resources.

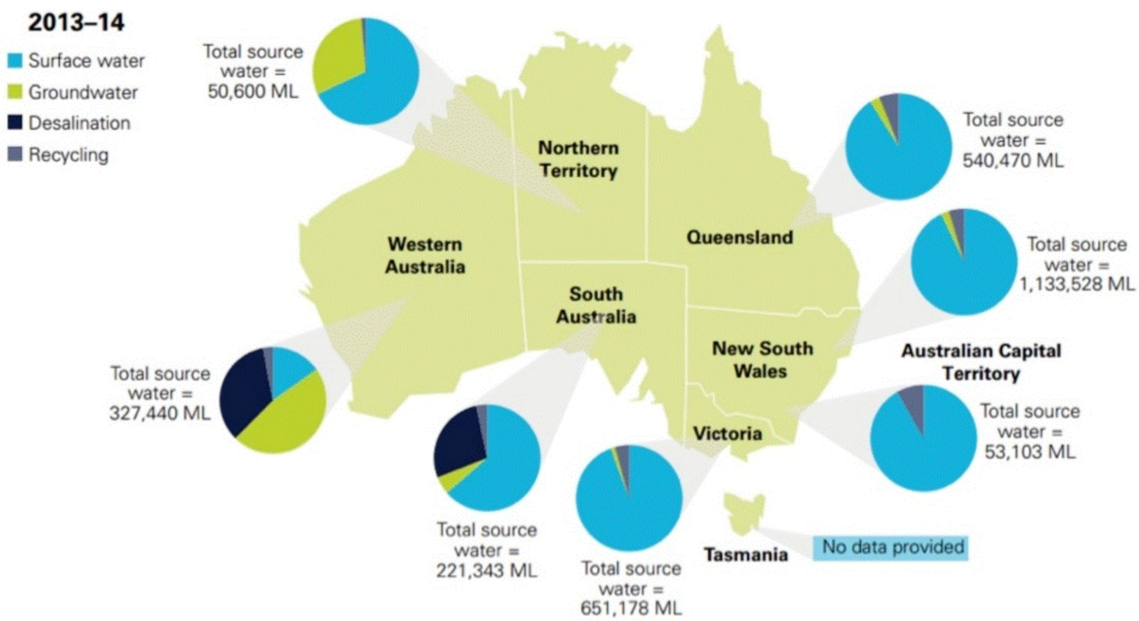
Descriptions of the specific conditions in illustrative examples of APEC economies follow below:

A. Australia

Australia's physical geography and climate are the main determining factors of water availability, with pockets of high rainfall on the northeast coast, and increasingly arid conditions in the interior of the continent. Climate change will diminish environmental flows on Australia's rivers and lead to more severe droughts.

Australia accounts for more than 5 percent of the world's landmass but only 1 percent of global freshwater resources. Additionally, there is substantial variation across the climates in Australia. The high diversity of the physical geography of Australia complicates water resource management greatly, as regional differences in rainfall complicate management, leading to areas with differing supplies of surface versus groundwater.[11] As seen in Figure 2 below, surface water is relatively plentiful in most parts of eastern Australia, while the southwest relies heavily on groundwater and desalination.

Figure 2: Australia Water use by type, regionally[12]



These regions also contain different proportions of Australia's industry and population, such as the northern tropical regions receiving most of the rainfall, while the significantly drier southern coastal regions hold most of the population, agriculture and industry. This leads to variability in groundwater and surface water availability seasonally and across regions, which complicates the capture, storage and transmission of water resources.[13]

Additionally, climate change has led to high variability in climate and precipitation patterns in Australia, which cause water scarcity, heat stress and increased climatic vulnerability in Australia's most productive regions.[14] These issues have led to droughts and diminishing environmental flows in Australia's rivers.[15] The variability will increase over time leading to more intense dry periods and floods, necessitating more conservation, capture and storage of water resources, as well as increased resilience to floods.[16] Rainfall will also become even more variable as climate change progresses, which could make water systems dependent on the current distribution of rainfall vulnerable.[17][18]

[11] Lehane 2014
[12] Australian Bureau of Meteorology n.d.
[13] Qureshi 2013
[14] Climate Council Australia, 2015
[15] Qureshi 2013
[16] Lehane 2014
[17] Lehane 2014
[18] Interview memo Peter Hyde

Falling rainfall volumes have increased dependence on groundwater. Since most water evaporates, groundwater resources are limited, but still a critical source in states with dry climatic conditions and rain variability. Unfortunately, there is a lack of sufficient monitoring and reporting mechanisms to ensure sustainable use.[19]

B. China

China's per capita water availability is low and unevenly distributed both spatially and temporally due to geographic and seasonal variations in precipitation, like the other economies discussed so far. In addition, China faces severe water quality issues.

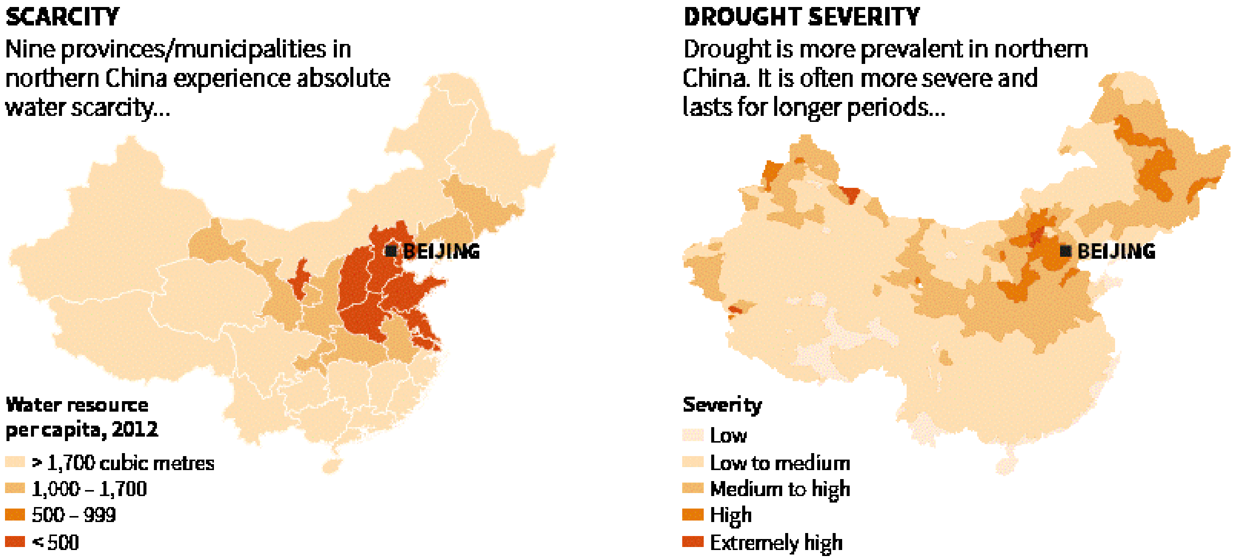
Precipitation is the main driver for resource availability, as well as reliability. Parts of China are dominated by a monsoon climate, and precipitation is characterized by both intra- and inter-year variations. In most areas, four consecutive months can account for up to 70 percent of annual rainfall.[20]

Four-fifths of China's water is in the south, notably the Yangzi river basin. Half the people and two-thirds of the farmland are in the north, including the Yellow River basin.[21] In northwest China there is a large degree of water scarcity. The region sources its water from two basins: the Junggar in the north and the Tarim in the south. The Tarim basin is one of the driest geographical places and relies heavily upon water sourced from the melting glaciers in surrounding mountains, similar to mountain regions in Peru. Climate related drought, glacial melt and human activities have significantly contributed to the region's dwindling water supply.[22]

Southwest China is increasingly experiencing longer and more numerous droughts that are lowering water levels in China, while at the same time experiencing an increase in floods due to greater concentration of heavy rains.[23] The figure below shows how the most severe drought and scarcity is experienced in the area surrounding Beijing and the northeast of the economy. Sichuan, a province in Southwest China, is home to 10 percent of China's total freshwater resources. But the abundance of water, which gave the province its name— "Four Rivers"—is running low in some sectors, in part due to climate change that is affecting rainfall and snowmelt, in part due to heavy pollution that has ruined supplies, and in part as the result of hydroelectric production (although hydroelectric production does not "consume" water, significant amounts evaporate during the process).[24]

[19] Lehane 2014
[20] Jiang 2015, p. 2
[21] The Economist 2013
[22] Lovelle 2016
[23] Interview memo Cecilia Tortajada
[24] Bebb 2011

Figure 3: Water scarcity and drought severity in China[25]



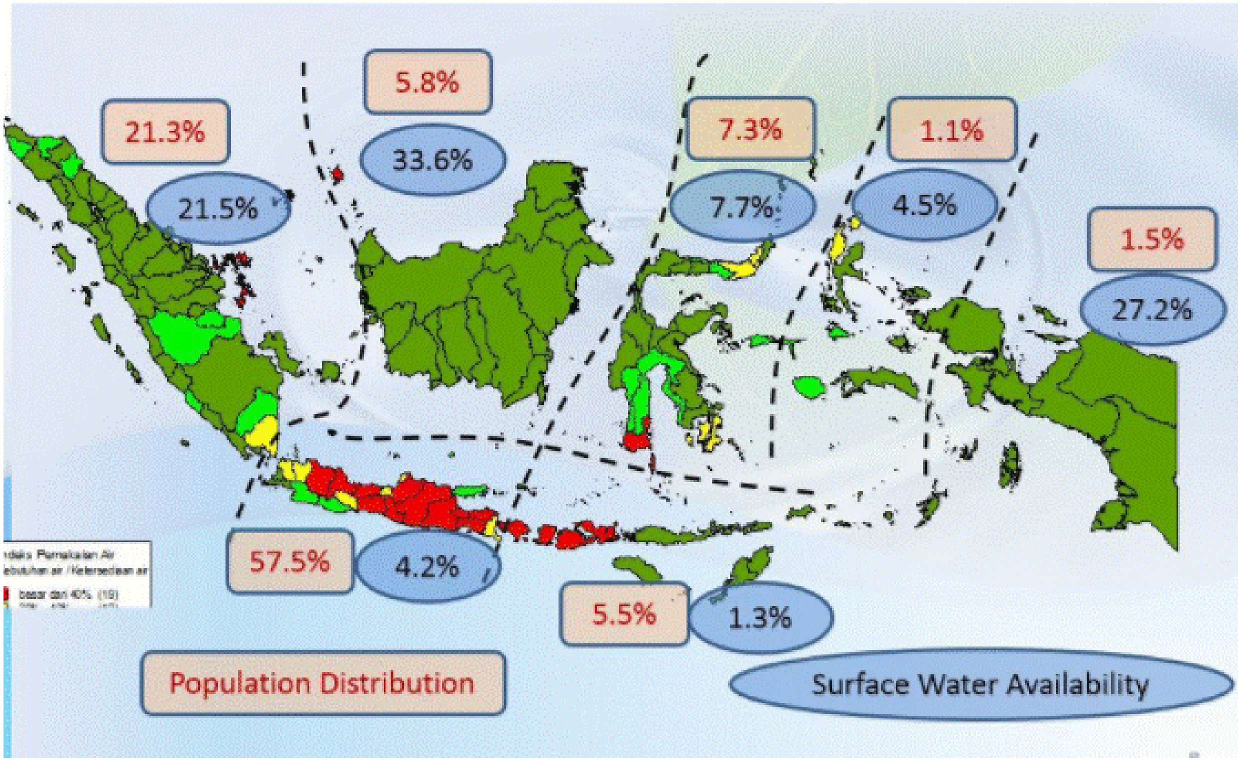
China is ranked fifth in the world in water resources behind Brazil, Russia, Canada, and Indonesia. However, due to its very large population, on a per capita basis China's water resource endowment is relatively low.[26]

C. Indonesia

Indonesia also has a highly uneven distribution of water resources, especially when compared to the distribution of population; almost 60 percent of the population lives on the island of Java, which contains only 4.2 percent of the economy's water resources. Seasonal distribution of water is also an issue, as 80 percent of the water becomes available during the five-month rainy season, and only 20 percent during the dry season for the rest of the year.[27] Figure 4 shows that Java, with only 4.2 percent of surface water availability, contains 57.5 percent of Indonesia's 260 million residents. Java is also the most intensively cultivated island in the archipelago.[28]

[25] Reuters Graphics 2014
26 Jiang 2015, p. 2
[27] ASEAN Working Group on Water Resource Management (AWGWRM) n.d.
[28] United States Department of Agriculture (USDA) 2012

Figure 4: Population vs. Surface Water in Indonesia[29]



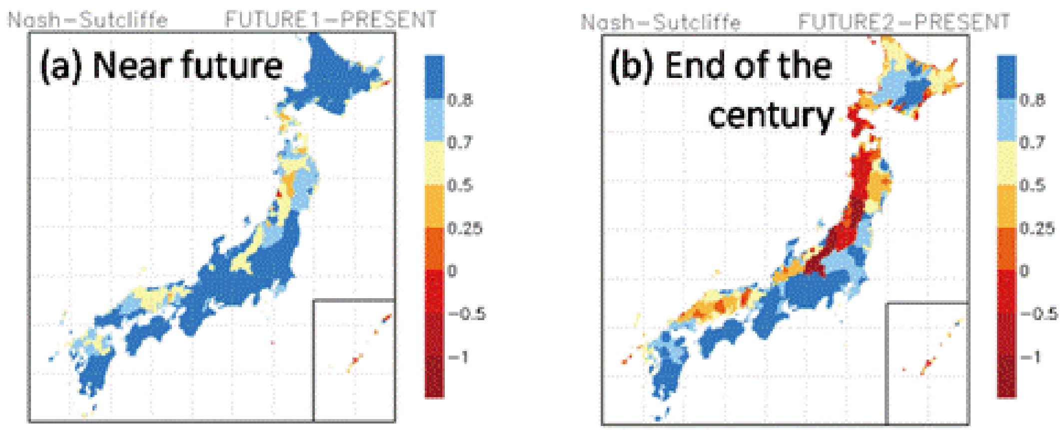
D. Japan

Japan is a relatively unique case in APEC; it is relatively abundant in water resources and does not experience significant water scarcity. It could even conceivably export fresh water to other economies.[30]

Japan, on average, gets hit 20-30 times a year with "unprecedented" rain, resulting in mass flooding and landslides. Most recently, the gap in rainfall between years of low and high precipitation has been expanding, reflecting an increased prevalence of extreme weather experienced by all APEC economies. Located in the Asia Monsoon zone, most of Japan's rainfall occurs in the rainy and typhoon seasons, and its mountainous topography and short fast-flowing rivers cause most of these potential water resources to be discharged into the sea without being used.[31]

[29] ASEAN IWRM (a) n.d.
[30] Ministry of Land, Infrastructure, Transport and Tourism (MLIT) n.d., p. 2
[31] MLIT n.d., p. 2

Figure 5: Predicted change in river flows[32]



The figure above shows significant projected reductions to environmental flows on Japan's rivers due to climate change from the Disaster Prevention Research Institute (DPRI) of Kyoto University. Longer, more frequent drought periods are expected in the future, as well as changes in snowfall and snowmelt patterns in Hokkaido. The onslaught of warmer weather due in part to climate change is also expected to decrease the quality of water. Warmer water contains less dissolved oxygen, which leads to less biological breakdown of disruptive chemicals. In lakes, higher temperatures interrupt the natural turnover processes that occur in winter or in spring and autumn, allowing higher levels of nutrients to concentrate at the surface and increasing the risk of algal blooms.[33]

E. Peru

Peru faces similar challenges to Australia related to a mismatch between water availability and population. The highly variable nature of water scarcity across regions in Peru makes management of water resources problematic. More than half of Peru's population and most of its economic activity is concentrated in its Pacific basin along the coast, which receives only 1.8 percent of the economy's total water resource endowment.[34] Figure 6 below shows the three major hydrographic basins of Peru, illustrating the severe imbalance between population concentrations and water availability.

[32] Disaster Prevention Research Institute (DPRI) of Kyoto University n.d.
[33] NatureAsia n.d.
[34] The World Bank 2017a, p. 10

Figure 6: Map of Peru's Hydrographic Basins[35]

The coastline and piedmont regions are vulnerable to floods and mud-flows due to precipitation in degraded upper basins, while the southern region is prone to drought. Furthermore, Peru is one of the economies that will be hardest hit by climate change due to increased frequency of extreme events and changing weather patterns, necessitating robust adaptation and mitigation

[35] Kuroiwa 2009, p. 4

initiatives.[36] Climate change will lead to glacial retreat and watershed deterioration, negatively affecting irrigated agriculture, hydropower generation and other uses, while exacerbating floods and droughts.[37]

F. United States

The US is one of the world's top agriculture producers and accordingly agriculture is important to IWRM in the US Estimates of agricultural water use is estimated by region by the U.S. Geological Survey (USGS).[38] Climate impact on American agriculture and forests, including water resources, is summarized and reported every four years in the National Climate Assessment.[39] Additionally, there are numerous reports on climate and US agriculture and forest systems and global trade and food security. The National Drought Resilience Partnership augments the National Oceanic and Atmospheric Administration's National Integrated Drought Information System by engaging a team of federal agencies to provide information and data, emergency and planning assistance, landscape-scale land management improvements, and investments in new technologies and approaches to improve water resource management, including drought preparedness and early warning.[40]

This study focused on the case of the US state of California, which is a major agricultural producer. The dollar value of California agricultural production in 2015 was $47 billion USD, more than 13 percent of the rconomy's total, and California is the dominant producer of many popular fruits and vegetables.[41] However, this high production level has become increasingly challenged by growing water scarcity and droughts.

Due to highly variable water availabilities geographically, vulnerability to climate change, large and growing populations, and its significance to US agricultural production and exports, California represents an interesting case study for the intersection of water, food and climate change issues, as well as rural to urban tensions regarding water availability. Most water resources come from the northern and eastern regions of the state, while population concentrates largely in the drier San Francisco Bay Area and southern coast.[42][43] The San Francisco Bay and South Coast regions account for most urban water use in California. Both rely heavily on water imported from other parts of the state.[44]

Competition for water resources between agriculture and other uses, mainly urban and ecological, is fierce. During a recent drought, a 25 percent mandatory reduction in consumption was issued for towns and cities, while the agricultural sector was spared as it had already suffered scarcity, leading to the fallowing of hundreds of acres of farmland. Water transfers were also necessary, with water scarce areas paying high fees.[45] This competition has also made water-intensive crops increasingly unpopular and difficult to sustain.

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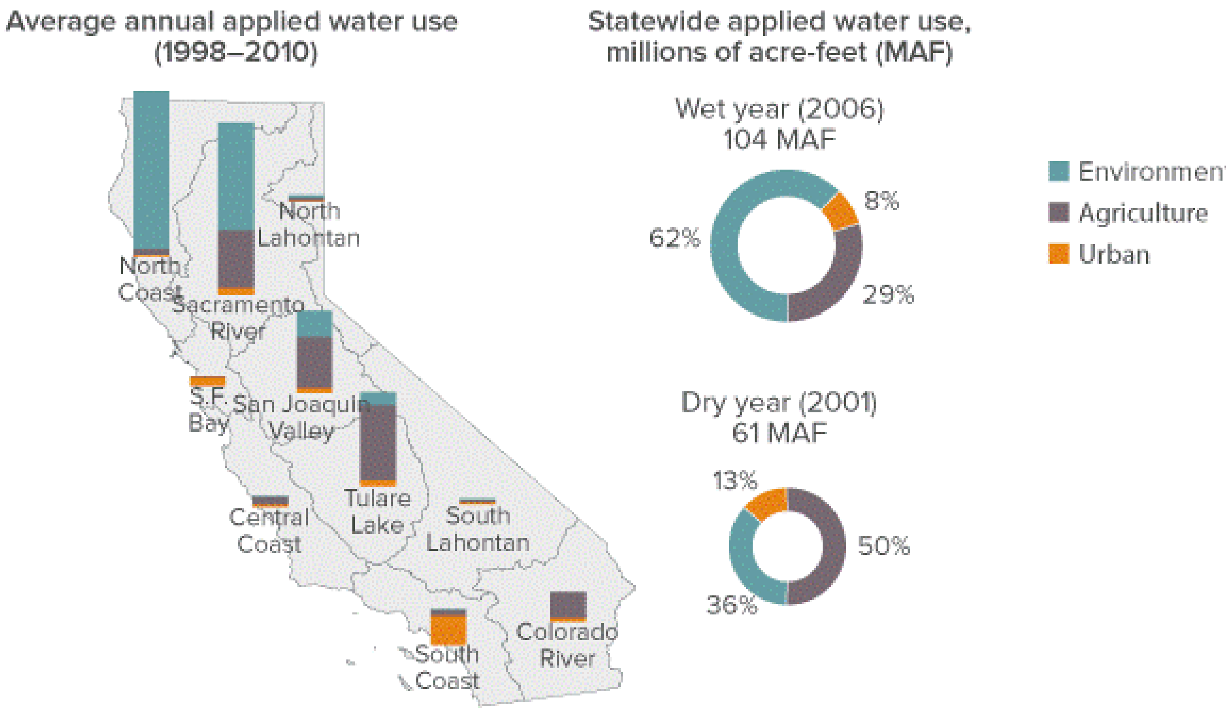
[36] The World Bank 2017a, p. 10
[37] The World Bank 2009, p. 1
[38] United States Geological Survey 2010
[39] National Climate Assessment (http://nca2014.globalchange.gov/)
[40] National Integrated Drought Information System (https://www.drought.gov/drought/)
[41] California Department of Food and Agriculture 2016
[42] "Delta Plan." Mavensnotebook.com
[43] U.S Census Bureau 2010
[44] Mount, Hanak 2016
[45] Siders, White 2015

Access to water across California is also highly variable, as roughly 70 percent of California's available water is from rain or snow in the less populated north. Meanwhile, 80 percent of the demand lies in the southern two-thirds of the state, much of which receives just a few inches of rain a year.[46] Figure 7 shows how over half of California's environmental water use is in the north of the state, reflecting the rivers' protected status and isolation from agriculture and industry.

Figure 7: California water use map by sector[47]



Flood protection is also dramatically underfunded, increasing the risk of catastrophic floods. Federal and state policies allow new development in floodplains without requiring adequate flood protection. Climate change is predicted to increase flood risk inland due to faster snow and ice-melt. Sea levels will also rise in coastal areas like the San Francisco Bay area.[48]

Many parts of the water system in the Sacramento–San Joaquin Delta are vulnerable to earthquakes. Earthquakes could also cause delta levee failures, which would lead to salinity intrusion into the watershed from the San Francisco bay, potentially ending intra-state (within the state) water exports for up to two years. Urban systems that rely heavily on a single source of vulnerable supplies are also at risk. The most susceptible counties in California include San Francisco, San Mateo, and parts of Alameda, Contra Costa, and Ventura Counties. Aquifers are also in danger due to overuse, as natural recharge is hindered by urban development that often creates hard surfaces such as roads, rooftops, and parking lots that prevent rain from soaking back into the ground.[49]

[46] Bourne 2010
[47] Department of Water Resources 2013
[48] Public Policy Institute of California (PPIC) 2012
[49] Public Policy Institute of California (PPIC) 2012

G. Viet Nam

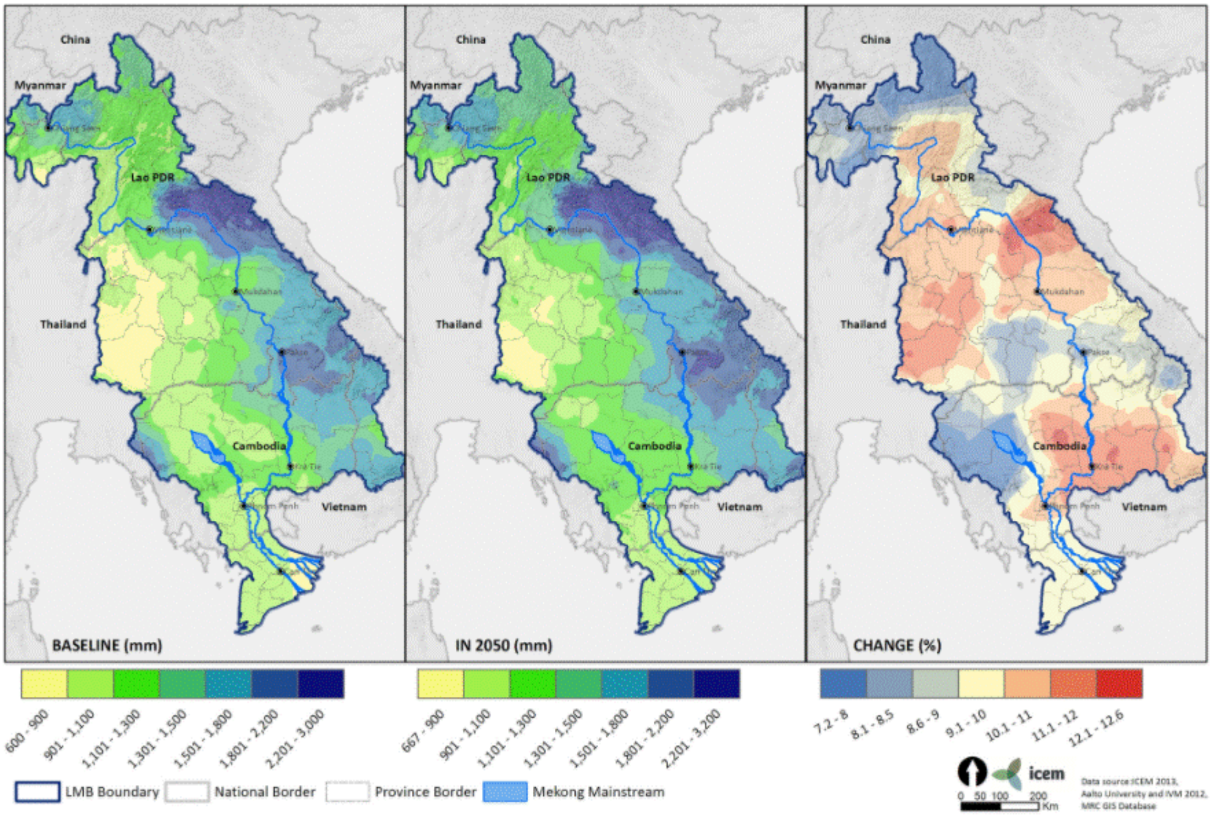
Viet Nam's water resource situation is highly dependent on the Mekong River system, which originates in China and flows though Myanmar, Thailand, Lao PDR, Cambodia and Viet Nam until it empties into the South China Sea. Changes in upstream development in these economies affect water and sediment flow patterns, while climate change is projected to increase the frequency of extreme weather events. Transboundary water resource management is an incredibly important issue to Viet Nam, as 60 percent of its surface waters originate in upstream economies.[50] The Mekong Delta alone accounts for 50 percent of Viet Nam's rice (90 percent of rice exports) and 60 percent of aquaculture products.[51]

The Mekong has highly seasonal discharge patterns that create wetland sand estuaries that contribute to fisheries and soil for agriculture. However, these discharge patterns lead to floods and droughts that can threaten livelihoods.[52] The uneven distribution of the river network, uneven rainfall across Viet Nam, and the prolonged dry seasons also result in water supply problems in some areas.[53]

The natural features of the river system have historically allowed for sufficient water availability throughout Mekong region, meaning there was no need to intervene with infrastructure to ensure uniformity in availability. However, the timing in water availability has begun to change, threatening livelihoods based on expected variations in water availability and bringing serious ecological consequences.[54] Additionally, climate change will raise sea levels, increasing salinity intrusion and erosion in the delta.[55] Figure 8 below shows dramatic increases in precipitation by 2050 predicted through climate modeling in the Lower Mekong Basin, with certain areas experiencing up to a 12 percent increase.

50The World Bank 2013, p. 2
51 The World Bank 2013, p. 2
52 The World Bank 2013, p. 2
53 Jolk et. al. 2010, p. 712
54 Interview memo Fiona Miller
55 Interview memo Pham Tuan Phan

Figure 8: Precipitation increase in Lower Mekong Basin to 2050[56]



3.1.2 Water in the Economy

As APEC economies develop new industries, experience urbanization and seek to raise the standard of living of their citizens, competition for water resources will increase among agriculture, industry and household end uses. This necessitates an assessment of how the development of various sectors affects water resources, food security and vulnerability to climate change. Policies will need to be devised that balance the increasing demand for water from industrial/urban sectors with the need for water to support food security, while at the same time ensuring that the agricultural sector is also responsibly managing and using water resources. Furthermore, energy generation technologies that use water more efficiently and cleanly will need to be considered, as well as methods to deliver water that are less energy intensive. Alongside necessary improvements in efficiency and conservation, all users of water must also decrease the amount of pollutants they discharge, as well as consider non-conventional sources of water to reduce strain on traditional freshwater resources and ecosystems.

Urbanization is occurring rapidly especially in the developing economies of the APEC region. Concentrated populations, production and energy demands have created a significant competitor for water resources for the agricultural sector. The energy generation necessary to serve growing cities comes from a variety of sources, some of them more harmful than others for different reasons. For example, coal power can be harmful due to the contamination of water involved in the mining and washing process and even acid rain, while hydropower can create issues due to its alteration of flow regimes and quality of water. In many APEC economies, the industrial sectors

[56] International Centre for Environmental Management (ICEM) 2013

driving economic development and raising living standards also tend to be water intensive and harmful to the environment.

A. Australia

Excluding services and construction, the largest industries of Australia are also among the most water intensive: electricity and gas (7 percent), manufacturing (7 percent) and mining (2 percent). Manufacturing, mining and agriculture combined employ 1.4 million Australians and account for 15.1 percent of GDP.[57] However, when comparing water use and expenditure in Australia, households and agriculture are the largest consumers of water, while household expenditure on water is dramatically higher than agricultural expenditure.[58]

Water issues in Australia are also heavily intertwined with energy concerns, as growing demand for water resources in in Australia's urban areas will require massive amounts of energy to supply and distribute. Projections to 2030 range between a 130 percent and 400 percent increase in energy requirements to meet increasing water demands.[59] Furthermore, coal fuels about 65 percent of Australia's electricity generation capacity, in which the mining and production processes are relatively water intensive in terms of withdrawal and consumption.[60] Australia's households are also large consumers of water, accounting for 9 percent of total consumption in 2005, with demand having grown in recent years, from 75,000 GL in 2011–12 to 92,300 GL in 2013–14 (ABS 2014a, 2015a). This was accompanied by a growth in household expenditure on distributed water from $4.3 billion to $5.3 billion.[61]

B. China

Rising population and rapid urbanization are dramatically affecting China's water resource management as well. The number of cities with a population beyond 500,000 rose from 40 in 1978 to 236 in 2013. The urban population itself has increased by more than 250 percent over the same period, above the world average.[62]

In China, decades of mismanagement of water have led to difficulties for companies in accessing the water and electricity they need. Climate change will exacerbate this. Measures to mitigate this include the promotion of thermal power plants that do not use water, and the use of unwashed coal.[63] Coal is the largest industrial user of water in China, responsible for 20 percent of all water withdrawals. Water is used throughout the process, including mining, coal preparation, transportation, conversion, and disposal of pollutants, emissions, and waste. Water is also used to extract, wash, transport, and burn coal, as well as control coal ash. China has about 15,000 coal mines, 70 percent of them located in water-scarce regions, and 40 percent of those expected to suffer severe water shortages.[64]

By 2020, water use in China is expected to increase to 670 billion cubic meters annually and the coal sector's share will increase to 28 percent, or 188 billion cubic meters. This means that 70

[57] Office of the Chief Economist 2016, p. 33
[58] Australia Bureau of Statistics 2014
[59] Kenway et al 2008, Executive Summary
[60] International Energy Agency (IEA) 2012, p. 6
[61] Argent 2017, p. 6
[62] Jiang 2015
[63] Interview memo Cecilia Tortajada
[64] Jiang 2015, p. 15

percent of the 71 billion cubic meter increase in annual water use over the next decade will be devoted to producing and using coal.[65]

The figure below shows pockets of land subsidence in Hunan Province as a consequence of a lowering of the water table due to coal mining, limiting the suitability of the land for agriculture.

Figure 9: Land subsidence in wheat field caused by coal mining, Hunan Province[66]

Industrial pollution in general has many damaging effects on China's water and agricultural resources. China's Ministry of Land and Resources estimates that heavy metal pollution destroys 10 million metric tons of grain and contaminates another 12 million metric tons annually. As much as 10 percent of China's rice, the economy's staple food, may be tainted by poisonous cadmium, a heavy metal that is discharged in mining and industrial sewage, according to scientists at Nanjing Agricultural University.[67] The largest polluting industries in terms of wastewater discharge (aside from coal) are the smelting/pressing of ferrous metals, chemical industry, paper, mining, and textiles.[68]

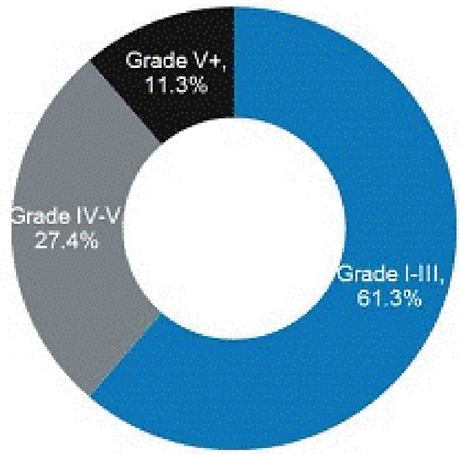
The situation of water quality is the biggest problem China now faces. More than 80 percent of the water from underground wells used by farms, factories and households across the heavily populated plains of China is unfit for drinking or bathing because of contamination from industry and farming. The latest study found that 32.9 percent of wells tested across areas mostly in Northern and Central China had water fit only for industrial uses. An additional 47.3 percent of wells were even worse, Grade 5. The contaminants included manganese, fluoride and triazoles, a set of compounds used in fungicides. In some areas, there was pollution caused by heavy metals.[69] Wastewater discharge has been steadily increasing to about 70 billion m^3 in 2012. The increase is caused by a rising discharge from domestic sources, accounting for 68 percent of the

[65] Schneider 2011
[66] Runze 2013
[67] Ivanova 2013
[68] Statista 2013
[69] Buckley 2016

increase.[70] The main challenges for wastewater resource management include enforcement of pollution treatment, increasing treatment facilities and coverage in rural areas, and improving the removal efficiency of nutrients and emerging contaminants and sludge disposal.[71]

The figure below shows the water quality, measured by grades I-V, in China's major river basins. Anything above Grade II is unfit for human consumption by law in China.[72]

Figure 10: China, water quality in main river basins[73]



C. Indonesia

Indonesia also has a highly water intensive industrial sector, which contributes significantly to deforestation. The industrial sector in Indonesia accounts for 26.38 percent of GDP, with six main sectors: manufacturing (e.g., steel, textile, oil and gas, chemicals, cement); agro-industry (e.g., rubber, palm oil, food and beverages, paper); transport (e.g., motor vehicle, shipping, railroads); electronics and information and communication technology; creative industry (e.g., fashion and software); and small and medium-sized industries. The most water intensive sectors are agro-industry, textiles, paper and pulp, oil & gas and chemicals, which together account for 17.37 percent of GDP.[74]

In Indonesia, deforestation, improper and informal mining practices, rapid plantation expansions and land use changes (oil palm, rubber, industry, and housing) are also leading to widespread degradation and depletion of water resources. Sanitation is also poorly developed in Indonesia, as only 5 percent of septage is treated, leading to ground and surface water contamination.[75] The strain on water resources has also led to infrastructure issues, as reservoirs fill with sediment and water resource and irrigation infrastructure reaches a state of disrepair.[76]

Flooding is a significant source of economic losses as well (as much as US$430 million/year), and from 2003-2013, floods led to: 1.58 million affected persons; 350 deaths and 13,640 injured;

[70] Jiang 2015, p. 3
[71] Jiang 2015, p. 4
[72] "More gauges of water pollution." *China.org.cn*
[73] China Water Risk 2013
[74] Asian Development Bank (ADB) 2016, p. 44
[75] Asian Development Bank (ADB) 2016, p. 55
[76] AWGWRM n.d.

223,000 homes fully or partly damaged; 168,000 ha of crops inundated; and significant disruptions in transfer of goods and services as transport arteries and access to ports are interrupted.[77]

The energy sector is also a significant user of water, with coal (51.6 percent of production), gas (24.3 percent), oil (12.1 percent) and hydropower as the most significant in terms of production per year. Hydropower is the most water intensive aside from biodiesel (which only accounts for 0.9 percent of total electricity generation), at 63.0 m^3 of water consumed per megawatt hour (m^3/MWh), followed by biodiesel (331 m^3/MWh), oil (15.2 m^3/MWh), gas (2.7 m^3/MWh) and coal (2.0 m^3/MWh).[78]

Figure 11: Coal Mine in Tanjung, South Kalimantan, Indonesia[79]

The figure above shows a coal mine in Indonesia. It is 18 km total in length, and mining will reach 300m below the surface; this is 280m below the water table.

Energy also has serious implications for water and food security due to its consumption and pollution of water resources. Coal is relatively less water intensive in terms of power generation in Indonesia, but coal production, in which Indonesia is a global leader, consumes water and produces effluents that pollute freshwater supplies such as the Mahakam River, which flows through rainforests and is home to 147 indigenous freshwater fish species. Mining also has increased flooding because it strips topsoil from hills, leading to rapid runoff of torrential rains into waterways.[80] Hydropower generation also places some strain on water resources as significant evaporation of water occurs from open water surfaces in artificial lakes.[81] Finally, production of fuel for biodiesel electricity generation competes with agricultural uses for land.[82]

D. Peru

Agriculture accounts for a heavy majority of water usage in Peru. Competing uses for water resources include manufacturing (6 percent), mining (2 percent) and municipal/public (9 percent). The water intensive agriculture and mining sectors are also key drivers of economic development for Peru, with agricultural and mining exports growing 9 and 21.4 percent respectively from 2015 to 2016.[83]

[77] Asian Development Bank (ADB) 2016, p. 47
[78] Asian Development Bank (ADB) 2016, p. 47
[79] Golder Associates n.d.
[80] Ives 2015
[81] Asian Development Bank (ADB) 2016,
[82] Asian Development Bank (ADB) 2016, p. 55
[83] INEI 2016, p. 2

Abandoned/inactive mines in Peru are a significant source of environmental pollution. Untreated mining effluents, insufficient wastewater treatment, unrestrained dumping of municipal and industrial waste, and uncontrolled use of agrochemicals all adversely affect the prospects for agricultural exports in Peru as well as contaminate drinking water supplies. Furthermore, the Regions of Tacna and Ica rely on overexploited aquifers to sustain agricultural activities of which the regional economy's GDP, employment and livelihood activities depend on. This has led to groundwater quantity and quality issues as well as land subsidence, and conflicts among farmers and other groundwater uses.[84] Given that Peru's export sectors are highly water-dependent, it is imperative to improve water resource management practices to sustain the robust economic growth it has experienced in the past decade.[85]

E. United States

As noted above, estimates of water use by agriculture and other sectors in the US are reported by the USGS.[86]

This study analyzed multisectoral coordination of IWRM water in California, where water is mainly shared across three sectors: 50 percent environmental, 40 percent agricultural and 10 percent urban.[87] Industries such as food processing, semiconductors, energy, tourism and leisure are water intensive and vulnerable to droughts. For the semiconductor industry, large amounts of ultra-pure water are important for the operation of a fabrication plant. Although energy is not a water-intensive industry in California, it depends on hydroelectric power generation for part of its mix which is vulnerable to decreased river flows. As less water is available to turn turbines and generators, utilities must find replacement power, which will typically be more expensive.[88]

Furthermore, water utilities in California suffer breaks and leaks in water infrastructure; the actual leakage rate for municipal water rate can be as high as 25 percent or 30 percent.[89] There is a growing uncertainty about the reliability of water supplies in California, which discourages business and infrastructure investments.

F. Viet Nam

As Viet Nam becomes a middle-income economy, stress on water resources is increasing, with water quality deteriorating due to industrial development. Rapid population growth, high population densities and economic development activities are drastically increasing water usage and leading to significant water quality issues, inter-sector competition for water and declining public water resource sector efficiency.[90]

As the quality of life increases, urbanization occurs, and agriculture continues to dominate the water supply, the demand for water will outpace the supply. In addition, the control over water allocation and resources is spread over many ministries and agencies, making comprehensive

[84] The World Bank 2017a, p. 12
[85] The World Bank 2017a, p. 9
[86] United States Geological Survey 2010
[87] PPIC 2015
[88] Sherman 2015
[89] Sherman 2015
[90] The World Bank 2013, p. 2

decision-making difficult. The combination of these factors and the environmental effects of deforestation and erosion cause the allocation of clean water to be unbalanced.[91]

Viet Nam's electricity demand is satisfied primarily by hydropower at 34 percent of total capacity, followed by coal (34 percent) and gas (19 percent).[92] Given Viet Nam's dependence on surface water, the drive for continuous hydropower development on rivers can involve serious threats to water and food security on a local and economy level.[93] As mentioned previously, the coal-fired electricity supply chain is also highly intensive in water consumption.

3.1.3 Water for Food Security

Concerning the most significant impact of climate on APEC economies' agricultural systems, most economies reported increasingly unpredictable and changing weather patterns, increased frequency of floods and droughts, and scarcity of water resources, which they attribute to climate change. Decreasing rainfall and environmental flows on streams and rivers were also observed. These changing weather patterns could force agricultural producers to adopt new practices or relocate. Additionally, water scarcity is a serious concern in the agriculture sector, as agricultural demand for water increases. Some economies have been observing rainfall concentration in wet seasons. Climate change impacts were also described as highly variable across geographies.[94]

Agriculture, mainly due to irrigation, is one of the largest sources of global water consumption. Many APEC economies rely on agriculture as a significant contributor to their total GDP and exports, and a significant portion of households in APEC economies rely on agriculture as their main source of income. The agriculture sector in some APEC economies is characterized by a number of inefficiencies related to outdated techniques, technologies and infrastructure, such as rice mono-cropping and inefficient irrigation methods. Economies are at varying stages in the process of modernizing their agriculture sectors, which can be massively complicated when there is a high concentration of small producers using traditional techniques and technologies.

IWRM holds that water resource planning must account for rising future global food demand. IWRM is concerned with the stress on water systems caused by agriculture activities, such as inefficient irrigation methods, nutrient runoff and pollution from pesticides and animal waste. The livestock industry also can be water intensive and a high contributor of GHGs to the atmosphere, further entwining water resource decisions, food security and climate change.[95] Additionally, IWRM should consider the concept of "virtual water", or the water that went into producing a certain good. Economies that lack sufficient water to satisfy food security needs must import food, therefore importing virtual water, or vice versa, where a water abundant economy exports virtual water in the form of food.[96]

Agricultural systems on which global food security and individual livelihoods are highly dependent are also highly vulnerable to climate change. Variability in weather creates significant uncertainty for farmers, while their crops face increasing threats from higher temperatures, floods, droughts, salinity and extreme weather events.

[91] Nguyen n.d., p. 10
[92] Economic Consulting Associates Limited 2016, p. 8
[93] Keskinen et. al 2015. Note: in this report "economy level" and "economy wide" refer to government institutions, policies, programs which are operated and administered by an economy's central level and applicable to the entire economy.
[94] Survey response (all)
[95] United States Geological Survey n.d.
[96] Muntisov n.d.

A. Australia

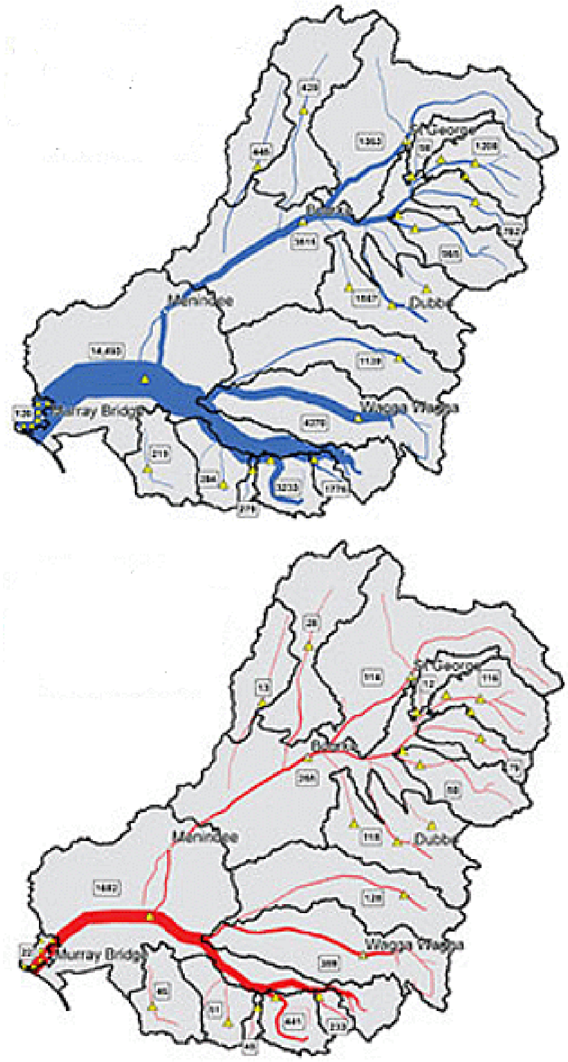
Challenges to food production in Australia include climate change, constraints on water, fertilizer, energy and land resources and a slowdown in agricultural productivity. Nevertheless, Australia ranks among the top five economies worldwide for affordable food availability. Australia's food security issues will likely lie mostly in the future, with climate change making weather patterns increasingly extreme and unpredictable and water increasingly scarce.[97] At present, the challenges to food security are mostly related to strengthening food supply chain resilience to deal with extreme weather.[98]

Australia's agricultural sector is comparatively less water intensive than Peru's, but it is still the largest water consuming sector in the economy, accounting for 65 percent of total consumption in 2005. The gross value of agricultural production in the Murray-Darling Basin in southeastern Australia alone in 2011/2012 was $18.6 billion. Agricultural exports account for 14 percent of the total value of Australian goods and services exports.[99] Livestock is also the most water intensive category of the agricultural sector and happens to be the fastest growing at 27 percent growth in output 2013-2014, accounting for over a third of the value of total agricultural production.[100]

In the Murray-Darling Basin, climate change will lead to decreased water levels and difficulties meeting demand for irrigation while maintaining environmental flows. Additionally, vegetation will consume more water under higher temperatures.[101] This is clear in the below images, which show the average of annual water availability over the 20th century above, and below the projected water availability in the Basin by 2030 based on the Sustainable Yields Assessment.

[97] Climate Change Council of Australia Ltd., p. IV
[98] Climate Change Council of Australia Ltd., p. IV
[99] Department of Foreign Affairs and Trade (DFAT)
[100] Australia Bureau of Labor Statistics n.d.
[101] Interview memo Mac Kirby

Figure 12: Murray-Darling Basin Water Availability
Average 20th Century (above in blue) 2030 (below in red) [102]

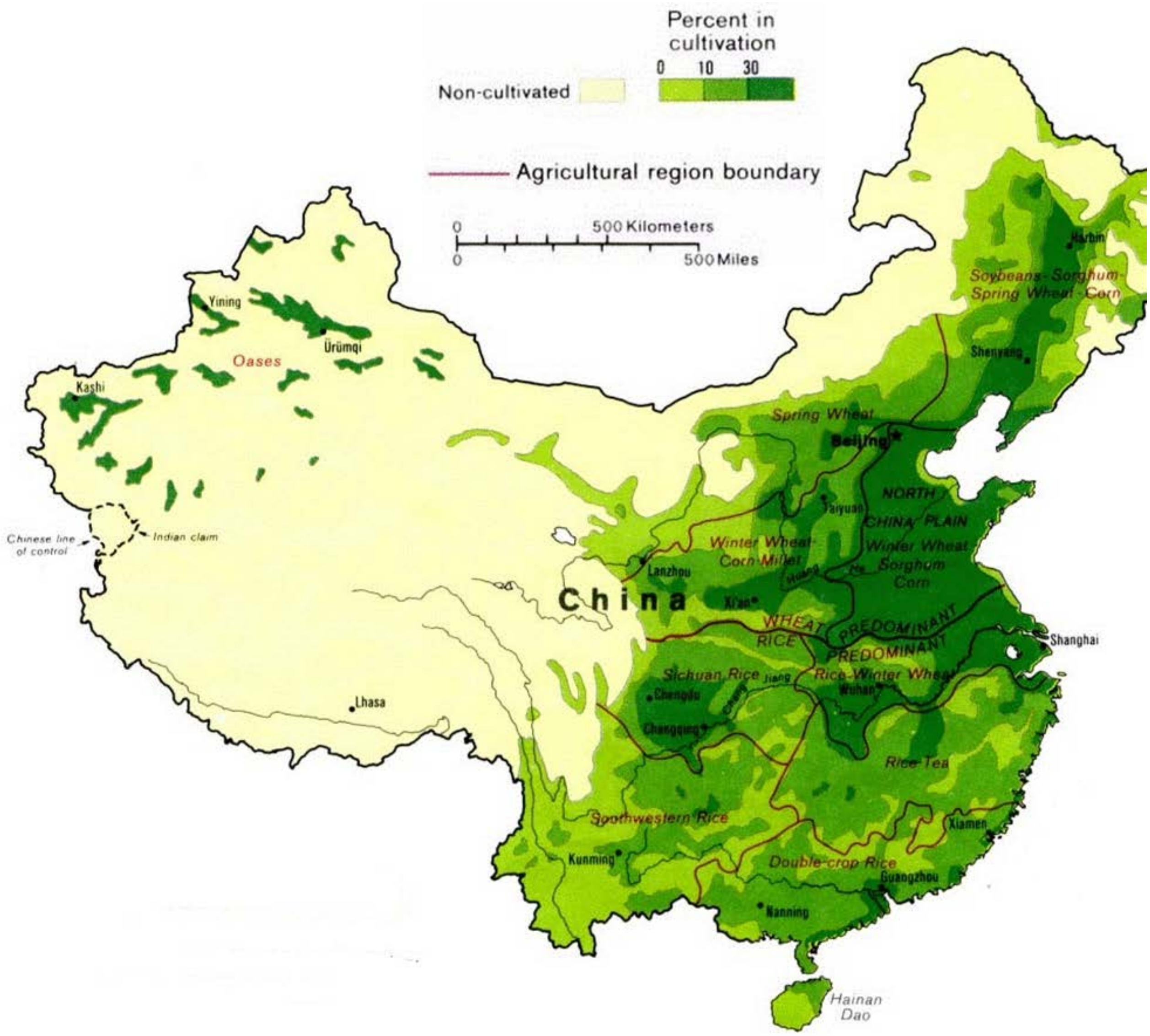


B. China

China's total water consumption has been steadily increasing; agriculture remains the biggest water user among all sectors, representing 62 percent of water use. China is a top global producer of all key meats and crops. As of 2012, China's agricultural value was first in the world at $829.76 billion.[103] As of 2008, China had the most farm workers at 498.73 million. It is also the world leader in gross value of agricultural output of rice, wheat, potatoes, corn, peanuts, tea, millet, barley, apples, cotton, oilseed, pork, and fish.[104] Exports of Agricultural Products in China averaged 5,765,840.95 USD THO from 2013 until 2017, reaching an all-time high of 7,763,542 USD THO in December of 2015.[105] The figure below shows that a large portion of China's total land area is under intensive cultivation, as indicated by the dark green areas.

102 CSIRO 2010
103 China Water Risk n.d.
104 Nation Master n.d.
105 Trading Economics n.d.

Figure 13: Percentage of land under cultivation in China[106]



The Yellow River in China supplies more than 50 cities and nourishes a majority of China's agricultural land. Unfortunately, coal mining projects in China are contaminating the Yellow River with industrial chemicals, and there is some evidence of river water being diverted for coal power generation.[107] Industrial activities in China have led to significant water quality issues in China, as well as soil contamination, which has significant impacts on agriculture.[108]

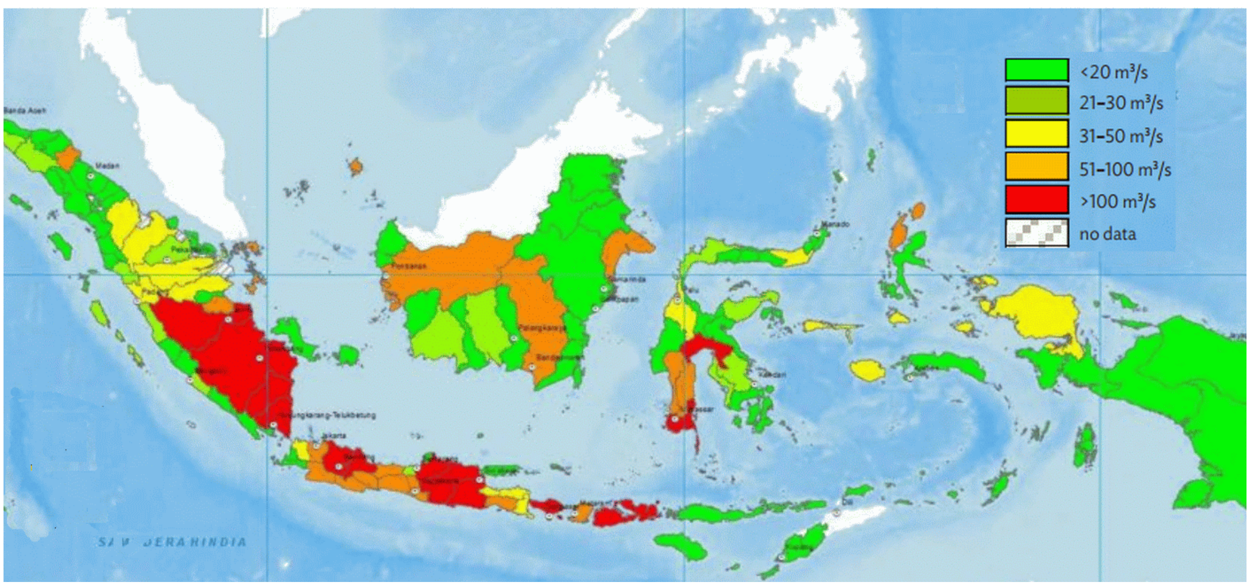
[106] Wordofmaps.net, n.d.
[107] Moore 2013
[108] Interview memo Cecilia Tortajada

C. Indonesia

Like Viet Nam, Indonesia has a high level of rice mono-cropping, as 77 percent of agricultural producers in Indonesia grow rice, primarily in subsistence conditions with an average farm size at less than 1 ha.[109] Out of Indonesia's 190 million ha of land area, 20 million ha are planted with permanent crops, and out of these 7.2 million ha are equipped with irrigation infrastructure. Agricultural production accounts for about 13.5 percent[110] of annual GDP and employs 31.7 million Indonesians out of a total population of 252 million.[111]

In contrast with economies where a high proportion of agricultural land is irrigated (Australia, Viet Nam, Peru), only about 20 percent of agricultural production uses irrigation, with the rest relying on rainwater, although 84 percent of the total rice area is irrigated. The water demand for irrigation in Indonesia is approximately 171.61 billion m^3/year, with 87 percent diverted from rivers, 12 percent from reservoirs and 1 percent from groundwater.[112] As of 2000, about 80 percent of water was withdrawn for agriculture.[113] The figure below shows irrigation water demands, showing the most intensive rice cultivation areas of the economy. The dark red areas indicated demand of more than 100 cubic meters per second.

Figure 14: Irrigation Water Demand in Indonesia[114]



Indonesia is a net importer of most foods aside from rice. Instability in food supplies since 2008 has necessitated measures to enhance food security. Food crop production continuously increases, although food security is threatened in the medium term by logistics and irrigation infrastructure deterioration due to lack of investment. Infrastructure began to deteriorate following the transfer of authority over irrigation infrastructure to regional governments as part of a broader decentralization of government power, who were unable to engage in planning, operation and maintenance, and financing of projects. This is further supported by the comparatively better

[109] Asian Development Bank (ADB) 2016, p. 37
[110] The World Bank n.d.
[111] AWGWRM n.d.
[112] Asian Development Bank (ADB) 2016, p. 38
[113] FAO (a) n.d.
[114] Asian Development Bank (ADB) 2016, p. 39

irrigation infrastructure in basins managed by the economy.[115] An increase in higher value cropping, greater commercialization and allowing land leasing to gain economies of scale in farm sizes is necessary to enhance food security.[116] Population growth will lead to an increased necessity for irrigated land area of 500,000 additional hectares every five years until 2030.[117]

Climate change related concerns for Indonesia's food security are numerous and could reverse or halt positive trends in production and productivity, with a possible 9-25 percent reduction in farm level net revenue in the future. Threats include: rising temperatures and sea levels; altered precipitation patterns leading to reductions in arable land area; increasing wildfires and forest loss; and increasing ocean temperatures and acidification leading to loss of fisheries. The likelihood of delays in monsoon rains could more than double in some Indonesia's most productive rice growing regions. Investments in water storage, drought resistance crops and crop diversification are necessary to adapt to these threats.[118]

D. Japan

Agriculture accounts for about 2/3 of total water consumption in Japan, mainly used in paddy rice cultivation.[119] However, water consumption for agriculture in Japan began to decline around 1995 due to reduced area under paddy cultivation.[120] Climate change will also have substantial effects on Japan's agricultural industries, with temperatures having favorable impacts for rice farming and unfavorable impacts for fruits.[121] Precipitation trends are unclear, although increasing variability has been observed by the IPCC; this could make planning for agriculture and water resources substantially more difficult.[122]

Typhoons can also lead to floods that destroy crops, such as the four that hit Hokkaido in 2016, leading to drastically reduced harvests in one of the most productive agricultural regions of Japan. These have become increasing common due to changing weather patterns.[123]

E. Malaysia

The greatest challenges to food security in Malaysia are flooding and drought. Climate change contributes to higher flood frequency, and managing the huge quantities of run-off is difficult, necessitating huge investments in flood management. Certain regions are also experiencing prolonged droughts, creating socio-economic stress as domestic consumption and agriculture compete for scarce water resources.[124]

F. New Zealand

New Zealand has unique relationships between water resources, agriculture and the economy. Its economy is dominated by the export of agricultural products (sheep, beef, lamb, wine, kiwi fruit), and is a relatively sparsely populated economy meaning there is little concern over food security. In 1998, New Zealand began promoting beef exports to China to take advantage of high demand and prices. However, cows produce lots of urine, which has created significant problems

[115] Asian Development Bank (ADB) 2015, p. 3
[116] Asian Development Bank (ADB) 2015, p. 3
[117] Republic of Indonesia Ministry of Agriculture 2013
[118] Asian Development Bank (ADB) 2015, p. 4
[119] Murakuni 2006, p. 2
[120] Murakuni 2006, p. 3
[121] The Japan Times 2016
[122] Case and Tidwell 2012, p. 5
[123] Yu 2017
[124] Interview memo Dato' Ir. Hj. Nor Hisham bin Mohd Ghazali

for New Zealand's waterways. Despite legislation and controls, the problem persists and measures to mitigate it have been ineffective to date.[125]

G. Peru

Peru's economic development is highly water intensive, with agriculture contributing about 5 percent of 2015 GDP[126], 11 percent of 2016 total exports,[127] and approximately 80 percent of total water withdrawals in the economy.[128] Additionally, 34 percent of Peruvian households rely on family agriculture as their primary source of income.[129] Furthermore, irrigation is characterized by low efficiencies at around 40 percent, and around 95 percent of irrigation users are informal, meaning they do not possess formal water rights to irrigate, creating a critical link between food and water security.[130]

MINAGRI estimates that 1/3 of Peru's total population is vulnerable to food insecurity. 20 percent of children suffer from chronic malnutrition, which is highly variable based on rural-urban divides. Food production in Peru is dominated by small cultivators with low productivity and competitiveness, who struggle with water resource inefficiencies. These producers are also highly vulnerable to climatic variations; Up until 2013, 15,000 hectares (ha) of agriculture land were reported lost due to climatic variations. Peru also had a yearly population growth rate of around 1.3 percent in 2015, and a total fertility rate between 2.1 and 2.5, indicating population will continue to grow and further stress food and water supplies.[131] Such pressures contribute to Peru's heavy dependence on food imports.[132]

H. United States

As noted above, the major impact of climate on American agriculture and forestry is summarized and reported every four years in the National Climate Assessment. In addition to research, programs, data and information, and tools and technologies throughout the US for IWRM, the US also recognizes the international importance of IWRM in both the US Global Food Security Strategy and the US Global Water Strategy.[133] Challenges to providing water for agriculture in California differ from the less-developed APEC economies in that they are more linked to the state's high agricultural production for export, rather than food security issues or household food stress.

California produces over 200 different crops, including almost all of US almonds, apricots, dates, figs, kiwi fruit, nectarines, olives, pistachios, prunes, and walnuts. The current drought cost the California agricultural sector an estimated $2.2 billion last year, and nearly 17,000 farmers lost their jobs in 2014 due to the combination of revenue losses from lower production and additional pumping costs.[134] The decline in California agricultural supply has resulted in higher prices for

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[125] Interview memo Jeff McNeil
[126] Calculated using MINAGRI Data (http://siea.minagri.gob.pe/siea/sites/default/files/anuario_produccion_agricola_ganadera2015.pdf) and World Bank GDP data, using 2015 USD→Sole Exchange Rate.
[127] INEI 2016, p. 2
[128] The World Bank 2017a, p. 70
[129] Food and Agriculture Organization of the United Nations (FAO) n.d., p. 10
[130]The World Bank 2009
[131] Population Reference Bureau (PRB) n.d.
[132] FAO n.d., p. 10
[133] The US Global Food Security Strategy (https://www.usaid.gov/what-we-do/agriculture-and-food-security/us-government-global-food-security-strategy) and the US Global Water Strategy (https://www.usaid.gov/what-we-do/water-and-sanitation/us-global-water-strategy)
[134] The Atlantic 2016

fresh fruit, vegetables and nuts. Furthermore, climate change exacerbates droughts and leads to other agricultural disruptions, as certain crops that rely on a winter chill might be threatened by rising temperatures.[135] The agriculture sector in California also produces a lot of methane, which is a potent GHG, creating further concerns over climate change.[136]

Groundwater over-pumping by large agricultural producers in California has also caused issues. Once an aquifer is depleted, the prospects of maintaining human settlement are extremely low. Furthermore, large producers are increasingly reliant on deeper and deeper wells, which are capital intensive and have led to a drilling "arms race," that has locked out smaller producers and led to significant environmental impacts. Aquifers also serve as a support for the ground that sits above them; once they are depleted, the ground begins to sink - a phenomenon called subsidence.[137] This can also become a significant issue in urban areas, such as Mexico City, Mexico, where subsidence as a result of aquifer overuse has led to the buckling of highways, damaged buildings and disruptions in water supply and wastewater treatment.[138]

The figure below shows how aquifer depletion in the San Joaquin Valley of California led to 9 meters in total subsidence between 1925 and 1977.

Figure 15: San Joaquin Valley, California, Subsidence 1925-1977[139]

[135] Interview memo Max Gomberg
[136] Interview memo Max Gomberg
[137] Estades 2016
[138] United States Geological Survey (a) n.d.
[139] United States Geological Survey (a) n.d.

I. Viet Nam

In Viet Nam as well, agriculture dominates water withdrawal, accounting for up to 95 percent of total withdrawal in 2005, followed by industrial withdrawal at 3.8 percent and municipal at 1.5 percent. Agriculture's large share of water withdrawal is unsurprising, as nearly 63 percent of the Vietnamese labor force is in this sector that accounts for approximately 20 percent of GDP.140 The agriculture sector will continue to be a key driver of economic development and poverty reduction in Viet Nam, although the government's socio-economic development strategy is promoting skills and infrastructure development to support modern industry.141 The figure below shows a terraced rice paddy in Viet Nam; terracing is a way to modify hilly land to make it suitable for cultivation.

Figure 16: Terraced Rice Paddy in Viet Nam[142]

The Mekong Delta alone accounts for 50 percent of Viet Nam's rice (90 percent of rice exports) and 60 percent of aquaculture products.[143] There is a high degree of rice mono-cropping in the Viet Nam, as 85 percent of food crops are rice.[144]

Food security is a concern since, even though Viet Nam is the second largest exporter of rice, many rural households require more food than they produce.[145] Therefore, if the agricultural sector were to suffer, the effects would be felt very strongly by individuals. As urbanization and development occur, the land available for rice paddies and fisheries is expected to decrease, and the maintenance of the remaining land will require sophisticated and innovative management solutions.[146] Climate change will have impacts on irrigation water demands and raise sea levels, increasing salinity intrusion and erosion in the delta.

However, these effects may be overshadowed by changing flow regimes; reduced wet season flows and increased dry seasons flows associated with the operation of dams throughout the basin may help reduce salinity intrusion and increase irrigation potential; but may also threaten

140 Nations Encyclopedia n.d.
141 The World Bank (c) n.d.
142 National Geographic n.d.
143 The World Bank 2013, p. 2
144 Van Luat n.d.
145 NIAPP 2012, p. 3
146 NIAPP 2012, p. 1

fish migration.[147] Inland fisheries are also an important traditional food source in the Mekong. Upstream damming of the Mekong to divert water for development related activities such as hydropower poses a challenge to these inland fisheries.[148]

3.2 Water governance and institutional arrangements in APEC

This section will describe water governance in certain APEC economies through describing their institutional arrangements, relevant legislation and regulations, the capacity of public authorities to achieve beneficial outcomes in water resource management, financial and budgetary concerns, and the engagement relevant stakeholders in decision-making. The institutional structures of certain APEC economies are arranged into three categories based on the involvement of actors at the economy and regional/local government levels, which impacts the implementation of IWRM based on the level of coordination across different sectoral authorities and between levels of government. The discussion of water governance will also analyze the level of linkage among the water, food, energy and other sectors in APEC to determine progress towards implanting IWRM. Furthermore, this section will also explore transboundary water resource management in APEC as a governance arrangement, largely through discussion of the Mekong River Commission.

This section contains analyses and excerpts of responses received from some APEC economies regarding the responsible organizations in their economies for water resource management and governance,[149] and includes discussions of the progress of various economies in enhancing water governance and implementing IWRM. This covers water governance and management challenges faced by economies, and different measures employed to respond to them, which include both political, social, environmental and technical/technological initiatives.

3.2.1 Detailed governance profiles

This section contains the detailed water governance profiles prepared as part of the preliminary research process that were classified into three categories based on the level of involvement of actors at the economy and regional/local government levels. This was included to give a basic understanding of how water governance structures differ from each other, and how the level of involvement of different types of authorities and actors at different levels of government varies across economies.

There is an additional fourth category for transboundary water governance, although this is not comparable to the other three as it involves non-binding and voluntary cooperation between sovereign states.

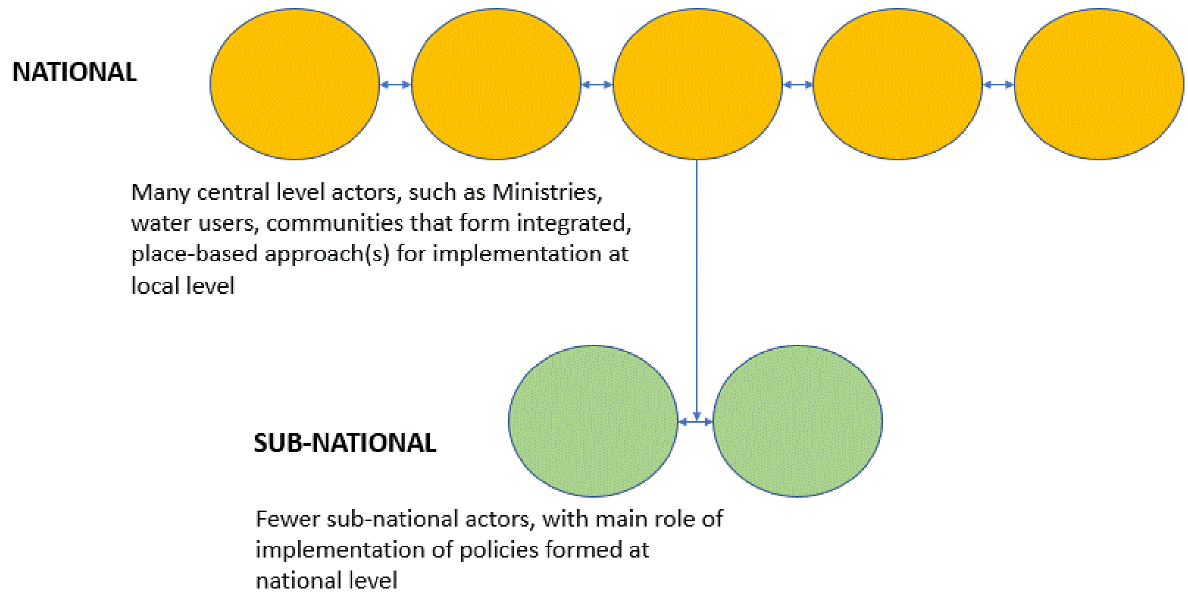
A. Consolidated water governance structures

Consolidated water governance structures are characterized by a central water agency that coordinates the implementation of place-based approaches to water resource management in the economies through regional and local bodies. Bodies are established at the river basin level to implement water resource management measures as they are directed to by the central agency. This central agency must coordinate with sectoral ministries and ensure the products of integrated planning are implemented at the basin level.[150] To be most effective, the authority of the central agency to manage water resources should be clearly defined in legislation, and conflicts of

[147] Interview memo Pham Tuan Phan
[148] Interview memo Mac Kirby
[149] Please note that the detail of economy responses varies, and 14 out of 21 APEC economies responded.
[150] OECD 2011, p. 56

jurisdiction or responsibility should be avoided. The figure below shows a diagram of this governance arrangement, showing a higher level of involvement of central authorities.

Figure 17: Consolidated Water Governance[151]



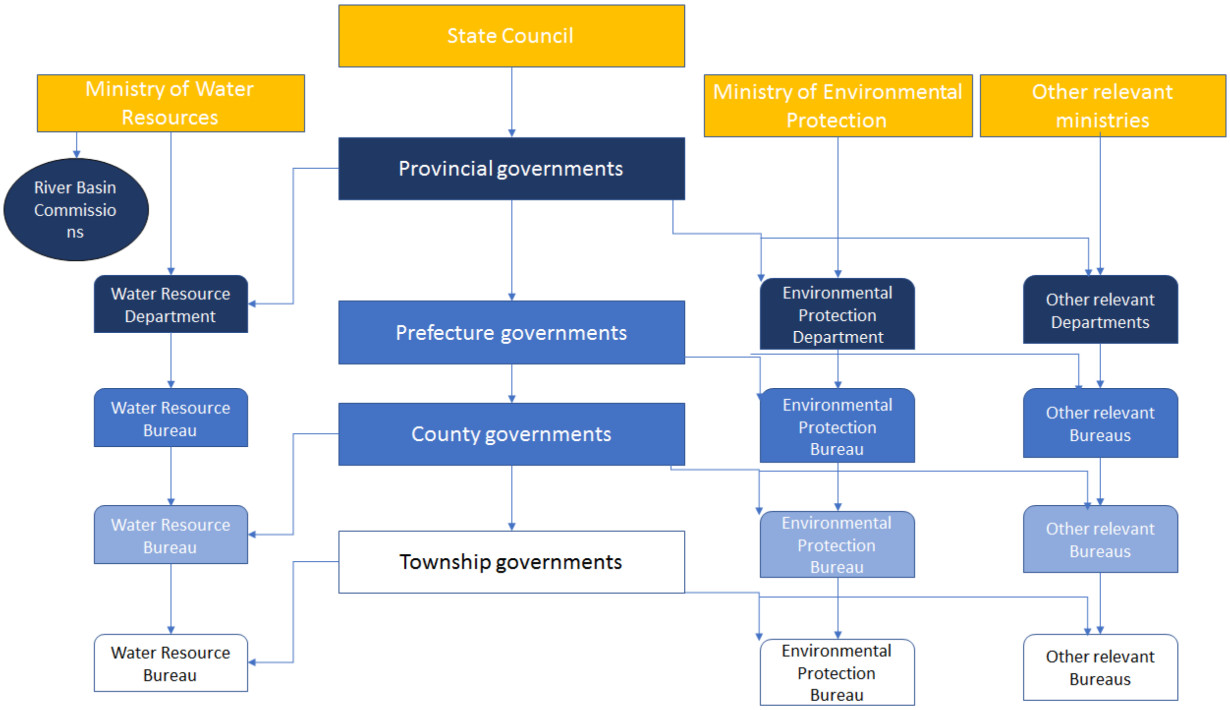
One example of an APEC economy with a consolidated water governance structure is China, where the state owns water resources and exerts a high-level of control at the economy level. Water is governed through a highly centralized hierarchy and a planned water use system including a water allocation and regulation subsystem; a water abstraction permit subsystem; and a water fee collection system. The management of irrigation systems is locally led by village and county level authorities.[152] River basin authorities are autonomous, so they can work within the unique situation of their respective hydrographic region, while adhering to obligations defined in national plans. Local governments have access to incentives to implement water resource management measures.[153]

At the economy level, the People's Congress formulates national laws that address different aspects of water, including the Water Law, Law on Prevention and Control of Water Pollution, and Flood Control Law. Within the framework of these laws, the State Council as the administrative branch of the Chinese government issues regulations guiding water resource management by different administrative departments at the economy level and by different branches of the government at the provincial level. Local water bureaus or departments are under the leadership of the central authorities, who also depend politically and financially on local governments.[154] The State Council issues regulations guiding water resource management by different administrative departments at the provincial level. National laws and rules set the general principles while the local governments determine how the laws and rules are implemented.[155]

The figure below shows the water governance institutional arrangement in China and how authority flows from the State Council and federal ministries at the top down to the local level.

151 Based on OECD 2011, page 147
152 Yu 2014
153 Interview memo Cecilia Tortajada
154 Jiang 2015, p. 5
155 Jiang 2015, p. 5

Figure 18: China Water Governance arrangement[156]



The Ministry of Water Resources (MWR) and the Ministry of Environment Protection (MEP) are responsible for water pollution control and transboundary water resource management. Additionally, the Ministry of Housing and Urban-Rural Development (MHURD) is responsible for urban water supply and sewage treatment.[157]

MWR drafts policies, strategies, plans, regulations, and laws related to water resource management. This includes mediating and coordinating water resource management among various interest groups competing for China's scarce water resources.[158]

MEP is responsible for establishing a sound basic system for environmental protection. It draws up and organizes the implementation of national policies, programs, and plans for environmental protection and pollution reduction; drafts laws and regulations; and formulates departmental rules.[159]

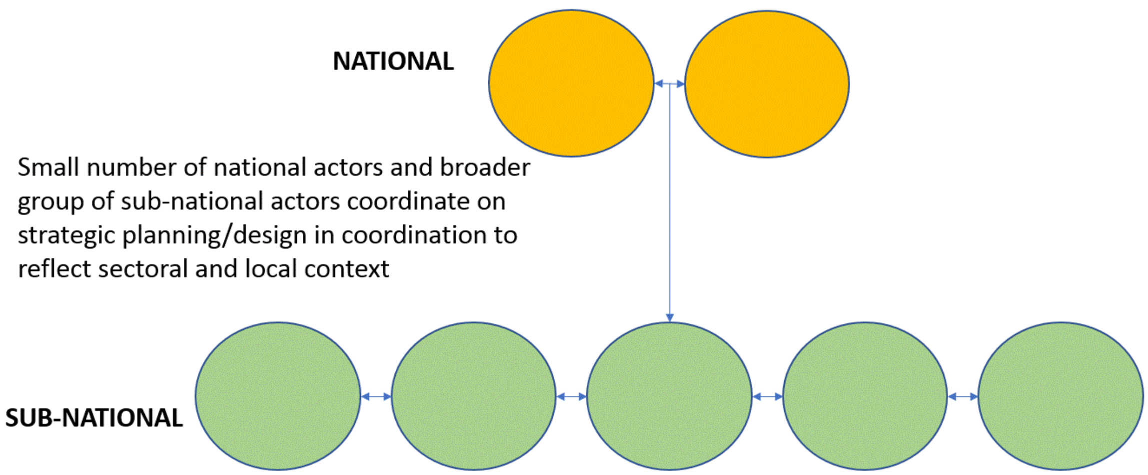
There are seven river basin management commissions (RBMC) within the MWR. The RBMCs are responsible for preparing basin-wide water allocation plans and providing technical direction and guidance to local governments within the basin. The annual water allocation scheme involves stakeholders from the agriculture and energy sectors to address water resource management issues. One notable RBMC is the Yellow River Conservancy Commission, which is in charge of the Yellow River basin and the inland river basins.[160]

[156] Washington CORE 2017; Reproduction of diagram from Jiang 2015, p. 10
[157] Jiang 2015, p. 5
[158] US-China Business Council n.d.
[159] Ministry of Environmental Protection of the People's Republic of China n.d.
[160] International Institute for Sustainable Development 2012, p. 11

B. Decentralized water governance structures

Decentralized water governance usually involves economies with a federal system that affords a high level of autonomy to provinces, states or departments. In these structures, central and regional/local actors collaborate through special bodies for water resource planning and management. Typically, there are a small number of central actors to ensure national targets are met, while a broader group of regional/local actors participate in planning and implementation. In this type of structure, it is essential that strong coordination exists across regional/local actors to form an integrated and place-based perspective, and between levels of government to ensure national water and environmental policies are followed.[161]

Figure 19: Decentralized Water Governance structure[162]



Australia is an interesting case for how federal and state governments can collaborate to form a decentralized water governance structure to address specific issues that are politically untenable to deal with in a top-down manner. Australia's model incorporates federal and state authorities; and includes a mechanism to incorporate stakeholders at the local level, allowing for a diverse range of concerns and priorities to be represented in water resource planning.

In addition to the climatic variations across the economy, water resource management in Australia is also shaped by its Federal system which divides authority between the central level and the 16 states and territories. In 1994, the intergovernmental body known as the Council of Australian Governments (COAG) agreed to the National Water Initiative (NWI), in which state and territorial governments would set their own water resource management plans, establish and expand water trading markets, and achieve sustainable use of stressed water systems along with other measures.[163]

The Commonwealth Government, through the Department of Agriculture and Water Resources, coordinates national efforts through collaboration with states and territories and runs several projects and programs designed to secure water resources, fund water infrastructure, return water

[161] OECD 2011, p. 147
[162] Based on OECD 2011, page 147
[163] Department of Agriculture and Water Resource 2017a

to the environment and improve water quality.[164] The Natural Resource Management Ministerial Council (NRMMC) is responsible for overseeing implementation and addressing implementation issues. The National Water Commission (NWC) is responsible for providing advice to COAG on national water issues and assisting in implementation.[165] The goal of the NWI is to increase the productivity and efficiency of Australia's water use, address the need to service rural and urban communities and ensure the health of river and groundwater systems by establishing pathways to return to environmentally sustainable levels of extraction.[166]

Key elements that inform agreed outcomes and commitments to specific actions of the NWI include water access entitlements, water markets and trading, best practice water, integrated management of water for environment and public benefit outcomes, water resource accounting, urban water reform, knowledge and capacity building and community partnerships.[167] All parties to the agreement guarantee adequate engagement of relevant stakeholders in order to improve certainty and confidence in the reform process, create transparency in decision making and ensuring availability of information to all sectors. Specifically, stakeholders are meant to be updated on progress of water plans and relevant issues on security of water access entitlements and sustainability of water use.[168]

Generally, the planning process of Australia's version of IWRM puts priorities on urban supply, even before agriculture. Australia allows a certain amount of water for consumption, like urban supply, industry, agriculture and energy. Energy in Australia isn't highly water intensive, and non-freshwater sources are utilized in coastal areas. Because the middle of Australia is mainly uninhabited, most people are near the ocean where there is an abundance of water. Agricultural areas are also sparsely populated, so there's less competition for that water. In terms of finances, Australia uses market forces to determine who gets the water. Industries must apply for licenses to have access to the specific amount of water needed to function.[169]

Each state government is responsible for implementing its own water resource management plan, which reflects local environmental and economic conditions. Inter-governmental coordination has also been important, especially in the Murray-Darling River Basin in southeastern Australia, a region that represents one-seventh of Australia's landmass and produces one-third of the nation's food supply, including half of the crops produced on irrigated farms. State governments within the Basin coordinate on the allocation of water to users in their region, which is subsequently reflected in their own water resource management plans.[170]

These state governments collaborate on water resource planning and management via the Murray-Darling Basin Authority (MDBA). The MBDA has the responsibility to manage water in the basin, advise on policies and programs for the management of the basin's environmental resources and oversee the implementation of programs to ensure their sustainable use. Its charter requires it to efficiently manage and equitably distribute water resources, protect and improve water quality and advise on water, land and environmental management in the basin.[171]

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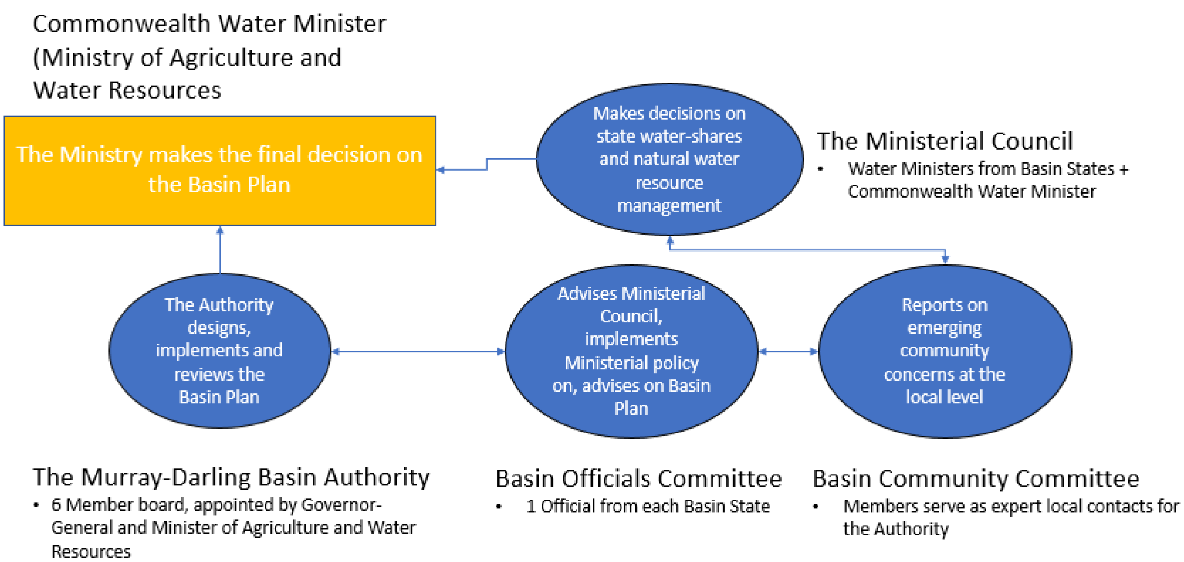
[164] Department of Agriculture and Water Resource 2017b
[165] Intergovernmental Agreement on a National Water Initiative n.d., p. 4
[166] Intergovernmental Agreement on a National Water Initiative n.d., p. 4
[167] Intergovernmental Agreement on a National Water Initiative n.d., p. 4
[168] Intergovernmental Agreement on a National Water Initiative n.d., p. 20
[169] Interview memo Peter Hyde
[170] Murray-Darling Basin Authority n.d.
[171] Hooper n.d., p. 3

MDBA is chaired by an independent President and contains commissioners from six state governments (Queensland, New South Wales, Victoria, South Australia, the Australia Capital Territory and the Commonwealth Government). Additionally, the Water ministers of each state government are incorporated in the arrangement through the Ministerial Council, which makes decisions on state water shares and environmental water. The Basin Officials Committee, which includes a official from each Basin state, implements Ministerial Council policy and advises the Authority on the Basin Plan. The MDBA also collaborates with the Department of Agriculture and Water Resources; Basin jurisdictions and communities; industry; environmental groups; and government organizations (including the Bureau of Meteorology and the Australian Competition and Consumer Commission) to secure Basin water resources.

Figure 20: Water Governance Arrangement in the Murray-Darling Basin[172]



The figure above shows the institutional arrangement for water governance in the Murray-Darling Basin. The MDBA designs and implements the Basin Plan, with input from the other committees and councils, which engages State Water Ministers and other officials, while a more local perspective is attained through the Basin Community Committee.

Malaysia is also an example of a relatively decentralized water governance structure. At the federal level, the water sector is divided administratively into two categories: natural water resources (environmental water) and water services. Natural water resources are the responsibility of the Ministry of Natural Resources and Environment whilst the water services industry is managed by the Ministry of Energy, Green Technology and Water. Both ministries act as a joint-secretariat to the National Water Council, the highest decision-making forum on water in the government. The council is also chaired by the Deputy Prime Minister and includes the chief ministers of every state in Malaysia. Several sub-committees have been formed under the

[172] Washington CORE 2017

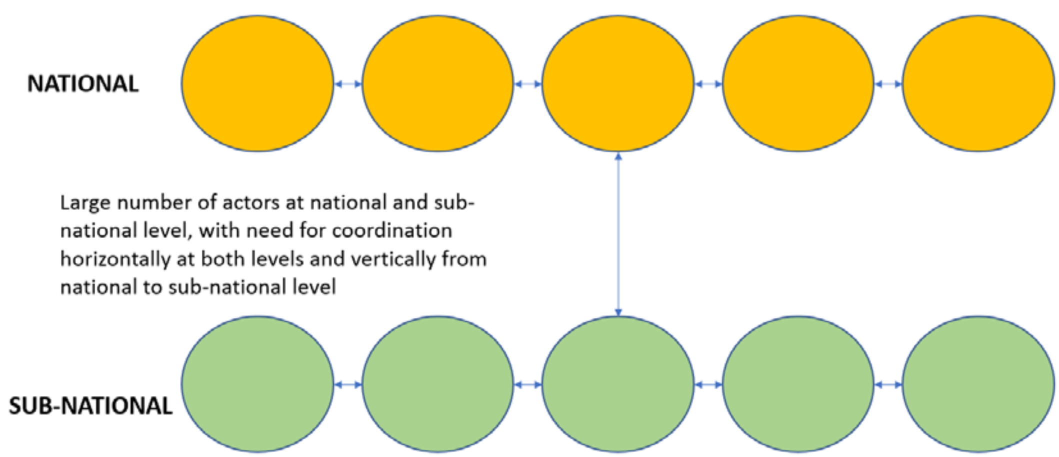
leadership of both ministries to address the key issues of water resource management and to ensure cross-consultation between the various sectors.[173]

At the state level, state governments have complete control over land and natural water resources.[174] Natural water resources are managed by the Department of Irrigation and Drainage. State governments typically have a regulatory agency to oversee the activities of water utility treatment and distribution licensees. However, treatment and distribution are still federal government responsibilities as provided for under the Water Services Industry Act. State governments are responsible for collection all necessary fees for abstraction and determination of tariffs.[175]

C. Multi-layer Water Governance Structures

In a multi-layer water governance structure, the involvement of numerous ministries and authorities with different responsibilities for water resource management is integrated at the central level, while another large group of regional/local actors representing various sectors also integrate and collaborate on planning and implementation. This means horizontal coordination at the central and regional/local levels is necessary, as well as vertical coordination among levels of government.[176]

Figure 21: Multi-layer Water Governance Structure[177]



Peru is an example of a multi-layer structure with sectoral integration at the central level, and involvement of various authorities and sectors at the regional/local levels. The
Water Authority of Peru (Autoridad Nacional de Agua- ANA), under the Ministry of Agriculture and Irrigation, was founded in 2008 as a financially and administratively autonomous agency with a clear mandate for integrated, basin-scale water resources management. ANA oversees River Basin Authorities (Autoridades Administrativas del Agua) in each of the economy's 14 hydrographic regions, as well as 72 Local Water Authorities (Autoridades Locales de Agua) in selected river basins.[178]

[173] Interview memo Dato' Ir. Hj. Nor Hisham bin Mohd Ghazali
[174] Interview memo Dato' Ir. Hj. Nor Hisham bin Mohd Ghazali
[175] Interview memo Dato' Ir. Hj. Nor Hisham bin Mohd Ghazali
[176] OECD 2011 p. 4
[177] Based on OECD 2011, p. 147
[178]The World Bank 2009

ANA has a consultative group representing the following 13 entities to ensure stakeholder participation: Ministry of Agriculture and Irrigation; Ministry of Environment; Housing, Construction and Water Supply and Sanitation Ministry; Energy and Mining Ministry; productive public sectors; health and sanitation public sectors; regional governments; rural municipalities; agrarian water user organizations; non-agrarian water user organizations; rural communities (comunidades campesinas); native communities (comunidades nativas); and the National Maritime Authority. Stakeholder participation is facilitated through River Basin Councils (Consejo De Cuenca), and the composition of each Council is based on the context of the basin it is situated in.[179]

The Ministry of Environment also has a critical responsibility in water resource management through generating hydro-meteorological information through the Meteorological and Hydrological National Service (Servicio Nacional de Meteorologia e Hidrologia - SENAMHI).[180]

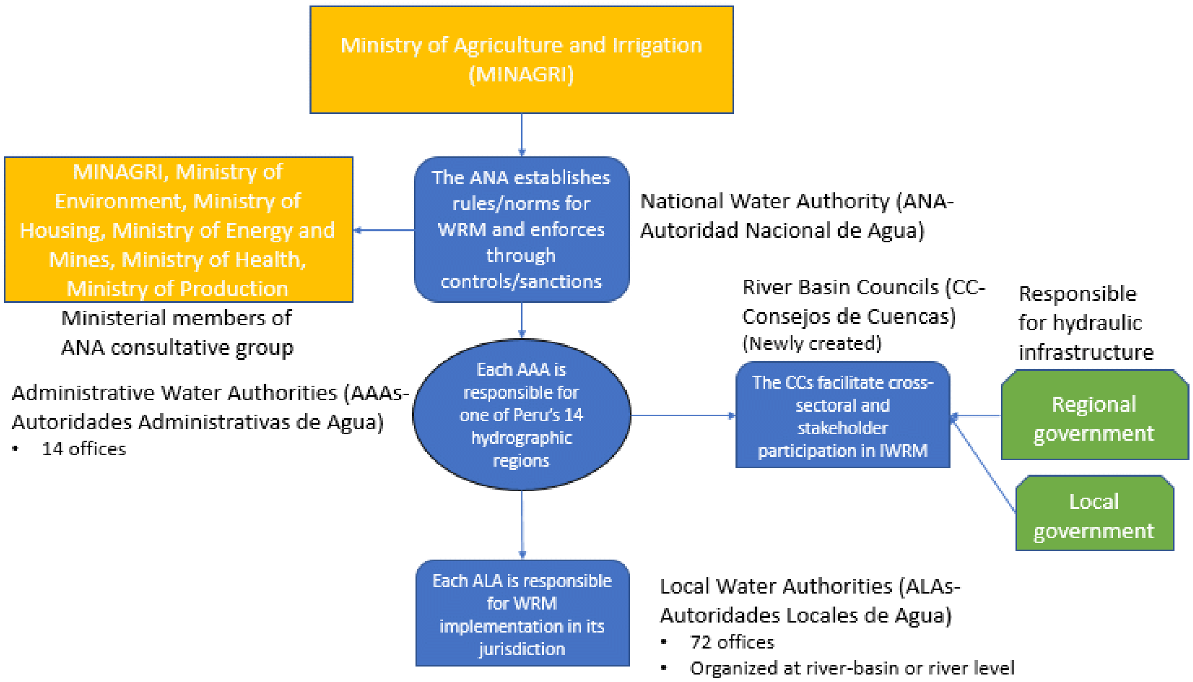
At the local/regional level, regional governments are responsible for the operation and maintenance (O&M) of major public hydraulic infrastructure, such as dams. Regional and local governments are important participants in basin-level water resource planning through the River Basin Councils, and also undertake water quality and discharge monitoring and control actions.[181]

Peru’s integrated and location-based governance approach is formed at the central level through representation of different ministries, sectors, water users and communities; which is then implemented territorially through ANA’s regional and local bodies and regional/local governments. The roles of regional and municipal governments extend beyond simple implementation due to their participation in the River Basin Councils.

[179] The World Bank 2009
[180] The World Bank 2009
[181] The World Bank 2009

The figure below shows how under ANA, there are increasingly local bodies down to the river basin level.

Figure 22: Peru National Water Authority (ANA) Institutional Structure[182]



In the case of Indonesia, the structure of water governance is characterized by many ministries with different, highly specific responsibilities for water resource management. The following table lays out each ministry's role regarding Indonesia's water resources.

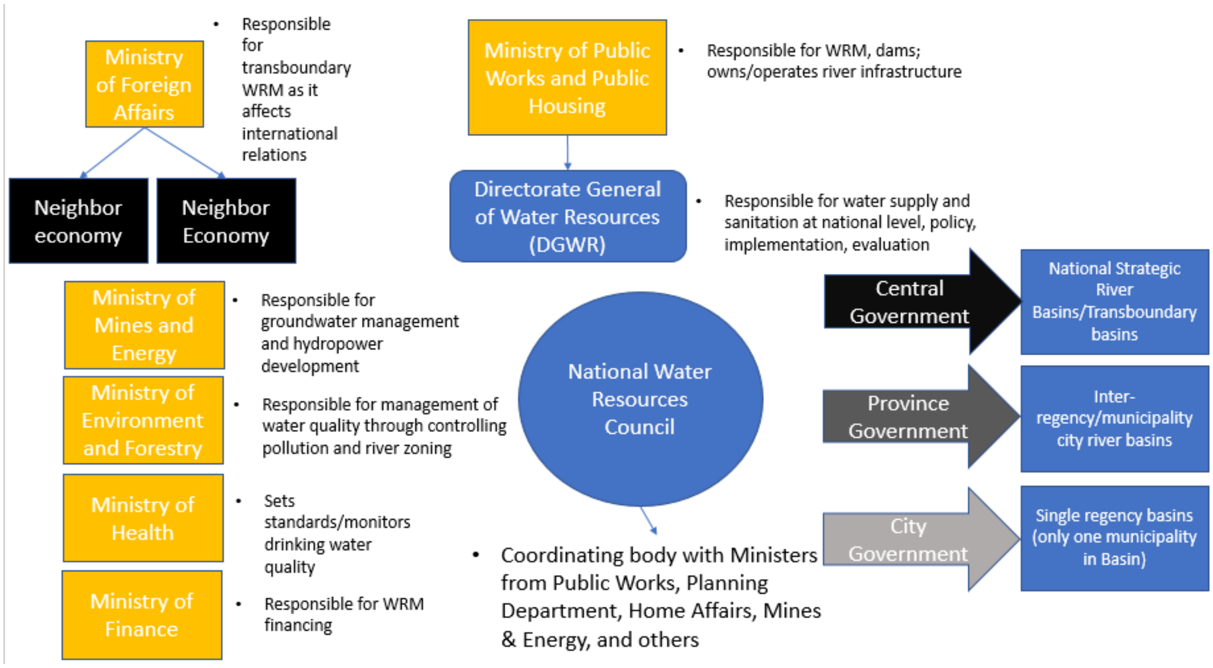
Table 1: Indonesian ministerial water responsibilities[183]

Agencies	Water Related responsibilities
State Ministry of National Development (BAPPENAS)	Responsible for national development planning matters, and this is undertaken through five-year plans in cooperation with the line ministries.
Ministry of Finance	Responsible in terms of government financing of water resources management (water resource management) through the normal government budgeting processes.
Ministry of Foreign Affairs	Responsible for the management of transboundary river basins in so far as the management affects international relations and the foreign affair policies
Ministry of Public Works and Public Housing	Responsible for water resource management, including dam safety and standard operating agreements such as for hydropower developers. Owns and operates river infrastructure (multipurpose dams, weirs), primary and secondary canals of irrigation system;

[182] Washington CORE 2017
[183] Asian Development Bank (ADB) 2016, p. 57

Agencies	Water Related responsibilities
	Directorate General Cipta Karya responsible for water supply and sanitation
Ministry of Mines and Energy	Responsible for groundwater management, including management and monitoring of the resource, both with regard to quantify and quality; licensing of groundwater drilling and use; maintaining databases of groundwater use, etc. The ministry is also responsible for hydropower development and may own and operate hydropower systems according to standard operating agreements.
Ministry of Agriculture	Responsible for food production, farmer welfare, sustainable agriculture, and economic development through agriculture.
Ministry of Environment and Forestry	Responsible for management of water quality through controlling pollution and river zoning (water quality targets in river reaches) and watershed management, including land use planning in watershed areas as well as its responsibilities for promoting and regulating the forestry sector. It is also responsible for Environmental Impact Assessment of major projects.
Ministry of Home Affairs (Interior Ministry)	Responsible for the domestic governance, public order, and regional development at provincial and district levels. This includes decentralization of policies, laws and local autonomy; and increasing community empowerment and poverty reduction.
Ministry of Transport	Responsible for transport facilities, infrastructure, community access, and quality of services. This includes navigation on rivers and lakes.
Central Statistics Agency	A non-departmental government responsible for the provision of basic statistical data, both for the government at all levels and for the general public
Ministry of Agrarian and Spatial Planning	Responsible for formulation of land policies and spatial policies and, in relation to water resource management, land mapping, land titles, and rights over land.
Ministry of Marine Affairs and Fisheries	Responsible for increasing the contribution of the marine and fisheries sector to economic growth
Ministry of Health	Responsible for the protection and improvement of public health. The ministry sets standards and monitors drinking water quality
Ministry of Enterprises	Responsible for state laws and regulations in relation to the Limited Liability Companies Act and for monitoring and improving the competitiveness of state-owned enterprises, including state-owned enterprise Jasa Tirta.

Figure 23: Indonesia Water Governance arrangement[184]



The figure above is a graphic representation of Indonesia's water governance institutions, showing that responsibilities over different types of water and basins is distributed across different ministries and levels of government. The five objectives behind the strategy for implementation of IWRM in Indonesia are: water resource conservation, efficient water resource utilization, control of the destructive potential of water, empowerment of water stakeholders and management of the water resources information system.[185]

Within the Ministry of Public Works and Public Housing is the Directorate General for Water Resources (DGWR), which has the responsibility for water supply and sanitation management at the economy level. Its specific responsibilities include: formulation of policies for water conservation, utilization of water resources (ground and surface) and control of damaged water resources; implementation of policies for integrated and sustainable water resource management; provision technical guidance and supervision in the field of water resources management; and evaluation of implementation and reporting of water resource management practices.[186]

Water resource management at the river-basin level is implemented and managed by river basin organizations (RBOs), which were initiated in the 1990s and now exist for 131 river basin territories. These are either controlled by the Central level, Provincial level or Municipal level.[187] Integration and coordination among stakeholders is pursued through River Basin Councils at the economy, provincial and local levels, which include nongovernment and government members. The Ministry of Public Works also coordinates with farmers unions and the association of water supply companies to account for their views and proposals in water resource management. The Indonesian government also established two Perum Jasa Tirta (PJTs), which are public

184 Washington CORE 2017
185 Satrini 2014
186 Directorate General of Water Resources n.d.
187 Asian Development Bank (ADB) 2016, p. 57

enterprises that operate river water resources infrastructure on a commercial basis to provide service to water users (essentially a corporate RBO). Other functions of PJTs include riverbank protection works, control of sand and gravel mining in rivers, irrigation system management and the collection of fees from users. These corporate RBOs are responsible for six of the 131 basin territories in Indonesia.[188]

While Viet Nam participates in the MRC, the water governance structure at the economy level can be characterized as fragmented due to the distribution of responsibilities across different line ministries.[189] The Vietnamese government has several ministries and agencies that are involved in water resource governance. The Ministry of Industry and Trade (MOIT), the Ministry of Agriculture and Rural Development (MARD), and Electricity of Viet Nam (EVN) are all active members of the water resource management structure.[190] MARD is the biggest authority for water resources for irrigation and agriculture, while MONRE focuses more on mitigation of climate change, river basin management and land management. The Ministry of Planning and Investment is active in climate change policymaking. [191]

The government granted the most power in water security to the Ministry of Natural Resources and Environment (MONRE) in the 2013 Law on Water Resources that outlined commitment to and plans for water security in Viet Nam.[192] The CEO of the Mekong River Commission (MRC) described MONRE as "weak" in capacity, although it is meant to "steer" while the sector ministries "row"; the sector ministries have historically had more capacity to manage water for their sectors, while MONRE sets policies and guidelines with which they must comply.[193] The majority of investment goes towards water infrastructure such as irrigation and canals, with future investments destined for more advanced monitoring and decision support.[194]

Provincial governments complicate the issue, as they generally lack the capacity to allocate water resources effectively. They also are wary of cooperation with the central level.[195]

An uncertainty over roles between MONRE and MARD has led to confusion and a lack of cooperation. Both ministries point to legislation or decrees that give them "state management" authority over water resources. MONRE is meant to set policies sand guidelines at the economy level, while MARD retains control over the River Basin Organizations (RBOs), where all actual management of water resources takes place. MONRE considers that the authority given to it by the government was a transfer of "state management" authority from MARD. Both ministries have put forth arguments regarding this, with MONRE alleging that MARD is too narrowly focused on agriculture and irrigation, while MARD claims that MONRE lacks the capacity to take on the responsibility of basin level water resource management.[196]

In the US responsibilities for water are split among Federal, State, and Native American Tribal jurisdictions. The US Environmental Protection Agency (EPA) is the primary federal agency responsible for water quality, and is responsible for implementing the Clean Water Act, the Safe

[188] Asian Development Bank (ADB) 2016, p. 57
[189] Interview memo Madhu Raghunath
[190]The World Bank 2013, p. 2
[191] Interview memo Madhu Raghunath
[192]The World Bank 2013, p. 2
[193] Interview memo Pham Tuan Phan
[194] Interview memo Le Duc Trung
[195] Interview memo Le Duc Trung
[196] Molle, Hoanh 2009 p. 4

Drinking Water Act and the Water Infrastructure Finance and Innovation Act, among others. However, other federal agencies, like the US Departments of Agriculture, Commerce and Interior also have responsibilities for water resources, such as conservation policies and programs, water data and supply, as well as water supply prediction, flooding, and climate science programs. The US Army Corp. of Engineers and Bureau of Reclamation have responsibilities for flood control and water supply associated with particular water development or management projects. State and Tribal jurisdictions play varying but key roles in water governance and policies, with federal policies underpinning water governance across jurisdictions within the tes.[197] This division of responsibilities across many authorities at the economy and regional/local levels constitutes a multi-layer governance arrangement.

The water governance structure and its legal framework in Japan could also be considered fragmented. Legislation for groundwater management in Japan is provided through economy level legislation and local legislation such as local groundwater ordinances, regulations, rules, and old traditions. Water laws are divided into four parts: (a) laws related to hydrology; (b) laws related to water uses; (c) laws related to groundwater quality preservation; and (d) laws related to groundwater research and development.[198]

The Ministry of the Environment oversees regulations and measures on preventing groundwater pollution and land subsidence. The Ministry of Land, Infrastructure, Transport, and Tourism is in charge of the development, use, maintenance, and other management functions for rivers, watercourses and water surfaces. The Ministry of Agriculture, Forestry, and Fisheries oversees reservation of land, water, and other resources for agricultural use irrigation business.[199]

The Japan Water Agency (JWA) focuses on the construction of facilities for integrated water resources management. Their activities range widely from securing water for domestic, industrial and agricultural use to controlling floods, and maintaining and improving normal functions of the river water (e.g. securing vested water and conserving the river environment). They are given objectives and missions by the central administration to carry out "administrative tasks and projects, which implementation should ensure public benefits such as stable public life and social and economic activities.[200]

Japan has introduced several policy efforts addressing river basin management (RBM). One of the most recent is the establishment of river basin comprehensive water resources management committees. These committees are authorized to set up the river basin comprehensive water resources management plans.[201]

D. Transboundary Water Governance Structures

Transboundary water governance is necessary when the actions of one economy affect the water resources of another, generally because of upstream economic activities affecting water availability and quality for downstream economies. Representatives from each economy collaborate to formulate water policy in such a way that addresses transboundary concerns. These activities include technology/knowledge sharing, formulation of joint information/monitoring tools and consultations to improve the central water policies of each economy. These

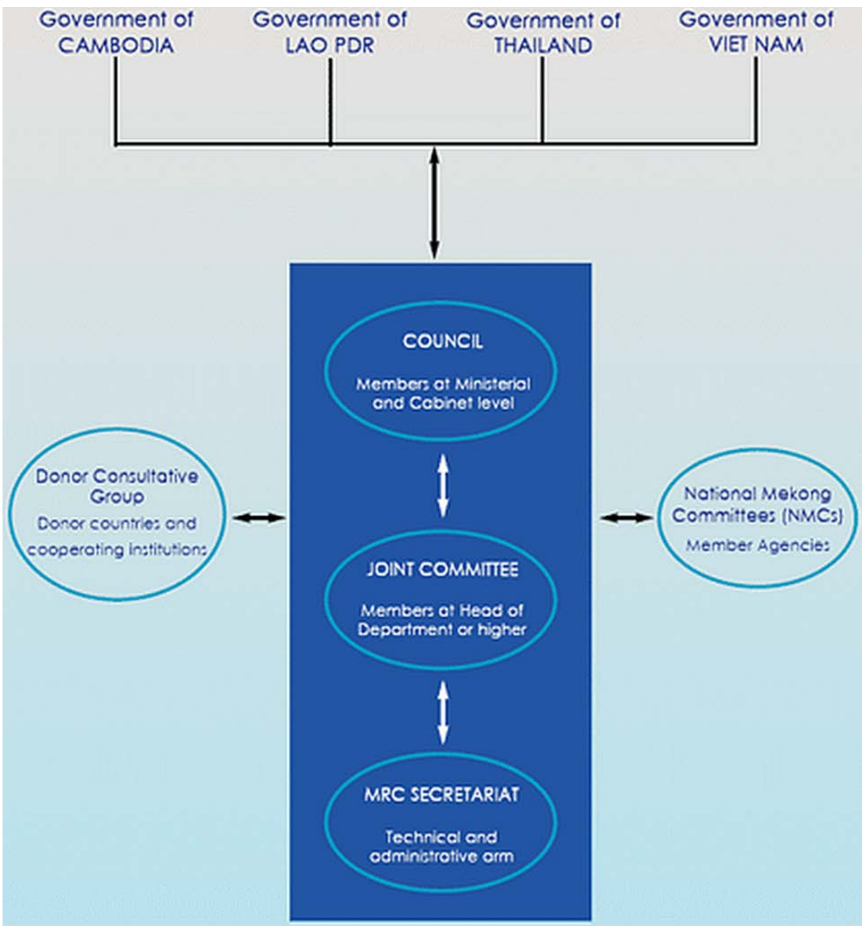
[197] Survey response US
[198] Ibid. 2008
[199] OECD 2015d, p. 1
[200] Japan Water Agency 2017
[201] Lee 2015

arrangements can happen between two sovereign economies or provinces/territories within an economy. Due to the political complexity of transboundary issues, identifying effective policies and best practices is difficult.[202]

For example, Viet Nam is a member of the Mekong River Commission (MRC), an inter-governmental organization to jointly 'manage' the shared water resources and the sustainable development of the Mekong River, including Cambodia, Laos and Thailand.[203] The MRC makes no actual decisions regarding allocation, rather it serves as an "enabling environment and institution for cooperating around the management of the water resources" of the Mekong system.[204]

The figure below shows the governance arrangement of the MRC, and how it includes ministerial and cabinet level officials of each economy through the Council, and then department level officials through the Joint Committee.

Figure 24: MRC Governance Structure[205]



202 Interview memo Delphine Clavreaul
203 Mekong River Commission n.d.
204 Interview memo Pham Tuan Phan
205 Mekong River Commission n.d.

The MRC has been promoting an integrated approach to water resource management since 1995, and is assisting member economies in implementing water monitoring parameters to enable transboundary management and data sharing.[206] The MRC's strategy provides an integrated basin perspective for assessment and improvement of each economy's plans.[207] Two key tools in this process are the Basin Development Strategy, which brings together the plans for each economy into a single document and plan, which highlights what the possible impacts and benefits of development could be, and the prior consultation process, which the MRC can use to encourage economies to take certain actions to prevent and mitigate negative impacts to the system.[208]

The most recent updated strategy emphasizes sector strategies to promote water-related security and equity, regional cooperation and integration through the development of joint and basin wide development opportunities, adoption of longer-term management measures and harmonization of regional and national planning.[209] The MRC considers cooperation, communication and reciprocal exchange of knowledge as essential to the implementation of IWRM in the Mekong region. Other activities include national capacity building and establishment of environmental baselines.[210]

Participation in the MRC is a key governance mechanism for IWRM through which Viet Nam is furthering awareness of transboundary water security-related issues in the Mekong River. With agreements among the economies involved in the MRC to share information and data, Viet Nam is able to accurately evaluate the situation in the Mekong and how the activities of upstream economies affect its water resources.[211] The MRC has also fostered cooperation between Viet Nam and Cambodia through different methods, including the development of a jointly owned trans-boundary hydrological model and the establishment of a data-sharing mechanism.[212]

The MRC is largely focused on fostering cooperation among the member economies and addressing governance issues related to transboundary water concerns. It has successfully established a technical basis and political structure for the discussion of sensitive transboundary water issues. This involves sharing experiences of successful attempts and limitations of water initiatives in each economy, such as the multiple pilot studies on water resource management. The governments of each economy also collaborate to form agreements that promote regional cooperation. The CEO of the MRC coordinates with the heads of the department in charge of water resource management in each economy.[213]

Some of the main areas of concern are flood and disaster risk issues and hydropower development. In particular, hydropower development in Laos has significant implications for the water of downstream economies. Viet Nam's main concern is to ensure the integrity of the Mekong delta, as it produces half of its food. Meanwhile, hydropower development could lead to billions in revenue for Laos, which is a very large sum to a small economy.[214]

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[206] The World Bank 2013, p. 3
[207] MRC 2016, p. 4
[208] Interview memo Pham Tuan Phan
[209] MRC 2016, p. 4
[210] MRC (b), n.d.
[211] The agreements were the 2006 Procedures of Water Quality (PWQ) and 2011 Procedures on the Maintenance of Flow in the Mainstream (PMFM), which were developed under the Global Environmental Facility (GEF)-funded Water Utilization Project. See The World Bank 2013, p. 3
[212] The World Bank 2013, p. 4
[213] Interview memo Hans Guttman
[214] Interview memo Hans Guttman

To date, China has built seven hydropower dams on the upper Mekong River and plans to build 21 more. There are concerns from the other recipients of the Mekong River on how these dams will impact their livelihoods. The dams could increase the water levels in the dry season, consequently harming agriculture along the Mekong River. During the wet season, the dams could decrease the flow of water, shrinking the floodplain area and reducing the flow of nutrients deposited on the floodplains. The dams have also decreased water temperature and fluctuated water temperature, which will change the behaviors of fish species, impacting their reproduction and migration activities. On top of this, the dam blocks fish migration channels, which are critical for reproduction.[215]

Some cases of negative environmental impact include:

- In August 2008, a flood in the northern parts of Laos and Thailand was linked by some to China's Jinghong dam on the river in Yunnan, which had begun to generate hydropower earlier that summer.
- In early 2010, China was confronted with criticism of its dam building after record-low water levels in the Mekong led to smaller fish catches, less water for irrigated agriculture, livestock and drinking and suspended river transportation affecting trade and tourism. The media and NGOs blamed the operators of the large reservoir behind China's Xiaowan dam for aggravating severe drought conditions at the time.[216]

In response to the petitions from its neighbors, China has agreed to share more hydrological data with the Mekong River Commission by extending the hydrological data provision by 30 days, starting on June 1 until October 31, every year, as well as increasing the frequency of the data sharing to twice a day.[217] In an effort to allay concerns, the foreign ministers of China, Myanmar, Laos, Thailand, Cambodia, and Viet Nam launched the Lancang-Mekong Cooperation Mechanism (LMCM) in November 2015 during their meeting in Yunnan province, China. The new mechanism will cover five priority areas: interconnectivity, production capacity, cross-border economic cooperation, water resources and cooperation on agriculture and poverty reduction.[218]

The commitment made by MRC members to IWRM principles is not enforced by any type of supranational law, although regional cooperation and dialogue is invaluable to improving water resource management on the Mekong. Despite this, the MRC has made significant achievements in promoting a cooperative approach to water resource management at the basin level, but there are no results and outcomes in terms of IWRM principles. The sovereign dealings between states has many political constraints that limit the ability to implement ambitious programs such as IWRM.[219]

3.2.2 Survey responses and supporting details

This section contains what responding APEC economy wrote in its survey response about the institutional arrangement for water resource management in their economies, supplemented with

[215] International Rivers 2014
[216] Biba 2016
[217] International Rivers n.d.
[218] Biba 2016
[219] Interview memo Hans Guttman

literature research.[220] Economies that have no content in this section were covered in more detail in Section 3.2.1.

A. Australia

A representative from the Department of Agriculture and Water Resources in Australia indicated that their agency's role is to improve the health of rivers and freshwater ecosystems and water use efficiency through implementing water reforms and ensuring enhanced sustainability, efficiency and productivity in the management and use of water resources.[221]

The Murray-Darling Basin Authority is responsible for preparing, implementing and reviewing an integrated plan for sustainable use of the Basin's water resources.

The Commonwealth Environmental Water holder was said to manage the portfolio of environmental water acquired by the Australian Government, while the Bureau of Meteorology provides regular weather forecasts, warnings and monitoring and advice across Australia's weather, climate and water.[222]

B. Brunei Darussalam

Management of water supplies in Brunei Darussalam is the responsibility of the Water Services Department/Public Works Department (DWS/PWD) within the Ministry of Development.[223] Main activities of this body include:

- Enforcement of Land Acts, Town and Country Planning Acts, Water Acts, Environment Acts to safeguard water catchment from pollution
- Climate change adaptation through reservoir construction, salinity intrusion prevention, water pricing and other conservation measures
- Supply and Demand Management with emphasis on infrastructure development, such as dams, treatment plants, and sewerage and drainage systems to cater to growing water demand
- Studies to identify new potential dams beyond 2035
- Reducing non-revenue water (NRW), which is water that is lost before it reaches the customer/user
- Risk management through auditing critical assets and enhancing water quality monitoring[224]

Main legislation includes:

- Land Acts
- Town and Country Planning Acts
- Water Acts
- Environment Acts[225]

[220] Survey responses were not received from Brunei Darussalam, China, Indonesia, Japan, Korea, Mexico, or Russia. Where possible literature research was conducted to cover basic details.
[221] Survey response (Australia)
[222] Survey response (Australia)
[223] ASEAN IWRM (b) 2015
[224] Ministry of Development (Brunei) 2009
[225] Ministry of Development (Brunei) 2009

C. Canada

The Federal Government in Canada has jurisdiction fisheries, navigation, federal lands, and international relations, including responsibilities related to the management of boundary waters shared with the US. It also has many responsibilities related to agriculture, health and the environment, aquatic research and technology, and federal environmental and health-related policies and standards.[226]

Over 20 departments and agencies at the federal level have responsibilities related to fresh water. Environment and Climate Change Canada works closely with these departments to form a more strategic and collaborative approach to addressing significant freshwater issues.[227]

Despite some federal involvement, waters that lie exclusively within the boundaries of a province are under the authority of that province, according to the Constitution.

Provincial legislative powers include, but are not restricted to, areas of

- flow regulation
- authorization of water use development
- water supply
- pollution control
- thermal and hydroelectric power development[228]

Table 2: Canadian responsible authorities for each province/territory[229]

Province	Authority
Alberta	Alberta Environment
British Columbia	Ministry of Environment Ministry of Health Services (drinking water)
Manitoba	Manitoba Conservation Manitoba Water Stewardship
New Brunswick	News Brunswick Environment New Brunswick Natural Resources
Newfoundland and Labrador	Department of Environment and Conservation
Northwest Territories	NWT Environment and Natural Resources NWT Public Works and Services. Water and Sanitation
Nova Scotia	Nova Scotia Environment and Labour Nova Scotia Natural Resources
Nunavut	Department of Environment
Ontario	Ministry of Environment Ministry of Natural Resources
Prince Edward Island	Environment, Energy and Forestry
Quebec	Centre d'expertise hydrique Québec Ministère du Développement durable, de l'Environnement et des Parcs Ministère des Ressources naturelles et de la Faune
Saskatchewan	Saskatchewan Environment

[226] Government of Canada 2017b
[227] Government of Canada 2017b
[228] Government of Canada 2017a
[229] Government of Canada 2017a

Province	Authority
	Saskatchewan Water Corporation Saskatchewan Water Security Agency
Yukon	Environment Yukon Yukon Health and Social Services

D. Chile

A representative of the National Commission of Irrigation in Chile responded that The Water Directorate (DGA), within the Ministry of Public Works, is the agency of the State that is responsible for promoting the management and administration of water resources in a framework of sustainability, public interest and efficient allocation.[230] The DGA is responsible for monitoring and enforcing water-use rights, and maintains a water cadaster, which also contains data on hydrological and water-quality data, withdrawals, water users associations (WUAs) and all transactions. WUAs are recognized by law and engage in user management of irrigation canals.[231]

Water Boards at three levels (river board - channels board - groundwater board) have the mission of distribute the water according the Water rights of their jurisdiction. Today, Chile has 46 river boards, 3400 channels boards and 11 groundwater boards.[232]

Important legislation includes the 1981 Water Law, which allowed for the granting of water rights to individuals and firms in a similar manner to real estate, as well as trading and sale, creating markets. Ecological minimums to preserve water flows were introduced in 2005.[233]

E. China

Please see governance overview in Section 3.2.1.

F. Hong Kong, China

Representatives from the Water Supplies Department; the Agriculture, Fisheries and Conservation Department; and the Environment Protection Department in Hong Kong, China, indicated that primary water sources (i.e. rainwater collected locally, Dongjiang water and seawater for toilet flushing) and related facilities are managed by The Water Supplies Department (WSD- www.wsd.gov.hk) while storm water drainage systems and facilities for collection, treatment and discharge of sewage are under the purview of the Drainage Services Department.

The Environmental Protection Department is primarily responsible for protection of environmental water quality through a multi-pronged approach including controlling pollution at source, providing sewers for sewage collection, proper treatment of sewage and water quality monitoring. On policy level, the Development Bureau is responsible for policies on flood prevention and water supply.

In addition, the Secretary for Development has appointed the Advisory Committee on Water Supplies (“ACWS”) which is an independent body comprising members from the public including academics, district councilors, green advocates, professionals, trades and officials from related government departments and bureau to provide advice on matters relating to water supplies particularly on water resources, quality of water supplies and network management.[234]

[230] Survey response (Chile)
[231] Donoso, Melo 2004, p. 10
[232] Survey response (Chile)
[233] Bitrán et. al. 2011, p. 7
[234] Survey response (Hong Kong, China)

Important legislation includes:

- The Waterworks Ordinance (Cap 102) and Waterworks Regulation (Cap 102a) which empower the Water Supplies Department to supply, acquire and conserve water, and to supervise and regulate water consumption
- Administrative tools and technical guidelines to supplement these regulations[235]

G. Indonesia

Please see governance overview in Section 3.2.1.

H. Japan

Please see governance overview in Section 3.2.1.

I. Korea

Water resource allocation in the Korea is primarily managed by different ministries depending on the type of use, with some involvement of municipalities. Ground water and surface water are publicly owned.[236]

Table 3: Korean responsible authorities[237]

Institution	Scale	Responsibilities
Ministry of Land, Infrastructure and Transport	Central	Water Quality Management, Policy, Planning, Monitoring, Management
Ministry of Environment	Central	Water Quality Management, Regional Water Supply Planning
Ministry of Agriculture, Food and Rural Affairs	Central	Agricultural Water Management, Planning
Ministry of Trade, Industry and Energy	Central	Hydropower management
Municipalities	Local	Local river maintenance

Important legislation includes:

- National Land Use and Management Act
- Han River law
- River Basin Law[238]

J. Malaysia

A representative of the Malaysian Agricultural and Development Institute (MARDI) indicated that the Ministry of Agriculture and Agro-Industry and the Drainage and Irrigation Department are the main bodies responsible for water resource management in Malaysia.

The National Water Resources Council (NWRC), under the Ministry of Natural Resources and the Environment (MNRE), was formed to coordinate water resource management among various stakeholders between Federal and State governments. MNRE was established in 2004 with

[235] Survey response (Hong Kong, China)
[236] OECD Secretariat 2015, p. 1
[237] OECD Secretariat 2015, p. 1
[238] Water Policy Reforms in South Korea: A Historical Review and Ongoing Challenges for Sustainable Water Governance and Management p. 11

combinations of departments from other ministries, also with the goal of integrating water resource management.[239]

Another apex body, The National Water Services Industry Commission (SPAN) is responsible for regulating water services in terms of licensing, supervision and monitoring.[240]

Important legislation includes:

- The National Water Services Industry Commission Bill and the Water Services Industry Act, which put all water resources under State jurisdiction[241]
- The Town and Country Planning Act 1976 encourages NGOs and CBOs to participate in water sector development[242]

K. Mexico

Three main groups of institutions in Mexico have the main responsibilities for water resource management:

1. The National Water Commission (Comision Nacional del Agua - CONAGUA) at the federal level
2. The States through the Water Commissions (Comisiones Estatales de Agua - CEAs)
3. At the local level, the municipalities and water utilities, as well as Irrigation Districts and Units

CONAGUA is the apex institution for the water sector, under the formal authority of the Ministry of the Environment and Natural Resources (SEMARNAT), although it has considerable autonomy. It holds federal authority for water policy, water rights administration, planning, irrigation and drainage development, water supply and sanitation, and emergency and disaster management (prevention and response) particularly with respect to flooding. It also administers financial flows for the water sector, including water resource management, irrigation, and water supply and sanitation.[243]

The State Water commissions (CEAs) are autonomous entities, usually under the authority of the State Ministry of Public Works, although their characteristics differ by region. They hold some authority and responsibility over water resource management, and some have responsibilities in irrigation, water supply and sanitation, and technical assistance to municipalities, irrigation districts and units. They also monitor the performance of service providers, operation of water distribution systems and bulk water supply.[244]

Most large cities and towns have created decentralized municipal water service providers, while in smaller municipalities, the municipality itself generally administers water services.[245]

[239] Mokhtar et. al n.d.
[240] Mokhtar et. al n.d.
[241] Mokhtar et. al n.d.
[242] Mokhtar et. al n.d.
[243] The World Bank 2006, p. 14
[244] The World Bank 2006, p. 14
[245] The World Bank 2006, p. 15

Mexico also has 13 river basin organizations that implement CONAGUA's policies in each hydrographic region, with an additional 26 that serve as consultative bodies.[246]

Important legislation includes the 2004 National Water Law, which restructured key functions of CONAGUA through the transfer of responsibilities from the central level to subnational entities.[247]

L. New Zealand

A representative from the Ministry for the Environment of New Zealand described the central administration of New Zealand as responsible for developing the economy's policy for managing fresh water. It guides and directs regional councils under the Resource Management Act.

On 13 August 2012, the Water Directorate was established at the representative's Ministry, the Ministry for the Environment (MfE) to lead ongoing development and implementation of freshwater reforms. The Directorate hosts staff from both MfE and the Ministry for Primary Industries (MPI), which co-lead the reform program, working with additional staff from Treasury and other government departments. The program delivers policy advice and Cabinet papers for durable freshwater reforms using an evidence-based approach.[248]

The Natural Resources Sector (NRS) was described as a grouping of the core government agencies responsible for the management and stewardship of New Zealand's natural resources, including fresh water. The NRS came together in 2008 to build a coherent and integrated approach to sector-wide issues such as freshwater, mineral use, biodiversity, and climate change.

The NRS recognizes that competition and conflict in resource use is increasing, and complex to resolve. Therefore, Ministers need advice that reflects all interests (economic, social, environmental and cultural) and identifies the impact their decisions will have on other portfolios, and in the future.[249]

Local government was described as in charge of freshwater planning at a community and regional level.

- Regional councils are responsible for managing water quality and quantity through their plans. They may permit some activities and require consents for others such as taking water and the discharge of contaminants.
- Territorial authorities are responsible for managing land uses and generally provide drinking water, stormwater and sewage services.[250]

Local authorities have plans that permit some activities and require consents for others such as taking water, discharge of contaminants and the use of land. New Zealand has 17 regional and unitary councils that are based generally on water catchment areas.[251]

Important legislation includes:

- The Resource Management Act 1991

[246] OECD 2011, p. 10
[247] The World Bank 2006, p. 16
[248] Survey response (New Zealand)
[249] Survey response (New Zealand)
[250] Survey response (New Zealand)
[251] Survey response (New Zealand)

- National Policy Statement for Freshwater Management
- National Environmental Standard for Sources of Human Drinking Water
- Regional Council Plans (http://www.mfe.govt.nz/rma/rma-processes-and-how-get-involved/council-plans-and-where-find-them)

M. Papua New Guinea

A representative of the Department of Agriculture & Livestock of Papua New Guinea (PNG) stated that there is no organization or agency in the PNG economy responsible for water resource management and governance. The representative indicated that PNG must have a body and agency established with responsibilities for water resource management, preferably within the Economy's leading agency for agriculture, and that is the Department and Ministry of Agriculture and Livestock.[252]

N. Peru

The Peruvian representative from the Ministry of Agriculture and Irrigation (MINAGRI) provided the list below of organizations involved in water resource management and governance. Please see the Peru governance overview in Section 3.2.1. for additional details.

1. Ministry of Agriculture and Irrigation
2. Ministry of Environment
3. Ministry of Housing, Construction and Sanitation
4. National Water Authority (ANA)
5. National Program for Rural Sanitation
6. Ministry of Health
7. Ministry of Production
8. Ministry of Energy and Mines
9. Regional governments and local governments
10. Agricultural user organizations
11. Nonagricultural user organizations
12. Native communities
13. Hydraulic operators[253]

Water governance is led at the economy level by:

- The Board of Directors of the ANA.
- Specialized Multisector Groups:
    - Multisector Commissions:
        - Permanent (DS, Regulation RM)
        - Temporary (RS)
    - Thematic Tables
- Advisory Commissions

The above groups collaborate with the following decentralized bodies:

- Basin Water Resources Councils
- Specialized Multisector Work Groups (GETRAM)
- Thematic Tables or Working Groups[254]

[252] Survey response (Papua New Guinea)
[253] Survey response (Peru)
[254] ANA 2017

O. Philippines

According to a representative of the Bureau of Soils and Water Management (BSWM) in the Department of Agriculture (DA) of the Philippines, the National Water Resources Board (NWRB[255]) is the leading government agency for the water sector in the economy regarding water resources and potable water, conferred with policy-making, regulatory and quasi-judicial functions within the Philippine government. The DA is tasked with helping and empowering the farming and fishing communities and the private sector to produce enough, accessible and affordable food for every citizen and a decent income for all. BSWM advises and renders assistance on matters related to the utilization of soils and water as vital agricultural resources. It engages in rainmaking projects for agricultural and watershed areas to address the problems of prolonged droughts and minimize their effects to standing agricultural crops.

The National Irrigation Administration (NIA) is responsible for developing and maintaining irrigation systems in support of the agricultural program of the government; and providing adequate levels of irrigation services on a sustainable basis in partnership with farmers and local government units.

The Department of Environment and Natural Resources (DENR) is responsible for ensuring the availability and sustainability of the economy's natural resources through judicious use and systematic restoration or replacement, whenever possible.

The Philippine Atmospheric, Geophysical and Astronomical Services Administration (DOST-PAGASA) provides protection against natural calamities and utilizes scientific knowledge as an effective instrument to insure the safety, well-being and economic security of all the people, and for the promotion of the economy’s progress.[256]

P. Russia

The following table details the different federal authorities involved in water resource management in Russia. Each Federal Ministry/agency generally has its own territorial bodies in Russia’s constituent entities, although those constituent entities also tend to have their own ministries/departments with similar functions. This leads to challenges in ensuring policy coherence among levels of government in Russia’s water sector.[257]

Table 4: Russian responsible authorities[258]

Institution	Responsibilities
The Ministry of Natural Resources and Environment	Makes policies and regulations for study, use and protection of water resources and water bodies. Also responsible for hydrometeorology and environmental protection.
The Ministry of Reginal Development	Regulates water supply and sanitation sector.
Ministry of Agriculture	Makes policy and regulations for the agro-industrial complex; represents agricultural water users.
Federal Agency for Fisheries	Makes, implements and regulates fisheries policy.

[255] www.nwrb.gov.ph
[256] Survey response (Philippines)
[257] OECD 2011, p. 24
[258] OECD 2011, p. 24

Institution	Responsibilities
Federal Agency for Maritime and River Transport	Maintains inland waterways, including supply of water to rivers, and navigational hydrotechnical structures.
Ministry of Health	Responsibilities relate to state control of drinking water quality.
Ministry of Energy	Responsibly for hydropower stations, and technical standards for energy and water resource efficiency.
The Ministry of Industries and Trade	Assists Russian industries in adopting more resource-efficient and cleaner technologies.

Main legislation includes:

- Water Code of the Russian Federation No. 74-FZ of 3 June 2006
- Inland Water Transport Code of the Russian Federation No. 24-FZ of 7 March 2001
- Federal Law on Hydrotechnical Structures Safety No. 117-FZ of 21 July 1997
- Federal Law on Fishing and Conservation of Aquatic Biological Resources No. 166-FZ of 20 December 2004
- Federal Law on Environmental Protection No. 7-FZ of 10 January 2002
- Federal Law on Water Supply and Sanitation No. 416-FZ of 7 December 2011
- Federal Law on Lake Baikal Protection No. 94-FZ of 1 May 1999
- Federal Law on Melioration No. 4-FZ of 10 January 1996.[259]

Q. Singapore

The Public Utilities Board (PUB), Singapore's National Water Agency, is responsible for managing Singapore's water supply, water catchment and water usage in an integrated way.[260]

The Resilience Working Group (RWG) is an interagency work group which studies Singapore's vulnerability to the effects of climate change and recommends long-term plans that ensure Singapore's adaptation to future climate change.

The Agro-Food & Veterinary Authority of Singapore (AVA) ensures a resilient supply of safe food; ensures the health and safeguards the welfare of animals; safeguards the health of plants; and facilitates agro-trade.[261]

The National Climate Change Secretariat (NCCS), which is part of the Strategy Group under the Prime Minister's Office, coordinates Singapore's domestic and international policies and strategies to address climate change, while the National Environment Agency (NEA) is the public organization responsible for improving and sustaining a green and clean environment in Singapore.[262]

Important legislation includes:

- The Public Utilities Act
- The Sewerage and Drainage Act[263]

R. Chinese Taipei

[259] OECD 2013, p. 25
[260] Survey Response (Singapore)
[261] Survey response (Singapore)
[262] Survey response (Singapore)
[263] Survey response (Singapore)

A representative from the Council of Agriculture of Chinese Taipei responded, detailing the various organizations with responsibilities for water resources governance and management, including:

1. Water Resources Agency, MOEA (http://www.wra.gov.tw/), which is in charge of water resources policies and laws, water resources development and management, reservoir storage area management, flood and drought disaster mitigation and relief, etc.
2. Farmland Irrigation Associations (http://doie.coa.gov.tw/), which are the main funding and managing agency for farmland irrigation development, and in charge of duties like
    a. Construction improvement, maintenance and management of irrigation facilities.
    b. Research and development of irrigation benefits.
    c. Coordinating with the implementation of government policies on farmland, agricultural industry and rural construction to develop the irrigation business.
3. Taiwan Water Corporation (https://www.water.gov.tw/mp.aspx?mp=1), which is involved with:
    a. water supply to public and industries;
    b. water resources development and modernization of infrastructure facilities; and
    c. Diversification of water business management.[264]

Important legislation includes:

- The Water Act
- Enforcement Rules of the Water Act
- The Water Supply Act
- The Hot Spring Act[265]

S. Thailand

A representative from the Land Development Department, within the Ministry of Agriculture and Cooperatives of Thailand, stated that the responsible authorities for water resource management in Thailand were the Department of Water Resources and the Department of Groundwater Resources within the Ministry of Natural Resources and the Environment, and the Royal Irrigation Department within the Ministry of Agriculture and Co-operatives.[266]

Thailand has an apex body for coordinating sectoral activities, also called the National Water Resource Committee.[267]

The Department of Water Resources has responsibilities in the areas of water resource management, conservation, rehabilitation and development, as well as hydrological monitoring and information systems.[268]

The Royal Irrigation Department is responsible for development and maintenance of the economy's main irrigation systems. They contribute to the development of basin water management practices and the prevention and relief of water-related disasters.[269]

[264] Survey response (Chinese Taipei)
[265] Survey response (Chinese Taipei)
[266] Survey Response (Thailand)
[267] Champathong et.al 2013
[268] Department of Water Resource (Thailand) 2016
[269] Firetide 2016

Important legislation includes:

- Royal Irrigation Act 1942
- Ground Water Act 1977[270]

[270] Survey response (Thailand)

T. United States

The United States Department of Agriculture (USDA) responded to the pre-workshop survey with an explanation that the responsibilities for managing water resources are split among Federal, State, and Native American Tribal jurisdictions. The US Environmental Protection Agency (EPA) is the primary federal agency responsible for water quality.

However, other federal agencies, like the US Departments of Agriculture, Commerce and Interior also have responsibilities for water resources, such as conservation policies and programs, water data and supply, as well as water supply prediction, flooding, and climate science programs. The U.S. Army Corp. of Engineers and Bureau of Reclamation has responsibilities for flood control and water supply associated with particular water development or management projects. State and Tribal jurisdictions play varying but key roles in water governance and policies, with federal policies underpinning water governance across jurisdictions within the US.[271]

Noting that Federal, State and Native American Tribal governments share responsibilities in the US, State and Tribal laws regarding water resources are not easily summarized. Nonetheless, important US legislation concerning water governance includes:

- The US EPA is responsible for implementing:
  - The Clean Water Act;
  - The Safe Drinking Water Act;
  - The Water Infrastructure Finance and Innovation Act;
  - The Resource Conservation and Recovery Act;
  - The Chesapeake Bay Program;
  - Portions of the Marine Protection and Sanctuaries Act;
  - Ocean Dumping Ban Act;
  - Shore Protection Act;
  - Marine Plastics Pollution Research and Control Act; and
  - Other key water-related US regulations[272]

U. Viet Nam

A representative from the Southern Institute for Water Resources Planning of Viet Nam stated that the responsible authorities for water resource management and governance are the Ministry of Natural Resources and Environment and the Ministry of Agriculture and Rural Development.[273]

Important legislation includes:

- Water Resources Law
- Water Resources Protection Law.[274]

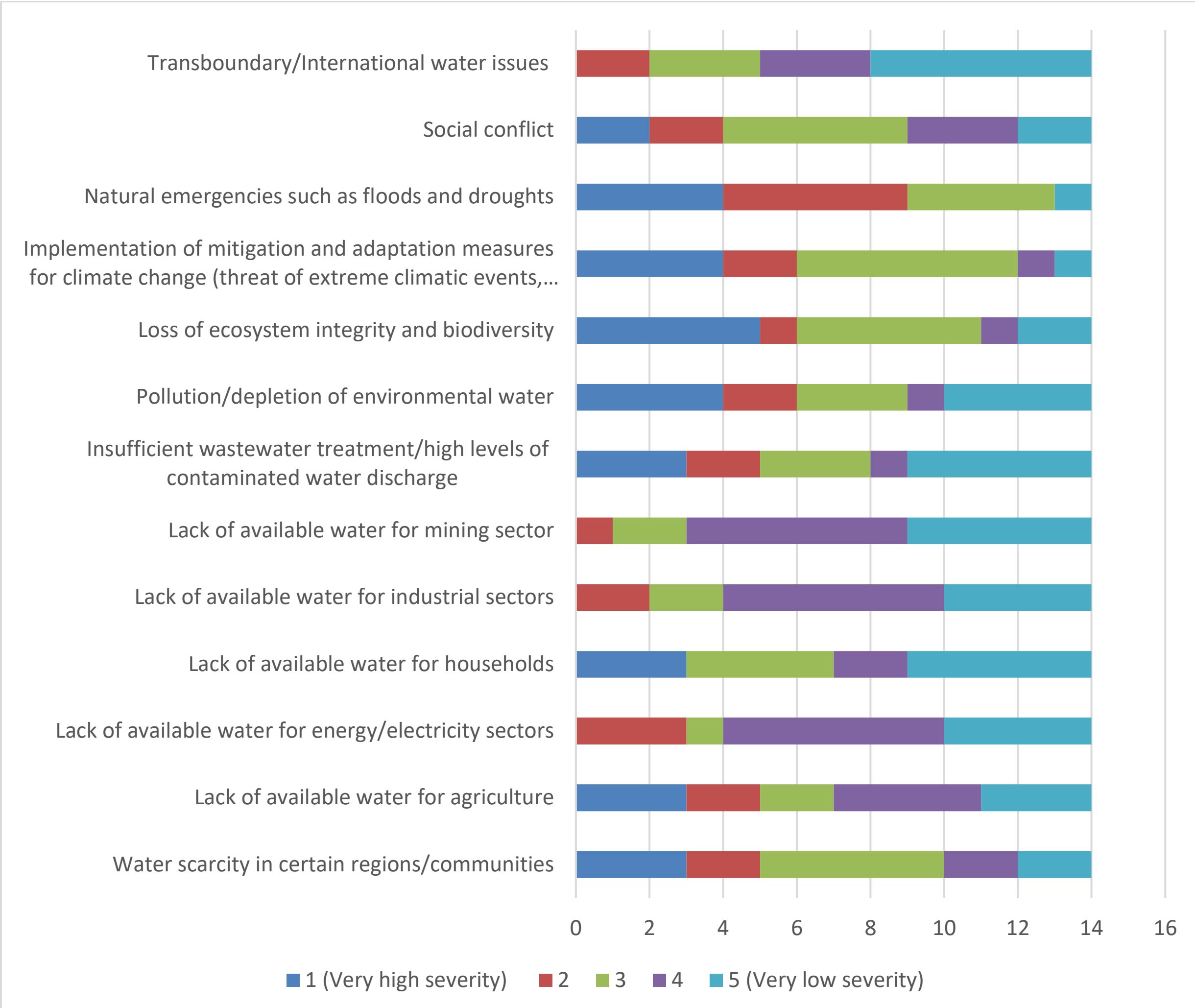
3.3 Water governance challenges

Economies were asked about the greatest water resource management challenges facing their economies, though not all responded. Among economies that responded, floods/droughts, climate change, localized water scarcity, loss of ecosystem integrity and pollution were commonly

[271] Survey response (US)
272 Survey response (US). Referred to https://www.epa.gov/regulatory-information-topic/regulatoryinformation-topic-water
273 Survey response (Viet Nam)
274 Survey response (Viet Nam)

cited as severe issues, whereas the lack of available water for mining, energy and industrial sectors was considered much less severe.

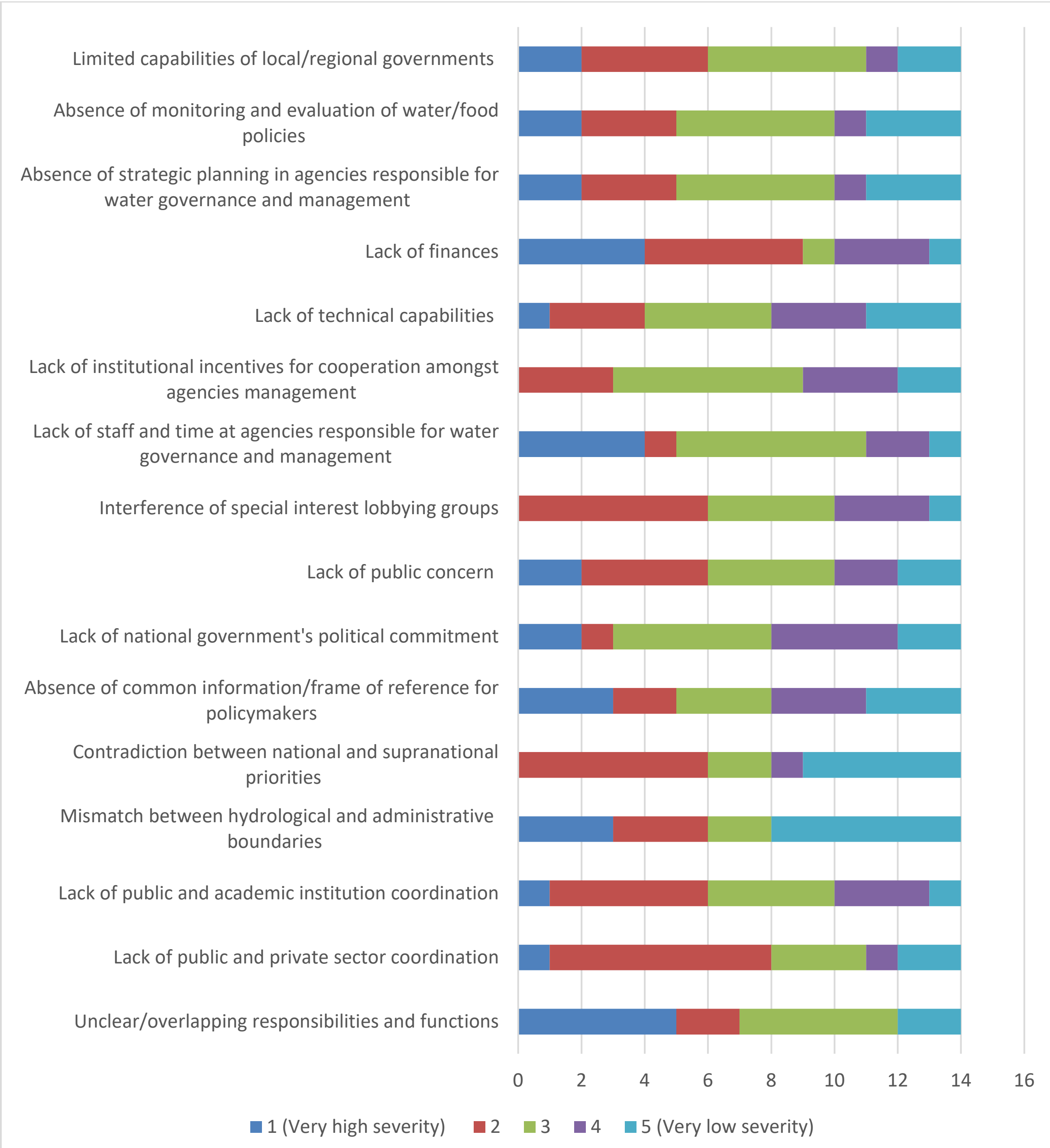
Figure 25: What are the greatest water resource management challenges facing your economy?[275]



Economies were asked to identify barriers to successful communication and coordination among different public authorities in water resource management for agriculture and climate change adaptation. Note that overlapping responsibilities, lack of staff and time and lack of finances were considered particularly severe.

[275] Washington CORE 2017. Note that 14 out of 21 APEC Economies responded to the survey.

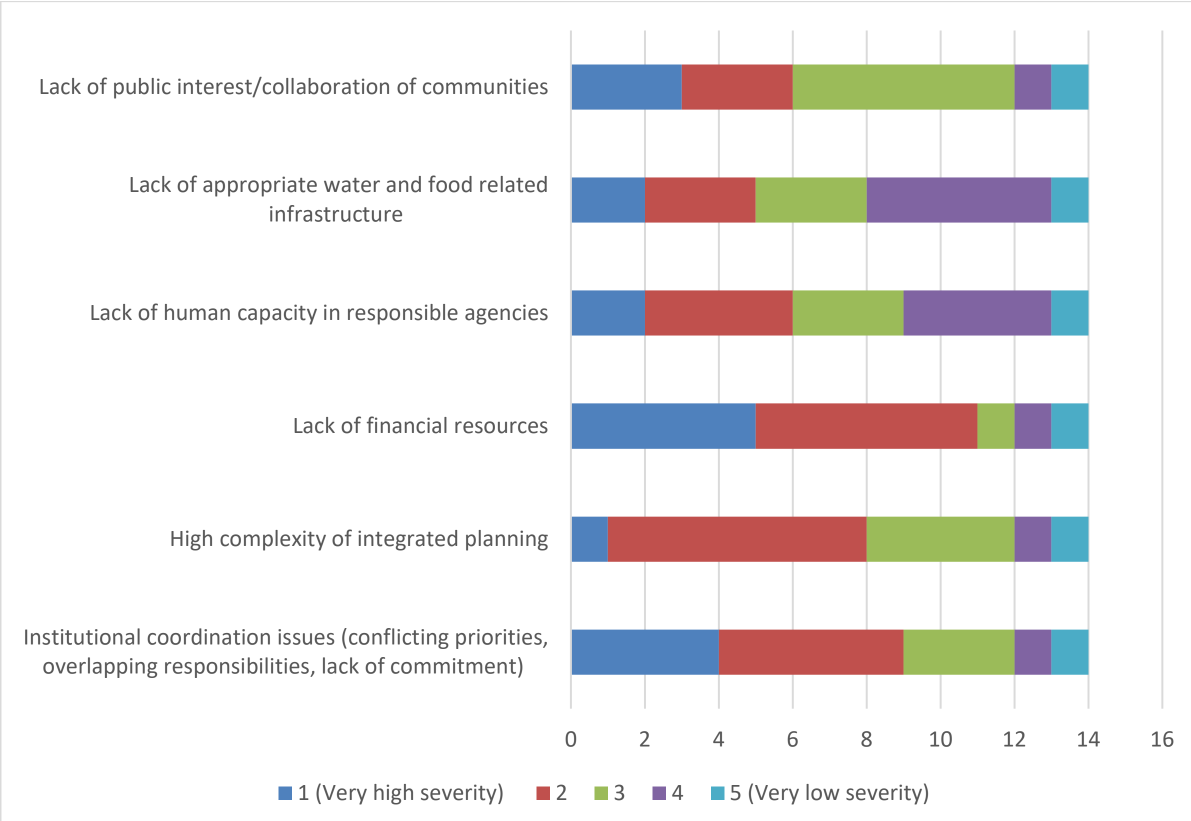
Figure 26: What are the primary obstacles to effective coordination in the public sector and management of water resources for agriculture, considering the context of climate change?[276]



Economies were also asked to identify barriers to beginning or enhancing implementation of IWRM initiatives. Among economies that responded, lack of finances was cited as the most severe barrier, followed by complexity of integrated planning and issues with institutional coordination.

276 Washington CORE 2017

Figure 27: What are the most significant barriers to beginning or enhancing implementation of IWRM initiatives in your economy?[277]



Economies were also asked (in an open-ended question) to describe current challenges in balancing the water-energy-food nexus, or the linkages between supply and demand of these three resources, and the fact that actions affecting one resource inevitably affect the others.

Most responding economies indicated that there were at least some issues with properly allocating water between uses due to scarcity. Scarcity resulted primarily from floods and droughts, with many economies indicating that climate change had exacerbated this issue. Uneven temporal and spatial distribution were also common issues, as well as competition between agriculture and other uses. Only one respondent indicated issues related to the energy needed to supply water resources (Hong Kong, China), and only one economy indicated that it experiences relatively little water stress (Canada).

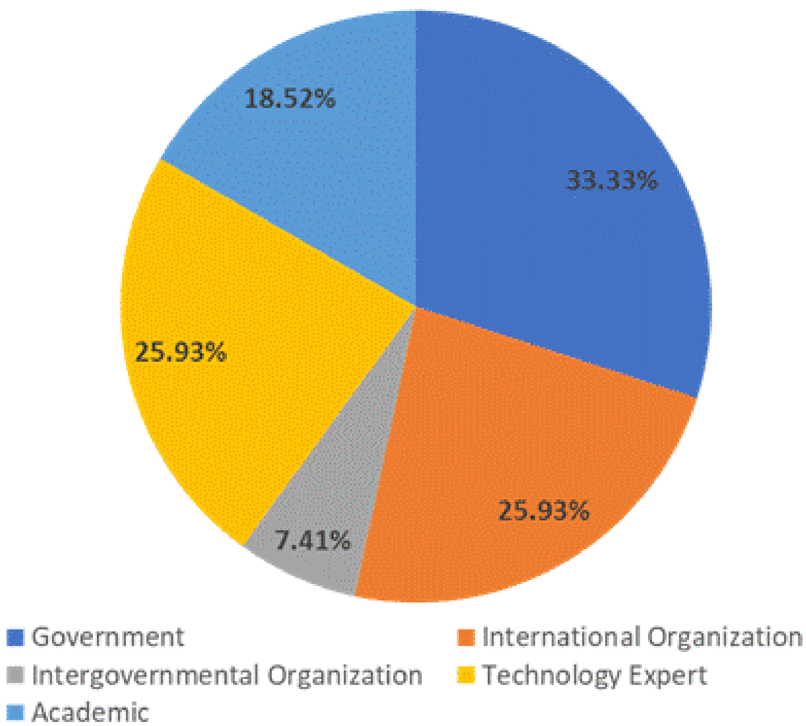
Additional literature and interview research conducted for the study produced the following findings regarding water governance challenges, from a wide range of sources and experts in numerous fields and economies. The following table and figure describe the backgrounds of the interviewees.

[277] Washington CORE 2017

Table 5: Interviewees by home economy[278]

Economy	Number of interviewees
Australia	3
Canada	1
Malaysia	1
Peru	1
Philippines	4
Singapore	1
Thailand	3
United States	9
Viet Nam	3
Non-APEC economies	5

Figure 28: Interviewees by profession[279]



[278] Washington CORE 2017. Note: Non-APEC economy interviewees were experts from international organizations such as the OECD
[279] Washington CORE 2017

A. Lack of institutional capacity

Technical and administrative constraints in central and local governments make effective planning and management of water and food security issues difficult, necessitating coordinating and harmonization of different agencies' programs, policy and responsibilities.[280] Without the appropriate level of staffing, technology and expertise, fulfilling basic water resource management responsibilities is difficult; IWRM requires an even greater investment of these factors. This could mean agencies lack the financial resources to make essential investments in infrastructure, staff and managers lack the training to make and implement the best decisions or outdated technology makes implementing modern water resource management impossible.

In the case of Peru, ANA has found it challenging to enforce Peru's ambitious 2009 Water Law and implement IWRM principles on its $50 million annual budget, though fortunately this budget is increasing. An ANA pilot project to bolster infrastructure for flood protection in the capital city Lima achieved mixed results: the targeted area was well protected, but due to limited coordination with local agencies other parts of the city sustained heavy damage. The ANA also has limited capacity to implement targets for payments from sectors for water or determine allocation by sector, but it has been making significant improvements in the last few years. As a result, river basin councils must step in, although they are only intended for consultation and have very limited resources and power. The new water governance modernization project starting in 2018 with World Bank support is making efforts to improve the financing of the River Basin Water Plans.

The above challenges indicate that the institutional arrangement as mandated by Peru's 2009 Water Law is not yet functioning as intended.[281] Overall, it seems Peru has some major pieces of the appropriate institutional architecture and fundamentals for IWRM in place, but ANA would benefit from more independence and resources such as the aforementioned World Bank project; and scaling up pilots to extend implementation down to the local level remains a challenge.

Staffing can also be a point of weakness for Peruvian institutions involved in water resource management, as implementing policies, monitoring progress and upgrading infrastructure require professional engineers, technicians, social scientists, hydrologists, geographers and managers. Dr. Eduardo Zegarra, a principal researcher at the Group of Analysis for Development (GRADE), considers that the ANA would benefit from adding more engineers skilled in water resource planning. Establishing a strong water authority requires strong training initiatives in topics such as pollution, engineering and climate change.[282]

Indonesia, China, Malaysia, and the US face similar challenges. Limited capacity for resource assessment and demand management in Indonesia lead to a lack of enforcement of water resource management guidelines, and low funding limits investment in technology and bolstering infrastructure, which can prove critical in disaster situations.[283] Indonesia is also challenged by limited staff capabilities in the water resource sector, especially in the field.[284]

China's basin authorities lack an institutional structure to enforce water pricing, making it difficult to change the behavior of farmers using century-old techniques.[285] The Malaysian government

[280] Asian Development Bank (ADB) 2015, p. 3
[281] Interview memo Eduardo Zegarra
[282] Interview memo Eduardo Zegarra
[283] Asian Development Bank (ADB) 2016, p. 63
[284] Asian Development Bank (ADB) 2016, p. 62
[285] Interview memo Cecilia Tortajada

face funding and manpower challenges that limit their ability to achieve comprehensive planning for water resource management.[286]

It is clear that many economies are experimenting with codifying principles of IWRM in legislation and rearranging institutional structures to support these provisions, although implementation at the local level, and scaling up pilots are difficult due to a lack of staff and administrative, scientific and technological capacity.

B. Overlapping responsibilities

When responsibilities for water resource management are not clearly assigned to government authorities, the prospects of developing an effective institutional arrangement for IWRM are severely diminished. In some cases, agencies may enter into disputes over jurisdiction and authority over certain activities, leading to delays in implementation, confusion and wasted resources.

The Indonesian government has chosen to issue separate regulations on the aspects of water resource management and distribute responsibilities across many agencies, due to the complexities of water resource management related to different technologies, communities, levels of governments and stakeholders. However, this has led to overlaps and gaps in responsibilities and functions, as well as intense competition among ministries/agencies and a politicization of budgets (preference for highly visible projects rather than maintenance).[287] Since the budgets for water resource management come from many different sources, it is difficult for them to take sustainable lifecycle approaches to investment in O&M for critical infrastructure.[288] The intermingling of regulatory and service provision functions is also a common issue.[289]

Complicating the matter even further, in 2015, the Water Law UU 7/2004 that stimulated a coordinate drive towards IWRM was invalidated in constitutional court as the law allowed private companies to sell packaged tap water, violating the principle of water as a basic right.[290] This necessitated the drafting of new water resource legislation. The Constitutional Court decided that the private sector must apply for licenses to sell specific amounts of water, to be determined by the government and local residents.[291] This legislation must address the need to better coordinate activities and define responsibilities across ministries.[292]

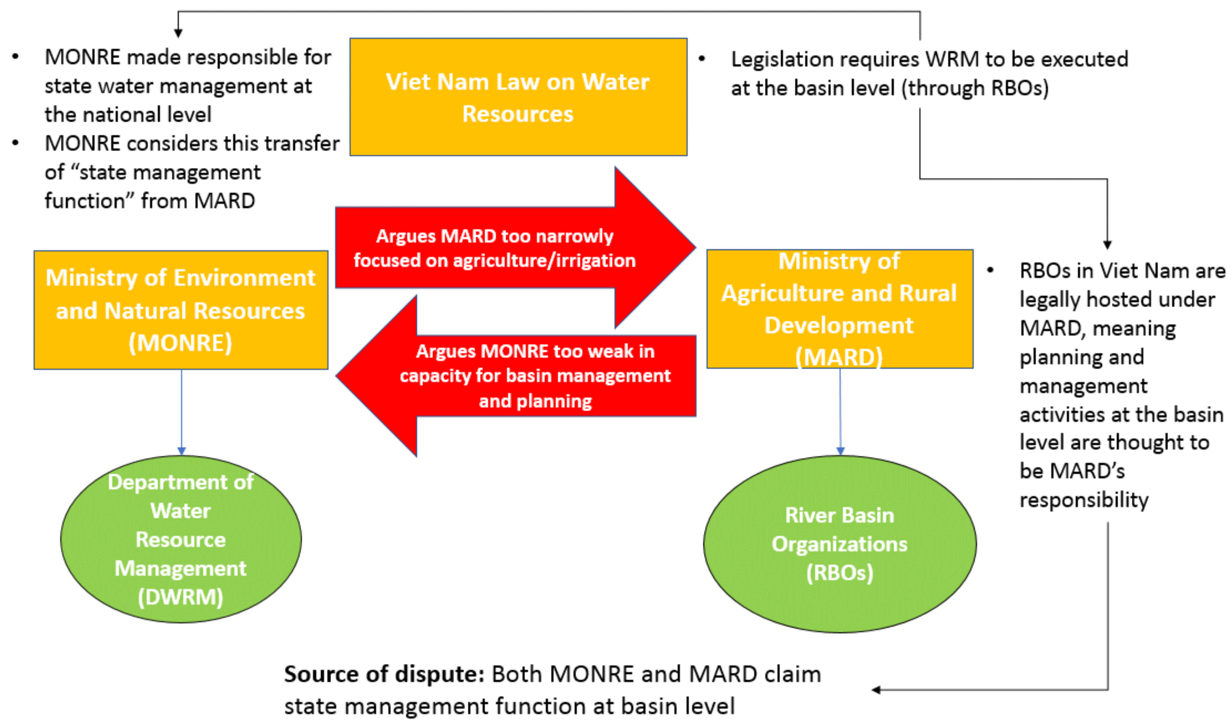
This was also an issue in Viet Nam, as the Ministry of Natural Resources and Environment (MONRE) was given the mandate for state water resource management from the Ministry of Agriculture and Rural Development (MARD) upon the creation of MONRE in 2002 and again in the 2013 Law on Water Resources. An uncertainty over roles between MONRE and the previous overseer of water related issues MARD has led to confusion and a lack of cooperation since the 2013 law. MARD possessed a more appropriate level of capacity and experience to manage water resources, although it was considered too narrowly sectorally focused on irrigation and flood issues. MONRE, on the other hand, was focused on a wide range of water resource management concerns, but was considered to have limited capacity.[293] It is important to note that

[286] Interview memo Sasha Koo-Oshima
[287] Asian Development Bank (ADB) 2016, p. 58
[288] Asian Development Bank (ADB) 2016, p. 63
[289] Asian Development Bank (ADB) 2016, p. 63
[290] Johnson 2015
[291] Johnson 2015
[292] Asian Development Bank (ADB) 2016, p. 59
[293] Molle, Hoanh 2009, p. 5

this particular dispute has since been resolved, and MONRE and the Department of Water Resources Management (DWRM) now hold a clear mandate for state management of water resources at the basin level.

The figure below is a graphic representation of this dispute. This case shows how small details in legislation can lead to uncertainty regarding the roles of highly significant ministry-level authorities.

Figure 29: MARD and MONRE Institutional Dispute[294]



C. Lack of institutional coordination

Institutional coordination is a challenge to enhance water resource management at all levels of government in APEC economies and between economies. The level of discussion and coordination between levels of government within economies and between economies is often a challenge faced when attempting to form implementable plans to address a worsening situation of water resources.[295] Without effective coordination among institutions that manage certain sectors, an integrated approach to water resource management is impossible. These issues can stem from the absence of legislation that mandates coordination across institutions and clearly defines roles and responsibilities, as well as a lack of frameworks to develop essential components of an IWRM strategy, such as guidelines for planning, stakeholder engagement and enforcement of water policies.

When decisions regarding water resources are made without consulting and coordinating with the appropriate bodies, there can be dramatic unforeseen consequences. For example, village residents in the Tien Giang province in Viet Nam sought to address drinking water pollution by digging individual wells, following the example of UNICEF initiatives. However, the residents did

[294] Diagram is based on analysis of water resource institutions in Molle, Hoanh 2009
[295] Interview memo Puspa Khanal

not engage in any type of resource planning prior, which led to wells with undrinkable water and aquifer deterioration when the wells were not sealed properly.[296] This case shows the importance of having an institutional arrangement through which local necessities and interests can be considered and addressed, with appropriate attention paid to the ecological, economic and social consequences of decisions.

The issue with a lack of coordination can also stem from planning arrangements that are overly centralized. In Viet Nam, many water resource plans have come from the National Institute of Water Resources Planning in Hanoi, and they tend to be top-down in nature. These plans have created issues with flood control for downstream coastal areas, meaning the plans lack a consideration of the entire Delta. Competition between provinces on their agriculture plans also creates issues for water resource management in the region.[297] Furthermore, provinces are wary of cooperating with the central level, despite the fact that they lack the capacity to properly allocate and manage water resources.[298]

A common issue with IWRM and water resource management in general is that institutions adopt certain principles but are unable to create or implement IWRM plans. Dr. Zegarra considers this to be the case in Peru, where the actual planning of water resources is delayed due to the lack of an institutional framework or guidelines to create effective allocation plans, meaning the decentralization of management activities has been weak and limited.[299] The consequence of this is that there is no instrument or framework to dictate who has access to what quantity of water, leading to the depletion of groundwater resources in some aquifers in the south of Peru. Furthermore, since large cities lack access to natural water, they must import from the basin of Lima. The ANA does not manage these transfers, and there is no authority or planning over this activity, according to Dr. Zegarra.[300]

In China, despite the high level of central control over water resource management, coordination between the central administration, provincial administrations, environmental authorities and sectoral departments is lacking. There is a need for greater departmental communication and legislative clarity, as there is currently no mechanism to effectively coordinate the administration of the involved responsibilities. Environmental authorities are also weak in terms of their authority and the size of fines they can impose; only provincial governments are authorized by the central administration to force companies to make changes in a certain time-frame. Since these fines are so small, provincial governments who are inactive in enforcing environmental laws effectively make it cheaper for companies to continue polluting and pay the fees rather than comply with the law.[301]

The jurisdiction over water resources has been disputed between the basin authorities and provinces in China. It has been a long process to foster cooperation between these entities, although in most cases the provinces have maintained control over the basins despite the official institutional arrangement. Furthermore, it is difficult to ensure local governments will implement and enforce water resource management plans from the central authority, which necessitates the use of incentives.[302]

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[296] GWP(a) 2013
[297] Interview memo Fiona Miller
[298] Interview memo Le Duc Trung
[299] Interview memo Eduardo Zegarra
[300] Interview memo Eduardo Zegarra
[301] Xiangcong 2007
[302] Interview memo Cecilia Tortajada

In Malaysia, standardization of methods and approaches to water resource management is difficult due to a high-level of State government autonomy in water resource management. Dato' Ir. Hj. Nor Hisham bin Mohd Ghazali, the director of Hydrology and Water Resources at the Malaysia Department of Irrigation and Drainage considers the biggest challenge to implementing IWRM is educating administrators at the district and state level on the importance of engaging stakeholders avoiding unilateral action regarding water resources. It is essential that administrators must understand competing water demands before making long-term commitments to certain sectors. Local administrators often lack appreciation of the long-term impacts compromising the integrity of water catchments and river basins.[303]

In Japan, there are a number of hindrances to the implementation of true river-basin management (RBM). It is difficult to communicate between the many bureaus in local governments and local offices from different ministries. Some local governments cannot afford to implement large-scale water projects like others. In general, there is a lack of sufficient research into RBM in universities and research institutes.[304]

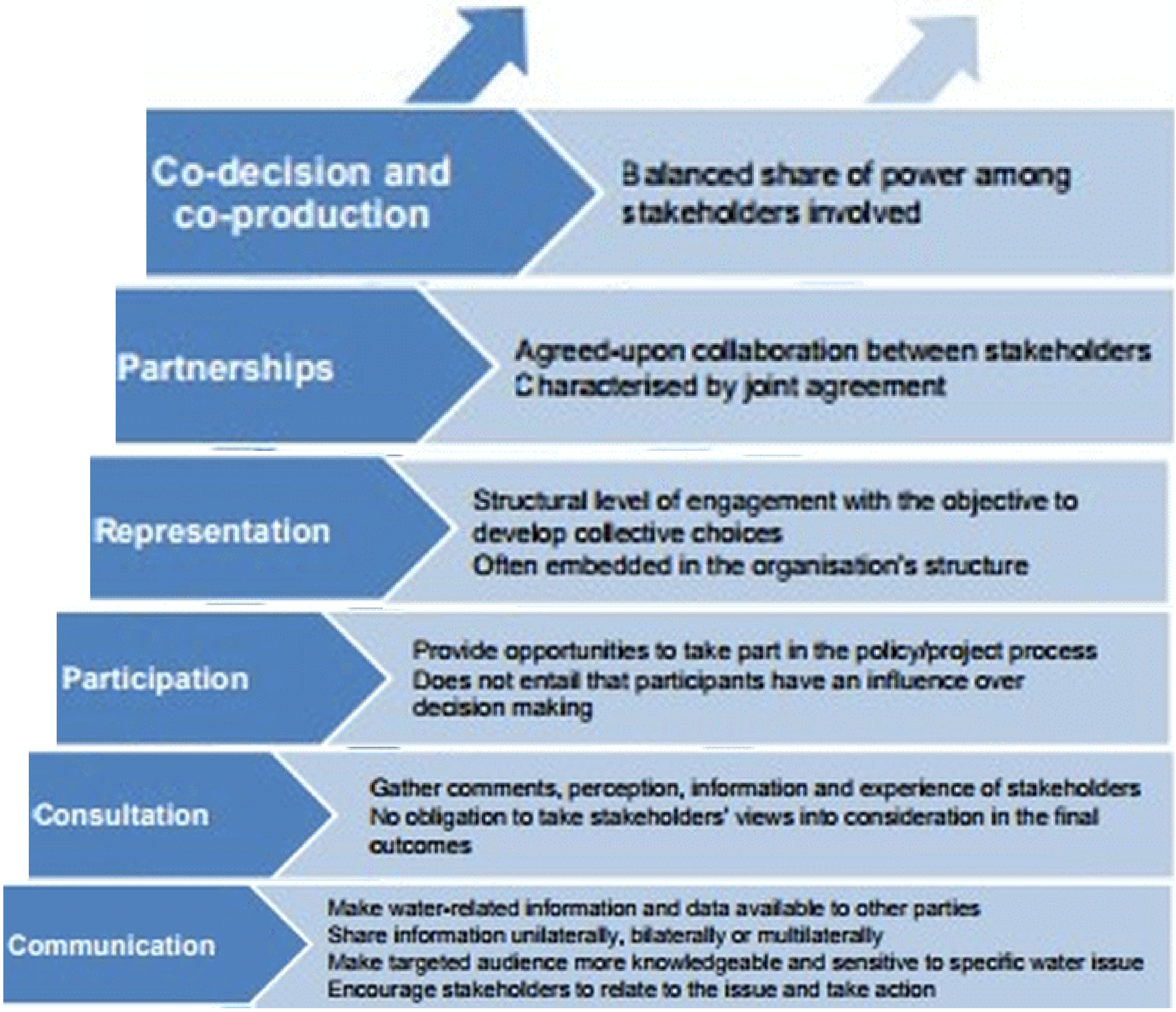
D. Lack of stakeholder engagement

Stakeholder engagement in water is especially important due to the highly decentralized and fragmented nature of consumption, and any integration initiative necessarily must consider and include the perspectives of various sectors in the water resource management process. Educating and sharing information with stakeholders is also important to enable a participatory and equitable approach to water resource management. Many IWRM projects have failed to achieve results as community participation was only pursued nominally and confined to donor-driven project timelines.[305] Absent a well-defined mechanism to engage stakeholders, water resource management decisions can lead to unintended consequences for the environment, food production and other economic activities. Engaging with local governments is especially important, as it is difficult to get them to change their practices when they have been doing things the same way for decades.[306] Furthermore, vulnerable groups and those living in remote areas often experience discrimination and are excluded from consultation in water resource related decisions.

The following image shows the OECD defined “Levels of Stakeholder Engagement,” which show that stakeholder engagement isn’t a simply concept or process, and ideally involves sophisticated mechanisms to reach a level of functionality that makes “good” water governance possible.

[303] Interview memo Dato' Ir. Hj. Nor Hisham bin Mohd Ghazali
[304] Lee 2015
[305] SOPAC et. al, p. 3
[306] Interview with Joop Stoutjesdijk

Figure 30: Level of stakeholder engagement[307]



Responsiveness and willingness on the part of agencies to communicate with stakeholders (especially agricultural producers) is key to improving water governance. These agencies tend to be staffed by engineers, while they lack the staff necessary to engage stakeholders and account for how their decisions might affect them (such as social scientists and economists).[308] This reflects how water resource management and especially IWRM are not purely or even primarily technical exercises, but involve numerous layers of stakeholders, conflicting priorities and competition surrounding water resources. A key tenant of IWRM is properly addressing the interdependencies of competing uses of water, and to properly achieve this, it is necessary to account for and integrate a diverse range of stakeholders' voices into a comprehensive and inclusive planning process.

For example, in Indonesia, community and private sector participation is limited due to a lack of knowledge and understanding of communities and business of water resource management and

[307] OECD 2015c, p. 36
[308] Interview memo Joop Stoutjesdijk

a lack of outreach by water resource management institutions. This has led to a neglect of O&M for water resource management facilities and water resource infrastructure.[309] Conflicts of interest among stakeholders are also common between sectors, administrative authorities and geographical areas (upstream vs. downstream); furthermore, some stakeholders perceive that their inputs are not sufficiently valued or included in the process to formulate a framework for water resource management. The issue with stakeholder participation is evidenced by the repeated and lengthy discussions on legislation, and lag time between drafting and passing a bill.[310] There is also an issue with water allocation plans, which RBOs are responsible to prepare; there are no approved guidelines for the preparation of these plans or for stakeholder engagement in water allocation decision, meaning that the relevant ministries are unwilling to approve them. This reflects staffing issues at RBOs, leading to negative consequences for water use efficiency and conflicts between water users and among regions.[311]

This is also an issue in Viet Nam and the Mekong system at large. Due to the top-down nature of many water resource plans, there is limited participation by the water users themselves. These plans are built from a very limited knowledge base of technical and engineering expertise, while natural/social sciences and local knowledge tend to be neglected in water resource planning. Water resource management in Viet Nam has typically been treated as a technical exercise of deciding how much water goes where, while it needs to recognize the values and priorities of different water users and incorporate those diverse values and knowledges into the planning process.[312] Mr. Joop Stourjesdijk, a senior irrigation researcher of the World Bank, echoes this sentiment, by calling for the integration of lower level farmers organizations into water resource management, as the current approach is overly focused on the delivery of water, rather than management of end uses.[313]

There is also an issue in Peru with the prioritization of agricultural concerns for water in the new Water Law of 2009. Dr. Zegarra observes that urban residents are not sufficiently included as stakeholders in water resource management decisions. The River Basin Councils (Consejos de Recursos Hídricos de Cuenca) are responsible for engaging stakeholders, including other sectors. In Peru, these conflicts over access to water resources are common. There is tension over the agricultural sector using water inefficiently, while other sectors' access is limited.[314] According to the Ombudsman Office of Peru, the formulation of Water Resource Plans with the help of the Water Resource Council has significantly helped reduce such water conflicts.

New Zealand has an interesting issue in terms of stakeholder engagement in water resource management with the resident indigenous group, the Maori. Following mistreatment by the British government, the Maori of New Zealand raised several water-related grievances that led to agreements in which the Maori received land and water. The government established a board to manage a river with government and Maori leaders, although the Maori view of water is far more spiritual than that of the government. In this case, the river was afforded the legal status of a 'person', with the government and Maori-appointed guardians to speak on its behalf. Jeff McNeil, a senior lecturer in Resource and Environmental Planning at Massy University, believes that this decision will have unintended consequences and lead to management issues.[315]

[309] Asian Development Bank (ADB) 2016, p. 61
[310] Asian Development Bank (ADB) 2016, p. 63
[311] Asian Development Bank (ADB) 2016, p. 58
[312] Interview memo Fiona Miller
[313] Interview memo Joop Stoutjesdijk
[314] Interview memo Eduardo Zegarra
[315] Interview memo Jeff McNeil

The Network of Asian River Basin Organizations (NARBO), in a 2016 meeting in Thailand, with representatives from Japan, Thailand, Cambodia, Indonesia, Lao PDR, Malaysia, the Philippines and Viet Nam concluded that implementation of IWRM at the river-basin level is very limited due to the lack of knowledge by practitioners at the basin level on IWRM. They suggested capacity building at the local level as a way to improve implementation of IWRM. They also noted a trend of local government leaders interfering in water resource management, which could also be potentially mitigated by capacity building and education on IWRM for those with management authorities and responsibilities.[316]

E. Lack of information/monitoring capacity

Officials with authority over water resource management require access to accurate and up-to-date information on water resources in order to make the best possible decisions, especially if an approach to IWRM is chosen. Without this information, it is impossible to know exactly how water resource management decisions will affect agriculture, industry and municipalities and vice versa. Furthermore, the central bodies that formulate IWRM policy must monitor the implementation of this policy by local jurisdictions, especially given the large investments necessary to overhaul water resource management structures.

Decreasing rainfall in Australia has required agricultural producers to increasingly utilize groundwater for their crops, although the states lack the capacity to monitor the effects this has on groundwater resources and the environment.[317]

In California, agriculture is highly dependent on groundwater resources. Groundwater accounts for almost a third of agricultural and urban water use statewide, but it many parts of rural California, it is oversubscribed. As a result, more water is pumped out than is replenished, which can result in lowering of the water table, increasing pumping costs, deterioration of water quality, and land subsidence. In short, the lack of effective regulation of groundwater can threaten the long-term viability of agricultural production and raise the cost of drinking water treatment.[318] In 2014, California passed the Sustainable Groundwater Management Act (SGMA) to provide the legal framework for the sustainable management of groundwater basins.[319] The figure below shows groundwater monitoring in Salinas, California by the USGS.

[316] Omoto n.d.
[317] Lehane 2014
[318] PPIC 2012
[319] Moran and Wendell 2015

Figure 31: Groundwater monitoring in California[320]

According to the water conservation manager of California's State Water Resources Control Board, the IWRM program for the state of California also does not engage in oversight or keep track of results of the implementation of their policy by local jurisdictions; local agencies simply promise to invest the resources they receive from the state appropriately.[321]

F. Trade-offs, sectoral conflicts and differing priorities

MDBA Director of Groundwater Peter Hyde considers that in Australia's Murray-Darling Basin, "The motto of the basin management is that everyone is equally angry no matter what actions take place, so it's more important to simply do it anyway,"[322] which reflects the fact that water resource management decisions often have significant trade-offs among groups and economic sectors with conflicting interests, and effective water governance and management is needed to properly manage them.

A recurring issue with IWRM is that it is treated as a technical solution to a technical problem; in reality, however, the allocation of water resources is intensely political and the authority to make decisions is hotly contested.[323] As it is the foundation of all life on earth, water is an incredibly sensitive topic, and in some cases, water resource decisions can even lead to civil unrest and rioting.[324] There are many issues related to different priorities in water resource management among different levels of government, ministries, sectors of the economy and communities.[325] Therefore, policy instruments are necessary to facilitate effective governance to reconcile these different tensions. Balancing water and food related concerns is difficult enough, while energy, land use and urban development must also be considered given the tradeoffs present between all these sectors.[326]

For example, in China, despite the high level of authority held by the central administration, there are still issues with differing priorities between the central and provincial governments. Specifically, the provincial authorities are focused on urban development and hydropower, while the central authority is attempting to mandate better stewardship of water resources and agricultural

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[320] United States Geological Survey 2013
[321] Interview memo Max Gomberg
[322] Interview memo Peter Hyde
[323] Interview memo Eduardo Zegarra
[324] Interview memo Yasmin Siddiqi
[325] Interview memo Xavier Leflaive
[326] Interview memo Xavier Leflaive

efficiency. The inverse can be observed in Brazil, where provincial authorities tend to focus on food security and agriculture, whereby the central authority is more concerned with energy security.[327]

The environment must also be considered a sector in water governance, and mechanisms are necessary to ensure the risks to the environment associated with the water use of other sectors are adequately considered. In Viet Nam, there is a need to prioritize the restoration of wetlands and floodplains. The water plans to date have had a large emphasis on water for intensive agriculture, which has come at the expense of wetland and floodplain degradation. In order to properly mitigate the effects of climate change, these vital features of Viet Nam's ecosystems must be restored and protected.[328]

Water pricing also leads to significant trade-offs; incentivizing responsible use could lead to political opposition or the elimination of small enterprises that use water, especially small agricultural producers. In China, water prices are determined by the central admnistration, rather than the market. The problem with state-control of water prices is that prices are often slow to adjust to supply and demand. Low water prices encourage waste and subsidize water-intensive households and corporations. In the case of China, such waste is costly. China's low water prices are pulling down the returns of water utilities and subsidizing water consumption. The average return-on-assets of Chinese water utilities over the past fifteen years have been too low to cover the cost of borrowing from banks, and even lower than the returns of electric power utilities.

To fix this issue China is introducing market reforms to water pricing, promising to raise water prices and improve the efficiency of water use. By international standards, Chinese water prices are the second lowest for urban residential users among 19 economies surveyed by Global Water Intelligence. Even Chinese businesses still pay less than the average urban households in most developed economies, and some upper middle-income economies. Low water prices are a problem for China because water resources are relatively scarce.[329] However, full on pricing of water based on supply and demand is politically difficult, due to many poor farmers who wouldn't be able to afford a market determined price of water.[330]

Poverty and food security issues at the household level make cheap or free water attractive to reduce economic stress and increase food production, but is counter-productive in increasing efficiency and environmental responsibility.[331]

3.4 Response to challenges

3.4.1 Institutional coordination solutions

Economies were asked about the most effective communication and coordination mechanisms for effective water governance in their economies. Among the economies that responded, the most effective measures identified by respondents included meetings, shared databases and joint programs.

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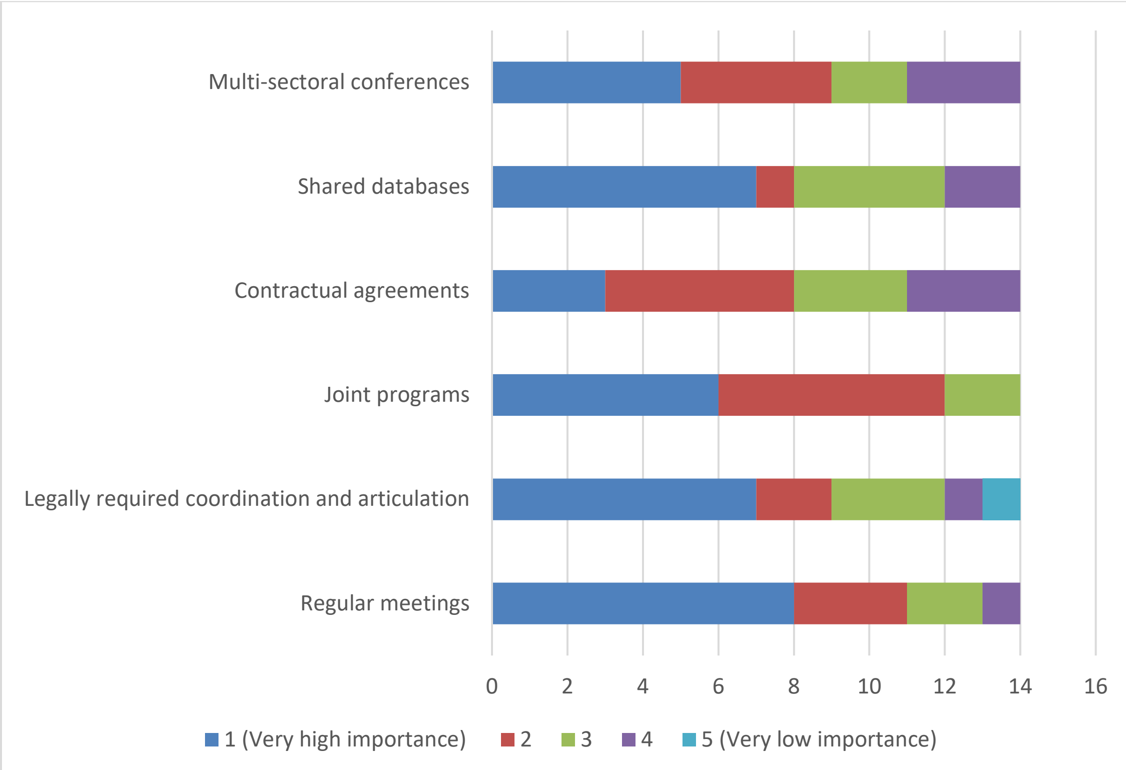
[327] Interview memo Xavier Leflaive
[328] Interview memo Fiona Miller
[329] Rutkowski 2014
[330] Interview memo Cecilia Tortajada
[331] Interview memo Xavier Leflaive

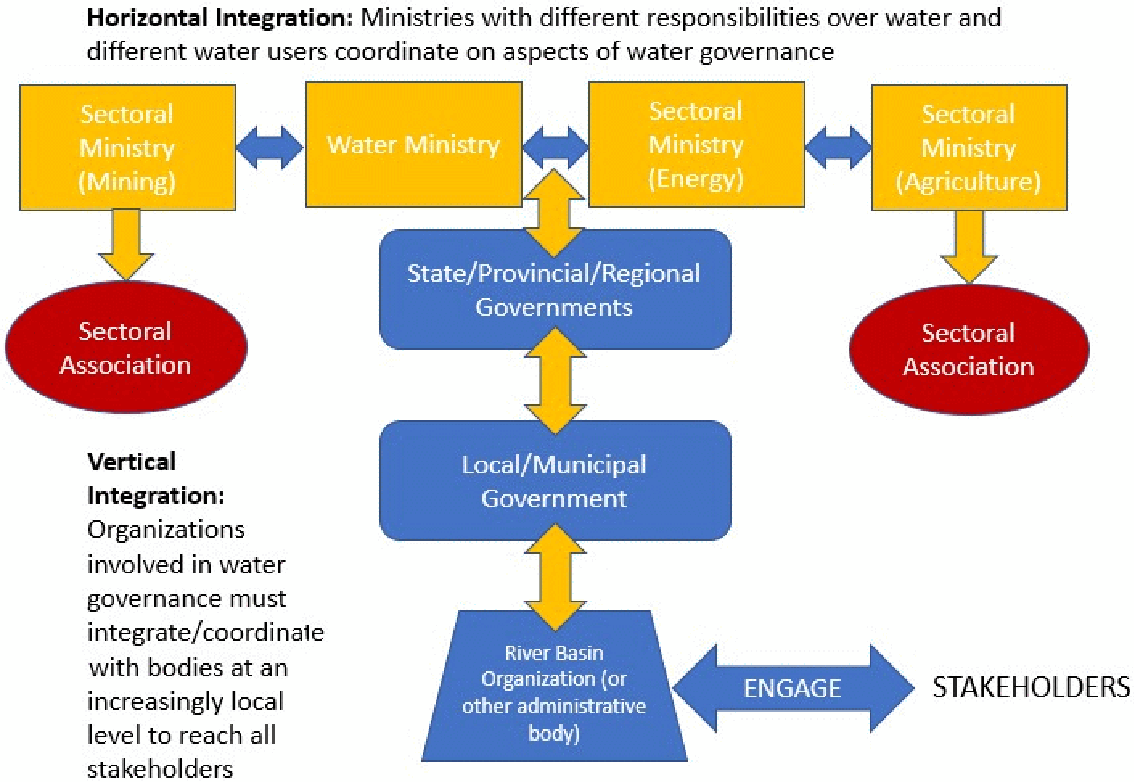
Figure 32: Which communications and coordination mechanisms are most helpful for your government's effective water governance?[332]



Following are the study findings on measures to improve institutional coordination in water resource management, based on literature and interview research. According to the World Bank, the key to improving water resource management and implementing IWRM is an effective institutional arrangement, and once this in place, technological improvements and infrastructure enhancements can follow much more easily.[333] Institutions require clearly defined responsibilities and mechanisms to coordinate with other institutions to properly carry out their mandate. Coordination is necessary both horizontally across sectoral ministries at the federal level, and vertically between central ministries and to sequentially more local bodies down to the community level. For example, central water ministries must coordinate with their economies' mining and forestry ministries to ensure sectoral policies align with water related development goals, while the mining and forestry industries must coordinate with their sectoral associations and local environmental agencies to ensure their industries are in compliance with water policies such as efficiency requirements and consumption/discharge reporting. The figure below provides a graphic representation of these modalities of coordination.

[332] Washington CORE 2017
[333] Interview memo Joop Stoutjesdijk

Figure 33: Horizontal and vertical integration in water governance[334]



In Viet Nam, unity and cooperation between major water users and regulators, such as MONRE, MARD, and MOIT, as well as further development of hydropower dams is necessary to continue the generally positive effects they have had on water management. The Vietnamese government is currently in the process of establishing a River Basin Committee (RBC) in the Sesan-Srepok Basin in the Mekong Delta to address issues of coordination among hydropower dams through integrated management of major water users and regulators, and to address transboundary management issues with Cambodia.[335] RBCs will be responsible for monitoring water use, coordinating among water users, identifying water related issues and exploring possible solutions.[336] This shows how coordination between economy governments down to the management unit itself (the river basin) is necessary to manage trade-offs between major water related developments, such as hydropower, with other concerns such as water quality and food security.

In Australia, an effective institutional arrangement for IWRM was established to respond to challenges of degraded water resource and disagreement over responsibility for remediation and authority over allocation. The Murray-Darling Basin Authority was created in response to institutional issues and difficulty reaching consensus between State governments and the Commonwealth (federal government) such as:

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[334] Washington CORE 2017. It is important to note that the arrows do not necessarily represent the flow of authority; they primarily represent engagement, communication and cooperation. The designation of “water”, “mining” or “energy” ministries is not meant to indicate which line ministries are most important in water governance.
[335] The World Bank 2013, p. 2
[336] The World Bank 2013, p. 4

- Resistance to further land clearing controls by State Governments
- Increasing conflict over who should pay for remediation of degraded common resources
- How to best mobilize and target the use of available resources for on-ground action and
- How to address poorly specified institutional arrangements for common property resource management.[337]

The MBDA has since effectively coordinated between the Commonwealth (federal) government, state governments and communities through its institutional arrangement and coordination mechanisms in response to these challenges in managing the Basin's water for competing agricultural and urban uses. Several intergovernmental committees help to bridge communications. The Ministerial Council, composed of water ministers from each Basin State, meets three to four times a year and the Basin Officials Committee, composed of other selected officials from each Basin State, meets every two months. A series of other committees meet more frequently to sort out more granular and local details, such as the Basin Communities Committee, which is a point of contact for MBDA composed of members with expertise or interest in community, water use, environmental water resource management, Indigenous or local government matters[338]. This institutional apparatus coordinates to form the master plan for the Basin's water resources, which is then reviewed and approved by the Commonwealth Water Minister.[339]

In Peru, institutional coordination occurs between the ANA and increasingly local water authorities down to the river-basin level. The World Bank has supported Peru extensively in the development of IWRM strategy and institutional capacity through projects and long-term programmatic engagement with the Peruvian water sector through technical assistance, advisory services and investments. The Water Resource Management Modernization Project (WRMMP) provided a $10 million loan in 2009 to support development of IWRM practices, with legal and institutional frameworks for IWRM successfully implemented in six pilot river basins. The World Bank also assisted with the implementation of the 2012 National Water Resources Policy by pursuing IWRM through the strengthening ANA at the central and river basin levels.[340]

ANA coordinates with other institutions through their board of directors, that includes: Ministry of Agriculture and Irrigation; the Ministry of Environment; Housing, Construction and Water supply and Sanitation Ministry; Energy and Mining Ministry; productive public sectors; health and sanitation public sectors; regional governments; rural municipalities; agrarian water users organizations; non-agrarian water users organizations; rural communities (comunidades campesinas); native communities (comunidades nativas); and the National Maritime Authority.[341]

The next stage of the World Bank project in Peru, funded with US$50 million from Peru and a US$40 million loan, will support improving participatory IWRM in ten priority river basins that are characterized by deficits in water and sanitation service, water pollution, and vulnerability to climate change and extreme weather events.[342] The new Basin World Bank project has two main focus areas, consolidating IWRM at the economy level and improving IWRM in selected pilot river

[337] Hooper n.d., p. 2
[338] MBDA (g) n.d.
[339] Interview memo Peter Hyde
[340] The World Bank 2017a, p. 11
[341] The World Bank 2009,
[342] The World Bank 2017a, p. 13

basins. IWRM plans will be updated and monitored and finance mechanisms will be defined to fund IWRM plans. In addition, four new River Basin Councils (CCs) will be established with their own respective water resource monitoring centers, participatory IWRM plans and "Water culture" programs.[343] The foci of these two World Bank initiatives in Peru show the importance assigned to establishing the proper institutional framework and relationships to ensure that policies and targets set at the economy level are properly implemented at the basin level.

The Delaware River Basin Commission (DRBC) in the US is a promising example of an institutional arrangement supporting IWRM through integration of the vertical and horizontal layers of government agencies and cross-sectoral integration and coordination. This marked the first time since the US's birth that the federal government and a group of states joined as equal partners in a river basin planning, development, and regulatory agency.[344]

The DRBC's mission is to manage water resources using the natural watershed boundary, rather than political boundaries. The members of the DRBC are the governors of the four basin states and an officer of the US Army Corps of Engineers who represents the President and all federal agencies. Each commissioner has one vote of equal power with a majority vote needed to decide most issues. It includes seven advisory committees, including water quality, toxics, regulated flows, monitoring and flood management, that engage the technical staff of the state and federal agencies as well as stakeholders from the regulated, environmental, and academic communities.

The DRBC is given the authority to manage water quality and quantity, including surface water and groundwater from the estuary to the headwaters. They are also involved with allocation of waters among the basin states to protect the uses of human and instream communities. Another requirement is to ensure that there is enough freshwater flow to prevent salinity intrusion from the Delaware Estuary, where it can affect industrial intakes and the water supplies of Philadelphia and a portion of New Jersey's population.[345]

It is also important to consider institutional adaptation as a path towards IWRM, rather than relying exclusively on the RBO model. Land Improvements Districts (LIDs) in Japan are a promising institutional arrangement to transfer the ownership and operation of water resource infrastructure to water users. LIDs are formed by a group of cultivators in a designated irrigated land area who agree to form an LID and apply to the Prefectural Government, along with a set of by-laws, activities and patterns of cost sharing agreed among themselves. These LIDs are responsible for water distribution, drainage facilities and environmental protection, while the Ministry of Construction controls overall water allocation. This sense of ownership over infrastructure and water for farmers, as well as shared responsibility, has led to effective participatory management of stakeholders in water resource management.

For example, in 1992, 78 percent of operation, maintenance and management of reservoirs, ponds, headworks, and irrigation/ drainage pumping stations in the Omonogawa River Basin were managed by stakeholders through LIDs. Experiences like these are especially important to consider in the context of difficulties faced in water sector reforms throughout Asia, namely those that have seen few results as an impact of instituting RBOs.[346]

[343] The World Bank 2017a, p. 11
[344] American Water Resource Association (AWRA) 2012, p. 26
[345] Ibid. 2012 page 27
[346] Bandaragoda 2006, p. 15

Coordination with research institutions such as the International Water Management Institute (IWMI) is also incredibly important to ensure a strong science to policy interface in water management. IWMI projects include continuous dialogue at the community-level with farmers, investors and community members to identify opportunities and constraints, check for policy impacts, assess feasibility of recommendations and connect with other related research initiatives. It is essential for institutions with authority and influence over water management and discourse on the topic to communicate and coordinate with institutions like the IWMI to include more perspectives in long-term assessment of water policies and decisions and identify positive and negative community-level impacts.[347]

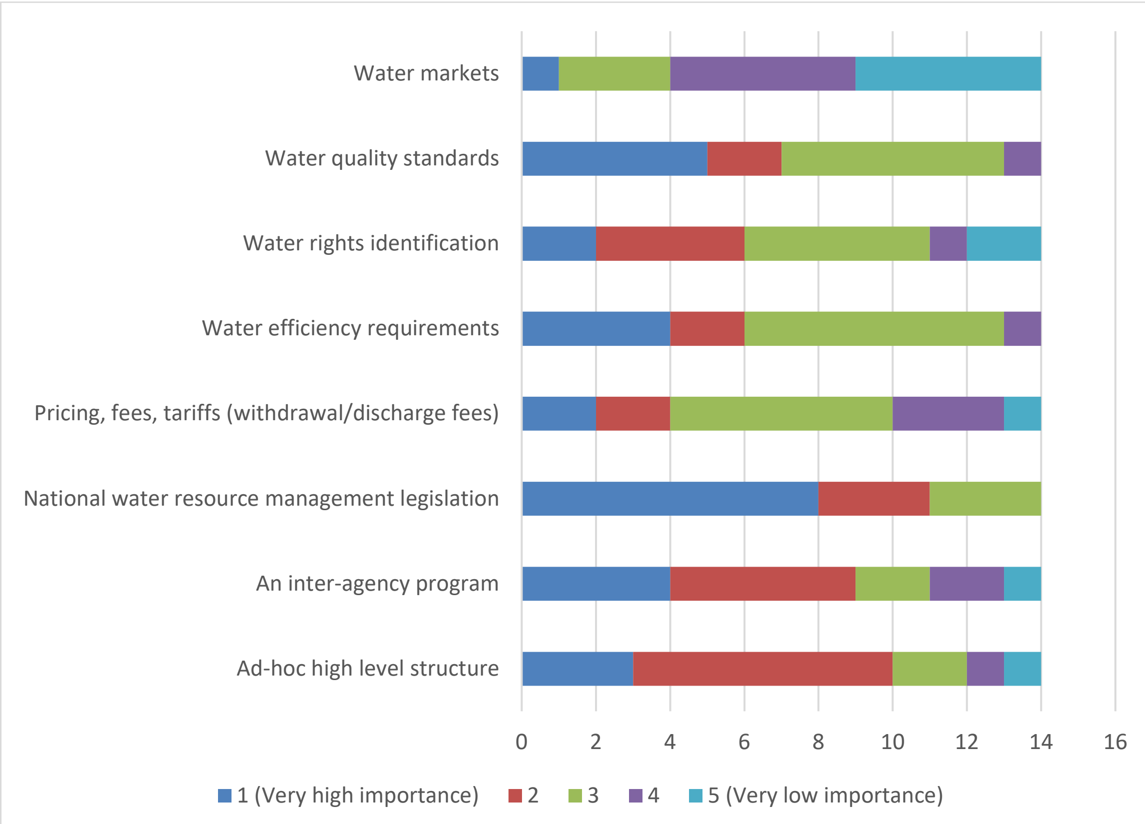
3.4.2 Legal/Financial solutions

Governments have several legal and financial tools at their disposal to influence how water resources are managed or how water governance functions. They can set national policies that mandate certain practices and set targets for water conservation, efficiency and quality, while also restricting individuals and the private sector from engaging in harmful or wasteful activities.

Economies were asked to identify the legal/regulatory measures employed to enforce water, food security and climate change adaptation policies. Among the APEC economies that responded, the most important legal measure identified by respondents was water resource management legislation, followed by inter-agency programs, water quality standards and ad-hoc structures. Markets were considered comparatively less effective.

[347] Interview memo Meredith Giordano

Figure 34: What types of legal or regulatory measures are used to promote and enforce your economy's approach to managing water and food security and climate change adaptation?[348]



In China, the Ministry of Water Resources of China's "Three Red Lines" policy sets targets for total water use, water use efficiency, and ambient water quality for a number of benchmark years to 2030, which include water quotas for each province.[349] Local governments will be responsible for defining the caps and targets, which will need the approval of the State Council. Water-scarce regions and areas that had been over-extracting groundwater have been enforced to set limits on exploitation of the resource.[350] These targets are subdivided to the provincial and county level.[351] The Chinese government has also set numerous targets regarding types of pollutants, waterway health and soil pollution. [352]

In Indonesia, pricing for water has been linked to infrastructural needs. Pricing for water is determined through two mechanisms: services fees for water resources management (SFWRM), and fees for processed drinking water by water utilities. SFWRMs are applied when there is a needed to improve infrastructure, such as damns and irrigation canals, allowing for cost recovery for O&M, although it is unclear whether SFWRMs incentivize agricultural users to use water more responsibly. Fees for drinking water are passed onto customers from public utilities when raw

[348] Washington CORE 2017
[349] Nickum 2013
[350] Jing 2016
[351] Jianqing 2016, p. 3
[352] Jianqing 2016, p. 3

water is processed, encouraging more responsible use of water resources in households to mitigate societal and environmental impacts.[353].

However, accountability measures need to be extended beyond the way in which annual budgets are allocated to include measures to ensure the quantity and quality of services provided is adequate. This will be essential to enable cost-recovery for implementing institutions.[354] Additionally, as services become more consistent, high-quality and responsive to community needs, presumably the willingness to pay for services will rise and water pricing as a tool to incentivize more responsible use will become more viable.

The MDBA's Basin Plan includes limits on the amount of water that can be withdrawn for consumptive use (industry, agriculture and other human uses) called sustainable diversion limits (SDLs). These have been determined for specific catchments and aquifers in the Basin. The SDLs will come into effect in 2019, with a seven-year period set between 2012 and 2019 for water users and managers to reduce extraction levels.[355] One method to achieve the SDLs is water recovery from the agricultural sector. The Department of Agriculture and Water Resources is responsible for water recovery through on and off farm (irrigation) infrastructure improvements and water purchases.[356]

Water markets in Australia are designed to allow water to flow where it will be used most productively. The system is based on a 'cap and trade' system, where the cap is a limit on the total pool of water for consumptive use, which is distributed based on water rights administered by Basin states. There are two types of water rights that are tradeable: rights to an ongoing share of total amount of water available in a system (water access entitlements); and rights to the actual amount of water available under water access entitlements in a given season.

Water is distributed against entitlements in response to factors such as changes in rainfall or shortages to provide certainty to users on the amount of water they will receive. Users determine whether to buy or sell their water at a particular time, with the price reflecting demand and supply factors. Prices also vary by region, type of water right and time of year.[357] The figure below shows the interstate trading zones of the Murray-Darling Basin; each numbered zone can only trade to certain other zones and in certain quantities to ensure sustainable management of the system.

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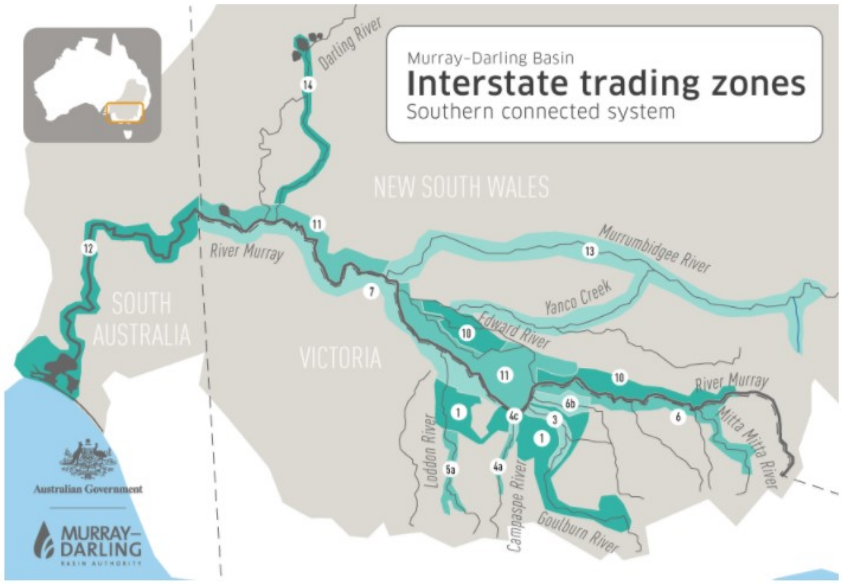
353 Asian Development Bank (ADB) 2016, p. 60
354 Asian Development Bank (ADB) 2016, p. 63
355 MBDA(c) n.d.
356 MBDA(d) n.d.
357 MBDA (h) n.d.

Figure 35: Interstate trading zones in the Murray-Darling Basin[358]



Water trading and pricing mechanisms were effective during the catastrophic Millennium Drought. The declining availability of water led to investments to use non-rainfall sources of water and use water more efficiently. While water for irrigated farms fell by 53 percent, the production of irrigated crops only fell by 29 percent.[359] The water pricing/trading mechanism is generally effective at ensuring fair allocation upstream and downstream in the system, although climate change impacts to the flow regime could complicate this greatly.[360] In addition to pricing and markets, most water users in Australia have to report their water use. The economy developed a system where there's a fixed fee for using water, and then an additional charge for extra water.[361]

In the US, California also has a similar system of water trading that is referred to as "water transfers," and they can be for agricultural, municipal or industrial uses, and environmental purposes. These transfers can be temporary, long-term or permanent. They serve to make water allocation across California more flexible and are primarily used to meet dry-year demands and critical needs during drought periods, rather than obtain a primary water supply for any type of development. This requires a "real water determination," whereby the individual or agency proposing the water transfer must determine the amount of water that will be newly available along the surface system as a result of the transfer. Most transfers occur from agricultural users in the Sacramento Valley to agricultural and urban users south of the Sacramento-San Joaquin Delta.[362]

Since water pricing is politically untenable in China as a main tool to enforce water resource management policy, penalties for overuse of water resources are preferred with some minor pricing.[363] China has also been successful in making industry comply with water resource decisions due to central planning.[364]

[358] MBDA(f) n.d.
[359] MBDA(e), p.22
[360] Interview memo Mac Kirby
[361] Interview memo Peter Hyde
[362] Department of Water Resources and the State Water Resources Control Board 2015, p. 1
[363] Interview memo Cecilia Tortajada
[364] Interview memo Cecilia Tortajada

Another important role of government in improving water management and conserving water is to employ legal and financial tools to accelerate the adoption of better practices and technologies. Given the prevalence of cheap or free water and difficulty implementing pricing, this is a massively important policy area to consider leading to more responsibly use of water to enhance food security and adapt to climate change.

A large part of the disconnect between the well-documented water issues of APEC economies discussed in Section 2.1 and the continuation of inefficient, outdated and harmful uses of water is the lack of signals to indicate when water is scarce or pollution is costly; the economic cost of using water inefficiently or polluting is often not properly felt by the responsible party.[365] This leads to the suggestion of pricing water as a means to incentivize users to become more efficient and environmentally responsible, although this method is not universally applicable, especially given political issues with pricing water and economies that have high levels of rural poverty. Without a proper policy framework to help make innovations and new practices seem more immediately necessary and competitive, technology and new practices will not be disseminated due to a lack of incentives to deviate from the status quo.

For example, the dominance of inefficient surface irrigation and rice mono-cropping in Asia is unlikely to change in the near future; although, the government can begin to encourage adoption of more efficient methods and crop diversification through subsidies to help farmers see the tradeoffs.[366]

In Gujarat State in Western India, heavily subsidized electricity for pumping to the agricultural sector led to aquifer depletion and a near-bankrupt electricity sector. The suggested IWRM response was simple; price water and electricity at cost. However, these measures were not politically implementable due to strong resistance by farmers that even led to the resignation of politicians and withdrawal of external funds to modernize the system. Instead of pricing at cost, rationally managed subsidies were used alongside pricing when possible, with irrigation electricity being provided for free, but only for 8 hours daily and on a pre-announced schedule designed to meet peak demands. The project led to a halving of the power subsidy to agriculture, reduced aquifer overdraft, led to non-farm enterprises and a more reliable electricity supply to rural villages.[367] This shows that IWRM discourse shouldn't become overly focused on pricing water at cost, and shouldn't rule out other methods to improve the efficiency of water use in the interim, before the true cost of water scarcity and pollution can be signaled to users.

In an example from the US, California has experimented in using incentives for local governments to implement principles of IWRM and address water related issues. Numerous integrated regional water management (IRWM) grants have been provided to help regional water management groups (RWMGs) in California develop and adopt IRWM plans for their respective regions. IRWM implementation grants have helped make more than 600+ IRWM projects identified in IRWM plans a reality across California. Key technical support to RWMGs is provided by the California Department of Water Resource's four Regional Offices, located in Glendale, Fresno, West Sacramento, and Red Bluff. While large inter-regional water management systems, such as the previously mentioned State Water Project, Central Valley Project, and flood management systems are important; the majority of California's water resource management investments are made at

[365] Interview memo Xavier Leflaive
[366] Interview memo Joop Stoutjesdijk
[367] Giordano, Shah 2014, p. 10

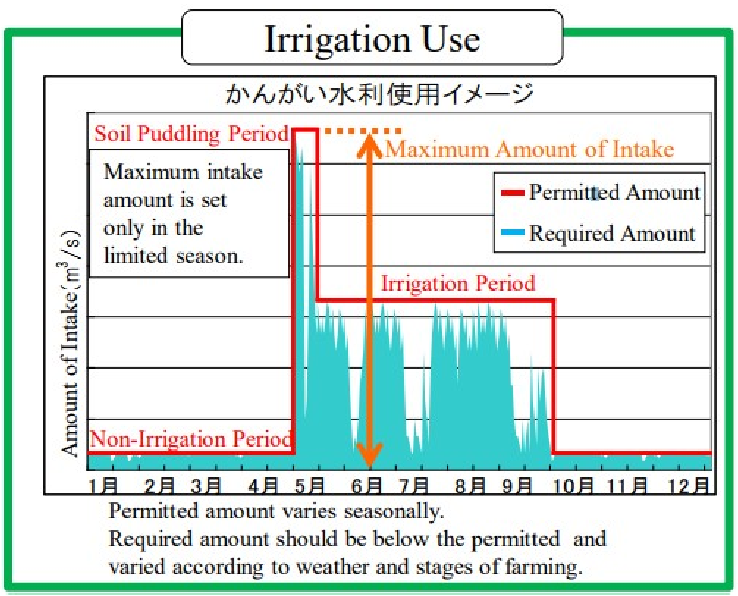
the local and regional level. IWRM has been critical in helping meet California's water resource management challenges, including the 2014 drought.[368]

The World Bank assisted ANA in Peru in defining a methodology for setting water use and pollution charges at the economy level, which constitute 77 percent of the ANA budget, and also created a water rights administration framework which seeks to formalize water rights and organize water users into recognized water user organizations, ensure water availability for small agricultural and sanitation projects, promote efficiency and sustainable use and to bring judicial security to water users in all sectors. In total, 28 percent of irrigated land area has been covered by formalized water rights. For other uses of water, rights have been formalized for about 5 percent of the population.[369]

A World Bank project in Hebei, Shanxi and Ningxia in China also created water users' associations to transfer responsibility over irrigation water to farmers, and a water rights certificate to clarify the amount of water and land rights allocated to each household.[370]

Japan has also engaged in water rights formalization for water users exploiting river waters. For irrigation, users must attain permission from a River Administrator, and water withdrawal is limited based on certain periods in the growing season with a max intake annually calculated based on maximum potential demand in a ten-year period.[371] This allocation scheme is shown in the figure below.

Figure 36: Irrigation intake limits in Japan[372]



Furthermore, given that water resource infrastructure is capital intensive and much of existing water resource infrastructure is highly outdated and deteriorating, it is imperative that governments and international organizations experiment with innovative financing tools to

368 California Department of Water Resources n.d.
369 Autoridad Nacional de Agua (ANA) n.d.
370 The World Bank (e) n.d.
371 Water Resource Division, Rural Infrastructure Department 2013
372 Water Resource Division, Rural Infrastructure Department 2013

address large backlogs of repairs and address new infrastructural needs. Government budgets, especially in developing economies, are usually insufficient to meet needs for water resource infrastructure.

Given the chronic lack of funds and inefficiency in water sectors worldwide, leveraging private sector financing should be explored. Public-private partnerships (P3s) can serve as a way to lessen the financial burden on governments to improve the water sector.[373]

The private sector can serve several roles. By putting down some of the capital for a project, it reduces the financial burden on the government to improve infrastructure. Furthermore, private companies can be used to implement unpopular, but necessary reforms (such as raising tariffs, reducing workforces). P3s also allow for risk-sharing between the public and private entity, while utilizing the expertise of the private entity. These agreements can range from full divesture (transfer of all public assets to private sector) to leasing and contracting (private sector merely operates water system).[374] Situations in which the involvement of the private sector is desirable include:

1. Deteriorating levels of service, lack of repairs, backlog in new connections
2. Severe budgetary pressure on the water undertaking and government reluctance to subsidize;
3. Good regulation is provided by government to ensure political and public confidence;
4. Tendering is open and transparent, and single bidder situations avoided;
5. Government ensures investment security through legislation;
6. Efficiency gains cannot be more cheaply and less controversially obtained by reforms to public undertakings;
7. The balance between up-front financial bonus gains and long term higher tariff costs is positive;
8. Specific targets are set for delivering services to the poor and socially excluded.[375]

Irrigation is a difficult activity to fund, especially on smallholder farms, as there are no immediate predictable financial returns. Irrigation projects are self-contained investments (only linked to viability of agricultural activities using the water), exposing infrastructure providers to market and commodity risks. Given this uncertainty, private-sector partners will only participate if they believe they will recover their investments, and less certainty means more public resources are required.

The private sector requires mechanisms to enforce financial obligations of project participants such as mechanisms for payments between smallholders, farm managers and irrigation providers; overall incentives for farmers to meet obligations under the scheme; and the design of land arrangements such as the terms of access to consolidated land, selection of farmers for high potential allocations, and procedures to incentivize farmers who do not pull their weight.[376]

There are a number of legal issues that arise through irrigation P3s.

1. **Land ownership:** Irrigation requires land for the infrastructure itself, and for the customers of the project (farmers). Government ownership of rural land and difficulties establishing

[373] The World Bank 2017c
[374] Global Water Partnership (GWP) n.d.
[375] Global Water Partnership (GWP) n.d.
[376] The World Bank 2017(d)

land title can cause issues.

2. **Water extraction:** Limits on water extraction, difficulty determining the responsible authority for issuing extraction permits, and complex/vague regimes for charges for water extraction complicate irrigation P3s as well.
3. **Public Sector Counterpart:** Uncertainty regarding the competent authority to authorize irrigation P3s can halt projects [377]

The World Bank has published a guide for governments, public authorities and other stakeholders to design and tender sustainable P3 irrigation projects. It claims that the development paradigm of the irrigation sector is seriously outdated; public funding is used for the capital investment, while public management is combined with supply of water resources to farmers at highly subsidized rates. Governments have begun to acknowledge that the available public resources for irrigation development are insufficient to address climate change, constraint on water resources and the need to enhance food security.[378]

Lower levels of investment in irrigation schemes is one specific challenge with a number of causes. High construction costs, poor production performance, falling real price of crops and concerns about environmental impacts of irrigations projects have all led to decreased investment, both at the economy level and by donors/international organization. Slim budgets and competing demands from urban development have also made it difficult to raise funds for irrigation. [379]

The lack of financing for operations and maintenance (O&M) of irrigation systems has also hampered investment. Irrigation systems have been aggressively expanded into the developing world without a means to mobilize funds to manage them post-construction. This leads to significant water waste, as only 65-70 percent of water is lost in the irrigations systems of developing economies due to deteriorating infrastructure. [380]

The inability to recover cost through water user fees jeopardizes both future development of irrigation projects and O&M. Without proper O&M, service deteriorates and water users are even less willing to pay user fees. Furthermore, subsidized water charges isolate the water/irrigation sector from actual market forces. [381]

Additionally, lack of consistency and continuity in irrigation policy have led to persistent problems in design, construction, operation and management of irrigations projects. Governments may lack the oversight capability or technical expertise to ensure irrigation projects are properly maintained and used, and as political regimes change in the long-term, projects are left in disrepair.[382]

To respond to these challenges, it is necessary to identify factors that contribute to the success of irrigation projects in the long run, how the private sector can deliver better services and incentives for the private sector, farmers and public agencies to play their respective roles optimally and establish sustainable irrigations systems. It is also critical to find ways to recover investment throughout the life cycle of an irrigation project and how agricultural offtake is linked to the project. Furthermore, projects must also consider the co-existence of large agricultural

[377] The World Bank 2017(d)
[378] Mandri-Perrott 2016, p. v
[379] Mandri-Perrott 2016, p. v
[380] Mandri-Perrott 2016, p. 114
[381] Mandri-Perrott 2016, p. 114
[382] Mandri-Perrott 2016, p. 115

businesses and subsistence farmers to balance economic development with provision of equal opportunity.[383]

The World Bank has identified several mechanisms to help private firms set and collect adequate water charges to recover costs. First, it is essential to understand farmers' willingness to pay, necessitating a detailed analysis. This can help determine the level of public support required to make private sector involvement feasible, and identify how much farmers would be willing to pay for improved irrigation services. Second, a system of pre-pay coupons can be used to reduce the collection risks around irrigation service charges from farmers. To make this possible, it is necessary to have adequate control over the flow of water to farmers to ensure they receive what they have paid for upfront. Contact farming arrangements can also be utilized to allow cost recovery, whereby agricultural producers agree to contribute a portion of their produce to the irrigations service provider. These work best for commercial crops where the off-taker has an incentive to ensure adequate water provided to farmers.[384]

A number of tools are also required to secure private investment in the first place. To date, irrigation P3s have had limited success in mobilizing private funds, as projects don't appear as bankable investment opportunities for private entities due to the high level of risk in primary agriculture. This also applies to major rehabilitations and greenfield projects. The World Bank has identified a few of these tools used in the developing world. Innovative financial instruments, such as patient capital (long-term subordinated capital invested at sub-commercial costs) could open up new sources of finance. International financial institutions (IFIs) could play a key role in exploring feasible financial instruments to mobilize investment. Other sources of revenue to sweeten the deal for private entities have been considered, such as the ability to charge fees to agribusiness for use of land at the project site, and leasing assets of the project (land, water) to aid cost recovery. Collateral put up by the parent company or a government guarantee can also help mobilize private investment.[385]

The need for public support will continue, and the World Bank considers that the best option may be for the government to retain governance functions, while using its resources to create incentives for the right private party to improve the economic benefit to farmers. Furthermore, third-parties such as water users' association (WUAs) can allow for risk sharing, as arrangements can have WUAs eventually taking over O&M responsibilities, incentivizing farmers to increase productivity.[386]

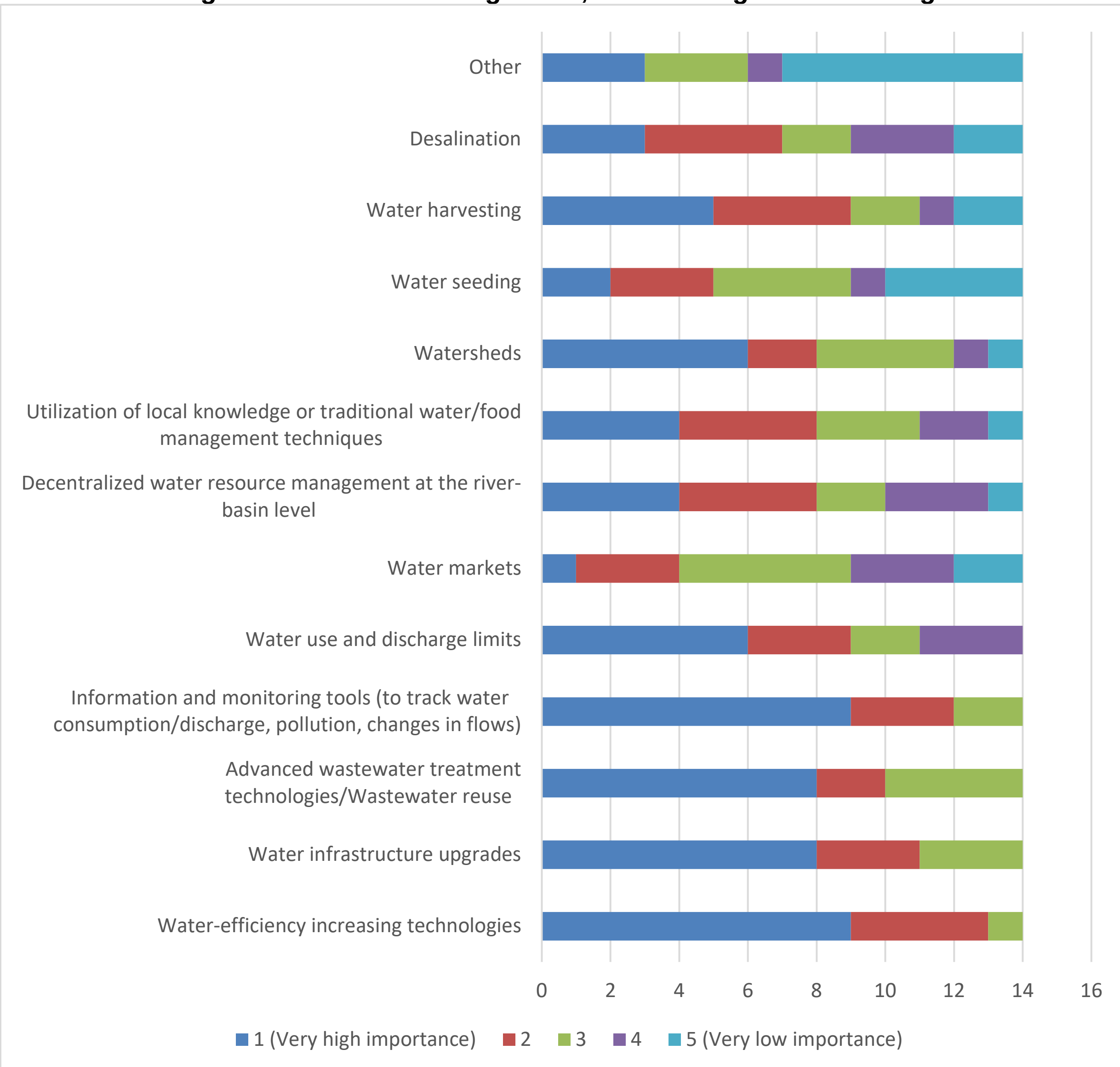
3.4.3 Technical solutions

Economies were asked which technologies and techniques can play a role in improving water resource governance and management in the context of climate change.

Among the APEC economies that responded, monitoring and decision support systems, water-efficiency technologies, water infrastructure upgrades and water use/discharge limits were cited as the most effective. Water markets were again considered comparatively less effective.

[383] Mandri-Perrott 2016, p. 116
[384] Mandri-Perrott 2016, p. 116
[385] Mandri-Perrott 2016, p. 117
[386] Mandri-Perrott 2016, p. 117

Figure 37: What technologies and techniques can play important roles in improving water resource governance and management, considering climate change?



Literature and interview research revealed several technical solutions that can be implemented to improve water resource management outcomes in APEC. Technical solutions are basic technologically, but highly necessary to address practical water related issues through changes in techniques and infrastructure repairs and improvements.

Two critical enabling factors of effective water resource management are knowing how much water is available in a system to determine how much water can be sustainably diverted or withdrawn; and being able to plan for future anticipated changes of climate change. A long-term study on water resources in the St. Johns River Water Management District in the USA was undertaken to inform important decisions on water resource management. In a response to the need for future alternative water resources, the St. Johns River Water Management District (SJRWMD) began a three-year study exploring the possibility of withdrawing water from the St. Johns River. The study found that it would be economically feasible to utilize the river as a water supply source. Also, in order to reduce conflict and improve coordination and better planning, the three regional water districts set additional restrictions on consumptive use permits within this Central Florida Coordination area, while agreeing to work together. The Water Supply Impact Study (WSIS), the most comprehensive models from 2007-2012 of the effects of water withdrawals on the ecosystem, helped to create a tool that could identify the tradeoffs between the benefits of water withdrawal and the benefits (or harm) to the ecosystem by utilizing hydrologic, water quality, and biologic data. This tool may have applications elsewhere.[387]

A project concluded in 2008 in the Murray-Darling Basin to quantify the maximum sustainable yield of the system. The project found that water resource development has caused major changes to the Murray-Darling Basin. It has changed the flooding regimes that support important floodplain wetland systems in the Basin; reduced the total water flow at the Murray Mouth by 61 per cent; and caused the river to cease flowing through the mouth of the Murray for 40 per cent of the time, compared to one per cent of the time at a time before water resource development.[388]

It became massively important in informing the planning, management and allocation of water resources in the Basin.[389] This type of science-policy dialogue is critical for securing ecosystem integrity in highly populated and economically active river basins.

The Authority has also been successful in increasing environmental flows through addressing irrigation losses and establishing water trading markets in several states.[390] In 2015-2016 alone, 33 gigalitres (a gigalitre is 1 billion liters) were recovered from irrigation efficiency improvements through the Sustainable Rural Water Use and Infrastructure Program (SRWUIP), while 6 gigalitres were covered through water purchases, expending AU$262 million on infrastructure and AU$40 million on water purchases. In total, 1,981 gigalitres have been recovered because of this program.[391]

Water recovery has been achieved through infrastructure improvements, both on and off-farm, which overtook water purchases in terms of government investment in 2011-2012.[392] These improvements have led to more efficient irrigation and farming practices; greater productivity; and opportunities for diversification. Off-farm infrastructure improvements include installation of automated systems; and reconfiguration and replacement of existing open channels with pipelines. On-farm improvements include automated irrigation layouts; upgrading and reconfiguring on-farm storages and irrigation delivery systems; and more efficient irrigation systems such as sprinkler and mist irrigation.[393]

Crop diversification initiatives can also incentivize farmers to plant more efficient crops and address ecological issues associated with monocropping. One program in Viet Nam restricted rice-growing to a portion of the Mekong delta area to encourage efficiency and high value cropping. Farmers adopted this program and became more efficient users of waters and found lucrative markets for their new products. The government is also starting to introduce piped, rather than canal, irrigation.[394] This shows how basic measures can contribute to more responsible use of water resources to address basic inefficiencies of the previous status quo.

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[387] American Water Resource Association (AWRA) 2012, p. 49
[388] CSIROPedia n.d.
[389] Interview memo Mac Kirby
[390] Bhat 2008, p. 210
[391] MBDA(e) n.d.
[392] MBDA(e) n.d.
[393] Interview memo Peter Hyde
[394] Interview memo Yasmin Siddiqi

Rainwater harvesting is an increasingly popular and necessary way for households to augment or substitute their water supplies due to scarcity, salinity, quality of service and for risk substitution. The storage of rainwater can allow households to deal with the effects of spatial and temporal variability of rainfall. This is especially important in regions where the majority of water falls in a small portion of the year, and in areas where there isn't a conventional, centralized government supply system for water. The ability to store rainwater also allows for the maintenance of emergency reserves in the case of natural disasters. It is an inexpensive, flexible and easily implementable technology.[395] Small on-farm ponds can also be utilized to capture rainwater for agricultural use.[396]

In an example from the US, California is making significant investments into water infrastructure, specifically in the areas of water storage, ecosystem restoration, water recycling, capturing runoff and IWRM. Investments have also been made in irrigation control, soil science and weather centers.[397] California and its partners also developed a cost-effective tool that could value energy and water from both perspectives. Whether through toilet replacement, irrigation, or any other means, the project wanted to find water and energy saving measures. The puzzle was to find when it is cost effective for the energy sector to fund a water efficiency program. The most important result from the project was that they identified a method to assign values to water savings from the energy perspective in a place like California where water delivery is very energy intensive.[398]

Measures related to environmental water conservation and water quality improvements include a Water Quality Program, improvement of the water conflict resolution mechanism, increased access to water resource data for end-users, a Dam Safety Program and strengthened economic incentives for increased water efficiency and reduced pollution.

Groundwater storage represents both a practical solution to the state's additional water storage needs and a tool to help manage groundwater more sustainably. Groundwater levels are continuing to decline across the state, not just from California's current drought, but from decades of chronic overuse. Augmenting water supply through recharge into aquifers presents a cost-effective way of increasing the availability of groundwater for the inevitable dry times ahead. California's Department of Water Resources estimates the total storage capacity 1000 km^3. In comparison, surface storage from all the major reservoirs in California is less than 60 km^3.[399]

The US EPA has published the 2017 Potable Reuse Compendium and the 2012 Guidelines for Water Reuse which serve as references on water reuse practices to provide planners and decision-makers with a summary of the current state of the practice. Specific knowledge and experience are drawn from case studies on existing reuse practices as part of an integrated water resources management approach developed at the state and local level to meet the water needs of multiple sectors including agriculture, industry, drinking water, and ecosystem protection. An integrated approach commonly involves a combination of water management strategies (e.g., water supply development, water storage, water use efficiency, and water reuse) and engages multiple stakeholders and needs, including the needs of the environment.

[395] Kobayashi-san technology memo
[396] Interview memo Meredith Giordano
[397] Interview memo Max Gomberg
[398] Interview memo Meredith Younghein
[399] Choy 2014

China has also been aggressively pursuing measures to improve water quality, beginning in 2014 when they launched its war on pollution which sought to reverse the damage to its skies, rivers, and soil. Within the first nine months of 2016, 70.3 percent of samples taken from 1,922 surface water sites around China could be used as drinking water, up 4 percentage points from a year ago. Later that year, China said it would spend 430 billion yuan ($62.4 billion) on around 4,800 separate projects aimed at improving the quality of its water supplies, though it did not give a timeframe.[400]

Malaysia also considers wastewater treatment a priority, with improved raw water treatment seen as key to ensure urban access to freshwater. The government plans to expand the network of connected sewage services to rural areas as well to increase the efficiency and productivity of water treatment facilities.[401] The importance assigned to wastewater treatment reflects how experts are exploring unconventional sources of water to address potential future shortages.

Smartphones also represent a potential asset to utilize to improve water management. They are cheap, and present even in remote villages. Pham Tuan Phan of the MRC suggests that local communities could receive water release information (from hydropower dam or for irrigation purpose), flood forecasting and warning information from a command center through mobile internet, social media or messaging applications. Community members could also utilize their phones to assist managers and policymakers, by providing information on localized climate, flood situation and river conditions using geotagging features embedded with photos taken from the phones.[402]

In climate change adaptation, China has taken significant steps to introduce flood control measures that also serve as storage to capture wet season precipitation. In 2015, China launched its ‘sponge city’ initiative to prevent flash-flooding in the wet season and enhance capture/storage for the dry season. China adopted the idea of sponge cities due to nearly half of its cities being considered water scarce or severely water scarce by UN measures and another half failing to reach China’s standards for flood prevention. While more than 230 cities were affected by flooding in 2013, 90 percent of older urban areas do not even have basic flood plans.[403] In April 2015, the Chinese Government announced the first 16 pilot sponge cities including Jinan, Wuhan, Chongqing, and Xiamen. Each district was allocated a budget of US$95.9 million for the next three years to develop ponds, filtration pools and wetlands, as well as to build permeable roads and public spaces that enable stormwater to soak into the ground. Ultimately, the plan is to manage 60 percent of rainwater falling in the cities.[404]

Large water transfer projects can also serve to transfer water from abundant areas to those experiencing significant scarcity. China’s $80 billion North-South Water Transfer Project (SNWDP) is a major strategic infrastructure aimed at alleviating severe water shortages in Northern China, optimizing the allocation of water resources, and improving the ecological environment.[405] The SNWDP is the largest and longest water diversion project in the world, and benefits the greatest number of people and regions. The SNWDP comprises three water diversion routes in the Eastern, Central, and Western China, diverting water from the lower, middle, and upper reaches of the Yangtze River, respectively. It also connects four major rivers—the Yangtze

[400] Stany, David, Sue-Lin Wong 2016
[401] Interview memo Dato' Ir. Hj. Nor Hisham bin Mohd Ghazali
[402] Interview memo Pham Tuan Phan
[403] Harris 2015
[404] Harris 2015
[405] Danning 2017

River, Huai River, Yellow River, and Hai River. Thus, the SNWDP establishes a pattern of water resources allocation in China that regulates three south-north water routes and connects four west-east rivers.[406] The figure below shows each route of this project.

Figure 38: China SNDWP water transfer routes[407]

3.4.4 Technological innovation

Innovative technology can play a pivotal role in water resource management, water conservation, mitigation of climate change and enhancements of food security.[408] However, it is important to keep in mind that many of the cutting-edge technologies related to water and agriculture today are still too expensive for widespread adoption by the public.[409] Part of this issue is that water is currently underpriced, making investment in water efficient technology a low priority for most water users.[410] Technology areas include innovative efficiency improvements for conventional technology (irrigation), precision agriculture (such as the Internet of Things and Geographic Information Systems) and wastewater treatment and reuse.[411]

Although not without challenges, promotion of innovative technology is necessary to address the world's highly outdated water systems, and set them up for long-term resilience and efficient management. In many cases economies set up modern water systems and then allow them to fall into disrepair. Large investments are necessary to prevent this situation in from occurring. A large part of this will be things like sensors and data analytics that can detect issues with infrastructure to allow for preventative maintenance.[412]

Technological innovations to conserve water, improve agricultural practices and enable more effective water resource management require an ecosystem of talented individuals, research institutions and capital to be conceived of and brought to market.

[406] Office of the South-to-North Water Diversion Project Construction Committee, State Council, PRC 2016
[407] Office of the South-to-North Water Diversion Project Construction Committee, State Council, PRC 2016
[408] Please see Section 3.4.3 for survey results regarding innovative technologies.
[409] Interview memo Max Gomberg
[410] Interview memo Peter Williams
[411] Interview memo Puspa Khanal
[412] Interview memo Peter Williams

Roger Royse of Royse Law Firm runs a law practice with a significant focus on Agricultural technology (or the Silicon Valley moniker 'AgTech') that has an Agricultural Technology Incubator and yearly conference. The objective of the firm is to build a community of technology groups to associate and share practices and work together to improve agriculture. It produces white papers on topics in which the government could provide assistance, and links large international organizations dedicated to food aid with innovators. The incubator has supported companies in developing numerous precision agricultural technologies such as automated and predictive irrigation systems, water selling/trading solutions and filtering/membrane technology to address polluted groundwater.

Royse considers technological innovation as the main path to improve water security for California, due to bureaucratic challenges with the state government.[413] AgTech solutions provider Aaron Magenheim agrees with this sentiment, and suggests that a primary role for government should be promoting the adoption of innovative technologies that achieve real water efficiency savings and productivity gains.[414] Daniel Ribeiro of Hidrosoph, a Portuguese precision agriculture company, also agrees and calls for more government awareness of innovative technology in this area, and for governments to invest in training farmers how to take advantage of available technology.[415]

Since 2007, a joint research project called Integrated Water Resource Management Viet Nam - funded by the German Federal Ministry of Education and Research (BMBF) - has been developing Planning and Decision Support tools for IWRM adapted to the Vietnamese context. The tool incorporates data on water quantity and quality to identify Water Management Units (WMUs) with high risk. The Team is collaborating with the Vietnamese Department of Water Resource Management.[416]

The goal of the project is to develop a concept for integrated consideration and analysis of water resources, water demands and land use. It has two specific objectives; the project will develop planning and decision support tools, as well as adapt water technology on the local level (drinking water, municipal and industrial wastewater).[417]

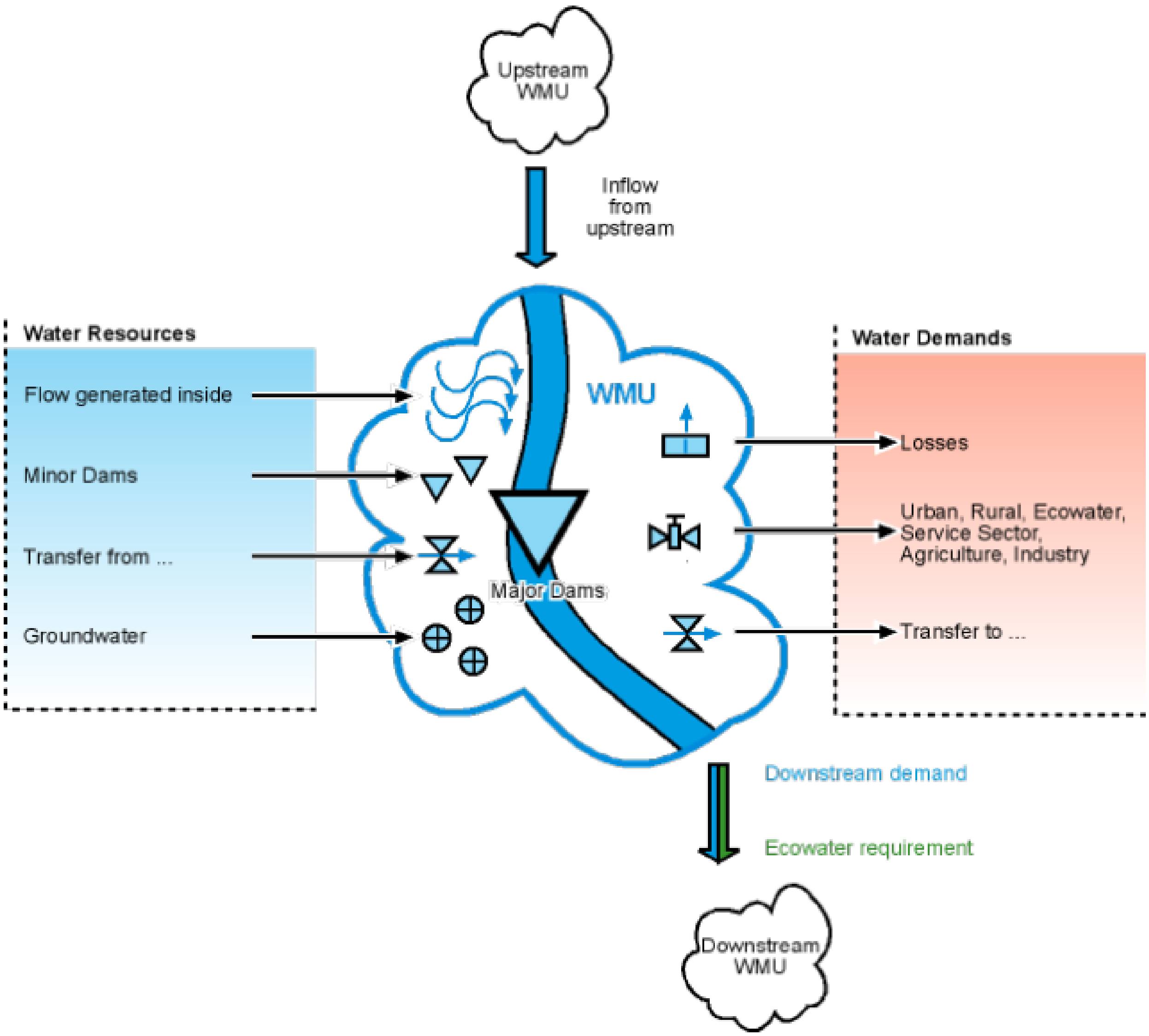
The project involved activities at five levels: At the international level activities on sharing international experiences and guidelines for IWRM; economy level activities by Vietnamese authorities to identify river basins with substantial problems; River-basin level activities to identify high-risk WMUs using a GIS-based evaluation of spatial and statistical information; WMU level investigations (field investigation of water balances, water quality, wastewater quantity) to identify locations for specific IWRM measures; and local level activities to plan and implement IWRM measures (monitoring, water supply, wastewater treatment) for priority areas.[418]

[413] Interview memo Roger Royse
[414] Interview memo Aaron Magenheim
[415] Interview memo Daniel Ribeiro
[416] Federal Ministry of Education and Research n.d.
[417] Federal Ministry of Education and Research n.d.
[418] Federal Ministry of Education and Research n.d.

- **Water Balance tool**

This tool is used to calculate and assess water demand and compares these with the quantity of water resources to identify surpluses and deficits.[419] Each WMU is connected in a cascade, with downstream WMUs receiving the surplus water of upstream WMUs.[420] The figure below is a diagram of how the Water Balance tool functions, showing the variables that are measured to determine the water balance.

Figure 39: Water Balance tool[421]



- **Contamination Risk tool**

This tool assesses the sensitivity of water resources (ground and surface) and the contamination potential to display water quality. It addresses three contamination paths: infiltration of contaminants into groundwater; erosive runoff or erosive discharge of contaminants into surface

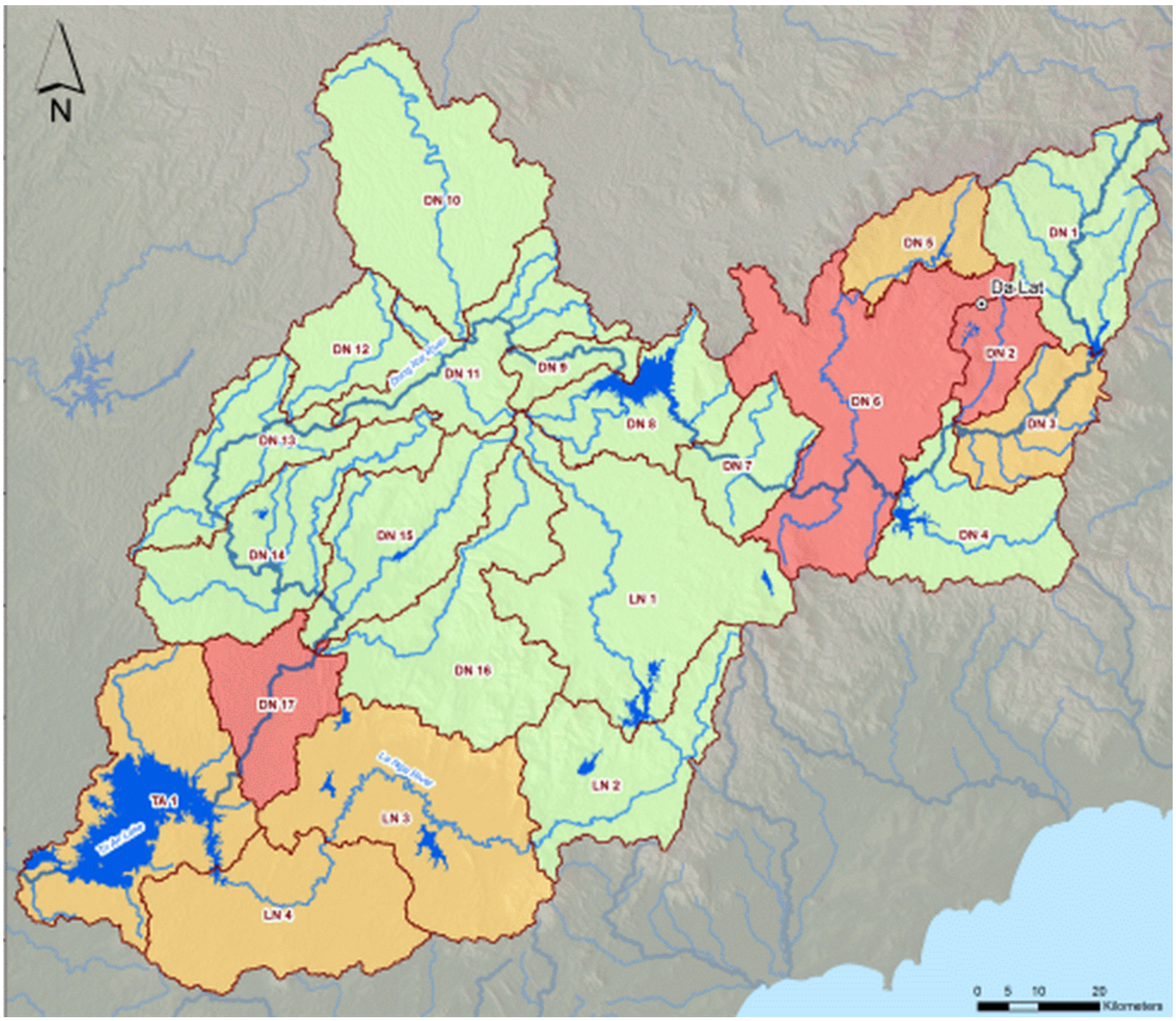
[419] Federal Ministry of Education and Research n.d.
[420] Ruhr-Universität Bochum n.d.
[421] Ruhr-Universität Bochum n.d.

water; and direct discharge of contaminates into surface water.[422] It is also a GIS-based tool and superimposes data on contamination potentials (agriculture, settlement and point sources) over the resource sensitivity (significance of specific water body and vulnerability to contamination).[423]

- **Ranking tool**

The Ranking tool identifies areas with high priority and need for action by prioritizing results from the other two tools. It incorporates an index for "surplus/deficit" for each month based on water resources and consumption. The figure below shows the visual output of the Ranking Tool for the contamination risk from settlements in the upper Dong Nai river basin near Ho Chi Minh City. The red color indicates areas of high risk.

Figure 40: Ranking tool assessment of contamination risk for Viet Nam monitoring project[424]



422 Federal Ministry of Education and Research n.d.
423 Ruhr-Universität Bochum n.d.
424 Ruhr-Universität Bochum n.d.

The World Bank is also supporting Viet Nam with a $25 million loan to enhance monitoring capacity on the Mekong system. The design process for hydro-met and water resources monitoring stations are underway to inform IWRM in the Mekong system.[425]

The World Bank has also provided significant assistance to Peru in establishing a monitoring and decision support network for IWRM. The project has made significant achievements in enhancing monitoring capacity through the establishment of water resource monitoring centers, as well as information and data tools to support decision making for the Peruvian water sector. This phase involves the acquisition and installation of equipment for: a digitized, real-time hydro-meteorological network; monitoring of water quality; monitoring of water use in irrigated agriculture; monitoring of groundwater for selected aquifers; and the modernization of monitoring equipment for dam safety.[426] Decision making tools and enhanced capacity for data storage and processing will also be implemented, and institutions to monitor groundwater will be established.[427]

Due to the needs of flood defense, drought relief, and disaster reduction in river basins, China established a comprehensive hydrological monitoring network which accumulates a large amount of hydrological data. By 2015, China established 93,617 different kinds of hydrological monitoring stations. These include 3,172 basic monitoring stations of main river control sections, 1,710 hydrological stations for intermediate and small rivers, 46,980 precipitation monitoring stations, 21 evaporation stations, and 1,927 soil moisture stations. There are 16,990 groundwater monitoring stations, 12,898 of those are monitored at a weekly basis and 4092 are monitored seasonally. There are more than 12,000 surface water quality monitoring sections, of which 596 focus on monitoring interprovincial boundary waters, 1,507 on water supply sources, and 5,064 for the 4,493 state-administrated water functional zones. Water quality is monitored by 4,640 waste water outlets to rivers and 4,115 representative groundwater monitoring wells.[428]

The World Bank also assisted in establishing an irrigation forecast system in Guantao County through the Water Conservation II project, which comprised of comprises six monitoring stations collecting data on the temperature, humidity, wind speed and direction, rainfall, soil moisture content and groundwater level. An information management center generates forecasts the water requirement using computer models. These are published on the internet and via LED signs outside the monitoring stations to guide irrigation scheduling.[429]

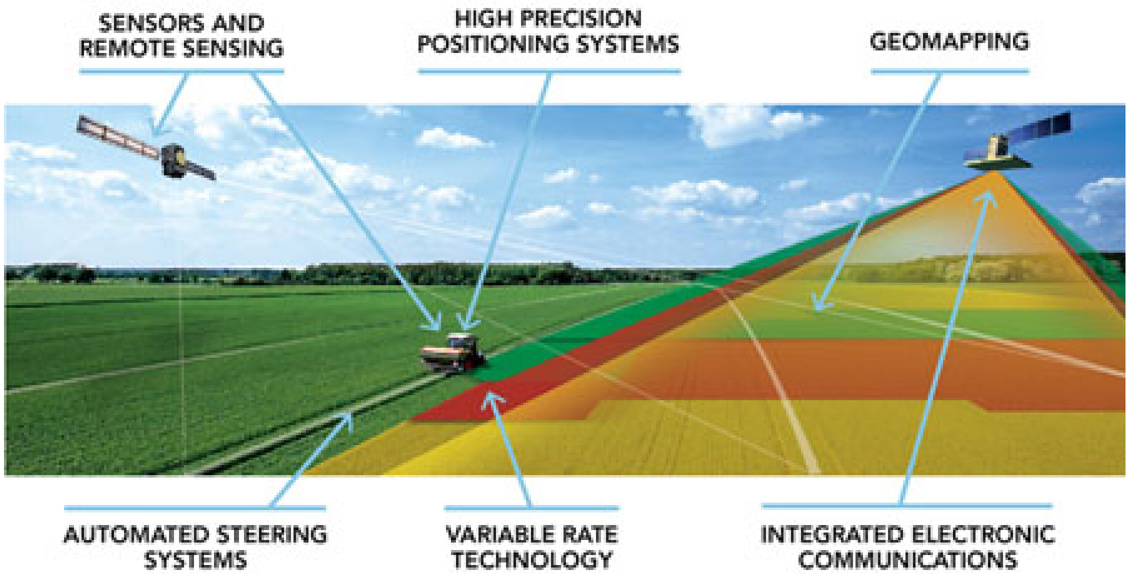
Malaysia is also active in improving monitoring capacities. To ensure water security, a water balance program was initiated to begin creating management tools to balance water needs in major river basins, prioritizing water-stressed regions. This involves an instrumentation program to enhance coverage and intensity of hydrological data stations throughout the economy for multiple objectives including flood early warning and drought management.[430]

The Internet of Things (IoT), data analytics, artificial intelligence and their application to ‘precision’ agriculture is a cutting-edge technology area that could potentially lead to significant achievements in securing water and food supply for a growing population facing significant consequences of climate change. IoT refers to the prevalence of internet-connected devices that

[425] The World Bank 2017b, p.2
[426] The World Bank 2017a
[427] The World Bank 2017a
[428] Jianqing 2016, p. 2
[429] Jianqing 2016, p. 2
[430] Interview memo Dato' Ir. Hj. Nor Hisham bin Mohd Ghazali

collect and communicate information that is later processed into valuable insights through data analytics, which searches for patterns in the data. Artificial intelligence can help process this data into useful insights as well. This data can be used to provide recommendations to farmers or automate certain processes, such as flow of irrigation water, application of fertilizer and other inputs. This is called variable-rate technology (VRT), which allows farmers to adjust the application of agricultural inputs to achieve site and time specific application.[431] The figure below is a diagram showing how this technology functions and provides insights to farmers.

Figure 41: Visual representation of Precision Agriculture[432]



There are various precision farming companies that aggregate agricultural data and process it through learning applications to produce insights for farmers. It utilizes a set of sensors to collect data on soil health, weather, crop specific and farm yield statistics from above ground and below ground to allow “just enough, just-in-time” irrigation, fertilization, and pesticide use saving water, energy and other resources all while increasing crop yield. The technology is also able to detect variations of physical, environmental and chemical aspects of plants to assess their health and detect disease. This technology is also proving attractive to California’s energy and water utilities, due to the prospects that the technology could monitor water in a way to allow increased efficiency for both sets of utilities.[433]

There are other companies that use autonomous irrigation systems to automatically allocate water based on environmental data collected from a weather forecast company and sensors in the ground and irrigation lines.

The aforementioned Hidrosoph provides the Irristrat irrigation management solution, that has been used for 3,000 agricultural operations, utilizing 300 separate crop models. It has been deployed in three APEC economies: Australia, Chile and Mexico.[434] It utilizes intelligent irrigation management software and monitoring equipment from leading manufacturers to capture and

[431] Alabama Cooperative Education System (ACES) n.d.
[432] CEMA n.d.
[433] Interview memo Victoria Vegis
[434] Interview memo Daniel Ribeiro

process field information in real time and providing accurate information to farmers, for more efficient irrigation. The data it collects includes: soil parameters (type, layers, and slopes); crop data (growth stages, root depth, water utilization and stress rates); characteristics and performance of irrigation systems; data from weather stations, probes, flowmeters, dendrometers; and the weather forecast.

China has been successful in promoting technologies to end the economy's overwhelming reliance on water, such as dry-cooling for thermal-power plants. They have also developed technology to bring polluted water from coal mines to a drinkable level. It is easier to pilot risky technologies in China due to the magnitude of water scarcity. China's investments in water resource management have largely focused on technological solutions, infrastructure improvements and technology to end severe water pollution.[435]

The Association of Membrane Separation Technology (AMST) in Japan is committed to development and promotion of the appropriate use for membrane filtration technology in water supply, water reuse, waste water treatment, water purification, water treatment and other water sciences and technology. Membrane technology is a generic term for several different separation processes. Membranes are used for the creation of process water from groundwater, surface water, or wastewater. The membrane acts as a filter that will let water flow through, while it catches suspected solids and other substances.[436] AMST's 29 companies (membrane manufacturers, engineering firms and membrane process users) conduct a range of activities including research of membrane technologies, relation and communication between government and other organizations.[437]

Given impending climate change impacts on water resources, it is necessary to explore niche technological applications that can contribute to increased availability of water resources, even if their potential application is limited geographically. The coastal area between the very north of Chile and southern Peru is characterized as an arid zone with virtually no rainfall, although special atmospheric conditions lead to thick fog clouds that settle on the Andean mountain slopes. A type of polypropylene mesh can be used to harvest this fog which is captured on the mesh. The water then flows by gravity into a receptacle. The technology has limited applicability due to the special climatic and topographical conditions required for best results, but it is relatively cheap and requires little operation and maintenance. It can be readily constructed and installed by individuals with readily available materials and little training. It can also be scaled up incrementally and has no significant environmental impact.[438]

Another innovative technology that is seeing increased demand, especially in Africa and Asia, are solar water pumps.[439] This technology reduces some of the interdependency of water and energy systems, namely the large amount of energy necessary to deliver water, by utilizing solar energy.

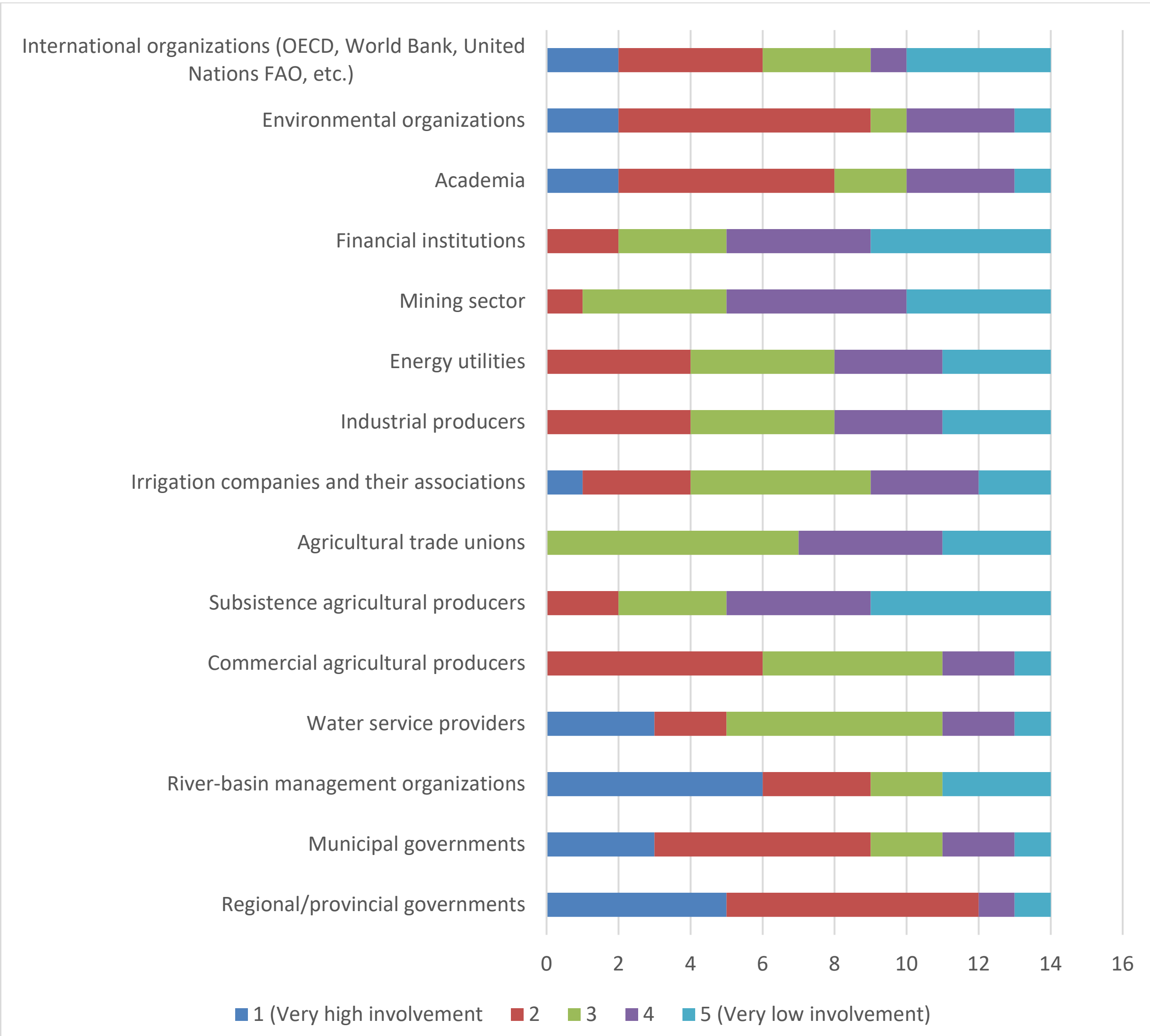
3.4.5 Stakeholder engagement and outreach

Economies were asked which stakeholders were most actively involved in initiatives for the improvement and integration of water resource management and governance to support food security and climate change adaptation goals. Among the APEC economies that responded, regional/provincial and municipal governments, RBOs, academia, environment organizations and

[435] Interview memo Cecilia Tortajada
[436] Lenntech n.d.
[437] Association of Membrane Separation Technology, Japan n.d.
[438] Espejo 1992
[439] Interview memo Meredith Giordano

international organizations were identified as highly involved, while economic sectors such as energy, mining and agriculture were comparatively less involved.

Figure 42: Which stakeholders are most actively involved in initiatives for the improvement and/or integration of management of governance and management of water, food security, and/or climate change adaptation?[440]

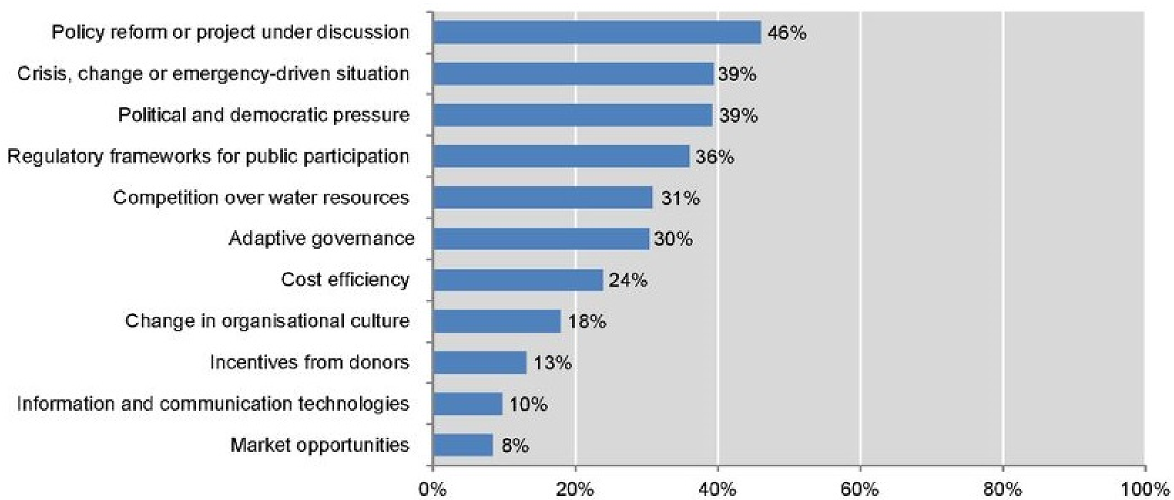


Literature and interview research results revealed it is essential to increase acceptance and a sense of 'ownership' of water resource management plans by communities to ensure successful implementation, which requires a representation of stakeholder interests at the governmental level.[441] These processes are expensive and require significant funding commitments.[442]

440 Washington CORE 2017
441 SOPAC et. al, p. 4
442 SOPAC et. al, p. 3

The first step in stakeholder engagement is to map out all stakeholders who will be affected by outcomes, and identify their roles, motivations and behaviors to inform the overall engagement strategy. There are both formal mechanisms (tools that have institutional or legal ground) and informal mechanisms (not institutionalized) of stakeholder engagement. ICT platforms are an innovative way to engage stakeholders through virtual meetings and social media. Regarding stakeholder mechanisms, the OECD ultimately recommends that they be tailored towards each specific context of stakeholder concerns, policy goals and local needs to create a more efficient and legitimated water governance system.[443] The figure below shows drivers of stakeholder engagement in water governance, identified in an OECD survey with 215 respondents.

Figure 43: Drivers of stakeholder engagement[444]



Other best practices for IWRM involve criteria in terms of representation of the diverse interests across all relevant sectors and criteria for functionality of engagement. One element is for stakeholders to collectively form an integrated perspective on water resource management in light of socio-cultural, political, environmental and economic considerations. To facilitate this participation, it is necessary to engage in capacity building and education to ensure stakeholders understand the complex issues related to water resources.[445] Furthermore, special care must be payed to ensure the interests of vulnerable or disadvantaged groups are represented, as well as to ensure gender equity. The criteria also call for vertical integration of stakeholders (e.g. community interests represented at the governmental level) as well as horizontal integration (e.g. all relevant ministries affected by water resource management decisions are included).[446] The OECD also calls for a strong science-policy interface to ensure scientific research is used in enhancing water governance practices.[447]

Criteria for the functionality of stakeholder engagement seek to ensure that the process can lead to better water governance, necessitating long-term commitment, with frequent and accessible

[443] SOPAC et. al, p. 2
[444] OECD 2015, p. 60
[445] SOPAC et. al, p. 4
[446] SOPAC et. al, p. 4
[447] OECD 2015, p. 11

meetings, free exchange of information among participants and an equal weighting of all voices.[448]

Trust and engagement in water governance is also a key goal of stakeholder engagement and can be achieved through integrity and transparency practices. These include legal/institutional frameworks that create accountability for authorities and stakeholders alike. It also necessary to take stock of potential incentives and sources of corruption. The OECD also suggests ways to mitigate sectoral trade-offs and conflicts between water users through non-discriminatory, participatory decision-making that includes rural-urban cooperation to identify barriers to water access. Furthermore, evidence-based assessment of water policies is necessary to guide decision-making. Public debate occupies the role of educating on the risks of water-related issues and decisions.[449]

Furthermore, stakeholder engagement suffers from a lack of assessment of results. The evaluation process is essential to strengthen accountability, draw lessons from projects and manage risks. This is often difficult due to a lack of frameworks for evaluation, variability in the engagement process and complexity and subjectivity of the topic (subjectivity makes developing indicators especially difficult).[450]

The tables below show indicators to measure stakeholder engagement progress, as well as common challenges.

Table 6: Stakeholder engagement indicators[451]

Type of indicator	Indicator
Quantitative indicators of participation	Improved and more effective service delivery
	Greater numbers of project-level meetings and higher attendance levels
	Higher percentage of different groups attending meetings (e.g. women, landless)
	Greater numbers of direct project beneficiaries
	Increased project input take-up rates
	Greater numbers of local leaders assuming positions of responsibility
	Greater numbers of local people acquiring positions in formal organizations
	Greater numbers of local people involved in different stages of the project[452]
Qualitative indicators of participation	Organizational growth at the community level
	Growing solidarity and mutual support
	Knowledge of the project's financial status
	Desire to be involved in decision making at different stages
	Project group is increasingly able to propose and undertake actions
	Representation in other government or political bodies with relation to the project
	Emergence of people willing to take on leadership
	Interaction and the building of contacts with other groups and organizations
	People begin to have a say in and to influence local politics and policy formulation

448 SOPAC et. al, p. 4F
449 OECD 2015c, p. 12.
450 Benson, et. al, p. 23
451 SOPAC, et. al, p. 3
452 SOPAC, et. al, p. 4

Table 7: Challenges to stakeholder engagement and corresponding best practices[453]

Challenge	Corresponding best practice
Consultation fatigue	• ICT, social media as engagement tool • Clearly define objectives of stakeholder engagement • Regularly assess the process and outcomes of stakeholder engagement to learn
Absence of political will/leadership	• Frequent meetings • ICT, Social media as engagement tool • Strong science-policy interface
Insufficient time, staffing and funding	• Customize engagement process to changing circumstances
Trade-offs and sectoral conflicts	• Rural-Urban cooperation • Non-discriminatory, participatory decision-making • Evidence-based assessment of water policies • Public debate • Map out all stakeholders, their responsibilities and motivations
Weak legal frameworks	• Institutional framework for stakeholder engagement • Evidence-based assessment of water policies • Regularly assess the process and outcomes of stakeholder engagement to learn
Consultation capture	• Ensure inclusion of disadvantaged/vulnerable groups • Ensure meetings are accessible geographically/temporally • Equal weighting of all perspectives • Free exchange of information and data • Legal/institutional frameworks for accountability and transparency • Strong science-policy interface
Resistance to change	• Strong science-policy interface • Evidence-based assessment of water policies
Reluctance to relinquish power	• Ensure inclusion of disadvantaged/vulnerable groups • Identify incentives for corruption • Legal/institutional frameworks for accountability and transparency
Weak capacity	• Strong science-policy interface
Lack of public concern/awareness	• Education and capacity building for public • Strong science-policy interface • Evidence-based assessment of water policies
Information asymmetry	• Education and capacity building for public • Free exchange of information and data • Strong science-policy interface
Fragmented institutional setting	• Vertical integration of stakeholders • Horizontal integration of stakeholders • Map out all stakeholders, their responsibilities and motivations
Complexity of issues	• Free exchange of information and data • Education and capacity building for public

[453] Based on OECD 2015c and SOPAC et. al

California has made significant efforts to engage the public at large about the importance of conservation of water resources and is attempting to make conservation a “way of life”. The Government’s mandatory water measures represent an important shift to conserving water and promoting innovative strategies as a state. The administration is also expanding existing programs to provide technical assistance, shared data and information, and incentives to urban and agricultural local and regional water agencies, as well as local governmental agencies, to promote agricultural and urban water conservation.[454]

Promoting environmental consciousness and efficient use of resources in the daily lives of individuals is incredibly important, as many inefficient uses of water and polluting activities are cultural; they reflect habits that are sufficiently socially acceptable so that the individual doesn’t feel pressure to change. Consciousness over the preciousness of water resources could inspire individuals to advocate for some of the principles of IWRM, create pressure on irresponsible users of water, whether individuals, private companies or government, and increase dialogue regarding water governance and management in the media.

The Philippines government utilizes an annual National Water Summit to introduce concerns of various stakeholder groups to inform water resource management policy. The government is also aggressive in consultations, public fora and meetings with water users to figure out more efficient ways to utilize water.[455]

IWRM initiatives in the Chao-Phraya and Yom River Basins in Thailand demonstrate the value of stakeholder engagement. The Chao-Phraya River provides water for irrigated areas in the central region, considered to be the rice-bowl of Thailand, and thus carries enormous economic significance in addition to supplying raw water for Bangkok industries and populations. Due to rapid industrialization, land conversion, housing development, and urbanization, the Chao-Phraya basin has encountered frequent flooding and water shortages, creating serious concerns about how to manage the basin’s water resources more effectively and sustainably. This led to the establishment of three river basin committees (RBCs) in the regions three sub-basins of the Chao-Phraya.

The project sought to engage stakeholders through regular meetings. The process of organizing meetings with real participation from all stakeholders and key line agencies created opportunities for frank exchange and cooperation. Additionally, with the raising of awareness about IWRM and the adaptive management approach, water resource management innovations emerged such that the sustainable management of water resources received more understanding and attention than its traditional development aspects. The creation of the Network of Sub-districts located along both banks of the Yom River facilitated the formation of a large group of stakeholders who share similar concerns and ideas, and are committed to addressing priority problems using local knowledge in managing water resources. At the same, time it allowed implementation of activities and projects in a more coherent manner from upstream to downstream.[456]

Education and capacity building were also a large part of the success of these initiatives. The Yom river basin project help training programs for DW region 9 staff to allow them to be more responsive change agents for the area. They also create a simple database from simple maps

[454] California Natural Resources Agency n.d., p. 8
[455] Interview memo Sevillo D. David.
[456] Anukularmphai 2013, p. 11

provided by each sub-district to prepare a practical information system, which stakeholders can understand and use. An information center was also created as a training facility for various stakeholders on water resources. A flood warning system was also created, as flooding of the Yom River is one of the problems in the area during the wet season, which led to the training of volunteers in water resource monitoring.[457]

First launched in 2012, China's cleanliness and water-saving campaign encourage citizens in China to "save 10,000 liters of water annually per household. The initiative also helps to raise awareness on the significance of water conservation. On 18 March 2017, Kao Holding Co, Ltd, a China-based group company and the Center for Environmental Education and Communications (CEEC) of China's Ministry of Environmental Protection are conducting a joint promotion of the initiative. The campaign in Guangzhou was attended by hundreds of people from schools, local communities, and government. The campaign focused on the importance of water-saving activities and water resources. Visitors were able to enjoy panel displays of water-saving information, participate in "fun to learn" games about water, view an exhibit of award-winning works from the Kao International Environment Painting Contest for Children, and observe demonstrations of Kao's water-saving laundry detergent that are marketed in China.[458]

In the previously mentioned St. Johns River Water Supply Impact Study in Florida, US, the St. Johns River Water Management District created a website to help the public understand the issues and provide information on options the District was considering as an alternative to groundwater supplies. In Phase two of project in 2008, the SJRWMD engaged with the National Research Council to peer review WSIS. Over the following three years the NRC held meetings with the District at which the public was allowed to ask questions.[459]

It is essential for water resource authorities to make data available to the public in an understandable manner to encourage involvement and input in the water resource planning process. Open access to data was also effective in supporting the Boundary Waters Treaty between the USA and Canada. An element that contributed significantly to the success of negotiations regarding was transparent and accessible information available to both parties. This has removed most suspicions and concerns over manipulation of data and has provided a more solid foundation for cooperation between the two economies.[460]

Another aspect of stakeholder engagement in water governance is revalorizing local knowledge about water and food systems and encouraging active participation of citizens in water resource initiatives. Within the Mekong Basin there are areas which are predominantly low-level subsistence systems and vulnerable to shocks such as climate variability. The Mekong system is highly complex with a fragmented water governance system. Throughout much of the region there are major gaps in the supporting knowledge and information about overall basin characteristics and local conditions. In response, the International Union for Conservation of Nature (IUCN) sought to scale up Tai Baan research (villagers' research) that enabled local communities to represent their own social reality through media and public forum. This knowledge can be mainstreamed into water resource management research and implementation. One example of

[457] Anukularmphai 2013, p. 11-12
[458] Kao 2017
[459] American Water Resources Association (AWRA) 2012, p. 50
[460] Interview memo Mike Renouf

Songkhram Basin, local villagers, mostly farmers and fisherman, compiled information and indigenous knowledge on local ecosystems and to assess environmental flows.[461]

Thailand, Lao PDR, Cambodia, and Viet Nam have all promoted Tai Baan research. Three communities in Lao PDR have used the Tai Baan research to determine the nutritional value of their wetland resources. The valuable compilation about environmental flows is now being used as the basis for developing a training manual and extension efforts to promote the replication of Tai Baan approaches in additional areas both within Thailand and in neighboring economies.[462]

3.5 Successful initiatives

Economies were asked to describe successful initiatives for enhancing the efficient management and use of water resource to better address agricultural water demand and climate change impacts

A. Australia

Australia discussed the success of their use of water markets to allow dynamic allocation of water resources based on supply and demand, while also maintaining environmental flows and the integrity of aquatic ecosystems. These markets have provided a useful tool for managing seasonal variation in water resource availability. Water infrastructure projects have also generated significant savings of environmental water, which are maintained for ecosystem integrity as well as provided to irrigators. On-farm water efficiency projects have also led to significant productivity benefits, such as increased crop rotation ability, water-use efficiency, improved soil management, and reduced maintenance and weed control requirements.

B. Canada

Canada pointed out watershed management practices in Eastern Canada that concurrently provided on-farm and environmental benefits.

C. Chile

Chile recognized the subsidies provided under the Irrigation Act between 1997 and 2007 as effective at funding 40 percent of efficiency projects in irrigation, while also promoting private investment in public irrigation projects.

D. Hong Kong, China

Hong Kong, China identified the use of seawater in a large scale for toilet flushing as innovative and significant contributor to freshwater conservation. Currently, the network covers about 85 percent of the population in Hong Kong, China, saving 270 million cubic meters of fresh water every year.

E. New Zealand

New Zealand highlighted their Managed Aquifer Recharge (MAR) program in the Poverty Bay Flats. The Poverty Bay flats in the Gisborne District are primarily for fruit and vegetable growing which are an important sector in the region’s economy. To prevent further deterioration of the Makauri aquifer, the largest aquifer underneath the Poverty Bay flats, Gisborne District Council (GDC), with support from the Ministries for the Environment and Primary Industries, is currently investigating options for a Managed Aquifer Recharge (MAR) scheme. The MAR will require

[461] GWP (b) 2014
[462] GWP (b) 2014

injecting water from the Waipaoa River into the aquifer through a number of injection wells. Input-output analysis showed that overall the MAR scheme produced positive economic impacts.

F. Papua New Guinea

Papua New Guinea lacks a coordinating water agency, so examples of private initiatives and technologies were highlighted. These included deep tube-wells for extracting underground or aquifer water for industrial use, small-scale irrigation in open-field crop production, and protective-house vegetable production. Other example includes extracting water from natural surface bodies such as rivers, lakes and surface ground reservoirs constructed specifically to impound water for later use in pumping and irrigation. The principal users of these technologies are the sugar industry; cattle ranges, and palm oil tree nurseries using sprinklers for irrigation.

G. Peru

Peru highlighted water seeding and harvesting in highland watersheds of Peru, leveraging local and ancestral knowledge to increase the economic well-being of target beneficiaries and increased resilience to climate change. The projects involve the creation of simple reservoirs, which require little investment in materials and labor, allowing families and communities to store water and recharge aquifers.

The Sierra Azul ("Blue Highlands") water seeding and harvesting program was launched to satisfy water demand in big cities and mitigate climate change impacts by increasing water supply in High-Andean areas. 600 minor water projects - 300 micro-reservoirs and 300 irrigation projects - were expected to be constructed under the program in 2017. These projects were expected to benefit nearly 30,000 Peruvian families in 2017, up from 1,200 families in 2016.[463]

H. Philippines

The Philippines identified the Small Water Impounding Project (SWIP) as an exceptionally popular and effective project. It involves small community-managed rainwater harvesting facilities and reservoirs, with multiple functions, such as irrigation, flood control and groundwater recharge, befitting to farms and communities.

I. Singapore

Singapore highlighted its efforts to mitigate climate change impacts via a drainage management approach that strengthens flood resilience and adds flexibility and adaptability to Singapore's drainage system to cope with higher intensity storms. Through the "Source-Pathway-Receptor" approach, measures are not only carried out along the Pathway (e.g., through widening and deepening of drains and canals), but also implemented at the Source where stormwater runoff is generated (e.g. through on-site detention) and at the Receptor where floods may occur (e.g. through platform levels, crest protection and flood barriers). Developers of new and redeveloped sites are required to implement "source solutions" to slow down surface runoff and reduce the peak flow of stormwater into the public drainage system.

J. Chinese Taipei

Chinese Taipei presented the Forward-looking Infrastructure Development Program as a highly successful initiative. Its goal is to deal with challenges of climate change, and to improve water use efficiency, water environment and flood control. The program integrates inter-agency opinions and new vision, utilizes ICT technologies and an "Internet of Things" platform, and uses an intelligent management system. The Council of Agriculture's iWater Project was also mentioned, which is an integrated, innovative and intelligent irrigation water management system, utilizing

[463] Peru News Agency 2017

innovative ICT and engineering technology, matching with systematic management, to cope with issues like: aged society, lack of staff and time, and water resources efficiency.

K. Thailand

Thailand recognized incentives to farmers to encourage crop diversification were successful at reducing water consumption.

L. United States

The US identified numerous successful initiatives to enhance efficient management and use of water resources across a number of departments and agencies. These included:

- The National Drought Resilience Partnership augments the National Oceanic and Atmospheric Administration's (NOAA) National Integrated Drought Information System by engaging a team of federal agencies to provide information and data, emergency and planning assistance, landscape-scale land management improvements, and investments in new technologies and approaches to improve water resource management, including drought preparedness and early warning
- The National Aeronautics and Space Administration (NASA) conducts research and observations on the global water cycle, from large-scale satellite-based remote sensing to in-situ field observations, data acquisition and analysis, prediction system development, and the applications of NASA data to improve decision support systems
- The National Science Foundation supports water-related research, including long-range projects that impact policy, like the ongoing program, Innovations at the Nexus of Food, Energy, and Water Systems
- USDA's Regional Climate Hubs, National Water and Climate Center, National Water Management Center provide services and tools to help US farmers, foresters and ranchers conserve and improve their water resources and overall productivity. USDA's Natural Resources Conservation Service maintains a general webpage about water (https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/water/)
- USDA's Water and Agriculture Information Center collects, organizes and communicates scientific findings, educational methodologies, and public policy issues related to water and agriculture. USDA's Water and Waste Disposal Loan and Grant Program protects and improves water quality and management in rural areas of the US.
- The USGS water use program estimates water used by region and economic sector every 5 years. The US Forest Service Resource Planning program estimates future economy-wide water use every 10 years.
- The US EPA delivers programs on green infrastructure climate resilience and water infrastructure programs and initiatives in addition to the following programs:
    - Creating Resilient Water Utilities (CRWU)
    - Effective and Sustainable Water Utility Management
    - Emergency Response for Drinking Water and Wastewater Utilities
    - Green Infrastructure and Low Impact Development
    - Sustainable Infrastructure
    - WaterSense
    - Climate Ready Estuaries (CRE)
    - Healthy Watersheds
    - Water Quality Models and Tools

M. Viet Nam

Viet Nam indicated that the Water Resources Planning for Mekong Delta in the context of climate change and sea-level rise project, carried out by the Southern Institute for Water Resources Planning, was successful.

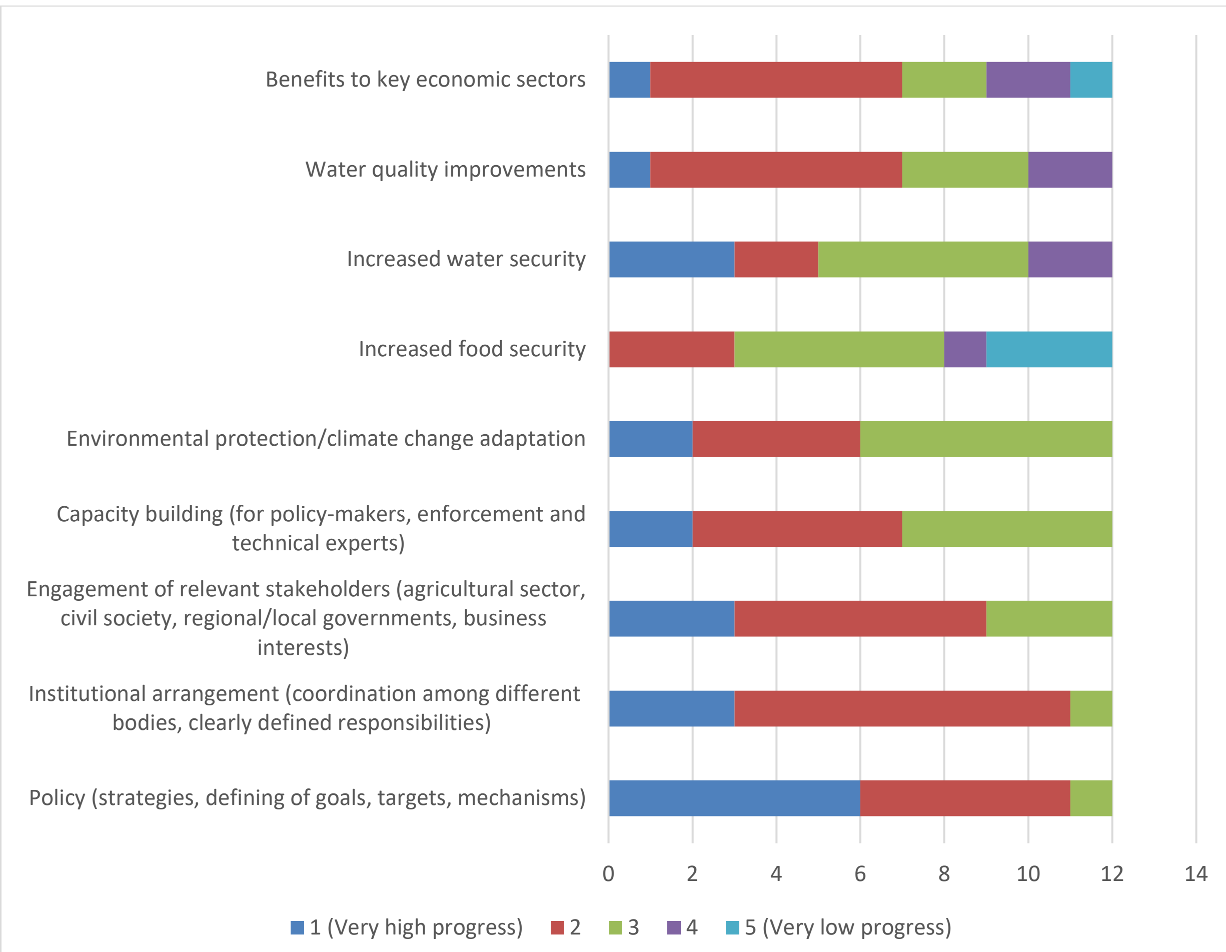
3.6 IWRM implementation and future plans

The survey also inquired about economies' progress in implementing IWRM, near and medium-term goals, future plans and priority topics for discussion among APEC regarding water resource management, food security and climate change.

3.6.1 Progress on IWRM initiatives

Economies were asked to indicate their progress in implementing IWRM in terms of benefits realized through initiatives. Among the APEC economies that responded, the most progress seems to have been made on policy, institutional arrangements and stakeholder engagement, while less progress has been made on food security, water security and environmental protection.

Figure 44: If your economy is implementing or has implemented an Integrated Water Resource Management (IWRM) approach, how would you rate this effort's progress in terms of the following aspects?[464]

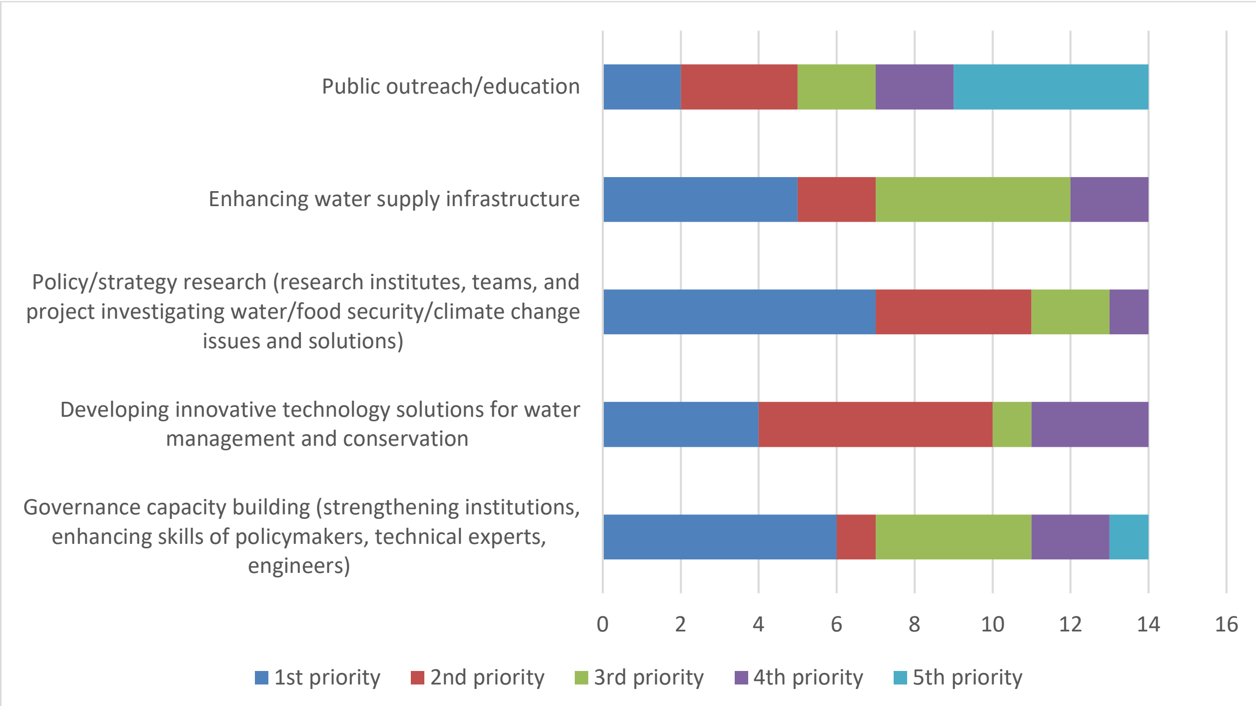


[464] Washington CORE 2017

3.6.2 Investments to improve governance and management of water resources

Economies were asked to rank the investments their economies were making to improve water governance and management. Among the APEC economies that responded, most considered policy and strategy research, infrastructure and capacity building as the highest priorities.

Figure 45: What investments are being made to improve the governance and management of water resources, considering climate change?[465]



3.6.3 Near and medium-term goals for water resource management and agriculture

Economies were also asked to describe their top goals in enhancing water resource management and governance in the short to medium term. Among the APEC economies that responded, the majority of economies formulated their goals around ensuring a reliable and clean supply of water resources to communities and agriculture users. Protection of ecosystems was also a prominent concern.

Capacity building for agencies, departments and local governments was also a significant goal, as economies seek to institutionalize IWRM and the river-basin approach and harmonize policies, programs and projects of agencies with water-related responsibilities.

Water infrastructure was a significant near-term focus in many APEC economies, such as on-farm infrastructure to increase resilience to climate change, such as ponds and reservoirs to assist farmers in managing unpredictable rainfall patterns. Irrigation infrastructure, both on-farm and off-farm networks, were also indicated as the targets of investments.

Economies also expressed desire to implement a range of technologies in the areas of:

[465] Washington CORE 2017

- Water-use efficiency
- Agricultural productivity
- Water quality rehabilitation/reuse

3.6.4 Topics for future discussion in APEC regarding water resource management, governance, IWRM, food security and climate change

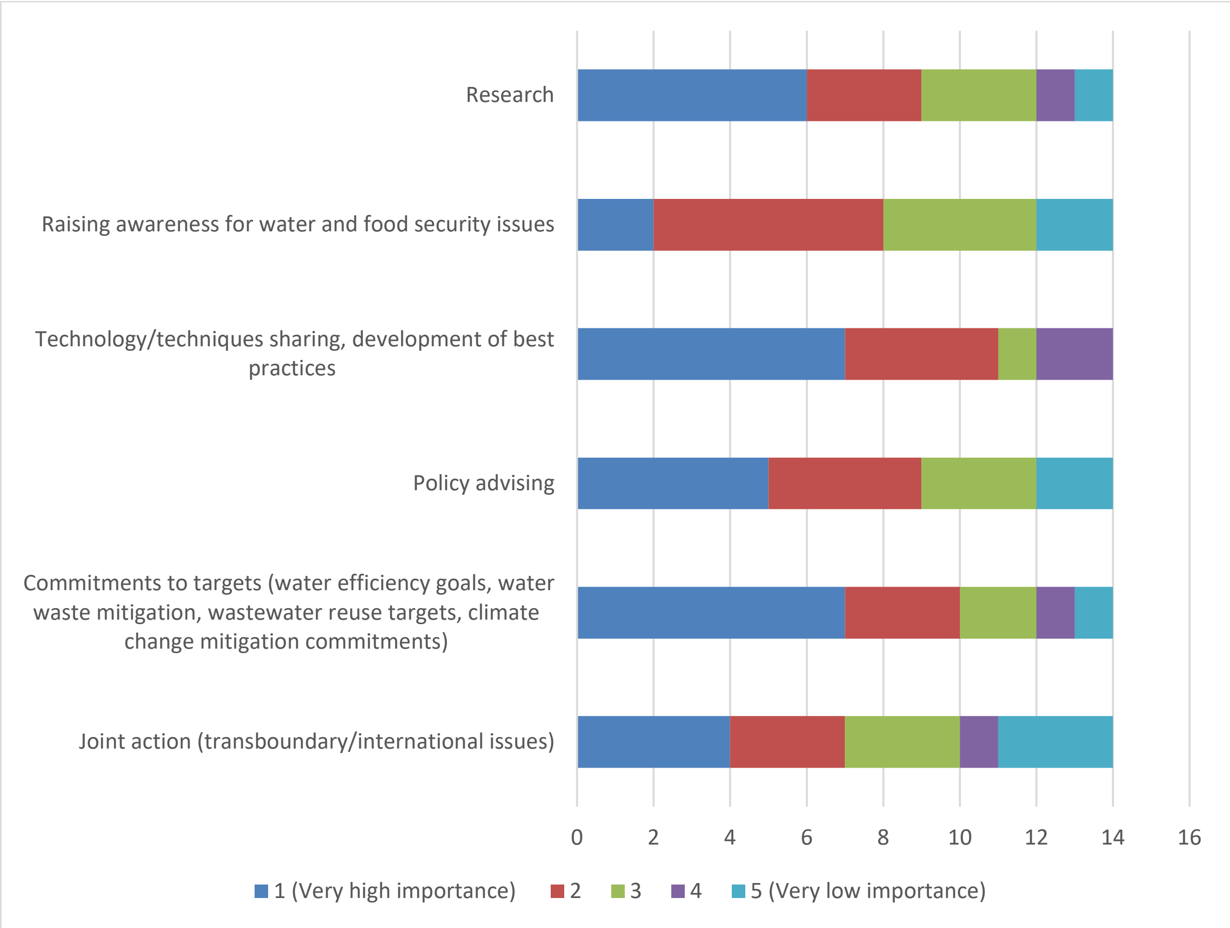
Common topics which respondents identified as priority topics for future APEC discussions around the themes of water resource management, governance, food security and climate change adaptation, included:

- Water governance: methodologies to create harmonized plans of action to implement the IWRM approach, regulatory and institutional arrangements to support IWRM;
- Case studies: participants were especially eager to learn from successful cases of IWRM implementation that would be replicable in their economies;
- Capacity building: strategies to support technical implementers of water and agricultural policy, and strengthening capacity building, knowledge sharing and technology transfer between economies;
- Climate monitoring, information and decision support tools: techniques and technologies to more effectively monitor the effect of climate on water resources, agricultural systems and ecosystems, in order to create more effective strategies for adaptation and information to guide business and policy decision making
- Opportunities and mechanisms for environmental (ecosystem services) markets

3.7 International cooperation on water resource management, food security and climate change adaptation

Economies were asked about the ideal roles for international partnerships and assistance were for improving water governance and management for food security and climate change adaptation from their perspective. Among the APEC economies that responded, technology transfer, research and commitments to targets were considered highly important.

Figure 46: Which roles of international collaboration are most important for enhancing water governance and management for food security and climate change adaptation in your economy?[466]



It is beneficial to consider how actors from different economies have worked cooperatively to find solutions to water resource management and governance challenges that are experienced in a unique way by each economy. Cooperation and assistance are especially important, given the high political, social and financial costs of IWRM that many economies cannot bear on their own.

Many international organizations have developed water conservation and management-oriented sectors due to a growing water security challenges posed by climate change and human development. As urbanization and deforestation occur, people demand more water, and water levels rise, many communities and economies face high risks to lives and GDP. These organizations take part in the water discussion through multiple means: direct funding and assistance for governments, research into water security and best practices, and outreach and awareness promotion. International organizations active in this field include the OECD, the World Bank, the United Nations (UN), the Global Water Partnership, the International Water Management Institute (IWMI), the International Water Resources Association (IWRA), the International Water Association, and the World Water Council.

466 Washington CORE 2017

A key tool to enhance water governance and management is financial assistance from international organizations to help build institutional capacity to develop and implement IWRM measures. International cooperation has been effective in providing incentives for economies to improve water resource management, but accountability on expenditure of loans, and assessment on progress of implementation and strengths and weaknesses of certain approaches needs greater attention.[467] A key strength of large international organizations like the OECD and World Bank is their ability to fund large, long-term and high impact projects, but these must be properly evaluated and assessed to make adjustments and gain insights for future projects in other locations.

Improving stakeholder engagement at all levels is important to make sure that project benefits are widespread. Along these lines, a senior irrigation engineer at the World Bank suggests that the way in which international aid is provided for agriculture and irrigation needs to change from a top-down, charity based model to one that includes low level farmer organizations.[468] This means expanding the perspective on irrigation from simple water delivery to how its use can be made more efficient on the farm level.

International organizations can also play a significant role in facilitating regional cooperation and dialogue among economies. Interviews of water resource experts for this study indicated that regional cooperation was the most important role of international partnerships and assistance, with just under 40 percent indicating it was highly important.

One important regional cooperation effort is the South Asia Water Initiative, a five-year (2013–2017) US$31 million multi-donor trust fund (MDTF) that aims to increase regional cooperation in the management of the major Himalayan river systems in South Asia to deliver sustainable, fair and inclusive development and climate resilience. Funded by the United Kingdom, Australia and Norway, this initiative covers the major Himalayan river systems- the Indus, Ganges and Brahmaputra — spanning multiple economies. The international initiative covers the major Himalayan river systems- the Indus, Ganges and Brahmaputra — spanning multiple economies (Afghanistan, Bangladesh, Bhutan, China, India, Nepal and Pakistan).

The program works across basins and economies to support knowledge generation and sharing, capacity development, dialogue, participatory decision processes, and investment designs. In the context of water resources planning and management, the program promotes poverty alleviation, economic development, gender inclusion and climate change adaptation.[469]

NARBO is a good example of regional cooperation to promote the implementation of IWRM and exchange of best practices. It was officially established in February 2004 to promote IWRM in monsoon areas in Asia. The NARBO member economies are Australia, Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Japan, the Republic of Korea, Laos, Malaysia, Myanmar, Nepal, Pakistan, the Philippines, Sri Lanka, Thailand, and Viet Nam. NARBO's objective is to strengthen the capacity and effectiveness of river basin organizations (RBOs) in promoting IWRM and improving water governance, through training and exchange of information and experiences among RBOs and their associated water sector agencies and knowledge organizations.[470] NARBO is composed of 86 organizations, but the lead players are Japan-based. As seen in the

[467] Interview memo Cecilia Tortajada
[468] Interview memo Joop Stoutjesdijk
[469] The World Bank (d) n.d.
[470] NARBO (a) n.d.

figure below, membership is open to organizations which implement or promote IWRM, including important stakeholders such as river basin organizations, federal/provincial/local governmental organizations, regional and inter-regional knowledge partners and bilateral and multilateral development cooperation agencies.[471]

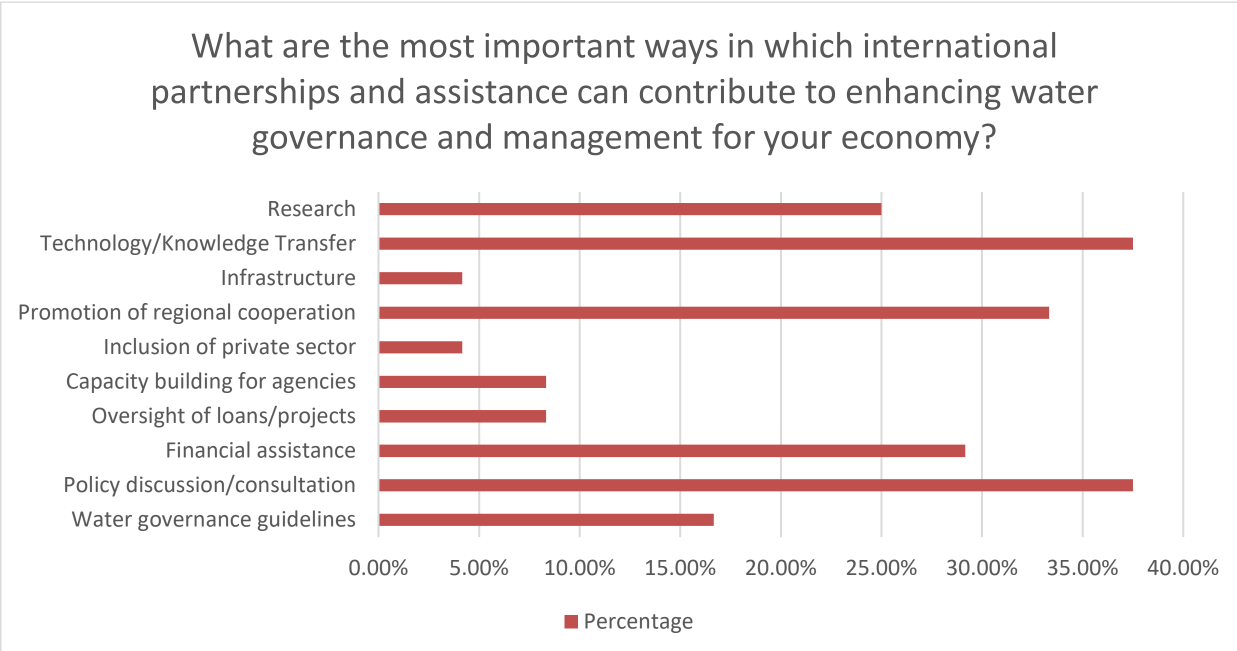
Figure 47: NARBO organizational structure[472]

Another way in which international organizations are very important is leveraging their reputations and influence to spread awareness regarding water-related issues, especially as they relate to the habits of individuals. As an example, Max Gomberg of the California State Water Resources Control Board suggests that international organizations are well suited to engage in public outreach to educate on the impact of eating habits on water resources, especially how reducing industrialized meat consumption could contribute significantly to climate change mitigation, water security and food security.[473]

The figure below shows the most important roles of international partnerships as indicated by interviewees and survey respondents for this study. A significant portion of interviewees noted the need for financial assistance from international organizations to address water-related issues, as well as the importance of facilitating regional cooperation and exchanging technological and policy expertise.

[471] NARBO (a) n.d.
[472] NARBO (a) n.d.
[473] Interview memo Max Gomberg

Figure 48: Roles of international partnerships according to Washington CORE interviewees[474]



A. Investment/Aid

The topic of IWRM is attracting a lot of funding interest from institutions such as the World Bank, which funds projects brought to them by economy governments. The World Bank has invested $24.5 billion in 177 water-related projects, which amounts to 11 percent of the World Bank's current lending portfolio.[475] Most recently, in April 2017 the World Bank loaned $40 million to Peru for a major five-year project that will start in 2018 to develop IWRM and secure the stability and sustainability of ten of Peru's water basins that are at high risk.[476]

Between 2012 and 2016, the World Bank worked closely with China to implement the Water Conservation Project II in Hebei, Shanxi and Ningxia, the three most water-scarce provinces in the northern China. An $80 million loan was provided to improve agriculture water resource management and agriculture water productivity. The project sought to reduce evapotranspiration[477] and increase water productivity of crops.

Although World Bank only loans to economy governments, it is trying to engage more with local governments. It tries to encourage communication through the creation of representative councils or other methods to increase coordination and cooperation among different levels of government to ensure that national reforms related to water governance and management are felt at the local level.[478] For example, the China project sought to transfer responsibility for managing irrigation to farming communities through the creation of water users' associations (WUA). Today there are 134 village-based WUAs in Guantao County alone that help the village reduce water consumption,

474 Washington CORE
475 The World Bank (b) n.d.
476 The World Bank 2017a, p. 12
477 In the process of evapotranspiration water evaporates from the soil and transpires through plants.
478 Interview memo Joop Stoutjesdijk

ultimately leading to awards recognizing the most efficient WUAs and farmers. In each village, the local WUA created a "water rights system." A water rights certificate was issued to each household that shows the amount of farmland and water allocated. Each household also received an integrated-circuit (IC) card to get a pre-determined quantity of water from the irrigation water resource management system. At the end of the year, efficient users receive incentives, and wasteful users are penalized. Eventually, the water rights will become tradeable between the farmers.[479]

The ADB operates mostly on the requests of economy governments and focuses on large infrastructural projects, without much attention to smaller scale projects.[480] This is an essential role in the suite of international assistance to complement efforts to reform the institutional arrangement for water resource management, in order to ensure practical water related issues are addressed simultaneously.

An example of a very important ADB project is the Investment Assessment and Application of High Level Technology for Food Security in Asia and the Pacific. The project is the first grant launched under the Knowledge Partnership Agreement signed by ADB and the International Rice Research Institute (IRRI) in 2016 to upscale the use of climate-smart agriculture and water-saving technologies to increase productivity through "cost-effective development, effective demonstration, and rapid dissemination." It also seeks to minimize the carbon footprint of rice production. IRRI is providing technical assistance for a comprehensive review of high-level technologies (reduced or zero tillage, mechanical seeding or transplanting, alternate wetting and drying or AWD, crop residue retention, crop rotation, and use of information and communication technology) in rice and non-rice crops.[481]

B. Water Governance guidelines

A highly significant publication that served as a landmark for future behavior and water policy is the OECD's "Principles on Water Governance."[482] The document was published in 2015 and set the standards for 12 actions that governments must take to develop and implement effective water policies along with other stakeholders. Among these 12, the most significant are:

- Allocate and distinguish roles and responsibilities to qualified, cooperative policymakers
- Develop IWRM strategies
- Adopt innovative practices and technologies
- Engage both with rural and urban areas
- Regularly monitor and evaluate water practices when necessary[483]

The OECD is also nearing completion in a project to develop indicators of good and poor water governance. The indicators are not intended for benchmarking, but rather as a means to create dialogue around water governance related issues and link policy responses to common challenges. Another activity of the OECD is to identify case studies of water governance to identify good practices and inform the development of indicators. These case studies will eventually become part of a database alongside the indicators.[484]

[479] The World Bank (e) 2016
[480] Interview memo Yasmin Siddiqi
[481] Asian Development Bank (ADB) and International Rice Research Institute (IRRI) 2017, p. 1
[482] OECD 2015
[483] OECD 2015
[484] Interview memo Delphine Clavreaul

Establishing such principles and indicators based on international cooperation is as essential tool to improve water governance globally and build on the successful experiences and lessons learnt by various economies.

C. Research

Research on water resource issues and water governance is essential to create a dialogue around these issues and raise awareness.

The UN developed a report titled "Towards Integrated Water Resources Management: international experience in development of river basin organizations" in April 2014.[485] Through empirical data, the report argues for the development of IWRM in capacity building and cost recovery in rivers and basins in Zimbabwe and South Africa. UNESCO developed a report, "Public Participation and Water Resources Management: Where Do We Stand in International Law?" This report discusses the public's participation in water security and the usefulness—or lack thereof—of international involvement if the public is not equally invested.[486] It also explores the concept of human right to water. The paper concludes though case studies that public support and awareness is vital to any efforts to develop water security, because they demand participation, not simply commitment.[487]

The International Water Management Institute (IWMI) is an incredibly important contributor to research activities regarding IWRM, specializing in detailed analysis of implementation and institutional aspects. Their report "Implementing Integrated River Basin Management: Lessons from the Red River Basin, Viet Nam" showed that policy reforms promoted by donors and development banks have triggered changes. These changes are not a result of the reforms themselves, but instead due to the institutional confusion they have created when confronted with the emergence of the Ministry of Natural Resources and Environment (MONRE). Consequently, financial resources and political power was relocated to RBOs.

Thus, the collision of donor-driven projects to establish RBOs and the conflict between Ministry of Agriculture and Rural Development (MARD) and MONRE helped strengthen changes in the direction of a better separation of duties and integrated planning. It is too early to assess whether this transition towards a separation of the operation and regulation roles will be sustained, and whether RBOs will be endowed with substantial power. However, institutional changes shown to result from the interaction between endogenous processes and external pressures, in ways that is barely predictable.[488]

The ADB tends to focus on technical aspects of water governance in their publications, and broader analysis of water resources in particular economies. For example, their "Indonesia Country Water Assessment (CWA)" was intended to provide the analytical foundation for water planning, management, and developing, including investment to further economic development. Priorities under the CWA are guided by the government. The CWA is intended to provide a platform for dialogue to advance water reform across Indonesia while providing guidance for planning, management, policy, and investment with a focus on three of the main economic regions: Java, Sumatera, and Sulawesi.[489]

[485] Jaspers 2014
[486] Jaspers 2014
[487] Jaspers 2014, p. 24
[488] Ibid. page 8
[489] Ibid. 2016 page 12

The Global Water Partnership is also very active in research into IWRM and have published "A Handbook for Integrated Water Resources Management in Basins" in collaboration with the International Network of Basin Organizations (INBO) to serve as a general guide for improving water governance and implementing IWRM at the basin level.[490]

The Inter-American Development Bank has also engaged in research on IWRM relevant to Latin America and the Caribbean. "Integrated Water Resources Management in Latin America and the Caribbean" contains the strategy of the IADB for its involvement in integrated water resources management in Latin American and the Caribbean. The paper found that although the region is well endowed with fresh water resources and ecosystems, there are extreme variations in availability within and between economies.[491] It found that current water resources practices cannot deal effectively with these conflicts and are not sustainable from either an economic or environmental point of view. The reason for this is subsidized water delivery by centralized and overextended agencies; emphasis on regulatory approaches through centralized government, rather than markets or other incentive-based approaches; inadequate stakeholder participation; inadequate enforcement of legislation; inadequate data; scarcity of trained personnel; and a general emphasis on sub-sectoral projects rather than IWRM. As a result, more than 84 million people in the region had no access to clean drinking water in 1995.[492]

The International Institute for Sustainable Development (IISD) has also contributed to the research body on IWRM. For example, the publication entitled "Ecosystem Approaches in Integrated Water Resources Management (IWRM): A Review of Transboundary River Basins" which discussed the synergistic use of IWRM and ecosystem services (ES) paradigms. It found that most transboundary watershed managers utilize an IWRM framework that looks at traditional water resources such as water quantity, navigation, and hydropower. This is seen clearly through the seven case studies of prominent transboundary basins in which IWRM commitments are being implemented. The selected basins represent Africa, Asia and the Pacific, Europe, Latin America and the Caribbean, North America, and West Asia, and showcase regional variables and different ecosystem service vulnerabilities.

The analysis of each basin highlighted whether or not management approaches recognized and incorporated bundled ES, such as uplands watershed management through afforestation, which addresses the combined services of climate regulation, water regulation, and water quality.[493] It concludes that IWRM implementation is limited in achieving its full potential due to inadequate resourcing and fractured governance structures that continue to manage ES as sector/department specific objectives. This can easily be overcome by adopting a more unconventional form of IWRM that incorporates ecosystem management principles, encourages incentives and markets for managing and providing healthy and sustainable ES, and addressing drivers of ecosystem change more systematically.[494]

The International Commission on Irrigation and Drainage (ICID) has also written about IWRM as it pertains to irrigation and maintenance of food security. "Integrated Water Management Approaches for Sustainable Food Production" found that poor management of irrigation and drainage sometimes creates adverse environmental impacts. The paper explores the water-food-

[490] Global Water Partnership (GWP) and International Network of Basin Organizations (INBO) 2009
[491] Garcia 1998, p. 6
[492] Garcia 1998, p. 6
[493] Roy 2011, p. 6-7
[494] Roy 2011, p. 7

energy-climate nexus, as well as the role of irrigation and drainage in food production and in providing other ecosystems services that are essential for the sustainable use of natural resources.[495] The paper argues that looking at water for food production in isolation would miss important developments outside the water sector that determine the sustainability of agricultural water resource management. Integrated approaches to food production also lead to higher benefits per unit of water. For example, integrated food production with ecosystem services provided by irrigation and drainage not only contributes to sustainability; it also leads to much higher economic value of benefits. This implies breaking disciplinary boundaries and encouraging greater cooperation from planning to implementation.[496]

D. Events

A wide variety of events ae held by international organizations to provide a platform for discussion of water resource management and water governance topics, and allow economies to exchange success stories, best practices, lessons learned and cautionary tales. They can also facilitate agreements and commitments to climate action and environmental responsibility. A list of selected major events follows below.

- **Global Water Partnership**

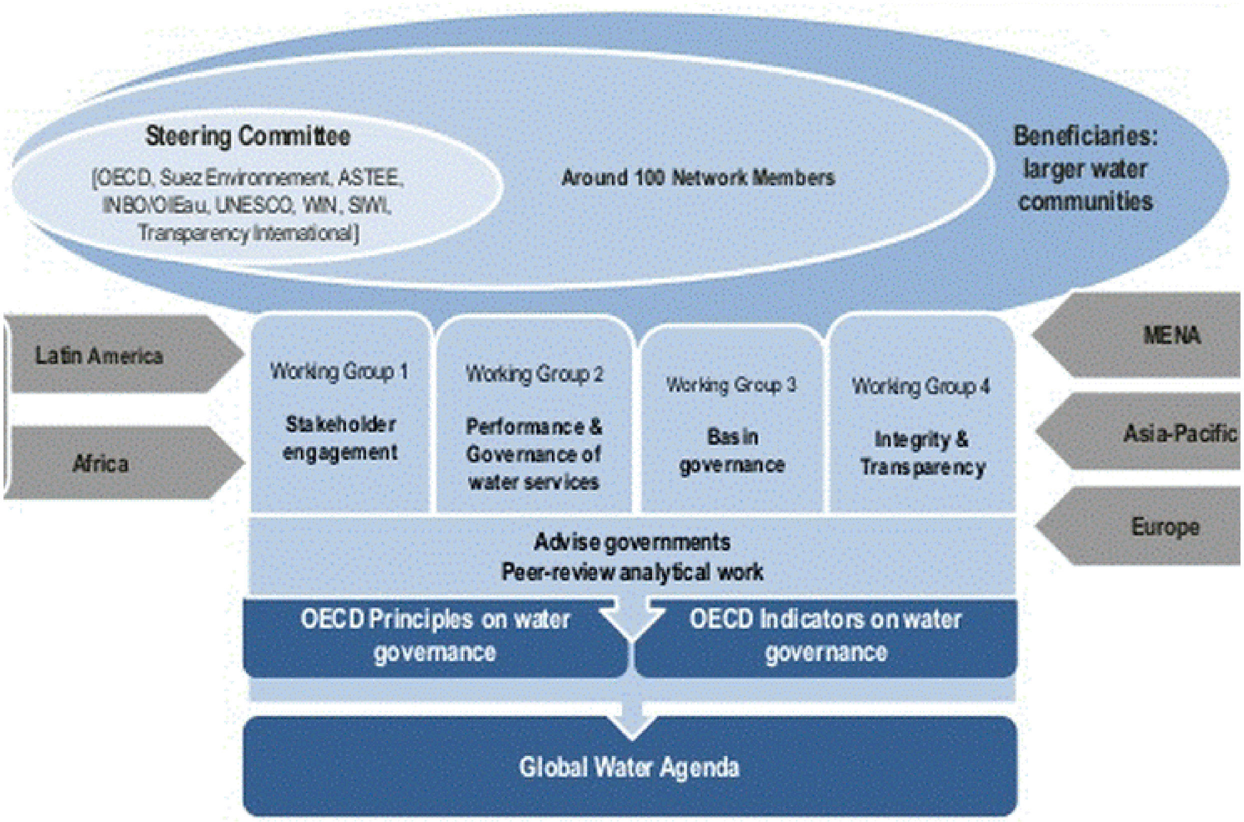
The Global Water Partnership (GWP) has sponsored several meetings and conferences regarding water security and the development of IWRM. One of these workshops, High Level Meeting on Gender Equality and Social Inclusion in Water Resources Management, will take place on 19 June 2017. The workshop will discuss the mainstreaming of gender-equality issues in water-related policies, development and investment programs with the goal of raising awareness for gender equality in environmental issues.[497] The Water Security and Climate Change Conference (WSCC 2017) aims to connect disciplines, sectors and different groups of stakeholders on the topic of water security. This conference will take place in September of 2017 and will serve as a platform for discussions towards water secure societies.[498]

- **OECD**

The OECD's Water Governance Initiative (WGI) represents an international stakeholder network composed of governments, NGOs, international organizations, and others, that gather twice a year to share information on best practices of water security, advise governments on future policies, and to provide consultations by the OECD's expert community.[499] WGI met for the 8th time in January 2017. The figure below shows the organizational structure of the Water Governance Initiative.

[495] Fraitture et. al 2013, p. 1
[496] Fraitture et. al 2013, p. 1
[497] GWP 2017c
[498] Institute for Technology and Resource Management in the Tropics and Subtropics n.d.
[499] OECD n.d.

Figure 49: OECD Water Governance Initiative Organizational structure[500]



Both the OECD and GWP hosted the Global Dialogue on Water Security and Sustainable Growth in 2013-2014. This was one of the largest conferences to discuss the issue of water security in developing economies. The dialogue brought together 40 economies to discuss the importance of water security and threats in the context of economic growth and human safety in 2015 and beyond. The conference led to three goals or policy recommendations: invest in water security, invest in risk management, and invest in knowledge, human development, and partnerships.[501]

- **International Water Resource Association**

The International Water Resource Association (IWRA) hosts the World Water Congress, which convened for the 16th time in June 2017. The goal of this conference is to collect policymakers, technical specialists, engineers, social and natural scientists. Together, the multiple stakeholders develop solutions for the multiple water challenges.[502]

- **World Bank**

The World Bank hosts the annual International Water Resource Economics Consortium (IWREC), which convened for the 12th time in 2016.[503] In attendance were individuals from the World Bank, academic community, and other international organizations. The goal of these meetings is to promote economic conversations about water-related issues, exchange research findings, and

500 OECD (a) n.d.
501 OECD/GWP 2015
502 World Water Congress n.d.
503 The World Bank 2016

discuss work done individually or as a group. The theme for the 2016 meeting was "Water Security in a Changing World" and addressed topics such as:[504]

- Urban and agricultural uses for water
- Groundwater management
- IWRM
- Financing water infrastructure
- Increasing efficiency of on-farm water use

- **World Meteorological Organization**

The World Meteorological Organization's (WMO) Commission for Hydrology and the Commission for Agricultural Meteorology have work areas in food and water coordination and hold regular conferences and other events. Australia, China, the Republic of Korea, Russia and the US are members of the WMO and regularly participate in these efforts.

- **World Water Council**

The World Water Council hosted a highly significant conference on water in the Republic of Korea in 2015.[505] The conference consisted of over 40,000 individuals from 168 economies. The meeting was under the theme "Water for our Future," and explored topics of cross-boundary cooperation, river management, and unity in water policy. This was a highly political conference and resulted in 18 memorandums of understanding, many bilateral and multilateral meetings and agreements, and the signing of strategy documents for city planning and development.[506]

E. Policy advisory/consultation

Sharing insights on a global scale regarding IWRM will accelerate progress in implementation and transfer advanced solutions and technologies from developed to developing economies. The OECD conceptualizes its role in improving water governance as a forum for economies to discuss innovative good practices and "debunk" myths about effective and ineffective policies. Aside from broader efforts to improve water governance internationally (OECD Principles of Water Governance, Water Governance Indicators), the OECD has provided assistance to several individual economies in assessing water governance institutional arrangements and suggesting improvements to policies.

The OECD has taken part in many advising situations that have led to improvements in economies' water resource management policies. For instance, OECD policy recommendations were used to help form Mexico's National Water Law and Brazil's Water Management Pact, both of which have helped the two economies preserve water security.[507] The OECD has also undertaken significant research and engagement with governments such as Mexico to analyze and make recommendations about how to improve water governance.

[504] The World Bank 2016
[505] World Water Council 2015
[506] World Water Council 2015
[507] OECD 2016b, page 8

Figure 50: OECD Mexico Study on Water Governance[508]

The MDBA in Australia has also been active in international and bilateral policy dialogues to share its expertise on IWRM. The MDBA collaborates extensively with international partners to share insights from research conducted in the Basin, lessons from the implementation of management policies and review the Authority's Basin Plan[509] and other proposed measures. Australia involves international scientists and policy experts to review the MDBA's Basin Plan.[510] The MDBA is also very active in international fora that discuss water issues, such as World Water Week, the International River Symposium, The Mekong River Commission Regional Forum, the Global Water Summit, India Water Week and APEC workshops. In the 2014-2015 period, the Authority hosted delegations from the Mekong, Pakistan, Niger Basin, Kazakhstan, Koshi Basin and Chile.[511]

International organizations can also serve as mediators in water-based conflicts between economies. The World Bank brokered the Indus Water Treaty between India and Pakistan, addressing secretiveness in water negotiations and tension between the two economies. The treaty mandates information sharing, which both parties have abided by.[512]

F. Technology transfer

In order to address global water-related issues, such as climate change adaptation and food security, economies with massive resources dedicated to research and technology development like China, Japan and the US must become active in disseminating innovations to areas where they are most needed and where there are adequate capacities for technology transfer, especially through commercial channels. International organizations are an effective medium to facilitate economy capacity building for technology transfer in these sectors, although more needs to be done to ensure awareness, infrastructure and access options to these technologies in developing economies.

[508] OECD 2012
[509] According to interview with Peter Hyde, basin plan is legally implemented but not yet "on the ground"
[510] MBDA(b)
[511] MBDA 2014
[512] Interview memo Mac Kirby

Recognizing the importance of effective water resource management, the US EPA and Singapore's National Water Agency PUB signed a memorandum of understanding (MoU) in June 2013 focusing on issues such as potable water reuse, contaminants of emerging concern, and wastewater treatment.[513]

In April 2017, China and Malaysia signed a memorandum of understanding (MoU) to facilitate the transfer of technology and expertise on water resource management form China to Malaysia. Areas in which the partnership will focus include IWRM, conservation and protection of water resources, adaptation to climate change, flood control and drought management.[514] China was also involved in a project with Bangladesh to utilize information and communication technology (ICT) to improve groundwater management.[515]

G. Capacity building

Capacity building is important to transfer the expertise gained in parts of the APEC region to areas where it is needed the most. Institutions such as the GWP and the World Bank have engaged in over 100 high-impact capacity building projects in economies around the world. For example, GWP trained the staff and stakeholders of local administration centers in Benin on IWRM and how to include water issues in local-level planning tools.[516] The training used practical applications that can be used in every village and community. This has had a direct impact on the area, as it has improved local systems' abilities to allocate water, reduced the amount of water used inefficiently, and ended the need to put chemicals in the water supply to purify it.

The GWP also assisted Myanmar after a heavy monsoon season in 2015 that affected over a million people by organization early warning training.[517] The training included individuals from the government, civil society groups, and the private sector. As a result, Myanmar was able to increase its capacity to develop an economy-wide early flood warning system.

Figure 51: APEC field trip to World Bank-funded flood control project In Can Tho, Viet Nam[518]

[513] Interview memo Sasha Koo-Oshima
[514] New Straits Times 2017
[515] Interview memo Puspa Khanal
[516] GWP 2017b, p. 17
[517] GWP 2017b, p. 23
[518] Washington CORE

4 Best practices on water management for food security in a context of climate change in APEC region

4.1 Introduction

This section reviews the water governance and management gaps that were identified as common and severe across APEC economies, and introduces principles for effective implementation of IWRM based on literature and expert interviews regarding successful strategies, initiatives and tools employed to respond to water resource challenges in APEC economies. This is followed by examples of initiatives and programs that embody the principles.

4.2 Best practice principles for water resource management and IWRM implementation

The following principles are designed to be general enough to be relevant to all APEC economies and non-prescriptive. They should be considered as a basic foundation for authorities to consider while formulating placed-based strategies to tackle the unique water, food security and climate change related challenges faced in that economy or geographic area.

Participants in the workshop and expert interviewees were also consulted. They were asked to comment and suggest additional content.

Table 8: Institutional coordination gaps and principles[519]

Gaps/Challenges	Best practice principles
Lack of clearly defined roles/ responsibilities: Cross-sectoral coordination needed for IWRM is difficult when responsibilities for water resource management are not clearly and explicitly assigned across government authorities/between levels of government. These issues can stem from the absence of legislation that mandates coordination across institutions and levels of government, and poorly defines roles and responsibilities of institutions. A lack of frameworks to develop essential components of an IWRM strategy, such as guidelines for planning, stakeholder engagement and enforcement of water policies.	**Comprehensive legislation and review of existing legal/regulatory measures:** New comprehensive legislation to codify an IWRM approach should be considered, in order to mandate activities such as communication, cooperation and sharing of information and data, as well as assign responsibilities across different bodies of government. The existing body of legislation and regulatory provisions should also be evaluated to determine how it could better support cross-sectoral integration and sustainability in water resource management for agriculture and climate change adaptation.

[519] Washington CORE 2017

Gaps/Challenges	Best practice principles
Fragmentation of roles/ responsibilities across many different ministries/agencies: Cross-sectoral integration is complicated when water-related responsibilities are fragmented across many different sectoral bodies, leading to redundancies and a lack of coordination. Furthermore, sectoral policies in these situations may be incompatible or work against each other, whereas achieving ambitious water, food security and climate change adaptation-related goals requires a high level of coordination of government activities.	**Transboundary communication and coordination:** Since creating binding legal and regulatory measures that impact multiple sovereign economies is difficult, procedures to facilitate communication and coordination among economies are necessary. Multi-economy coordination and consultation bodies can be effective at facilitating such an approach. Transboundary cooperation can be enhanced by holding regular meetings among decision-makers and technical staff, maintaining shared models of hydrological systems, implementing procedures for prior notification and consultation and seeking methods to optimize cost/benefit sharing in sustainable development. Furthermore, transboundary cooperation can enhance the implementation capacity of each individual economy through technology and knowledge transfer.

Table 9: Institutional capacity gaps and principles[520]

<table>
<tr><th>Gaps/Challenges</th><th>Best practice principles</th></tr>
<tr><td rowspan="2">Lack of communication/ coordination: In many cases, the level of communication between sectoral authorities is inadequate to form strategies to address cross-cutting water-related issues. For example, the traditional water sector (e.g. water services, wastewater, water engineering and infrastructure) may not communicate at all with the agricultural, forestry and mining sectoral authorities; hence sectoral authorities conduct actions and form policies independent of one another, and without respect to how their activities affect the other sectors.</td><td>River basin organizations: Sectoral integration and coordination can be facilitated it through the formulation of River Basin Organizations (RBOs). These allow integration of upstream/downstream concerns and target the hydrographic basin itself as a management unit. They can also serve to integrate the concerns of different sectors as well as environmental and socioeconomic issues.[521]</td></tr>
<tr><td>Central committees/coordinating bodies: Forming committees and initiatives at the economy level is also important to launch and maintain the sectoral integration and coordination needed for an IWRM approach, such as multi-sectoral ministerial councils, joint initiatives etc. Discussing these issues at a high level of authority is beneficial to securing political commitments to IWRM, food security and climate change adaptation.</td></tr>
<tr><td>Lack of institutional capacity: Technical and administrative constraints water and sectoral authorities make effective planning and management of water and food security issues difficult, while coordination and harmonization of different authorities' policies and programs is even more demanding. Highly trained technical and administrative staff plus advanced technology are not available in sufficient supply.</td><td rowspan="2">Technical staff: From the economy to the local level, governments should pursue capacity building efforts to ensure authorities are equipped with the adequate technical staff/knowledge to engage in water resource management.

Non-technical staff: Water resource authorities must recognize that water resource management is not solely a technical exercise. This requires authorities to train and recruit staff such as social scientists and communications specialists, so authorities can properly engage and communicate with communities and the public on the importance of water issues. Understanding how socioeconomic impacts of various trade-offs in water resource management are experienced by individuals is highly important to formulating popular and implementable plans and strategies.</td></tr>
<tr><td>Weak decentralization: Many economies that have attempted decentralizing water-related responsibilities from the economy to increasingly local levels have not invested enough effort and resources to ensure that local actors have the capacity to take on new water-related responsibilities and implement/enforce policies and reforms.</td></tr>
</table>

[520] Washington CORE 2017
[521] UNESCO

Table 10: Financing gaps and principles[522]

Gaps/Challenges	Best practice principles
Lack of funds to carry out water resource management activities: Many public water authorities, especially in developing economies, lack the appropriate funding to carry out even basic water resource management activities, while IWRM has even higher political, financial and human resources burdens.	**Stable, shared funding mechanisms:** Authorities must seek mechanisms to finance day-to-day operations and initiatives that are consistent, stable, and draw upon multiple sources due to the multi-sector nature of IWRM. Due to the high degree of interconnectivity between different sectors, communities and activities facilitated through water, responsibility for management, remediation and protection of water resources should be better distributed, especially in terms of finances.
	Public-private partnerships: Given the scarcity of public funds in many economies, it is necessary that projects for public benefit also involve private sector actors to share costs. This is especially necessary when public water services are deteriorating and there is a backlog of repairs and new connections.
Inability to implement and enforce fees for water services: Many economies have trouble collecting fees for water services, such as water for irrigation, which leads to difficulties in financing activities, especially operations and maintenance (O&M) of hydraulic infrastructure. Low income levels in certain farming communities make charging fees for water difficult or politically untenable, and supplying cheap or free water may be necessary to preserve rural livelihoods	**Pricing:** Pricing water to some degree should be considered to incentivize efficient use and investment in water-saving technologies, as well as a method of cost recovery for water services and infrastructure, and strategically as a tool to improve water allocation across different sectors. Water using sectors should pay for water according to economic, social and environmental criteria set by central authorities. This is especially relevant when use of water is highly inefficient and other methods of changing behavior are difficult. However, authorities must be cautious to avoid pricing small agricultural and household users out of the market, and price hikes should be accompanied by service improvements.
	Markets: Authorities may consider allowing the buying, selling and trading of water-use rights in order to allow water to 'flow' dynamically to higher value uses. However, authorities must include mechanisms to restrict buying, selling and trading as to maintain adequate environmental flows and ensure availability to household and agricultural users. Additionally, authorities must consider high transaction costs and externalities, and acknowledge popular skepticism of water markets privatization. Furthermore, water markets may be inappropriate in areas with low incomes and dependence on water for livelihoods. Measures should be included to discourage speculation on water resources.

[522] Washington CORE 2017

Table 11: Technical and technology gaps and principles[523]

Gaps/Challenges	Best practice principles
Outdated technology in water and agriculture sectors: These sectors can be slow to adopt new technological innovations, meaning that industries can be dominated by outdated processes that are less efficient and/or wasteful. This can be especially challenging when there is no direct economic cost for wasting water, meaning there is little to no incentive to invest in water-efficient technology and techniques.	**Crop diversification:** Economies should experiment with programs and incentives for farmers to diversify what they cultivate. This is especially relevant in areas where mono-cropping of water intensive crops is prevalent. This should be pursued both as a measure to increase water efficiency, as well as increase farmer incomes, insulate them against price fluctuations and increase their resilience to climate change.
	Promising technologies and innovations that economies should consider include: **Big data and advanced analytics for decision support systems (DSS**): Collecting large amounts of water and agriculture-related data, and creating tools to analyzes it to produce useful insights, could significantly increase institutional capacity to target initiatives and resources towards high-stress areas, as well as in formulating long-term plans of action **Precision agriculture**: integrating sensors, Big Data analytics, geomapping and other technologies to collect, store and analyze data to produce insights for farmers on when and where to apply specific amounts of inputs (water, fertilizer, seeds etc.)- these technologies significantly reduce the inputs needed for agriculture, including **Water-energy nexus technologies:** any technology that reduces the water intensity of electricity generation across the entire supply chain, and vice versa (using less energy to deliver water services), such as solar water pumps - these technologies provide concrete benefits in terms of resource conservation while making the interconnectedness between sectors more evident **Advanced wastewater treatment:** technologies such as membrane filtration should be implemented to allow more efficient treatment and reuse of water for drinking, domestic use and agriculture- these technologies reduce environmental pollution, increase sanitation while also conserving water resources

523 Washington CORE 2017

Gaps/Challenges	Best practice principles
Deteriorating infrastructure: Water supply and irrigation infrastructure in APEC suffers from a lack of investment, even in advanced economies. Additionally, many deficiencies exist in terms of the arrangements to finance operations and maintenance (O&M), leading to long backlogs of deferred maintenance.	**Water storage:** Economies should invest in large and small-scale water storage infrastructure to address temporal (seasonal) issues with water availability. Water storage infrastructure can serve multiple purposes, such as integrated systems for flood drainage and irrigation, and drinking and cooking supplies. Rainwater storage is also a cheap way to alleviate water stresses faced by households in arid areas, or areas with dry seasons. This is especially relevant due to rainfall concentration in the wet season due to climate change.
	Irrigation efficiency enhancements: Economies should invest in modernizing irrigation systems, both on-farm and off-farm. There are wide range of potential technical enhancements at the farm level to reduce water waste and improve efficiency. Improvements can be made to off-farm irrigation networks to enhance efficiency and improve management. Water saved through these measures can be returned to the environment or used to support other irrigation projects.
Informational asymmetry: Many APEC economies face challenges in studying the water situation, such as environmental flows, quality and groundwater, as well as challenges in monitoring withdrawals and discharges from commercial and agricultural users. When monitoring of water resources and weather is not conducted properly, or data is not actively shared among authorities, different levels of government and stakeholders, informational asymmetries lead to issues in making efficient allocation decisions and identifying problems, as well as coordinating responses.	**Monitoring and decision support networks:** Economies should make significant investments in establishing or enhancing monitoring and decision support networks for water resources, including hydro-meteorological monitoring stations, data infrastructure and analytics tools. Data on socioeconomic activities and infrastructure should be integrated into models. This is necessary to allow an adaptive management approach that can change strategies based on an understanding of current hydrological conditions, and the range of environmental and socioeconomic factors affecting it, as well as monitoring climate change impacts. Authorities should also develop methods to monitor the use of water by households, industry and other authorities. This should include withdrawal, consumption, diversion, discharge and water quality attributable to individual households, industrial/commercial facilities etc. Monitoring should be accompanied by legal/regulatory measures to hold users accountable for their use and/or pollution of water. These can include fees, penalties and quotas for water withdrawals and discharges.
Lack of assessment/ evaluation: In order to understand the consequences of new policies, and the deployment of new management instruments, tools and technologies; it is essential to have data on the impact of these changes on hydrological systems.	**Science-based allocation plans:** Allocation plans for water resources must be based on scientific assessment. Comprehensive basin-wide studies are an effective way to establish a baseline to inform water allocation plans and withdrawal/diversion/consumption limits. Allocation plans should be based on equitable access and prioritize uses most essential to public wellbeing.

Gaps/Challenges	Best practice principles
Monitoring and information capacity is essential for this purpose, and to monitor the effects of climate change and suggest adaptation measures to secure water resources and food supply.	**Collaborative modelling:** A collaborative approach to modelling should be pursued whenever possible to increase understanding and uptake of the models' conclusions by decision-makers and stakeholders, while also providing modelers with a more social perspective and helping them better investigate the concerns of stakeholders in modelling activities. This can also allow modelers to better demonstrate the trade-offs of decisions across different groups of stakeholders.

Table 12: Stakeholder engagement gaps and principles[524]

Gaps/Challenges	Best practice principles
Difficulty generating bottom-up demand/support for water reform: Authorities face difficulties in generating support and a sense of urgency to execute reforms when stakeholders are not included in the process or equipped with the knowledge to participate. Without a sense of urgency and demand for reform, water users will be reluctant to change their practices as many do not feel immediate consequences for their misuse of water resources. Additionally, private entities with a large water footprint and significance to food security, such as large agro-food companies, are not sufficiently involved in initiatives to bolster food security and use water more responsibly.	**Commitment:** To be effective, stakeholder engagement must be a long-term, genuine commitment of public authorities. This requires a significant investment of resources and staff. Authorities should not treat stakeholder engagement as an obstacle, but rather an opportunity to create genuine participation and engagement; and invest resources appropriately. Furthermore, authorities should clearly define the objectives of stakeholder engagement.
Lack of capacity/knowledge to take on new responsibilities: Community and private sector participation is generally limited in water resource management and initiatives to implement IWRM, due to a lack of knowledge and understanding of communities and business of water resource management and a lack of outreach by water resource management institutions. IWRM also requires stakeholders to be more active in water resource management at the local level, which requires capacity building and education.	**Capacity building and education:** Stakeholders should be trained and educated to understand the importance of an integrated approach to water resource management in order to form a more holistic perspective of water in light of socio-cultural, political, environmental and economic considerations. Additionally, IWRM requires that stakeholders at the local level assume a more active role in water resource management, so scientific and leadership skills are also beneficial. University extension services and research could play a key role in capacity building for stakeholders, especially agriculture producers.

[524] Washington CORE 2017

Gaps/Challenges	Best practice principles
Exclusion of vulnerable/ disadvantaged groups: Vulnerable and disadvantaged groups, whom are often the most directly affected by water policy and management decisions, are often not included or lack access to the consultations and meetings of water authorities. In some cases, these groups may have intimate knowledge of local hydrological conditions which would be beneficial to include in the decision-making process.	**Stakeholder mapping:** The first step in stakeholder engagement in water resource management is to map all affected stakeholders, as well as their roles, motivations and behavior. This review should inform the overall stakeholder engagement strategy through analyzing the concerns of different areas and sectors of the economy and population. This analysis should occur both horizontally and vertically to capture all affected authorities, community members and sectors, as well as economy to local bodies.
Consultation capture: The most vocal and privileged groups can dominate the stakeholder engagement process; hence their concerns become overrepresented in the consideration of stakeholder views. This may lead to a certain economic sector benefiting from access to water at the expense of nearby communities. The combination of exclusion of vulnerable groups and consultation capture can lead to distrust of authorities and the proliferation of water conflicts.	**Inclusivity, representativeness:** Special care should be taken to ensure stakeholder engagement is inclusive and representative of the diverse range of stakeholders. Meetings should be frequent and accessible, and provisions should be made to include vulnerable and disadvantaged groups. Non-discriminatory and participatory decision-making processes are essential. ICT platforms, social media, virtual meetings and other methods can contribute to a more accessible process. Authorities should monitor consultations and meetings to discourage "consultation capture."
Limited technical/engineering base for planning: Water resource plans are often formulated from an exclusively technical/engineering standpoint, which leads to the neglect of human and social concerns. Social scientists and economists are not often employed by water resource authorities to assess the impact of water resource decision-making on communities. Without this type of staff, managing the numerous layers of stakeholders, trade-offs, conflicting priorities and competition surrounding water resources is difficult.	**Communications:** To create a sense of urgency and responsibility among stakeholders about water issues, food security and climate change adaptation, authorities should design and employ sophisticated communications strategies. It is essential these issues be communicated to the public in a way that is relevant to them, and that presents them with opportunities to become engaged, participate in initiatives and make their voices heard. **Seek involvement of highly influential stakeholders:** Authorities should make efforts

Gaps/Challenges	Best practice principles
Difficulty engaging local government stakeholders: Local governments who have become accustomed to the same water-related practices over decades are often reluctant to change their practices to align with something as complex and costly as IWRM implementation.	to engage stakeholders with a high level of influence, whether it be over public discourse or large industrial sectors. The involvement of Presidents, Prime Ministers and other power figures can advance public discourse around IWRM, food security and climate change, while securing a high level of political commitment to initiatives. Furthermore, stakeholders such as large agro-food companies and other industrial sectors should be involved to explore how corporations can support initiatives through providing assistance or changing their practices.
Assessment and evaluation: Stakeholder engagement efforts often suffer from a lack of assessment of results, meaning valuable insights on how to improve future efforts are lost.	**Integrity and transparency practices:** Trust and transparency in the stakeholder engagement process is essential in securing the support and participation of stakeholders. Authorities must employ integrity and transparency frameworks to ensure this, such as legal and institutional frameworks that create accountability for authorities and stakeholders. Evidence-based assessment of policies, and frequent public debate can also contribute to this.
	Assessment and evaluation: Evaluation of stakeholder engagement processes is essential to draw lessons, manage risks and strengthen accountability. Authorities should develop frameworks for evaluation and use indicators.

4.3 Best practices/guidelines: experiences

This section presents a sampling of successful experiences that embody the principles for effective water resource management and governance in the section above, as identified during through literature, interview and survey research, as well as the First APEC Water Authorities Meeting.

4.3.1 Institutional coordination

The Murray-Darling Basin Authority, Australia: An effective institutional arrangement for IWRM in the Murray-Darling Basin, an incredibly significant river system in southeast of Australia for the economy and environment, was established to respond to challenges of degraded water resources and disagreement over responsibility for remediation and authority over allocation. The Murray-Darling Basin Authority was created in response to institutional issues and difficulty reaching consensus between State governments and the Commonwealth (federal government) such as:

- Resistance to further land clearing controls by State Governments
- Increasing conflict over who should pay for remediation of degraded common resources

- How to best mobilize and target the use of available resources for on-ground action and
- How to address poorly specified institutional arrangements for common property resource management.

The Murray-Darling Basin Authority (MBDA) has since effectively coordinated the efforts of the Commonwealth government, state governments and communities through its institutional arrangements and coordination mechanisms to better deal with these challenges in managing the Basin's water for competing agricultural, urban and industrial uses. Several intergovernmental committees help to bridge communications. The Ministerial Council (Water ministers from each Basin State) meets three to four times a year, the Basin Officials Committee (other selected officials from each Basin State) meets every two months. There is also a series of other committees which meet more frequently to sort out more granular and local details, such as the Basin Communities Committee (a point of contact for MBDA with expertise or interest in community, water use, environmental water resource management, Indigenous or local government matters). This apparatus coordinates to form the master plan for the Basin's water resources, which is then reviewed and approved by the Commonwealth Water Minister.

These institutional mechanisms contribute to the formation of the Basin Plan, which is a master plan for the allocation and management of the Basin's water resources. The MBDA has employed tools such as a comprehensive basin study to determine the maximum sustainable yields of different parts of the system, which led to the creation of the Sustainable Diversion Limits (SDLs). The SDLs are limits on the amount of water that can be withdrawn for consumptive use, such as industry, agriculture and other human use, which will go into effect in 2019, allowing users to voluntarily lower consumption in anticipation. This science-based approach, combined with its institutional arrangements, allows the MBDA to effectively allocate water resources to maintain ecosystem integrity as well as economic prosperity.

The Mekong River Commission (MRC): The Mekong River Commission (MRC) is an inter-governmental organization consisting of Cambodia, Laos, Viet Nam and Thailand; which discusses and consults on water issues and developments in the Mekong Basin. It is largely focused on fostering cooperation among the member economies and addressing governance issues related to transboundary water concerns. It has no regulatory role. The MRC has successfully established a technical basis and political structure for the discussion of sensitive transboundary water issues. This involves sharing experiences of successful attempts and limitations of water initiatives in each economy, such as the multiple pilot studies on water resource management. The governments of these economies also collaborate to form agreements that promote regional cooperation. The CEO of the MRC coordinates with the head of the department in charge of water resource management in each economy.

The MRC's strategy provides an integrated basin perspective for assessment and improvement of economy plans.[525] Two key tools in this process are: the Basin Development Strategy, which brings together the plans for each economy into a single document to highlight what the possible impacts and benefits of development could be; and the prior consultation process, which the MRC uses to encourage economies to take actions to prevent and mitigate negative impacts to the system.[526]

Participation in the MRC is a key governance mechanism for IWRM through which Viet Nam is furthering awareness of transboundary water security-related issues in the Mekong River. With

[525] MRC 2016, p. 4
[526] Interview memo Pham Tuan Phan

agreements among the economies involved in the MRC to share information and data, Viet Nam is able to accurately evaluate the situation in the Mekong and how the activities of upstream economies affect its water resources.[527] The MRC has also fostered cooperation between Viet Nam and Cambodia through different methods, including the development of a jointly owned trans-boundary hydrological model and the establishment of a data-sharing mechanism.[528]

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4.3.2 Institutional capacity building

Peru and World Bank institutional capacity building for IWRM: With the support of the World Bank, Peru has advanced significantly in building the technical and administrative capacity of its National Water Authority ANA, as well as that of regional Administrative Water Authorities, and Local Water Authorities. Peru has also established several Water Resource River Basin Councils, as well as a Water Culture program, to engage with and build capacity among communities and other stakeholders. Capacity building among these bodies has allowed Peru to make significant advancements in the implementation of IWRM.

The World Bank has supported Peru for a decade with the development of IWRM strategy and institutional capacity through projects and long-term programmatic engagement with the Peruvian water sector through technical assistance, advisory services and investments.[530] In 2009 the Integrated Water Resource Management Modernization Project (IWRM-MP) was launched, funded with two US$10 million loans from the World Bank and Inter-American Development Bank (IDB) respectively, plus US$20 million from Peru. The project supported development of IWRM practices, with legal and institutional frameworks for IWRM successfully implemented in six pilot river basins, which prepared participatory IWRM plans.[531] The World Bank also assisted with the implementation of the 2012 National Water Resources Policy by pursuing IWRM through the strengthening of ANA at the central and river basin levels.[532] The new 2018 World Bank project will continue to improve IWRM in Peru.

4.3.3 Financing

Caribbean Wastewater Revolving Fund (CReW): CReW is a four-year project that was launched in 2011 to develop regional financial mechanisms in the provision of water infrastructures with the Inter-American Development Bank (IDB). It is an integrated and innovative approach to reducing the negative environmental and human health impacts of untreated wastewater discharges. At the regional level, it has catalyzed a unique partnership between the

527 The agreements were the 2006 Procedures of Water Quality (PWQ) and 2011 Procedures on the Maintenance of Flow in the Mainstream (PMFM), which were developed under the Global Environmental Facility (GEF)-funded Water Utilization Project. See The World Bank 2013, p. 3
528 The World Bank 2013, p. 4
529 Interview memo Hans Guttman
530 The World Bank 2013, p. 13
531 The World Bank 2017, p. 11
532 The World Bank 2017a, p. 11

IDB, the United Nations Environment Programme (UNEP) and the Secretariat for the Cartagena Convention. At the economy level, project implementation is further supported by partnerships between wastewater utilities, the Ministries of the Environment, Finance, Health, Education, and local communities.

It is utilizing four different financing modalities based on the successful revolving fund project of the US EPA (Clean Water State Revolving Fund) for pilot projects in Jamaica, Belize, Guyana, and Trinidad & Tobago. A revolving fund is one meant to finance an organization's continued operations through replenishing funds as they are withdrawn. The project is also utilizing Credit Enhancement, by which the state borrowers take measures to improve their credit worthiness, while the Guyana project is utilizing a public-private partnership.

Water markets in Australia: Water markets in the Murray-Darling Basin of Australia are designed to allow water to flow where it will be used most productively. The system is based on a 'cap and trade' system, where the cap is a limit on the total pool of water for consumptive use, which is distributed based on water rights administered by Basin states. There are two types of water rights that are tradeable: rights to an ongoing share of total amount of water available in a system (water access entitlements); and rights to the actual amount of water available under water access entitlements in a given season.

Water is distributed against entitlements in response to factors such as changes in rainfall or shortages to provide certainty to users on the amount of water they will receive. Users determine whether to buy or sell their water at a particular time, with the price reflecting demand and supply factors. Prices also vary by region, type of water right and time of year. There are designated interstate trading zones of the Murray-Darling Basin; each numbered zone can only trade to certain other zones and in certain quantities in order to ensure sustainable management of the system.

4.3.4 Technical and technology solutions

Water seeding and harvesting, Peru: Water seeding and harvesting using local knowledge has been successful in highland watersheds of Peru. Community members pool their ancestral knowledge to respond to climate change. The creation of simple reservoirs, which requires little investment in material and labor, allows families and communities to store water and recharge aquifers which have become dangerously depleted in certain basins of Peru. These initiatives have contributed significantly to increasing farmer incomes, increasing resilience to climate change and conserving scarce water resources.

'IWRM in Vietnam' project planning and decision support tools: Since 2007, a joint research project called Integrated Water Resource Management Viet Nam, funded by the German Federal Ministry of Education and Research (BMBF) in collaboration with the Vietnamese Department of Water Resource Management, has been developing Planning and Decision Support tools for IWRM adapted to the Vietnamese context. The project is exemplary in that it has developed a tool to provide an integrated perspective of water and land use; and uses the tool to inform local level activities and implementation of IWRM measures. The tool incorporates data on water quantity and quality to identify Water Management Units (WMUs) with high risk. The goal of the project is to develop a concept for integrated consideration and analysis of water resources, water demands and land use. The project objectives are to develop planning and decision support tools, as well as adapt water technology on the local level (drinking water, municipal and industrial wastewater).

The project involved activities at five levels: At the international level activities on sharing international experiences and guidelines for IWRM; economy-level activities by Vietnamese authorities to identify river basins with substantial problems; river-basin level activities to identify high-risk WMUs using a GIS-based evaluation of spatial and statistical information; WMU level investigations (field investigation of water balances, water quality, wastewater quantity) to identify locations for specific IWRM measures; and local level activities to plan and implement IWRM measures (monitoring, water supply, wastewater treatment) for priority areas.

Methodology for implementation of advanced agricultural technology (AgTech): The California-based agricultural technology promotion firm, AgTech Insight, has developed a methodology for promoting adoption of advanced agricultural technology at the economy level. Technologies should be easily understandable and usable by everyone on the farm, regardless of skills and education, address issues on the farm such as water and other input efficiency and produce a return on investment.

The first step is talking to engaged entities, such as trade associations and governments to ascertain who can help integrate technology, what technologies are currently employed and 2-3 regions/crops to focus on. Next, targets in each region should be visited to implement a baseline technology plan and develop a five-to-ten year integration plan with options specific to each region and benchmarks to monitor progress. Included in this process is establishing a training structure to assist adoption by growers, and to establish an agricultural technology dealer network as a place for growers to go for all their agricultural technology needs, including continued support to achieve maximum benefits from investment.

ICT smart cards for Irrigation in Bangladesh: A pilot project in Bangladesh, administered by the United Nations Food and Agriculture Organization (FAO), has experimented using refillable cards that farmers use at a card reader/meter to receive irrigation water for their crops; the system is completely on-demand and at the control of the farmer to support crop diversification and expansion. The system is also completely transparent, allowing for monitoring of water withdrawal for the purpose of enforcement of tariffs and quotas. Installation has only a nominal incremental cost, and no incremental cost in system operation and maintenance.

The introduction of these cards has led to significant benefits, such as a more than 50 percent reduction in irrigation costs to farmers, and a 66 percent increase in cost recovery. Furthermore, farmers have also increased the irrigated area served by each electronic groundwater pump, and significantly reduced total water withdrawal. Furthermore, the social acceptance of the card has been largely positive.

iWater Project, Chinese Taipei: The iWater Project is an integrated, innovative and intelligent irrigation water management system. It applies information, communication and engineering technology to support an intelligent and systematic management for irrigation. It is administered by the Council of Agriculture and helps to cope with issues such as: an aging society; a lack of staff and time; and the need for water resources efficiency.

4.3.5 Stakeholder engagement

IWRM Implementation in Chao-Phraya and Yom River Basins, Thailand: This project sought to engage stakeholders through regular meetings. The process of organizing meetings with real participation from all stakeholders and key line agencies created opportunities for frank exchange and cooperation. There was significant awareness raised regarding IWRM and the adaptive management approach as opposed to the more conventional water development practices, leading to the emergence of water resource management innovations. The creation of the Network of Sub-districts located along both banks of the Yom River facilitated the formation of a large group of stakeholders who share similar concerns and ideas; and are committed to addressing priority problems using local knowledge in managing water resources. At the same time, it allowed implementation of activities and projects in a more coherent manner from upstream to downstream. Education and capacity building were also a large part of the success of these initiatives.

The Yom river basin project provided training programs for staff in the region to allow them to be more responsive change agents for the area. They also created a simple database from simple maps provided by each sub-district to prepare a practical information system, which stakeholders can understand and use. An information center was also created as a training facility for various stakeholders on water resources. Furthermore, a flood warning system was created, as flooding of the Yom River is one of the problems in the area during the wet season, which led to the training of volunteers in water resource monitoring.[533]

This project increased the engagement of relevant stakeholders and resulted in a plan of action that reflected their interests. Once implemented, it yielded significant benefits towards addressing upstream and downstream issues, building capacity and creating an information system for water resources for highly beneficial applications to protect livelihoods like flood warning.

[533] Anukularmphai 2013, p. 11-12

5 Conclusions

The challenges facing the APEC region related to water resources will become more serious and complex as climate change advances and economic development progresses. IWRM allows the exploration of these interdependencies between sufficiently available and clean water resources, ecosystem integrity, agriculture and food security, individual livelihoods, industry and energy in a holistic manner. The hydrological cycle and human development facilitate the extreme level of interconnectivity between these factors, necessitating an integrated approach to the management of water resources.

Despite similar anxieties related to water resources and food security, the way in which this stress is felt by populations is highly variable based on geographical, economic, social and political factors. Water governance and institutional arrangements for water resource management are also highly variable and are subject to continuous reform. The unique circumstances of water resources and water governance in each economy means that the dialogue of IWRM must focus on how its principles can be actualized optimally in different contexts to respond to the prevailing water stresses faced by populations. The dialogue surrounding this research study and the workshop is essential for sharing and learning from challenges and solutions to water governance and management. The maintenance of such a dialogue will hopefully facilitate the successful implementation of such an innovative and ambitious approach of IWRM.

There is no universally functional or ideal model for water governance, as they depend on the unique institutional and social context of each economy, and each arrangement has advantages and disadvantages. Although, a universal principle should be that legislation must clearly define roles and responsibilities of federal ministries related to water resources and food security to empower them to employ the necessary measures to manage water resources for optimal outcomes. IWRM requires coordination among numerous sectors such as water, environment, agriculture, industry, energy and households, and this is only possible with comprehensive and harmonized action.

It is clear that the pressures on water resources and food security are felt by water resource authorities in the APEC region, as evidenced by the participation of many APEC economies in the First APEC Water Resource Authorities Meeting. The wide variety of water resource management challenges and approaches highlighted the complexity of IWRM. Due to varying levels of economic development, not all economies have the human, financial, technological and managerial resources to implement IWRM. International partnerships, assistance and continuous engagement can potentially fill this gap by promoting transfers of knowledge, resources, technology and expertise in the areas of water resource management, food security and climate change adaptation. Considering these are global threats, it is in the best interest of all APEC economies to participate in a proactive manner.

Engagement of an ever-wider group of stakeholders is necessary to support an IWRM approach, which requires long-term and focused efforts on the part of public authorities. This will become increasingly important to mitigate water resource disputes as scarcity becomes more severe. Stakeholder engagement must also empower individuals with an understanding of how water resource management affects their livelihoods to facilitate participation in water resource planning, as well as with tools to better conserve water in their daily lives. It will become increasingly important for water resource and food security experts to demystify their disciplines and explore social science methods to engage the public, as research findings indicate that water resource management is often treated as an exclusively technical exercise. In reality, water resource issues are intensely political and intertwined with culture and individual beliefs.

However, this is not meant to detract from dialogue on the technical and technological side of water resource management, as the prospects for IWRM are dim without the proper knowledge, management instruments, infrastructure and technology. It is essential to understand how hydrological systems respond to human activities and changing climate, and for this reason, interviewees and literature sources repeatedly highlighted the importance of monitoring and decision support systems for water resource management. These range from hydro-meteorological monitoring of entire river systems to allow long term assessment of factors such as maximum sustainable yield, water quality, environmental flows and various impacts of climate change, to on-farm networks of sensors providing detailed information to farmers on soil, weather and crops to increase productivity. It is essential that all levels of water users, from the decision-making bodies for a whole region, down to family agricultural producers, are empowered with the tools to use water more efficiently and responsibly and contribute to enhanced climate resilience and global food security.

The First APEC Water Resource Authorities Meeting confirmed that the conversation surrounding water resource management and governance, IWRM, food security and climate change adaptation initiated by Peru is essential and concerns many cross-cutting issues that warrant continued discussion and engagement among APEC economies. It was suggested that this dialogue be institutionalized within APEC, especially to help promote consistency among representation from each economy

Speaker presentations show that APEC economies are struggling with a wide range of issues related to water resource management, food security and climate change adaptation. Aside from the physical issues with water endowment and climate change, issues with water governance were continually identified as the most significant obstacles, especially issues of fragmented roles and responsibilities across authorities, a lack of coordination among authorities responsible for different sectors and a lack of resources and expertise to implement ambitious policies at the local level.

Further discussion is necessary to build on the achievements of the workshop and examine each issue in greater depth. Based on participants' comments, the dialogue started in this workshop should be formally transformed into a multi-year project spanning at least three years to allow a more profound exchange of ideas and track the implementation of enhanced water governance and management in APEC. Furthermore, these issues warrant an active and continued discussion, and mechanisms to facilitate this dialogue in between formal events should be implemented.

Figure 52: First APEC Water Resource Authorities Meeting, 18-19 August 2017 Can Tho, Viet Nam[534]

[534] APEC

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