MANAGING WATER SCARCITY IN ASIA AND THE PACIFIC REGION

Trends, experiences and recommendations for a resilient future

Food and Agriculture Organization of the United Nations

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About the Authors
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1. Highlights

- **Water scarcity refers to an imbalance between freshwater supply and demand in a given domain (e.g., a country, region or river basin) where demand exceeds available supply under prevailing institutional arrangements and infrastructure. Signs of water scarcity include unsatisfied demand, tensions and competition for water between users; over-extraction of groundwater; and insufficient environmental flows (Food and Agriculture Organization of the United Nations [FAO], 2012).**
- **Asia and the Pacific region encompass several countries across four climate zones**: arid, cold, tropical and temperate. It is home to a rapidly growing population of approximately 4.3 billion people (United Nations Entity for Gender Equality and the Empowerment of Women, 2013) and has highly variable water scarcity risks.
- **The region is undergoing significant development. While there is growing economic diversification towards industrialisation, agriculture remains a key source of employment and domestic food security, making Asian and Pacific societies vulnerable to water scarcity.**
- The agricultural sector's dependence on freshwater for production, which accounts for 70 per cent of global freshwater withdrawals and over 90 per cent of its consumptive use, places strain on local hydrological systems in many areas of Asia and the Pacific region.
- **There are significant regional differences in water scarcity profiles** that vary from absolute scarcity in arid and semi-arid regions to seasonal or interannual scarcity. Various types of water scarcity, such as too little water, overutilisation, too variable water or poor water quality, threaten to undermine the development progress of recent decades.
- **The region's population living under high or severe water scarcity grew from** 1.1 billion to over 2.6 billion between 1975 and 2010. For green-blue water scarcity, there was an increase from approximately 0.2 billion to nearly 1.5 billion people over the same period.
- **Seasonal water scarcity predominates during the dry season** in monsoonal, wet tropical and subtropical countries. Absolute scarcity is evident in Java, with hotspots in Central Viet Nam, Hanoi and Ho Chi Minh City, and fast-growing cities like Kathmandu. Nepal and Myanmar experience economic scarcity due to insufficient investment in water storage and supply infrastructure to meet dry-season demands.
- **Groundwater over-abstraction is rising** in some areas, including Bangladesh; the Central Highlands and central Mekong Delta in Viet Nam; the central Dry Zone and coastal cities of Myanmar, Jakarta; and some cities in Java.
- **Water quality is declining rapidly** across the region due to agricultural and urban runoff. Natural arsenic and fluoride contaminate groundwater resources in some countries, such as Bangladesh and Nepal. Salinity threatens Fiji, Central Myanmar, Thailand, Viet Nam, Australia and coastal Bangladesh.
- **Countries across the region can be placed along four key stages of a trajectory of water management:** (1) state-led irrigation development (e.g., Fiji); (2) multisector development (e.g., Lao People's Democratic Republic, Myanmar, Nepal, Cambodia and Bangladesh); (3) integrated water resources management (e.g., Viet Nam, Indonesia and Thailand); and those moving towards (4) sustainable water management (e.g., Australia).
- **Water scarcity management varies across the region**. Despite having well-developed, high-level regional and national water laws and policies, implementation and compliance are weak for many reasons, including insufficient resources and capacity, conflicting economic incentives and goals, corruption and insufficient intent within governing bodies.
- **Water quality issues need attention and political commitment** through integrated planning and investment in city wastewater treatment and pollution regulations for industry and agriculture.
- **Countries not yet facing severe water scarcity could establish frameworks for water-sharing** and management, including water accounting, safeguarding environmental flows and formal allocation processes, before overallocation occurs and climate change amplifies scarcity issues.
- **Asian and Pacific countries with water scarcity require long-term, well-informed policy planning**, consensus-building on best approaches, consistent effort and regular adaptation of strategies.

2. Managing water scarcity in Asia and the Pacific region

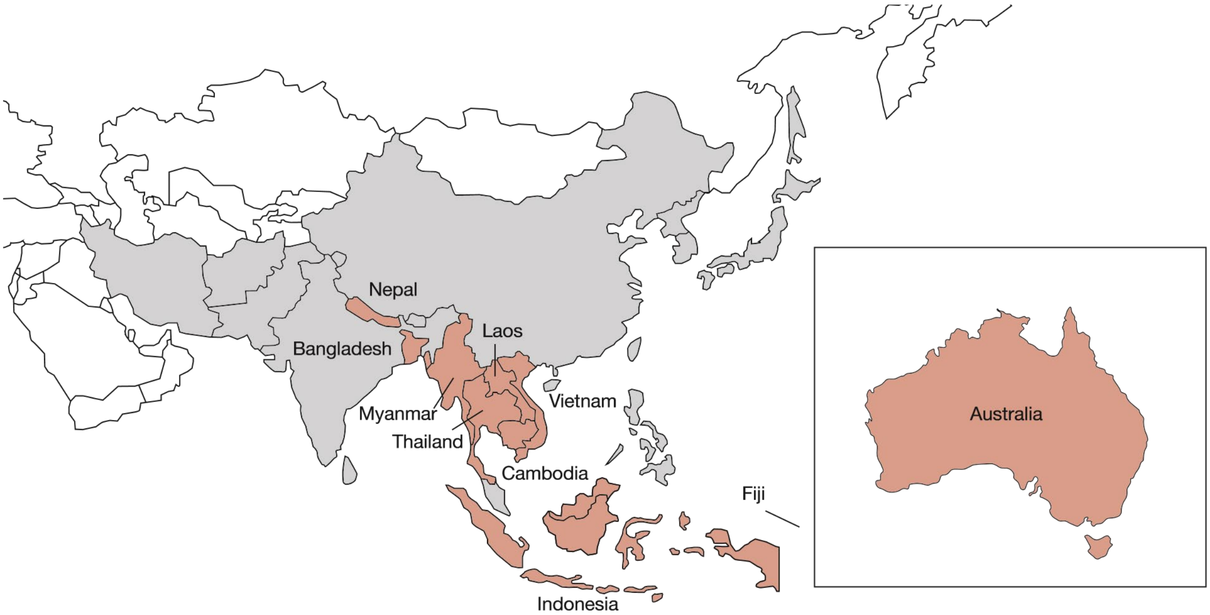

Figure 1. Asia and the Pacific region (in grey), with the 10 countries studied highlighted in orange.

In Asia and the Pacific region, water resources form the basis of agrarian prosperity and economic development. However, increasing water demand due to population growth, rapid industrialisation, urbanisation and a changing climate undermine those water resources. Like many parts of the world, Asia and the Pacific region faces increasing water scarcity, with varying characteristics, causes and trends across a diverse range of countries at different stages of development.

Our understanding of the spatial and temporal differences in water scarcity across the region is limited. While policies and management strategies are under development in all countries, their effectiveness varies significantly. Responses to water scarcity are often for acute issues, such as drought or conflicts between competing water users. While regional and national level policies exist in most cases, they often lack subsidiary legislation, program development or the resources needed for successful implementation.

The main objective of the present study was to understand the dynamics of water scarcity across Asia and the Pacific region and how countries manage that scarcity. This work will ultimately inform more effective management approaches that can be scaled across the region.

Specifically, the study aimed to:

1. Provide insights into (i) water scarcity policy targets in water resources management, agriculture, water development, urbanisation, and urban and industrial development; (ii) information related to water rights; and (iii) emerging policies and practices on environmental flow and provision flows.
2. Reveal options, commonalities and differences in the institutional structures, legal underpinning, instruments and possibilities for improvement and exchange of approaches between countries
3. Highlight the features of water accounting, water allocation provisions and any caps employed in managing water scarcity in the region.

To characterise the nature of water scarcity across the region, we examined the spatial and temporal patterns of water scarcity over the last five decades. We then selected 10 countries reflecting a wide range of climate and landforms across the region: Bangladesh, Nepal, Cambodia, Viet Nam, Thailand, Myanmar, Lao People's Democratic Republic, Indonesia, Fiji and Australia. We reviewed each country's historical and contemporary approaches to managing water scarcity and examined what did and did not work (see Figure 1).

The country-level analyses were used to develop a realistic framing of governments' strategies to manage water scarcity. The country profiles included a formal analysis and review of 10 or more policy instruments across all water-using sectors concerning the management of water scarcity. National policymakers were also interviewed to provide additional insight and context.

Finally, we extrapolated from these experiences to summarise pathways for water reform. We sought to understand what best practices of water scarcity management could look like and how countries could utilise these best practices to improve their water scarcity management strategies and avoid the mistakes and missteps of others.

The structure of this report is as follows. It:

- introduces the concept of water scarcity and the regional patterns and trends across Asia and the Pacific region;
- presents case studies of 10 countries, detailing their water scarcity profiles and water scarcity management approaches;
- examines possible trajectories towards sustainable water management;
- proposes best practice guidelines for policy; and
- describes overall outlooks for the region.

The study was conducted as part of the Asia−Pacific Water Scarcity Program, run by FAO. The program's overarching objective is to prepare Asia and the Pacific region's agriculture sector for a future of increasing water scarcity by improving how government and non-government actors manage water scarcity and its implications for food production and rural prosperity. It seeks to provide countries in the region with a pathway towards sustainable social and economic development by providing tools for achieving food and water security. The program focuses on the sustainable use of water and the changes being forced on agricultural water use in response to drought, rising demands from other sectors and the continuing imperatives for food security and ecosystem health.

In addition to this report, a summary has been developed for policymakers published by the United Nations Food and Agriculture Organization in partnership with the Australian Water Partnership. The policymakers summary draws policy, regulatory and planning lessons on what has worked, and what needs to be improved, to mitigate the risks of water scarcity for a water-secure and resilient Asia-Pacific (FAO & AWP 2023).

The findings of this study support the realisation of the Asia–Pacific Water Scarcity Program's long-term goal of sustainable use of water resources in all countries in Asia and the Pacific region and the achievement of the United Nations' (UN) Sustainable Development Goals relating to water access, poverty reduction and food security. **Mitigating and managing water scarcity will require long-term and well-informed policy planning, difficult consensus-building on best approaches, consistent effort and regular adaptation of strategies when required. Every country mentioned in this summary must act now to address sustainable water management, scarcity and challenges.**

3. Water scarcity in Asia and the Pacific region

3.1 What is water scarcity?

Water scarcity refers to societal water requirements exceeding the amount or quality of water available for these purposes (Alcamo & Henrichs, 2002; Falkenmark et al., 1989; FAO, 2012; Vörösmarty et al., 2000). Ultimately, it comprises two key dimensions: water availability (supply and access) for a specific purpose and water demand (use) for that purpose. Water availability is primarily determined by geography and is affected by spatial and seasonal precipitation patterns, as well as the availability of groundwater as a buffer and store for any seasonal and annual fluctuations in rainfall.

There are four key dimensions of water scarcity: too little water, too variable water, overutilisation and poor water quality. We assessed the Asia and Pacific region's water scarcity status and trends between 1971 and 2010. Numerous approaches to estimating water scarcity exist (e.g., see reviews in Hussain et al., 2022, Liu et al., 2017, and Pedro-Monzonís et al., 2015), which may be because water scarcity is difficult to characterise and assess across scales (Rijsberman, 2006). Due to various limitations, none of the available indicators can provide a truly holistic view (Hussain et al., 2022). Therefore, we integrated four simple key dimensions to build a more holistic picture of water scarcity (see Figure 2).

First, we assessed water shortage using the Water Crowding Index (WCI) (Falkenmark et al., 1989), which is an indicator of competition for water (i.e., as water availability per capita declines, competition increases for available water resources). We then calculated water stress using the Water Stress Index (WSI) (Alcamo & Henrichs, 2002; Vörösmarty et al., 2000), which indicates excessive water use compared to water availability. Finally, we calculated agricultural water scarcity using the Green-Blue Water Scarcity Index (GBWSI) (Gerten et al., 2011; Kummu et al., 2014; Rockström et al., 2009) as an indicator of the sufficiency of local water resources in satisfying agricultural needs. The influence of water quality is also discussed in the country profiles (see Section 4) based on interviews and policy document analyses.

We handled certain deficiencies in currently available water scarcity indicators (as highlighted by Hussain et al., 2022) by considering the following: spatial and temporal variability in blue water (as water in rivers, streams, lakes and wetlands) and green water (as actual water use in rain-fed and irrigated agriculture and pasture), environmental flow requirements, population, water use and spatially varying water requirements. Considering these factors offers a more reliable overview of regional water scarcity and provides a more detailed view of the evolution of water scarcity during the study period.

TOO LITTLE WATER Low natural precipitation and runoff conditions, inducing low per capita water availability and general water scarce conditions.	**TOO VARIABLE WATER** Seasonal and interannual variability in precipitation, producing highly variable water availability regimes and driving drought incidence.
OVER-UTILISATION Utilisation of water resources for domestic and agricultural purposes exceeding water availability, or causing water quality issues.	**POOR WATER QUALITY** Inadequate quality of water resources for water users and reduced effective availability of water for some or all users, depending on degree of pollution.

Figure 2. Four types of water scarcity (FAO, 2012).

We combined these three indicators with a fourth dimension: water quality. Hussain et al. (2022) argue that many of the current water scarcity indicators are deficient due to missing dimensions. We explicitly handled these deficiencies in the indicators by considering the characteristics described in Table 2, where appropriate: blue water (in rivers, streams, lakes and wetlands), green water (water consumed in agriculture), environmental flow requirements, population, water use and spatially varying water requirements. For water shortage and green-blue water scarcity indicators, water consumption was implicitly considered through the hydrological model simulations used in the study. A summary of these indicators is presented in Table 1.

Table 1. Indices used to assess water scarcity.

Index	Definition	Key references
Water Crowding Index	An indicator of competition over water resources, whereby water users begin to compete for water resources as water availability per capita falls.	Falkenmark et al., 1989.
Water Stress Index	An indicator of excessive water use relative to water availability as the proportion of (all) water withdrawals from surface water availability.	Alcamo and Henrichs, 2002; Vörösmarty et al., 2000.
Green-Blue Water Scarcity Index	An indicator of the sufficiency of local water resources in satisfying agricultural needs.	Gerten et al., 2011; Kummu et al., 2014; Rockström et al., 2009.

Table 2. Water scarcity indicators used in this study and the aspects of water supply and conditions considered.

Indicator	Considered in this study					
	Blue water	Green water	Environmental flow requirement	Population	Water use	Variable water requirement
Water Crowding Index	X		X	X	(x)	
Water Stress Index	X		X		X	
Green-Blue Water Scarcity Index	X	X	X	X	(x)	X

Note: For water shortage and green-blue water scarcity indicators water consumption is implicitly considered through the hydrological model simulations used in the study

A large portion of Asia and the Pacific has a monsoon climate, leading to seasonality in water resources that cannot be ignored in water scarcity assessments. Therefore, we assessed the status and trends in water scarcity across two temporal scales–seasonal (monthly) and decadal scales. The varying seasonal and decadal water resource, increasing population and changing water use patterns brings varying degrees of water scarcity. We characterised water scarcity into three categories: (1) when scarcity is chronic and only particularly wet years lead to no scarcity conditions; (2) when scarcity is variable, where conditions fluctuate between scarcity and no scarcity; and (3) when water is used at an unsustainable level. We also considered how water quality may influence water scarcity conditions.

3.2 Subregional geographical variability

Climate, landforms and population distribution are highly variable across the region.

There are substantial seasonal differences in water availability across Asia and the Pacific region, primarily due to the monsoonal climate influencing a significant part of the region. Seasonal differences, combined with an increasing population and changing water use patterns, lead to varying degrees of water scarcity across the region. These differing climate zones and the distribution of cropland and population within the zones are shown in Figure 3.

A high proportion of the region's population lives in temperate conditions (notably in China), while populations in South and West Asia are more evenly distributed across arid, temperate and tropical areas.

Asia and the Pacific region can be divided into five subregions:

1. **Arid and semi-arid West and South Asia**—including the Islamic Republic of Iran, Pakistan, Bangladesh and North and South India, where water scarcity has long been prevalent.
2. **Continental South-East Asia**—predominantly the Mekong countries.
3. **Island South-East Asia and the Pacific**—including Indonesia, the Philippines and Malaysia.
4. **East Asia**—predominantly China, the Republic of Korea, the Democratic People's Republic of Korea and Japan.
5. **Continental Australia**—Australia.

In this study, we examined 10 countries from four of these subregions to include a wide range of climates, landforms and population distributions across Asia and the Pacific: **Bangladesh** and **Nepal** in West and South Asia; **Cambodia**, **Viet Nam**, **Thailand**, **Myanmar** and **Lao People's Democratic Republic** in Continental South-East Asia; **Indonesia** and **Fiji** in Island South-East Asia and the Pacific; and **Australia** in Continental Australia (see Table 3 for background information on each country analysed). Some countries were outside the scope of the study, such as countries in East Asia and certain Pacific islands, due to their small size in relation to the resolution of the models used in the analysis (including Fiji, though Fiji was included in the country profiles and policy analysis as an example for the Pacific Islands).

Population sizes vary among the countries studied, with the highest number of inhabitants recorded in Indonesia (281.2 million people) and Bangladesh (169 million people) (Worldometers, 2023). The selected countries have diverse economic backgrounds and include developed and developing countries. High-income countries include Australia, Fiji and Thailand, with an unequal gross domestic product (GDP) of US$1,552.7 billion, US$4.3 billion and US$505.9 billion, respectively. The remaining low-income and middle-income countries have significantly different GDP, ranging from US$27 billion to US$1,186.1 billion. The share of employment in the agricultural sector in the region is high; however, the sector's contribution to national GDP is declining due to a shift towards industrialisation, particularly in Nepal and Lao People's Democratic Republic, where more than half of the workforce is engaged in agricultural activities. Although the percentages of cultivated land vary among evaluated countries (with cultivated land accounting for between 8.8 and 76.1 per cent of total land area), it remains the highest water consumer in these countries, accounting for more than 85 per cent of the total freshwater withdrawals in the sector (excluding Australia and Fiji) (World Bank Group, 2023).

Table 3. Country profile data.

Country	Population (M people) 2023	GDP (US$b) 2021	Agriculture (% GDP) 2020	Employment in agriculture (%) 2019	Agricultural land (%) 2020	Total water withdrawal (10^9 m^3) 2019	Agricultural freshwater withdrawals (%) 2020
Australia	26.3	1,552.7	2.3	2.6	46.3	9.8	58.4
Bangladesh	169	416.3	11.6	38.3	76.1	35.9	87.8
Cambodia	17.3	27.0	22.8	34.5	32.8	2.2	94.0
Fiji	0.9	4.3	14.5	17.6	17.1	0.1	58.9
Indonesia	281.2	1,186.1	13.3	28.5	33.2	222.6	85.2
Lao People's Democratic Republic	7.6	18.8	16.1	61.4	8.8	7.3	95.9
Myanmar	55.4	65.1	23.4	48.8	19.9	33.4	88.6
Nepal	30.5	36.3	23.1	64.4	28.7	9.5	98.1
Thailand	70.3	505.9	8.5	31.4	45.0	57.3	90.4
Viet Nam	99.7	366.1	12.6	37.2	39.4	81.9	94.8

Abbreviations: b, billion; GDP, gross domestic product; M, million. Adapted from World Bank Group (2023) and Worldometers (2023).

3.3 Regional patterns and trends

Water scarcity in Asia and the Pacific varies considerably between regions and seasons and includes some of the most water-scarce areas in the world. Between 1971 and 2010, with some seasonal and temporal variations, high levels of water scarcity were reported, particularly in the most water-scarce countries (see Figure 3). Degradation of water quality is also rampant across the region.

Countries like Pakistan, the Islamic Republic of Iran, Afghanistan, northern China and parts of northern, western and southern India experience chronic water shortages, with more severe shortages in the dry seasons. Most South, East and South-East Asian countries experience extensive flooding in the monsoon season, which can be highly destructive. Though water scarcity in Lao People's Democratic Republic and Cambodia is not yet as pronounced in the geospatial analysis (in terms of overutilisation, too little water or too variable water, based on Water Crowding Index (WCI), Water Stress Index (WSI) and Green-Blue Water Scarcity Index (GBWSI)), both countries have issues regarding inadequate water storage, which may exacerbate water scarcity in the coming years.

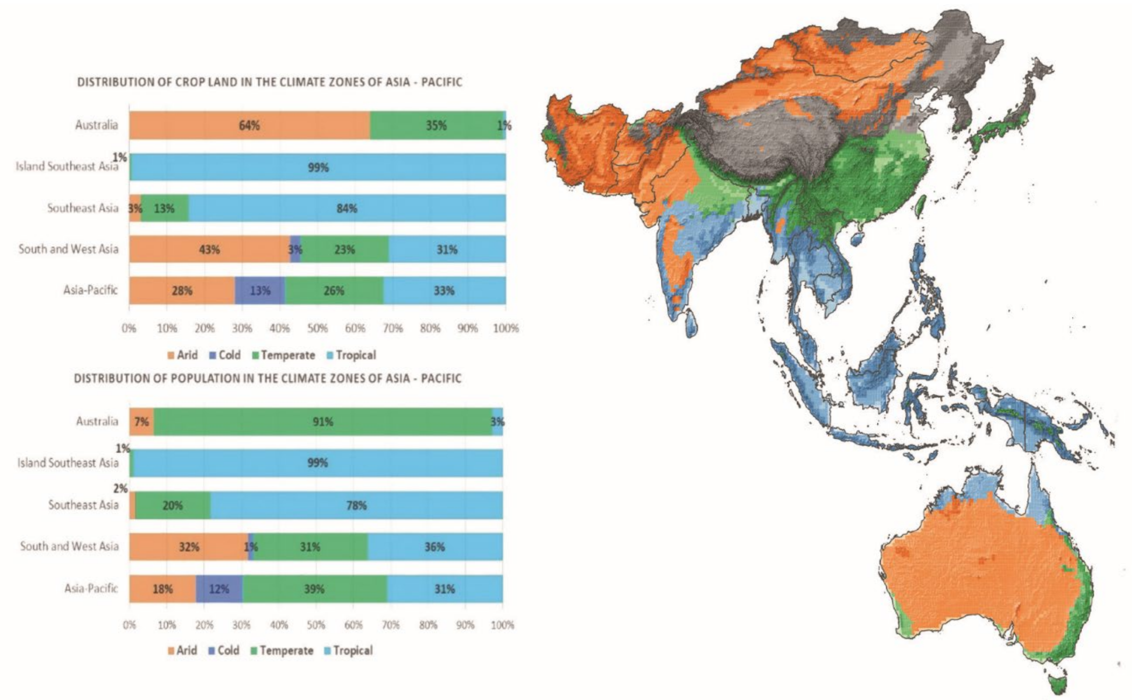

Figure 3. The proportion of cropland and population in each climate zone across subregions of Asia and the Pacific region. Data shown includes (a) cropland as a percentage, (b) population as a percentage of the total population in each subregion and (c) a map of the spatial distribution of climate zones. Data are based on the Köppen-Geiger climate classification in Beck et al. (2018)[1] and cropland data from the HYDE 3.2 dataset (Klein Goldewijk et al., 2017).[2]

[1] The Köppen-Geiger classification is based on temperature and seasonal precipitation (not only on mean annual precipitation), with different precipitation thresholds for aridity depending on whether more or less than 70% of precipitation falls within summer. The threshold is computed based on mean annual temperature (see Beck et al., 2018, for details) and the main classes of 'tropical', 'arid', 'temperate' and 'cold'. Note that data are aggregated to 0.5 degrees spatial resolution, with climate zones aggregated based on the majority (i.e., they do not capture internal distribution of climate zones).

[2] Cropland (land use) data were sourced from the ISIMIP experiment 2, originally from the HYDE 3.2 dataset (Klein Goldewijk et al., 2017). Agricultural areas are disaggregated into irrigated and rain-fed cropland and pastures. We did not use pastures in the computation.

Most of the Indian subcontinent faces some degree of water scarcity. While water scarcity occurs to a lesser spatial extent in West Asia, in the Islamic Republic of Iran and Afghanistan, scarcity is heightened near large population centres. In East Asia, most of China outside the Tibetan Plateau experiences low water availability per capita and high water use, resulting in high scarcity (i.e., all three indicators) in provinces between Beijing and Shanghai.

In South-East Asia, water scarcity occurs in distinct areas across the mainland and the Mekong region (covering Myanmar, Lao People's Democratic Republic, Thailand, Cambodia and Viet Nam). The central Dry Zone in Myanmar is affected by water stress and water crowding, as are certain locations north and east of Bangkok (Thailand). The indicators highlight the Mekong and Red River Delta in Viet Nam as water scarce. Relatively dry areas north of Tonle Sap Lake (Cambodia) exhibit water crowding. While water scarcity is not pronounced in Lao People's Democratic Republic, there are concerning trends of water resource exploitation and seasonal water scarcity.

Islands in South-East Asia (Malaysia, Indonesia, the Philippines, Papua New Guinea, Brunei Darussalam and Singapore) show similar water scarcity hotspots. Water scarcity issues are concentrated in the highly populated islands of Java, Bali and Nusa Tenggara Timur/Nusa Tenggara Barat in Indonesia and around hotspots in the Philippines, such as the capital city, Manila. Similarly, Malaysia's cities of Kuala Lumpur and Malakka show water scarcity due to their concentrated populations. In Australia, many locations experience high water stress—particularly the Murray–Darling Basin (MDB) in New South Wales and Victoria. Water crowding is experienced in larger cities, including Canberra, Sydney, Melbourne, Perth and Brisbane (see Figure 3).

Table 4 provides a numerical summary of WCI and WSI for the whole region for periods 1971–1980 and 2006–2010, as well as the change between these two periods. The table shows the population-weighted mean levels in scarcity during the first (1971−1980) and the last (2001−2010) analysis decade and the change between the two decades. Notably, water stress has remained relatively stable, despite diminished water availability per capita in every country. Values are population-weighted to highlight the conditions experienced by the population (while reducing the influence of unpopulated areas).

Table 4. Water crowding and water stress in Asia and the Pacific countries.[3]

Country	Water Crowding Index (m^3 per capita per year)			Water Stress Index (water withdrawals/water availability)		
	1971–1980	2001–2010	change	1980	2010	change
Afghanistan	1,214	888	−326	6%	7%	1%
Australia	1,754	1,366	−387	57%	89%	32%
Bangladesh	1,504	1,117	−387	3%	3%	0%
Bhutan	3,360	3,099	−261	0%	0%	0%
Brunei Darussalam	3,400+	3,400+	0	0%	0%	0%
Cambodia	2,244	1,933	−312	0%	1%	0%
China	952	739	−213	21%	22%	1%
India	939	645	−294	35%	38%	3%

[3] Low, high and severe scarcity levels are highlighted with shading.

Country	Water Crowding Index (m³ per capita per year)			Water Stress Index (water withdrawals/water availability)		
	1971–1980	2001–2010	change	1980	2010	change
Indonesia	1,803	1,533	−269	11%	10%	−2%
Islamic Republic of Iran	973	549	−424	76%	82%	7%
Japan	1,218	1,118	−100	72%	64%	−8%
Lao People's Democratic Republic	2,939	2,705	−234	0%	0%	0%
Malaysia	2,694	2,458	−236	11%	9%	−2%
Mongolia	2,429	2,088	−341	3%	3%	0%
Myanmar	2,425	2,194	−231	5%	5%	0%
Nepal	1,803	1,418	−385	12%	12%	−1%
North Korea	1,501	1,229	−273	16%	12%	−3%
Pakistan	837	427	−410	101%	102%	1%
Papua New Guinea	3,363	3,339	−24	0%	0%	0%
Philippines	1,873	1,527	−347	18%	15%	−3%
South Korea	973	966	−8	23%	17%	−6%
Sri Lanka	1,270	972	−298	31%	32%	1%
Taiwan	1,176	1,085	−91	15%	11%	−5%
Thailand	1,741	1,560	−182	9%	8%	−1%
Viet Nam	2,096	1,741	−355	7%	7%	0%

3.3.1 Monthly variation in water scarcity

While there are clear geographical trends in water scarcity across Asia and the Pacific, there are strong seasonal differences. Figure 4 shows the monthly changes in water scarcity levels, averaged across WCI, WSI and GBWSI indicators (under the assumption that each month has the same water requirement, including agricultural). Under the wet season of the Southwest Monsoon, South Asia received substantial rainfall, essentially eliminating water scarcity (except in small regions of southern India and along the Western Ghats Mountains). At the same time, West Asia experiences significant water scarcity during its driest months of the year. However, as the monsoon season passes, water scarcity worsens across South Asia to 'severe', while West Asia receives rainfall and, thus, only experiences localised scarcity in heavily populated areas.

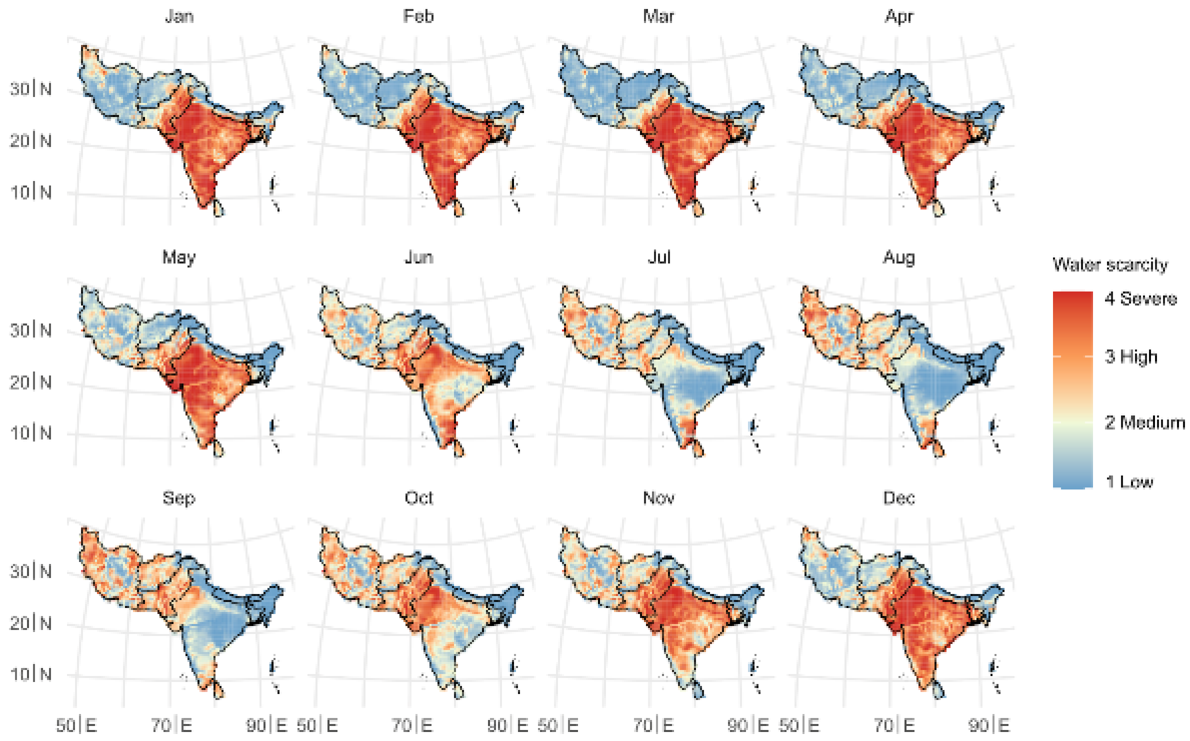

Figure 4. Monthly variance in mean water scarcity levels over the three indicators: WCI, WSI and GBWSI.

3.3.2 Water scarcity hotspots

Competition is clearly emerging in hotspots where demand is highly concentrated and water resources are either unavailable locally or financially and technically challenging to augment. Hotspots occur around large cities in all countries and are exacerbated by trends of declining water quality. A classic pattern of water development in cities has been extensive private groundwater pumping in response to limited surface water provision or poor and erratic public water supply. This often leads to an extensive cone of depression in groundwater below the city, which increases the cost of abstraction, leads to water quality degradation and may cause significant infrastructure damage due to land subsidence and flooding (e.g., as evident in Bangkok, Jakarta, Dhaka and Manila).

Competition within and between large irrigation systems is also evident in Thailand, Indonesia and Viet Nam. Groundwater levels are falling in many countries, resulting in economic competition between users and the loss of shallow groundwater for household use.

Deltas—such as those of Bangladesh, Viet Nam, Indonesia, Thailand and Myanmar—are particularly complex hotspots for water scarcity and stress. They are also very vulnerable to flooding, particularly during high tides, and vulnerability will increase with the climate change–induced rising of sea levels and related increases in salinity, which will further contribute to water scarcity. Many countries in the region are highly dependent on transboundary river systems. As populations continue to increase and water availability per capita declines, the vulnerability of these downstream countries to upstream water policy increases. Given that individual countries may prioritise economic interests at odds with sustainable water management, some tough water scarcity challenges may emerge (see Figure 5).

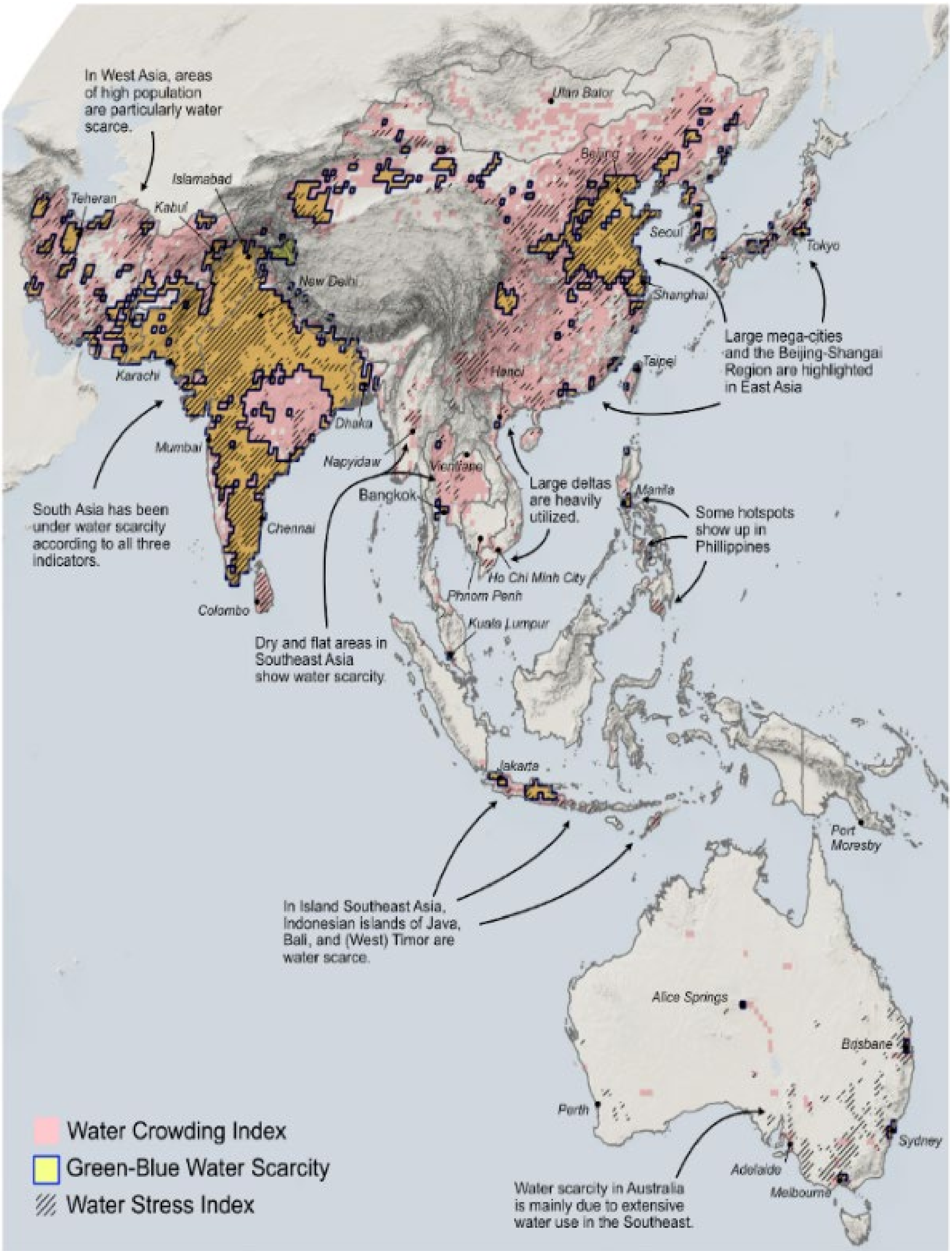

Figure 5. Water scarcity hotspots in the region during the historical 40-year period (1971–2010). The map highlights areas with chronic (water scarcity in at least four out of five years) or variable (water scarcity in at least every one in five years) water scarcity across the three indicators used in the regional assessment.

3.3.3 Evolution of water scarcity

In Asia and the Pacific, water scarcity is worsening in every country. The sharpest rises in water scarcity are observed in arid countries, which also experience higher interannual variability. However, there are more issues with water *shortage* than water *stress,* though water stress shows the most variation.

During the period 1971–2010, water scarcity increased in all countries, progressively reaching more severe categories of scarcity. While data was only available for the period between 1971 and 2010, water scarcity trends have continued across the region and are expected to worsen in the coming decades under growing pressures on water resources and climate change. As water scarcity increases in all countries, each experience more severe categories of scarcity. Some countries experience little or no scarcity due to low populations and high rainfall, even if rainfall is seasonally distributed. Arid countries with high populations or high agricultural water use experience higher water stress. The trajectories of water scarcity typically alter over periods of around five years in response to factors like changes in climate, population and land use as well as (often unknown) adaptations (see Figure 6).

Countries respond to challenges that water scarcity presents in various ways through different governance processes. Water governance consists of the structures and processes through which different state and non-state actors across society, including government and non-government organisations (NGO) and civil society, interact and engage in decision-making to regulate, influence and shape water resource use and management. An important element of governance is the formal institutional arrangements based on legal rights and regulations. These, in turn, are implemented to varying degrees of success, depending on informal institutions based on history, culture, social networks and daily practices.

A national policy analysis was conducted for each country profile to understand the various governance responses across Asia and the Pacific. The analysis focused on how governments allocate state resources to manage water scarcity and agricultural water security through different governance strategies, including policy instruments.

The following country-level analyses were used to develop a realistic framing of governments' strategies to manage water scarcity. The country analyses included a formal analysis and review of 10 or more policy instruments concerning water scarcity management, as utilised across multiple water-using sectors at the national and subnational levels according to a set of criteria regarding the policy's effectiveness, efficiency, equity and legitimacy. A SWOT (strengths, weaknesses, opportunities, threats) analysis was conducted to understand the underlying political, social and economic assumptions affecting how policy instruments are chosen, their implementation process and the enabling conditions for good water policy. These findings fed into country-level and region-level recommendations for managing water scarcity. National policymakers were also interviewed to provide additional insight and context. The country profiles highlighted what has worked and what needs to be improved to mitigate water scarcity risks for a water-secure and resilient Asia and the Pacific.

The following sections present summaries of countries in four regions of Asia and the Pacific. The sections detail each country's water availability and status, their water scarcity profile and how they address water scarcity through different policy instruments.

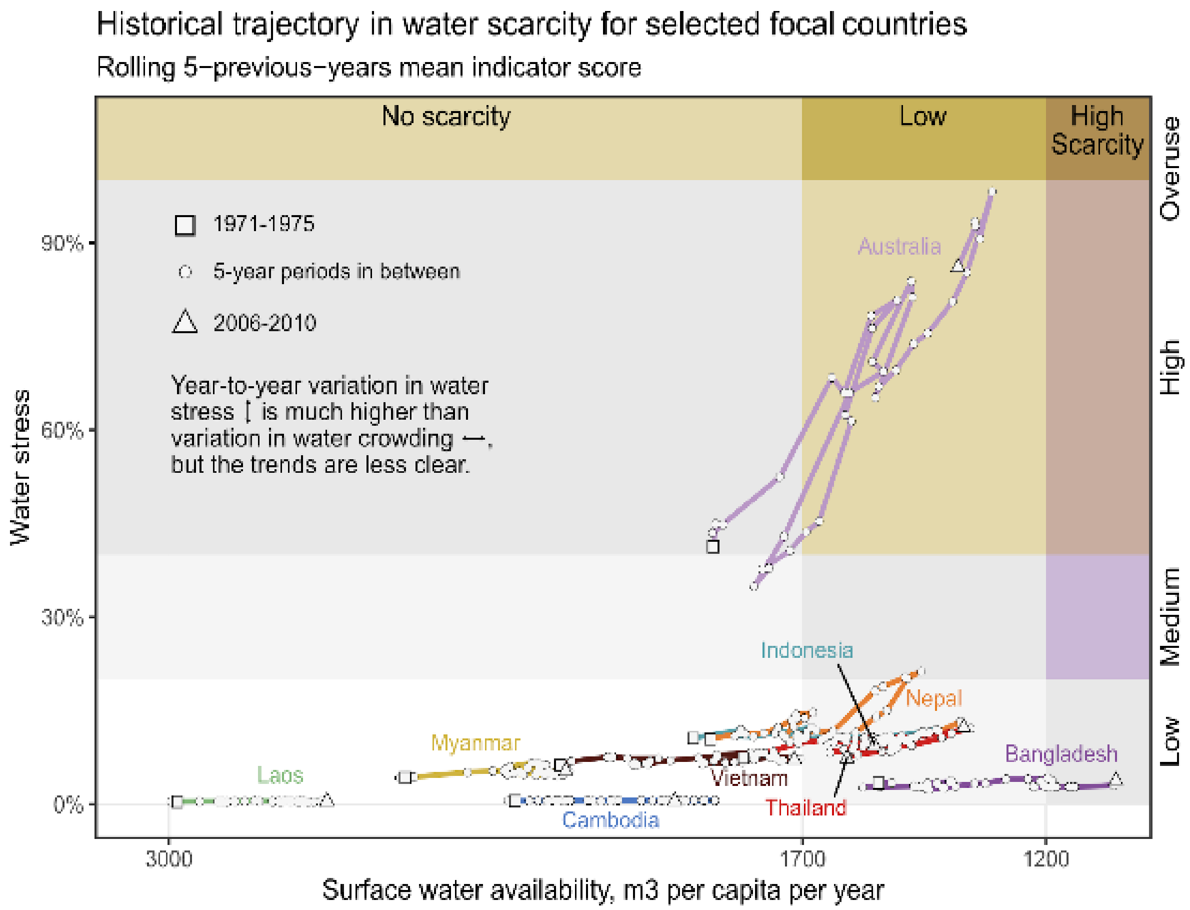

Figure 6. The evolution of water scarcity in countries in Asia and the Pacific region (1971–2010). Water scarcity severity is shown by the distribution of country trajectories between the Water Crowding Index on the X-axis and water stress on the Y-axis.

4. Country profiles

4.1 West and South Asia

West and South Asia are home to over 1.9 billion people, 70 per cent of whom live in rural areas and rely on agriculture for their livelihoods. The area covers vastly different topographies and climates. Deltas and floodplain areas are highly cultivated and densely populated, as are the plains and plateaus, except for some arid plains. There is approximately 969,000 km^2 of agricultural area across the region.

The region has great economic potential and growth, with India being the fastest growing economy. However, this growth has led to rapid urbanisation and associated slums, poor sanitation and high pollution levels in and around cities (World Bank Group, 2022).

Across the region, water resources are concentrated in the temperate and tropical areas of West and South Asia. In the arid and semi-arid areas, there is little rainfall or available surface water resources (e.g., in the western region of Pakistan, except for the Indus River), while surface water variability is particularly high in southern Islamic Republic of Iran and Pakistan. **All arid areas in the region are under severe water scarcity, with annual water resources of less than 500 cubic metres (m^3) per capita. Water withdrawals are nearly 100 per cent in arid areas (especially arid coastal areas), indicating highly unsustainable water resource utilisation (see Figure 7).**

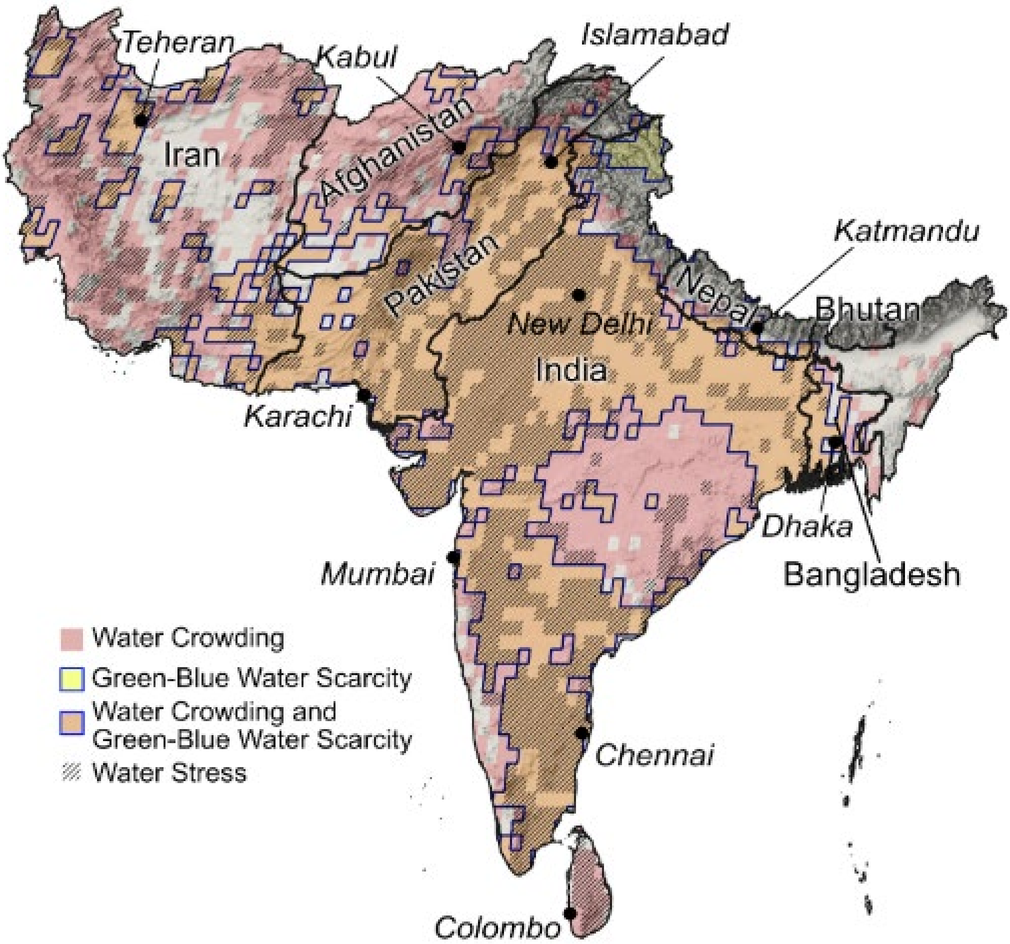

Figure 7. Water scarcity hotspots in West and South Asia.

4.1.1 Bangladesh

KEY FINDINGS

- **Bangladesh experiences two types of water scarcity: too variable water and poor water quality. The country is approaching a situation of chronic water scarcity.**
- **Gaps between researchers and policymakers** inhibit the transfer of knowledge and science-based solutions. It poses a barrier to public discussion and decision-making for alternative solutions.
- Estimates suggest that water scarcity could cost Bangladesh up to 6 per cent of its GDP in the year 2050.
- **Natural arsenic contamination in groundwater is found in 60 of the 64 districts in Bangladesh.** Water and agricultural policies are progressive and based on sound technical analysis. However, policy formulation is siloed, and implementation, monitoring and regulation are weak, with low transparency.
- **Engagement between private sector and the public sector is limited.** Policy frameworks that address irrigation and agriculture do not give adequate attention to the private sector in developing supply chains for agricultural products.
- **Enforcement powers and support are limited.** Enforcement power remains with the Ministry of Home Affairs, and there are no specific provisions for decentralisation from the agency.

Context

Located in South Asia, Bangladesh shares a border with India (in the north-east and west), Myanmar (in the south-east) and the Bay of Bengal (in the south). Bangladesh is one of the most densely populated countries in the world (> 1,000/km^2), with 169 million inhabitants across approximately 148,460 km^2. The GDP is US$416billion (World Bank Group, 2023). It is one of the world's fastest growing economies and is rapidly transforming into a middle-income country. The country has an abundance of water resources; however, water scarcity is a prominent issue in the country and could cost Bangladesh up to 6 per cent of its GDP by 2050 (World Bank Group, 2016a).

Water resources and water use

Fifty-seven transboundary rivers flow through Bangladesh as part of the Ganges-Brahmaputra-Meghna Basin. As the most downstream riparian country in the basin, Bangladesh is highly dependent on water from upstream countries (India and Nepal) (Afroz & Rahman, 2013).

Bangladesh has a tropical climate with four seasons per year, including the monsoon season, during which it receives approximately 80 per cent of the total annual precipitation. The monsoon season (June–September) often leads to widespread flooding, while the country experiences severe water stress in the dry season (November–May) (FAO, 2014). The country is highly vulnerable to climate change and is approaching chronic water scarcity (2030 Water Resources Group, 2015). The internal renewable water resources of the country include approximately 105,000 Mm^3 per year, consisting of 84,000 Mm^3 (surface water) and 21,000 Mm^3 (groundwater). Groundwater occurs from shallow depths (prolific aquifers in the floodplains annually recharged by floodwater) to deeper depths (higher terraces and hilly areas) (Banglapedia, 2021).

There is high potential for groundwater storage in Bangladesh because of the tropical climate and favourable geological and hydrogeologic characteristics (Zahid & Ahmed, 2006). Bangladesh's north-western and north-eastern regions have approximately 9,786 Mm^3 and 9,594 Mm^3 of groundwater resources available, respectively (Master Plan Organisation, 1991). The annual groundwater withdrawal in Bangladesh's Bengal Basin is approximately 30 per cent of the total groundwater withdrawals (32 Km^3); 90 per cent of the total water withdrawn is spent on irrigation, and 10 per cent will be shared between domestic and industrial sectors (Nowreen et al., 2020).

Social and economic context

Agriculture plays a key role in the country's economy and provides work for 50 per cent of the labour force. Rice is the dominant crop, covering 75 per cent of cropped areas and representing 70 per cent of the value of crop output (Gautam & Faruqee, 2016). Rice cultivation relies on the water supply seasons. Annual rice production tripled between 1977 and 2019, leading to a six-fold increase in fertiliser use and tripling pesticide use over the 20-year period from 1990 to 2010.

While agricultural growth is an essential contributor to poverty reduction in Bangladesh—with a poverty level reduction of 34 per cent between 1991 and 2016 (Bangladesh Bureau of Statistics, 2017)—concerns around equity and poverty are high in the agricultural sector, largely due to the disproportionate representation of the poorest within this sector. Fifty per cent of the agricultural workforce is female. Despite national goals of equal opportunities and rights for women, societal restrictions still cut women off from information regarding water and agriculture. They also have lower literacy, land ownership and access to mobile phones and mobility (International Food Policy Research Institute, 2019).

Water scarcity drivers and status

Bangladesh experiences two types of water scarcity: too variable water and poor water quality. The country is slowly approaching a situation of chronic water scarcity.

Bangladesh experiences long periods of low precipitation, during which moderate-to-severe water scarcity is experienced in some regions (Mekonnen & Hoekstra, 2016). High agricultural water requirements in the dry season put pressure on water resources, yet dry-season yields remain higher than wet-season yields due to complications from wet-season flooding. During dry periods, moderate-to-severe scarcity spreads across a region of 5.46 million hectares (ha), while water availability in 33 per cent of the total land acreage falls below the minimum sustainable cultivation threshold (Habiba et al., 2011).

The quality of surface water and groundwater is a primary concern in Bangladesh during the dry season. Water quality is significantly degraded due to economic and population growth and climate change. The country's economy is growing fast; increased urbanisation, industrialisation and agricultural development have raised water demand and led to high volumes of wastewater. Agricultural runoff contains chemical fertilisers and pesticide residue. In the last two decades, interior coastal districts have been salinised, with the area affected by soil salinity increasing from 2.96 million ha in 2000 to 3.76 million ha in 2007 (Ahsan & Sattar, 2010). Saline intrusion in coastal areas has also increased due to climate change. Natural arsenic contamination also affects groundwater in 60 of the 64 districts, affecting human health and welfare (Ahmed et al., 2004; Nickson et al., 1998). Figure 8 shows water-related challenges facing the country in terms of drought, floods, surges and salinity.

Water scarcity management

Key actors and policy instruments

Most of Bangladesh is situated within the deltaic floodplain of some of the world's largest rivers. Bangladesh's national water management strategy has historically focused on flood protection and drainage and improved surface irrigation to increase crop production. Agricultural strategy has played a central role in managing water in the country. However, over the last decade, policy has evolved to consider issues around water scarcity (see Figure 8).

In Bangladesh, there are 35 central government agencies, affiliated with 13 ministries, that are directly or indirectly working on water sector planning, development and management (Ministry of Water Resources, 2001). Irrigation and agriculture are mainly the focus of the Ministry of Water Resources, Ministry of Agriculture and Ministry of Local Government, Rural Development and Cooperatives. The Executive Committee of the National Water Resources Council conducts macro-level water resources planning, coordination and implementation of the Bangladesh Water Act, 2013. Local government institutions (e.g., the zila (district) parishad, upazila parishad, union parishads and municipalities) guide management activities.

Groundwater is governed by the water Act and the Bangladesh Water Rules 2018, through which permits for large-scale groundwater withdrawal are licensed. The Groundwater Management Ordinance 2018 and Groundwater Management Rules 2019 made licensing mandatory for installing irrigation tube wells. The government has issued multiple relevant policies reflecting the country's Seventh Five Year Plan: FY2016–FY2020, including those related to improving land and water productivity in irrigated areas. Several policies endorse water use efficiency, effective groundwater management and water pollution management (Bangladesh Delta Plan 2100; Bangladesh Water Rules 2018; Integrated Micro Irrigation Policy, 2017, and National Agricultural Policy 2018). These legal instruments use a decentralised implementation approach. Additionally, the Bangladesh Environmental Conservation Act, 1995, with amendments in 2000, 2002 and 2010 and the Environment Conservation Rules 1997, are the main legislative framework for environmental protection, including water quality, in Bangladesh.

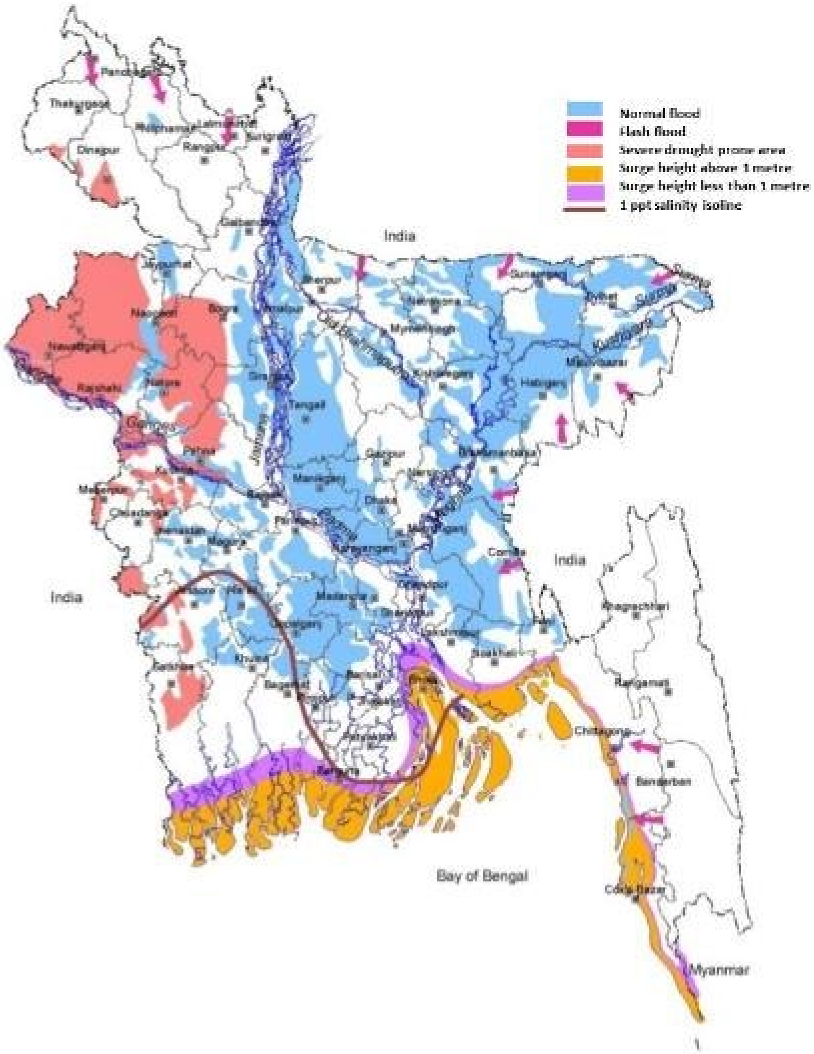

Figure 8. Water-related challenges in Bangladesh (Ministry of Environment and Forests, 2009).

The 2018 delta plan is a 100-year vision for the delta that integrates different sector plans and policies, spending approximately 2.5 per cent of the country's GDP on project implementation. Part of the plan involves identifying priority areas in need of flood protection, river erosion management and river management (Embassy of Bangladesh to the Netherlands, 2020).

Strengths and weaknesses

There has been a significant policy shift towards a more holistic approach that considers sustainability measures and stakeholder participation, as observed in the government's policies around agricultural production, groundwater governance and the role of energy in irrigation. Increasing water productivity is also high on the agenda, with advances made in agricultural research and technology.

Many Bangladesh policies related to water and agriculture are progressive and based on sound technical analysis, and a wide range of legal instruments are available to restrict overabstraction, manage water equitably and provide multiple entry points for water scarcity initiatives. However, policy formulation often takes a siloed approach, and institutional complexity has led to an unclear distribution of responsibilities across governance scales. Implementation, monitoring and regulation are also weak. Policy formulation remains highly centralised and uncoordinated; thus, it is influenced by political pressures and interests. National policies are formulated with stakeholder consultations, but there remains a lack of accountability and transparency. Gaps also remain between researchers, policymakers and the private sector—particularly around managing irrigation development—which hinders knowledge transfer and evidence-based solutions (see Figure 9).

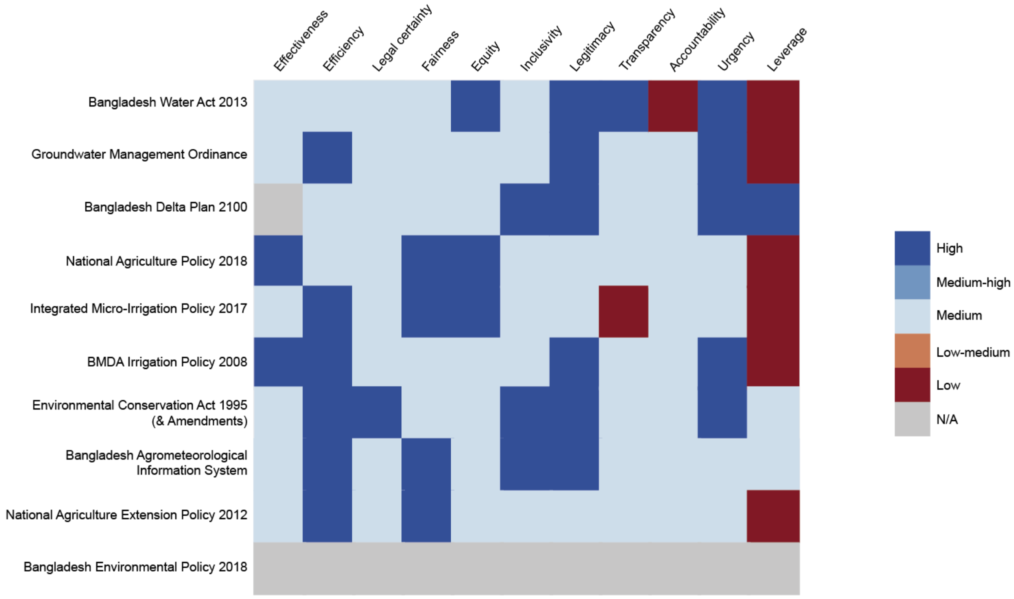

Figure 9. Assessment of Bangladesh's key policy instruments in managing water scarcity.

Country outlook

While Bangladesh has a wide range of legal instruments for managing water scarcity, challenges remain in implementation—particularly monitoring and regulation. Improvements are needed in developing innovative financial instruments and potential technology transfer, improving awareness and identifying possible policy leverage points. Equal participation of different social groups, particularly women, is vital throughout such efforts.

4.1.2 Nepal

KEY FINDINGS

- **Although Nepal has abundant water resources on an annual basis, the country faces three types of water scarcity: too variable water, overutilisation and poor water quality. Nepal also faces issues like flash floods in the wet season and drought in the dry season.**
- **Government ambitions of increasing groundwater use for irrigation face barriers**, including a lack of farmer incentives, poor electricity networks and the high cost of alternative energy sources.
- **There is a need for capacity building**, improved coordination between ministries, support from civil society organisations and improved data collection.
- **Transboundary water resources management could be strengthened.** Given the effects of flash floods during the wet season and water shortages during the dry season due to dam operations in upstream countries, efforts are needed for stronger transboundary agreements.
- The current institutional structure for dealing with water scarcity is constrained by insufficient capacity and weak implementation, leading to poor access to safe water resources for poor and marginalised families and communities.

Context

Nepal is a landlocked country between China (to the north) and India (to the east, south and west) that lies primarily on the southern slope of the Himalayas. The country is home to approximately 30 million people and experiences climatic zones ranging from humid tropical and subtropical to arctic conditions. It is a lower-middle-income country with a GDP of US$36 billion (World Bank Group, 2023). Nepal has four seasons, including a monsoon season between June and September, which provides up to 80 per cent of the country's annual rainfall (Nepal et al., 2021). Agriculture covers about 28.7 per cent of Nepal's area and uses 95.9 per cent of surface water and 20 per cent of groundwater. Agriculture contributes 23.1 per cent to the country's GDP and employs more than 80 per cent of Nepalese (World Bank Group, 2023).

Water resources and water use

Nepal has around 6,000 rivers. The three primary rivers—the Kosi, Gandaki and Karnali—originate in Tibet before flowing into India to meet the Ganges and then to the Bay of Bengal (Agriculture Project Services Centre et al., 1995). The total surface water available in the eight months between monsoons is 125.85 Bm^3, of which 39.33 Bm^3 flows into India, 50.19 Bm^3 is lost to evapotranspiration and soil moisture, and 26.03 Bm^3 sustains first-order and second-order rivers. This leaves only 10.3 Bm^3 of water for uses like drinking water, household supply and food production. Due to its extreme topography and seismic activity, water storage options are limited. In the mid-hills, most communities are situated high above the rivers, which flow in deeply incised valleys (Nepal Research Institute & CARE Nepal, 2020).

Groundwater availability varies across the country but is crucial for irrigation and drinking water, sanitation and hygiene (WASH). Annually, approximately 1,900 Mm^3 of the 20,000 Mm^3 of renewable groundwater is exploited (FAO, 1964–2020). The natural annual recharge of groundwater is approximately 8,800 Mm^3 and 5.5 Mm^3 annually in the Terai and Kathmandu Valley regions, respectively. Groundwater contributes to 20 per cent of irrigation water use, mainly in the Terai. It also supplies over 50 per cent of Kathmandu Valley's drinking water needs (Shrestha et al., 2018). Kathmandu Valley's shallow aquifer depends heavily on rainfall for recharge and, thus, is vulnerable to drought effects. Accelerating urban sprawl further limits aquifer recharge (see Figure 10).

Social and economic context

Nepal's land is composed of hills and mountains. Only small regions located on mountain slopes and river valleys are suitable for cultivation, with about 18 per cent of the total area used for cultivation. Rice is the main crop, which relies on irrigated and rain-fed water (Minister of Energy, Water Resources and Irrigation, 2018). Nepal has become a net importer of rice since the early 1980s, caused by the increasing population and agricultural land conversion (Joshi et al., 2020).

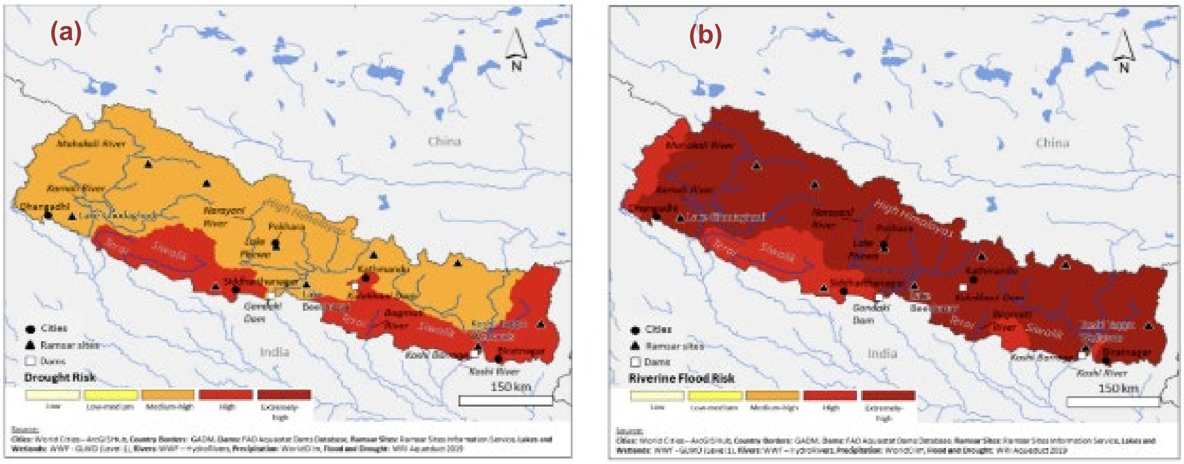

Figure 10. (a) Drought risk and (b) riverine flooding risk in Nepal. Source: World Bank Group, 2021a.

Women and socially excluded groups in Nepal face high poverty and inequality due to legal and sociocultural norms (e.g., the patriarchal society). Efforts have been made to increase inclusion and engagement in governance processes, such as policy and institutional reforms (Asian Development Bank, 2010). The engagement of women in local government has increased considerably. The transition of Nepal to a federal governance structure has provided opportunities for women's participation in governance processes, though men still dominate higher positions (World Economic Forum, 2018). Women participate more actively in subsistence agriculture, with more 80 per cent of women involved in agriculture and forestry in 2019 (World Bank Group, 2019). However, their wages remain lower than their male counterparts.

Water scarcity drivers and status

Though Nepal has abundant water resources annually, the country faces three types of water scarcity: too variable water, water stress and poor water quality. The country also faces transboundary issues, such as flash floods in the wet season and drought in the dry season.

Some regions of Nepal experience seasonal water scarcity during the dry season (Gyawali, 2003). Erratic monsoons with concentrated cloudbursts and long, intermittent dry spells cause water stress due to extreme oversupply and undersupply within a short time frame (four months or less). This causes a threat to rain-fed agriculture and drinking water (USAID, 2021). For example, during 2006–2007, the late arrival of monsoons and declines in monsoon rainfall resulted in a 16 per cent decrease in typical monsoon rainfall, reducing rice yields by 21–30 per cent (Dyoulgerov et al., 2011). In terms of groundwater, increasingly frequent drought events in the monsoon and winter seasons will limit groundwater recharge, particularly in the west of the Terai plains, as shown in Figure 10 (World Bank Group, 2021a).

Water quality is also a challenge, where high loads of untreated domestic and industrial wastewater are discharged into rivers (Uprety, 2014). Untreated industrial and municipal sector effluents have caused heavy metals and arsenic contamination (USAID, 2021). Both natural and anthropogenic factors have degraded groundwater quality, also largely driven by industrial and municipal waste. Lead concentrations in shallow groundwater have been recorded at levels five times higher than the World Health Organization (WHO) standard for drinking water (United States Agency for International Development, 2021). Microbial contamination stems (*Escherichia coli*) have also been detected in shallow and deep tube wells (e.g., in the Terai and some large valleys in the mid-hills), which is caused by poor sanitation systems (Thanju, 2012).

Overuse of water resources is a problem in Nepal, and water demand has steadily increased since the 1970s due to population growth and industrialisation. Groundwater extraction has increased and exceeds aquifer sustainable yields in key places (Shrestha et al., 2016). For example, groundwater withdrawals in Kathmandu Valley have exceeded recharge rates since the mid-1980s. The shallow aquifer depends heavily on rainfall for recharge. Thus, it is vulnerable to drought effects, and accelerating urban sprawl further limits aquifer recharge (Pandey & Kazama, 2012). Urban development also accelerates runoff and a decline in water infiltration, leading to more extensive local flooding and reduced groundwater recharge (Thapa et al., 2018).

Water scarcity management

Key actors and policy instruments

In Nepal, water policies and legal regulation and implementation are centralised, with authorities in numerous ministries, commissions and departments. Decision-making and resource distribution are becoming increasingly decentralised, while current policies also emphasise the role of stakeholder engagement across scales.

At the national level, the National Water Resource Development Council is the central power in water resources management and issues directives for execution at lower government levels. It oversees water policy developed by the Water and Energy Commission Secretariat, which is responsible for implementation, coordination, interagency planning and budgetary oversight. The Ministry of Energy, Water Resources and Irrigation oversees water resources, irrigation and hydropower development, planning and infrastructure construction. The Ministry of Water Supply issues policies, plans and regulations related to water and sanitation. Several committees and commissions, such as the District Water Resources Committee, Water Resources Utilisation Investigation Committee and Electricity Tariff Fixation Commission, monitor energy tariffs and deal with conflicts in the water sector (Regmi & Shrestha, 2018).

Since the Constitution of Nepal as a federal democratic republic was promulgated in 2015, the government has been restructured, moving towards decentralisation and sharing of resources with local governments. It is believed that this will help the country cope with climate change, particularly concerning water scarcity. The government has adopted several policy instruments that directly and indirectly affect water scarcity, including policies on livestock, irrigation, water resources, forest and soil conservation, land use, urbanisation and climate change. There has been limited focus on drought, except for immediate, short-term issues; however, the issue of water scarcity is implicitly embedded in certain water-related programs and policies, such as the National Water Supply and Sanitation Sector Policy 2014 and more explicitly in the Irrigation Policy 2003 and National Water Resources Policy 2020 (Regmi & Shrestha, 2018). More recently, a new water resources Act has been scheduled for consideration, which may increase the authorisation for water accounting and allocations to assist with water scarcity management.

Strengths and weaknesses

The policy regime in Nepal largely ignores issues around water scarcity, except for cross-cutting issues like climate change and increasing urban water demands. Agricultural policies and programs do not typically consider water availability as a factor for success, and irrigation-related policies and programs tend to focus on the macro level, with little consideration of water scarcity at the micro level. Government agencies related to forestry, the environment, climate change, land management and drinking water and sanitation also typically operate in silos.

While the government has committed to decentralisation and power devolution across government scales, the framework is contested and in flux, with conflicts between ministries regarding their roles and responsibilities. Institutional challenges—especially in terms of capacity and financing—have led to jurisdictional disputes regarding water, particularly concerning interbasin transfers. Nevertheless, hope remains that decentralisation will be beneficial in coping with water scarcity, climate change and related issues that are often experienced at the local level.

Nepal has several policy instruments and strategies for water management in place, but the country suffers from insufficient resources, regime uncertainty and limited capacity at the national level. At the local level, limited resources also undermine implementation. Poor data collection and a lack of credible data are also barriers, largely caused by insufficient resources and the country's geography. For example, the Department of Hydrology and Meteorology has insufficient resources and struggles to successfully run a network of disparate stations across the country.

Government ambitions of increasing groundwater use for irrigation also face barriers, including a lack of farmer incentives, poor electricity networks (making pumping unreliable) and the high cost of alternative energy sources, such as diesel (Hartung & Pluschke, 2018) (see Figure 11).

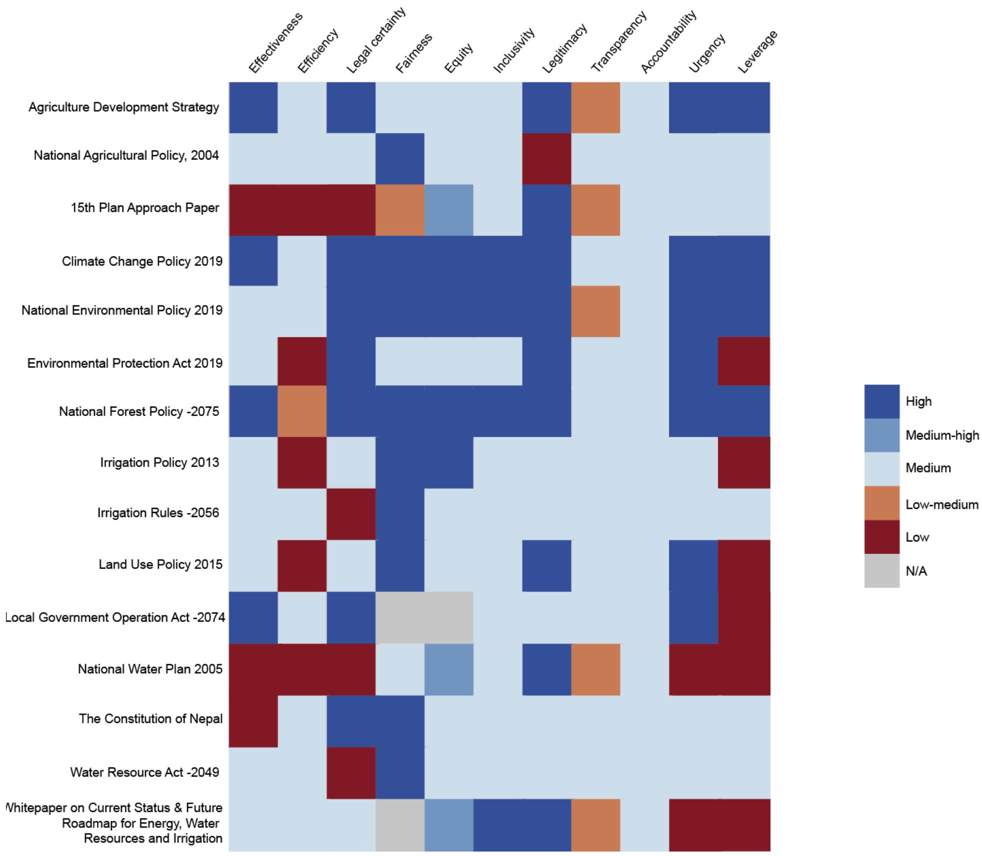

Figure 11. Assessment of Nepal's key policy instruments in managing water scarcity.

Country outlook

Key issues facing Nepal's water scarcity management, such as a lack of resources and capacity for policy implementation, can be improved and strengthened through improved ministerial coordination and support from civil society and international organisations. Improved data collection and dissemination are also needed, as well as more sustainable and cheaper energy sources for farmers. Finally, attention should be paid to transboundary water agreements (which exist with India but not with China).

4.2 Continental South-East Asia

Continental South-East Asia is home to over 250 million people, 65 million of whom live within the Lower Mekong River Basin. The region's population is concentrated in the delta and floodplain areas, as well as the plains and plateaus. Rugged terrain covers most of the region, though with lower population density than other topographic areas. Most of the region sits within the tropical climate zone, except for temperate climates in the rugged terrains in the north and arid climates in the central Dry Zone of Myanmar.

An estimated 80 per cent of those living in the Lower Mekong River Basin depend upon the river for their livelihoods, and the economies of the Lower Mekong rely heavily on their predominant water user: agriculture. Over centuries, this vital sector has regularly suffered seasonal water scarcity and longer term droughts, which are worsening due to increasing water demands and degrading water quality. Climate change is projected to compound these issues and further worsen water scarcity in the region in the coming decades.

While there are generally sufficient water resources in the region, the monsoonal climate causes significant seasonal water variability and scarcity. During the dry season, significant scarcity arises across the region (see Figure 12).

Figure 12. Water scarcity hotspots in continental South-East Asia.

4.2.1 Cambodia

KEY FINDINGS

- **Cambodia experiences relatively limited water scarcity compared to other countries in the region, though it does experience it in the form of too variable water availability and poor water quality.**
- **Water supply for industry is important for economic development.** Ensuring sufficient quality and quantity of water supplies for the industry is critical for economic growth. Industry as a water user is a competitor to agricultural water users, so a clear strategy on how water can be sustainably supplied to the industrial sector is needed.
- The financing of irrigation schemes needs to include the initial capital works for **operation and its ongoing maintenance**. Implementing water charging provides a pathway to funding ongoing maintenance.
- Support (finance and capacity) is needed to set up a strong **monitoring and evaluation** system to assess the impacts of policies and to enable adaptive management of water scarcity.
- **Capacity development is critical.** Capacity development is often needed to support implementation of new instruments (e.g., strategies, policies, tools, organisations).
- **Cambodia's water scarcity is particularly evident in rural areas**, and rural communities and agricultural activities are the most affected by water variability. The issues of too variable water availability and poor quality also interact. When there is no rain during the dry season, villagers in rural areas often face a shortage of drinking water and resort to using unsafe water from ponds, rivers or streams. Climate change may worsen intra-annual variability in water availability, with evidence emerging of a longer dry season (and a delayed wet season) and longer dry periods during the wet season (Ministry of Water Resources and Meteorology [MoWRAM], 2012).

Context

Cambodia is located within mainland South-East Asia. It has a tropical climate, with a distinct wet and dry season. This country recorded a value of 96 people per square kilometre in 2023. Cambodia is home to the Tonle Sap Lake—a dynamic lake with a unique flood pulse system that supports millions of people's livelihoods and food security. Cambodia has a population of 17.3 million in 2023, and its GDP is US$27 billion (as of 2021). Agriculture accounts for approximately 90 per cent of the GDP and employs around 80 per cent of the workforce. National water use is 7.9 Bm^3 per year, of which 96 per cent is used for agriculture.

Water resources water use

Cambodia has 4,520 km^2 of surface water–equivalent to 1,750 km of inland waterways (World Bank Group, 2013). The major rivers are the Mekong, Bassac and Tonle Sap and their tributaries (Ministry of Public Works and Transport Cambodia, 2018). The country has a mean annual rainfall of 1,280–1,520 mm/year. Annual inflow is 410 Bm^3, though annual internally generated runoff is only 90 Bm^3. Cambodia has 17.6 Bm^3 of groundwater (shallow wells) that could be used (Water Environment Partnership in Asia, 2021).

There are currently nine operational hydropower dams in Cambodia. Over 2,525 irrigation schemes cover an estimated 901,543 ha in the wet season and 321,167 ha in the dry season. However, due to a lack of maintenance, only over a third of the schemes are functional (Sithirith, 2017).

National water use is 7.9 Bm^3 per year, of which 96 per cent is used for agriculture, 3 per cent for domestic use and 1 per cent for industrial use. Most farmers still rely on rainwater in the wet season for farming. Groundwater is also widely used for irrigation in many provinces in the Tonle Sap region, Phnom Penh region and in the South (Phok, Nandalal, Pitawala, & Dharmagunawardhane, 2018). Access to water supply and sanitation in rural areas is improving.

Social and economic context

Agriculture is an important component of Cambodia's economy, with rice accounting for half of the country's agricultural GDP. Cambodia has over 2,525 irrigation schemes covering an estimated 901,543 ha in the wet season and 321,167 ha in the dry season (equating to wet-season coverage of 39 per cent and dry-season coverage of 14 per cent of the total cultivated area in the country) (Sithirith, 2017).

It attracted 57 per cent of total employment in 2020 (FAO, 2020). Women play a major role in Cambodian agriculture and rural development, and agriculture is an important source of employment for those with disabilities. Women face difficulties in terms of access to land, extension services, financial services, markets and technology. The Royal Government of Cambodia has made significant progress in providing land titles to women, widows and indigenous women in line with national policies and plans. In 2017, 42,278 (21 per cent) of 204,684 land titles were provided to women, and 6,442 land titles (3 per cent) were provided to widows (UN, 2018).

Water scarcity drivers and status

Cambodia experiences relatively limited water scarcity compared to other countries in the region, though it does experience too variable water and poor water quality, particularly in rural areas. While there is sufficient supply during the wet season, there is insufficient supply (and storage) during the dry season. Rural communities and agricultural activities are the most affected by water variability.

The issues of too variable water availability and poor quality also interact. When there is no rain during the dry season, villagers in rural areas often face a shortage of drinking water and resort to using unsafe drinking water from ponds, rivers or streams. Climate change may worsen intra-annual variability in water availability, with evidence emerging of a longer dry season (delayed wet season) and longer dry periods during the wet season (MoWRAM, 2012). This will particularly affect the flood pulse system of the Tonle Sap Lake, which provides food security through fisheries for millions of people.

Between 1970 and 2010, water scarcity in Cambodia has been variable, with a steady trajectory towards water scarcity. Most parts of the country did not experience water scarcity, though the delta and floodplain began to experience low water availability in some years (World Bank Broup, 2021a). This has manifested as severe drought during the dry season. Urban areas also face dry-season water shortages occasionally.

Untreated wastewater is an issue near Phnom Penh and the delta, and groundwater is contaminated by arsenic in many parts of the country. Surface water is also commonly polluted due to poor sanitation (e.g., open defecation) in rural areas and agricultural and industrial practices (Lifewater International, 2020).

Over the last 30 years, Cambodia has been on a steady trajectory towards water-scarce conditions. The delta and floodplain have begun to experience low water availability in recent years, as observed during several droughts in 2002, 2012, 2015, 2016, 2019, 2020, 2021 and 2022. This is partly due to climate change, which has lengthened the dry season by one month compared to the 1990s (World Bank Group, 2021b). Along with increasing pressures due to a growing population, water scarcity is expected to worsen in the coming years. The primary legal basis of water resources management in Cambodia is the 2007 Law on Water Resources Management of the Kingdom of Cambodia, which outlines the regulatory framework of water policy for the country. An overarching water law is essential to provide an overall vision and responsibilities, but more-detailed regulation is needed to outline how water scarcity can be dealt with within the confines of the law (see Figure 13).

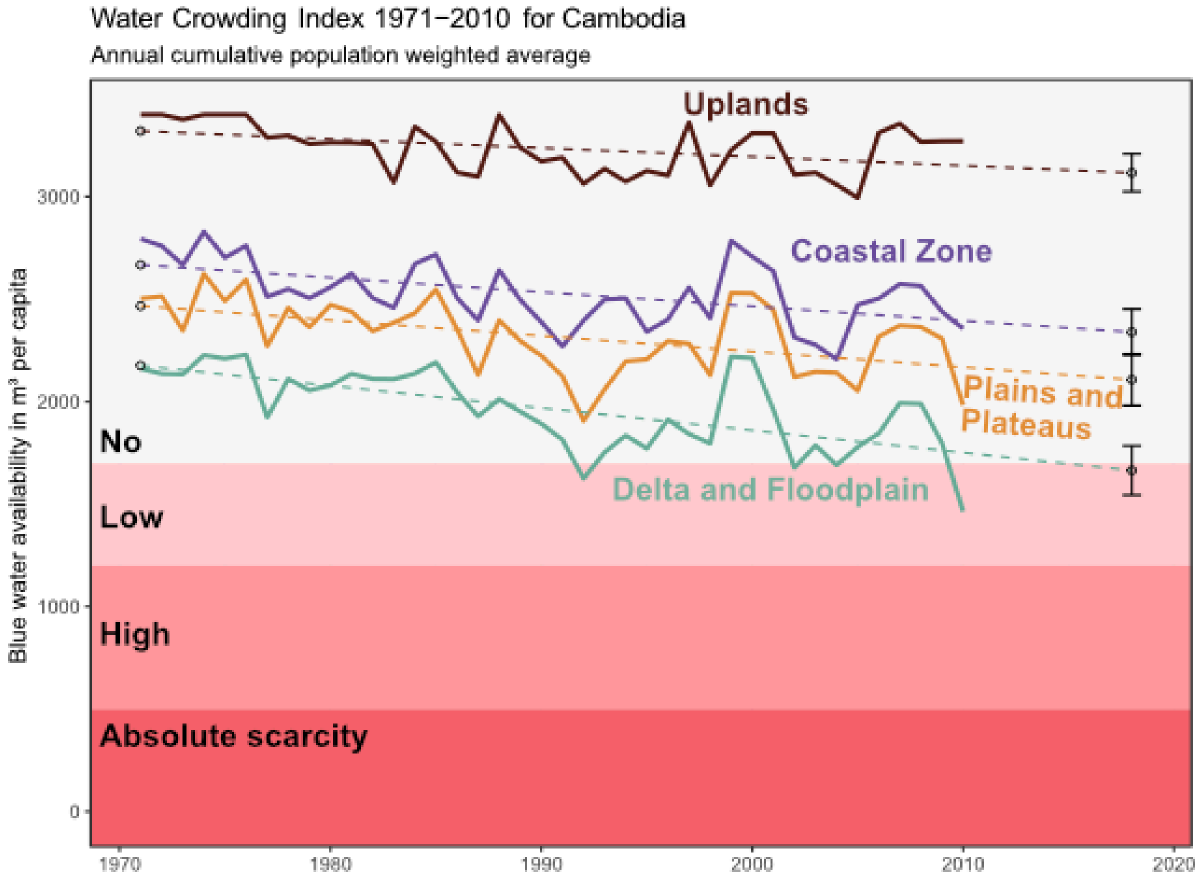

Figure 13. Water Crowding Index in Cambodia (1971–2010).

Water scarcity management

Key actors and policy instruments

Numerous government agencies exist in Cambodia to handle water resources management. The primary agency, MoWRAM, was founded in 1993 to develop and govern the country's water resources and oversee irrigation development and flood control. It is also responsible for fresh and marine water resources management and coordinates with other agencies, including the Ministry of Rural Development; the Ministry of Agriculture, Forestry and Fisheries; the Ministry of Industry, Science, Technology & Innovation; the Ministry of Environment; and the Cambodian National Mekong Committee. Ten key policy instruments emerging from these ministries are summarised in Figure 14.

The main legal basis of water resources management in Cambodia is the 2007 Law on Water Resource Management of the Kingdom of Cambodia, which outlines the country's regulatory framework of water policy. MoWRAM has stated that agricultural production has increased due to implementing projects responding to certain policies through work alongside the Ministry of Agriculture, Forestry and Fisheries. However, verification of such successes is still needed.

Strengths and weaknesses

In Cambodia, there is generally good coverage and cross-scale coordination of policy instruments implemented at national and subnational levels. Access to safe water has increased significantly across the country. Further, attempts have been made to increase water supply coverage for domestic use during the dry season and improve distribution during the wet season, for example, by establishing canals and reservoirs and restoring some irrigation systems.

However, some key weaknesses prevail in Cambodia's responses to water scarcity. Not all policies reviewed have adequate monitoring and evaluation processes in place, nor do they have the funding to do so (e.g., policies related to irrigation). Some laws (e.g., the 2007 Law on Water Resources Management of the Kingdom of Cambodia and the 1996 Law on Environmental Protection and Natural Resource Management) are broad, with hard-to-achieve goals; they require further sub-decrees to guide their implementation.

Water scarcity remains a challenge in remote areas of the country, particularly during the dry season, which mostly affects the agricultural sector and villagers in remote areas. While MoWRAM and related ministries have focused on building large canals, dams and reservoirs, little attention has been paid to smaller distribution canals to reach farms. Furthermore, while many irrigation systems have been built, not all have been well maintained (see Figure 14).

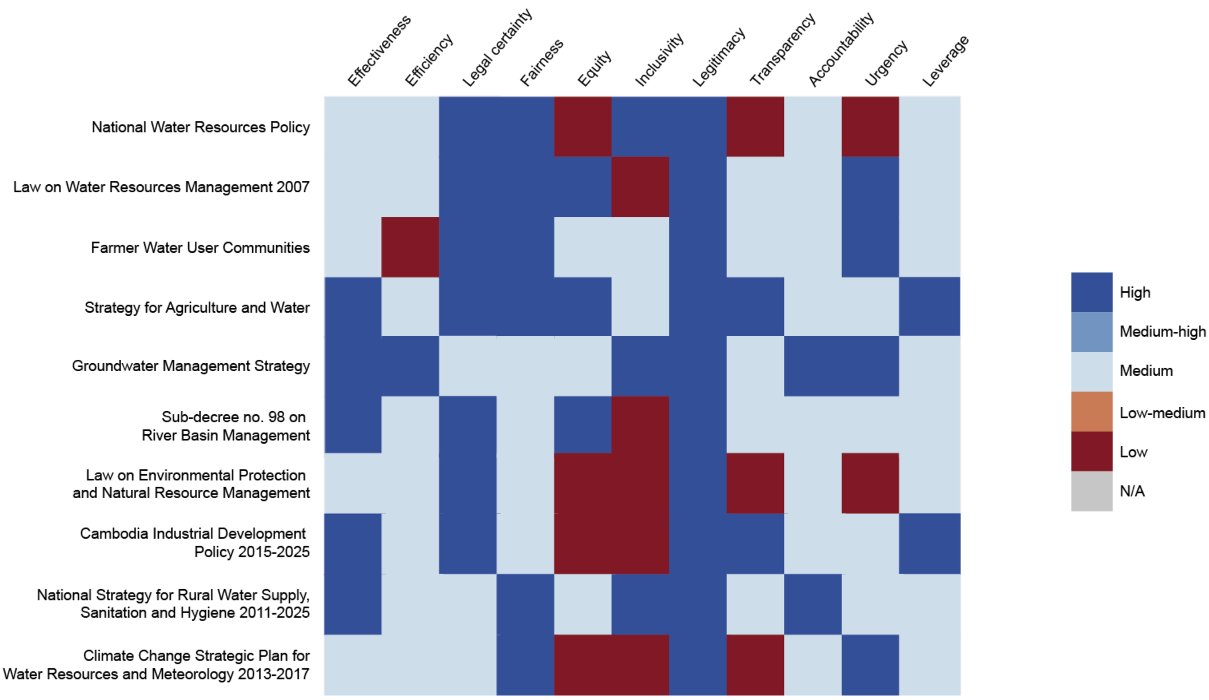

Figure 14. Assessment of Cambodia's key policy instruments in managing water scarcity.

Country outlook

While Cambodia has made progress in terms of access to safe drinking water and ministerial coordination, it must deal with several growing issues to adequately prepare for the increasing water scarcity projected for the coming decades. It must maintain existing irrigation infrastructure through adequate budget allocation rather than focusing on building new irrigation schemes, which would benefit farmers struggling with aging infrastructure and issues of water scarcity during the dry season. The country must also prepare for increasing climate variability and projected alterations in the flood pulse of the Tonle Sap. Improvements in institutional equity and inclusivity (see Figure 14) are also needed.

4.2.2 Viet Nam

KEY FINDINGS

- **Viet Nam experiences all types of water scarcity: too little water, too variable water, over-utilisation and poor water quality.**
- With 63 per cent of the country's surface water sourced from transboundary rivers, **downstream Viet Nam faces the impacts of the intensive water development** and increasing water demands by upstream countries.
- **Water scarcity is experienced differently across eight regions:** in the Northern Viet Nam (which comprises the Northwest, Northeast region, and Red River Delta regions), water scarcity types are mainly over-utilisation and poor water quality; the North Central Coast region experiences too variable water and poor water quality; the Central Highlands and South Central Coast regions experience too little water and poor water quality; the Southeastern region has faced over-utilisation and poor water quality; and the Mekong River Delta experiences too variable water, poor water quality and over-utilisation.
- **Decreasing transboundary water flows and deepening of river channels due to sand mining** have intensified saline intrusion in the Delta, while agricultural and domestic wastewater also contribute to pollution.
- **Groundwater is over-exploited in some areas**, leading to land subsidence and further water quality problems, especially in acid-sulphate and saline soils.
- **Viet Nam's legal framework regarding water resources management is comprehensive, though it is less successful in managing water quality.** Financial resources are constrained and there are challenges in data collection and monitoring.

Context

Viet Nam is located along the eastern edge of mainland South-East Asia and has a population of 99.7 million people. It is one of the highest population density countries in Asia and the Pacific region, with more than 319 people per square kilometre of land area in 2023. Viet Nam is a lower-middle-income country, with a GDP of US$366.1 billion (World Bank Group, 2023). The country has a monsoon-influenced climate; northern areas have a monsoonal climate (with four distinct seasons), while southern areas have a tropical monsoon climate (with two seasons: wet and dry). Agriculture uses 83−85 per cent of total water withdrawals. While agriculture has a dwindling contribution to GDP (12.6 per cent), it continues to employ half of Viet Nam's society (as of 2018).

Water resources and water use

Viet Nam has over 3,450 rivers longer than 10 km, six of which cover an area of between 2,500 km^2 to 10,000 km^2 and ten of which have a basin larger than 10,000 km^2. These rivers flow over eight regions: the Northwest, Northeast, Red River Delta, North Central Coast, South Central Coast, Central Highlands, Mekong Delta and Southeast. Annually, Viet Nam receives a total surface inflow of 830−840 Bm^3, of which 60 per cent and 16 per cent of water resources belong to the Mekong River and the Red-Thai Binh River system, respectively. Runoff generated inside Viet Nam only accounts for approximately 37 per cent of the country's total surface water resources, while streamflow from outside the country in transboundary rivers accounts for 63 per cent (2030 Water Resources Group, 2017). Thus, Viet Nam depends on neighbouring countries' jurisdiction and cooperation.

There are around 2 million groundwater wells in the delta, 550,000 of which are large wells withdrawing approximately 2 Mm^3 per day. Water tables in all aquifers have declined between 0.2 m and 0.4 m per year since 1995—this number is as high as 0.93 m per day in areas with high extraction rates.

Agriculture is the dominant water consumer in Viet Nam (Ministry of Agriculture and Rural Development, 2017). The Mekong Delta is the primary rice producer: 45 per cent of the total irrigation water used in the Mekong region is extracted in the delta (Asian Development Bank, 2019). Aquaculture is mainly located in the Mekong River Basin, which accounts for 65 per cent of the total aquaculture water demand. The hydroelectric power industry also diverts considerable water resources: 29 hydroelectric powers are already constructed (814 MW), and water demand is expected to increase by 2030 (2030 Water Resources Group, 2017). Between 70 and 80 per cent of the country's rural population depends on groundwater.

Social and economic context

In 2020, the total annual rice cultivated area (all seasons) was 7.3 million ha, with 54 per cent of the total rice cultivated area in the Mekong Delta. The agriculture sector contributed only 15 per cent of the country's GDP (2018) but consumed the highest proportion of water use (83–85 per cent). This sector attracted 37 per cent of the total employment, and ethnic minorities are more intensively engaged in the sector, with about 36 per cent of female employment in 2019 (International Labour Organization, 2021).

Viet Nam's Constitution has recognised equality between men and women since its creation in 1946, and the government has committed to improving women's opportunities to participate in and benefit from political, economic, cultural and social domains. However, representation of women and ethnic minorities remains limited, and the burden of domestic roles lies with women due to prevailing gender norms. Women comprise about half of the workforce in the agricultural sector, and ethnic minorities are more intensively engaged in the sector. In 2010, the government launched the National Target Program for New Rural Development and the National Target Program for Sustainable Poverty Reduction to improve the livelihoods of ethnic minorities through investments in rural infrastructure, improved electricity access, clean water and hygiene, and loans. Yet, both have been criticised for being too 'gender neutral' (Care International in Viet Nam et al., 2020; United Nations Entity for Gender Equality and the Empowerment of Women et al., 2021). Therefore, they have been complemented with technical support to promote gender mainstreaming in the two national target programs for 2021–2025.

Water scarcity drivers and status

Water scarcity in Viet Nam has high spatial and temporal variability, driven by increasing demand and competition between sectors, dependency on upstream development and climate change. Thus, the country experiences all types of water scarcity: too little water, too variable water, overutilisation and poor water quality.

With 63 per cent of the country's surface water sourced from transboundary rivers, downstream Viet Nam faces the effects of intensive water development by and increasing water demands of upstream countries (Ministry of Agriculture and Rural Development, 2017). Meanwhile, climate change is causing prolonged dry periods and higher average temperatures, affecting evaporation rates. Thus, there are increasing water demands from agricultural, domestic and industrial uses.

Scarcity is experienced differently across eight regions. In the northern region (containing the Northwest, Northeast region and Red River Delta), water scarcity types are mainly **overutilisation** and **poor water quality**. Overutilisation occurs mainly during the winter–spring cropping season, when water storage is insufficient to meet irrigation and hydropower generation demands. Poor water quality is caused by both internal and external (i.e., upstream) sources.

The North Central region has recently experienced **too variable water** and **poor water quality** due to extreme weather conditions, such as drought and heatwaves. The Central Highlands and South Central Coast have also experienced **too little water** and **poor water quality** due to the wet–dry monsoonal climate causing a prolonged dry season, the overabstraction of groundwater for coffee production, and untreated wastewater from domestic, agricultural and industrial sectors. The Southeastern region has faced **overutilisation** and **poor water quality**, largely due to poorly planned reservoirs constructed before 1990, which were designed for irrigation without considering domestic, aquacultural, power, flood protection or tourism water needs. High pollution load discharges in surface water have also led to higher water scarcity in this area.

The Mekong Delta experiences **too variable water**, **poor water quality** and **overutilisation**. Reduced water flows in the Delta, which subsequently intensifies saline intrusion, are primarily caused by decreasing transboundary flows (e.g., due to major dams upstream) and deepening of river channels due to sand mining. Saline contamination is particularly high 60 km further inland, rising above 4 g/L (Viet Nam Red Cross Society, 2020). This has resulted in severe water shortages affecting agricultural and domestic water uses. Furthermore, groundwater is overexploited in some areas, leading to land subsidence and further water quality problems, especially in acid sulphate and saline soils (Erban et al., 2013; Phi & Strokova, 2015). Agricultural and domestic wastewater also contribute to pollution in the delta—agriculture alone uses approximately two million tons of fertiliser and 500,000 tons of pesticides.

Water scarcity management

Key actors and policy instruments

Water scarcity management has been, and continues to be, a high priority for the Vietnamese government, involving institutions across all levels and many ministries. The legal framework for water resources management is comprehensive, with many laws and legislative documents related to water resources management. Related programs have been well implemented, such as rural development, poverty reduction and rural clean water and sanitation programs, though some issues prevail.

Responsibilities related to water resources management are shared across several ministries at the national level, each of which formulate their own policies, strategies and master plans for various aspects of water management and development. This includes the National Water Resources Council (which advises the government on water resources–related decision-making), the Ministry of Natural Resources and Environment, the Ministry of Agriculture and Rural Development, the Ministry of Industry and Trade, the Ministry of Transport, the Ministry of Construction and the Ministry of Health.

At the provincial level, various departments then enact the policies established by the central government (e.g., the Ministry of Natural Resources and Environment). At the district and commune level, the sub-department agencies or bureau implements and monitors administrative activities related to water. River basin organisations (RBO) also exist for transboundary and interprovincial river basins to settle water use conflicts and assist with coordinating activities.

Numerous laws and policies relating to water scarcity management exist in Viet Nam, including the 2012 Law on Water Resources; 2017 Law on Hydraulic Works; 2013 Law on Natural Disaster Prevention and Control; 2017 Law on Planning; 2014 Law on Environmental Protection; 2020 Viet Nam's Hydraulic Work Strategy through 2030, with a vision toward 2045; 2006 National Water Resources Strategy to 2020; 2017 120/NQ-CP Resolution on Sustainable and Climate-Resilient Development of the Mekong River Delta; and the Prime Minister's Directive no. 4/CT-TTg on emerging solutions for prevention of drought, water scarcity and saline intrusion (see Figure 15).

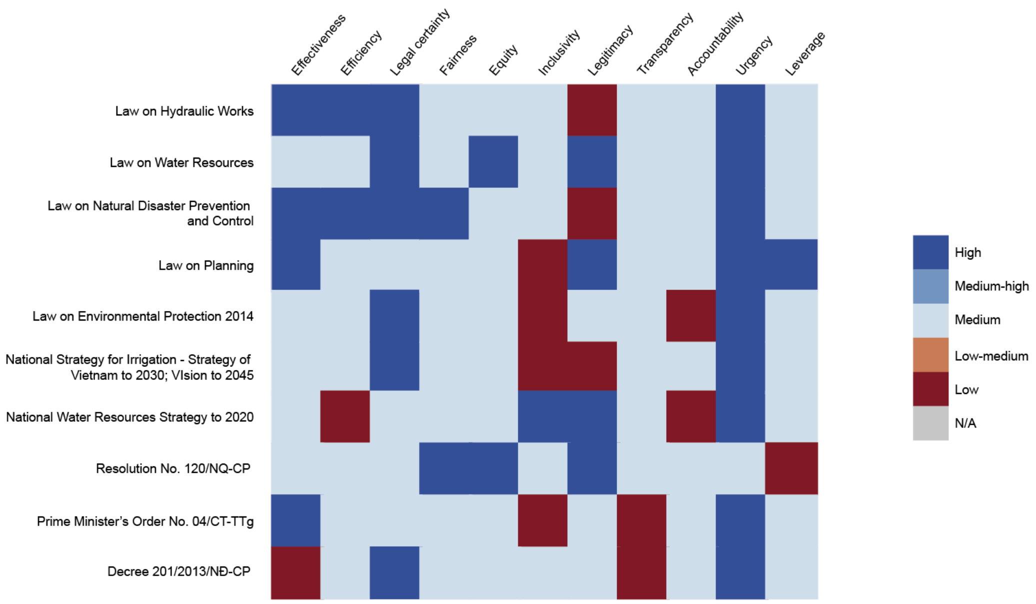

Figure 15. Assessment of Viet Nam's key policy instruments in managing water scarcity.

Strengths and weaknesses

Viet Nam has a comprehensive legal framework for water resources management. The country has several well-implemented programs on rural development, poverty reduction, rural clean water and sanitation. However, it is less successful in managing water quality, and there are significant issues in terms of overlapping mandates and policy incoherence. While integrated water resources management (IWRM) has been endorsed at a national level, it is not entirely effective. There are significant challenges in data collection and monitoring, as well as a reluctance to share data between organisations. Further, users of water resources information must pay to access it. Financial resources are also constrained, making it difficult to provide the comprehensive and timely data needed to develop the various master plans required under the 2012 Law on Water Resources or to fulfil other water management tasks. Viet Nam is undertaking a review and amendment of the country's water law, which may provide an opportunity to address some of the key issues related to water scarcity.

The country faces high interannual and seasonal water variation, uneven geographical groundwater distribution and overexploitation in the major agricultural regions (e.g., the Mekong Delta and Central Highland), which lowers the water table and causes land subsidence. There is also a lack of civil society engagement, cross-sectoral cooperation and private sector engagement.

Country outlook

Water-saving irrigation techniques and technologies are currently being developed and adopted in Viet Nam, as well as efforts to incorporate nature-based farming. International support continues to be important for implementing water resources management and climate change adaptation plans in the country, as well as transboundary agreements with upstream countries in the Mekong.

4.2.3 Thailand

KEY FINDINGS

- **Thailand experiences all four types of water scarcity: too little water, too variable water, overutilisation and poor water quality.**
- **Poor water quality is widespread across the country due to industrial and agricultural pollution** and high population density, with low rates of wastewater treatment (except Bangkok). Recent droughts have led to increased saline intrusion (e.g., in Chao Phraya).
- **Improved mandate and funding are expected to assist river basin committees**, but local support is needed for collaboration between institutions, as well as innovation and technologies that could ensure farmers and local people have water access in the dry season.
- **Evaluation processes for the local implementation of water policies, plans and strategies remain limited.**
- **River basin planning also remains fragmented** due to a lack of authority and financial resources for river basin committees, as well as competition between different sectors and historical institutional mandates.

Context

Thailand is part of the Indochina peninsula, bordered in the north by Lao People's Democratic Republic, in the east by Cambodia and Lao People's Democratic Republic, in the south by the Gulf of Thailand and Malaysia and in the west by the Andaman Sea and Myanmar. It has a population of 70 million people, with a population density of 141 people per square kilometre in 2023. Thailand is an upper-middle-income country with a GDP of US$505.9 billion.

Water resources and water use

Thailand has 22 river basins across a land area of 415,000 km^2 and 27 major aquifers (with the exploitation potential of 45,385 Bm^3). The total surface water runoff in the country is 198,880 Mm^3, with significant regional variability. Existing storage is around 37 per cent of annual runoff, 91 per cent of which is stored in 36 large reservoirs. About 29 per cent of the surface runoff (i.e., approximately 70,770 Bm^3 per year) is stored for irrigation, with a total irrigable area of 4.96 million ha (THAICID, n.d.).

The country's rainfall is highly variable due to its unique location at the confluence of several different climatic influences. The climate is tropical, with three distinct seasons: hot from March until May, rainy from May until October, and drier and cooler from November until February (Power et al, 2020).

The last three decades have been characterised by sustained, rapid economic growth, which has stimulated water demand for irrigation, domestic use, energy and industry. The proportion of land area under agricultural production has significantly increased over the last 60 years to 43 per cent; it accounts for 75.1 per cent of the total consumptive water demand, though groundwater is rarely used for agriculture (World Bank Group, 2023).

Social and economic context

Agriculture's contribution to the country's GDP is dwindling (around 8.6 per cent). Rice is a dominant crop; it remains important to food security, livelihoods (31 per cent of all employment) and the export economy (World Bank Group, 2023). Historically, Thailand has been a successful agricultural society due to the country's well-endowed natural resources.

About 28 per cent of women were working in the agricultural sector in 2019 (World Bank Group, 2023). Thailand has a strong legislative position regarding gender equality; however, considerable inequality exists in several areas, particularly in rural areas affected by poverty, discrimination and exploitation.

Multiple barriers prevent women and girls from obtaining access to justice and effective remedies to violations of their rights. They highlight the lack of access to justice for rural, indigenous and ethnic minority women and those from diverse religions and women with disabilities (CEDAW, 2017).

Water scarcity drivers and status

Thailand has a long history of climate variability, resulting in droughts punctuated by rapid flooding. Rapid population growth and economic development, in conjunction with increased climate variability, have driven a trend towards water scarcity across all geographic zones. Each region of the country experiences water scarcity challenges differently. Overall, Thailand experiences all four types of water scarcity: too little water, too variable water, overutilisation and poor water quality. Figure 16 details the Water Crowding Index in different regions of the country.

Water insufficiency (**too little water**) is a significant issue across large parts of the country—particularly in the central, north and northeast areas. **Too variable water** is an ongoing challenge across the country, where monsoonal rainfall patterns result in limited water availability during the dry season (except for water stored in reservoirs). There are also widespread reports of increasing interannual variability.

Overutilisation of water is also an issue in certain parts of the country. For example, the development of the Eastern Economic Corridor (covering Chon Buri, Rayong and Chachoengsao provinces) has rapidly increased water demand in the area, increasing water allocation to industry (Manorom, 2020).

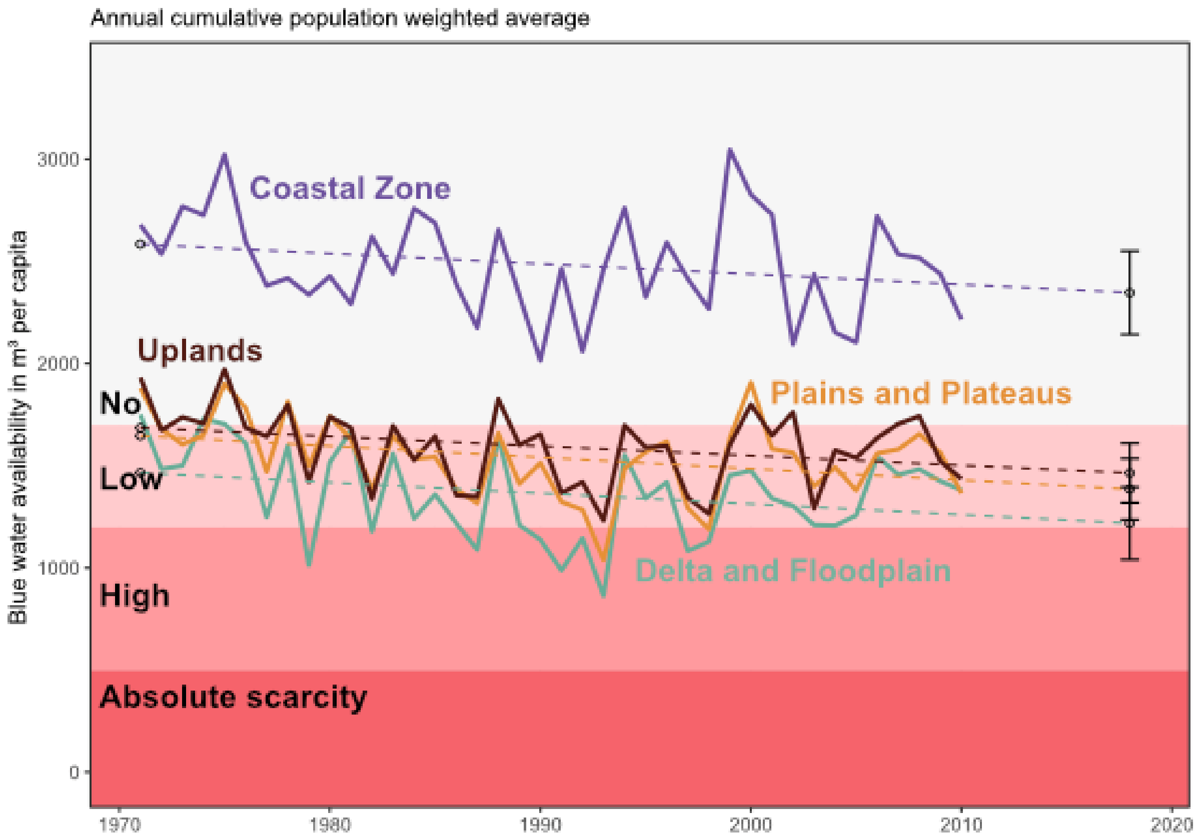

Figure 16. Water Crowding Index for Thailand (1971–2010).

Poor water quality occurs widely across Thailand due to a high level of industry and high population density. Except for Bangkok, there are low wastewater treatment rates in the country, meaning industrial and agricultural pollution is widespread. Recent droughts have also highlighted a concerning trend of saline intrusion during low flows (e.g., in Chao Phraya) (Chandran, 2020).

Climate change may have detrimental effects on the country's agricultural sector. While overall annual precipitation is projected to increase, the variability is expected to increase both seasonally and geographically due to three distinct seasons (e.g., rainfall may decrease between September and October, which is a rice-producing phase). However, there is high uncertainty regarding precipitation changes due to varying model estimates and emissions pathways. Temperature increases are also expected to affect crop productivity negatively under high-emissions scenarios, though little seasonal variability is projected. However, as with precipitation, the effects of temperature changes on agriculture are expected to vary geographically (e.g., eastern, south-central and north-eastern areas are likely to suffer the most negative effects) (World Bank Group & Asian Development Bank, 2021a).

Water scarcity management

Key actors and policy instruments

Thailand's national water management institutions have undergone significant restructuring, as issued by the head of the National Council for Peace and Order through order 46/2017. This was primarily due to *Thailand's Water Vision,* published in 2000, which reported a lack of coordination between the seven ministries involved in water resources management, each with differing priorities and programs.

Thailand's response to this need for reform, along with ongoing flood and drought challenges, has involved the establishment of four key pillars for water resources management: (i) the creation of a central agency to restructure the country's water management institutional framework (Office of National Water Resources, established in 2017); (ii) the establishment of a legal foundation for water management (the 2018 Water Resources Act, which streamlines water management previously coordinated across 48 different agencies); (iii) the 20-year Master Plan on Water Resources Management (approved in 2019, outlining six strategies for managing water scarcity using a water security framework to inform priorities for action); and (iv) the modernisation of water information collection and planning (e.g., through agro-economic zoning). Various new or existing policy instruments are supported by these four pillars (see Figure 17).

Strengths and weaknesses

The more systematic focus on policies, measures and an institutional framework has begun to strengthen the enabling environment for improved water management, which has helped direct specific guidelines, measures and implementation plans for management activities across different scales. The establishment of the Office of National Water Resources has improved coordination between ministries and made roles and responsibilities clearer. This has already benefited Thailand's response to crises; the government responded more rapidly and effectively to the recent 2019–20 drought in Thailand and limited damage to the agricultural sector (though it was still significant). The new National Hydroinformatics and Climate Data Center has also significantly improved data availability by integrating information from water and weather-related agencies in Thailand, which has helped inform decision-making across all scales.

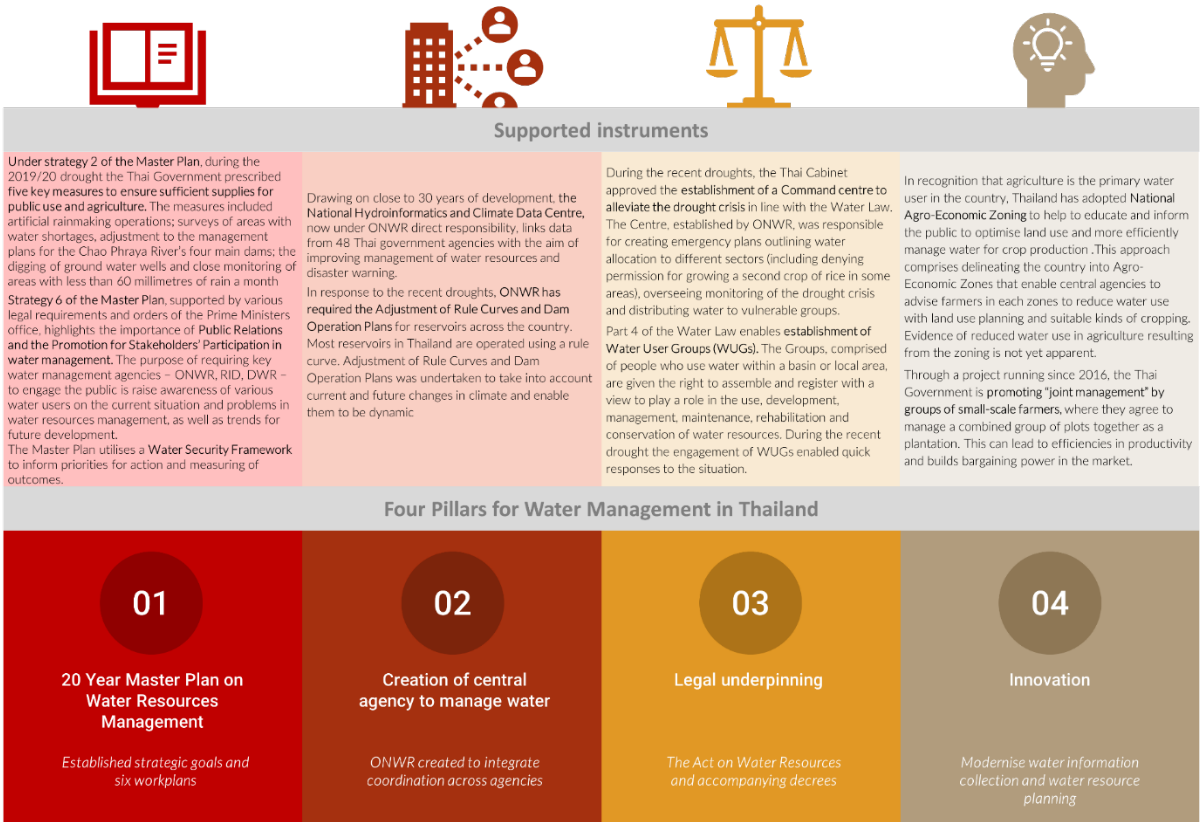

Figure 17. Review of key policy instruments for managing water scarcity in Thailand.

However, some redundancies remain within the institutional framework regarding the guidelines and implementation plans of line agencies and national committees (see Figure 18). Evaluation processes for implementing these policies, plans and strategies at the local level also remain limited. River basin planning also remains fragmented due to a lack of authority and financial resources for river basin committees, as well as competition between different sectors and historical institutional mandates (though this is improving). There is also limited systematic monitoring and evaluation for policy implementation at the local level, which would be beneficial. Finally, while a clear stakeholder consultation platform has been established, stakeholder engagement remains focused on large-scale water users.

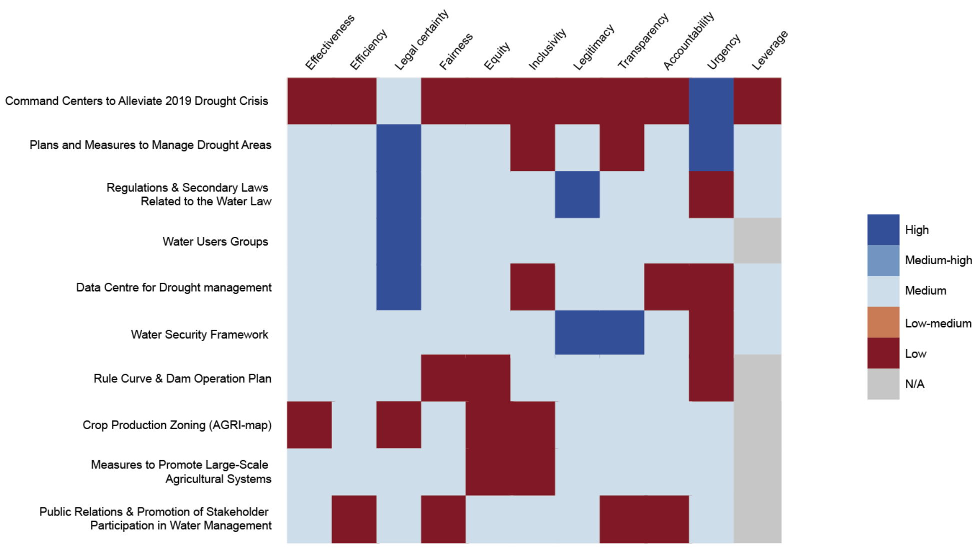

Figure 18. Assessment of Thailand's key policy instruments in managing water scarcity.

Country outlook

More systematic monitoring and evaluation processes are required to implement Thailand's various policies and strategies effectively. Local support is also needed for technologies and innovations. Increased stakeholder engagement would help to reduce ongoing public uncertainty about how water resources are shared and managed, as well as to help local people secure water rights and inclusive development.

4.2.4 Lao People's Democratic Republic

KEY FINDINGS

- **Lao People's Democratic Republic experiences water scarcity in the form of variable water, overutilisation and poor water quality.**
- **Increasing water demands from the agricultural, industrial and domestic sectors are likely to increase water scarcity** (likely to be localised). Intensive irrigation is already an issue in some areas.
- Significant regulation and **fragmentation of river hydrology due to hydropower reservoirs is a common cause of water scarcity** in the country.
- **Water quality issues occur due to human-induced pollution in industrial and urban areas** (e.g., Vientiane) and agricultural diffuse pollution. Arsenic contamination is also a minor issue for groundwater in central and southern regions.
- Given the country's relative abundance of water, Lao People's Democratic Republic has somewhat limited policy instruments explicitly linked to water scarcity. However, **growing pressures on water resources indicate a need for more concerted efforts to adequately prepare for and manage water scarcity.** This will be threatened by the country's over-reliance on the Mekong River for agricultural production and limited cross-sectoral integration and enforcement of existing regulations.
- In addition to financial resources for implementation, a focus should be placed on developing human resources.

Context

Lao People's Democratic Republic is in the centre of South-East Asia, in the mainland between Cambodia, Myanmar, China, Thailand and Viet Nam. It has a population of approximately 7.6 million people, with 33 people per square kilometre in 2023, many of whom live in the valleys of the Mekong River and its tributaries. Lao People's Democratic Republic is a lower-middle-income country, with a GDP of US$18.8 billion (as of 2021). The country has a land area of 236,800 km^2. Agriculture provides about 16 per cent of GDP, employing around 60 per cent of the labour force.

Water resources and water use

The Mekong Basin dominates Lao People's Democratic Republic 's water resources, with the main rivers of this country predominantly consisting of first-order and second-order tributaries of the Mekong River. With a tropical monsoon climate and average annual rainfall of 1,800 mm leading to internal freshwater resources in the country totalling around 240,000 Mm^3 per year, the country has relatively abundant internal freshwater resources for its small population (World Bank Group, 2023).

The primary water-using sectors are agriculture (95.9 per cent of total withdrawals), followed by industry (2.4 per cent) and domestic consumption (1.7 per cent) (World Bank Group, 2023). Hydropower is an important non-consumptive user of water in the country. Hydropower accounts for over 90 per cent of power production in the country and, therefore, is an important factor for water resources management in Lao People's Democratic Republic (McCartney & Brunner, 2020).

Agricultural production in Lao People's Democratic Republic relies heavily on seasonal water availability, especially in the wet season. In the dry season, irrigation is needed to enable crop production, though this is not widespread (CGIAR, 2020).

Social and economic context

As the country transitions from being a least developed country, the government is prioritising industrial development. Agriculture remains an important sector of the country's economy, providing about 16 per cent of GDP and employing about 60 per cent of the labour force, with about 64 per cent female employment in 2019 (World Bank Group, 2023). Rice accounts for 50 per cent of national agricultural output. Lao People's Democratic Republic has been steadily improving access to domestic water supplies across the country; between 2015 and 2020, the percentage of the population with access to basic or safely managed water supplies increased from 70 to 78 per cent in rural areas and from 92 to 97 per cent in urban areas (WHO & United Nations Children's Fund, 2020).

While the significant involvement of females in agriculture might be considered to provide empowerment for women, there are a range of factors limiting this empowerment. Women are often left out of decision-making and discussions at all levels (FAO, 2018).

Water scarcity drivers and status

Lao People's Democratic Republic has relatively abundant water resources per capita and is one of South-East Asia's few water-scarce countries. Nevertheless, spatial and temporal variability causes too variable water and increasing trends towards overutilisation and poor water quality.

Lao People's Democratic Republic generally has sufficient water resources, except for the Xieng Khouang Plateau (see Figure 19). Due to the monsoonal climate, water scarcity is seasonal (i.e., in the interannual and intra-annual cycles). **Overutilisation** by agriculture, industry and domestic use is currently a minor problem in Lao People's Democratic Republic, though some areas have intensive irrigation. A more common form of overutilisation comes from the high degree of regulation and fragmentation of river hydrology due to hydropower reservoirs.

Water quality issues are predominately related to human-induced pollution in urban and industrial areas (e.g., Vientiane) and agricultural diffuse pollution. Arsenic contamination is also a minor issue for groundwater in the central and southern parts of the country (Chanpiwat et al., 2011).

Increasing water demands for agriculture, industry and urbanisation will likely increase water scarcity issues in Lao People's Democratic Republic. This is expected to continue as the government prioritises economic development (e.g., expanding agriculture). Nevertheless, any water scarcity is likely to be localised. In areas of Lao People's Democratic Republic that rely on the Mekong River mainstream for water supplies (Lauri et al., 2012), the construction of hydropower reservoirs on the mainstream Mekong will cause significant changes in the timing of water availability throughout the year (e.g., by flattening seasonal variability) (see Figure 19).

It remains unclear whether climate change will be a significant driver of future water scarcity in Lao People's Democratic Republic. While temperatures are projected to increase, precipitation trends are highly uncertain. The occurrence of drought in the country may increase due to climate change, and changes to peak flows may have complex implications for water resource management (World Bank Group & Asian Development Bank, 2021b). Research suggests that the construction of reservoirs in the Mekong River Basin will likely have a more significant effect on the Mekong's hydrology than climate change in the coming 20 to 30 years—particularly during the dry season—though climate change will increase the uncertainty of reservoir operation effects (Lauri et al., 2012). Therefore, there is a need for a better understanding of the effects of climate change on river flow and increased transparency of reservoir storage and operations across the basin.

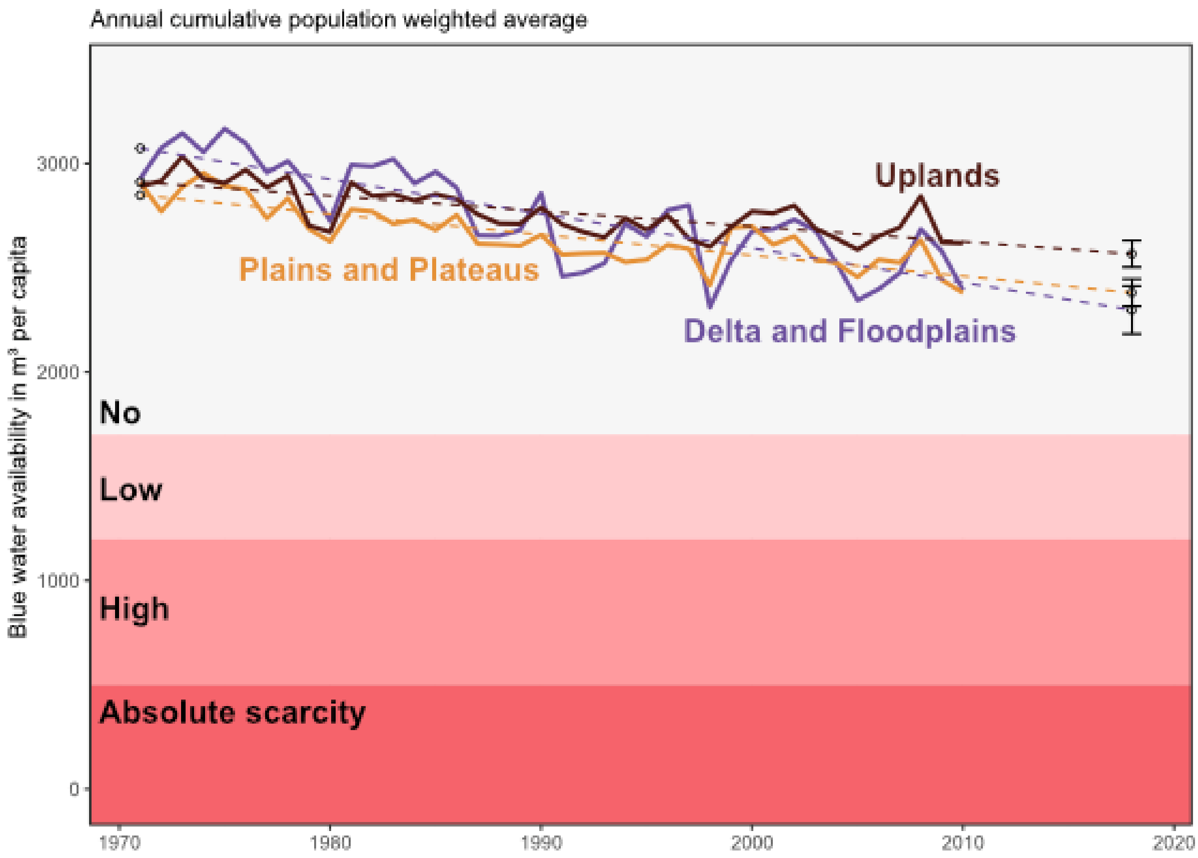

Figure 19. Water Crowding Index for Lao People's Democratic Republic (1971–2010).

Water scarcity management

Key actors and institutions

Lao People's Democratic Republic has been developing the national legislative basis for water resources management over time through an iterative process. The country has recently established a range of legislative and policy instruments regarding water resources development and management; however, the success of these instruments is dependent on implementation. The 2017 Law on Water and Water Resources is the primary legislative instrument in Lao People's Democratic Republic, along with the decrees on Reservoir and Reservoir Management (2021) and Groundwater (2019). Several related strategies, policies and plans also guide how Lao People's Democratic Republic manages water scarcity: Ministry of Natural Resource and Environment's Vision toward 2030 and Natural Resources and Environmental Strategy (2016–2025); the National Water and Water Resources Management Strategy (2020–2025); the Agriculture Development Strategy to 2025 and Vision to 2030; the Strategy on Climate Change of Lao People's Democratic Republic (2010); the National Land Allocation Master Plan (2016–2030) and the Policy on Sustainable Hydropower Development in Lao People's Democratic Republic (2015) (see Figure 20).

Strengths and weaknesses

The recent legislative and policy reforms in Lao People's Democratic Republic provide a strong basis for IWRM. Given the country's relatively abundant water resources for its population size, it has limited policy instruments explicitly focusing on water scarcity. Further, water scarcity is not generally a focus in terms of water management, leading to some discrepancies across the different instruments.

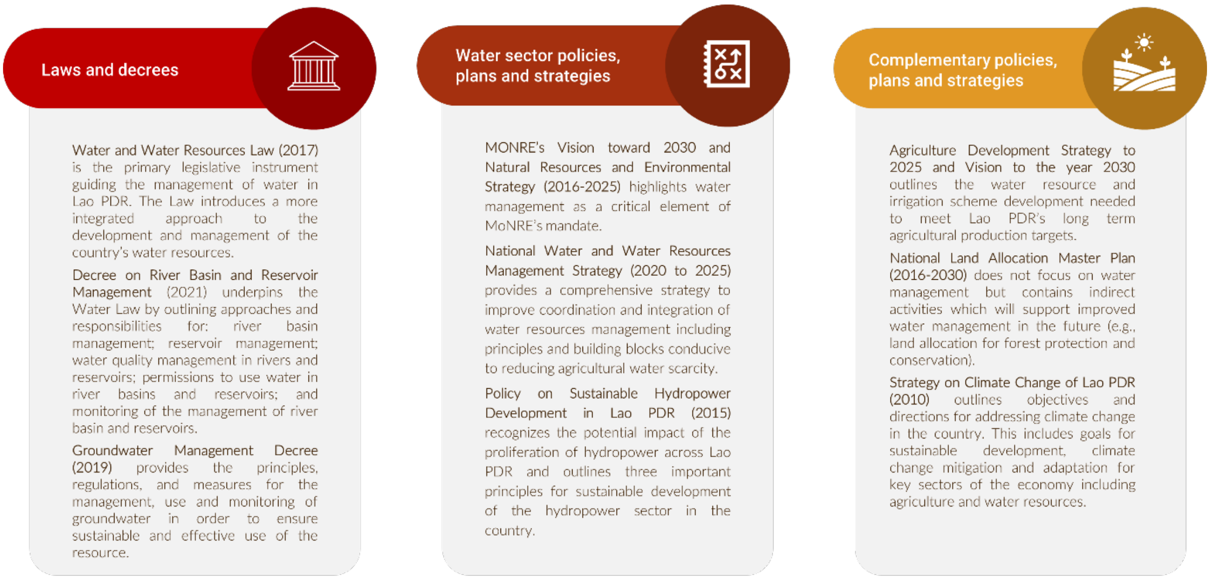

Figure 20. Review of 10 key policy instruments for managing water scarcity in Lao People's Democratic Republic.

However, Lao People's Democratic Republic does experience seasonal water scarcity (i.e., relatively limited water availability during the dry season) and has a growing population, putting more pressure on water resources. This, combined with threats posed by hydropower reservoirs on water flows and general uncertainty regarding the human and financial resources available to deliver on the country's current mandate, indicates a need for more scarcity-specific instruments in the future (see Figure 21). Other weaknesses in the country's current approach include an over-reliance on the Mekong River for agricultural production during the dry season and limited cross-sectoral integration and enforcement of regulations.

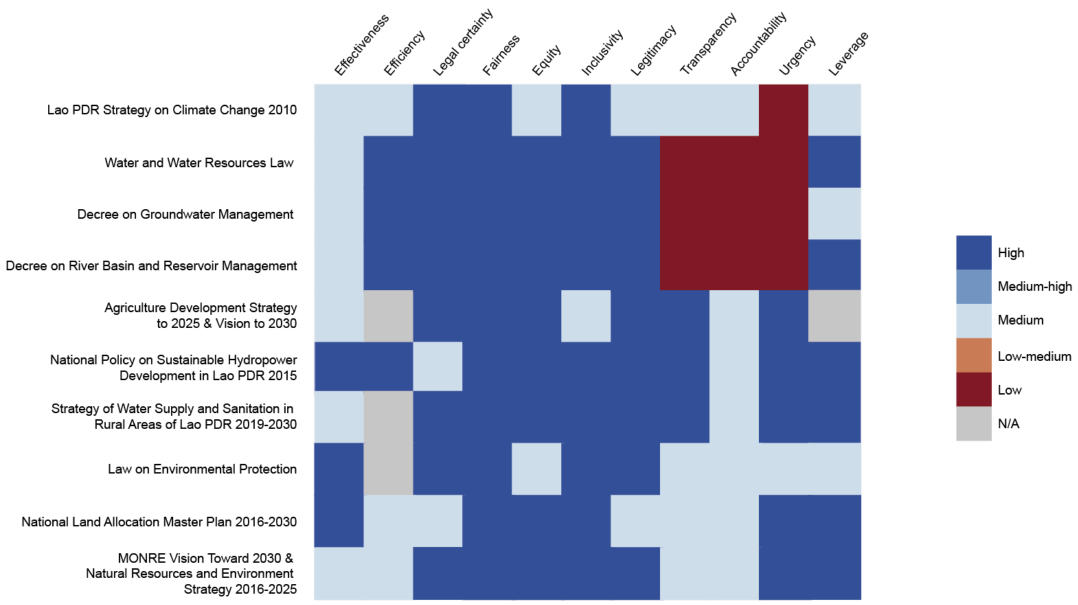

Figure 21. Assessment of Lao People's Democratic Republic's key policy instruments in managing water scarcity.

Country outlook

Lao People's Democratic Republic's historical struggle with cross-cutting institutional mandates has shown that implementation needs coordination across a wide range of institutions involved in water management. Despite the country's high per capita water resources, Lao People's Democratic Republic will need more concerted efforts in preparing for and dealing with water scarcity specifically, especially as pressures on water resources grow. Effective collaboration between agencies and with the public will be critical to successfully implementing the Lao People's Democratic Republic government's ambitious water management plans. For the new laws and policies to be smoothly implemented, capacity building is needed for government officials; financial and human resources will be required for this.

4.2.5 Myanmar

KEY FINDINGS

- Myanmar has abundant water resources, but **experiences too variable water and dry-season** shortages and has a lack of infrastructure for water storage to alleviate shortages.
- **The country is currently in a state of emergency and under military control, which has significantly affected society and stalled many important projects related to water scarcity.**
- Prior to the current political unrest, Myanmar had made progress in developing a strong legal framework to manage its water resources; however, much of this progress has now stalled.

Context

Myanmar is the second-largest country in South-East Asia and is currently under martial law. The current political unrest in Myanmar and COVID-19 effects have stalled many important projects and initiatives related to water development and scarcity. This country is home to 55.4 million people, with more than 80 people per square kilometre in 2023. It is a lower-middle-income country, with a GDP of US$65 billion. Agriculture is the backbone of Myanmar's economy: it uses 20 per cent of the land area. Agriculture accounts for 89 per cent of total water use. In 2020, agriculture provided 23.4 per cent of the country's GDP.

Water resources and water use

Myanmar has abundant water resources with an average annual rainfall of 2,435 mm (Oo, 2015). However, there is significant temporal and spatial variability in rainfall across the northern and southern regions of the country. The average annual potential water resources available is 1,082 km^3 of surface water and 495 km^3 of groundwater (around 20,000 m^3 per person per year). However, rapid population growth over the last few decades has contributed to a significant reduction in per capita freshwater availability (World Bank Group, 2023). Most regions of the country face high water scarcity during the middle of the dry season (November to April) and low water scarcity during the wet season (June to October). This is particularly evident in agricultural areas.

Myanmar has eight main river basins: the Ayeyarwady, Thanlwin (Salween), Mekong, Sittaung, Bilin, Bago, Tanintharyi and Rakhine. Of these basins, three major transboundary basins—Ayeyarwady, Thanlwin and Mekong—cover around 79 per cent of the country. Groundwater recharge is variable across the country, with two-thirds of available groundwater located within the Ayeyarwady Basin (International Finance Corporation, 2018).

Myanmar's water resources provide for critical freshwater ecosystems and a range of vital services, for example, fish (Myanmar's primary source of animal protein), flood protection, biodiversity, economic wellbeing and livelihoods, and clean drinking water.

Social and economic context

Around 25 per cent of the total population of Myanmar lived below the poverty line in 2017 (1,590 kyat per adult per day), particularly in rural areas (Myanmar Central Statistical Organisation, UNDP & World Bank Group, 2019). Myanmar is in a state of emergency, with the military currently controlling the country through martial law. This has led to ongoing political unrest, violence, arrests and deaths.

Agriculture is the backbone of Myanmar's economy, involving 20 per cent of the land area (Mar, 2015). Agriculture accounts for 89 per cent of total consumptive water use in Myanmar (Asian Development Bank, 2017). In 2019, agriculture provided 22 per cent of the country's GDP and employment for almost half of the population (World Bank Group, 2023). Rice dominates the agricultural sector, with around

91 per cent for domestic consumption. However, Myanmar suffers from low agricultural productivity compared to its neighbouring countries (World Bank Group, 2016b). Women comprise more than 50 per cent of rural farm labour in some regions and typically bear the burden of accessing water for domestic use yet are typically under-represented in leadership and financial benefits (Water for Women Fund; OXFAM, 2020).

Water scarcity drivers and status

Myanmar experiences water scarcity in the form of too variable water. While there are sufficient water resources per capita and for growing food across most of the country, there is high variability of water availability between seasons (wet and dry) and a lack of infrastructure to allow for intra-annual and interannual storage.

Most of the country faces high water scarcity during the middle of the dry season (November–April) and low water scarcity during the wet season (June–October). This is particularly evident in agricultural areas (e.g., the central Dry Zone, delta and Shan Plateau; see Figure 22). At a finer scale, some regions also appear to be experiencing water scarcity related to **insufficient water** and **poor water quality.**

Two key drivers of water scarcity in Myanmar are population growth and urbanisation. The population increased from 21.7 million to 54.4 million between 1960 and 2020; the rural population drastically decreased from 81 per cent to 29 per cent during the same period. This growing population has increased water demand for domestic water, agriculture and industry. Annual freshwater withdrawals increased from 2.26 Bm^3 in 1987 to 33.23 Bm^3 in 2017 (World Bank Group, 2023). Overextraction of groundwater for irrigation has also led to groundwater depletion in several regions, such as the central Dry Zone. Climate change has also driven water scarcity trends in Myanmar; the country is consistently classified among the most climate-vulnerable in the world and is experiencing altered monsoon seasons (e.g., higher rainfall intensity and extended pre-monsoon droughts) (Nagpal et al., 2020).

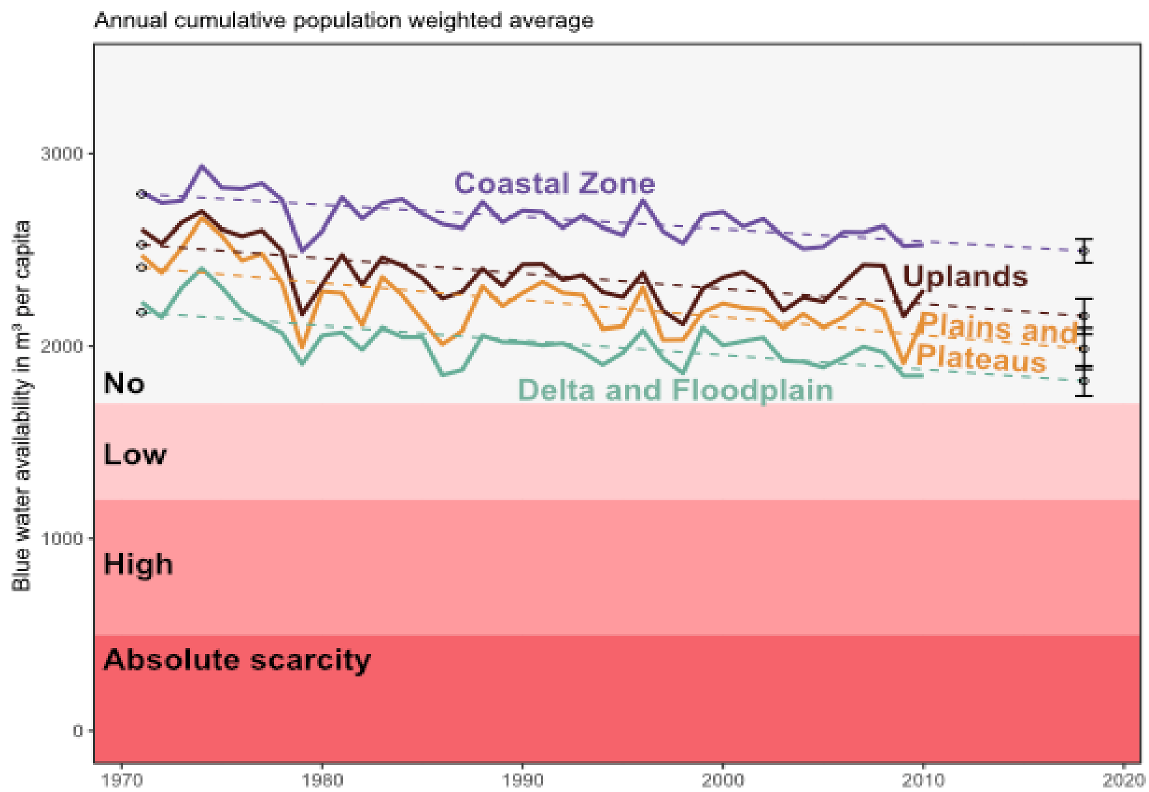

Figure 22. Water Crowding Index for Myanmar (1971–2010).

Water scarcity management

Key actors and institutions

Myanmar's Constitution provides the legal basis for water-related institutions, including the Directorate of Water Resources and Improvement of River Systems, the Irrigation and Water Utilization Management Department, the Department of Fisheries, the Department of Hydropower Implementation and the Environmental Conservation Department. However, no institution has a clear overarching responsibility for water resources management.

Before the political unrest in Myanmar, there had been strong improvements over the past decade in how water resources were managed in the country. Myanmar has made progress in developing a strong legal environment to manage its water resources (e.g., the establishment of the National Water Resource Commission in 2013); however, it has not yet passed a water law (see Figure 23). Collectively, these documents: (1) establish an overall requirement to protect and conserve the natural environment, including through provisions in the Constitution; (2) recognise the importance of protection and sustainable management of water resources and the benefits they provide; and (3) establish a legal head of power for managing freshwater resources, particularly via the Conservation of Water Resources and Rivers Law and Environmental Conservation Law.

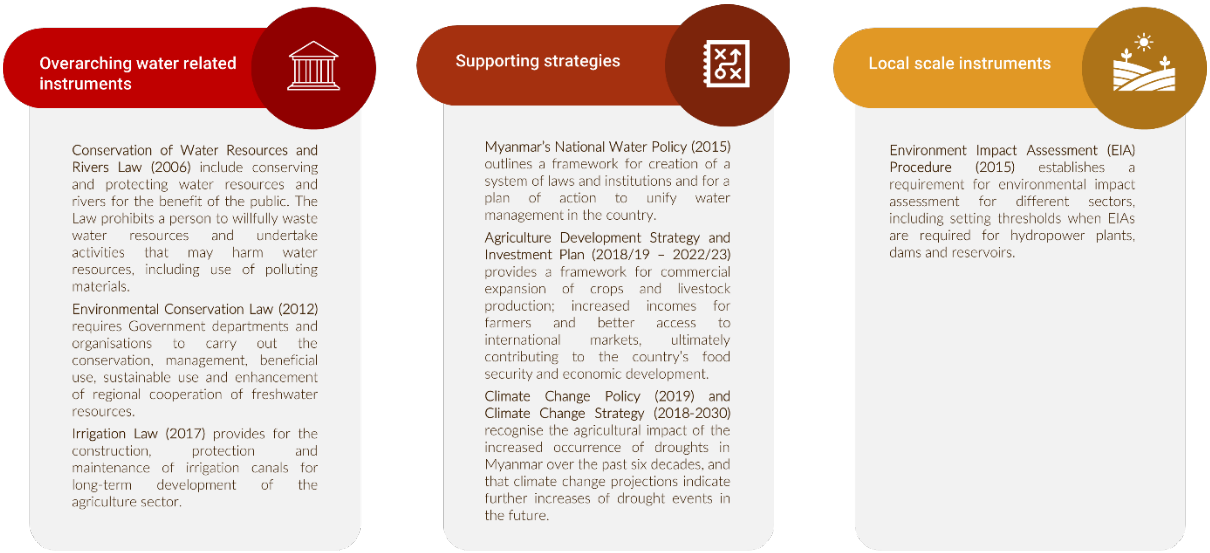

Figure 23. Review of 10 key policy instruments for managing water scarcity in Myanmar.

Strengths and weaknesses

Before the current unrest, Myanmar had successfully developed some water scarcity–related institutions and policy instruments (see Figure 24) and strong relationships with bilateral and multilateral donors. While there are dependency risks (e.g., dual agendas), it helped fund infrastructure improvement works and planning and governance projects, such as the now-stalled Master Plan for the Ayeyarwady Basin. With the current political unrest, many donors have also curtailed their funding (see Figure 24 for key strengths and weaknesses).

Country outlook

Much of Myanmar's future water scarcity management depends upon the country's political situation, which has recently stalled many important projects and initiatives. When possible, establishing an overarching institutional framework for water management would help reduce institutional overlaps and drive action. If the current unrest can be resolved, it would also be beneficial for prior bilateral and multilateral relationships to be re-established, which could provide opportunities to further develop responses to water scarcity, including strengthening the water governance framework, river basin planning and infrastructure upgrades.

To overcome the uncertainties around rain-fed agriculture and gaps in existing formal irrigation schemes, some farmers in the Dry Zone already use pumps to obtain surface and groundwater sources year-round. Redesigning agricultural outreach programs may help farmers shift from exclusively monsoon paddy production to dry-season production. Improvements in small-scale water supply infrastructure and water management technologies (e.g., rainwater harvesting, ponds and small-scale pumping) could also help to grow the agricultural sector and provide a decentralised approach to ensuring water access for irrigation.

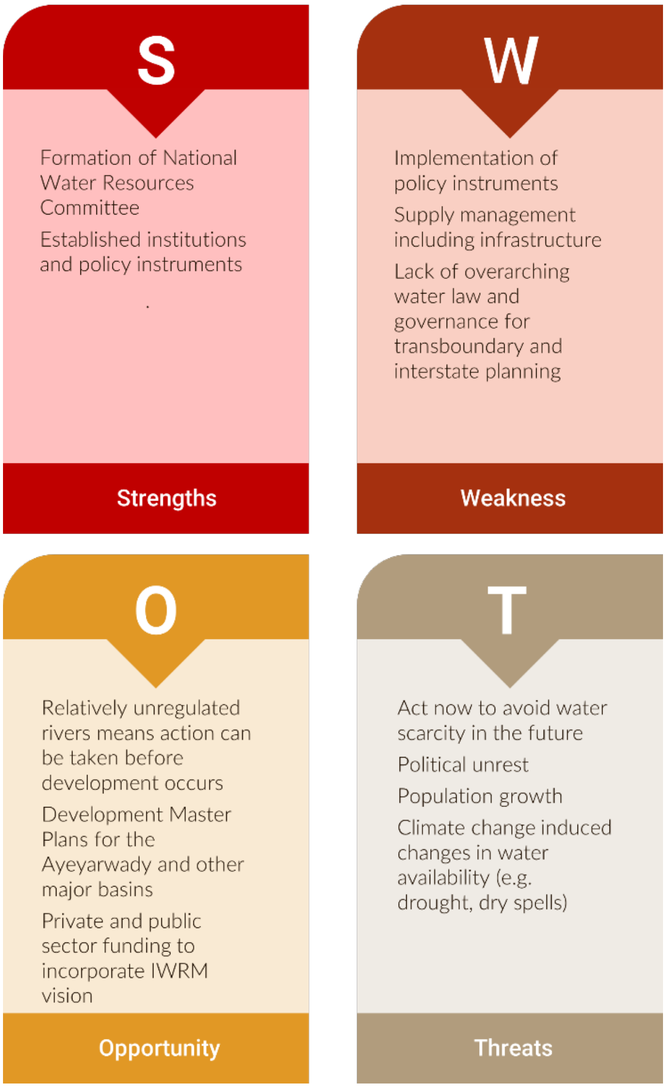

Figure 24. SWOT analysis of water policy in Myanmar.

4.3 Island South-East Asia and the Pacific region

The island South-East Asia and the Pacific region are home to approximately 424 million people and is the least homogenous region of this study, with a mostly tropical climate, except for central New Guinea, which has a temperate climate. The islands generally have rough terrain, with flat deltas and plains in eastern Sumatra, southern Borneo and southern New Guinea. The region's population is concentrated in the islands of Java, Sumatra and smaller southern-Indonesian islands and the Philippines.

Limited natural resources constrain the islands' economic diversity and cause heavy reliance on a few economic sectors like tourism. Moreover, islands are dispersed over a vast area, with many people reliant on internal renewable water resources. Agriculture covers approximately 516 000 km^2.

Water scarcity occurs in a few hotspots, particularly the island of Java due to its high population, as well as the Indonesian islands of Bali and (west) Timor, some areas of the Philippines and large population centres of Malaysia's Kuala Lumpur and Malakka. Java is the most water-scarce island, with less than 1000 m^3 per capita of available water resources (see Figure 25).

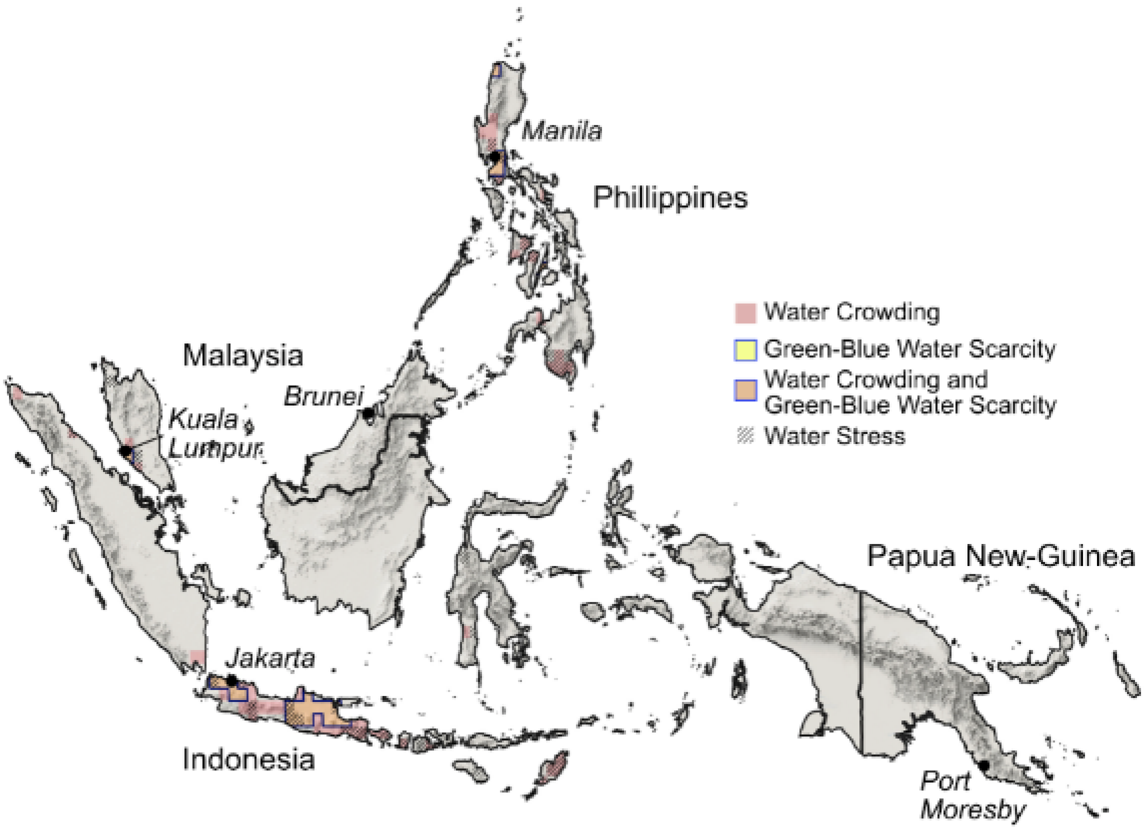

Figure 25. Water scarcity hotspots in the island South-East Asia and the Pacific.

4.3.1 Fiji

KEY FINDINGS

- **Fiji faces two types of water scarcity: too variable water and poor water quality.**
- Although Fiji has abundant water resources with high annual rainfall, its **uneven distribution across the islands and between seasons cause frequent droughts and floods**.
- **Degraded water quality occurs in areas of Fiji where urbanisation and industrialisation are increasing rapidly.** Poor wastewater treatment and management lead to untreated waste and effluent discharge into water bodies.
- **Fiji's water policy environment is somewhat fragmented** and in need of an overarching water sector policy to integrate the many subsectors and better define different departments' roles and responsibilities More efforts are needed to explicitly deal with water scarcity.

Context

Fiji is an archipelago of 322 islands, of which about a one-third are inhabited. Located in the heart of the Pacific Ocean between the equator and the South Pole, Fiji is positioned between awaii to the north, New Zealand to the south, Vanuatu to the west and Tonga to the east (Digital Logistics Capacity Assessments, 2017). Fiji's total area is 18,333 km^2, with population of 0.9 million people (about 51 people per square kilometre in 2023). Two islands,Viti Levu and Vanua Levu, account for 80 per cent of Fiji's population (Fiji Bureau of Statistics, 2017).

Fiji is an upper-middle-income country, with a GDP of US$4.3 billion. Agriculture covers 17.1 per cent of Fiji's land area and accounts for 58.9 per cent of total water withdrawals. Agriculture contributes approximately 44 per cent of Fiji's US$4.3 billion GDP per annum.

Water resources and water use

Fiji has 28,550 Mm^3 of renewable surface water resources, with significant seasonal and geographic variability (Knoema, n.d.). Permanent surface water sources are primarily found on large mountainous islands, with atolls and small islands with low elevations generally have little to no permanent surface water available (Pacific Islands Applied Geoscience Commission, 2007). Additionally, Fiji has about 5,273 m^3 per year of renewable groundwater. Shallow groundwater plays a crucial role as a water source during the dry season. It should be noted that groundwater on small islands (including Fiji) is limited and susceptible to saline intrusion, requiring careful management.

The majority of water development efforts in Fiji are geared towards potable water supply, sanitation, agro-industry, and tourism. Agriculture covers 13.7 per cent of Fiji's land area and accounts for 58.9 per cent of total consumptive water demand in (Knoema, n.d.). However, it is important to highlight that sectoral water use varies between regions, depending on topography, rainfall distribution and population density.

Social and economic context

Tourism is an essential driver of socio-economic progress, contributing approximately 40 per cent of the country's GDP and providing jobs for almost 150,000 people (the Guardian, 2020). The Fiji Government intends to expand the sector, which may lead to higher water demands and increase the degree of water scarcity during the dry season in some areas like the western side of Viti Levu and the Coral Coast in Fiji (Pacific Water, 2014).

Agriculture also makes an increasing contribution to Fiji's GDP and employs a quarter of the population. Men dominate the agricultural sector, while women primarily engage in subsistence farming and 'gardening', cultivating crops such as taro. Rual women's wages are generally lower than men's (USD 133 compared to USD 178, respectively), and there is a significant gap between urban and rural wages

(FAO & the Pacific Community, 2019). Cultural norms, religion and social practices lead to discrimination and exclusion of certain groups, including women, LGBTQ+ and disabled people (UN Women, 2020).

Water scarcity drivers and status

Fiji faces two types of water scarcity: too variable water availability and poor water quality. Seasonal scarcity is widespread throughout Fiji, especially in dry zones, due to seasonal rainfall fluctuations. The country frequently faced extended dry periods lasting three to four months. Additionally, issues of groundwater overexploitation are prevalent in the Nadi Valley and other large islands.

Interannual variability is on the rise in Fiji, leading to more frequent and severe water supply shortages in both urban and rural areas, particularly in drought-prone areas **(i.e, variable water availability**). These areas include almost all of the Western Division, Northern Vanua Levu in the Northern Division, and many of the Yasawa, Mamanuca, Lau, Macuata, and Lomaiviti groups.

Water pollution is a significant issue in densely populated urban, industrial and mining areas, resulting **in poor water quality**. Inadequate wastewater treatment and management have led to untreated solid waste and effluent discharge into water bodies. In the Vatukoula Goldmine region, contamination levels of cadmium, lead and manganese in water bodies exceed Fiji and international standards (Kumar et al., 2021). Water quality is also subpar in estuaries and marine recreational waters along the Suva foreshore, with high levels of *E. coli* and faecal coliforms (Lal et al., 2021).

Groundwater overexploitation is an issue in the Nadi Valley and other large islands, leading to the degradation of coastal aquifers on several islands due to formal and informal settlements. Water conflicts also arise between different sectors due to poor water management, such as conflicts between irrigation and other water-using sectors in the Sigatoka River (Pacific Islands Applied Geoscience Commission, 2007).

Water scarcity management

Key actors and institutions

Fiji's institutional framework for its water sector can be divided into government entities dealing predominantly with agriculture, water supply and sanitation, hydropower, environmental management and water scarcity risk management. While some departments, agencies and relevant NGOs have mandates for aspects of the water sector, many also also include provisions to address water scarcity.

The newly established Ministry of Waterways and Environment is mandated to address the growing threat that water scarcity poses to Fijian communities through promoting the sustainable use and development of Fiji's environment and efficient implementation and enforcement of environmental policies, legislation and programs. The Water Authority of Fiji is responsible for providing access to clean drinking water and wastewater services. Other relevant ministries and departments include the Ministry of Lands and Mineral Resources (responsible for land management and resource allocation including groundwater), the Fiji Meteorological Service (providing weather forecasting and climate-related information), the National Disaster Management Office (dealing with disaster preparedness and response), the Department of Water and Sewerage (with a specific role in water management, including strategies for water and sanitation and the Water Supply Management Plan (WSMP) for rural water schemes), the Ministry of Agriculture (relevant to water resource, soil erosion, land and fluvial management), and the Department of Energy (with responsibilities related to water and energy interactions). Numerous policies and strategies exist in Fiji that either explicitly or implicitly relate to water scarcity management. Relevant policies can be divided into three categories: umbrella policies (such as national policies, strategies and plans with a broader focus, such as climate change), overarching policies (i with a specific water focus and often several sub-policies, including the National Water and Sanitation Policy no. 1 2011/2014 and the National Water and Sanitation Policy no. 2) and sectoral policies (targeting specific sectors, such as the Fiji 2020 Agricultural Sector Policy Agenda). Policies related to water scarcity include the Fiji National Development Plan, the A Green Growth Framework for Fiji, the Republic of Fiji National Climate Change Policy 2018–2030 and the National Adaptation Plan Framework. Several other policies are still under revision by the government.

Strengths and weaknesses

S	W	O	T
An enabling environment and guidance for sound water management, in terms of IWRM principles and water scarcity management. Interventions from NGOs with a focus on environmental /integrated natural resource management with potentially important lessons learned and best practices. Focus on climate change and climate resilience	Lack of consolidated inter-sectoral & inter-institutional coordination. Unclear and defined roles and responsibilities of each actor, causing overlap in some focal areas. The weak legal foundation for actors in the water sector and water scarcity management. Insufficiently addressed IWRM principles and water scarcity management. Lack of data and evidence in assessing the situation of water and natural resources. Limited control of EIA process and of implementation of Environment Act.	Acknowledged the overall context of climate change and disaster risk reduction. Calls for water scarcity and drought management plans and actions.	Climate change is heavily impacted health and livelihood in Fiji, especially coastal communities and dominant economic sector-tourism
Strengths	**Weakness**	**Opportunities**	**Threats**

Figure 26. SWOT analysis of the Fiji water policy context.

Water scarcity is addressed in several water-related policy instruments, such as the “A Green Growth Framework for Fiji”, which presents 10 thematic areas for water scarcity, including ‘Building resilience to climate change and disasters’.

However, several limitations and opportunities for improvement exist (see Figure 26). Some relevant policy instruments do not explicitly mention water scarcity and, as a result, lack specific measures to address this issue. For example, while the “National Water and Sanitation Policy no. 2” acknowledges the overall context related to climate change and disaster risk reduction, the policy primarily focuses on WASH and does not specifically mention water scarcity (see Figure 27 for further issues). Furthermore, the “National Water Resource Management Policy” under formulation also places a strong emphasis on WASH focus and, consequently, falls short of covering the full scope of an overarching water sector policy.

Country outlook

Several aspects of Fiji’s water policy could be strengthened to better prepare for water scarcity issues. While Fiji has developed sufficient umbrella policies related to water, there is still an absence of a more sophisticated overarching water sector policy that could effectively integrate various subsectors. The fragmented nature of Fiji’s water sector is also reflected in a lack of consolidated intersectoral and interinstitutional coordination, which leads to ill-defined roles and responsibilities. These roles and responsibilities should be properly demarcated and defined.

Many of the relevant policy instruments focus on WASH-related issues. Efforts should be made to broaden the scope of water resources management in Fiji to a address other aspects of water, including water scarcity. Additionally, there is a need for capacity building within the government to address the challenges posed by high staff turnover rates and the migration of well-educated staff abroad. Furthermore, issues related to trust in the government and its messaging regarding water and environmental problems also need to be addressed. Currently, interventions from NGOs and other non-state actors in Fiji remain somewhat scattered; therefore, efforts could be made to better integrate lessons learned at the policy level.

Climate change is likely to affect Fiji more severly than other countries included in this study due to combined threats from sea level rise, especially affecting fragile groundwater resources in atolls,, storm surges and cyclones and increasingly variable rainfall. This may have significant implications for rain-fed agriculture and the agroforestry sector.

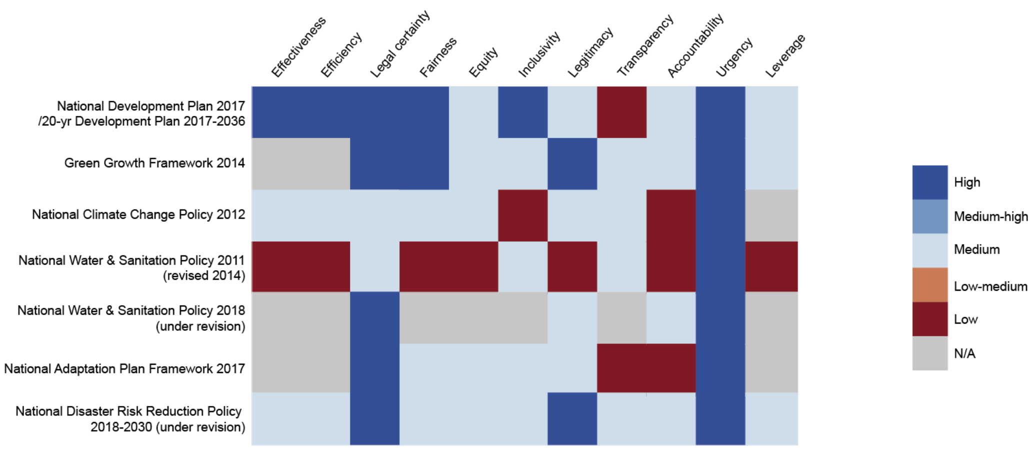

Figure 27. Assessment of Fiji's key policy instruments in managing water scarcity.

4.3.2 Indonesia

KEY FINDINGS

- **Indonesia experiences three types of water scarcity: too variable water availability, overutilisation and poor water quality.**
- **Operation and maintenance** of irrigation infrastructure in Indonesia remain problematic, requiring further subsidies and cyclical investment in rehabilitation and modernisation of existing systems. There is also a clear need for further infrastructure development in new agricultural areas. However, this comes at the cost of effective and sustainable use of water resources and complicates water accounting and allocation. Sustainable financing of operation and maintenance is crucial.
- **Adequate water supply for industry and services is essential for economic development.** Ensuring sufficient quality and quantity of water supplies for industry is critical for economic growth. However, industries, as significant water users, compete with agricultural water users. Therefore, a well-defined strategy is required to sustainably supply water to the industrial sector. Poor regulation, monitoring and enforcement of industrial water pollution exacerbate water scarcity and stress key river basins in Java.
- **Support in the form of finance and capacity building is needed to strengthen monitoring and evaluation systems,** to allow for the assessment of policy impacts and enabling adaptive management of water scarcity. A more comprehensive review of policy effectiveness would be benificial.

Context

Indonesia is the world's largest archipelagic country, with 16,056 islands and a total area of over 1.9 million km^2. It has a complex geography due to its position across three tectonic plates, which create intense seismic and volcanic activity. The country is home to approximately 281.2 million people with about 153 people per square kilometre in 2023. Indonesia is a lower-middle-income country, with a GDP of US$1,186 billion (World Bank Group, 2023). Agriculture covers 37 million ha and uses 80 per cent of total water use, contributing 13.3 per cent of the country's GDP (World Bank Group, 2023).

Water resources and water use

Indonesia has 5,590 rivers, 840 large lakes and 735 small lakes. Around 3,960 Bm^3 of water is available per year, making the water availability per capita one of the highest in the world, at 15,631 m^3 per person per year, though this is not evenly distributed (Rondhi et al., 2019). For example, only six per cent of its available water resources can be found in Java, despite it being home to over 57 per cent of Indonesia's population (World Bank Group, 2021c). Indonesia's water storage capacity is far below that of countries with similar water availability, at just 71 m^3 per capita. The country has a tropical climate, with an average annual rainfall of 2,859 mm (World Bank Group, n.d.). The wet-season falls between December and March, and the dry season is from June to September (Wirjomidjojo & Swarinoto, 2010).

Social and economic context

Agriculture covers 37 million ha (Rondhi et al., 2019) and utilises 80 per cent of total consumptive water demand. Indonesia has around 7.1 million ha of rice paddy fields (Statistics Indonesia, 2021), 3.8 million of which are irrigated (Indonesian Agricultural Statistics, 2019). Only 12 per cent of irrigation is supplied from reservoirs, with most depending on direct diversions from rivers or by impoundments (World Bank Group, 2021c). Currently, 31 per cent of paddy areas are located within river basins with high or severe water stress. Over 60 per cent of Indonesia's GDP is generated from 12 of the 128 river basins. The goal of achieving rice self-sufficiency was achieved by 1984, and irrigation is expected to increase by up to 10 per cent between 2019 and 2045 (World Bank Group, 2021c). Rural development has been a priority in Indonesia since the 2000s; however, targets have not been fully achieved, and the country continues to struggle with issues of poverty (World Bank Group, 2012). Representation of women in parliament has increased recently, with mandates on the inclusion of women in decision-making processes (including around water resources). However, this does not always happen due to social and cultural barriers (WRI, 2020). Around 49 per cent of agricultural households have female participation in farming, yet their roles are often under-recognised and underpaid (FAO, 2019).

Water scarcity drivers and status

Indonesia experiences three types of water scarcity: too variable water, overutilisation and poor water quality. According to a 2021 report from the World Bank, Sumatera, Kalimantan, Sulawesi, Maluku and Papua have surplus water availability, Java, Nusa Tenggara Timur and Nusa Tenggara Barat experience localised water scarcity of varying types and severities (World Bank Group, 2021c). Scarcity levels range from absolute water scarcity in arid and semi-arid regions to seasonal or interannual scarcity to scarcity issues associated with groundwater dependency, water pollution and saline intrusion.

Seasonal scarcity in parts of Indonesia results in **too variable water**. During the dry season, 24 of 128 river basins cannot meet water demands. Half of the country's GDP is produced in 'high' and 'severe' stress river basins during the dry season. Climate change is expected to worsen this seasonal variability (World Bank Group, 2021c).

Overutilisation of water resources is also a pressing issue in Indonesia, leading to conflicts over water resources among various users. The increasing demand for water can be attribute to economic pressures, including the rapid growth of industries. Industrial water demand alone is projected to surge from 9 Bm^3 to 36 Bm^3 between 2015 and 2045 (World Bank Group, 2021c).

Furthermore, as of 2015, 108 rivers across Indonesia are experiencing severe degradation and critical conditions due to **poor water quality**. 68 per cent of rivers are heavily polluted, primarily stemming from agricultural runoff, inadequate sanitation, and wastewater treatment.. For instance, 68 percent of rivers in the Sumatra region, 68 percent in Java, 65 percent in Kalimantan, and 64 percent in Bali and Nusa Tenggara are heavily polluted. Additionally, in eastern regions, such as Sulawesi and Papua islands, many rivers, lakes and reservoirs also suffer from severe pollution. Recognising the gravity of this issue, one of the key pillars of Indonesia's overarching vision for 2045 places a strong emphasis in ensuring water security (World Bank Group, 2021c).

Water scarcity management

Key actors and institutions

One of the key pillars of Indonesia's 2045 vision is centred on ensuring water security and a sustainable environment, focusing on stabilising the quantity, quality, continuity, and accessibility of water resources. For example, before 2045, 108 priority river basins are targeted to be restored (World Bank Group, 2021c).

Indonesia has three main levels of water management authority at national, provincial and local levels and four key pillars of water management (see Figure 28). At the national level, water resources are managed through several ministries, including the Ministry of National Development Planning (Bappenas), the Ministry of Public Works and Public Housing (under which is the Directorate General of Water Resources), the Ministry of Environment and Forestry, the Ministry of Health and the Ministry of Energy and Mineral Resources. National RBO's manage internal and interprovincial river basins, while the National Water Council supports the development of national policies and strategies. At the provincial level are RBO's and water councils, while districts and municipalities manage water locally through district RBO's and basin councils. Districts tend to focus on irrigation and forestry policies, while municipalities deal with urban water and sanitation (Wieriks, 2011). Water allocation plans consist of the Pola (seasonally updated allocation schedules) and Rencana (longer term strategic allocation plans), which are developed and administered by RBO's (Al'Afghani, 2022).

IWRM is embedded across the legislative framework, including the 2019 Law No. 17 of 2019 on Water Resources. Various other laws and regulations also deal with water resource management.

Four Pillars for Water Management in Indonesia			
Boundary Legal *Focus on the types of the river basin area and watershed management*	**Regulation for Irrigation** *Water resource and infrastructure supplies for irrigation*	**Regulation for water resource and users**	**Disaster managment** *Have a specific focus on disaster impacts in agriculture*
Supported instruments			
Law No. 26 of 2007 regarding Spatial Planning classified the protected areas and cultivations areas in the river basin. It accounts for the development of watershed management to avoid administrative conflicts, assesses the balance of water resources and demands, and considers drainage network systems and flood control.	**Government Regulation (GR) No. 20 of 2006 concerning Irrigation** focuses on the development and management of irrigation systems. These activities will be prioritizing the interests and farming community participants in the whole decision-making process. **Government Regulation No. 38 of 2011 concerning Rivers** points out to protect river from the threat of land conversion and damage and prioritizes use for irrigation without causing pollution and disruption to the flows in the river. It encourages rainwater harvesting and acknowledges the role of community and community empowerment in watershed management. **Presidential Instruction (Inpres) No. 1 of 2018** plans to develop reservoirs and other water storage infrastructure in the village for irrigation under the Indonesian Government State Budget.	**Law No. 17 of 2019 on the Water Resources** addresses state authority and people's right to water; the authority and responsibility of the Central and Regional Governments in managing water resources; water licensing; water resources information system, community participation and coordination. The priorities of water use follows the fulfilment of people's daily basic water needs at least 60 L/day, agriculture, drinking water needs, business or private non-business. **Government Regulation No. 43 of 2008 concerning Groundwater** requires individual management policies and strategies for basin to support sustainable use, maintain quality and function, and control pollution toward meet the prioritized user's demand and others.	**Law No. 26 of 2007 concerning Disaster Management** classifies natural, non-natural and social disasters. Prevention of disaster impacts in agriculture, the government carries out the provision of agricultural facilities and infrastructure assistance to farmers/groups in the disaster areas.

Figure 28. Review of key policy instruments for managing water scarcity in Indonesia.

Strengths and weaknesses

While there is good subsidiarity in legislation and regulation in Indonesia, implementation proves to be challenging and varies across the country due to overlapping roles and responsibilities of different stakeholders, coupled with limited cross-sectoral coordination.

Ongoing land tenure issues further complicate water rights in Indonesia. For example, a lack of secure tenure and property rights within urban areas poses a major barrier to achieving water, sanitation and household waste management objectives (Bennett et al., 2019). Law enforcement regarding natural resource–related crimes is notably weak, as indicated in Figure 29 and Figure 30.Indonesia has detailed regulations that support overarching laws, including Government Regulation No. 20 of 2006 concerning irrigation, Government Regulation No. 43 of 2008 concerning groundwater, Government Regulation No. 38 of 2011 concerning rivers and Law No. 17 of 2019 on Water Resources.

Although water scarcity is evident in Java, Bali, and NusaTenggara, specific policies to address this issue have not yet been formulated. Furthermore, management of wastewater and solid waste faces significant challenges, with functioning sewerage networks currently operating in only 11 cities.

S	W	O	T
Have the elements in place (planning, laws, policy, decentralization, technical responsibility for water management (RBOs/RBTs, irrigation coordination committees (across provincial boundaries). Emergency responses to drought and flooding Encourages the community to participate in watershed management and irrigation.	Weak law enforcement in the field of natural resources. Variable provision of access to safe drinking water (SDG targets not likely to be achieved) and UNPDF estimates 42.8% of population has no sustainable access to improved water sources, while 22% still practice OD. Funds and staffing (capacity and presence) are not yet committed to a level that integrates water resources planning and management. High levels of surface water pollution from multiple sources, including agriculture, human wastes and industries. Poor wastewater and solid waste management	Implementation of Vision 2045 Improved data capture, processing and sharing through a central hydromet data centre and between users at all levels. The Corruption Eradication Commission could pursue new cases in partnership with 12 ministries to preserve natural resources. Capacity building, particularly at RBO and local government levels (Kabupaten and lower) Groundwater is (theoretically) licensed and reserved for non-agricultural use. Monitoring and better enforcement will safeguard this resource for the future.	Climate change affects rainfall patterns with longer and more frequent dry periods predicted despite higher and more intense rainfall. Coupled with high temperatures has serious implications for agriculture and for water resources management – especially where scarcity and water stress are already observed (seasonally). Sea level rise in coastal areas, especially where groundwater use is high (major cities) Limited policy development on emissions and climate change impacts Limited action to remediate poor water quality
Strengths	**Weakness**	**Opportunities**	**Threats**

Figure 29. SWOT analysis of the Indonesia water policy context.

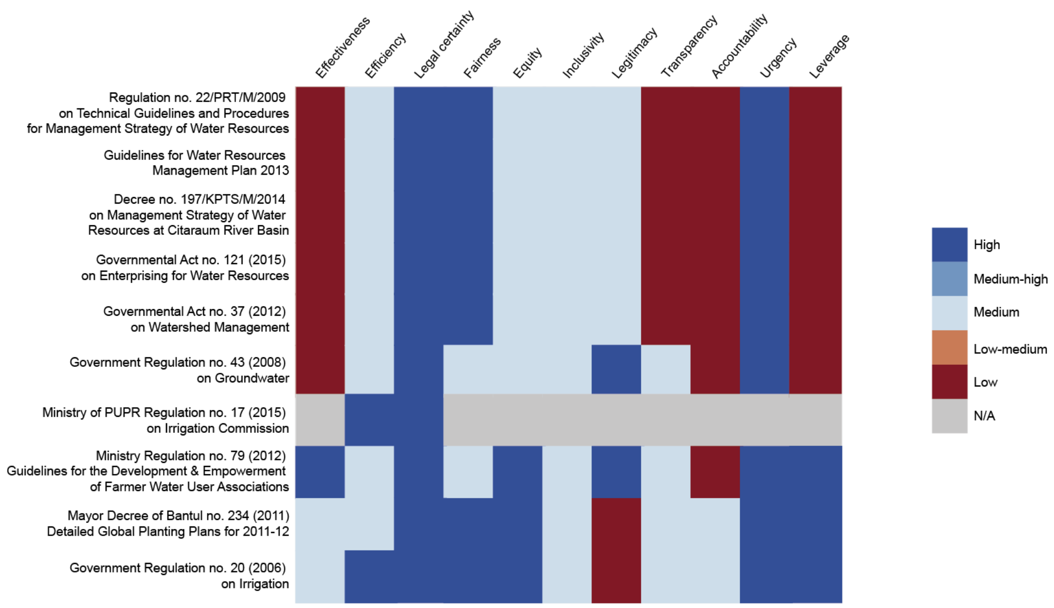

Figure 30. Assessment of Indonesia's key policy instruments in managing water scarcity.

Country outlook

As Indonesia advances its vision for 2045, there are several opportunities for improvements in how it manages water scarcity (see Figure 29). This is particularly crucial as the government intends to expand the irrigated area by a million hectares, which will have significant implications for water and the environment. The government is already working towards improving data capture, processing and sharing through a central Hydromet Data Centre, although it is yet to be fully funded and staffed. Monitoring and enforcing existing regulations (e.g., regarding groundwater licences) would help to safeguard water resources. More attention should also be paid to policy aspects such as transparency and accountability.

4.4 Continental Australia

The continent of Australia covers a land area of 8.56 million km^2, with a relatively sparse population of approximately 39 million people. The continent consists of a continental shelf overlain by shallow seas. The temperate zones in the southwest are predominantly plains, while the eastern coast is mainly rugged, mountainous terrain.

The continent's climate is mainly arid or semi-arid, with the southern coastal areas having a temperate climate, and the northern areas having a tropical climate. The continent has around 420,000 km^2 of agricultural land, the majority of which is for farming. Intensive agriculture is typically practiced in rural areas with low populations. Water scarcity in Australia is driven by high agricultural water demands rather than population.

Australia generally has limited water resources, except for a few major rivers and experiences much larger annual water variability than other regions studied. Water scarcity is most pronounced in the populated south-eastern areas, while water stress occurs mainly in agricultural areas, particularly in the wheat-growing zone in the southwest and the Murray Darling Basin (MDB) (see Figure 31).

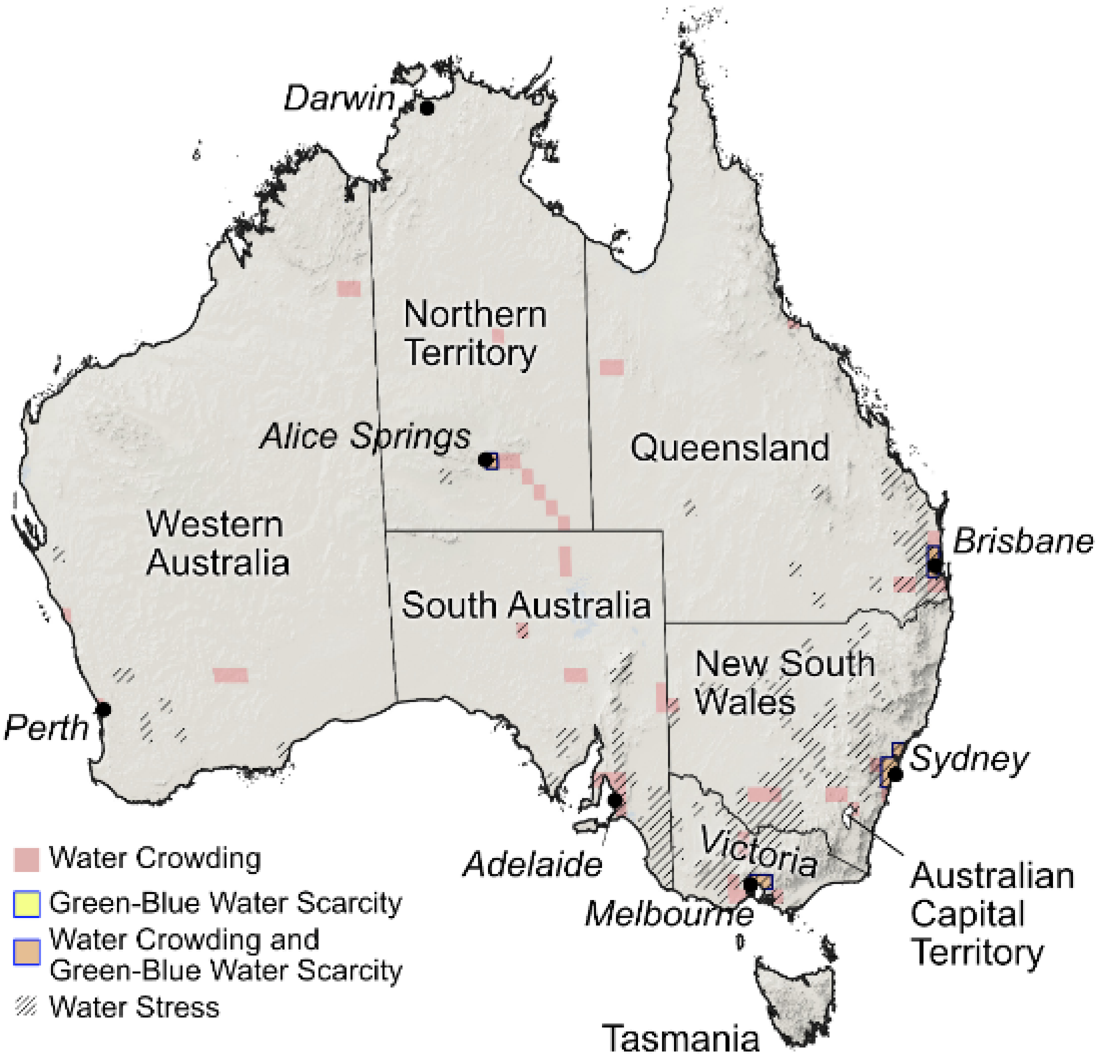

Figure 31. Water scarcity hotspots in continental Australia.

4.4.1 Australia

KEY FINDINGS

- **Australia experiences all four types of water scarcity—too little water, too variable water, poor water quality and overutilisation—to varying degrees in various parts of the country.**
- **Coastal cities (home to around 80 per cent of the population and most industries) have depleted their reliable local catchment water resources;** as a result, major capital cities have developed desalination plants to augment water supply. Unlike many countries in Asia and the Pacific region, Australia's water resources are not extensively utilised for hydropower or transportation.
- **There is limited capacity to service growing needs in certain regions due to mountains separating large irrigation areas and major cities.** Market-based mechanisms to compensate irrigation water users for transfers are also often undermined by political sensitivities.
- **Australia serves as an example of how costly and challenging it can be to restrict water use** once a country's water resources have become overallocated. The country continues to employ a combination of policy and market-based instruments to manage its water resources.

Context

Australia, one of the Oceania countries, lies between the South Pacific Ocean and the Indian Ocean. It is home to approximately 26.3 million people, with less than five people per square kilometre in 2023. Australia covers a land area of approximately 8.6 million km^2. Agriculture uses around 50–70 per cent of total water withdrawals and accounts for A$67 billion (two per cent of GDP) as of 2020.

Water resources and water use

Australia can be divided into 12 drainage regions, 246 river basins and 340 surface water management zones. On average, Australia receives around 2,789 Bm^3 of rainfall per year. From this, eight per cent (243 Bm^3) becomes runoff, contributing to surface water, while two per cent (49 Bm^3) infiltrates into the ground (New South Wales Irrigators' Council, 2012). This results in an average 19,998 m^3 of renewable freshwater resources per capita. However, the availability of this water varies significantly by geographic region. Australia extracts around 5 Bm^3 of groundwater per year, with 60 per cent allocated to agriculture.

In Australia, there are more than 820 dams that collectively store more than 91 Bm^3 of surface water. Most of these dams are located in southern coastal Australia and serve interannual and intra-annual storage needs. Thirty-eight percent of the dams are used for water supply, 18 percent for hydroelectricity production, 17 percent for irrigation, and the remaining dams serve various purposes, including recreation, flood control, and multi-use(McMahon & Petheram, 2020). However, in comparison to other countries in Asia and the Pacific region, Australia's water resources are not extensively utilised for hydropower. While dam development has slowed in the past decade, the recent Agricultural Competitiveness Green Paper has identified 27 new potential dam sites for developing new agricultural zones (Australian Government, 2015).

Australia's primary productive basin, the MDB, encompasses 14 per cent of the country and spreads over five states and territories: Queensland, New South Wales, Victoria, the Australian Capital Territory and South Australia. It is the most advanced basin in the country regarding water resources management and governance. In 2011, 48 per cent of the surface water in the basin was stored and utilised for irrigation and other purposes. The basin has a long history of interventions to manage water scarcity.

Social and economic context

Agriculture-related sectors (e.g., crop and livestock, forestry and fisheries) have increasingly contributed to the country's GDP over the last 20 years. Most agricultural production occurs in the southern and eastern parts of the country, and the agricultural sector consumes around 50–70 per cent of the total available water in the MDB, of which 90 per cent is for irrigation. The agricultural sector is predominantly comprised of male workers, with less representation of women, people with disabilities and culturally diverse people. These groups are often under-represented within leadership positions in the water sector in Australia, especially in decision-making and policy positions. Common obstacles include gender biases in hiring and promotions, poor retention rates, under-representation in senior positions and a substantial pay gap between the sexes. The Australian water sector has been actively working on and has made progress towards improved inclusion and diversity in the workforce.

Water scarcity drivers and status

Australia is a large country with many distinct regions, each facing unique water scarcity issues and exhibiting specific hydroecological and socio-economic characteristics. The two primary regions experiencing water scarcity are the south-eastern coastal area cities and the MDB. All four types of water scarcity are experienced in various parts of the country.

The south-eastern coastal area cities, where most of the population (around 80 per cent) and most industries reside, have depleted their local catchment water resources (see Figure 32). Consequently, major capital cities have established desalination plants to supplement their water supplies in dry years.

Scarcity in the MDB has largely been driven by human interventions, including irrigation expansion throughout most of the 1900s and new storage infrastructure. Trends in temperature, precipitation and streamflow have also driven water scarcity in the basin (e.g., increasing temperatures and reduced streamflow over the last 100 years).

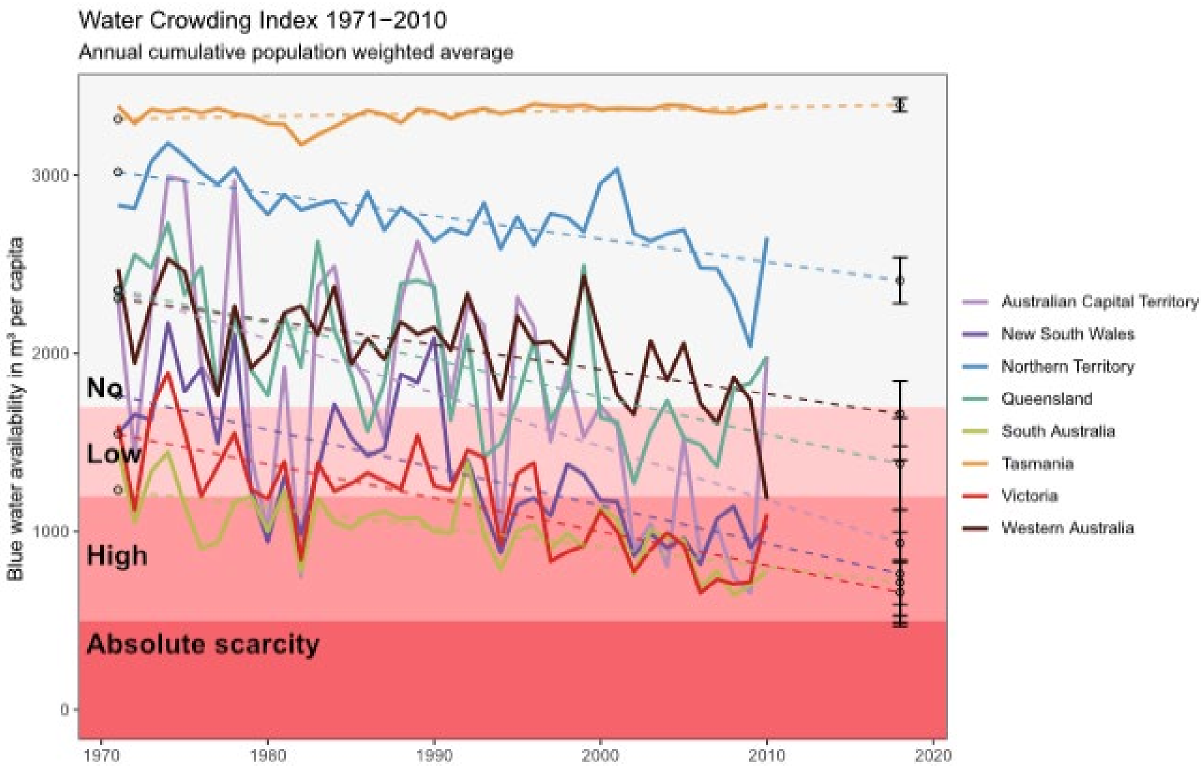

Figure 32. Water Crowding Index[4] in Australia.

Water scarcity management

Key actors and institutions

Under the Australian Constitution, state and territory governments are responsible for land and water resources management. The federal government plays a role in oversight, facilitation and investment and ensuring that national interests are met, especially in transboundary river and groundwater basins (e.g., the MDB, the Great Artesian Basin and the Lake Eyre Basin). Whereas the State and Territory governments are responsible for overseeing urban water supply, sewerage, and drainage.

In response to increasing pressures on water resources, water management institutions in Australia have evolved from early state-based management to more centralised management by the federal government. This transformation has resulted in the development of a relatively sophisticated policy framework. Policy instruments can be categorised under four key areas: (a) building blocks to enable management of water scarcity, (b) national policy and legislative framework for water reforms, (c) planning framework with a focus on the MDB and (d) specific interventions and tools to achieve policy objectives.

A significant water policy in Australia involved reallocating water to the environment in the MDB through the Murray–Darling Basin Authority's sustainable diversion limit adjustment mechanism. To date, over 2.1 Bm^3 has been reallocated from a previous irrigation entitlement of around 10.8 Bm^3. This policy has been marked by significant costs and controversy, serving as a poignant example of the complexities inherent in water reallocation activities (see Figure 33).

[4] a measure of the annual water resources per capita in a watershed

Figure 33. Review of key policy instruments for managing water scarcity in Australia.

Strengths and weaknesses

Over time, coastal cities have developed local catchments by building more dams as populations grow and droughts lead to water scarcity. Urban storages have been progressively interconnected to optimise water availability for urban growth. For example, infrastructure exists to transfer water across the most heavily populated regions. Demand management and a total cost recovery approach to water pricing have also been introduced over the last 40 years.

Yet, there is limited capacity to serve growing needs in certain regions of Australia (e.g., due to mountains separating large irrigation areas and major cities). Despite market-based and other mechanisms to compensate irrigation water users for transfers, significant political sensitivities continue to present barriers (see Figure 34).

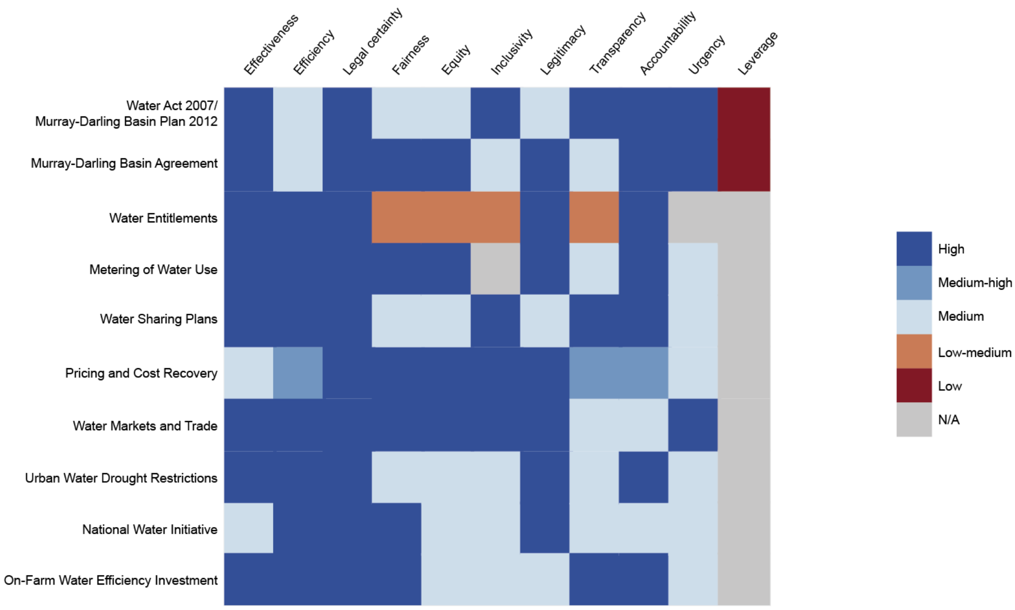

Figure 34. Assessment of Australia's key policy instruments in managing water scarcity.

Country outlook

Australia serves as an example of how difficult and costly restraining water use can become once a country's water resources are overallocated. Nevertheless, the country continues to utilise a wide range of instruments to do so, though continued political commitment and efforts to identify key leverage points (e.g., in the Water Act and Murray–Darling Basin Agreement, see Figure 34) will be needed to deal with future challenges, including climate change.

5. Trajectories towards sustainable water management

Water resources development and management across Asia and the Pacific largely follows a trajectory whereby countries move from irrigation-focused water development towards increasing water withdrawals as economies develop. The goal of this journey is sustainable and equitable water management. The dynamism of the water sector means that we must constantly balance and manage a shifting availability and utilisation relationship. It is useful to visualise and identify where other countries currently sit along the different stages of the trajectory to learn from their experience with water scarcity—particularly to identify key opportunities for 'leapfrogging' problematic stages through well-planned water development.

There are four phases (A–D) along the trajectory:

A. State-led irrigation development (increasing water demand);
B. Multisectoral development (increasing water competition);
C. IWRM (coordinated management of demand and supply); and
D. Sustainable water management (balanced economic, social and environmental outcomes).

Each phase is represented along the ribbon flowing from the top left-hand corner to the end of Figure 35. The circles represent milestones in the four phases (dark red, light red, dark tan, light tan and caput mortuum) that respond to development drivers (discs), which in turn often arise from system shocks (yellow triangles).

Water scarcity in the region is primarily driven by population growth, associated economic development and agricultural expansion. However, climate change also poses major threats to already stressed water systems and will continue to constrain opportunities for development and productive water use in the future. Climate change will further complicate the balance of water use between human needs and environmental requirements in countries where water resources will decline and become more variable (e.g., in arid and semi-arid regions, such as Australia, northern China, West Asia and parts of South Asia), indicating a need for more emphasis on water scarcity management.

5.1 Trajectory 'leapfrogging'

The sustainable water management trajectory is not necessarily a linear path; countries might jump forward, or 'leapfrog' certain hurdles (see Figure 35), or even move backwards from one phase to another. For example, countries at an early stage of water development could leapfrog the consequences of excessive water. Countries may also encounter different aspects of each of the four phases simultaneously or in different ways within a country (e.g., Bangladesh is implementing IWRM in some areas). This trajectory towards more sustainable and resilient water resources management is not a race but rather a way to find improvement opportunities.

5.2 The four trajectory phases

5.2.1 Phase A: state-led irrigation development

Many countries in Asia have a long history of communal, mostly small-scale irrigation development, using springs or temporary weirs to divert river flows. Other systems include recession agriculture and water management in large rivers, such as the Mekong, and cultivation of (or at the margins of) wetlands. Some countries also developed shallow groundwater for irrigation. As populations in the region grew, the state (or colonial administrations) used irrigation to improve food supply (especially in dry or seasonally dry areas), mitigate drought and periodic famine and create a land tax revenue base. The transition from traditional small-scale irrigation to larger, state-administered systems occurred during the mid-to-late nineteenth century across what is now India and Pakistan, which was in parallel with new developments in Australia, Indonesia and Thailand from the end of the century.

Colonial administrations in India, Pakistan, Myanmar, Indonesia and Viet Nam expanded the area of large-scale and medium-scale, publicly managed irrigation between the two world wars. Emerging national governments continued to do so post-independence following the Second World War. In Australia, public investment in irrigation was spurred by resettlement programs after the First World War (and, to a lesser extent, the Second World War).

Expansion of modern irrigation schemes in Asia occurred after the Second World War, alongside the green revolution and opportunities to significantly increase the production of key staples, such as rice and wheat (bred to be highly responsive to nitrogen fertiliser).

International aid funding and technical assistance accounted for large proportions of irrigation development in the region from the 1960s to the late-1980s (Kajisa, 2021; Mukherji et al., 2009). However, international finance for irrigation has steadily declined in South Asia, Indonesia and China, with a shift towards programs related to the UN's WASH goals and from irrigation construction towards management. However, investments continued in Viet Nam, Cambodia and Lao People's Democratic Republic, with a resurgence in Asia and the Pacific region since 2018.

Private groundwater exploitation started slowly in the 1960s, enabled by cheap pumps, cost-effective borehole drilling and subsidised power. This accelerated rapidly from the mid-1980s to the present day, becoming India's dominant water source for agriculture by the early 2000s and playing a vital role in other countries such as China, Pakistan and Bangladesh.

Over abstraction of groundwater in many of these countries has led to declining groundwater levels, rising costs, reduced yields, water contamination and public health issues from naturally occurring chemicals, such as arsenic and fluoride. Such problems are more acute near large cities, where excessive groundwater use often results in a cone of depression below the urban area, leading to issues like land subsidence, infrastructure damage and increased flood risk. Groundwater overexploitation is common in major cities (e.g., Bangkok, Jakarta, Kathmandu and Manila) but is also emerging in smaller cities and towns. Excessive groundwater use for agriculture is also evident in parts of Viet Nam, Indonesia and Nepal. Meanwhile, Bangladesh has made a bold transition from surface irrigation—vulnerable to seasonal flooding—to smallholder use of shallow groundwater (replenished by seasonal flooding). However, careful planning, monitoring and regulation is necessary to avoid future overexploitation. This is particularly important in areas where groundwater overexploitation has already been raised as a concern, such as the Barind Tract and Dhaka (Kirby et al., 2015).

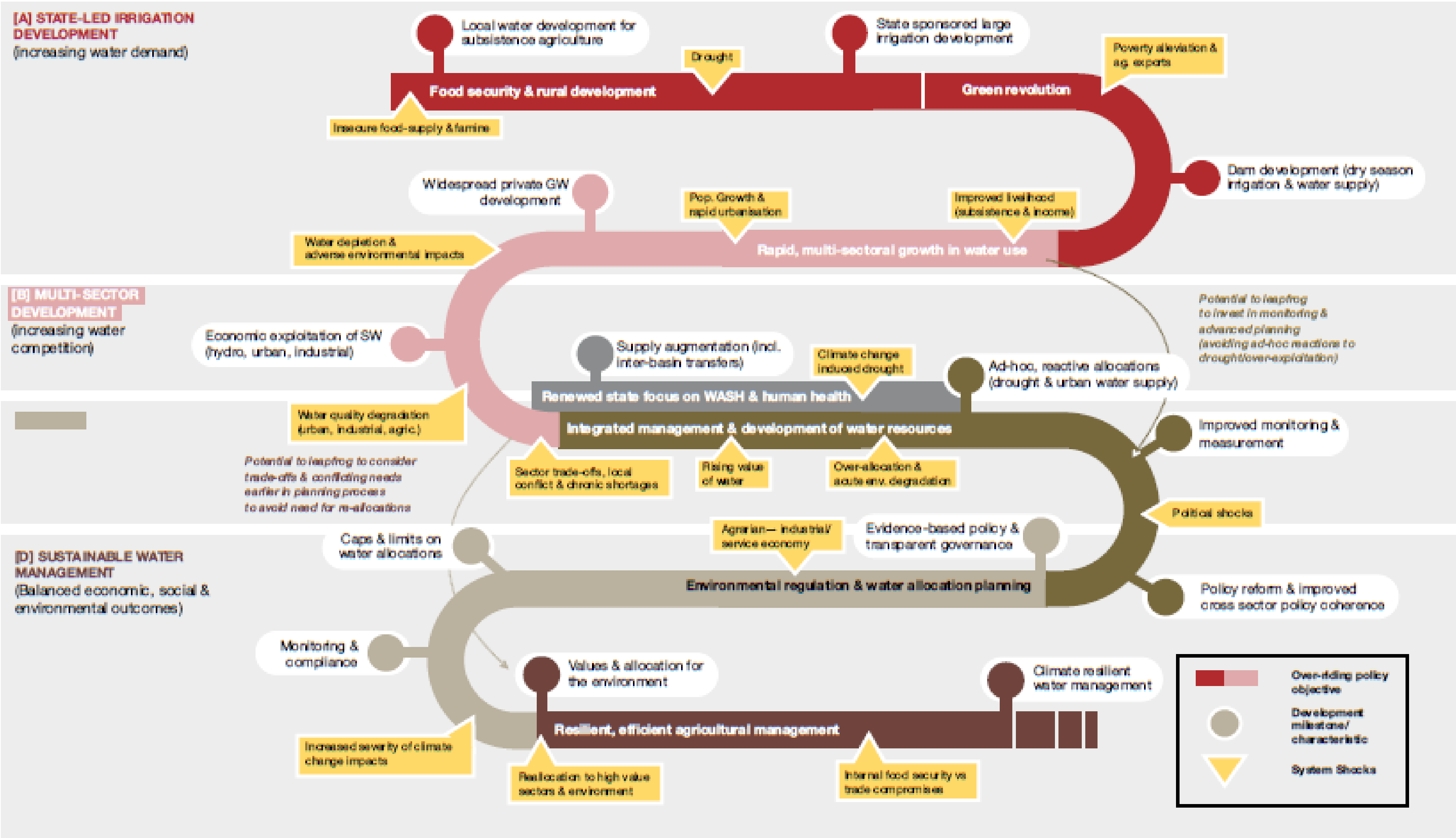

Figure 35. Water resources development and management in Asia and the Pacific.

5.2.2 Phase B: multisectoral development

With population growth and economic development, more diverse opportunities for employment and remuneration appear, driving rapid urbanisation and shifts in farming and rural living. However, declines in food prices (not including recent spikes after the financial crises and the COVID-19 pandemic) have made it harder for smallholders to satisfy food requirements and generate profits.

Water demands typically broaden in this phase, increasing the proportion of water used by non-agricultural sectors. Investments in water infrastructure also expand, with interest in multipurpose uses of dams—for example, for hydropower, flood mitigation, urban water supply and irrigation.

Where water shortages arise, policy tends to focus on supply-side solutions in this phase, even if resources are already highly developed. As observed in Nepal and China, more expensive engineering solutions such as interbasin transfers follow, while Thailand and India are also interested in the same solutions.

As water demand increases, its productive value simultaneously increases. This increased value can spark the transfer or capture of resources, for example, where irrigation companies sell bulk water supply to cities. Currently, environmental needs are poorly recognised by governments, while evidence of degradation begins to arise from academic and activist spheres. Issues around climate change and variability or water over abstraction receive little consideration.

Severe water quality problems also arise during this phase due to limited wastewater treatment in urban areas and non-point source agrochemical runoff. As countries grow wealthier, demand for meat and fish rises, resulting in livestock aquaculture intensification, which are often poorly regulated point source polluters.

During this phase, the existence or prospect of rising water competition, warnings of consequences of droughts and the limitations or costs of supply augmentation begin to shift policies away from water resources development towards management. Countries like Bangladesh, Lao People's Democratic Republic, Nepal and Cambodia are in this phase of the trajectory.

5.2.3 Phase C: integrated water resources management

IWRM has been on the global agenda for almost 20 years, with numerous prescriptive ideas, funding packages and programs to develop it. Nevertheless, few countries have succeeded in adopting IWRM in practice. During the transition from development-focused policy to sustainable management, interest in improving the monitoring of water flows and quality increases. Formal and informal mechanisms developed to manage water transfer from agriculture to other uses. Simultaneously, water laws and policies are reformed to emphasise management, sustainability and environmental stewardship—though often the necessary funds, capacity and tools for implementation are lacking. Countries like Viet Nam, Indonesia and Thailand are in this phase.

However, the momentum of multisectoral development continues despite emerging evidence of the need for restrained water use, severe overallocation at the basin scale, water user competition and acute environmental effects, despite commitments to resource management. Indonesia,Thailand and Viet Nam are approaching this third phase, while Australia has made significant progress with evidence-based policymaking in reacting to such challenges.

5.2.4 Phase D: sustainable water management

It is unlikely that a single country worldwide has successfully established a sustainable water management regime that fully balances economic, social and environmental outcomes. Instead, it is likely that adaptive management processes, as established in Phase C, will continue to address water scarcity and related water issues as they will evolve in different ways.

Food security is a major policy and welfare concern for all countries in Asia (even those that make significant exports, such as Thailand and Viet Nam). The politics of constraining agricultural water use are complex and unforgiving in Asia and the Pacific, and structural changes in farming will be challenging. Despite the value of water for environmental flows beginning to be appreciated in Viet Nam, Indonesia and Thailand, trade-offs with urban, energy and industrial needs will continue.

5.3 Challenges of surface water storage

In Viet Nam, Thailand and Indonesia, the management of water storage and flows is emerging as a point of contention between electricity companies and irrigation and urban water users. Large-scale water storage sits at the centre of trade-offs between the benefits versus harms arising from attempts to manage water scarcity, and it can cause issues even when water is assumed to be abundant. In many countries, storage infrastructure is historically built for single purposes: predominantly hydropower. In such situations, reservoirs offer limited capacity to buffer extreme floods or alleviate droughts. Conversely, even multipurpose storage can cause conflicts between water users if allocations and storage management are not clear and transparent. Cascades from reservoirs and run-of-river infrastructure can also fundamentally alter the natural hydrology and ecology of a river basin—for example, long-term interannual storage in Australia's MDB has reversed natural river flows.

In the Mekong River Basin, hydropower dam cascades on the Lancang River, along with regulation on upstream tributaries in Lao People's Democratic Republic and Cambodia, have caused excessive flooding and reduced flows in Viet Nam and Lao People's Democratic Republic. This is due to dam releases during cyclone events and reduced dry-season flow in the Mekong Delta and Cambodian floodplain. River regulation along the Mekong has also weakened the natural flood pulse supporting fisheries and agriculture in the Tonle Sap.

5.4 Environmental water management and environmental flow requirements

In most countries, the extent of the overallocation of water for irrigation is masked by the loss of environmental flows. Environmental flows are mentioned in all reviews, and some countries have modest specifications for them (e.g., 10 per cent of the mean annual flow in Indonesia, which is insufficient for sustaining ecosystems). Nevertheless, estimates of utilisable water resources do not typically account for environmental flow requirements.

Efforts to balance water use for humans and the environment is needed. Minimum flows are a good start, but ecosystem health requires a broader understanding of natural cycles. Such research is in its early stages in Viet Nam, Indonesia and Thailand, while innovation can also be observed in some cases, for example, the night-time release of minimum flow requirements from hydropower dams in the 3S River Basin in Viet Nam.

5.5 Differences in the Pacific region

This trajectory does not directly apply to Fiji or other Pacific Islands, largely because irrigated agriculture is not the region's main driver of water development. Demand is typically propelled by the need for potable WASH. Despite high rainfall, accessible water resources are limited in the Pacific Islands (especially in the small atolls, where the only freshwater in the dry season is found in shallow groundwater lenses that are highly vulnerable to saline intrusion). Tropical cyclones and storm surges also present a high risk to infrastructure and vegetation; thus, much investment is directed at repairing and maintaining potable water supplies.

6. Best practice guidelines for policy

Across Asia and the Pacific region, countries vary considerably in how they manage water scarcity through various legislative frameworks, policies and associated regulations. Despite the differences in climate and topography, governance and historical contexts influencing and shaping how each country manages water—and, thus, how they respond to water scarcity—there are several overlapping policy challenges and lessons drawn from the country profiles, indicating certain windows of opportunity for improved policy relevant to the region.

6.1 Key policy challenges

A major policy challenge to achieving sustainable water resources management in Asia and the Pacific is the differing approaches to balancing the benefits of excessive water use now and fixing problems later versus realising benefits now that would avoid complex challenges later. At the political level, most countries—particularly those with monsoonal climates—have limited awareness of established and emerging water scarcity trends and associated risks. However, drought awareness is generally increasing (e.g., with new drought policies in Thailand and Viet Nam), and the country profiles indicated a common interest in improving water scarcity management for the future, particularly in light of the region's dependence on agriculture for livelihoods—a sector especially vulnerable to climate change.

6.1.1 Overlapping jurisdictions and policy incoherence

The overarching legal frameworks in most countries are recent and well developed. Policy instruments typically have a good balance of managing water across different sectors, and environmental management (including organisations with mandates for water management) is strengthening. However, water management typically involves overlapping jurisdictions due to the many sectors involved, which presents challenges in policy coherence, though some countries have established coordinating bodies to deal with this. Nevertheless, coordination between water, agriculture, environment and energy agencies remains limited, and environmental concerns are particularly under-represented and poorly monitored. Engagement across sectors is often done poorly, and there is also a lack of clarity in many countries regarding the tenure of water (e.g., a system of clearly defined water access requirements).

Policies to manage water scarcity, where they already exist, often differ in detail but not in principle compared to those guiding the sustainable development of water resources more broadly. A notable difference is that financing for sustainable water development is needed for assessment, feasibility, design and construction, plus water accounting analysis and inclusion of new users within an allocation framework. By contrast, funds to manage water scarcity specifically are mostly required for water resources assessment, administration of water allocation (including environmental water needs), and in some cases, compensation for the reallocation of water from one use to another.

In practice, policy instruments are rarely implemented in isolation. Typically, they are proposed as a mixture of complementary instruments designed to collectively meet a policy objective. These mixes are often injected into an already saturated policy environment that can create additional interactions (both complementary and contradictory) with existing policies, laws, strategies and programs. Given the rapid pace of urban and economic development in the region, there is also significant (though not always evident) involvement of the private sector in managing and adapting to water scarcity, though formal coordination is often lacking.

Continued focus on irrigation investment is motivated by the continuing political importance of domestic food security, distrust of (increasing) food trade and structural changes occurring in the agriculture sector through rural-to-urban migration, low attractiveness of farming to younger generations, declining margins in small-scale production and labour shortage for key operations. There appears to be a rising trend of interest in and development of private, industrial and commercial agriculture in many countries, notably Thailand, Indonesia (outside Java), Cambodia and Lao People's Democratic Republic, which require a secure water supply. Concurrently, industrial growth requiring power and water is paramount for Viet Nam, Indonesia, Thailand and Cambodia, which highlights the need for improved intersectoral coordination and policy coherence.

Investment in WASH has been high over the past 20 years, and the provision of safe drinking water is more advanced in Asia and the Pacific region than the treatment of wastewater from settlements (ESCAP, UN-Habitat & Asian Institute of Technology, 2015). While the absolute volumes of water required for urban use are very modest, dry-season shortages emerge in the dry season (e.g., in parts of Cambodia) and during drought (most recently in Thailand since 2019), which propels the argument for better bulk water allocation, management and security of supply and more strategic and coordinated cross-sectoral planning. The widespread pollution and contamination of surface water from urban, industrial and agricultural sources diminishes effective water availability, increases supply costs to all sectors and incurs public health effects and costs. Again, a well-coordinated, cross-sectoral response is needed for effective mitigation and restoration.

6.1.2 Technical and resource capacities

Technical capacity in water management in many countries (e.g., Thailand, Viet Nam, Bangladesh and Indonesia) is well developed at a national level and improving in several others. However, resource constraints are a significant and widespread issue across all countries, undermining governments' capacity to respond to water scarcity.

High-level policy instruments are often adopted from developed country practice or under the influence of international financial institutions and are relatively well developed and cohesive across the region; however, their effectiveness is often weakened by a lack of tailoring to specific country contexts. There is also typically a lack of subsidiary regulation, regionalisation and financial support for decentralised, local decision-making and policy implementation to realise the ambitious strategies set nationally.

Where they exist, RBO's tend not to engage in functional activities, such as water accounting and allocation in connection with nominal basin plans. This is often due to issues of understaffing and low levels of data and information on water resources. Infrastructure maintenance is also a key issue in many countries, with investment typically focused on construction rather than maintaining existing infrastructure.

6.1.3 Governance and stakeholder engagement

Genuine engagement of local water users is a challenge in most countries profiled, particularly for women and marginalised groups, who are usually most affected by water scarcity issues. This is compounded by the complex and often contentious, broader political contexts in many countries. For example, Myanmar is currently in a state of emergency, while several other countries continue to neglect the need for transparency and accountability in legal processes, both of which are fundamental to good governance. Many of these issues exist outside the jurisdiction of water resources management but significantly shape the institutional setting within which water scarcity responses are planned and implemented.

6.1.4 Competing water needs

A prominent issue in all country profiles was the difficulty of sharing water between several sectors with competing water requirements and uses—particularly between industry, agriculture and domestic water use—and ecosystem needs were often neglected. As competition for water increases, there is a significant danger of inequitable water access unless appropriate governance, water accounting and allocation processes are developed and implemented. Here, regulation and monitoring are essential. Water users do not hold equal power in terms of influencing allocation processes, and with economic development a high priority in most countries, industrial pollution continues to grow unabated.

There are also conflicting water needs, perceptions of water use and riparian rights in transboundary river basins. Politically motivated competition can overwhelm national arrangements for rational and sustainable water management and will likely exacerbate water scarcity in downstream countries (e.g., Nepal, Bangladesh and Viet Nam).

The management of water storage and flow is emerging as a point of conflict between electricity companies and operators and irrigation and urban water users and authorities in Viet Nam, Thailand (declining) and Java (emerging). It is a common aspect of water competition as demand for energy increases and is often contracted to the private sector. Although hydropower is not a consumptive use, the storage and release requirements do affect the supply to cities and agriculture, as observed in the South Central Coast of Viet Nam.

Irrigation will remain the dominant water user by volume for the foreseeable future, but, in certain locations (demand hotspots), water will flow away from agriculture to higher value uses, continuing a trend that is observed worldwide. Orderly arrangements to manage, and if necessary, compensate for such transfers will be contentious but more desirable than ad hoc and inequitable interventions and capture. There is a major challenge for irrigated agriculture production in many Asian countries in how to successfully produce more, higher quality and varied food in an environmentally acceptable manner with declining net water allocation. Increasing land and water productivity without increasing environmental externalities is perhaps the next major challenge for agricultural development and policy and will be highly relevant to adaptation to climate change.

Environmental water requirements for ecosystem health are particularly undervalued and, thus, not adequately considered in water allocation policies across the region. As water scarcity worsens, environmental flows can be expected to diminish even further, with serious consequences for the ecosystems that sustain our food systems. Some countries have made progress with allocation of water to the environment (e.g., the MDB's sustainable diversion limit accounting framework in Australia, which emphasises water reallocation to the environment), but this needs to be sustained and expanded to secure ecosystem services.

6.2 Lessons for managing water scarcity

Ten key policy lessons emerged from the case studies, indicating either areas needing improvement or where benefits have already been realised with varying degrees of success. While every country has context-specific challenges, several lessons are applicable across the region. Many lessons also interlink with others. For example, increased financial resources supports not only good water accounting and data collection but also regulatory enforcement and local government capacities. These ten lessons provide guidance for governments and their development partners in setting priorities and designing programs that address water scarcity issues and improve the resilience of water management practices in the Asia – Pacific.

1. Water accounting is important for understanding water resource availability and dynamics.

Many countries have undertaken one-off water accounting at a basin, catchment or irrigation system scale, but few have established routine water accounting across scales. Proper quantification of water uses between sectors supports evidence-based decision-making. Water accounting for groundwater is especially important as countries expand their groundwater use. Technologies such as remote sensing provide opportunities for data-scarce countries to conduct water accounting assessments.

2. River basin management and planning provide a useful framework for managing water scarcity.

There is a strong focus on disaster management in all countries (e.g., through prioritising and funding flood control, forecasting, warning and preparedness). Drought policies have been developed throughout most of the region, though they are rarely integrated with water resources planning; this offers options for improved integration in the future. Long-term planning—for example, predicting future water demands and preparing for climate change–related extreme events—is as important as adopting emergency measures.

3. Establishing water-sharing and participatory allocation processes before water resources have been overallocated helps avoid the difficulties and costs associated with restraining water use and reallocating water between sectors and jurisdictions once water resources are overallocated.

Undeveloped catchments present an important opportunity to for countries to establish participatory water allocation processes before they face the effects of overallocation, which is much more difficult to rectify, with significant potential conflicts between competing water users. Australia has made substantial efforts in water reallocations to the environment, though this has been costly and politically challenging. Ad hoc water-sharing arrangements are developing in critical hotspots (e.g., in Thailand, Viet Nam and Indonesia). Some countries, such as Thailand, Indonesia and Viet Nam, have expressed interest in developing more comprehensive water allocation processes to better manage rising competition between sectors. Transboundary allocations must also be addressed (e.g., in downstream countries such as Viet Nam).

Water allocations for aquatic ecosystems are also important. Some countries require minimum flows for environmental purposes (e.g., Viet Nam, Indonesia, Thailand and Myanmar), but implementation is patchy. Experience from other regions has shown minimum flows are insufficient to sustain key ecological assets in rivers and wetlands, indicating a need to quantify environmental flow requirements, which assess the amount of water needed to sustain freshwater ecosystems (Pastor et al., 2013).

4. Successful water scarcity policy implementation requires institutional coordination across scales and sectors.

Agency coordination and efforts to develop coherent policy between major sectors are generally poor, though some countries are adopting strategic planning principles and institutions with the mandate for various ministries to coordinate water resources management (e.g., Bangladesh, Indonesia and Thailand). IWRM has been adopted as a central principle in all countries, though implementation falls well behind aspirations. Considering the region's rapid economic development, policy coherence is needed between the water, environment and energy sectors.

Enabling laws and subsidiary legislation exist in nearly all countries. However, implementation is low, especially at provincial and district levels, where there is typically insufficient expertise and finance which sometimes reflects continuing tensions between the central government and regional administrations. Empowering decentralisation appears to be a widespread need and opportunity, with a specific focus on coordination between river basin management arrangements and local government that operates within administrative boundaries. Concurrently, the expectations of community-based management of irrigation through water user associations and the like remain unrealistic for a variety of well-documented reasons such as Cambodia and Lao People's Democratic Republic (Senanayake et al., 2011).

5. Climate change policy may be an important leverage point for ensuring policy coherence.

Climate change policies have been developed in all countries in the study. The policies are typically well-integrated across ministries and agencies, as they involve most key economic and natural resource sectors. Therefore, climate policy may act as an important leverage point for improved policy coherence in the future regarding water scarcity.

6. Decentralisation of water management links higher level policy to local action but needs adequate resources and incentivisation to succeed.

Higher level, umbrella, sophisticated water policies exist in several countries but do not always translate into action at the provincial or local level. Decentralised decision-making may facilitate locally relevant implementation practices if properly resourced and supported—decentralisation on its own is not a panacea. The policy reviews note that better funding, staffing, authority transfer and local stakeholder engagement are needed for effective local water management. Nepal is the most recent country in the region to implement formal decentralisation, though it faces funding and capacity challenges. In theory, RBO's facilitate decentralisation, though in reality they typically lack sufficient funding, staff and capacity.

7. Improved monitoring and information systems are the basis of robust decision-making.

All countries identified the need for improving collection, management and access to better hydrometric data (including water quality) as the basis of evidence-based decision making. Further investment is needed in water quality and flow measurements across the region. There is strong interest in the potential of remote sensing to augment and substitute ground-based data collection. Some countries (Thailand, Bangladesh and Viet Nam) have strong capacity in research institutes and academia (e.g., modelling and assessment capacity), while others seek to strengthen this capacity (e.g., Cambodia, Fiji, Myanmar and Bangladesh). Freely available remote sensing can also support this.

8. Genuine stakeholder engagement is important for ensuring equitable decision-making and allocation processes, including the involvement of civil society and the private sector.

Managing water scarcity requires state and non-state actors' involvement and a willingness to listen to opposing perspectives between water users, government and the public. Engagement with women and marginalised water users is particularly important in countries with persisting poverty and inequitable water access, as well as countries where such groups are overrepresented in the agricultural sector. The private sector is also playing an increasingly important role in urban water supply and sanitation. Involvement of this sector in agriculture remains confined to input supply and market chains, though commercial leasehold farming is growing. Groundwater development for irrigation is mostly a private sector activity which requires supervision, monitoring and regulation. Private sector stakeholders have a limited voice in water resources management, and some countries (e.g., Indonesia) remain cautious of their involvement.

9. Water quality regulations and standards, as well as adequate monitoring, are urgently needed across the region.

While most countries have updated their water quality standards, water quality across the region continues to degrade. Insufficient monitoring, poor cross-sectoral coordination and weak enforcement are key issues that must be addressed. All country reports also highlighted the urgency of improving water quality through (1) improved sanitation and wastewater treatment, (2) prevention of discharge of untreated industrial wastewater and better monitoring and compliance, (3) better treatment of livestock effluents and (4) reduction of non-point source pollution through reduced use and better management of nitrogen and phosphate fertilisers.

10. Investment in resources (human and financial) is fundamental for implementing water scarcity management policies, building and maintaining infrastructure and enhancing agricultural productivity and food security in the face of worsening water scarcity.

Financial support is vital for data collection and monitoring activities, infrastructure and water-saving technologies, and proper regulation enforcement, while human resources are needed for building capacity and relationships. Continued support from international financial institutions will be important for policy implementation; however, their effectiveness is often undermined by a lack of tailoring to specific country contexts.

Most countries have developed programs and policies to improve water use efficiency and increase crop productivity (e.g., through advanced irrigation technologies and drought-resistant crops); however, a more nuanced understanding of the effects of specific efficiency interventions in terms of actual water savings is needed. Investment in infrastructure maintenance and development is also important as water supply augmentation continues to be a key response to seasonal water scarcity (e.g., interseasonal storage in dams), particularly in countries at earlier stages of water development (e.g., Lao People's Democratic Republic, Cambodia and Myanmar).

7. Outlook for water scarcity management across Asia and the Pacific region

Growing pressures on water resources across Asia and the Pacific region—including an expanding population, increasing competition for water resources and unabated water pollution due to industry and agriculture—continue to exacerbate water scarcity across the region. This is compounded by climate change and requires urgent regulatory and financial attention, as exemplified by this study. Countries that do not adequately commit to developing their water scarcity responses may face severe effects, particularly impacting the poorest and most vulnerable groups in society who are highly dependent on water resources for their livelihoods.

Water scarcity challenges in many countries of the Asia-Pacific tend not to be about chronic scarcity but about too variable water—this is typically exhibited as intermittent interannual drought and seasonal scarcity due to monsoonal climates, growing competition for water resources and pollution impeding access to good quality water. This is being worsened by climate change, for example with the lengthening of the dry season, as has happened in Cambodia and other parts of monsoon Asia. Water quality is also deteriorating across the region due to industrial and agricultural pollution coupled with inadequate infrastructure and wastewater treatment, with direct effects on human and ecosystem health and food security.

7.1 Regional priorities

Based on the lessons learned from the 10 country profiles, there are several key windows of opportunity for policymakers to make swift and effective changes to how water scarcity is managed and prepared for in Asia and the Pacific region. This will require long-term commitment from many stakeholders across sectors and scales and improvements in stakeholder engagement; funding; data collection and water accounting; allocation mechanisms; and policy cohesion.

7.1.1 Tailor water policies to country contexts

While commitment to IWRM in principle is strong at the national level, it is difficult to achieve in practice due to competition between sectors and water uses, as well as institutionally challenging contexts (e.g., those with limited financial resources or capacity to implement ambitious strategies). Improving stakeholder engagement—particularly of the most vulnerable water users at the local level—will help authorities to tailor water resources management to local contexts in terms of the climate and socio-economic contexts. Adaptive management and governance approaches and learning cycles, especially those centred around socio-ecological systems more broadly (i.e., not only water), could support such tailoring (e.g., see Armitage et al., 2007, Armitage, 2008, Brunner et al., 2005, Folke et al., 2005 and Huitema et al., 2009).

While population growth and the economic development that accompanies it in industry, urbanisation and food production will continue to be the main drivers of water scarcity, climate change will increasingly twist the knife through increased variability and extremes as well as long-term shifts in water balance, especially in arid, semi-arid and seasonally arid areas. Water policy across all sectors must balance the response to these stresses and meld them as practically and strategically as possible, considering national scale options and local hotspot challenges.

7.1.2 Invest in training and capacity building in local government agencies

Higher level policies are generally well developed, but agencies require properly staffed offices and adequately trained personnel for successful implementation. Therefore, investments and training programs are needed to build capacity across different institutional scales, particularly in countries that aim to decentralise decision-making (e.g., Nepal).

7.1.3 Improve data collection and sharing

Huge improvements in data collection and management are needed to support proper water accounting (i.e., measuring stocks, flows and abstractions), determine water quality and groundwater status and model future scenarios. Data improvements would also improve our understanding of return flows in river basins and how they are re-used.

Remote sensing, data assimilation and system modelling, along with cheap, internet-enabled data collection, would support monitoring and planning activities. This can be improved by involving academic and research institutions and encouraging cooperation between institutions and countries for data sharing.

In the long run, effective routine water management and good water accounting rely on good spatial and temporal measurements of stocks and flows in the water system. This can require considerable investment, particularly where water quality parameters must also be monitored. Furthermore, the experience of many countries shows that hydrometric networks need continued financial support for maintenance and replacement.

7.1.4 Prioritise water quality

Political prioritisation and financial resources are needed to tackle water quality issues across the region, which are rampant, largely due to the agricultural and industrial sectors. This would involve regulating polluters, enforcing and incentivising compliance, investing in water treatment and infrastructure and facilitating citizen action for river restoration.

7.1.5 Improve water storage for variable water availability, but take care of river and ecosystem health

Seasonal variability in water availability means improvements are needed to manage water storage cascades or systems to ensure water supply during the dry season. However, care should be taken to safeguard natural river hydrology and ecology, which can be significantly fragmented by infrastructure. This has been witnessed in Lao People’s Democratic Republic and other countries due to hydropower dam construction and other infrastructure along rivers.

Groundwater is strategically important and, if managed carefully, provides resilient water storage options under climate change, especially in comparison to surface water storage. Groundwater needs special attention as early as possible to establish conditions for sustainable use. This seems easy and obvious, but regional groundwater governance has already fallen well behind. Radical responses are already required to avoid what is likely to be a real catastrophe in many parts of South and South-East Asia.

7.1.6 Develop fair and transparent water allocation processes and enfranchisement

As water scarcity worsens in certain regions, there will be a need to adjust processes for water allocation to balance conflicting water uses between (and within) sectors. Processes for genuine stakeholder engagement and enfranchisement of the most vulnerable groups will be needed to ensure fair and equitable allocations. Such processes will include adequate conflict resolution mechanisms.

Legal reforms and administrative changes in allocation processes and priorities should be informed by a detailed analysis of who uses water—whether legally, customarily or otherwise (i.e., water tenure analysis)—to ensure equitable, inclusive and transparent arrangements. Although it is not always easy to recognise opportunities for gender inclusiveness in water resources management, understanding water tenure is likely to provide practical possibilities. A greater representation of women in the technical and administrative apparatus of water management is also desirable and possible to improve sensitivity, awareness and much-needed action.

7.1.7 Prepare for shifting demographics and livelihood structures in rural areas

Although agriculture remains a significant form of employment across the region, urbanisation, a growing reluctance of younger generations to work in agriculture and the declining value of agriculture signify a need for accession planning for future agriculture. Subsistence agriculture, rural livelihoods, agricultural export earnings and national food security will all provide strong political motivation to continue to develop water use for irrigated agriculture. Therefore, significant adaptations will be required to balance food production with sustainable water management, as well as 'climate smart' agricultural practices.

7.1.8 Adapt to future climate change and worsening water scarcity

Asia and the Pacific region are more vulnerable to climate change than most other regions in the world, particularly due to their dependence on agriculture, densely populated coastal areas, institutional challenges and the high proportion of the poor population (Anbumozhi et al., 2012). Climate change is projected to have significant negative effects on water availability and, thus, on food production in the region. This will occur through increased climate variability, reduced water availability, increasing water demand and changes in cropping patterns. The cropland area under water scarcity is largest in East Asia and the Pacific region (50 per cent of total croplands), followed by South Asia (46 per cent of croplands), which is expected to worsen under projected climate change (Liu et al., 2022).

Domestic food production for food security remains a political priority in many countries in the region, and the agricultural sector must adequately prepare and adapt to projected climate change. Agricultural policies that are better integrated with water policies are needed to avoid the effects of water scarcity on the agricultural sector in the future. The pressure to produce high-value crops with dwindling water supplies, which is driving structural changes in farming throughout the region, will likely refocus irrigated production towards fruit, vegetables, aquaculture and specialty crops (away from dry season rice irrigation). As farm management units increase in size and become more commercially orientated, regulatory challenges concerning water rights and allocation should become more straightforward and incur lower transaction costs, though this must be handled carefully.

Many governments place faith in irrigation efficiency measures, yet these do not automatically lead to water savings and may even stimulate greater water consumption. Similar hopes have been placed in groundwater as a strategic form of water storage to increase the resilience of water resources during droughts and in the face of climate change. However, it must be regulated and managed sustainably—

a task that faces significant transaction costs associated with pricing, metering and monitoring and subsequent potential trade-offs, as faced in India (see Shah et al., 2008). Vast improvements in the scope, extent and quality of data for diagnosis and management are urgently required.

Therefore, considerations will be needed to improve crop production while using the same quantity (or less) of water, for example, to minimise the effects of climate change on crop yields, limit the loss of agricultural area due to the construction of settlements and infrastructure, and compensate for migration from farming areas (rural-to-urban migration). Past interventions that intensify production using high levels of fertiliser and agrochemical inputs will not be effective solutions. The environmental footprint of agriculture must be reduced simultaneously as overall production increases.

Increased agricultural production and food security will result from raising average productivity across the farming community as a whole—likely through better husbandry and improvement of all the factors of production. This will require a more detailed understanding of production variability, the reasons for land and water productivity gaps and the range of solutions available. Consolidation of farmed areas is expected, even though land ownership may remain fragmented; this could either lead to more intensified high-input 'western' style farming or some better and more sustainable and relevant alternative. There may also be niche opportunities for hyper-intensive closed systems (forms of protected cropping) within and outside cities, which trade off high capital investment against a small land footprint and offer employment activities in packing, processing and marketing, which may be more appealing than labouring in the field. Large-scale greenhouse developments that follow this model are under consideration in Sumatera, Indonesia.

7.1.9 Facilitate equitable transboundary water-sharing

Transboundary water management features in commentaries on many countries in Asia and the Pacific region, including Bangladesh, Myanmar, Nepal, Thailand, Lao People's Democratic Republic, Cambodia and Viet Nam. Water-sharing is a fundamental—and perhaps the most politically challenging—component of transboundary water management. As countries improve their internal assessments (e.g., water accounting), more open and realistic information sharing would help broker water-sharing agreements and support management arrangements. However, data sharing also comes with political constraints and may continue to be restricted in some instances.

Regional cooperation is also needed to build high-level political recognition of water scarcity and to encourage policy reform and practical actions. Consensus-building and knowledge-sharing are also required regarding water use and management across various sectors and administrative levels.

7.2 Policy windows of opportunity

Policymakers may identify and act on windows of opportunity in terms of best practices and actions that can address multiple threats, challenges and associated effects of water scarcity across Asia and the Pacific region. These include improvements in river basin planning (especially water accounting) and institutional coordination across administrative scales, as well as support for policy implementation and decentralisation (including enfranchisement of marginalised water users). Both human and financial resources underpin these efforts (Figure 36).

Given the region's high vulnerability to water-related risks due to its dependence on the agricultural sector and densely populated coastal regions (Anbumozhi et al., 2012), climate change poses additional threats to Asia and the Pacific region if worsening water scarcity is not adequately prepared for. More anticipatory water scarcity management actions should be taken.

For countries not yet facing water scarcity, there is an opportunity for setting a legislative framework of water-sharing before overallocation occurs. This is much easier, less expensive and less disruptive than recovering and reallocating water later (e.g., as observed in Australia's MDB). RBOs can be strengthened through improvements in water accounting, data management, stakeholder engagement and the formulation of water allocation processes and rules that can be adequately enforced and monitored.

Improvements in living standards across the region are expected to reduce agricultural water use in favour of uses with higher economic value. However, this may pose challenges regarding food security (particularly self-sufficiency) and rural livelihoods. Declining water availability for agriculture will also increase pressure to intensify cropping systems to maintain production; therefore, it will be important to do so without exacerbating existing water quality and ecosystem health issues. Thus, there is a strong need to prioritise environmental flow requirements, which are often overlooked in favour of more economically valuable water uses, including irrigation (Jägermeyr et al., 2017).

THREATS & CHALLENGES	WATER SCARCITY IMPACTS	GOALS	BEST PRACTICES & ACTIONS
• Growing population • Industrialisation • Urbanisation • Increasing water demands and sectoral competition (agriculture, domestic/urban, industry, energy)	**Over-utilisation** • Unsustainable withdrawals/ overabstraction (especially agricultural) • Water quality issues • River hydrology fragmentation	**Sustainable water resources** • Sufficient water for ecosystem + human health • Climate change adaptation (e.g., drought preparedness, interseasonal storage)	**River basin planning and water accounting** • Water accounting • Long-term planning > ad hoc response • Evidence-based decision-making • Protection of environmental flows • Balancing conflicting needs/priorities • Transboundary/ interbasin agreements
• Seasonal water availability (monsoonal climate) • Climate change • Pollution (agriculture, urban + industry) • Poor wastewater management & treatment • Lack of seasonal storage (infrastructure)	**Too little water** • Low precipitation/runoff • Too little per capita availability	**Good quality water** • Reduced pollution (urban, agricultural + industrial) • Wastewater management + treatment	**Institutional coordination** • Inter-sectoral, interministerial • Across scales (national to local) • Cross-cutting issues (e.g. climate change, agriculture, drought response, energy, rural development, land)
	Too variable water • Seasonal/interannual variability • Floods during wet season, drought during dry season • Lengthened dry season (climate change)	**Well-balanced allocations** • Management of water competition within/ between sectors • Evidence-based decision-making • (Re) allocation processes • Conflict resolution + trade-offs mediated between sectors • Political prioritisation + commitment	**Decentralisation & implementation** • Higher-level policy > subsidiary actions • Engage stakeholders across sectors + scales (incl. women, marginalised groups, private sector)
• Low institutional coordination • Resource constraints • (human + financial) • Uneven policy implementation • Low regulation & enforcement • Political priorities • Data & information gaps • Historical & cultural contexts	**Poor water quality** • Saline intrusion • Polluted water sources (E. Coli, faecal matter, • fertilisers/pesticides, metals) • Reduced water availability	**Equitable water access** • Genuine stakeholder engagement • Empowerment of women + marginalised groups	**Resources (human + financial)** • Local/subsidiary implementation support • Data collection + monitoring • Infrastructure maintenance • Investments in innovations/technology • Investment in interseasonal storage • Capacity building, policy implementation • Regulation + enforcement

Figure 36. Linking water scarcity threats, effects, goals and proposed best practices for Asia and the Pacific region.

A stronger focus on environmental flow requirements will provide an entry point for dealing with water quality issues while making important provisions for ecosystems as competition for water increases and water availability decreases. Given the many competing sectors vying for water resources, environmental flows must not be left out of the equation in water allocation processes. This will also support the attainment of several of the UN's Sustainable Development Goals relating to water and the environment. However, given concerns that increases in irrigation water withdrawals—which are important for attaining Sustainable Development Goals related to food security—may increasingly occur at the expense of environmental flows (e.g., see Jägermeyr et al., 2017), it will be important to compensate for these losses through appropriate management interventions (e.g., improved irrigation practices, including more nature-based farming practices).

Responses to water scarcity and related challenges will also involve a redistribution of benefits among existing users and provide appropriate compensation for losers. Most countries in Asia have opted for industrialisation as the main development path and, as such, must manage a delicate transition over a period when most of the population remains engaged in agriculture, despite its declining proportion of GDP.

Ultimately, managing water scarcity in Asia and the Pacific region is a long-term task with no simple or quick fixes. Rather, water policy will require long-term political commitment, consistent financial support and adaptive approaches to navigate conflicting water demands and needs fairly and under a rapidly changing climate. No matter where a country sits on the sustainable water resources management trajectory, the time for action is now.

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