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WATER RESOURCES PROFILE SERIES

The Water Resources Profile Series synthesizes information on water resources, water quality, the water-related dimensions of climate change, and water governance and provides an overview of the most critical water resources challenges and stress factors within USAID Water for the World Act High Priority Countries. The profile includes: a summary of available surface and groundwater resources; analysis of surface and groundwater availability and quality challenges related to water and land use practices; discussion of climate change risks; and synthesis of governance issues affecting water resources management institutions and service providers.

Indonesia Water Resources Profile Overview

Indonesia has significant renewable water resources, but water supply and demand often do not align. Freshwater is abundant on Sumatra, Kalimantan, and Papua where population density is low. Freshwater is less available on more densely populated islands like Java. Risks to urban water security in West Java are high, driven by low access rates to piped water and widespread pollution.

Water stress is highest in Java, which contains more than half of the total population but only four percent of surface water supply. Irrigation and community water supplies are often insufficient during the dry season, and some cities such as Bandung are projected to have shortages in the near future. According to the Falkenmark Index[i] for water stress, some studies project that Java will experience absolute water scarcity (476 m^3 per person) by 2040.

Palm oil plantations and small-scale agriculture have increased erosion and sedimentation in reservoirs, decreased dry season river flows, and intensified the impacts of monsoon flooding. Palm oil plantations are concentrated in Sumatra and Kalimantan, whereas small-scale agriculture is concentrated in Java and the eastern Lesser Sundas. Biodiversity in the peatland swamp forests throughout Kalimantan, Sumatra, and Papua have been particularly affected.

Poor sanitation systems, agricultural runoff, and aquaculture have led to eutrophication in key surface waters and degraded aquatic and coastal habitats. Solid waste and industrial effluent pollute the Citarum River in West Java, which is a key water source used by 27 million people.

Contamination from mercury, which is used artisanal gold mining, and acid mine drainage from coal mining are widespread. This has reduced pH in surface waters and pose risks to the environment, public health, and fisheries, particularly in Kalimantan.

Several cities are sinking (subsidence) due to the over-exploitation of aquifers, threatening infrastructure and livelihoods, and worsening flood risks caused by land use changes and climate change. Subsidence rates in Jakarta are among the highest in the world, with some parts of the city having sunk over four meters total. Subsidence is highest in north Jakarta, which has sunk 2.5 meters in the past 10 years alone. Climate change and over-pumping are also accelerating saline intrusion into aquifers.

Climate change will increase drought frequency and severity, and lead to severe dry season water shortages in water stressed areas. Climate change will increase the vulnerability of peat swamp forests to forest fires and degradation. Peatland fires reduce air quality, contribute to greenhouse gas emissions, and destroy critical wetland habitat. Increased rainfall and rainfall intensity, coupled with sea level rise, pose serious risks to coastal cities, especially Jakarta.

Key water management responsibilities are fragmented across several government entities, but they lack technical capacity and adequate funding to coordinate management efforts and implement basin master plans.

[i] The Falkenmark Water Stress Index measures water scarcity as the amount of renewable freshwater that is available for each person each year. A country is said to be experiencing water stress when water availability is below 1,700 m^3 per person per year; below 1,000 m^3 is considered water scarcity; and below 500 m^3 is absolute or severe water scarcity.

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Water Resources Availability

KEY TAKEAWAYS

- Indonesia has significant renewable water resources, but water supply and demand often do not align. Freshwater is abundant on Sumatra, Kalimantan, and Papua where population density is low. Freshwater is less available on more densely populated islands like Java.
- Groundwater availability is heterogeneous across each island, with several parts of each island having low productivity. There are significant groundwater resources in Sumatra, Kalimantan, and Papua, as well as the northern alluvial plains in Java.

This section summarizes key characteristics of surface and groundwater resources. Table 1 summarizes key water resources data and Figure 1 presents key surface water resources, wetlands, and dams.

Surface Water Resources

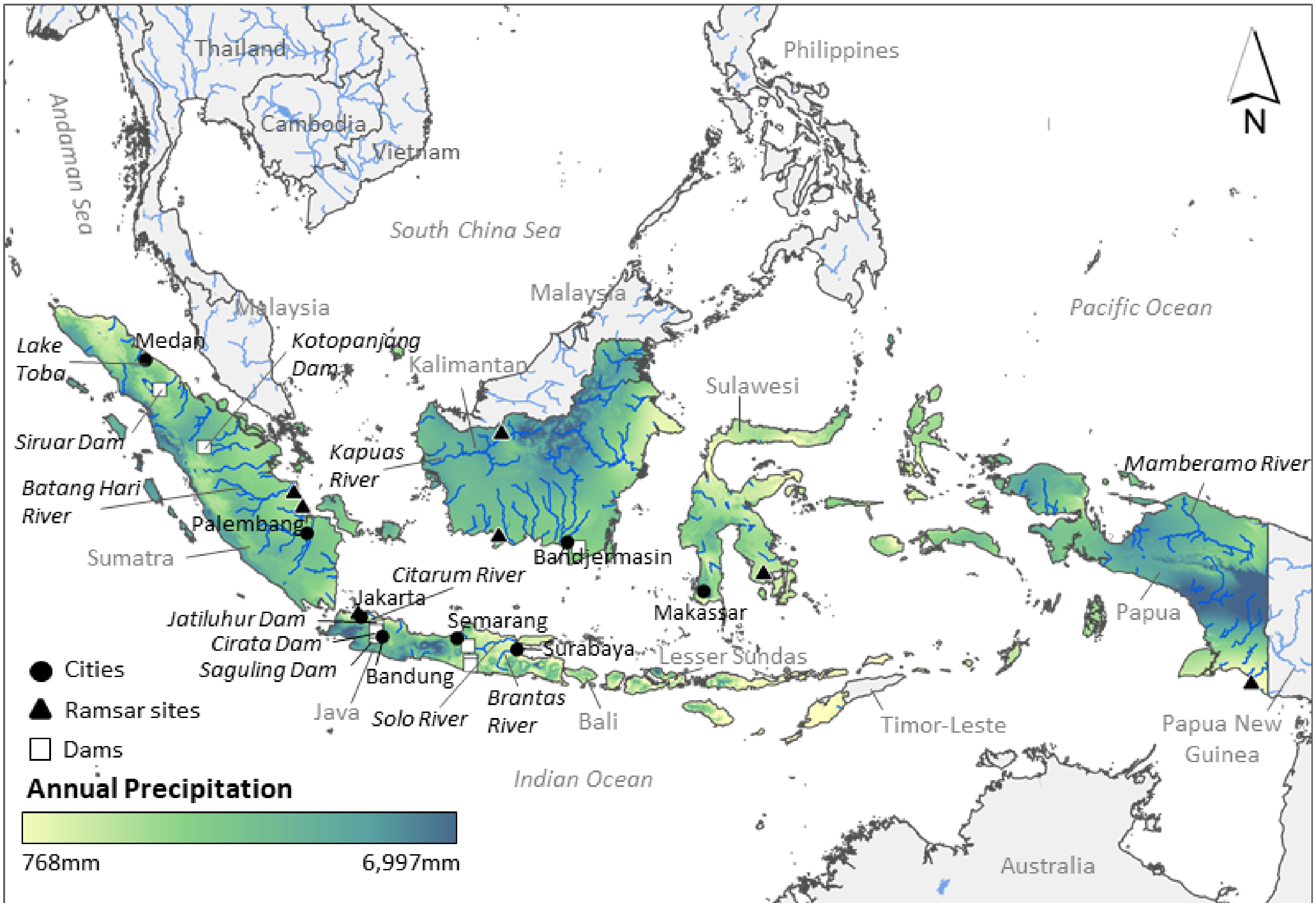
Indonesia has more than 5,700 rivers that are managed within 133 official river basin territories, referred to as Wilayah Sungai (WS).[2] WS are classified as transboundary, inter-provincial, national strategic, inter-district, and sub-district. The most important basins are managed by the central government, including five transboundary basins shared with Papua New Guinea, Malaysia, and Timor-Leste. There are also 27 inter-provincial basins, and 37 national strategic basins.[3,4]

Main Island	WS	Key Information
Java	24	Contains half the total population but only 4 percent of total surface water. The Brantas River (East Java) and Citarum River (West Java) are important for municipal water supply and agriculture. River flow rates are highly seasonal and can significantly decline in the dry season.
Kalimantan	17	Contains the Kapuas River, which is Indonesia's longest. Has one transboundary WS with Malaysia. Together with Papua (see below), contain 60 percent of total surface water but less than 10 percent of population.
Papua	5	Contains the Mamberamo River, which is the largest river by volume. Features two transboundary WSs with Papua New Guinea.
Sumatra	45	Contains one-quarter of population and one-quarter of total freshwater resources.
Sulawesi	22	Contains 8 percent of total surface water resources and 8 percent of population.

TABLE 1. WATER RESOURCES DATA	Year	Indonesia	Southeast Asia
Long-term average precipitation (mm/year)	2017	2,702	2,220
Total renewable freshwater resources (TRWR) (MCM/year)	2017	2,019,000	477,550
Falkenmark Index - TRWR per capita (m3/year)	2017	7,648	13,798
Total renewable surface water (MCM/year)	2017	1,973,000	471,500
Total renewable groundwater (MCM/year)	2017	457,400	64,000
Total freshwater withdrawal (TFWW) (MCM/year)	2016	222,600	31,215
Total dam capacity (MCM)	2015	23,020	13,570
Dependency ratio (%)	2017	0	14.13
Interannual variability	2013	1.1	0.9
Seasonal variability	2013	1.9	2.6
Environmental Flow Requirements (MCM/year)		1,269,000	227,500
SDG 6.4.2 Water Stress (%)	2016	29.68	29

Source: FAO Aquastat

FIGURE 1: MAP OF WATER RESOURCES



Source:
Cities: World Cities – ArcGIS Hub, **Country Borders:** GADM, **Dams:** FAO Aquastat Dams Database, **Ramsar Sites:** Ramsar Sites Information Service, **Lakes and Wetlands:** WWF - GLWD (Level 1), **Rivers:** WWF – HydroRivers, **Precipitation:** WorldClim, **Flood and Drought:** WRI Aqueduct 2019

Indonesia's peatlands, freshwater wetlands, and mangroves cover 21 percent of the country[5] and are important to livelihoods and biodiversity. There are seven Ramsar wetlands covering approximately 1.4 million hectares across the main islands.[6] The country also has over 500 lakes, with Lake Toba (north Sumatra) being the largest,[7] as well as several large dams in West and Central Java.

Groundwater Resources

Indonesia organizes and manages groundwater through 421 "groundwater basins" that are based on hydrogeological boundaries.[2] Total groundwater potential is 457,400 MCM/year, but safe yield is estimated to be 137,200 MCM/year because most groundwater recharge outlets to rivers.[8] Safe yield estimates are lowest in Bali and Nusa Tenggara, Java, and Sulawesi (400-7,700 MCM/year) and highest in Kalimantan, Sumatra, and Papua (26,000-59,000 MCM/year).[8] Aquifer productivity is high in parts of South and West Papua, South Kalimantan, East Sumatra, South Sulawesi, and in Java's northern plains. Java's aquifers are particularly important sources of drinking water supply. Much of the Java's north coast is underlain by alluvial plains with a shallow unconfined aquifer and numerous confined layers.[9,10]

Surface Water Outlook

KEY TAKEAWAYS

- High municipal and irrigation demand are leading to water stress in Java, particularly in the dry season. Urban water security in West Java is threatened by low access to piped water supply and extensive pollution of most water sources.
- Deforestation is widespread and driven by small-scale agriculture and the palm oil industry. Deforestation reduces dry season water availability, increases flood risks, and reduces dam capacity.
- The Citarum River is highly polluted from industry and poor sanitation systems. Heavy metals pollute key reservoirs and threaten Jakarta's municipal water supply, while widespread eutrophication of lakes and rivers threaten aquatic biodiversity.
- Gold and coal mining in most provinces (especially in Kalimantan) contaminate surface water resources with mercury pollution and harm aquaculture.

This section describes key sources of demand and uses of surface water, and associated challenges stemming from water availability and water quality challenges.

Agriculture is the main source of surface water demand. Total Irrigation demand is high (177,100 MCM/year), particularly in Java, Southeast Sumatra, South Sulawesi, Bali, and West Nusa Tenggara.[2] Municipal (23,800 MCM/year) and industrial (9,135 MCM/year) withdrawals are very low in comparison.[11] Around 99 percent of irrigated croplands use surface water, mostly for rice.[2,8,12] Jakarta's municipal water system depends on the Citarum and Cisadane Rivers.[13] Surface water also has important non-consumptive uses, including hydropower generation at 88 large hydropower plants (2,589 MW capacity),[2] although only a fraction of Indonesia's 75,000 MW hydropower capacity is developed.[14]

High demand for municipal and agricultural water supply, and low surface water availability cause dry season water stress in Java. Current per capita water availability in Java is only 1169 m^3 and is projected to fall to 476 m^3 by 2040.[15] Existing water stress threatens agricultural and domestic water supply during the dry season.[16,17] Current water demand already exceeds surface water supply by at least 25 percent in 14 basins in Java, including the Brantas, Solo, and Citarum Rivers.[18] Demand is projected to exceed supply in major cities such as Bandung by 2034.[19] While Jakarta's available water supply is not immediately at risk from shortages, low access to piped water supply (60 percent) and widespread pollution severely limits accessibility to safe, freshwater sources for drinking.[20] Recent droughts have strained irrigation and drinking water supplies. In 2017, seven irrigation reservoirs in Central Java dried up for over a month.[21–23] During the 2019 drought, a state of emergency was declared in 55 regencies (sub-provincial administrative unit) in Java and Nusa Tenggara.[15,24]

Deforestation driven by small-scale agriculture and agroindustry, including palm oil, is degrading watersheds, reducing dam capacity, straining dry season water availability, and increasing flood risks. Indonesia produces 57 percent of the world's palm oil[17] and almost half of all existing palm oil production occurs in North Sumatra, Riau, and Central Kalimantan Provinces in Kalimantan and Sumatra.[25] Indonesia has one of the highest deforestation rates in the world,[26] with approximately 117,000 hectares deforested annually just for palm oil, mostly in Sumatra, Kalimantan, and Papua.[27] Peatlands are also threatened by agroindustry, logging, small scale agriculture, and fires. Only seven percent of wetland peat forests on Sumatra and Kalimantan are undisturbed.[28] Deforestation has led to increased erosion[29] and have filled reservoirs with sediment, including the Sengguruh Dam (Brantas River).[4]

West Java's Citarum River is severely contaminated with municipal and industrial waste. Chemical analysis of the Citarum River indicated high biological oxygen demand (BOD) along with high concentrations of heavy metals. Lead levels were also found to exceed WHO Guideline values for drinking water by 1,000 times.[30,31] In the less populated upper reaches of the Citarum River, BOD and fecal coliform levels exceed local ambient water quality standards by nine and 5,000 times, respectively, largely from untreated domestic waste and leakage from septic tanks.[32,33] Contamination worsens near Bandung as industrial effluent and nearly 250,000 m^3/year of solid waste contaminate the Saguling Reservoir (Citarum River).[31,34,35]

Agriculture, aquaculture, and poor sanitation systems have led to widespread eutrophication. Poor sanitation systems, agricultural runoff, and unregulated aquaculture have led to eutrophication in fifteen major lakes[2] and in the Saguling, Cirata, and Jatiluhur Reservoirs on the Citarum River.[36] Lake Toba's phosphorus levels have also tripled in recent years as aquaculture production exceeds capacity by two to three times. In 2016 and 2018, severe oxygen depletion led to massive fish die offs in the lake.[37,38]

Artisanal gold mining and acid mine drainage from coal mines pose risks to public health and biodiversity. Artisanal and small-scale gold mining is practiced in 27 provinces.[39] While recently prohibited,[40] mercury is often used for gold amalgamation by artisanal miners, threatening rivers and public health.[41] Mercury levels are over three times local drinking water quality standards and contaminate the food chain in the Kapuas Rivers in Kalimantan.[40] Similar pollution from gold mining can be found in West Java, Bengkulu, Gorontalo provinces,[42–44] and in West Nusa Tenggara.[45] Coal mining is also widespread, particularly in South Sumatra, South Kalimantan, and East Kalimantan. In East Kalimantan, drainage from coal mining has led to high concentrations of heavy metals and low pH, which harm aquaculture.[46]

Groundwater Outlook

KEY TAKEAWAYS

- Around 15 percent of all water withdrawals are for groundwater, mostly for domestic use. Groundwater is an important resource in cities like Jakarta which have poor coverage from municipal supply systems.
- Numerous cities are sinking (subsidence) due to over exploitation of aquifers. Jakarta exhibits one of the fastest subsidence rates in the world, increasing flood risks and threatening infrastructure.
- Catchment degradation decreases groundwater recharge and reduces spring outflows, while over exploitation is causing groundwater levels to decline in some locations.
- Aquifers are contaminated by poor sanitation systems and industrial pollution. Coastal aquifers in urban areas are also increasingly saline.

This section describes key sources of demand and uses of groundwater, and associated challenges stemming from water availability and water quality challenges.

Groundwater over-abstraction and land use changes are depleting aquifers, drying up perennial springs and rivers, and increasing flood risks. In Bali, over abstraction from tourism and land use changes are causing groundwater tables to decline by up to 50 meters in some locations. This is jeopardizing spring outflows and causing many rivers to run dry.[47] Between 1972 and 2012, forest cover in the Ciliwung Basin declined from 46 to 19 percent, while urban land cover increased from 7 to 50 percent. Rapid urbanization has accelerated runoff and increased flood risks in Jakarta. Droughts and deforestation are also straining groundwater supplies in the Kediri District in East Java.[48] The conversion of forests to oil palm plantations has been found to reduce overall groundwater recharge, causing wells to dry up earlier in the dry season in Sumatra, Kalimantan and Sulawesi.[49]

Groundwater depletion is causing subsidence in several cities; Jakarta is one of the fastest sinking cities in the world. Poor groundwater management, along with urbanization and unique aquifer characteristics, have caused Jakarta to sink an average of 1 to 15 centimeters every year.[50] Rapid urbanization has reduced groundwater recharge[51] while increased groundwater withdrawals, which accelerated 24 percent between 2011 and 2014, have caused the water table to fall and the soil to compact.[52] Half of Jakarta is currently below sea level[53] and is protected in part by a large sea wall, however, rising sea levels and continued subsidence may undermine the wall and cause flooding.[54] Land subsidence occurs in several other cities in Java, including Bandung, Semarang, Pekalongan, and in the northeast (Blanakan) and Medan in Sumatra.

Over-abstraction of groundwater, coupled with sea level rise and land subsidence, is increasing saltwater intrusion into coastal aquifers. Saltwater intrusion is occurring in Java, Bali, Kalimantan, and Sumatra. In Jakarta, the annual rate of seawater intrusion is between 3-50 meters[55] while saline groundwater can be found as far inland as 10km inland in some areas.[8] Seawater intrusion has also been observed in Samarinda in East Kalimantan, at Lampung Bay in South Sumatra, and Riau Province in East Sumatra. However, parts of the aquifers in Semarang and Surabaya contain naturally saline fossil water.[55]

Approximately 70 percent of groundwater is polluted by leakage from septic tanks, landfills, industrial waste, and infiltration of fertilizers. Water treatment facilities only process four percent of Jakarta's wastewater[56] and widespread use of latrines and septic tanks contaminate 80 percent of the city's groundwater sources with E. Coli.[2] Poor sanitation systems also contribute to high levels of nitrates, nitrites, and phosphates in groundwater.[57,58] Toxic heavy metals from untreated industrial effluent, including mercury, cadmium, lead, chromium, and arsenic, have been found in aquifers in Jakarta and 12 other cities on Central Java's northern coast.[59,60]

Water Resources and Climate

KEY TAKEAWAYS

- Climate change is increasing drought frequency and intensity, which will exacerbate peatland and forest fires, especially during El Niño years, while total rainfall will decline in parts of East Java and the Lesser Sundas.
- Monsoon rainfall and rainfall intensity will increase flood risks, while cyclones will occur less frequently but with greater intensity.
- Indonesia is highly vulnerable to sea level rise and coastal flooding.

This section covers climate variability and climate change, their impacts on water availability and water quality, and the risks they pose to local communities and their economies.

Rainfall variability is increasing across Indonesia. Most of Indonesia has one monsoon season (November-April) followed by a dry season (May-October), with high average precipitation (2,702 mm/year).[12,61,62] Climate oscillations such as the Indian Ocean Dipole (IOD) and El Niño-Southern Oscillation (ENSO) can cause drought and heavy rainfall. Dry season temperatures have increased 0.2°C per decade[63] and total rainfall, rainfall intensity, and inter-annual rainfall variability have also increased; however, dry season rainfall has declined 12 percent.[62] Average temperature and total rainfall are projected to increase by 1.4-3°C and 120-160 mm/year by the end of the century.[64] Most rainfall gains will be in Sumatra, Kalimantan, and Papua, while losses are expected in East Java and the Lesser Sundas.[65] Nationally, rainfall intensity and drought risk will also increase.[64]

Climate change is increasing drought frequency and intensity, threatening rainfed agriculture and increasing the risk of peatland fires, particularly during El Niño droughts. Around 80 percent of cropland is rainfed and 90 percent of irrigation schemes use surface water sources[2] which are vulnerable to drought. Between 1993 and 2003, droughts (especially during El Niño) impacted 2.5 million hectares of cropland, destroyed 462,000 hectares and 300,000 tons of rice worth USD $61 million. Forest and peatland fires from agricultural clearing are also common during El Niño droughts, and will worsen with increasing temperature and drought severity.[28] In the 2015 El Niño season, slash-and-burn agriculture caused underground peatland fires that affected nearly one million hectares.[28] These fires degrade catchments, water quality, ecosystems and biodiversity, air quality, and contribute significantly to global greenhouse gas emissions.[66]

Increasing rainfall and rainfall intensity in the monsoon season will significantly increase flood risks nationwide. Over 600 of Indonesia's rivers have high flood risk. Heavy rainfall events are projected to increase by 15 percent within this century[62,67] and significantly increase some peak discharge in some rivers.[68] Between 1980 and 2014, floods displaced an average of 150,000 people and damaged 11,000 homes annually.[2] While there is much uncertainty, preliminary studies also indicate that tropical cyclones will become less frequent but more intense.[63]

Rising sea levels place millions at increased risks of coastal flooding. With 55,000km of coastline and a large coastal population, Indonesia is particularly vulnerable to inundation from sea level rise.[69] Between 2009-2012, annual sea level rise ranged from 1 mm in Maluku province to 14 mm in West Papua.[70] Sea level rise and land subsidence contribute to flooding and saltwater intrusion in coastal cities. The future rate of sea level rise is expected to range from 6 mm/year to 12 mm/year,[65] which will increase the number of people living below the high tide line by five to ten times current levels and expose tens of millions of people to storm surges.[71,72]

FIGURE 2: DROUGHT RISK

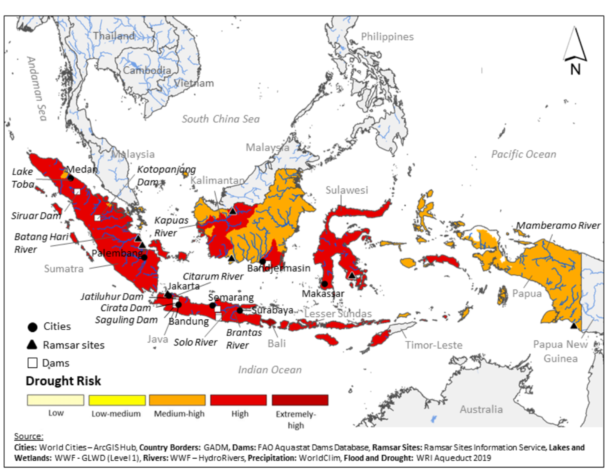
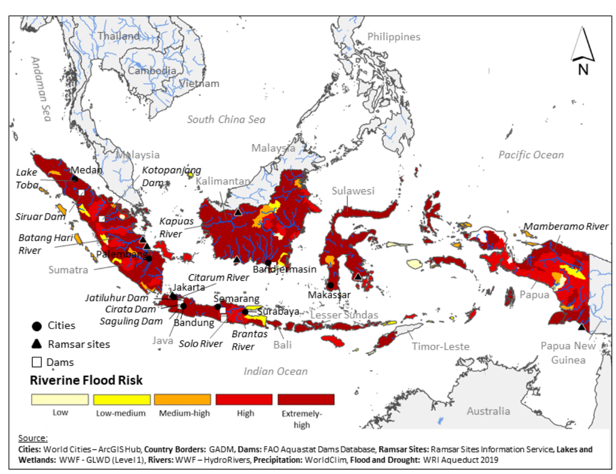


FIGURE 3. RIVERINE FLOOD RISK



Water Policy and Governance

KEY TAKEAWAYS

- River basin organizations struggle to coordinate basin development efforts as water management responsibilities are fragmented across many entities. Low technical capacity impedes the development and implementation of basin master plans. Low funding and inefficient budget allocation mechanisms compound these challenges. Sectoral policies and regulations are not always enforced by sub-national governments.
- Water quality monitoring responsibilities overlap among several entities but monitoring stations, data quality, and systems to consolidate data are lacking.

This section provides an overview of key policies, institutions, and management challenges. Key laws, policies, and plans are summarized in Table 2 and the roles and responsibilities of select transboundary, national, and sub-national water management entities are summarized in Table 3.

TABLE 2. KEY LAWS, POLICIES, AND PLANS

Name	Year	Purpose
Law No. 11 Jobs Creation Law (Omnibus Law)	2020	Broadly impacts job creation and taxation structures nationwide. Impacts the water and environmental sectors by changing the environmental assessment and permitting structure for businesses.
Law No. 17 on Water Resources	2019	Replaces 2004 Water Law. Prioritizes water uses for domestic, irrigation, and commercial uses. Requires water use licenses from private sector and affirms central and regional government control and regulatory authority for water resources.
Regulation of the State Minister of Living Environment No. 1 on Water Pollution Control System	2010	Establishes guidelines for national and sub-national control and management of water pollution, addresses wastewater permitting requirements and water quality monitoring.
Government Regulation No. 43 on Ground Water	2008	Defines "groundwater basins" around hydrogeological boundaries, requirements for groundwater management plans and groundwater use permits, and addresses data management.
Presidential Regulation No. 12 concerning the Water Resources Council	2008	Established key entities, including the National Water Resources Council and Provincial Water Resources Council, and defined their responsibilities for river and groundwater basin strategies and policies.
Public Works Regulation 11A regarding Criteria and Declaration on River Basins	2006	Established criteria for delineating river basins and classification systems.
Regulation on the Management of Water and or Water Resources in the River Basins	1990	Designated government authorities responsible for basin management.

Low capacity and funding impedes sectoral coordination from river basin organizations. Water management functions are distributed across 18 ministries, including watershed conservation, groundwater management, environmental mitigation, and regulatory enforcement. River basin organizations are supposed to coordinate management across the ministries within each basin, however, they lack funding and capacity to effectively fulfill this mandate. Funding and capacity constraints also hinder the implementation of Recanas (basin master plans), which are important for annual work planning and budgeting. Funding allocation mechanisms are not streamlined, making budget allocations inefficient, unsynchronized, and at times, competitive.[4]

Poor integration and enforcement of sectoral regulations and policies compound key groundwater and surface water risks. Some estimates suggest that Jakarta's unregistered abstractions are between 50 and 120 percent of registered abstractions, and deep wells continue to be installed in zones where they are prohibited, like North Jakarta. Provincial policies, regulations, and permitting systems are often not consistently implemented in districts, especially with respect to IWRM and palm oil expansion. Some provincial governments also struggle to fulfill policy, as less than one percent of community complaints regarding palm oil's impacts to water resources are investigated in Central Kalimantan. Surface and groundwater planning and management are not integrated

TABLE 3: WATER RESOURCES MANAGEMENT ENTITIES

Mandate	Institution	Roles and Responsibilities
National	Ministry of National Development Planning/National Development Planning Agency (BAPPENAS)	BAPPENAS develops national policies related to planning, budgeting, and regulation, including the national development plan.
	Directorate General of Water Resources (DGWR)	Under the Ministry of Public Works (MWP), manages river basin organizations at national, provincial, and district levels, and oversees implementation of the water laws and regulations. Develops Water Resources Management (WRM) Strategic Plans (Pola) and Master Plan (Rencana) for both medium-term (5 year) and long-term objectives (20-year) for district and provincial WSs.
	National River Basin Organizations (B(B) WS)	B(B)WSs manage international basins, inter-provincial basins, and river basins defined as being "national strategic" in 69 WSs. Responsible for the development of international and inter-provincial irrigation systems, licensing for surface and groundwater use, and developing Polas and Recanas.
	National Water Council	Helps prepare national policy and strategy on WRM and reports directly to the president. Council is represented by governmental and nongovernmental stakeholders.
	Ministry of Environment and Forestry	Responsible for monitoring and reporting on surface water quality and controlling pollution, and catchment management.
	The Ministry of Health	Regulates and monitors drinking water quality for water service providers.
	The Ministry of Energy and Mineral Resources	Monitors the quantity and quality of groundwater through the management of 421 groundwater basins.
Sub-national	Provincial River Basin Organizations (Balai PSDA)	Provincial governments manage 51 WSs through Balai PSDAs for WSs spanning more than one district and for those not already managed by the central government (B(B)WSs). Responsible for developing provincial-level irrigation systems and licensing for surface and groundwater use.
	Provincial Water Councils	A Dewan SDA is required for each province. Coordinate WRM at the provincial level and is composed of stakeholders from government and non-governmental organizations. Advise the development of basin plans and support water conflict resolution.
	District River Basin Organizations	District governments manage 13 WSs. In charge of developing district-level irrigation systems, and licensing for surface and groundwater use.
	Basin Councils (TKPSDA)	Basin-level coordination platforms that may be created as needed. Focus on water dispute resolution, stakeholder engagement, and supporting the development of Recanas and Polas.
	Water Users Associations (WUA)	Involved in the design, construction, operation, and maintenance of water use systems, especially for irrigation.

as river basin organizations focus more on surface water development, groundwater abstractions are managed by district heads, and the Ministry of Energy and Mineral Resources manages groundwater planning.[2,73,76,77]

Water Quality Monitoring

Various government ministries are responsible for water quality monitoring, but data is not often insufficient, low quality, and not consolidated. Water quality targets are based on four classes of intended use and are defined by the central government, although local governments are allowed to set more stringent standards.[2] River basin organizations, the Ministry of Energy and Mineral Resources, and Ministry of Environment and Forestry all share water quality monitoring responsibilities but data is not consolidated and shared across institutions.[73,78] At least 21 surface water quality parameters are monitored by the Ministry of Environment and Forestry at over 700 sampling sites. Most data is collected manually, which can lead to data quality issues and delays in compiling data.[73,78]

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