INDONESIA

COUNTRY WATER ASSESSMENT

ASIAN DEVELOPMENT BANK

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ABBREVIATIONS

AWDO	*Asian Water Development Outlook*
BPS	*Badan Pusat Statistik* (Statistics Indonesia)
COD	chemical oxygen demand
CRBOM	Center for River Basin Organizations and Management
CWA	country water assessment
DAS	*Daerah Aliran Sungai* (watershed)
ENSO	El Nino-Southern Oscillation
GDP	gross domestic product
HDI	human development index
IRR	internal rate of return
IWRM	integrated water resources management
JWRSS	Java Water Resources Strategic Study
MP3EI	*Masterplan Percepatan dan Perluasan Pembangunan Ekonomi Indonesia* (Masterplan for the Acceleration and Expansion of Indonesia Economic Development)
MPI	multidimensional poverty index
NRW	nonrevenue water
O&M	operation and maintenance
PDAM	*Perusahaan Daerah Air Minum* (water utility)
PJT	*Perum Jasa Tirta* (state-owned enterprise Jasa Tirta)
PLN	*Perusahaan Listrik Negara* (National Electricity Firm)
PP	*Peraturan Pemerintah* (government regulation)
PPP	public–private partnership
PRC	People's Republic of China
PSS	pumped storage system
R&D	research and development
RBO	river basin organization
RPJMN	*Rencana Pembangunan Jangka Menengah Nasional* (National Medium-Term Development Plan)
SFWRM	service fee for water resources management
SLR	sea level rise
UU	*Undang-Undang* (law)
WRM	water resources management
WS	*Wilayah Sungai* (river basin)

WEIGHTS AND MEASURES

GW	gigawatt	**m^3**	cubic meter	**Rp**	rupiah
ha	hectare	**MCM**	million cubic meter	**s**	second
km^2	square kilometer	**MW**	megawatt	**TWh**	terawatt-hour
l/c/d	liters per capita per day	**MWh**	megawatt-hour		

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The publication describes the country water assessment that focuses on the three main economic development corridors (Java, Sumatera, and Sulawesi). Securing reliable water supply for the Indonesia's future is becoming increasingly challenging. More evidence is emerging about a real and rapidly increasing gap between the growing demand for water and the supplies that are realistically and sustainably available. With more than 70% of water demand used by agriculture, this imminent gap will threaten food security and the stability of food prices, as well as supplies for energy, industry, and urban areas. The assessment presents an inventory of possible measures to deal with any imbalance or gap between supply and demand, and their respective cost and impact.

The report's main contributor and editor is Kees (C.A.) Bons of Deltares in the Netherlands. Contributors for the various chapters in the publication are Asep Soekmono, Nidhom Azhari, August Restiawan, Liliana Tunggal, Adam Yazid, Isja Dini Uljati, Bambang Tata Samiadji, Tangkas Panjaitan, and Suryana of PT Wiratman; Aart van Nes, Rudolf Muijtjens, Dida de Groot, and Suherwan of Royal HaskoningDHV; and Mark de Bel and JanJaap Brinkman of Deltares.

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chapter one

INTRODUCTION

Water is a major determinant of the well-being of the people in Indonesia. As Indonesia grows, enjoying an average annual economic growth of 5.7% in 2005–2010, which accelerated to 6.5% in 2011, water challenges intensify and jeopardize sustained development. To guide its economic development, Indonesia prepared the Masterplan for the Acceleration and Expansion of Indonesia Economic Development, 2011–2025 (MP3EI), which is based on the following three pillars:

(i) developing the economic potential of six regional corridors;

(ii) strengthening national connectivity locally and internationally; and

(iii) strengthening human resource capacity, science, and technology.

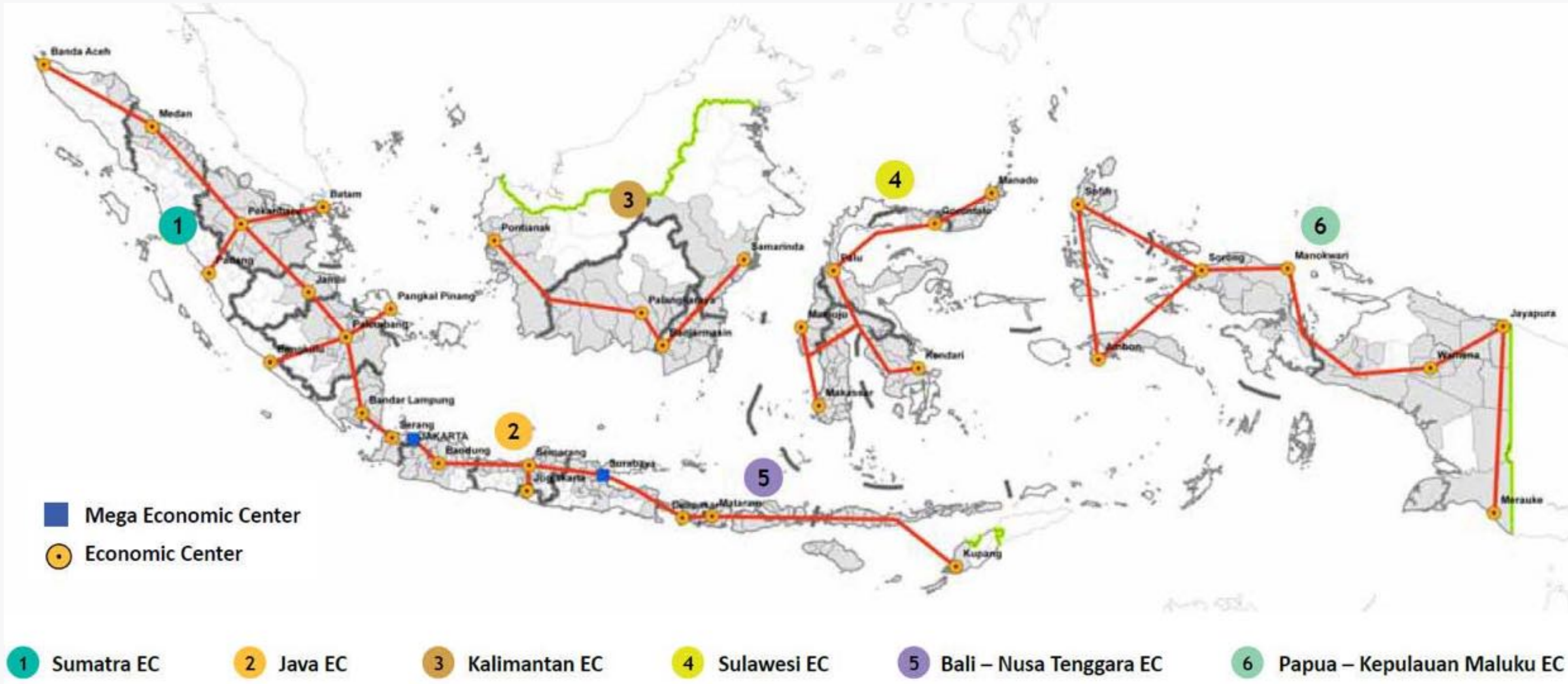
The MP3EI put forth food security and improved water and energy policies as prerequisites for its implementation. In 2014, Indonesia updated its National Medium-Term Development Plan (RPJMN), 2015–2019, which guides planning within and across sectors. The RPJMN follows the priorities set by the newly elected government *Nawa Cita* (a Sanskrit term for nine priorities). Together, the RPJMN and the new government policy provide an economic and development planning framework for Indonesia, within which the government has to prioritize water concerns to sustain economic growth.

The Asian Development Bank formulated a technical assistance project (TA-8432 INO: Improving Water Sector Planning, Management and Development) to assist the Government of Indonesia in analyzing the water concerns and priorities nationwide. This assistance includes support for a country water assessment (CWA) that will help provide the analytical foundation for water planning, management, and development, including investment to further economic development. The government policy guides the priorities to be addressed under the CWA, and detailed water sector plans can support the economic development agendas of the different regions in Indonesia. The CWA intends to provide a platform for dialogue to advance water reform across Indonesia while providing guidance for planning, management, policy, and investment with a focus on three of the main economic regions (Figure 1.1): Java, Sumatera, and Sulawesi.

The CWA supported the development of RPJMN and ensured synergy with the government policy. The CWA also provides guidance to help address the many challenges facing effective water resources management and reliable water service delivery in Indonesia.

This is the concise version of the CWA. The full report is published separately.

Figure 1.1: MP3EI Economic Regions Map



MP3EI = Masterplan for the Acceleration and Expansion of Indonesia Economic Development, 2011–2025.

Source: Coordinating Ministry for Economic Affairs, Republic of Indonesia. 2011. Masterplan for Acceleration and Expansion of Indonesia Economic Development 2011–2025.

chapter two

NATIONAL SETTING

A. Geography

Indonesia is the largest archipelago in the world. It consists of five major islands and about 30 smaller groups. The total number of islands is estimated to be 17,508 according to the Indonesian Naval Hydro-Oceanographic office. This archipelago is located between the Pacific and the Indian Oceans, and bridges two continents, Asia and Australia. This strategic position has influenced the cultural, social, political, and economic life of the country.

The territory of Indonesia stretches from 6°08' north latitude to 11°15' south latitude and from 94°45' to 141°05' east longitude. The sea area of Indonesia (about 7.9 million square kilometers [km^2], including an exclusive economic zone) constitutes about 81% of the total area of the country and is four times its land area (1.9 million km^2).

The five main islands are Sumatera (473,606 km^2), the most fertile and densely populated island; Java–Madura (132,107 km^2); Kalimantan (539,460 km^2) comprises two-thirds of the island of Borneo; Sulawesi (189,216 km^2); and Papua (421,981 km^2), which is part of the world's second-largest island, New Guinea. The other islands in Indonesia are smaller.

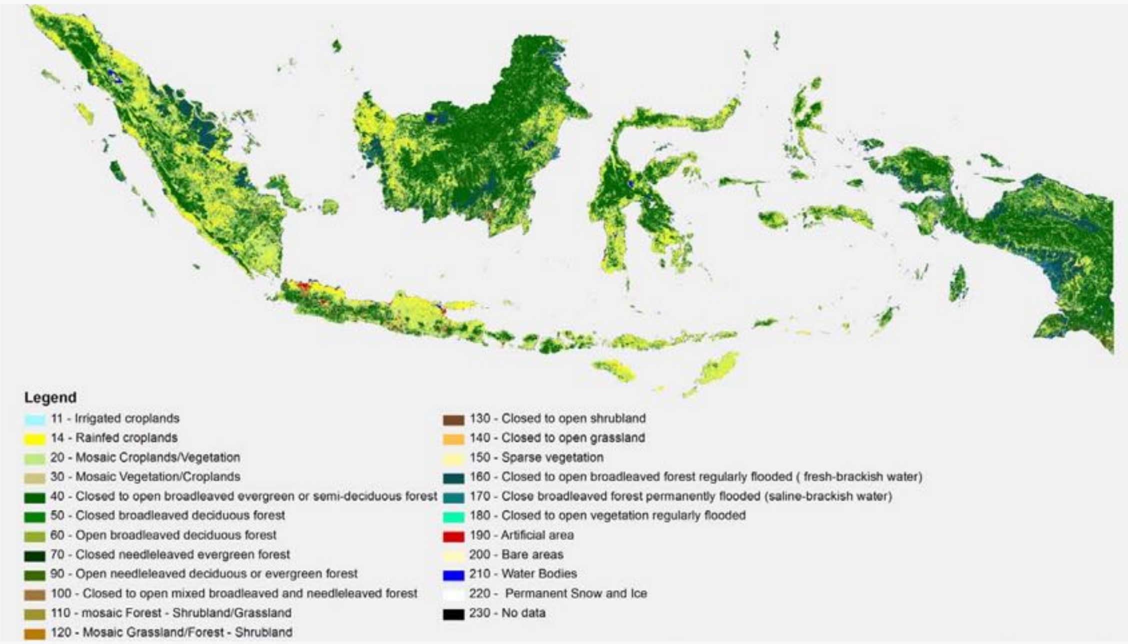
Indonesia has been divided into 131 river basin territories (*wilayah sungai*) with more than 5,700 rivers, containing many dams, weirs, and canals.

Indonesia is a tropical country, and the climate is fairly even all year round. The year can roughly be divided into two distinct seasons, "wet" and "dry." The East Monsoon, from June to September, brings in dry weather whereas the West Monsoon, from December to March, brings in rain. Even in the midst of the wet season, temperatures range from 21°C to 33°C, except at higher altitudes where it can be much cooler. The heaviest rainfall is usually recorded in December and January. Average humidity is generally between 75% and 100%.

Figure 2.1 shows the main land uses in Indonesia. It is clear that a large portion of the original forest cover of all the islands has been replaced with cropped land, except in the heart of Kalimantan, Sulawesi, and Papua, and along the volcanic mountain ranges.

Geologically, the Indonesian archipelago is an extremely complex collection of continental blocks, active and extinct volcanic arcs and associated subduction complexes, and old and young ocean basins. It is now at the convergence of three major tectonic plates: Eurasia, the Pacific, and Australia. The area of Sulawesi contains elements of all three plates.

Figure 2.1: Land Use Map of Indonesia



Source: The Food and Agriculture Organization of the United Nations. DATA.FAO.ORG/MAP

Western Indonesia ("Sundaland") is a complex of continental blocks that amalgamated in Late Paleozoic–Early Mesozoic time. Eastern Indonesia contains a number of small continental microplates derived from the Australia–New Guinea Gondwanan margin, now separated by young age oceanic marginal basins and volcanic arc systems.

B. Population

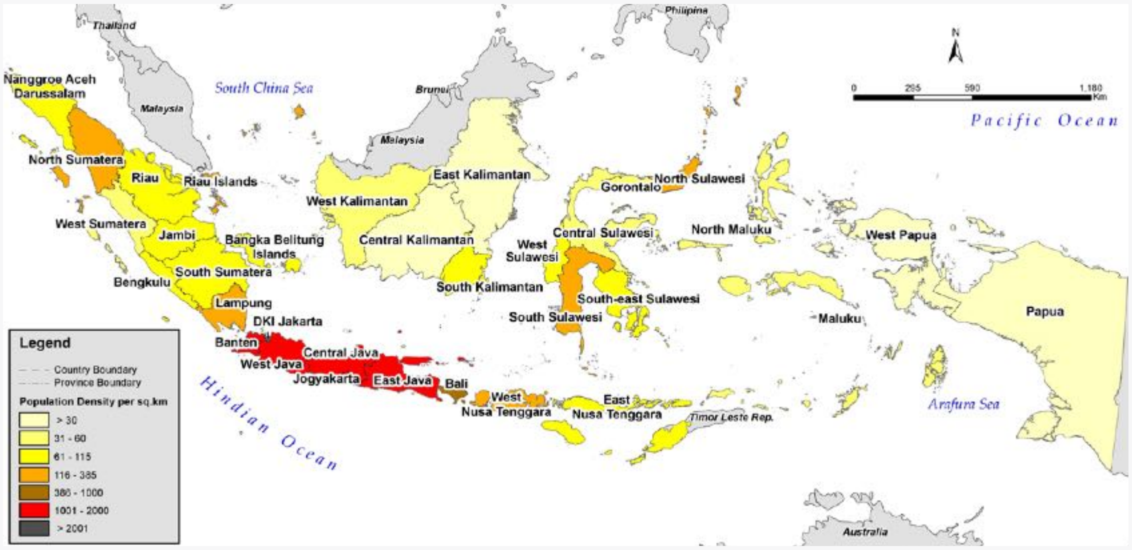
As the fourth most populous country in the world, the population of Indonesia in 2014 was estimated to be 254 million, an increase from the 2013 estimate of 250.5 million. According to the last official census in 2010, the population of Indonesia was 237,424,363 people living across its 17,508 islands. This equated to a population density of 123.76 people per square kilometer. About 58% of Indonesia's population lives on the Island of Java, which makes it the most populous island in the world (Figure 2.2).

Ethnic Variation

Approximately 719 individual languages are listed in Indonesia, of which 13 are extinct.[1] Sumatera comprises about 35 tribes or ethnicities, Java comprises 9 ethnicities, and Sulawesi comprises 113 ethnicities. Each ethnic group has its unique customs and some are still practicing specific customs (local term: *adat*) related to water and land use.

[1] *Ethnologue: Languages of the World.* www.ethnologue.com (accessed end-2014).

Figure 2.2: Population Density Map of Indonesia, 2013



Source: Statistics Indonesia. 2014. *Statistical Yearbook of Indonesia 2013*.

Human Development Index

The human development index (HDI) has three dimensions: a long and healthy life, access to knowledge, and a decent standard of living. Indonesia's 2013 HDI value of 0.684, which falls in the medium human development category, positioned the country at 108 out of 187 countries and territories.[2] Between 1980 and 2013, Indonesia's HDI value increased from 0.471 to 0.684, an increase of 45.3%.

Indonesia has a Gender Inequality Index[3] value of 0.500, ranking it at 103 out of 149 countries in the United Nations Development Programme 2013 index. In Indonesia, 18.6% of parliamentary seats are held by women, and 39.9% of women have reached at least a secondary level of education compared with 49.2% of their male counterparts. For every 100,000 live births, 220 women die from pregnancy-related causes; and the adolescent birth rate is 48.3 births per 1,000 live births. Female participation in the labor market is 51.3% compared with 84.4% for men.

The 2013 female HDI value for Indonesia was 0.654 in contrast with 0.709 for males, resulting in a gender development index (based on the sex-disaggregated HDI, defined as a ratio of the female to the male HDI) value of 0.923. In comparison, the gender development index value for the Philippines was 0.989 and for the People's Republic of China (PRC) it was 0.939.

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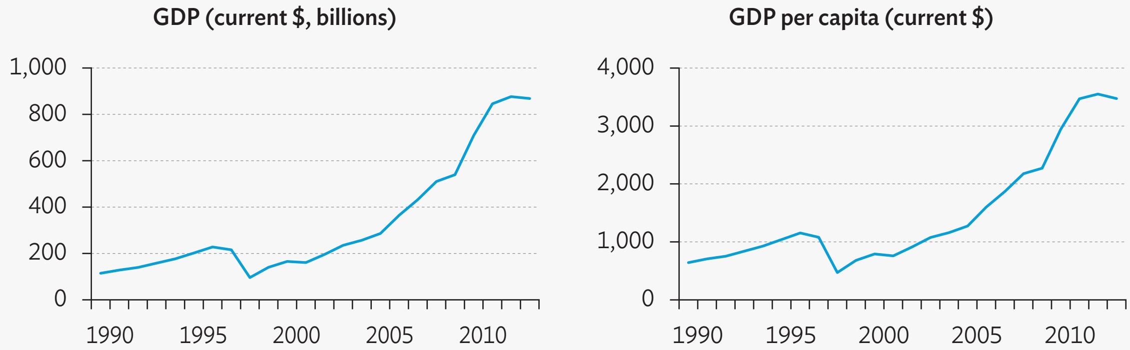
[2] United Nations Development Programme. 2014. *Human Development Report 2014*. New York: United Nations Development Programme. http://hdr.undp.org/sites/default/files/hdr14-report-en-1.pdf (accessed March 2015).

[3] Gender Inequality Index is a composite measure reflecting inequality in achievement between women and men in three dimensions: reproductive health, empowerment, and the labor market. See Technical Note 3 at http://hdr.undp.org/enfor details on how the Gender Inequality Index is calculated.

C. Economic Development

The gross domestic product (GDP) in Indonesia was $868.35 billion in 2013. The GDP value of Indonesia represents 1.40% of the world economy (Figure 2.3).

Figure 2.3: Indonesia's Gross Domestic Product and Gross Domestic Product per Capita



GDP = gross domestic product.

Note: At current prices in US dollar between 1990 and 2013.

Source: World Bank. World Development Indicators. http://data.worldbank.org/data-catalog/world-development-indicators (accessed 24 March 2015).

The GDP per capita was $1,810 in 2013. The GDP per capita is equivalent to 14% of the world's average. GDP per capita averaged $805 from 1960 until 2013, reaching an all-time high of $1,810 in 2013 and a record low of $275 in 1967. Inflation rate in Indonesia averaged 11.5% from 1997 until 2014, reaching an all-time high of 82.4% in September 1998 and a record low of –1.2% in March 2000.

Since the 1970s, Indonesia has been recording trade surpluses due to growth in exports. However, in 2012, the country posted a trade deficit, due to a plunge in exports because of a slowdown in the global economy and a surge in imports. Exports have been an engine of growth in Indonesia in recent years. Major export partners are the People's Republic of China (PRC) (14%), Japan (12%), the United States (9.5%), and India (8%). Others include Singapore, Malaysia, and the Republic of Korea.

Imports averaged $2.83 billion from 1959 until 2014 and increased to $14.79 billion in August 2014. Main import partners are the PRC (19%), Japan (15%), the United States (7.5%), and Singapore (7%).

New Government Targets

The government targets to be addressed are (i) fight corruption; (ii) cut domestic fuel subsidy, estimated at Rp291.1 trillion ($24.9 billion); (iii) realize over $300 billion in infrastructure to drive social development and economic growth: 2,000 km of roads, 10 new airports, 10 seaports, and 10 industrial estates; and (iv) an annual growth of 7% to be realized by increasing foreign investment.

Urbanization

The urban population in Indonesia has been growing rapidly. According to the 2010 census, 86% of the urban population of Indonesia is located in Java and 20% in the urban conglomerate around Jakarta: Jabodetabek. The number of megacities with more than 1 million inhabitants increased significantly, from 1 in 1950 to 10 in 2010, including four in the Jabodetabek region (Table 2.1).

Table 2.1: Indonesian Urban Areas with More than 1 Million Inhabitants

World Rank	Urban Area	Population (million)	Year	Land Area (km^2)	Density (persons/km^2)
2	Jakarta (Jabodetabek)	26.75	2013	2,784	9,600
74	Bandung	4.76	2013	427	11,100
76	Surabaya	4.70	2013	673	7,000
196	Medan	2.25	2013	246	9,100
246	Semarang	1.85	2013	259	7,100
291	Makassar	1.60	2010	179	9,000
306	Palembang	1.54	2013	220	7,000
356	Yogyakarta	1.25	2010	233	5,400

km^2 = square kilometer.

Source: T. Firman. 2013. Demographic Patterns of Indonesia's Urbanization, 2000–2010: Continuity and Change at the Macro Level. School of Architecture, Planning and Policy Development ITB Bandung.

There is a correlation between level of urbanization (percentage of urban population) and the level of economic development (gross regional domestic product/capita) in the provinces. Urbanization in Indonesia between 2000 and 2010 shows the same trend as the 1990–2000 period. However, the rate of annual population growth has declined significantly.[4]

Rural Development

Some 119.3 million people, or 47.6% of the population, live in rural areas, where agriculture is the main source of income.[5] Poverty is increasingly concentrated in these areas: 16.6% of the rural population is poor compared with 9.9% of the urban population. Millions of smallholder farmers, farm workers, and fishers are materially and financially unable to tap into the opportunities offered by years of economic growth. They are often geographically isolated and lack access to agricultural extension services, markets, and financial services.

4 T. Firman. 2013. Demographic Patterns of Indonesia's Urbanization, 2000–2010: Continuity and Change at the Macro Level. School of Architecture, Planning and Policy Development ITB.

5 World Bank. http://data.worldbank.org/indicator/SP.RUR.TOTL.ZS/countries/1W?display=graph (accessed March 2015).

The transition from smallholder agriculture and agriculture for subsistence to commercial agriculture leading to market incorporation in the most remote corners affects all rural areas and relationships of production.[6] Multiple impacts of this transition are visible such as the outflow of rural labor from agriculture to the commercial sector and service sectors in intermediate towns and the main urban centers of Indonesia, changing consumption styles, market-dependent livelihoods, and increased dependency on food imports and multinationals for seeds and fertilizer. Related and entangled, a major demographic transition is taking place in rural Indonesia. On average, the age of farmers is rising; rural labor surpluses are declining; and the rural, educated youth are less, or not at all, interested in taking over the family farm. The implications of this transition might lead to major transformations in land ownership and expansion of agricultural practices in rural Indonesia.[7]

As a result of the previous transformations, collective arrangements of mutual help, labor, and welfare are under pressure or have disappeared. Village life and village welfare systems are changing, and the income gap between the rich and the poor and the urban and the rural areas is rising. But there are also differences between regions. In some areas, farmers are doing very well, whereas in other places poverty remains pervasive and indigenous people and peasants are largely excluded from the benefits of economic development. This becomes especially visible in rural areas with poor soils and poor resources such as Nusa Tenggara Timur, East Java, Madura, and some parts of Sulawesi.[8]

Poverty

In Indonesia, 5.9% of the population is multidimensionally poor, whereas an additional 8.1% is close to multidimensionally poor. The intensity of deprivation in Indonesia, which is the average of deprivation scores experienced by people in multidimensional poverty, is 41.3%. The multidimensional poverty index (MPI), which is the share of the population that is multidimensionally poor, adjusted by the intensity of the deprivations, is 0.024. The Philippines has an MPI of 0.038 and the PRC has an MPI of 0.026.

Poverty is most severe in the remote eastern islands of Indonesia (Figure 2.4), where 95% of the rural populace is poor. In many of these eastern provinces, farmers eke out a largely subsistence existence. These provinces are home to many *adat*, or indigenous communities, who have often been on the margins of development processes and programs. Women in Indonesia are particularly vulnerable to poverty: they have less access to education, earn less than men, and are subject to discrimination and exclusion from decision-making processes within households and communities.

In absolute numbers, however, the poor are concentrated in Java, with West Java, Central Java, and East Java each having more than 5 million poor people on average during 2006–2011.

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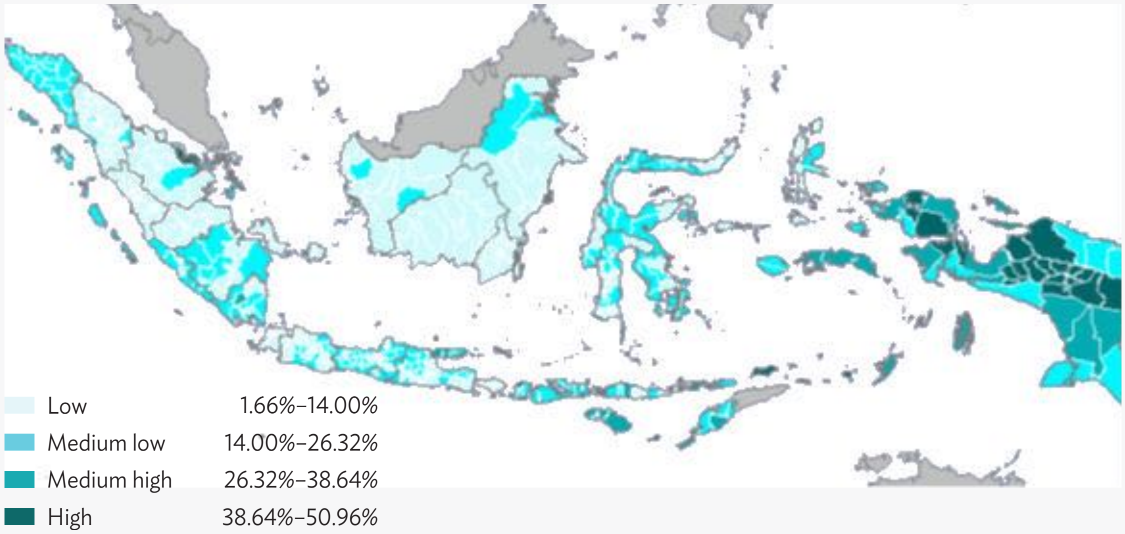
6 Van der Ploeg. 2014. Masterclass on Land, Rural Change and Neoliberalism in Indonesia. KNAW/UGM/NWO OpenScience Meeting, 29–30 January 2014, Yogyakarta. http://opensciencemeeting.org/plant-sciences/

7 L. De Graaf, G. Nooteboom, and P. M. Kutanegara. 2014. Rural Transformation and Afforestation in Java: Understanding Farm Tree Planting in Central Java, Indonesia. Paper prepared for KNAW/UGM/NWO OpenScience Meeting, 29–30 January 2014, Yogyakarta. https://humanecologysophia.files.wordpress.com/2015/01/gerben-nooteboom_gsgs-workshop.pdf

8 T. Li. 2014. *Land's End: Capitalist Relations on an Indigenous Frontier.* Duke University Press; and G. Nooteboom and L. Bakker. 2014. Beyond the Gulf State Investment Hype: The Case of Indonesia and the Philippines. In M. Kaag and A. Zoomers, eds. *The Global Land Grab: Beyond the Hype.* London: Zed Books. pp. 170–184.

Figure 2.4: Indonesia Poverty Map, 2010



Source: SMERU Research Institute. www.indonesiapovertymap.org. Analysis is based on 2010 Statistics Indonesia data and national poverty standard.

D. Sociopolitical Setting

Indonesia is divided into provinces, regions (*kabupaten*), districts (*kecamatan*), and cities (*kota*), each of which has a local government. The transfer of authority between central and local governments is based on three patterns:

(i) **Decentralization.** The transfer of power by the government to the autonomous region government to regulate and administer the affairs of the government in the system of Indonesia.

(ii) **Deconcentration.** The delegation of government authority by the government to the governor as representative of the government and/or the vertical institutions in a particular region.

(iii) **Coadministration.** The assignment from a higher-level to a lower-level government to carry out a specific task or assignment with funding and other resources. This can be from the central government to the province (or lower), from provincial governments to the district, city, village, or from the district or city governments to the village.

Implementation of Decentralization, Deconcentration, and Coadministration

The arrangements for role sharing for water resources management are shown in Table 2.2. To ensure effective and efficient implementation, the readiness and capacity of the implementing agencies are a factor in the effectiveness of the model.

Table 2.2: Current Arrangements for Role Sharing

Affairs Distribution	Approach	Central	Province	District or City	PJT
River Basin Management					
Trans state	Coadministration	✔			✔
Trans province	Coadministration	✔			✔
National strategic	Coadministration	✔	✔	✔	✔
Trans district	Decentralization		✔		
Within district	Decentralization			✔	
Irrigation System Management					
Area >3,000 ha	Coadministration		✔	✔	
Area: 1,000–3,000 ha	Decentralization		✔		
	Coadministration			✔	
Area <1,000 ha	Decentralization			✔	
Water Supply and Sanitation					
	Decentralization		✔	✔	
Coordination	Deconcentration		✔		

ha = hectare, PJT = Perum Jasa Tirta (state-owned enterprise Jasa Tirta).
Note: Analysis of existing and past regulations in the present study.
Source: Asian Development Bank.

Public Participation

Community activities have originally played an active role in development, but since the implementation of the Development Cabinet under President Suharto, the public role has been degraded. Since the 1999 political reform, civil society has regained a role in the development and management of water resources. The central and local governments developed nongovernment organizations. The civil society participated in the water council and the basin council.

One objective of the national policy for water resources management is increasing the role of communities and businesses in water resources management. However, the implementation of community and business involvement is still relatively limited. This is due to the reluctance of government institutions to involve other parties (than contractors), as well as due to limited ability and awareness of the community.

chapter three

WATER RESOURCES

A. Overview: Current Water Resources

The total water availability in Indonesia is 690 × 10^9 cubic meters (m^3) per year, which is a lot more than the demand of 175 × 109 m^3/year. Kalimantan and Papua, which house only 13% of the total population in Indonesia, has about 70% of the water resources (Figure 3.1). Furthermore, Kalimantan and Papua are not main centers of economic activities as Java is.

B. Data on Water Resources

Data on water resources are collected in the basins by the river basin organizations. They monitor rainfall, river flow, and water levels throughout the basin. The water resources management strategy (Pola) and plan (Rencana) of the river basins provide an overview of the data available at the river basin level.

Data on water balance (supply and demand) are also collected by the Research Centre for Water Resources (Puslitbang Sumber Daya Air or PusAir) in Bandung.

The 2012 Java Water Resources Strategy Study (JWRSS) report appeared formulating suitable strategies for integrated water resources (both surface water and groundwater) and land management, as an input for new or updated Polas and Rencanas as well as spatial plans in Java. The aim was to assist the Government of Indonesia to formulate a draft Pola for island-wide water resources management, parallel to the island-wide spatial planning as already implemented by the Director General for spatial planning.

C. Rainfall

Average annual rainfall in Indonesia is around 2,350 millimeters. Indonesia can be divided into three climatic regions,[9] each with distinct characteristics (Figure 3.1):

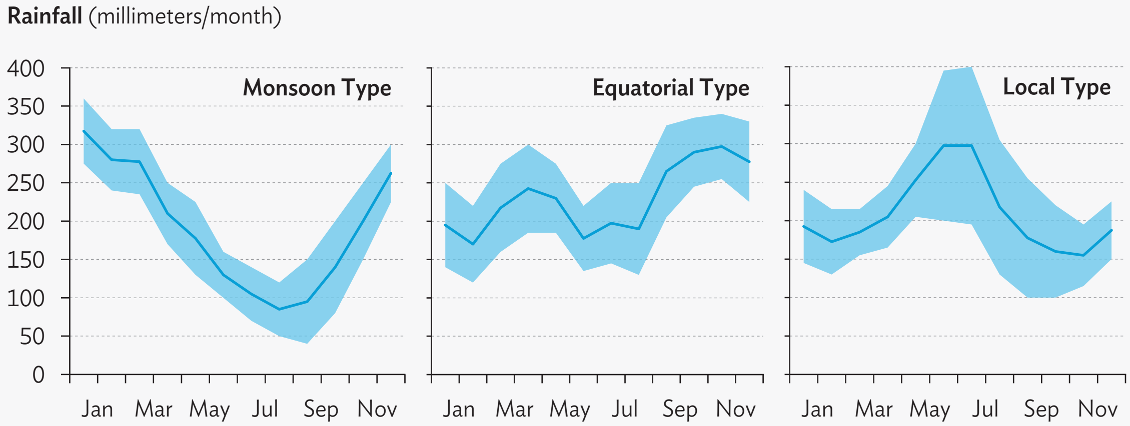
(i) A region with monsoon-type rainfall is located in southern Indonesia from south Sumatera to Timor Island, southern Kalimantan, Sulawesi, and part of Papua.

(ii) A region with equatorial-type rainfall is located in northwest Indonesia from northern Sumatera to northwestern Kalimantan.

(iii) A region with a local rainfall type encompasses Maluku and northern Sulawesi.

[9] E. Aldrian and R. Dwi Susanto. 2003. Identification of Three Dominant Rainfall Regions within Indonesia and Their Relationship to Sea Surface Temperature. *International Journal of Climatology*. 23: 1435–1452.

Figure 3.1: Annual Rainfall Patterns in the Three Regions



Note: Shaded zones indicate one standard deviation below and above average.

Source: E. Aldrian and R. Dwi Susanto. 2003. Identification of Three Dominant Rainfall Regions within Indonesia and Their Relationship to Sea Surface Temperature. *International Journal of Climatology*. 23. pp. 1435–1452.

All three regions show strong annual variation, with equatorial and local-type regions also exhibiting semiannual variability. The local type shows the strongest El Nino–Southern Oscillation (ENSO) influence, and the equatorial type the lowest. The regions with monsoon and local types show significant correlations between sea surface temperature and rainfall variability, indicating a good possibility for seasonal climate predictions.

The average yearly rainfall data in Indonesia, including the details for Java, are shown in Figure 3.2 to illustrate the impact of mountains on the local rainfall distribution.

The surface water availability for Indonesia is summarized in Figure 3.3. The highest surface water potential is in Kalimantan (34%), followed by Sumatera (22%), Sulawesi (8%), and Java (4%).

D. River Systems

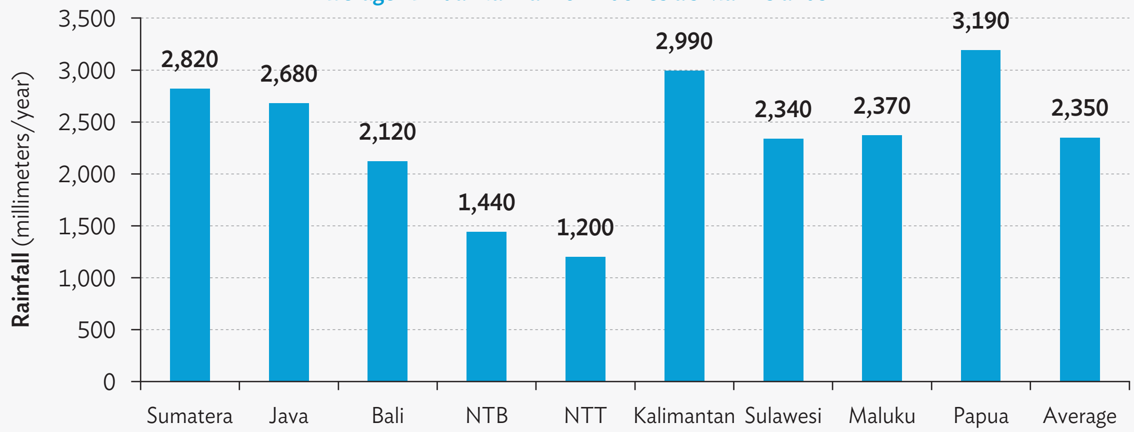
Indonesia has almost 8,000 watersheds (*Daerah Aliran Sungai* [DAS]), which are managed in 131 river basins. Five river basins (304 DAS) cross international boundaries (Malaysia, Timor-Leste, and Papua New Guinea), 29 basins (859 DAS) cross provincial boundaries, and 37 basins are considered to be of national strategic importance.

Java

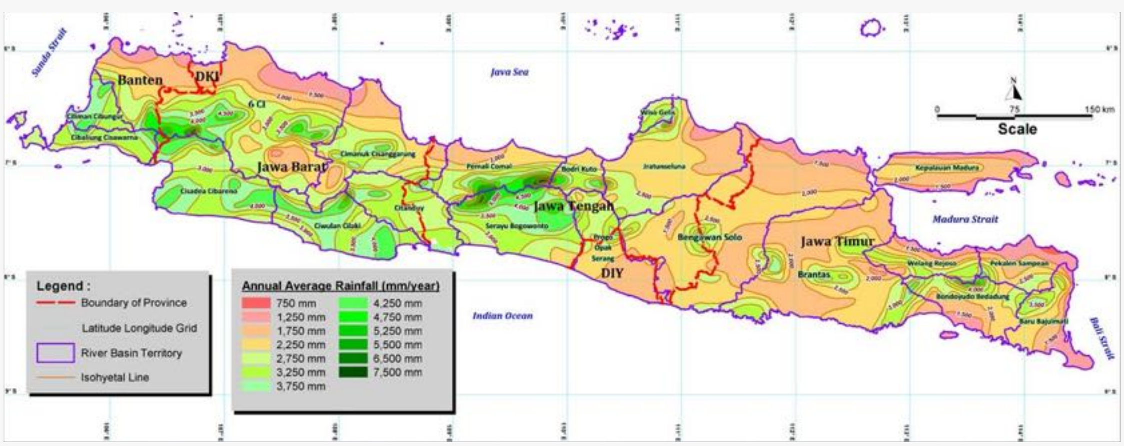
The main rivers of Java include the Citarum and Cimanuk in the west, the Serang and Serayu in central Java, and the Solo and Brantas in the east. All meander across the broad lowlands of Java, and several are laden with silt due to the extensive farming in their basins.

Figure 3.2: Average Annual Rainfall for Indonesia's Main Islands and Yearly Rainfall Distribution in Java

Average Annual Rainfall for Indonesia's Main Islands



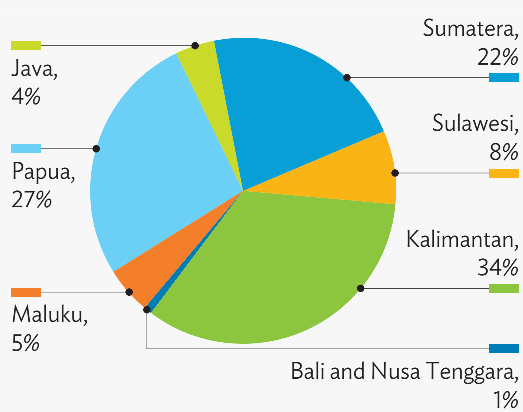
Yearly Rainfall Distribution in Java



Sources: Ministry of Environment. 2013. *Status Lingkungan Hidup Indonesia 2012*; Deltares et al. 2012. *Java Water Resources Strategic Study*. Report submitted to the World Bank.

Figure 3.3: Surface Water Availability in Indonesia

Islands	Water Availability (million m³/year) Qaverage	Q80%	Q90%
Java	164	88.909	69.791
Sumatera	840.737	571.703	485.732
Sulawesi	299.218	184.478	154.561
Kalimantan	1,314,021	900.381	727.301
Bali and Nusa Tenggara	49.62	35.632	32.165
Maluku	176.726	132.103	117.296
Papua	1,062,154	794.496	716.443
Total Indonesia	**3,906,476**	**2,707,702**	**2,303,289**

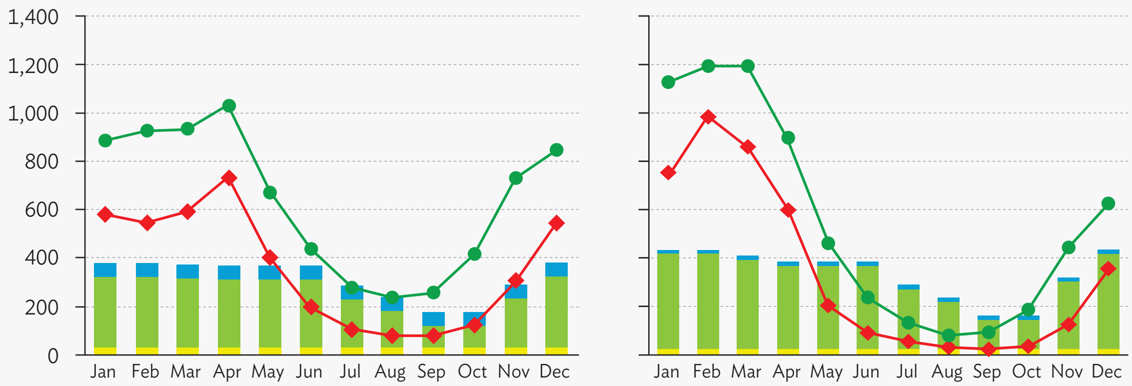


m^3 = cubic meter, Q = quarter.

Source: W. Hatmoko et al. 2012. *Water Balance of Water Availability and Water Demand in Indonesia River Basins, Water Resources Research Agency, Bandung* (Neraca Ketersediaan dan Kebutuhan Air pada Wilayah Sungai di Indonesia Puslitbang SDA Bandung).

The river flows show a clear seasonal effect that becomes more pronounced in the eastern part of Java, from the Citarum in West Java to the Solo river in East Java (Figure 3.4).

Figure 3.4: Yearly Flow Variation in Citarum (Left) **and Solo** (Right) **Rivers**



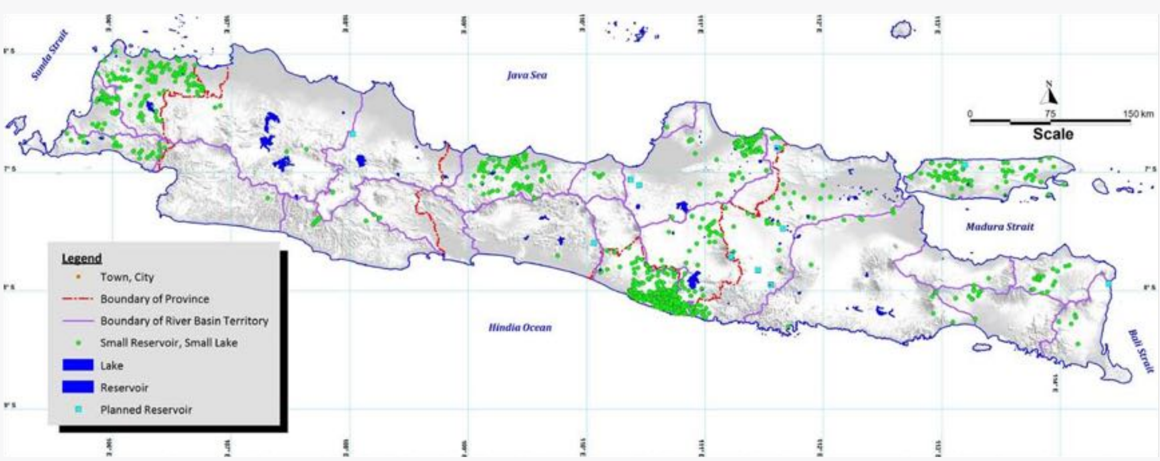
m^3/s = cubic meter per second, Q80 = mean magnitude of flows exceeded 80% of the time.

Note: Flow in m^3/s. Green line = average flow, red line = Q80. Columns: blue = maintenance flow; green = irrigation demand; yellow = domestic, municipal, and industrial water demand.

Source: W. Hatmoko et al. 2012. *Water Balance of Water Availability and Water Demand in Indonesia River Basins, Water Resources Research Agency, Bandung* (Neraca Ketersediaan dan Kebutuhan Air pada Wilayah Sungai di Indonesia Puslitbang SDA Bandung).

Java has 87 reservoirs with a volume of 5.8 billion m^3 of which 77.2% is active storage (Figure 3.5). The major operation objective for 52 reservoirs is irrigation. Two reservoirs are solely constructed for hydropower. Sixteen reservoirs are multipurpose (irrigation; hydropower; flood control; and domestic, municipal, and industrial water supply).

Figure 3.5: Main Reservoirs in Java



Source: Deltares et al. 2012. *Java Water Resources Strategic Study*. Report submitted to the World Bank.

Sumatera

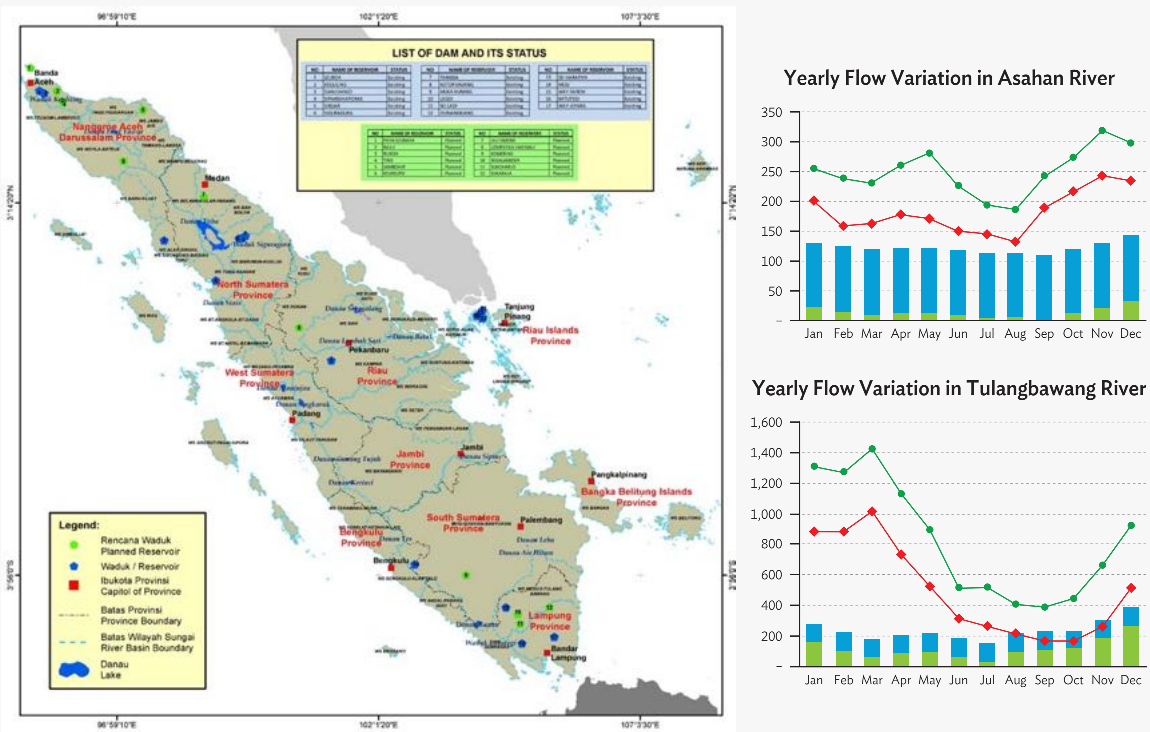
The main rivers on Sumatera are Krueng Aceh (in Aceh), Batang Hari (Jambi), Tulang Bawang (Lampung), and Asahan (North Sumatera).

Tulangbawang Way (*Way* means river in the Lampung language), which has a catchment area of 1,285 square kilometers, is the widest in the province of Lampung.

Asahan River in North Sumatera flows from the mouth of Lake Toba passing Porsea in Asahan District before ending in the Nibung Gulf, the Strait of Malacca.

The river flows shown in Figure 3.6 illustrate the difference in seasonal flow between the northwest (Asahan) and southeast (Tulangbawang) part of Sumatera.

Figure 3.6: Main Reservoirs in Sumatera, and Yearly Flow Variation in Asahan and Tulangbawang Rivers



m³/s = cubic meter per second, Q80 = mean magnitude of flows exceeded 80% of the time.

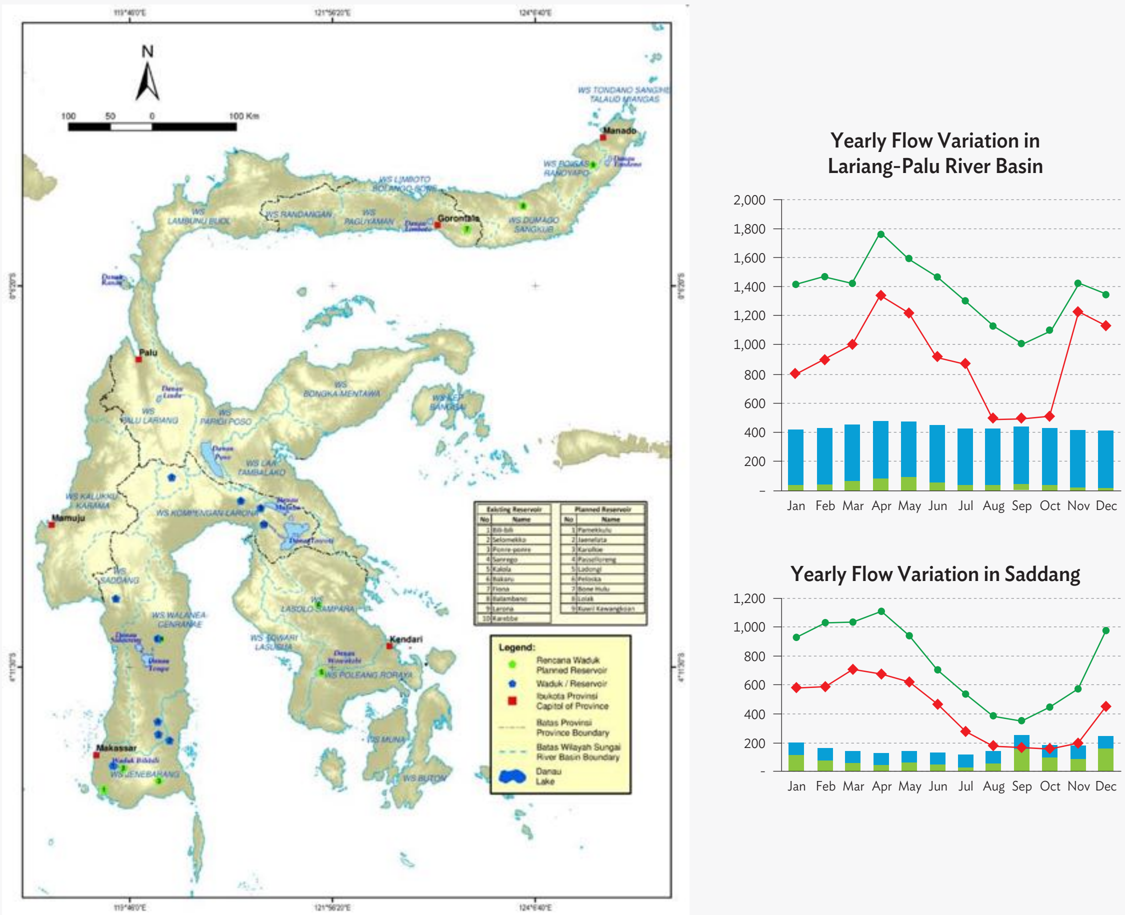
Note: Flow in m³/s. Green line = average flow, red = Q80, blue column = maintenance flow, green column = irrigation demand.

Sources: W. Hatmoko et al. 2012. *Water Balance of Water Availability and Water Demand in Indonesia River Basins, Water Resources Research Agency, Bandung* (Neraca Ketersediaan dan Kebutuhan Air pada Wilayah Sungai di Indonesia Puslitbang SDA Bandung); Deltares et al. 2012. *Java Water Resources Strategic Study*. Report submitted to the World Bank.

Sulawesi

Major rivers on Sulawesi are Lariang (Central Sulawesi) and Saddang (in South Sulawesi). The river flows shown in Figure 3.7 illustrate their seasonal variations.

Figure 3.7: Main Reservoirs in Sulawesi and Yearly Flow Variation in Lariang-Palu River Basin and Saddang



m^3/s = cubic meter per second, Q80 = mean magnitude of flows exceeded 80% of the time.

Note: Flow in m^3/s. Green line = average flow, red = Q80, blue column = maintenance flow, green column = irrigation demand.

Sources: W. Hatmoko et al. 2012. *Water Balance of Water Availability and Water Demand in Indonesia River Basins, Water Resources Research Agency, Bandung* (Neraca Ketersediaan dan Kebutuhan Air pada Wilayah Sungai di Indonesia Puslitbang SDA Bandung); Deltares et al. 2012. *Java Water Resources Strategic Study*. Report submitted to the World Bank.

Kalimantan

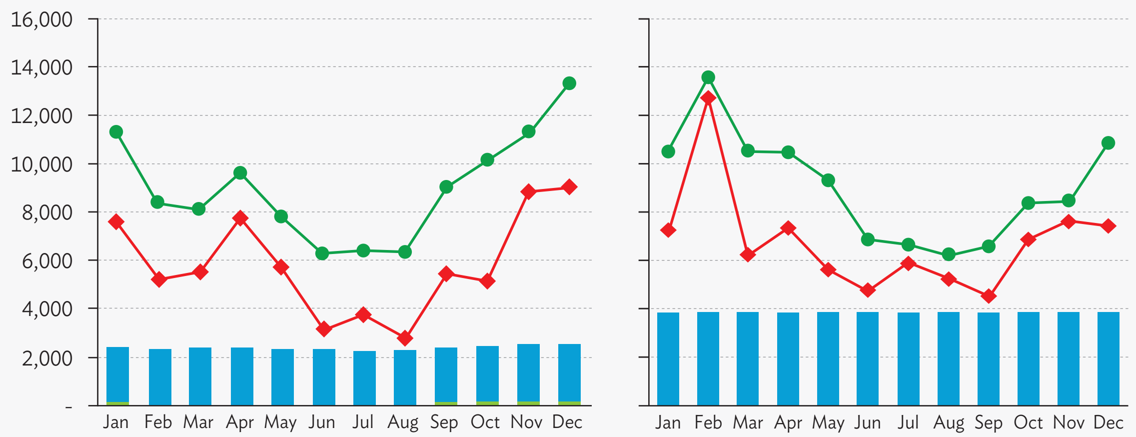
The Kapuas River in Kalimantan with a length of 1,143 kilometers is the longest river in Indonesia and one of the longest island rivers in the world. It originates in the Müller mountain range in the middle of the island and flows westward into the sea creating an extended marshy delta. The delta is located west–southwest of Pontianak, the capital of the West Kalimantan Province.

Papua

The Mamberamo is a large river in the province of Papua. It is the largest river in Indonesia by volume of discharge, and also the widest. The source of the river is the confluence of its upper tributaries, the Tariku and Taritatu Rivers. From there it flows northward through a great valley in the Van Rees Range (Pegunungan Van Rees) to reach the lowland marshes of its broad river delta. The Mamberamo discharges into the Pacific Ocean at the northern point of Tanjung (Cape) D'Urville.

The river flows shown in Figure 3.8 illustrate the seasonal flows of the Kapuas and Mamberamo.

Figure 3.8: Yearly Flow Variation in Kapuas (Left) **and Mamberamo** (Right) **Rivers**



m³/s = cubic meter per second, Q80 = mean magnitude of flows exceeded 80% of the time.

Note: Flow in m³/s. Green line = average flow, red line = Q80, blue column = maintenance flow, green column = irrigation demand.

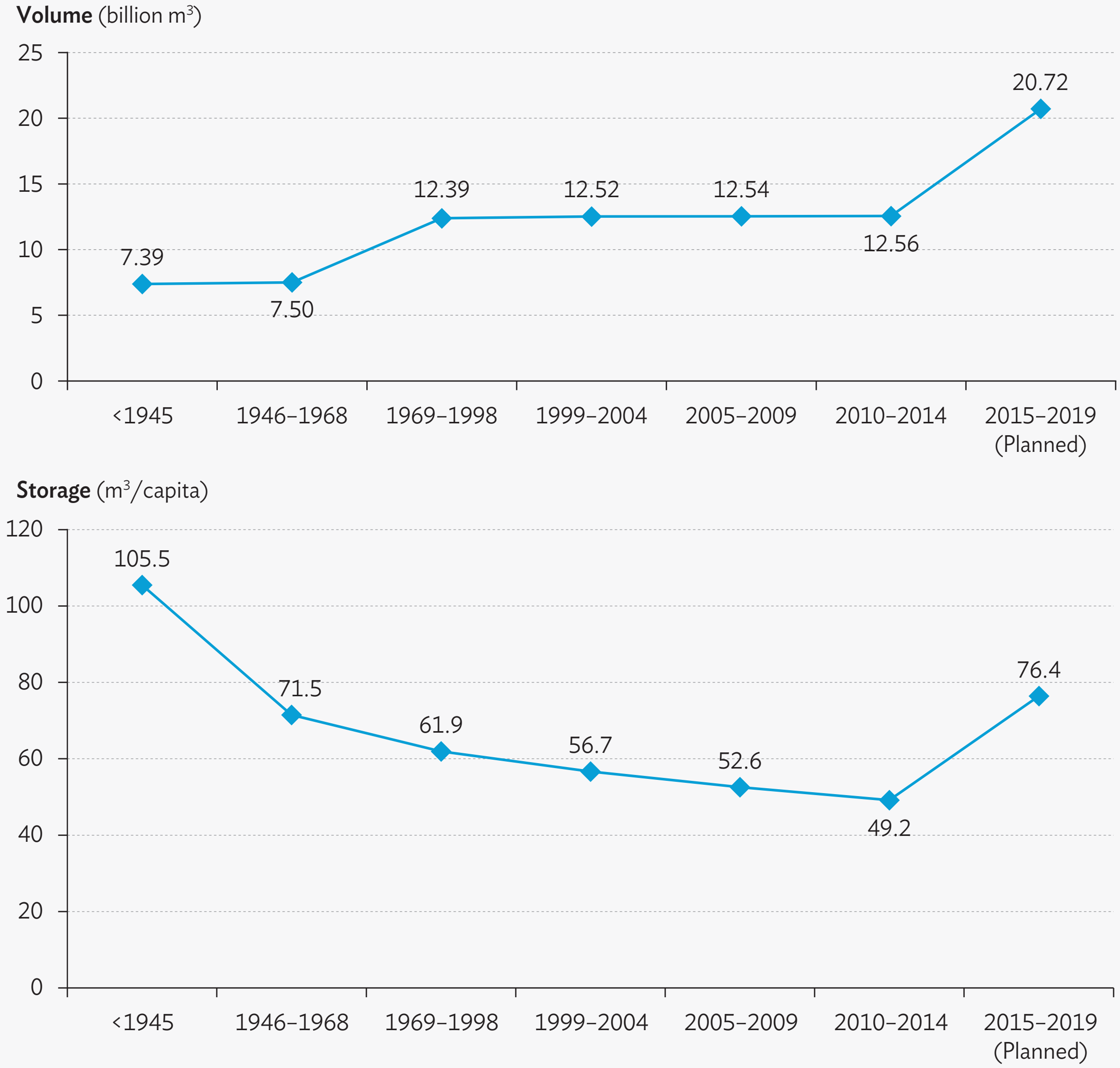
Source: W. Hatmoko et al. 2012. *Water Balance of Water Availability and Water Demand in Indonesia River Basins, Water Resources Research Agency, Bandung* (Neraca Ketersediaan dan Kebutuhan Air pada Wilayah Sungai di Indonesia Puslitbang SDA Bandung).

Storage

The development of water storage per capita in Indonesia from 1945 to 2014, including expectation in 2019, is shown in Figure 3.9. At present, Indonesia has a total reservoir capacity of about 12.56 billion m^3 or a ratio of storage per capita of about 52.55 m^3 per capita. This number is very small compared with storage per capita in other countries in Asia. This shows that the Indonesian wate resources system is very sensitive and it is getting worse with environment degradation and climate change issues.

Water storage per capita declined over the years (until 2014); this is because storage capacity did not keep pace with population increase. To overcome this problem, the government plans to build 65 new reservoirs with a capacity of 8.2 billion m^3 by 2019; water availability per capita is expected to rise from 49.2 m^3 in 2014 to 76.4 m^3 in 2019.

Figure 3.9: Reservoir Storage Volume Development and Per Capita Storage



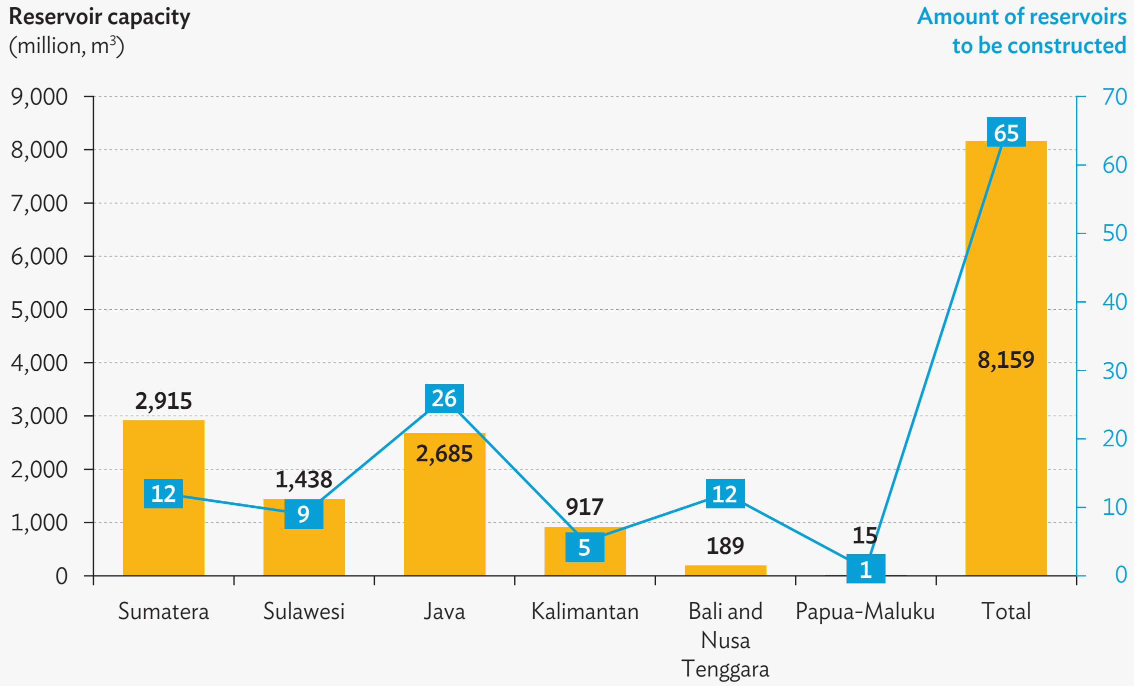
m^3 = cubic meter.

Source: Indonesian National Committee on Large Dams. 2014. *Dam of Indonesia.* Directorate of River and Coasts, Directorate General of Water Resources Development Ministry of Public Works and Public Housing, Jakarta.

The newly planned reservoirs are in Sumatera (12 reservoirs), Sulawesi (9 reservoirs), Java (26 reservoirs), Kalimantan (5 reservoirs), Bali–Nusa Tenggara (12 reservoirs), and Papua–Maluku (1 reservoir), as shown in Figure 3.10.[10]

10 Personal information. Directorate of River and Coastal, Directorate General Water Resources Department, Ministry of Public Works 2014.

Figure 3.10: Planned Reservoirs to be Constructed, 2014–2019



Source: Directorate of River and Coasts, Directorate General of Water Resources Development Ministry of Public Works and Public Housing, Jakarta.

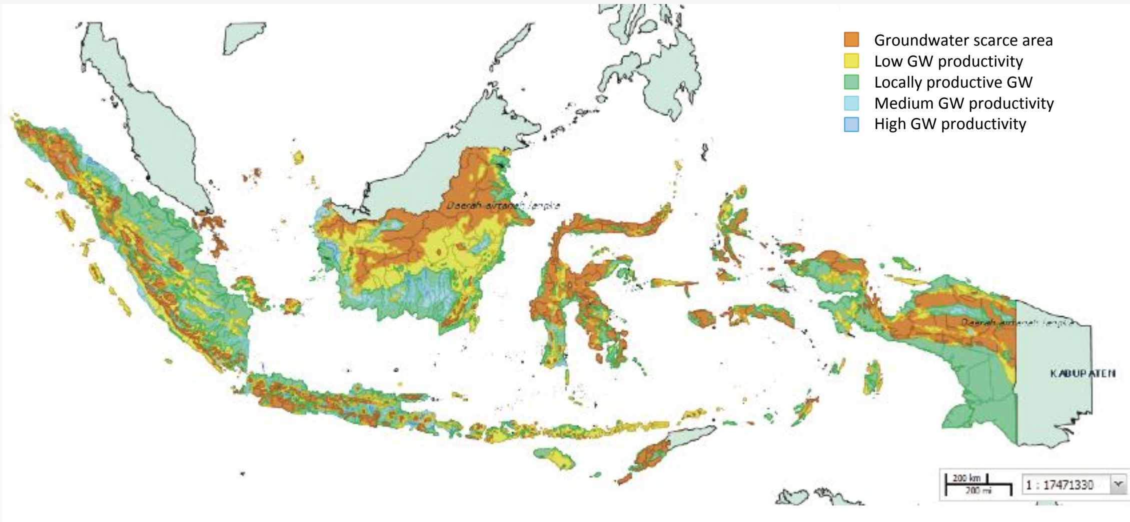
E. Groundwater

There are many groundwater basins in Indonesia with about 520 billion m^3/year of groundwater potential, and assuming a ratio of 30%, a safe yield of about 155 billion m^3/year of groundwater. As the determination of basins is based on hydrogeological boundaries, quite a few basins are located across two or more administrative regions (Figure 3.11).

Groundwater availability is dependent on the hydrogeological situation. Deep sandy aquifers generally only exist in the sedimentary basins. As such, the most productive groundwater basins can be found toward the north of Java and Sumatera, and toward the south of Kalimantan and Sulawesi.

Deep groundwater is overexploited in most urbanized areas. Low coverage or poor performance of water supply companies, combined with lack of permit enforcement, leads to many industries and housing estates using deep groundwater. The deep aquifers from which groundwater is drawn are usually not replenished and, as a consequence, they are gradually depleted. This causes rapid drawdown of the groundwater table and land subsidence. Serious impacts are felt in North Jakarta, Bandung, and Semarang.

Figure 3.11: Groundwater Availability and Safe Yield of Groundwater by Region, Map of Groundwater Aquifer Productivity in Indonesia



Region	Number of basins	Area (km²)	Quantity (million m³/year)		
			Unconfined	Confined	Safe Yield
Sumatera	65	272,843	123,528	6,551	39,024
Java and Madura	80	81,147	38,851	2,046	12,269
Kalimantan	22	181,362	67,963	1,102	20,720
Sulawesi	91	37,778	19,694	550	6,073
Bali	8	4,381	1,577	21	479
West Nusa Tenggara	9	9,475	1,908	107	605
East Nusa Tenggara	38	31,929	8,229	200	2,529
Maluku	68	2,583	11,943	1,231	3,952
Papua	40	26,287	222,524	9,098	69,487
Total	**421**	**907,615**	**496,217**	**20,906**	**155,137**

GW = groundwater, m^3 = cubic meter.

Sources: Geological Agency 2008; Bakusurtanal 2001; and Sistem Informasi Air Tanah Badan Geologi—PSDGATL. http://airtanah.bgl.esdm.go.id/?q=content/peta-hidrogeologi-indonesia (accessed October 2014).

F. Ecology and Water Quality

Ecology of Rivers, Lakes, and Estuaries

Triggered by the fierce economic growth of the past decades and the continuing population growth and urbanization, the pressures on the aquatic water systems in Indonesia are increasing, especially in the highly urbanized areas. Increased water consumption and a decrease in the availability of clean water affect both the freshwater systems and the groundwater systems.

Deforestation, drainage of wetlands, and conversion into agricultural land-use all over the country reduces the buffering capacity of the river catchments, resulting in higher peak flows in the wet season and lower base flows in the dry season, thereby increasing the risks of floods and droughts. Increased concentrations of suspended solids resulting from erosion and human activities leads to higher levels of turbidity, and thus reduces photosynthesis. Dams and reservoirs play a major role in fragmenting and modifying aquatic habitats, transforming flowing ecosystems into stagnant systems, altering the flow of matter and energy, and establishing barriers to fish migration. Eutrophication, as a result of agricultural practices, is a major cause of deterioration in water quality and might, in some cases, result in harmful algae blooms and fish mortality.

Surface Water Quality

The following institutes play a role in water quality monitoring and management:

(i) The Ministry of Environment and Forestry is responsible for monitoring water quality and pollution control. Overviews of water quality are given in yearly reports.

(ii) River basin organizations can conduct all or some of the following activities: sampling, laboratory measurement of water samples, and water patrol.

(iii) The Ministry of Health is responsible for the protection and improvement of public health, regulation of drinking water standards, and monitoring of drinking water quality provided by water supply agencies.

Water quality targets

Water quality targets for individual water systems or parts of the rivers are set by the government. The targets can be changed every year depending on the improvement in water quality. The local government is also allowed to set more stringent effluent targets for industrial discharges into water resources within their jurisdiction, based on the prevailing national regulations. Water quality is then classified into four classes:[11]

(i) Class I, water that can be used as standard water for drinking purposes;

(ii) Class II, water that can be used for water recreation, fresh fish preservation, livestock, water for irrigation, and other usages requiring the similar quality;

(iii) Class III, water that can be used as tools/facilities of fresh fish preservation, livestock, water for irrigation, and/or other usages requiring the similar quality to the benefit; and

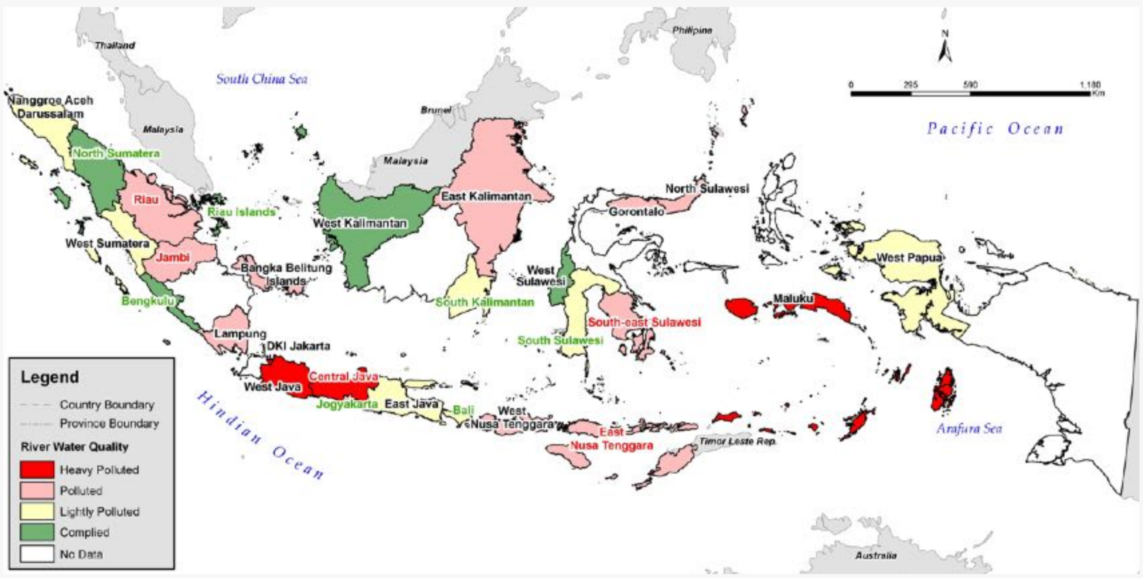
(iv) Class IV, water that can be used for irrigation, and other usages requiring similar quality.

[11] Article 8 Government Regulation No. 82/2001 dated 14 December 2001.

Status of the rivers and lakes

The water quality of rivers and lakes in Indonesia is poor (Figure 3.12). Monitoring results show that over 50% of the parameters, such as biological oxygen demand, chemical oxygen demand (COD), fecal coli, and total coliform, do not meet the norms set for water quality Class I. More than half of the river water samples do not meet the Class II criteria. An overview of 44 large rivers all over Indonesia shows that only four of them meet the Class II standard all over the year. The monitoring of water quality in 15 major lakes in Indonesia[12] shows that most of them fall into the hypereutrophic[13] category.

Figure 3.12: River Water Quality by Province, 2012



Note: Color of province name indicates improvement (green), constant (white), or deterioration (red).

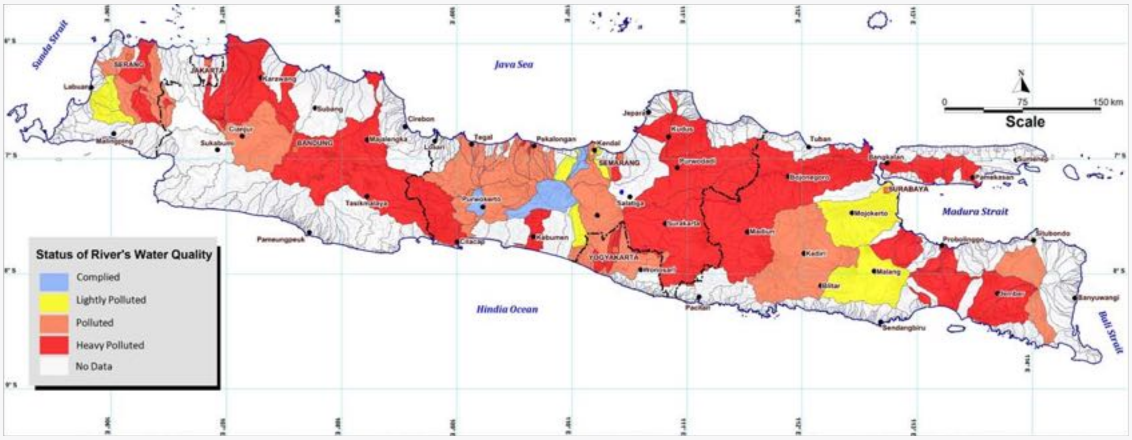
Source: Kementrian Lingkungan Hidup Republik Indonesia (Ministry of Environment and Forestry). *Status Lingkungan Hidup* (State of the Environment) *Indonesia 2012*.

Most of the river water in Java (Figure 3.13) is already in Class III or even Class IV status. Downstream of Ciliwung River (Jakarta area), the river water has far exceeded the standards of Class IV. The combination of untreated domestic sewage, solid waste disposal, and industrial effluents has led to a major public health crisis.

[12] Ministry of Environment. *Status Lingkungan Hidup* (State of the Environment) *Indonesia 2012*.

[13] Hypereutrophic is the extreme condition of euthrophication.

Figure 3.13: Java River Water Quality Status



Source: Ministry of Environment. *Status Lingkungan Hidup* (State of the Environment) *Indonesia 2012*.

Water quality trends

In the past decade, water quality has been showing a steady decline. Although some reports may indicate stabilization or even small improvements, it is expected to be applicable only to specific locations or substances.

Main sources of pollution

- **Domestic wastewater:** Wastewater from households contains large amounts of COD, nutrients, and fecal coli, which represents by far the most important source of pollution of the surface water in the country. In the urban areas (110 million people), about 1% of the wastewater is safely collected and treated, and about 4% of the sewage is safely collected and safely disposed or treated. In rural areas (130 million people), wastewater is neither collected nor treated.
- **Industry:** The Ministry of Environment estimates 12,000 medium and large industries and 82,000 small enterprises with the potential to pollute surface water. About half of the industries can be found in the food and beverage sector. Other relevant sectors are textile (20%), rubber (13%), chemicals (9%), leather (6%), paper (3%), and mining (1%).
- **Mining:** It is estimated that about 1 million miners and peripheral workers work in the small mining sector on nearly every island in the country. In illegal mining, usually large amounts of mercury are used, which damages not only the environment but also the health of the miners.
- **Agriculture:** Agriculture land is a major source of pollution by COD, nutrients, fertilizer (urea and triple superphosphate), and pesticides. Waste from livestock husbandry is an important source of wastewater. One bovine is capable of generating waste equivalent to that of five human beings.
- **Fish farming:** Considerable organic pollution results from fish farming in the reservoirs. Improper or excessive fish feeding in the floating cages adds to the waste load as unconsumed feed accumulates on the reservoir bed.

- **Solid waste:** Municipal solid waste pollutes the water with COD, biological oxygen demand, nitrates, phosphates, and pathogen content. The contribution is, however, rather small compared with that from other sources.
- **Other sources:** Other sources of pollution, such as urban runoff and atmospheric deposition of heavy metals and polycyclic aromatic hydrocarbons (PAHs) caused by bad air quality, are mainly related to the urban areas, thus raising the already high pressure on the local water systems with a wide range of toxic substances.

Economic impact of water quality degradation

Some of the economic impacts of water quality degradation can be calculated, while most are difficult to quantify. The main negative economic impacts are on health, tourism, recreation, biodiversity, fishery, agriculture, production of drinking water, real estate costs near surface water areas, and pressure on groundwater.

Groundwater Quality

The Ministry of Mines and Energy is responsible for monitoring both the quantity and quality of the groundwater. The JWRSS reports a pollution of the shallow groundwater in all large cities of Java. In Jakarta, 45% of groundwater had been contaminated by fecal coliform and 80% by *Escherichia coli*.

Major sources of groundwater pollution are septic tank contamination, discharges of untreated domestic wastewater, leachate from landfill, and industrial effluent contamination. Saline groundwater is a natural occurrence in coastal aquifers when deposits influenced by the marine environment, such as salt marshes, alternate with deposits from fresh environments. Where freshwater is abstracted, the interface between fresh and saline water may be drawn inward or upward causing saline intrusion.

G. Water Hazards

Water-related risks in Indonesia will continue to rise due to increasing populations in cities. Over 110 million people in about 60 Indonesian cities are exposed to natural hazards, including tsunamis, earthquakes, flooding, and impacts of climate change. Climate change scenarios predict that higher temperatures, changes in precipitation patterns, and rising sea levels could result in inundation of productive coastal zones and more frequent water-related disasters.

Floods

The climate in Indonesia is characterized by high rainfall, frequent intense storms, and high runoff. Floods are natural phenomenon. Their impacts are, however, gradually increasing due to settlement and economic development in flood-prone areas. Flooding has become a major problem in Indonesia, particularly in Java where a high and expanding population combined with past lapses in spatial planning and land management has permitted substantial development in flood-prone areas, escalating the danger and damages from flooding.

The following flood types can be distinguished:

(i) **Flash and river flooding.** Rainfall causes at times flooding of floodplains and agricultural areas adjacent to rivers.

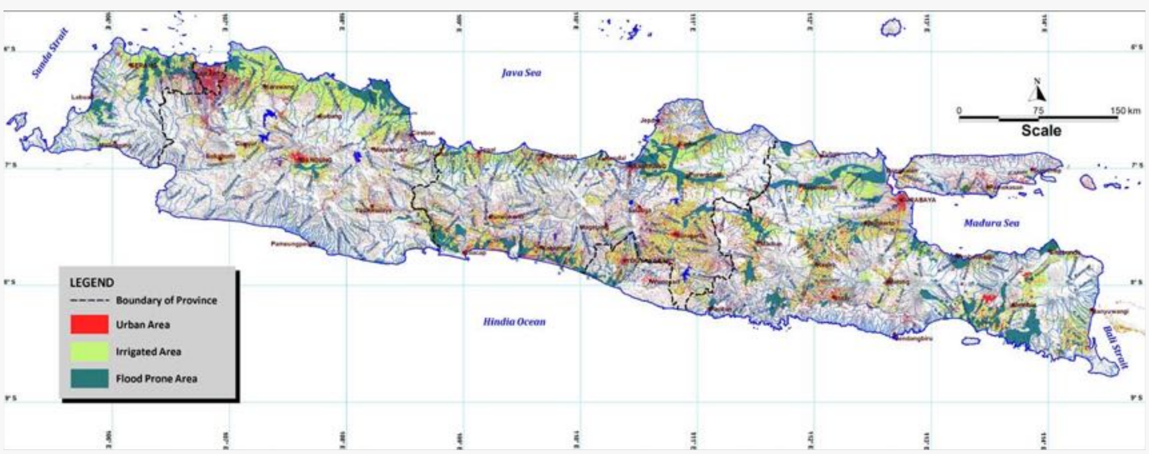
(ii) **Coastal flooding.** Caused by storm surges, tsunamis, and regional land subsidence.

(iii) **Urban flooding.** Widespread heavy rainstorms result in occasional flooding in polder areas in large cities.

Floods in Java

The JWRSS has made a classification of flood risk per unit area on Java. This classification of flood vulnerability is presented in Figure 3.14. The categorization is based on the number of people affected by flooding (>700,000; >200,000; or less), share of population affected (>15%, >5%, or less), and hindrance for traffic. It is shown that the main problem areas are Jakarta, Bandung, Semarang, and along the north coast of Java at the Strait of Madura.

Figure 3.14: Flood Vulnerability Hotspots



Source: Ministry of Environment. *Status Lingkungan Hidup* (State of the Environment) *Indonesia 2012*.

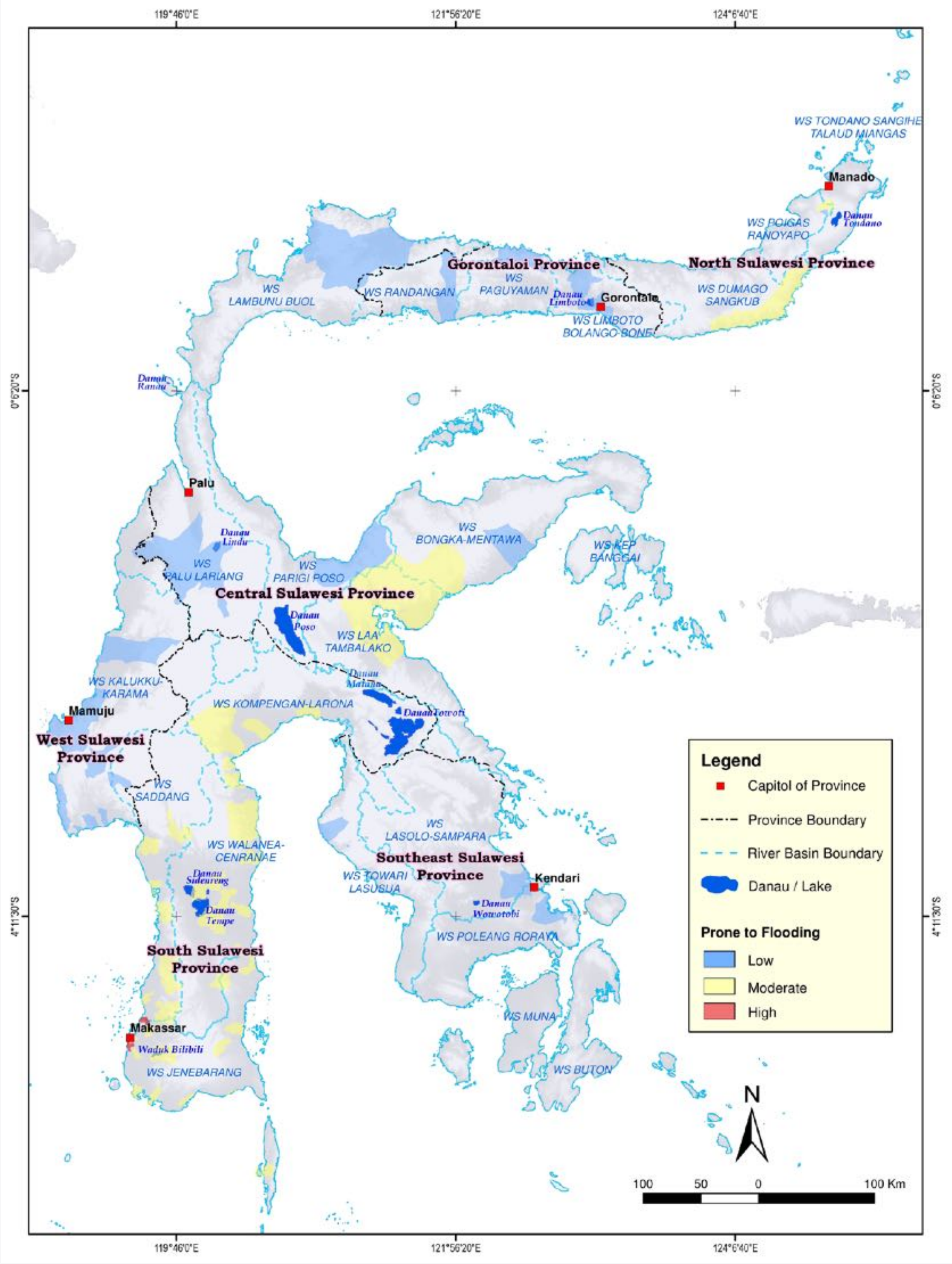
Floods in Sulawesi

In Sulawesi, floods often occur along the Maros, Tallo, and Pappa rivers in southern Sulawesi, and along the Dumoga and Onggak Mongondow rivers in the North. An overview of flooding on Sulawesi is shown in Figure 3.15.

Floods in Sumatera

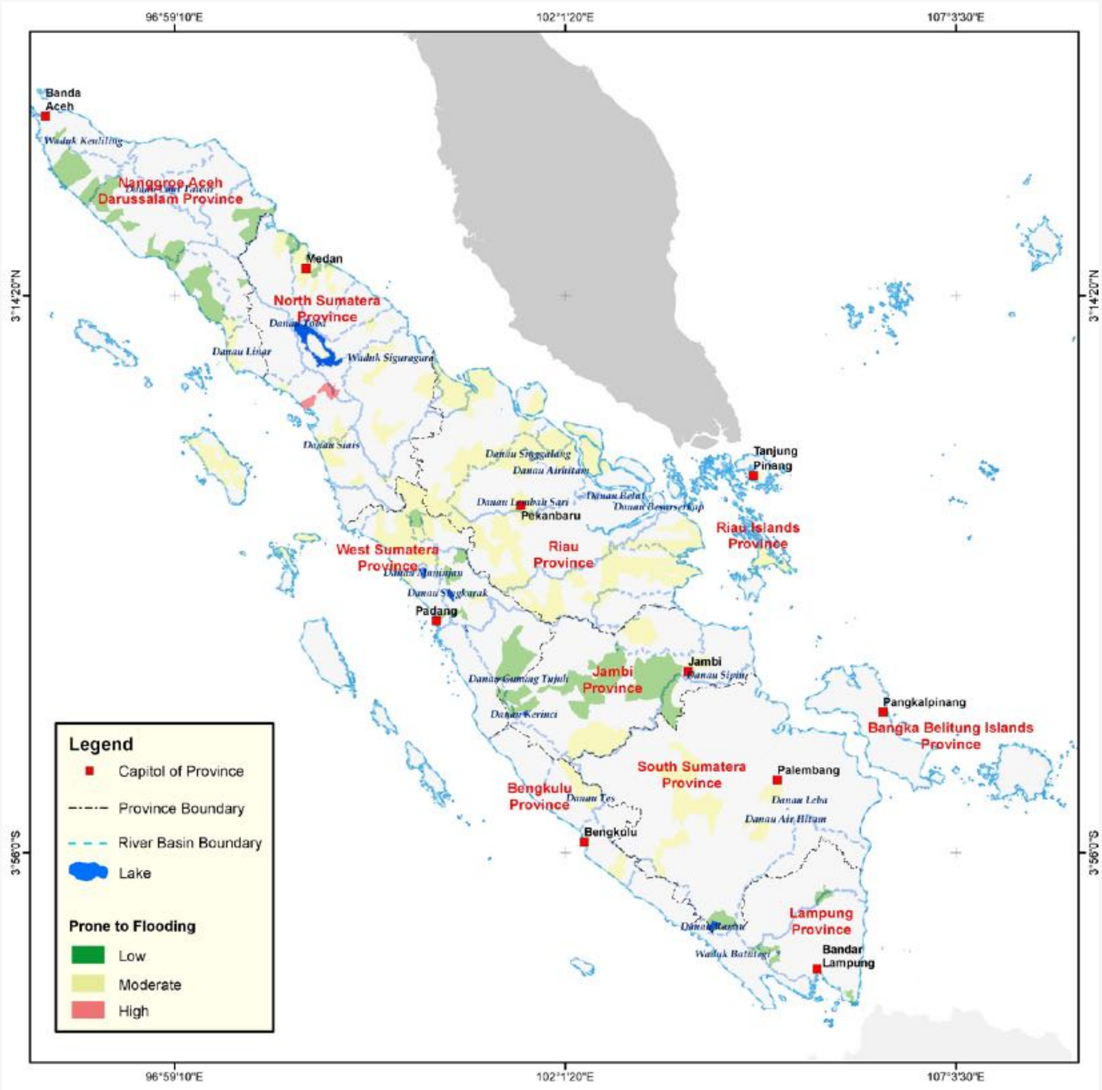
Floods in Sumatera occur mainly in the downstream reaches of Jambo Aye river basin in Aceh Province and along the Tulang Bawang River in Lampung Province. An overview of flood-prone areas on Sumatera is presented in Figure 3.16.

Figure 3.15: Flood-Prone Areas on Sulawesi



Source: Map of Flood Prone Area, 2013–2014, National Meteorology, Climatology and Geophysical Agency (BMKG)–Geospatial Information Agency–Directorate General of Water Resources, Ministry of Public Works.

Figure 3.16: Flood-Prone Areas on Sumatera



Source: Map of Flood Prone Area, 2013–2014, National Meteorology, Climatology and Geophysical Agency (BMKG)–Geospatial Information Agency–Directorate General of Water Resources, Ministry of Public Works.

Impacts

Between 1970 and 2011, 3,980 flood events in Indonesia damaged an estimated 1.1 million hectares (ha) of cropland and 65,000 kilometers of roads.[14] Between 1980 and 2014, the yearly average of people who had to be evacuated from their homes reached nearly 150,000, and on average 210 people lost their lives in yearly flood events, damaging about 11,000 houses every year.[15] Table 3.1 illustrates the impacts of floods on Java.

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14 J. A. Lassa. 2012. Emerging 'Agricultural Involution' in Indonesia: Impact of Natural Hazards and Climate Extremes on Agricultural Crops and Food System. In Y. Sawada and S. Oum, eds. *Economic and Welfare Impacts of Disasters in East Asia and Policy Responses.* ERIA Research Project Report 2011–8. Jakarta: ERIA. pp. 601–640.

15 National Disaster Management Center. http://dibi.bnpb.go.id (accessed March 2015).

Table 3.1: Impacts of Floods in Java

	Java
Impact on population	
total (million)	135.0
in flood-prone areas (million)	13.0
in flood-prone areas (%)	10%
Impacts on land use	
area (km^2)	128,297
flood-prone area (km^2)	8,900
flood-prone area (%)	7%
flood-prone urban area (km^2)	
flood-prone agricultural area (km^2)	
Impacts on economy	
GDP ($ million)	245,700
annual flood damages ($ million)	800
annual flood damages (% of GDP)	0.3
homes affected annually (nr)	20,000
crops affected annually (km^2)	1,000
evacuated people annually (nr)	100,000
Lives lost annually	**140**

GDP = gross domestic product, km^2 = square kilometer, nr = number.

Note: Estimated damages are translated to 2010 using 5% of annual gross domestic product growth.

Source: Asian Development Bank. 2011. *Flood Management in Selected River Basins.* Consultant's report. Manila (TA 7364-INO).

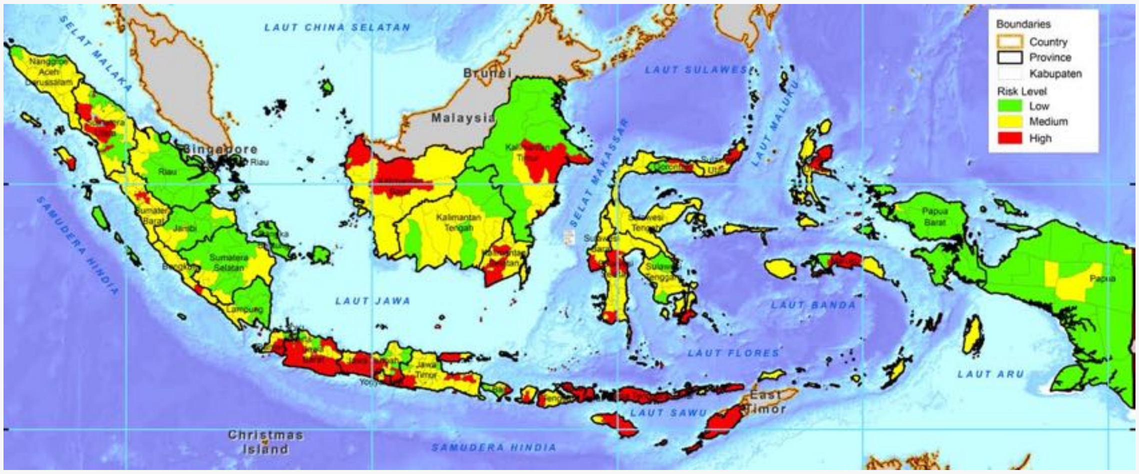
A large part of the damage is concentrated in the large urban areas in the country, such as the greater Jakarta agglomeration. For example, OAN Benfield reports about the flood of January 2013, which involved 41 deaths, 100,274+ structures/claims, $3.31 billion+ in economic losses of which $311 million were insured losses.[16]

Soil Erosion and Land Loss

In many upper catchments in Indonesia, especially in the densely populated areas in Java, the natural forest vegetation is removed to allow for agriculture. This practice results in increased exposure of the land surface to rainfall and subsequent aggravated soil erosion. In time, the productive topsoil is removed and agricultural productivity deteriorates. Landslides and gullies reduce the productive land area, and may damage roads and buildings. The hydrologic regimes of the rivers change and the number of flash floods and potential mudflows increase. The increased sediment load in rivers results in silting up of riverbeds, reservoirs, and irrigation systems. The erosion risk map for Indonesia is presented in Figure 3.17.

[16] Impact Forecasting. 2013. *AON Benfield: November 2013 Global Catastrophe Recap.* Impact Forecasting.

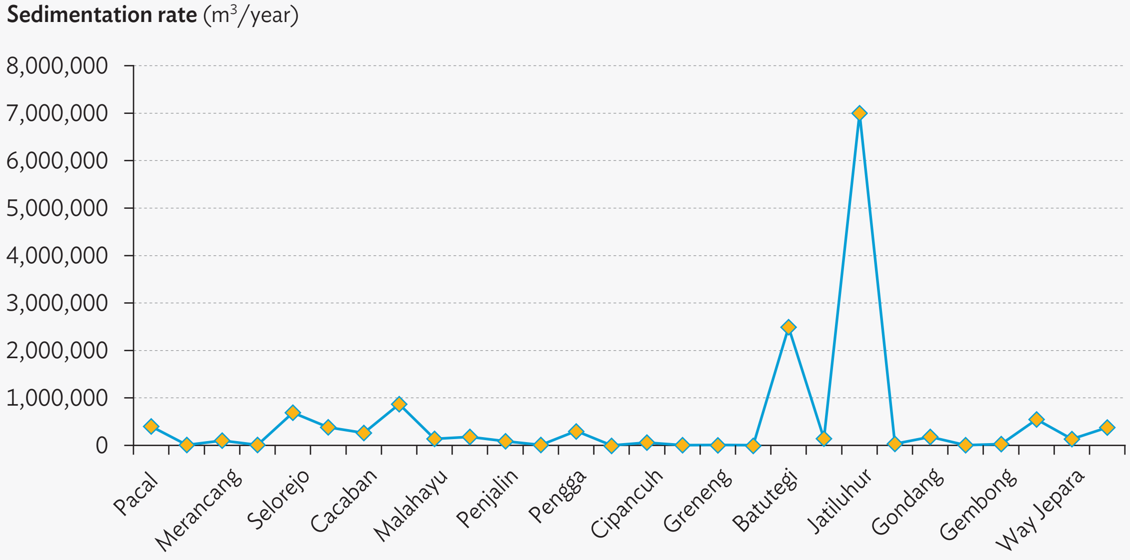
Figure 3.17: Erosion Risk Map for Indonesia



Source: Peta Indeks Risiko Bencana Erosi di Indonesia (Erosion hazard map for Indonesia), Badan Nasional Penanggulangan Bencana (BNPB). 2010.

Environmental degradation and sediment in catchment areas affect the storage capacity of the existing reservoirs. Reservoir monitoring conducted in the dam operational improvement safety project shows that all reservoirs decreased their capacity, in some cases with serious consequences (Figure 3.18).

Figure 3.18: Sedimentation Rates for Several Reservoirs



m^3 = cubic meter.

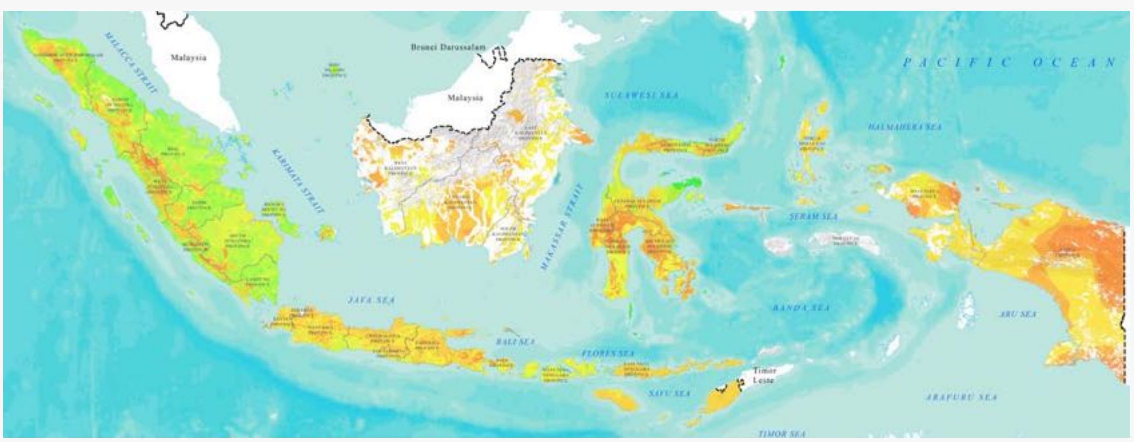
Source: World Bank. 2014. TA Services for Supporting Implementation Management and Supervisor of Dam Operational Improvement and Safety (DOISP). Consultant Evaluation of Spillway Adequacy. Jakarta.

Coastal erosion is observed along larger stretches of low-lying coastal zones. Transformation of mangrove mud coasts into built-up areas or fishponds often results in coastal abrasion due to the loss of the sediment trapping capacity of the coastline. It is a major cause of coastal erosion and land loss. Other reasons for coastal erosion include, for example, construction of breakwater, changes in sediment load in the coastal waters due to trapping upstream in reservoirs, sand mining, and loss of natural wave breakers such as coral reefs.

Droughts

The climate in Indonesia is naturally variable from year to year and, at times, drought may occur. Also, within a year, dry and wet seasons can be identified. Most recorded droughts can be related to "warm" ENSO episodes and Indian Ocean dipole mode index situations. During warm ENSO episodes (see Figure 3.20), the normal patterns of tropical precipitation and atmospheric circulation become disrupted. Rainfall is reduced over Indonesia, Malaysia, and northern Australia. A similar correlation is found with the Indian Ocean Dipole Mode Index, where a strong Indian summer monsoon rainfall from June to September can generate easterly wind that eventually causes drought in Java–Sumatera. The droughts are most notable in the period from August to December, resulting in a late and reduced onset of the rainy season. The drought hazard map for Indonesia is presented in Figure 3.19.

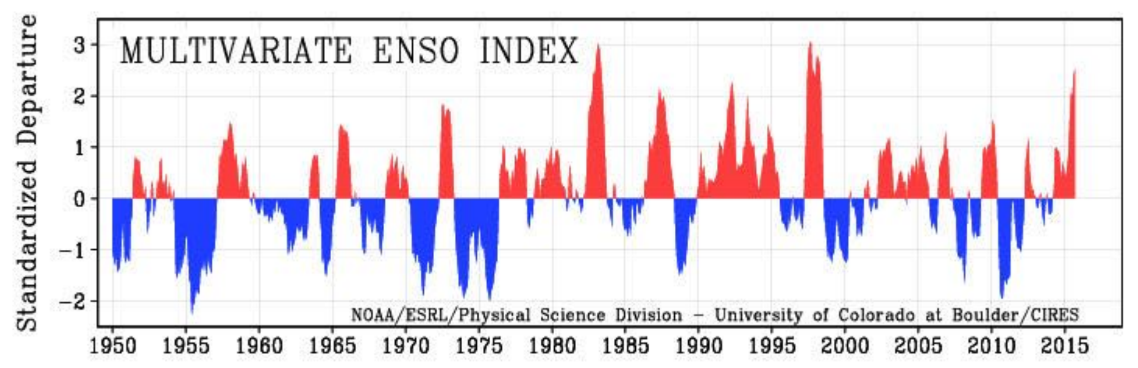
Figure 3.19: Drought Hazard Map in Indonesia



Source: National Agency for Disaster Management (BNPB). 2011. http://geospasial.bnpb.go.id/wp-content/uploads/2012/10/2012-10-16_Hazardmap_Drought_risk_assessment_2011.pdf

The total accumulation of rice area affected by floods in 2003–2008 equaled 15% of the total area under cultivation in 2009 (about 1.8 million ha out of 12 million ha). During the same period, drought affected 17% of the 12 million ha of rice fields. Floods and drought combined affected 32% of the total cultivated areas. Java was the most affected island followed by Sumatera and Sulawesi.

Figure 3.20: Variation of El Nino-Southern Oscillation Index, 1950–2014



Source: www.esrl.noaa.gov/psd/enso/mei/ (accessed March 2015).

Land degradation and forest fires in Indonesia have also contributed to hydrometeorological disasters such as floods, droughts, and landslides. They all have resulted in considerable losses in agricultural production, threatening national food security. The 2007 drought event resulted in crop failure in about 8,000 ha of paddy fields.

Health

Water-related health hazards are mostly related to harmful organisms or chemicals consumed when drinking water and to diseases which have part of their life cycle in water or with water-related vectors (e.g., malaria). Of the most important causes of under-5 mortality in Indonesia, two—diarrhea and typhoid—are fecal-borne illnesses directly linked to inadequate water supply, sanitation, and hygiene issues.[17]

Poor sanitation and hygiene cause significant burden of disease in Indonesia through illness and premature death.

The total number of deaths attributed to poor sanitation and hygiene exceeds 50,000, of which 24,000 are accounted for by direct diseases (mainly diarrhea) and 26,000 by indirect diseases related to malnutrition, which include only children aged under 5 and therefore underestimate the total deaths in all age groups.

17 Indonesia National Program for Community Water Supply and Sanitation Services. 2005. *Improving Hygiene & Sanitation Behavior and Services.* Technical Guidance to the World Bank/Indonesia and Government of Indonesia's Ministry of Health team in the preparation of hygiene and sanitation promotion components for the proposed *National Program for Community Water Supply and Sanitation Services Project*. Prepared by Andy Robinson for the World Bank. December.

Phase I of the Economic Impacts of Sanitation in Indonesia study[18] estimated the overall economic costs of poor sanitation in Indonesia to be $6.3 billion (Rp56 trillion) per year at 2005 prices, equivalent to 2.3% of gross domestic product (GDP); 52.7% of these economic costs were health costs (Table 3.2).

Table 3.2: Financial and Economic Losses Related to Health Due to Poor Sanitation

	Financial Losses			Economic Losses		
Impact	Value (Rp billion)	Per capita (1,000 Rp)	%	Value (Rp billion)	Per capita (1,000 Rp)	%
Health care costs	1,236	5.3	11.5	1,642	133.3	2.9
Productivity costs	1,033	4.4	9.6	3,090	7.1	5.5
Premature death costs	441	1.8	4.1	24,780	14.1	44.3
Total health costs	**2,719**	**12.4**	**25.3**	**29,512**	**112.1**	**52.7**

Rp = rupiah.

Source: L. Napitupulu and G. Hutton. 2008. *Economic Impacts of Sanitation in Indonesia: A Five-Country Study Conducted in Cambodia, Indonesia, Lao PDR, the Philippines, and Viet Nam under the Economics of Sanitation Initiative (ESI) World Bank, Water and Sanitation Program.* 2008. www.wsp.org

Climate Change Impacts

Limited observational data are available for the Indonesian archipelago but where data are present for the period 1960–2010, there has been a warming trend.[19] In Sumatera and Borneo, where daily temperature data are available, there has been a trend between the late 1960s and 2003 toward fewer cool nights and more warm nights and days.

For the A1B emissions scenario projected, temperature increases over Indonesia are generally in the range of 2°C–2.5°C. There are a few areas of Borneo and Sumatera where temperatures of 2.5°C–3°C are projected. There is good agreement between the Coupled Model Intercomparison Project (CMIP3) models over all of Indonesia.

Precipitation changes show quite low agreement between CMIP3 models over Indonesia, although there are some regions of good agreement over New Guinea.

Over New Guinea, rainfall is projected to increase in the region of 10%–20%. Farther west, over Borneo, increases of 5%–10% are projected, with smaller increases of 0%–5% projected over Sumatera.

Climate change impacts as reported by the MetOffice are presented in Table 3.3.

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18 L. Napitupulu and G. Hutton. 2008. *Economic Impacts of Sanitation in Indonesia: A Five-Country Study Conducted in Cambodia, Indonesia, Lao PDR, the Philippines, and Viet Nam under the Economics of Sanitation Initiative (ESI).* World Bank, Water and Sanitation Program. https://www.wsp.org/sites/wsp.org/files/publications/esi_indonesia.pdf (accessed March 2015).

19 MetOffice. 2011. *Climate: Observations, Projections and Impacts. Indonesia.* http://www.metoffice.gov.uk/climate-guide/science/uk/obs-projections-impacts

Table 3.3: Climate Change Impacts for Indonesia

Crop yields	Climate change could be associated with declines in maize yields and increases in rice yields from 2050 onward. National-scale studies show that uncertainty in future crop production is dependent on potential changes to El Nino–Southern Oscillation, which are not yet fully understood.
Food security	Global-scale studies project that Indonesia could remain "food secure" over the next 40 years. However, one study projects the 10-year averaged maximum fish catch potential from 2005 to 2055 could decline by 23% under SRES A1B.
Water stress and drought	There are currently few studies on the impact of climate change on water stress and drought in Indonesia. Recent simulations by the AVOID program show no appreciable increases or decreases in the population projected to be exposed to water stress with climate change.
Pluvial flooding and rainfall	The Intergovernmental Panel on Climate Change AR4 predicts an increase in precipitation over Indonesia under global climate change scenarios. Large uncertainties remain, particularly regarding the response of the El Nino–Southern Oscillation to climate change.
Fluvial flooding	Results from a recent global-scale study suggest that extreme flooding could increase in Indonesia with climate change. A majority of the models show a tendency for increasing flood risk, particularly later in the century and in the A1B scenario, and in some models this increase is very large.
Tropical cyclones	There remains large uncertainty in the current understanding of how tropical cyclones might be affected by climate change. To this end, caution should be applied in interpreting model-based results, even where the models are in agreement.
Coastal regions	Sea-level rise (SLR) could have major impacts on Indonesia's coastal regions. A 10% intensification of the current 1-in-100-year storm surge combined with a prescribed 1-meter SLR could affect 39% of Indonesia's coastal gross domestic product and 14,400 square kilometers of coastal land. Another study showed that the country's population exposed to SLR could increase from 600,000 at present, to 2.7 million under unmitigated A1B emissions in the 2070s—aggressive mitigation policy could avoid exposure of around 156,000 people.

Source: MetOffice. 2011. *Climate: Observations, Projections and Impacts.* Indonesia. http://www.metoffice.gov.uk/climate-guide/science/uk/obs-projections-impacts (accessed 2015).

Box 3.1 summarizes Indonesia's water resources condition and trends.

Box 3.1: Summary of Water Resources

Overall, Indonesia is a country rich in water resources. Water availability exceeds demands in almost all locations, although seasonal variability creates water stress in the dry season. As such, water stress is the result of lack or malfunctioning of infrastructure rather than absolute lack of water.

The main threat to water availability is poor management. Urban development, uncontrolled by spatial planning, leads to encroachment of towns into flood-prone areas, and uncontrolled land-use changes lead to serious degradation of the catchments, resulting in high sediment loads to reservoirs. Low wastewater treatment levels for the very large population reduce the quality of the available levels seriously.

Climate change adds a level of uncertainty to the above situation, but the main drivers are related to population growth and economic activities.

The major overarching trends in national accessible water availability are determined by the following:

(i) Continuing urban and industrial expansion in the country, that impose a greater need of the improvement of water supply to the existing water users.
(ii) Rapid urbanization and industrialization, especially (among others) in the Jakarta, Bandung, Surabaya, Semarang (Java), Medan, Palembang, Lampung (Sumatera), Makassar, Palu, and Manado (Sulawesi) areas, lead to a considerable increase in pollution loads and deterioration of the water quality.
(iii) Water use will further evolve from a situation with large-scale surface water use for irrigation and hydropower and predominantly local use of shallow groundwater for domestic use, and use of deep groundwater, especially in the urban areas by the industrial and services sectors, into a situation with a need for a larger coverage with public, piped water systems. Deep groundwater resources are being exploited at a rate that is not sustainable, which in turn contributes to significant subsidence.
(iv) Higher stakes, the massive subsidence in cities such as Jakarta and Bandung, and possibly the increased peak discharges due to upstream urbanization have considerably increased the risk of floods.
(v) Deterioration of watersheds damages the environment and leads to negative consequences downstream, including massive sedimentation of reservoirs, and possibly a change in the rainfall runoff pattern, leading to higher peak flows and reduced dry season flows. This effect will possibly be aggravated by the impacts of climate change.
(vi) After decentralization, the river basin management of water resources under regional government responsibility is lagging behind the centrally managed basins in planning, operation and maintenance, and financing of projects, resulting in deterioration of water infrastructure and reduced availability of water for productive use.

Source: Asian Development Bank.

chapter four

WATER USES AND DEMAND

A. Water Footprint and Virtual Water

The average water footprint (defined as the total amount of water that is used to produce goods and services) in Indonesia in relation to consumption of crop products is 1,131 cubic meters per capita per year (m^3/cap/year),[20] but there are large regional differences. The provincial water footprint varies between 859 and 1,895 m^3/cap/year. The average provincial water footprint consists of 84% of internal water resources. The remaining 16% comes from other provinces (14%) or countries (2%). All island groups except Java have a net export of water in virtual form. Java, the most water-scarce island, has a net virtual water import and the most significant external water footprint. This large external water footprint is relieving the water scarcity on this island (Figure 4.1).

The water footprint of rice is about 3,500 cubic meters (m^3) per ton, but there are large differences between provinces. Java accounts for 56% of the total rice production. Besides Java, major rice-producing areas are Sulawesi Selatan with a water footprint of rice of 3,800 m^3/ton and Sumatera Utara with 3,900 m^3/ton. These values are higher than the average water footprint of rice on Java, which is 2,800 m^3/ton. The reason for the low water footprint of rice on Java is the combination of relatively high yields (5.3 tons per hectare [ha]) and moderate evapotranspiration (4.6 millimeters [mm] per day). The other two regions do not have this combination of high yield and moderate evapotranspiration.

The interprovincial virtual water flows are primarily caused by trade in rice. The products such as cassava, coconut, banana, and coffee have the largest interprovincial water flows relative to water use for production. The biggest amount of virtual water from provinces or countries goes to Java, the only main Island in Indonesia with a net virtual water import of about 2000 × 106 m^3/year between 2000 and 2004, as it is densely populated and the production of crops is not sufficient to satisfy the total consumption. Sumatera's contribution is the largest in the virtual water export. The provinces that have the highest imports of water in virtual form from other provinces are DKI[21] Jakarta, West Java, Riau, and Banten. These provinces account for 55% of the total interprovincial virtual water import. Because of the high consumption quantity and/or the low production of crops, these provinces have a high virtual water import.

This paragraph illustrates that strategic development of water-dependent products in areas that have abundant water resources will increase water security in the country provided the interisland transport is efficient.

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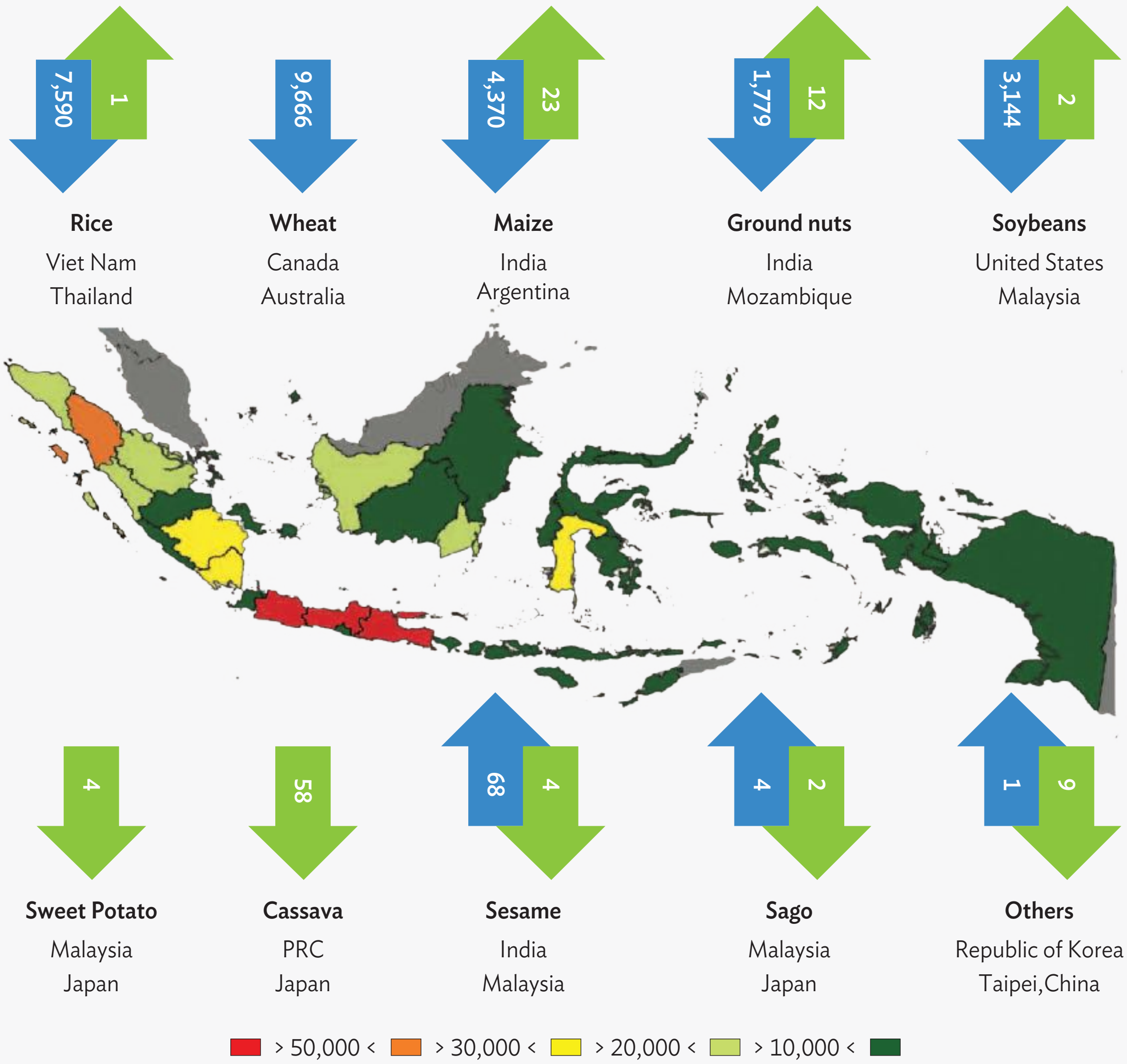
[20] F. Bulsink, A.Y. Hoekstra, and M.J. Booij. 2009. The Water Footprint of Indonesian Provinces Related to the Consumption of Crop Products. *Value of Water Research Report Series*. Vol. 37. Delft: UNESCO-IHE. The water use refers to the production for food only, not to the production for feed, seed, and other uses.

[21] Daerah Khusus Ibukota (DKI) = Special Capital Region.

Figure 4.1: Virtual Water Use of Indonesian Islands and Food Crops Import and Export, 2011 (million m^3)

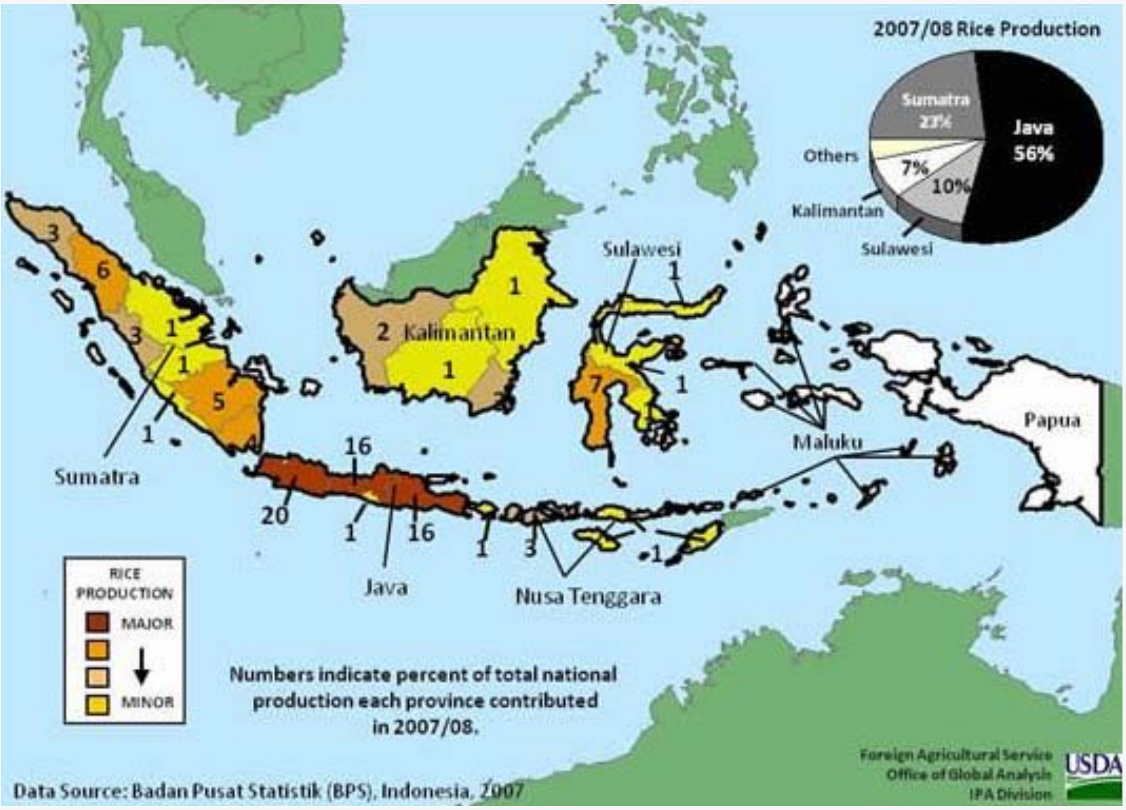


Source: Tapak Air dan Strategi Penyediaan Air di Indonesia (Water Footprint and Water Provision Strategy in Indonesia). 2013. Direktorate Jenfdral Sumber Ddaya Air-Kementrian Pekerjaan Umum (Directorate General of Water Resources, Minsitry of Public Works).

B. Water for Agriculture

The combination of abundant rainfall and fertile soils make many areas of Indonesia ideal for farming. In 2010, the Government of Indonesia estimated (Statistics Indonesia) the total agricultural land to be roughly 40.7 million ha, or 22% of the total land area in the country. The major crops produced in Indonesia include, but are not limited to, rice, oil palm, sugarcane, cassava, coconut, corn, banana, rubber, mango, orange, chili, sweet potato, soybean, and peanut.

Figure 4.2: Regional Rice Production in Indonesia



Note: The water use refers to the production for food only, not to the production for feed, seed and other uses.

Source: United States Department of Agriculture (USDA). 2012. Indonesia: Stagnating Rice Production Ensures Continued Need for Imports. *Commodity Intelligence Report.* 19 March. http://www.pecad.fas.usda.gov/highlights/2012/03/Indonesia_rice_mar2012/

The agricultural environment in Indonesia is divided largely by geography and altitude (Figure 4.2),[22] with intensive food crop production occurring on the inner islands (Java, Bali, Lombok, and Madura), whereas less intensive perennial cropping systems (estate crops such as oil palm, sugar, rubber, cacao, coffee, tea) predominate on the outer islands of Sumatera, Kalimantan Sulawesi, and Papua. Natural soil fertility is highest on the inner islands, whereas lower-fertility acid soils predominate on the outer islands.

Indonesia has a rice (paddy field) area of 7.8 million ha (including irrigated rice area of 4,417,582 ha[23]), whereas the harvested area of rice in 2011 was around 13.1 million ha (Table 4.1).

Rice is grown by approximately 77% of all farmers in the country (25.9 million) under predominantly subsistence conditions. The average farm size is very small at less than 1 ha, with the majority of farmers cultivating landholdings between 0.1 and 0.5 ha in size.

22 United States Department of Agriculture, Foreign Agricultural Service. 2012. Indonesia: Stagnating Rice Production Ensures Continued Need for Imports. *Commodity Intelligence Report.* 19 March. http://www.pecad.fas.usda.gov/highlights/2012/03/Indonesia_rice_Mar2012/ (accessed November 2014).

23 Ministry of Agriculture. 2012. Statistics of Agricultural Land, 2008–2012. Center for Data and Information System, Secretariat General. Jakarta.

Table 4.1: Harvested Area and Cropping Intensity of Paddy Crop in Indonesia

Corridors	Area of paddy field (ha)	Harvested area of paddy (ha)	Cropping intensity in a year (%)	Production (ton)	Crop yield (ton/ha)
Sumatera	1,997,054	3,427,651	1.72	15,686,847	4.58
Java	3,251,694	6,165,079	1.90	34,404,557	5.58
Bali-Nusa Tenggara	464,814	765,848	1.65	3,516,824	4.59
Kalimantan	1,068,491	1,147,648	1.07	4,574,149	3.99
Sulawesi	939,834	1,481,260	1.58	7,280,888	4.92
Papua-Maluku	58,582	75,555	1.29	293,639	3.89
Indonesia	**7,780,469**	**13,063,041**	**1.68**	**65,756,904**	**5.03**

ha = hectare.

Source: Statistics Indonesia. *Statistical Year Book of Indonesia 2013*.

Irrigation

The total water requirement of agriculture in Indonesia is estimated to be about 3,500 billion m^3 per year, or 11,000 cubic meter per second (m^3/s).[24] However, most agriculture is rainfed. Only about 17%–20% of agriculture relies on irrigation. The irrigation water demand (Figure 4.3) is estimated to be 5,441 m^3/s.[25] Water productivity, expressed as constant $2,000 GDP per cubic meter of total freshwater withdrawal, rose from 1.5 in 1990 to 3.5 in 2011.[26]

About 1% of irrigation water is drawn from groundwater[27] and 12% from reservoirs.[28] The main part (87%) is diverted from rivers without a large structure, making the irrigation schemes vulnerable to variations in river flow.

According to Indonesia's Ministry of Public Works in 2012, approximately 84% of total rice area in Indonesia is irrigated, whereas the remaining 16% relies on rainfall. Rice is grown throughout the year, with some farmers being able to cultivate three crops within a given 12-month period. The Food and Agriculture Organization of the United Nations estimates that approximately 70% of total lowland rice area produces two rice crops each year. About 60% of the total rice production occurs in the first crop cultivated during the wet season (November–March), while two smaller harvests occur during the dry season (see the crop calendar in Figure 4.3).

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24 Estimated update based on F. Bulsink, A.Y. Hoekstra, and M.J. Booij. 2009. The Water Footprint of Indonesian Provinces Related to the Consumption of Crop Products. *Value of Water Research Report Series.* Vol. 37. Delft: UNESCO–IHE.

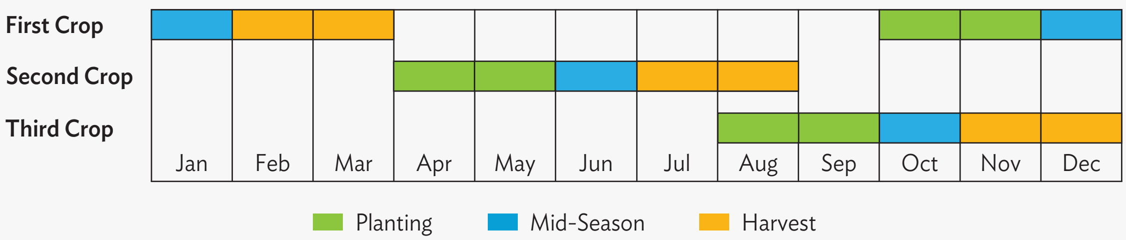
25 W. Hatmoko et al. 2012. *Neraca Ketersediaan dan Kebutuhan Air pada Wilayah Sungai di Indonesia Puslitbang SDA Bandung* (Water Balance of Water Availability and Water Demand in Indonesia River Basins, Water Resources Research Agency, Bandung).

26 World Bank. World Development Indicators: Indonesia Water Productivity. http://ycharts.com/indicators/indonesia_water_productivity (accessed November 2014).

27 Food and Agriculture Organization. Aquastat Database. http://www.fao.org/nr/water/aquastat/countries_regions/IDN/index.stm (accessed November 2014).

28 International Commission on Irrigation and Drainage. *Irrigation & Drainage in the World—A Global Review: Indonesia.* http://www.icid.org/i_d_indonesia.pdf

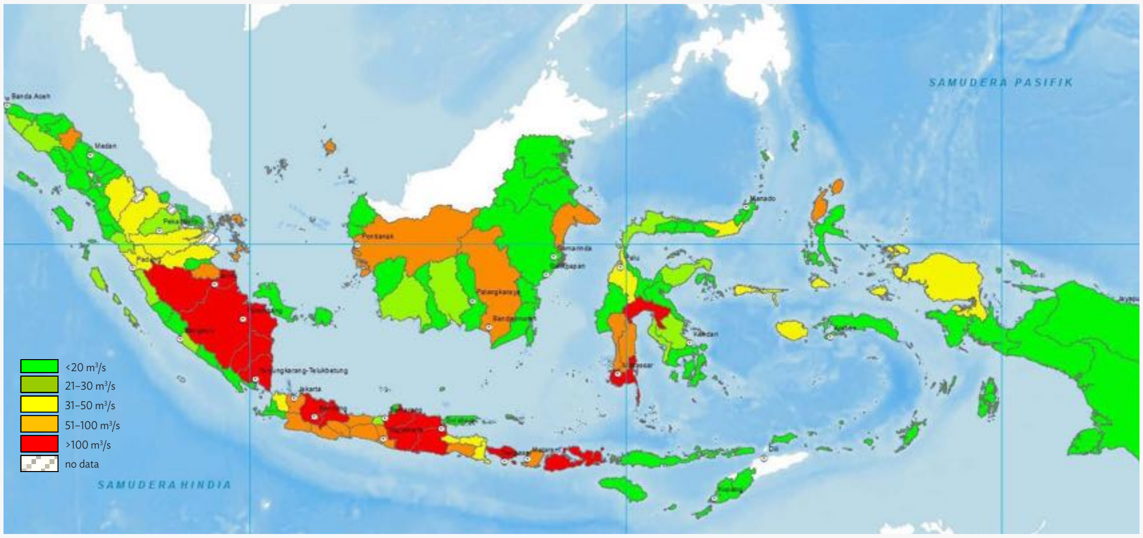
Figure 4.3: Seasonal Rice Crop Calendar



Source: Ministry of Agriculture.

Besides food crops, other important annual crops such as palm oil, rubber, cacao, and coffee are cultivated across the country, especially on Sumatera. The crops are generally managed in large plantations by private farmers, state-owned enterprises, or private companies. The crops generally do not require irrigation; however, water is very important for the processing industry such as palm oil extraction. In 2013, the total area of oil palm plantations in Sumatera was about 6.5 million ha with a total yield of crude palm oil of almost 20 million ton. It is estimated that every ton of crude palm oil requires 6.7 m^3 of water for processing.

Figure 4.4: Irrigation Water Demand per River Basin



m^3/s = cubic meter per second.

Source: W. Hatmoko et al. 2012. *Neraca Ketersediaan dan Kebutuhan Air pada Wilayah Sungai di Indonesia Puslitbang SDA Bandung* (Water Balance of Water Availability and Water Demand in Indonesia River Basins, Water Resources Research Agency, Bandung).

Despite a large increase in output, the maintenance and repair budgets of existing irrigation systems are perennially in short supply as shown in Table 4.2.

Table 4.2: Condition of Irrigation Schemes According to Responsible Government Level

Responsible Management and/or Conditions	Irrigation Area Condition (ha) 2010	2014
Central Government		
Good	1,250,100	2,047,099
Slightly damaged	300,950	106,055
Moderately damaged	648,200	367,560
Severely damaged	115,750	129,994
Province		
Good	555,057	515,099
Slightly damaged	170,787	181,820
Moderately damaged	526,592	182,575
Severely damaged	170,787	225,987
District or City		
Good	1,676,141	1,500,610
Slightly damaged	698,392	671,758
Moderately damaged	698,392	691,270
Severely damaged	419,035	799,539

ha = hectare.

Source: Personal communication with Directorate of Operation and Maintenance, Directorate General of Water Resources, Ministry of Public Works.

Agriculture and Plantations on Peat

Indonesia has more than 0.20 million square kilometers of tropical peat, mainly in Kalimantan, Sumatera, and Papua.[29] Since most of the tropical peatlands are situated at low altitudes in coastal and subcoastal locations where human population growth is high, they seem attractive areas to be developed. Currently, the palm oil and paper industries are fueling rapid agricultural development. Between 1990 and 2010, more than 5.1 million ha of peat swamp forest in peninsular Malaysia, Sumatera, and Borneo were lost. At the same time, the area used for industrial plantations of oil palms and paper pulp trees increased by 3.1 million ha and covered 20% of the region's peatland. It is predicted that by 2020, the area under industrial plantations will increase to between 6 million and 9 million ha.

[29] S.E. Page, J.O. Rieley, and C.J. Banks. 2011. Global and Regional Importance of the Tropical Peatland Carbon Pool. *Global Change Biology*. 17(2): 798–818.

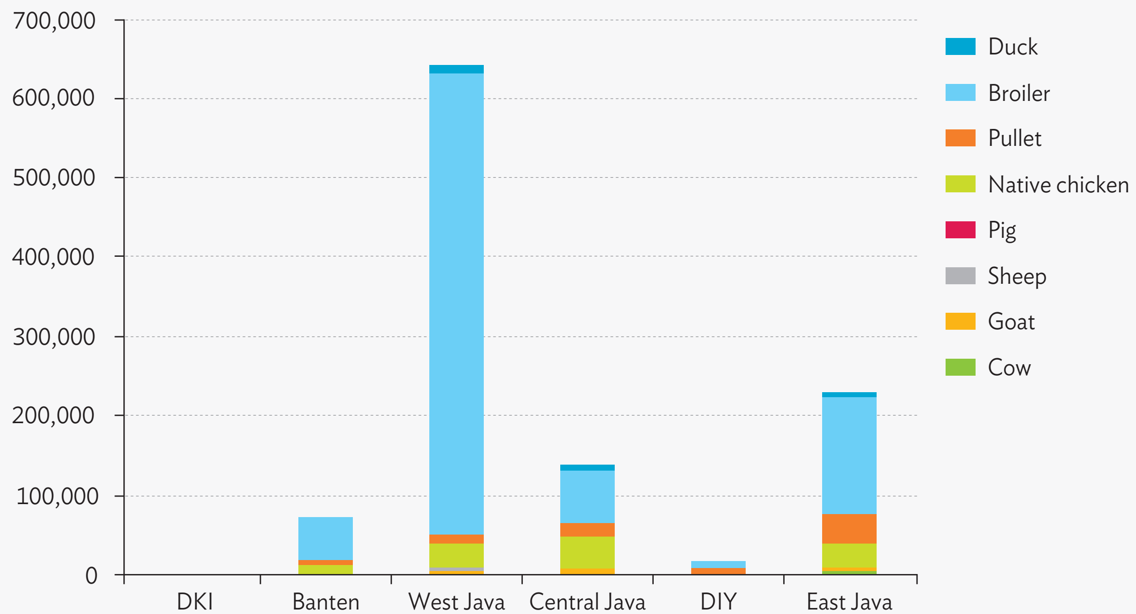
The conversion of peatland forests to productive use creates a very large release of greenhouse gases due to the clearing and burning of original forest.

A second problem is that peatland drainage leads to land subsidence. Soil subsidence is caused by consolidation, compaction, and oxidation processes. These processes continue until the carbon store is totally depleted or until the drainage limit is reached.

Livestock

Generally, livestock such as cattle, goat, sheep, pig, birds, and ducks are kept to support farmer's income, improve food supply, and also plow the land in rural areas. The population of livestock in Java is presented in Figure 4.5.

Figure 4.5: Total Population of Livestock in Java, 2011 ('000)



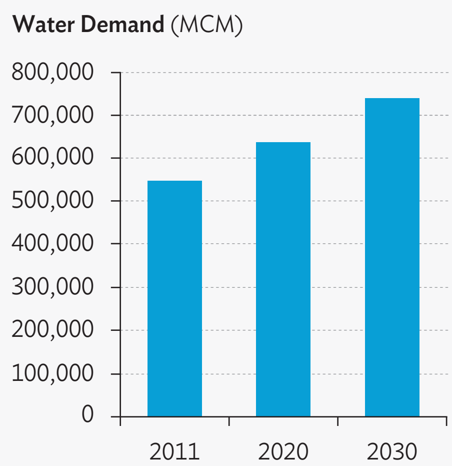
DIY = Daerah Instimewah Yogyakarta (Yogyakarta special region), DKI = Daerah Khusus Ibukota (Capital special region).

Source: Personal communication with Directorate of Operation and Maintenance, Directorate General of Water Resources, Ministry of Public Works.

Livestock requires water for drinking; water is also required for washing the livestock and for cleaning stalls or stables. Most water for livestock is supplied by groundwater. Water demand per unit of livestock is estimated at 40 liters (l) per day for cattle, 5 l/day for goat or sheep, 6 l/day for pigs, and 0.6 l/day for birds. Assuming that the livestock population would grow by 1%–2% per annum, the estimated water demand for livestock in 2020 is shown in Figure 4.6.

Figure 4.6: Estimated Livestock Population (×1000) and Water Demand in Java, 2020

Livestock	Population in 2011	Population in 2020	Water demand in 2020 (MCM)
Cow	8,104.3	9,493.1	138.60
Goat	9,697.6	11,589.3	21.15
Sheep	10,985.8	13,129.1	23.96
Pig	215.4	257.5	0.64
Native chicken	109,048.9	130,322.7	28.54
Pullet (*ayam potong*)	75,894.8	88,922.9	19.47
Broiler (*ayam pedaging*)	857,235.1	1,004,384.5	219.96
Duck	21,408.9	25,083.9	5.49



MCM = million cubic meter.

Source: Statistics Indonesia. 2012. *2011 Statistical Yearbook*. Jakarta.

Aquaculture

Nationally, the total area of brackish water ponds, fresh water ponds, and paddy field ponds used for fisheries was about 1 million ha in 2011, 70% of which was in Sumatera, Java, and Sulawesi. This was again divided into 225,000 ha of brackish water ponds, 295,000 ha of fresh water ponds, and 195,000 ha of paddy field ponds. Paddy field ponds are generally not used each year, depending on the water availability (irrigation and/or rainfall) in July–September. Permanent aquaculture (brackish and fresh water ponds) are usually managed using high technology, infrastructure and equipment such as the use of groundwater, piping, and application in large areas.

Water demand for aquaculture is estimated based on a use of 7 mm/day/ha (Ministry of Public Works 1993). By this assumption, estimated water demand for aquaculture in 2011 was about 2,000 million cubic meters (MCM) with about 1,400 MCM in Sumatera, Java, and Sulawesi (Table 4.3). Note that this cannot always be separated from irrigation water needs as farmers tend to use irrigation water for fisheries.

With an estimated increase of about 2% per year, it is estimated that, by 2030, the total area of aquaculture would be almost 1.5 million ha, with a water demand of 2,800 MCM.

Table 4.3: Area and Water Demand of Aquaculture

	Aquaculture	2011	2020	2030
Sumatera	Area ('000 ha)	225	270	323
	Water demand (MCM/year)	484	578	694
Java	Area ('000 ha)	294	350	428
	Water demand (MCM/year)	525	628	766
Sulawesi	Area ('000 ha)	193	230	277
	Water demand (MCM/year)	439	525	630
Other regions	Area ('000 ha)	290	345	422
	Water demand (MCM/year)	520	620	755
	Total demand (MCM/year)	**1,968**	**2,351**	**2,845**

ha = hectare, MCM = million cubic meter.

Source: Statistics Indonesia. 2012. *2011 Statistical Yearbook*. Jakarta.

C. Water for Industry

In Indonesia, the industry sector is the largest contributor to the national GDP with 26.38% of the GDP. The following six main sectors are distinguished by the Ministry of Industry:

1. manufacturing Industry (e.g., steel, textile, oil and gas, chemicals, cement);
2. agro-industry (e.g., rubber, palm oil, food and beverages, paper);
3. transport (e.g., motor vehicle, shipping, railroads);
4. electronics and information and communication technology;
5. creative Industry (e.g., fashion and software); and
6. small and medium-sized industries.

Table 4.4 shows the main industries and the estimated water demand.

Considering the importance of the sector, the relative size of the sector, and the water demand per ton of product, the water demand for a number of sectors is further highlighted.

Oil and Gas

National crude oil output has been on a declining path for more than a decade, sliding from a peak of around 1.6 million barrels per day in 1995 to 831,000 barrels per day in 2013. Amid rising domestic consumption, Indonesia turned into a net importer of oil by 2004. Proven reserves fell from 5.6 billion barrels in 1992 to 3.7 billion barrels by the end of 2012.

Table 4.4: Industry Sectors with Relative Water Demand

Sector	% Share in Economy	Number of Plants	Water Demand	Number of Workers
Oil and gas	3.81		High	8,700
Agro industry, food, and beverage	7.49	6,000	Very high	832,000
Textile	2.08	2,853	Very high	478,000
Wood	1.43		Low	222,000
Paper and pulp	1.09		Very high	104,000
Chemicals	2.90		High	227,000
Steel	0.48		Medium	
Transport	6.17		Low	
Others	0.17			
Total	**26.38**			**4,335,000**

Source: Bank Indonesia. www.bi.go.id (accessed March 2015).

Natural gas has seen a gradual increase over the past decade. Annual output rose from 69.7 billion m^3 in 2002 to 71.1 billion m^3 in 2012, making Indonesia the 10th largest gas producer. Indonesia's proven gas reserves rose from 1.8 trillion m^3 in 1992 to 2.9 trillion m^3 by the end of 2012, about 1.6% of global supply.

Oil and gas wells produce a significant amount of water (6–12 m^3 water per cubic millimeter of oil)[30] after well development. Water that naturally exists in subsurface formations and is brought to the surface with hydrocarbon resources is termed "produced water." Produced water is considered the largest by-product of oil and gas generation and is generally managed as a waste product. Most of the water produced during oil and gas production is disposed of, using methods such as deep well injection or evaporation.

Oil refineries require large amounts of cooling water and process water.

Fiber, Textile, and Garment Sector

The fiber, textile, and garment sector is one of Indonesia's oldest and most strategically significant industries. It employs an estimated 11% of the total industrial labor force or 1.34 million people across 2,853 companies and accounted for 8.9% of total exports in 2010. Almost 90% of the textile industry is located in Java, and 55% is concentrated in West Java alone. The garment industry is concentrated in West Java, Jakarta, and Batam.[31]

[30] K. Guerra et al. 2011. Oil and Gas Produced Water Management and Beneficial Use in the Western United States. *United States Bureau of Reclamation Science and Technology Program Report* No. 157. Denver, Colorado. http://www.usbr.gov/research/AWT/reportpdfs/report157.pdf (accessed November 2014).

[31] *Indonesia Global Business Guide—Indonesia's Textile and Clothing Industry*. 2012. http://www.gbgindonesia.com/en/manufacturing/article/2014/indonesia_s_textile_and_clothing_industry.php (accessed November 2014).

The textile industry uses vast amounts of water throughout all processing operations. Almost all dyes, specialty chemicals, and finishing chemicals are applied to textiles in water baths. Most fabric preparation steps, including desizing, scouring, bleaching, and mercerizing, use water. A large textile plant can consume up to 1 MCM of water a day.

The textile industry is currently one of the major contributors to industrial toxic water pollution in West Java, with 68% of industrial facilities on the Upper Citarum producing textiles.

Food and Beverages

The food and beverage sector is fueled by rising incomes and an increased spending on food by the middle class. The sector is dominated by large local companies (Indofood, Garuda Food, Mayora) and some large multinational companies (Nestle, Unilever). On the whole, the sector has more than 6,000 companies. Output of the sector grew by 176.3% over the period 2000–2009 putting the industry as a whole at a value of $194 billion at the end of 2010.[32]

Water is used in large quantities, either as a component of the product or for washing of the meat, fruit, and vegetables.

Chemical Industry Sector

The oldest chemical industry is the fertilizer sector. Also, the rubber-based industry dates back to many decades. Other chemical compounds such as plastics, palm oil, paints, coating, solvents, and so forth were developed more recently. Most of the smaller chemical plants are located in Java and Sumatera. Presently, some 227,000 people are employed in the chemical sector.

Water is used in large quantities for process water and cooling, and indirectly for the large amount of energy needed in this sector.

Industrial Estates in Indonesia

Indonesia has 61 main industrial estates with a total of 27,000 ha and 7,211 companies: 2 estates in Sulawesi, 2 in Kalimantan, 15 in Sumatera, and 42 in Java (Table 4.5). Demand for industrial land is about 1,000 ha per year, with about 600 ha of land demand in Bekasi and Karawang, West Java, and the rest scattered in other areas.

The water demand of the estates can be estimated, without analyzing each independent company, by calculating the size of the estate and the upper/lower water demand estimate for an estate in Indonesia. This evaluation is summarized in Table 4.5.

The current industrial water demand is estimated between 513,468 and 1,911,241 m^3/day. Roughly 73% of the water use is in Java. Average water demand is 443 MCM per year.

[32] *Indonesia Global Business Guide Overview of the Food & Beverage Sector*. 2012. http://www.gbgindonesia.com/en/manufacturing/article/2011/overview_of_the_food_and_beverage_sector.php (accessed November 2014).

Table 4.5: Estimate of the Water Demand from Industrial Estates in Indonesia

Location	Number of Estates	Total Size	Number of Firms	Water Demand (m^3/ha/day)	Estimate of Total Water Demand (m^3/day)	
					Min	Max
Sulawesi, North	1	1,500		18–67	27,000	100,500
Sulawesi, South	1	703	224	18–67	12,654	47,100
Kalimantan	2	546	5	18–67	9,828	36,582
North Sumatera	3	1,403	332	18–67	25,254	94,001
West Sumatera	1	200	6	18–67	3,600	13,400
Riau	2	1,590	299	18–67	28,620	106,530
Batam	8	1,328	251	18–67	23,904	88,976
Bintan	1	273		18–67	4,914	18,291
Jakarta	3	1,089	518	18–67	19,602	72,963
Banten—Cilegon	2	1,705	80	18–67	30,690	114,235
Banten—Serang	2	1,712	80	18–67	30,816	114,704
Banten—Tangerang	3	723	839	18–67	13,014	48,441
West Java—Bogor	2	240	72	18–67	4,320	16,080
West Java—Sumedang	1	200	1		3,600	13,400
West Java—Karawang	6	4,090	252	18–67	73,620	274,030
Central Java	7	1,766	973	18–67	31,788	118,322
West Java—Purwakarta	2	1,350	48	18–67	24,300	90,450
West Java—Bekasi	11	6,693	2,992	18–67	120,474	448,431
East Java	3	1,415	551	18–67	25,470	94,805
Total	**61**	**28,526**	**6,406**		**473,814**	**1,911,241**

ha = hectare, m^3 = cubic meter.

Sources: Water demand by ADB; industry data from Indonesia Industrial Estate Association as referred to by Indonesia Investment Coordinating Board (BKPM) in September 2012; http://www.bkpm.go.id/img/file/Paparan%20Kawasan%20Industri%20Indonesia%20(2012)%20english.pdf (accessed November 2014).

D. Water for Energy

The context of water use and demand for energy in Indonesia is mainly related to the specific use of and demand for water for generation of electrical energy by hydro, fossil fuel, and geothermal power plants.

Water Uses for Electric Energy Generation

An overview of water consumption for various energy generation systems is shown in Table 4.6. The total amount of water consumed in the energy sector is estimated at 2,825 MCM. This figure includes coal mining for domestic use but excludes water use by coal mining for export.

Table 4.6: Summary of Water Consumption for Power Generation

Fuel	Installed Capacity (MW)	Percentage of Total	Production per Year (MWh/year)	Percentage of Total	Water Consumption (m^3/MWh)	Water Consumption (MCM per year)
Hydropower	2,589	6.30	17.5	8.1	63.0	1,099
Coal	21,124	51.40	111.2	51.6	2.0	222
Oil	5,672	13.80	26.2	12.1	15.2	398
Gas	9,535	23.20	52.4	24.3	2.7	141
Geothermal	1,973	4.80	6.5	3.0	1.7	11
Biodiesel, solar	205	0.50	2.0	0.9	331.0	662
Coal mining (excluding export)						291
Total	**41,098**	**100**	**216**	**100**		**2,825**

m^3 = cubic meter, MCM = million cubic meter, MW = megawatt, MWh = megawatt-hour.

Note: Data from Royal HaskoningDHV projects.

Source: Asian Development Bank.

Biodiesel power is by far the largest water consumer with 331 m^3 per megawatt-hour (MWh) for palm oil feedstock. The second largest is hydropower with a water consumption of 63 m^3/MWh due to evaporation.

The average water consumption for power generation in 2012 was 13.09 m^3/MWh. This number will change when the energy mix changes over the years, when technologies are improved, or when the water–food–energy nexus results in a more efficient use of water.

Water Use for Hydropower

Currently, there are some 88 hydropower plants in Indonesia of 5 megawatt (MW) capacity and larger with a total installed capacity of 2,589 MW in 2011.[33] There are numerous smaller systems operated by private operators, and many new projects with a total capacity of over 3,000 MW are being prepared.

Water Withdrawal of Hydropower Plant

The water withdrawal of hydropower stations depends on the technology:

- Run-of-river projects: 6,000–12,000 m^3/MWh.[34] The water is fed through the turbines and discharged again to the river a few kilometers downstream.
- Reservoir systems: 3,000–7,000 m^3/MWh.[35] The water is discharged back into the river.

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[33] Kementrian Eenergi dan Sumber Daya Mineral (ESDM). 2009. Statistic ketenagalistrikan dan Energy; Indonesia Hydro Consult. 2014. *Small Scale Hydropower Plants in Indonesia.*

[34] ADB consultants' experience in Royal HaskoningDHV projects.

[35] T.H. Bakken et al. 2012. Water Consumption from Hydropower Production. Presentation for the Review of Published Estimates from the Norwegian University of Science and Technology. http://www.cedren.no/Portals/Cedren/Pdf/EcoManage/EcoManage_brukermote_2014_3_Vannforbruk.pdf?ver=2014-02-03-130012-053 (accessed November 2015).

Most existing plants are reservoir-type hydropower, but most future plants will be run-of-river projects. Currently, the water withdrawal by hydropower in Indonesia is estimated to be 52,000–122,000 MCM.

Water Consumption of Hydropower Plant

Storage of water behind large hydropower dams leads to consumptive water use through evaporation from the open water surface of the artificial lake. A study in 2011[36] determined the water footprint of 35 major dams in the world, including the Saguling reservoir near Bandung. This reservoir has 5,600 ha water area, 700 MW installed hydropower, and an evaporation of 63 m^3/MWh. Similar studies[37] in the United States show values of 47–208 (average: 68) m^3/MWh measured at the end consumer.

The water consumption is estimated as follows:

- Reservoir-type hydropower: With a current production capacity of 17.45 million MWh per year and a consumption of 63 m^3/MWh, the current water consumption is estimated to be 1,100 MCM.
- Run-of-river hydropower: We assume the area of these reservoirs is just 10% of the area of reservoir-type hydropower; the water consumption of run-of-river is approximately 6 m^3/MWh.
- Pumped storage: For the only pumped storage project in Indonesia, the Cisokan project, the Environmental Impact Assessment mentions the evaporation losses are estimated to be 15.3 MCM per year based on an average evaporation of 4.5 mm/day for the upper reservoir of 80 ha and the lower reservoir of 260 ha. The water consumption is 3.7 m^3/MWh.
- In-stream micro hydropower systems: neither water consumption nor withdrawal is measurable.

Water Use for Fossil Fuel Thermal Power

Over 87% of the total energy in Indonesia is produced by power plants that burn fossil fuel such as coal, gas, or oil to produce electricity. All systems consume significant amounts of water, in particular in the cooling water cycle (Figure 4.7).

Coal-Fired Power Plant

A typical coal plant with a once-through cooling system withdraws between 200 MCM and 600 MCM of water per year and consumes 1–4 MCM of that water.[38] A typical coal plant with a wet-recirculating cooling system withdraws only a fraction of water compared with that of a once-through-cooled plant but consumes up to 15 MCM per year, whereas a typical coal plant with a dry-cooled system consumes much less.

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36 M.M. Mekonnen and A.Y. Hoekstra. 2011. The Water Footprint of Electricity from Hydropower. *Value of Water Research Report Series*. No. 51. Delft: UNESCO-IHE.

37 P. Torcellini, N. Long, and R. Judkoff. 2003. *Consumptive Water Use for US Power Production.* Golden, Colorado: National Renewable Energy Laboratory (NREL).

38 T. Younos, R. Hill, and H. Poole. 2009. Water Dependency of Energy Production and Power Generation Systems. *VWRRC Special Report*. No. SR46-2009. Virginia: Virginia Polytechnic Institute and State University.

Figure 4.7: Different Types of Cooling Towers (using Natural and Mechanical Induced Draft)

Source: Royal HaskoningDHV.

In Indonesia, in 2012, 51.4% of electricity was produced by coal-fired power plants with a total capacity of 21,124 MW. There are 19 coal-fired power stations: 5 in Sumatera with a total capacity of 950 MW and 14 in Java with an installed capacity of 20,174 MW. Independent power producers own 33% of the total capacity. The state-owned National Electricity Firm (Perusahaan Listrik Negara) and PT Indonesia Power own the other 67%.[39]

Coal Mining in Indonesia

Indonesia is one of the world's largest producers and exporters of coal. A significant portion of this exported thermal coal is of medium quality (between 5,100 and 6,100 kilocalories per kilogram) and of low quality (below 5,100 kilocalories per kilogram) for which there is huge demand in the People's Republic of China and India.

The reserves are estimated by the Ministry of Energy to last around 80 years (from 2015) if the current rate of production is to be continued. Production, exports, and domestic sales are estimated to increase by at least 10% annually over the next 5 years. In 2013, the production was 421 million tons, of which 72 million tons were used domestically.

The water used for coal production is heavily polluted, and the water footprint of coal mining is estimated to be 0.164 m^3/giga joule (GJ).[40] An annual production of 421 million tons of coal, with an average caloric value of 23.4 GJ/ton in 2013, resulted in a total water consumption of 1,615 MCM in 2013. This amount would increase by 10% per year in the next decade.

39 Ministry of Energy personal communication.

40 P.W. Gerbens-Leenes, A.Y. Hoekstra, and Th.H. van der Meer. 2008. The Water Footprint of Bio Energy and Other Primary Energy Carriers. *Value of Water Research Report Series.* No. 29. Delft: UNESCO-IHE.

Gas-Fired Power Plants

Gas-fired power plants can either be a simple gas turbine or, in the most advanced layout, a natural gas combined cycle plant. Currently, 23.2% of the electricity supplied in Indonesia is produced by gas-fired power plants with a total capacity of 9,534 MW. There are 11 gas-fired power stations in Java, Sumatera, Sulawesi, and Kalimantan. Approximately, 33% of the plants use combined cycle with an average water demand of 1,200 l/MWh, with the remainder of the electricity being produced by gas steam turbine plants with a much higher average water demand of 4,500 l/MWh (Table 4.7).

Table 4.7: Water Requirements for Cooling by Type of Gas Turbine in Liters per Megawatt-Hour

	Once-Through Cooling		Closed Loop		Dry Cooling	
	Withdrawal	Consumption	Withdrawal	Consumption	Withdrawal	Consumption
Gas steam turbine	40,000–230,000	<1,200	3,600–5,500	2,500–4,400	0–150	0–150
Gas combined cycle	28,000–80,000	600–400	600–1,100	500–1,200	0–150	0–150
NGCC	0	0	0	0	0	0

NGCC = natural gas combined cycle.

Source: US Department of Energy (DOE). 2006. *Energy Demands on Water Resources: Report to Congress on the Interdependency of Energy and Water*. http://www.circleofblue.org/waternews/wp-content/uploads/2010/09/121-RptToCongress-EWwEIAcomments-FINAL2.pdf (accessed March 2015).

With a production of 52.35 million MWh, the total amount of water used is estimated to be 20.7 MCM for the combined cycle and 157.8 MCM for the gas turbines. The total water usage for gas-fired power plants is 178.5 MCM. The water consumption is estimated to be 142 MCM.

Oil-Fired Power Plants

The process is similar as with coal-fired power plants. However, the indicators show a much higher (10×) water consumption for oil power plants due to the larger amount of water consumed during the production and processing of oil in a refinery.

Most oil-fired power plants comprise thousands of small diesel generators that are mainly installed on the smaller islands. These systems are quickly being phased out as the operational costs are very high (expensive diesel) and cheaper alternatives are available. In 2012, 13.8% of the electricity being produced in Indonesia was still being generated by oil-fired power plants, and this percentage is set to fall to 5.5% in 2015.

The water usage is estimated to be 15,200 l/MWh.[41] This high number includes not only the cooling water but also the water which is required to process the oil/diesel in a refinery. With a production of 26.2 million MWh in 2012, the amount of water consumption is estimated to be 398 MCM.

41 Footnote 37.

Biomass Power Plants

It is estimated that Indonesia produces 146 million tons of biomass per year, equivalent to about 130.5 MWh of electricity per year. The biggest potential can be found in the Islands of Kalimantan, Sumatera, Papua, and Sulawesi. Studies assume that the main source of biomass energy in Indonesia will be rice residues with a technical energy potential of 48 MWh per year. Other potential biomass sources are residues from rubber wood, sugar processing, palm oil, plywood and veneer, logging, sawn timber, coconut, and also other agriculture wastes.

Currently, the major crop residues to be considered for power generation in Indonesia are from palm oil, sugar processing, and rice processing residues. Sixty-seven sugar mills are in operation in Indonesia and eight more are under construction or planned. Sugar processing in Indonesia produces 8 million ton bagasse and 11.5 million ton canes top and leaves.

Water use in the process of a biomass power plant is similar to the coal-fired power plant. The total life cycle water use is considered very large as a lot of water is needed to grow the biomass fuel. This often involves irrigation.

The conflict between food and energy is most clear in this sector. Worldwide policies are being developed so that food cannot be used for energy, and only waste materials may be used for this purpose. The materials used for biomass energy in Indonesia are presented in Table 4.8.

Table 4.8: Biomass Materials Used and Output Potential in the Present Situation

Industrial Sector	Waste Material	Amount (ton/year)	Potential (MWh/year)	Remarks
Sugar	Bagasse Cane tops and leaves	8,500,000 1,290,000	21.7	75 sugar mills in operation
Rice	Husk	12,500,000	47.8	
Palm oil	Shell Fiber Effluent Empty fruit bunches	3,450,000 6,700,000 31,000,000 12,900,000	18.6	5 million ha, 47 palm oil plants
Wood	Plywood, sawn, logging residues Rubber wood residues	8,346,000	5.5 33.2	
Others	Municipal solid waste		3.6	Estimated potential
Total			**130.5**	

ha = hectare, MWh = megawatt-hour.

Source: H. Saptoadi. 2012. Biomass Wastes and Biomass Technology in Indonesia. Presentation at the 4th International Symposium of Advanced Energy Science-Principle of Zero-Emission Energy. Kyoto, Japan.

The 2012 biodiesel production was 2 million MWh per year, although the potential is 130 million MWh, Biodiesel is mainly produced from palm oil. This 2 million MWh electricity, currently generated by biodiesel, requires 331 m^3/MWh of water, totaling 662 MCM, consisting primarily of the demand for producing the feedstock. The water demand for cooling the power plant is relatively negligible compared with the high number of 331 m^3/MWh.

Water Use for Geothermal Power

Indonesia's geothermal reserves are estimated to be 29 gigawatt (GW) from 285 identified locations. This is a rough estimate: today 2.39 GW is "proven," 0.82 GW is "probable," and the remaining capacity is "possible." At the moment less than 1.34 GW is installed, and this accounts for only 3% of the Indonesian energy mix. This percentage is expected to grow to 12% in 2020.

Indonesia had nine geothermal plants in 2013 with a total capacity of 1,344 MW, of which 1,142 MW was produced in Java. With an average of 1.68 m^3/MWh, these nine plants consume 12.8 MCM geothermal water per year.

E. Municipal Water Supply

The "improved" water sources most commonly used by Indonesian households are protected dug well (29.2%), borewell (24.1%), and piped water/water utility (PDAM) (19.7%). In urban areas, most households are using bored well (32.9%) and PDAM (28.6%), whereas in rural areas the protected dug well is most common (32.7%).[42]

WHO–UNICEF definition for an "improved" drinking-water source is one that, by the nature of its construction and when properly used, adequately protects the source from outside contamination, particularly fecal matter.

Improved drinking water is water from a piped network, public tap or standpipe, tube well or bore well, protected dug well, or rainwater collection.

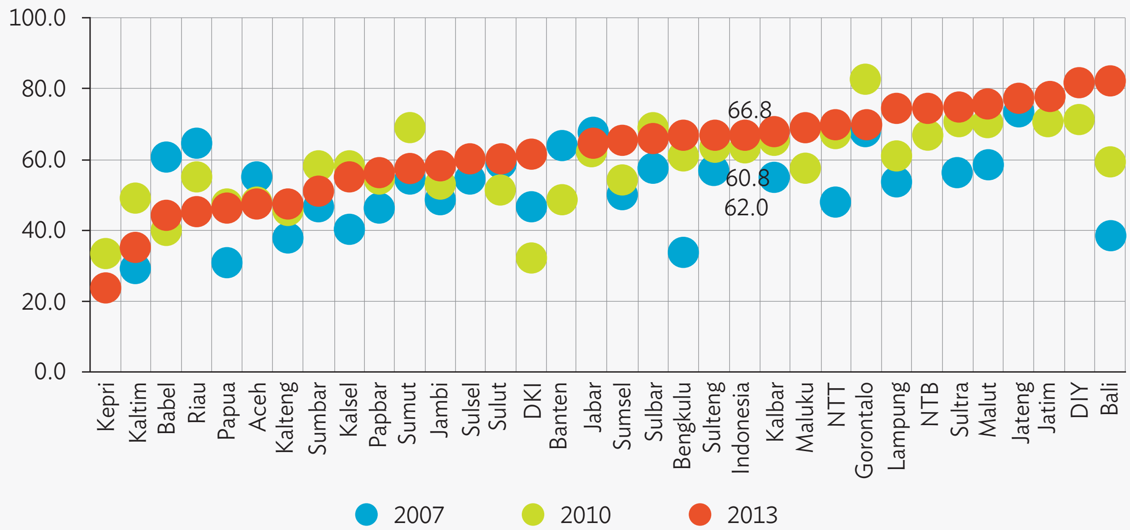
Unimproved drinking water is water from an unprotected dug well or spring, cart with small tank or drum, tanker truck, and surface water or bottled water.

The proportion of households that has access to improved drinking water source in Indonesia is 66.8% (urban 64.3%; rural 69.4%). The proportion of improved drinking water is highest in Bali (82.0%) and lowest in Papua (45.7%). Figure 4.8, presenting the percentage of households with access to improved drinking water, shows that there is an incremental tendency of the percentage of households having access to "improved" drinking water sources; in 2007 this was 62%, in 2010 it increased to 62.9%, and it reached 66.8% in 2013.

Most of the municipal water supply is served by PDAMs, which are local, government-owned utility companies. A Support Agency for the Development of Drinking Water Supply Systems (*Badan Pendukung Pengembangan Sistem Penyediaan Air Minum*) report on 2011 PDAM Performance reports a PDAM coverage of only 37% of the population in the service area. Most of the PDAMs rely on river water for a source.

42 Badan Penelitian dan Pengembangan Kesehatan (National Institute of Health Research and Development). 2013. *Riset Kesehatan Dasar* (Basic Health Research). Ministry of Health. Jakarta.

Figure 4.8: Percentage of Households Having Access to Clean Water in Each Province



Source: Badan Penelitian dan Pengembangan Kesehatan (National Institute of Health Research and Development). 2013. *Riset Kesehatan Dasar* (Basic Health Research). Ministry of Health. Jakarta.

F. Sanitation

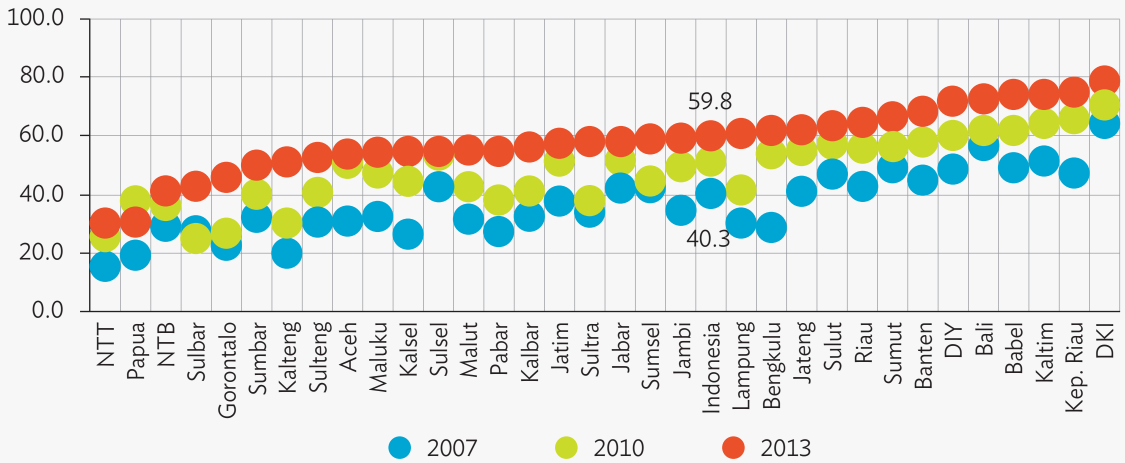
In the Medium Term Development Plan, 2010–2014 the following sanitation targets are mentioned: (i) Indonesia to be 100% open defecation free; (ii) 10% of the total population to use off-site wastewater management systems; and (iii) 90% of the population to have improved onsite or shared facilities.

According to the 2013 *Riskesda* results, currently 76.2% of the households have a private toilet facility, 6.7% are using a communal toilet, and 4.2% are using a public toilet. The remaining 12.9% of the households still do not use a toilet for defecation. Only 58.9% of the population has access to improved sanitation (Figure 4.9).

The WHO–UNICEF Joint Monitoring Program criterion for "improved" sanitation facility is a facility that hygienically shields human excreta from human contact. An improved sanitation system can be a flush or pour flush attached to a piped sewer system, a septic tank, or a pit latrine, and uses a ventilated improved pit latrine, a pit latrine with slab, or a composting toilet. All other systems are considered "unimproved."

The predominant wastewater management technology in urban Indonesia is the septic tank. Moreover, most of the septic tanks in Indonesia are in fact *cubluks* (i.e., one compartment, lined but open bottomed pits) that rely on wastewater absorption in the subsoil and overflow to water bodies. More than 60% of the households with wells also have a septic tank (either their own or that of the neighbor) located within less than 10 meters of the well, posing a potential contamination hazard. There are no national or local regulations governing septic tank sludge management or disposal.

Figure 4.9: Percentage of Households with Access to Improved Sanitation



Source: Badan Penelitian dan Pengembangan Kesehatan (National Institute of Health Research and Development). 2013. *Riset Kesehatan Dasar* (Basic Health Research). Ministry of Health. Jakarta.

In rural areas, less than 30% of households have toilet facilities and only about 20% are served by septic tanks or *cubluks*: an unsealed tank or soak pit also referred to locally as a septic tank. About 14% of the population still practices open defecation.

There are limited centralized sewerage systems. At this moment, centralized piped system sanitation can only be found in a few cities.

Although sanitation systems are referred to as "improved" in practice, the sewage is rarely treated. In fact, of all sewage produced in Indonesia, only less than 5% is actually properly treated. Most sewage is discharged untreated into surface and groundwater systems, resulting in massive pollution of valuable resources.

G. Water for Navigation

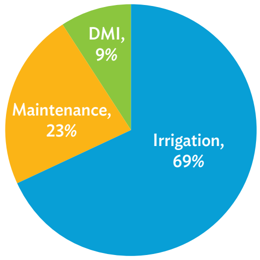
There are more than 10,000 kilometers of navigable waterways among 50 river systems. Over half of these rivers are in Kalimantan and the rest in Sumatera and Papua. These were originally used mainly for long-haul transport. Most of the vessels and terminals on the inland waterways system are owned and operated by the private sector.

Some infrastructure improvements have been carried out, such as the construction of new wharves, dredging of river channels at several river ports, and installation of navigational aids. However, because of the high seasonal variation in the water level of many rivers, without further investment for the improvement of crucial sections, the role of inland waterways is relatively minor and is limited to certain areas of Sumatera, Kalimantan, and Papua.

Box 4.1 describes the overview of Indonesia's water demand and uses.

Box 4.1: Overview of Demands and Uses

Existing Water Demands in Java (m^3/s)



DMI = domestic, municipal and industrial demand, m^3/s = cubic meter per second.

Source: Deltares et al. 2012. *Java Water Resources Strategic Study*. Report submitted to the World Bank.

Water demand and use in Indonesia is concentrated on Java where most people live, most commercial activities take place, and the most rice is produced. Java is the only Indonesian island that is a net importer of virtual water through its trade with other islands. Due to the abundance of water resources, actual demand is still well below the potentially available resources in the river basins.

Water Demand for River Flow Maintenance

In accordance with Regulation No. 38/2012 on Rivers, the water required for maintenance flow is determined as the mean flows exceeded 95% of the time (Q95) of the natural river flow for the month with the lowest average flow. In Kalimantan and Papua, the maintenance flow is larger than any other use.

Water Demand for Agriculture (Irrigation)

The total water requirement of agriculture in Indonesia is estimated to be around 3,500 billion cubic meters (m^3) per year, or 11,000 m^3 per second (s).[a] However, most agriculture is rain fed. Only about 17%–20% of agriculture relies on irrigation. Irrigation water demand (mainly from rice production) is about 5,441 m^3/s: 87% is supplied using diversion of rivers, 12% is provided from reservoirs, and 1% from groundwater. The relative low volume of reservoirs results in drought vulnerability. Poor operation and maintenance of irrigation infrastructure limits the effectiveness of irrigation schemes, especially those under Provincial or Kabupaten responsibility.

Water Demand for Domestic, Municipal, and Industrial Use

Domestic, municipal, and industrial demand is estimated to be 240 m^3/s: 64% of urban population and 69% of rural population have access to improved water supply, albeit more than half being obtained from dug or bored wells. Water supply companies provide less than 30% of clean water supply. Urban water demand, including commercial and social uses, is strongly increasing with the high urbanization rate in Indonesia, putting a huge stress on water utility as groundwater in urban areas is often already overused.

Sanitation is very poorly developed in Indonesia, with only about 5% of septage being properly treated. Most septage is drained into the groundwater through poorly functioning "septic tanks" or is drained into waterways and rivers. As a result, groundwater and almost all rivers are heavily polluted. This subsequently limits its use as a drinking water source downstream.

Water Demand for Energy Production

Water demand for energy production ranges from 2 m^3 per megawatt-hour (MWh) to 331 m^3 per MWh. Most demands fall within the range for industrial facilities, but hydropower (63 m^3/MWh) and biodiesel (331 m^3/MWh) require more water. Biodiesel production does not rely on irrigation, but it competes with food crops for land rather than water. Hydropower potential in existing and future infrastructure is promising when multiple uses are promoted.

[a] Estimated update based on: F. Bulsink, A.Y. Hoekstra, and M.J. Booij. 2009. The Water Footprint of Indonesian Provinces Related to the Consumption of Crop Products. *Value of Water Research Report Series.* Vol. 37. Delft: UNESCO–IHE.

chapter five

MANAGING WATER

A. Units of Government

Administrative Hierarchy

A brief inventory of central government ministries involved in water, directly or through delegated subnational departments, is given below.

Table 5.1: A Brief Inventory of Central Government Ministries Involved in Water

National Agency	Water-Related Responsibilities
State Ministry of National Development (BAPPENAS)	Responsible for national development planning matters, and this is undertaken through five-year plans in cooperation with the line ministries.
Ministry of Finance	Responsible in terms of government financing of water resources management (WRM) through the normal government budgeting processes.
Ministry of Foreign Affairs	Responsible for the management of transboundary (transcountry) river basins in so far as the management affects international relations and national government's foreign affair policies.
Ministry of Public Works and Public Housing	Responsible for WRM, including *dam safety and standard operating agreements* such as for hydropower developers. Owns and operates *river infrastructure* (multipurpose dams, weirs), *primary and secondary canals* of irrigation system; Directorate General *Cipta Karya* responsible for *water supply and sanitation*.
Ministry of Mines and Energy	Responsible for *groundwater management*, including management and monitoring of the resource, both with regard to quantify and quality; licensing of groundwater drilling and use; maintaining databases of groundwater use, etc. The ministry is also responsible for *hydropower development* and may own *and operate hydropower* systems according to standard operating agreements.
Ministry of Agriculture	Responsible for food production, farmer welfare, sustainable agriculture, and economic development through agriculture.
Ministry of Environment and Forestry	Responsible for *management of water quality* through controlling pollution and river zoning (water quality targets in river reaches) and watershed management, including land use planning in watershed areas as well as its responsibilities for promoting and regulating the forestry sector. It is also responsible for *Environmental Impact Assessment* of major projects.
Ministry of Home Affairs (Interior Ministry)	Responsible for the domestic governance, public order, and regional development at provincial and district levels. This includes *decentralization* of policies and laws and local autonomy, and increasing *community empowerment* and poverty reduction.
Ministry of Transport	Responsible for transport facilities, infrastructure, community access, and quality of services. This includes *navigation on rivers and lakes*.
Central Statistics Agency	A nondepartmental government responsible for the provision of *basic statistical data*, both for the government at all levels and for the general public.
Ministry of Agrarian and Spatial Planning	Responsible for formulation of land policies and spatial policies and, in relation to WRM, land mapping, land titles, and rights over land.

continued next page

Table 5.1: *Continued*

National Agency	Water-Related Responsibilities
Ministry of Marine Affairs and Fisheries	Responsible for increasing the contribution of the marine and fisheries sector to national economic growth.
Ministry of Health	Responsible for the protection and improvement of public health. The ministry sets standards and monitors drinking water quality.
Ministry of Enterprises	Responsible for state laws and regulations in relation to the Limited Liability Companies Act and for monitoring and improving the competitiveness of state-owned enterprises, including state-owned enterprise Jasa Tirta.

Source: Asian Development Bank.

River Basin Management

Efforts to form river basin organizations (RBOs) in Indonesia started in the 1990s. Supported by projects, the institutional reforms were addressed and focused on fostering basin operations with integrated water resources management (WRM), and this resulted in the establishment of river basin WRM agencies (Balai PSDA[43]) in the provinces of Java around 1998. After that the government continued the development of the agencies outside Java. The river basin authorities under central government (Large River Basin Organisation and River Basin Organisation) were established in 2006 (Table 5.2).

Table 5.2: Distribution of Responsibility for River Basin Organizations

Management Responsibility	River Basin Organizations	River Basins (WS)
Central control	33 (31.7%)	63 (48%)
Provincial control	57 (54.8%)	53 (40%)
Districts/city control	14 (13.5%)	15 (12%)
Total	**104**	**131**

WS = wilayah sungai (river basin).

Source: Ministry of Public Works. Ministerial Decision No. 02. 2013. Jakarta.

The Indonesian government has established two *Perum Jasa Tirta* (PJTs). The principal purpose for establishing these enterprises is to recover costs for providing services (operation and maintenance [O&M]) and to provide services in a business-like and professional manner. PJTs are established as state-owned enterprises as the operator of river water resources infrastructure on a commercial basis and to provide high-quality service to water users. In addition to managing river infrastructure, they may also provide other services, including river bank protection works, control of sand and gravel mining in rivers, and irrigation system management. Fees for service (O&M) are collected from water users (hydropower operators, urban water users).

[43] PSDA stands for *Pengelolaan Sumber Daya Air* (Water Resources Management).

To build integration and synergy among the stakeholders, operational WRM activities are coordinated through a coordination forum at the level of the river basin called the river basin WRM council or basin council. The basin council has government and nongovernment members. The WRM policies are coordinated among stakeholders in the water (resources management) council. The water council has several levels: the national water council, the provincial water council, and the district or city water council.

The presence of water users such as farmer unions (WUA/P3A) and the association of water supply company (Perpamsi) as coordination forum members are assured by Minister of Public Works Regulation No. 04/PRT/M/2008 on guidelines for the establishment of a coordination forum of WRM and their role is quite active in conveying their views and proposals.

B. Policies and Strategies

The main policies and strategies are presented in the long-term development plan 2005–2025 (RPJPN) that functions as the direction in the preparation and the national medium-term development plan (RPJMN), which is further detailed in the annual plans. A few relevant components are as follows:

- economic development is directed to the use of environment-friendly services that do not accelerate degradation and environmental pollution. Restoration and rehabilitation of prioritized environmental conditions are targeted in an effort to increase the carrying capacity of the environment to support sustainable development;
- stimulate the economy by strengthening the domestic economy to be globally oriented and competitive; and
- adequate and modern infrastructures.

Specifically for the management of water resources, the government set a Presidential Regulation (PerPres 33/2011) on the national policy of water resource management from 2011 to 2030.

C. Legal and Regulatory Framework

There are many laws and regulations that are relevant to the water sector. Almost all ministries have a relation with water resources. The most important of these laws for the water sector was Law 7/2004. It is a framework law, which means that government regulations must further elaborate the general provisions. Given the complexities of the water resources environment involving different technologies, communities, levels of government, and a wide variety of stakeholders, the Government of Indonesia has elected to issue separate regulations on the different aspects of WRM. Nine of these were already in force, whereas a few were still in preparation. The decision to elaborate the different but interrelated aspects of water management in separate government regulations has resulted in overlaps and gaps.

On 18 February 2015, the constitutional court, through its Decision No. 85/PUU-XI/2013, canceled the applicability of the Water Law UU 7/2004, stating that Water Law 7/2004 was contrary to the 1945 Constitution. To fill the legal vacuum during the process of drafting a new water law, the constitutional court reinstated the old Water Law UU 11/1974.

As can be expected, there are gaps between UU 11/1974 with the existing regulations related with water governance. It is, therefore, necessary to develop fast and simple regulations that can facilitate the bridging between UU 11/1974 and other laws related to the governance of water resources. Definitions are also a problem as there are some different terms used in UU 11/1974 compared to the terms used in the existing other legislation relating to the water governance.

Overview of the Law 11/1974 and its derivative regulations

The Water Law 11 of 1974 on water resources has the following characteristics: simple, but it can include fairly distant future prospects; contains policies as the basis for further implementation regulations; and covers all aspects of water resources.

The fundamental principles of the law encompass:

(i) water and its sources, including natural resources contained in it, are the gift of God Almighty, which has versatile benefits fulfilling human needs of all times, both in the economic, social and cultural aspects;

(ii) earth, water, and natural resources contained in it are controlled by the state and are used for the greatest prosperity of the people in a fair and equitable way; and

(iii) commercial operation of water resources should be devoted to the interests and welfare of the people while creating growth, social justice, and the ability to be autonomous in a just and prosperous society based on *Pancasila*.

Adaptations Needed

Adaptation of the old law is needed with regard to harmonization of definitions, establishment of governance and authority, building synergies and integration, O&M, conservation, financing, commercial operation, public participation, and disaster management.

While drafting a new legislation in water law, the following considerations are relevant:

(i) the decision of the constitutional court regarding the right of control by the state over the water, which forms the crux of the law, should be manifested in the laws and their derivatives;

(ii) the bureaucratic reforms 2010–2025 regulated in the Presidential Regulation (PerPres 81/2010);

(iii) proper design of structure of the new water law and their derivative regulations;

(iv) consistency of the subjects of government regulation must be maintained; and

(v) preparation of all derivative regulations of the water law should be completed in 5 years.

Water Allocation

A water allocation plan is prepared every year for each river basin by the RBO with reference to the guidelines established by the Minister of Public Works and the involvement of the community through the basin council. The prepared annual water allocation must be approved by the minister of public works/governor/regent/mayor in accordance with their authority.

So far, the guidelines for the preparation of water allocation plans have not been approved by the relevant authorities. The Director General of Water Resources issued a circular, No. 04/SE/D/2012, on the preparation of technical guidelines for the implementation of water balance and water allocation to support large river basin organisation/river basin organisation to prepare the water allocation plans.

The limited ability of human resources in the management unit of the RBO is one of the causes of annual water allocation plans not being able to pass through the screening prior to being approved by the authorities. The fact that no formal water allocation plans exist negatively affect the efficiency of water use and causes conflicts between the water users and between regions.

Costs of Water

Indonesia has two systems for charging water users for water services: service fee for water resources management (SFWRM)[44] and fee for processed drinking water by water utility (PDAM).

The SFWRM is applied when there are efforts to conserve water resources and facilitate utilization of water through the development of infrastructure, such as dams and canals, by which the dammed water can be delivered continuously to the water users. The users include farmers (irrigation), PDAMs, industries, and hydropower generators (for dams). When the raw water is processed into drinking water by PDAM, the fees to be charged to customers are regulated in MoHA Regulation (Permendagri) 23/2006 regarding *The Technical Guideline and Procedure of Water Tariff for PDAM*.

Service Fee for Water Resources Management

In order to build, operate, and maintain new infrastructure, the SFWRM fee can be utilized. For this purpose, organizations such as the Technical Implementation Unit (UPT/Balai) BUMN/BUMD (government-owned enterprises) or a special purpose PT/Limited Company is formed. The fees are used for covering of the costs comprising (i) depreciation costs, (ii) amortization and interest rate in case of a loan, (iii) O&M costs, and (iv) development costs (as regulated by PP 42/2998 regarding WRM). These fees are not used to cover the capital investment costs when the infrastructure is financed by the government as sunk cost. The SFWRM is calculated as the total operating costs divided by the volume of water produced.

The Asian Development Bank, through the 2012 TA 7189-INO report "Service Fee for Bulk Water Supply from Citarum," suggested using a new approach called the long-run marginal cost, which takes into account the whole economic life of an investment.

[44] PP 42/2008 regarding Water Resources Management, Article 116(1).

Tariff of PDAM

Water supply by PDAMs generally serves 55% of the urban areas, and the remaining 45% is catered to by shallow wells. The source of raw water of PDAMs is mostly the surface water (river/canal) but sometimes deep wells as well, sourced through electric pumps. In rural areas, the provision of drinking water (sourced mostly from rivers, shallow wells, and water springs) is sometimes done by the community-based organization (CBO). As of now, tariff charged by the CBO for drinking water is not regulated. The tariff charged by the CBO is determined with the consent of the users.

Tariff for Sanitation

A few cities have regulations for the management of septage and charge fees for solid waste/sanitary service and septic tank desludging services. In reality, however, these regulations often do not provide proper wastewater and septage management. Palembang neither has septage treatment plant nor an official septage disposal facility. The tariffs for septage collection are Rp60,000–Rp80,000 per cubic meter, and Rp30,000–Rp40,000 per cubic meter for disposal by truck.

D. Community and Private Sector Participation

Community participation in the management of water resources is still limited. This is caused by a lack of knowledge and understanding of communities and businesses in the management of water resources and a lack of encouragement from WRM institutions, resulting in decreased attention toward sustaining water resources, especially O&M of facilities and water resources infrastructure.

The policy of restriction or moratorium on the acceptance of civil servants has impacted the management of water resources, especially in the O&M of water resources, including irrigation. This is related to the government policy of focusing only on the role of the regulator and the facilitator, whereas the role of the operator is entrusted with the public and private sectors.

Community and business involvement in WRM is very important as the need for public services is likely to increase. The role of the corporate RBO and implementation of service contracts for O&M should be considered using legal entities formed in local communities.

E. Knowledge and Awareness

Ministerial Research Institutes

Every ministry in Indonesia has a Research and Development Institute (*Badan Penelitian dan Pengembangan*) tasked with developing, maintaining, and disseminating knowledge and innovations in the relevant fields. Often, there are several specialized Research and Development Centers (PusLitBang) in each ministry.

Indonesia Institute of Sciences

Indonesia Institute of Sciences (LIPI) is a nondepartmental research institution of the government, and it is also one of the five non-ministerial government institutes (*Lembaga Pemerintah Nondepartemen*) coordinated by the State Ministry of Research and Technology (*Kementrian Negara Riset dan Teknologi*). The mission of LIPI is to master science and technology in the incessant efforts toward strengthening national unity and vitalizing the competitiveness of the nation.

Center for River Basin Organizations and Management

Indonesia hosts the Regional Water Knowledge Hub for River Basin Organizations and Management (CRBOM), which is an alliance of agencies of the Government of Indonesia, comprising the Ministry of Public Works' Directorate General of Water Resources, the Ministry's Research and Development Agency, and two corporate-type RBOs—Jasa Tirta Public Corporations I and II. These entities have decades of experience establishing and operating public-utility-type and corporate-type RBOs; planning and developing water resource use and conservation; managing technical, financial, and management issues associated with RBOs and their management; operating and maintaining water resource infrastructure; managing watersheds and river environments; and conducting research and development in hydrology, hydraulic structures and geotechnical engineering, river engineering, and sediment management. The activities of the CRBOM will be implemented through the Network of Asian River Basin Organizations in collaboration with the Network of Asian River Basin Organizations secretariat partners—the Japan Water Agency (JWA), the Asian Development Bank, and the Asian Development Bank Institute.

The CRBOM aims to provide local, regional, and national-level government agencies; RBOs; water service providers; and others with the most reliable, effective, and practical information; analysis; advice; and capacity-development services in the field of RBOs and their management.

Box 5.1 summarizes the main water governance issues in managing water in Indonesia.

Box 5.1: Summary of Main Water Governance Issues

Integrated water resources management in Indonesia is already quite advanced, because it has a strong legal and institutional framework. Modern legislature is provided by Water Law 7/2004 and related government regulations. Indonesia is subdivided into 131 comprehensive water resources management (WRM) units (river basin territories or *wilayah sungai*). For all of these river basin territories, a responsible river basin organization (RBO) has been established or appointed, and for most of these river basin territories, a WRM plan has been prepared, or is in the advanced stage of preparation, according to the "one basin, one plan, and one management" principle.

Most of these river basin territories have a stakeholder platform, which regularly convenes and deals with WRM conflicts and is involved in the formulation of the basin plan or regular reviews. Spatial planning and water resources planning recognize their mutual relation and the need for coordination. However, the systems still have a number of weaknesses.

continued next page

Box 5.1 Continued

Development and management of water resources is spread over many different sectors: WRM of surface water resources is still mostly by the Ministry of Public Works, DG Water Resources; groundwater is managed by the Ministry of Mining; conservation of land and water is mainly the responsibility of the Ministry of Forestry; conservation of water quality is dealt with by the Ministry of Environment; utilization through piped water supply is mainly the responsibility of MPW Directorate of Human Settlement (Cipta Karya); utilization for agriculture is the responsibility of the Ministry of Agriculture, or Horticulture, or Fisheries, etc., with each of these ministries assisted by relevant provincial or district/city agencies.

The Water Law 7/2004 was recently canceled, and the prevailing Law 11/1974 needs to be revised in the short term to enable continuation of the main regulations awaiting a new water law. Priorities are adherence to the leading principle of state control over water resources, inclusion of bureaucratic reform principles, consistency in used terms, and speedy implementation of regulations.

Irrigation management is also carried out jointly by the central, provincial, and district governments. River basin water distribution is carried out by Large River Basin Organisation/River Basin Organisation (central government), BPSDA (provincial government), DPU (district government), and state-owned enterprise Jasa Tirta (PJT) (corporate RBO). The performance of PJT I and PJT II (the corporate RBOs) are better than large river basin organisation and/or river basin organisation. However, so far the role of PJT is limited to only 4.6% (six of 131) of the river basins. Therefore, it is important to develop the role of the corporate RBO to improve WRM and financing.

The wholesale and retail of water resources are implemented in a mixed manner at several levels, creating a complex system with overlaps and gaps in the implementation of tasks and functions among the water resources agencies, thereby rendering the management of water resources ineffective and inefficient. In the short term, it is necessary to develop role-sharing agreements between the water resources agencies to synchronize programs and activities. Public Works Ministerial Guideline 06/SE/M/2011 aims at a simplified and higher-level role of sharing agreements; however, it is not widely implemented.

Also, financing of development and management is distributed over many sectors, which leads to high competition between the different sectors, making it difficult to realize synchronized activities. Focus of budgets is politically biased and therefore usually not consistent (preferring highly visible projects over less visible routine maintenance) with frequent high fluctuations (high budgets for flood management after floods have occurred, declining in the years after that when no more floods occur). The competition between irrigation and energy development in the Cisadea–Cibareno river basin illustrates the lack of coordination. The Caringin irrigation area of 1,500 hectares is developed by the West Java provincial government located in Sukabumi, whereas the construction of small-scale power plants (microhydro power) of 45 megawatts is managed by the Banten provincial government located in the district of Lebak.

Most budgets are not enough to cover identified basic needs. Common investments and regular operation and maintenance (O&M) are separated and provided from different channels, which does not support more sustainable life-time approaches for setting priorities (higher investments to optimize benefits and/or reducing cost for O&M). Budget for O&M must be provided by local governments as responsible managers, whereas the central government can help through a special allocation fund for rehabilitation of irrigation networks, though not for O&M. The special allocation fund is limited and consequently leads to deterioration in the condition of irrigation networks, especially those managed by the district or city.

Accountability of all the different services is mostly oriented toward higher command levels within the sector, and concerns mostly annual budgets provided and used. Accountability hardly covers performance concerning quantity and quality of the services provided, and only minimal information is provided to the users and stakeholders. This is amplified because there is hardly a framework for cost recovery, and most services are provided completely (conservation, irrigation, flood management) or partly (piped water supply, hydropower) through subsidies. This does not stimulate the users to contribute in kind or in cash.

Source: Asian Development Bank.

chapter six

FUTURE SCENARIOS

A. Trends and Drivers

In its economic quarterly, the World Bank predicted that over the next decade, four domestic and external factors—which good policies can turn into powerful drivers of growth, or "pull factors"—will shape economic prospects in Indonesia.[45]

(i) **Demographics:** Indonesia has abundant labor. Between 2013 and 2020, the working-age population in Indonesia will increase by 14.8 million, reaching 189 million from the 174 million as of 2015. In 2014, 50% of the population is under the age of 30. This increasingly educated youth, exposed to information technology, is an asset that can be used to boost overall productivity and economic growth.

(ii) **Urbanization:** In Indonesia, which is one of the most rapidly urbanizing countries in the world, urbanization is increasing at an annual pace of about 4%. By 2025, 68% of the population is projected to live in urban areas against 52% in 2012 according to UN projections. As income levels increase and the existing large metropolitan areas such as Jakarta and Surabaya become saturated, the demand for consumer durables, shopping space, and housing will increase significantly in smaller cities.

(iii) **Softening of global commodity prices:** The share of manufacturing in total investment dropped to 12% in 2002–2011 against almost one-fifth in 1990–1996. Going forward, lower commodity prices should increase the relative profitability and attractiveness of (noncommodity-related) manufacturing and can help Indonesia develop its industrial base.

(iv) **Rapidly rising wages in the People's Republic of China (PRC):** It presents Indonesia with a potential second chance in regaining a comparative advantage in labor-intensive export sectors. The nominal wages in the PRC have grown by an annual average of almost 15% since 2001 which, together with slowing productivity growth in low-skilled sectors in recent years has seen PRC unit labor costs grow by almost 70% since 2005.

In relation to water, population growth, urbanization, and the needs related to water supply, energy and food security for the population are the dominant factors.

[45] World Bank. 2014. *Indonesia Economic Quarterly*. March.

B. Population Growth and Domestic, Municipal, and Industrial Water Demand

The population predictions of Statistics Indonesia (Table 6.1) show the combined effects of local growth, migration within the region, and migration between regions. The relative growth is the highest in Maluku–Papua and Kalimantan, although in absolute numbers the growth is still the largest on Java. Urban growth is particularly high in Java and Sumatera, whereas Java shows the highest decrease in rural population (both in absolute numbers as well as percentage). Note that the urban areas of Sumatera and Kalimantan will more than double in size in 20 years with Bali and Sulawesi showing very high growth as well.

Table 6.1: Population Predictions by Statistics Indonesia per Main Island Group (in millions)

	2010			2015			2025			2035			Growth, 2010–2035 (%)			Absolute Growth, 2010–2035 (%)		
Islands	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
Sumatera	19.9	31.0	50.9	22.9	32.3	55.3	29.3	33.5	62.9	35.7	32.8	68.5	80	6	35	15.8	1.8	17.6
Java	80.2	56.8	137.0	91.1	54.0	145.1	111.9	46.8	158.7	129.8	37.5	167.3	62	−34	22	49.6	−19.3	30.3
Bali and NT	5.1	8.0	13.1	6.0	8.1	14.1	7.9	8.0	15.9	10.0	7.5	17.5	94	−6	33	4.8	−0.4	4.4
Kalimantan	5.9	8.0	13.9	7.0	8.4	15.3	9.5	8.6	18.1	12.3	8.0	20.3	109	1	47	6.4	0.1	6.5
Sulawesi	5.9	11.6	17.4	7.0	11.8	18.7	9.5	11.6	21.0	12.1	10.6	22.7	107	−9	30	6.3	−1.0	5.3
Maluku-Papua	1.8	4.4	6.2	2.1	4.7	6.9	2.9	5.3	8.2	3.7	5.6	9.3	104	27	50	1.9	1.2	3.1
Total	**119**	**120**	**239**	**136**	**119**	**255**	**171**	**114**	**285**	**204**	**102**	**306**	**71**	**−15**	**28**	**84.8**	**−17.7**	**67.1**

NT = Nusa Tenggara.

Source: Statistics Indonesia. 2013. Proyeksi Penduduk Indonesia (Indonesia Population Projection) 2010–2035. Badan Pusat Statistik, Jakarta-Indonesia.

Figure 6.1 shows the predicted yearly available surface water per capita for (sub) basin in Sulawesi, Sumatera, and Java. The impact of the very high population in Java is clear. The average in Sumatera (13.300 m^3/cap) and Sulawesi (12.400 m^3/cap) is 10 times the average of Java (1.484 m^3/cap).[46] For comparison, urban use of 200 liters per capita per day (l/c/d) equals 73 m^3/capita.

Domestic Water Demand

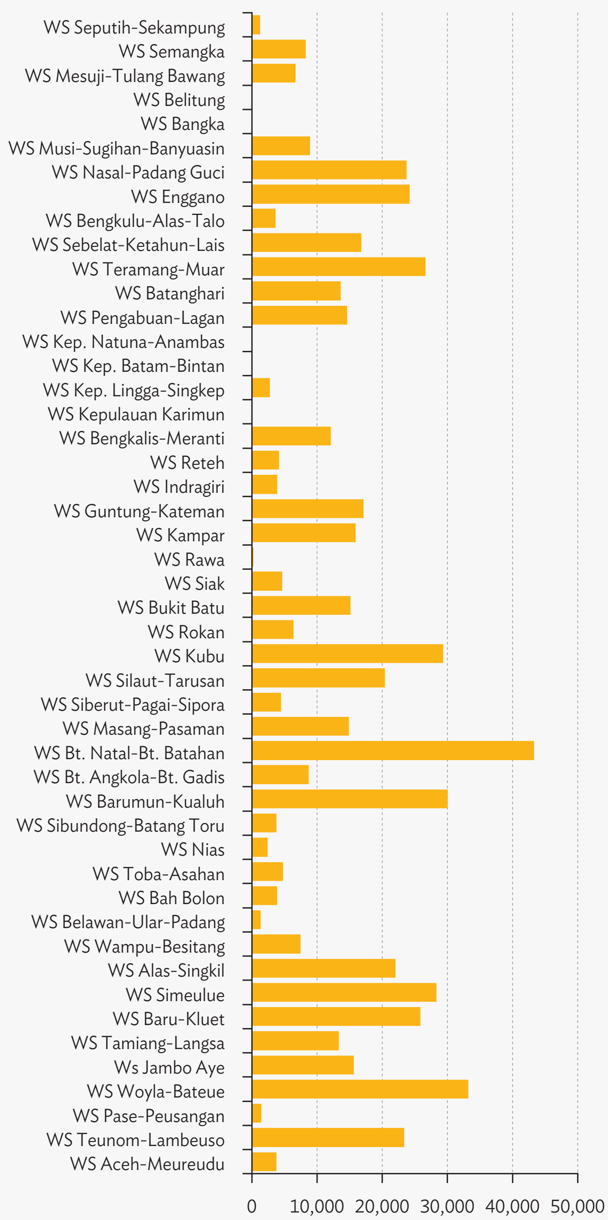
The domestic water demand (see Figure 6.2) is calculated with the assumption that all people will use water through managed or unmanaged systems. Unmanaged systems can include rainwater, dug wells, lakes, or rivers, the sources of which are usually untreated. The managed system is a piped system managed by PDAMs or by the community themselves. This water demand projection is calculated with the assumption that the average per capita demand in urban areas is 120 l/c/d and that in rural area is 80 l/c/d.

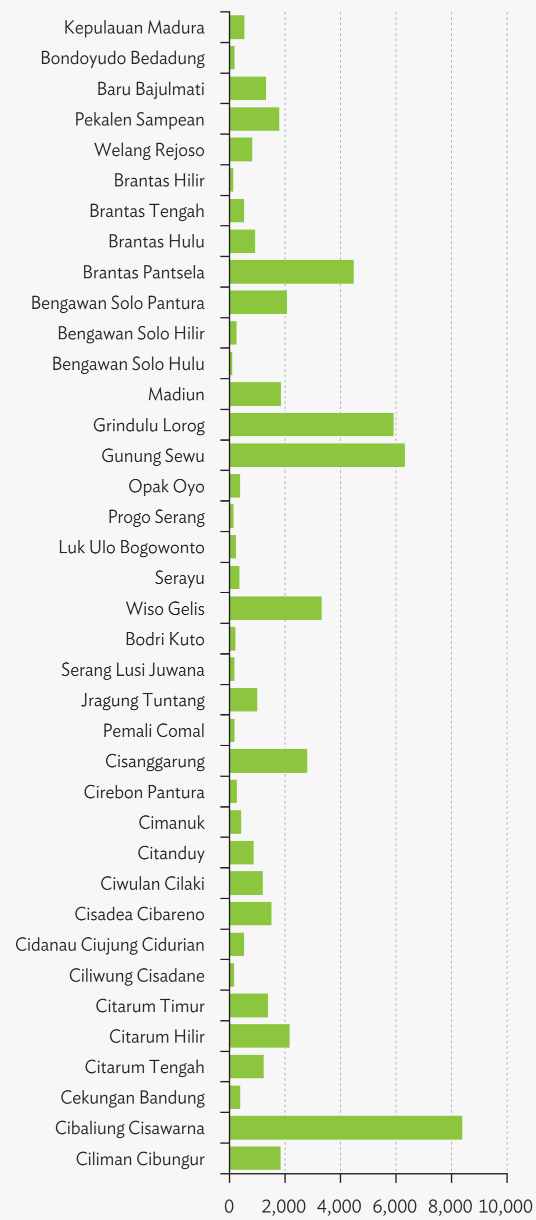
[46] BPS population predictions per Kabupaten projected to river basins in this study and JWRSS (Java).

The urban domestic demand is predicted to rise from about 205 m^3/s in 2015 to 283 m^3/s in 2030, whereas the rural demand will decline from 100 m^3/s to 86 m^3/s.

The growth in the demand for sanitation is directly related to population growth. Figure 6.1, therefore, provides a perfect prediction of the growth in sanitation needs in urban and rural areas.

Figure 6.1: Predicted Available Water per Capita in the River Basins of Sumatera and Java, 2035 (m^3)

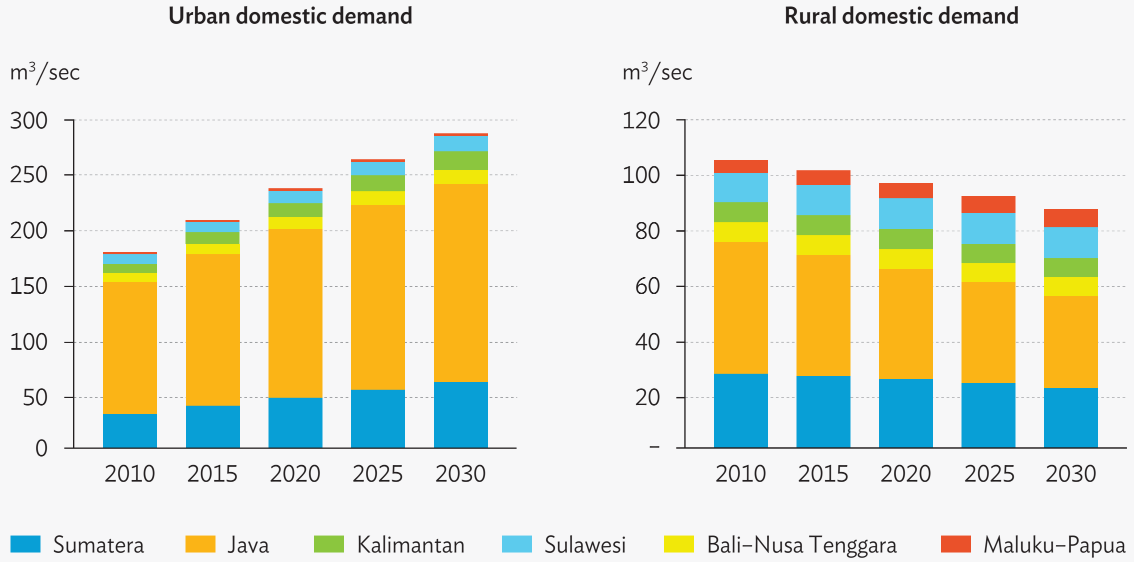




Note: Available water from Hatmoko et al. 2012; population predictions based on Statistics Indonesia.

Sources: W. Hatmoko et al. 2012. *Neraca Ketersediaan dan Kebutuhan Air pada Wilayah Sungai di Indonesia Puslitbang SDA Bandung* (Water Balance of Water Availability and Water Demand in Indonesia River Basins, Water Resources Research Agency, Bandung); Statistics Indonesia predictions and for Java improved with Java Spatial Model.

Figure 6.2: Predicted Urban and Rural Domestic Water Demand



m^3/s = cubic meter per second.

Note: Assuming a per capita urban demand of 120 liters/day, and 80 liters/day for rural areas.

Source: Statistics Indonesia. 2013. Proyeksi Penduduk Indonesia (Indonesia Population Projection) 2010–2035. Badan Pusat Statistik, Jakarta.

Industrial Water Demand

The industrial water demand is calculated based on the estimated data presented in Table 6.2 which includes data for Java, Sumatera, Sulawesi, and Kalimantan. The totals of regional data values are considered as data for Indonesia minus regions such as Bali, Nusa Tenggara, and Maluku–Papua.

Table 6.2: Daily and Annual Industrial Water Demand by Region and Total

	Daily Water Demand (m^3/day)			Annual Water Demand (million m^3/year)		
Industry Region	Min	Max	Average	Min	Max	Average
Java	377,694	1,405,861	891,778	137.86	513.14	325.50
Sumatera	86,292	321,198	203,745	31.50	117.24	74.37
Sulawesi	39,654	147,600	93,627	14.47	53.87	34.17
Kalimantan	9,828	36,582	23,205	3.59	13.35	8.47
Indonesia[a]	**513,468**	**1,911,241**	**1,212,355**	**187.42**	**697.60**	**442.51**

m^3 = cubic meter, max = maximum, min = minimum.

[a] Without Bali, Nusa Tenggara, and Maluku–Papua.

Source: Stockholm International Water Institute (SIWI). 2005. *Making Water a Part of Economic Development: The Economic Benefits of Improved Water Management and Services.*

Considering that industry development is in line with the gross domestic product in industrial sector development, the average annual water demand for industry in Indonesia and the regions of Java, Sumatera, and Sulawesi may be projected for the time horizon up to 2030, as presented in Table 6.3.

The industrial demand is predicted to double from about 14 m^3/s in 2013 to 29 m^3/s in 2030.

Table 6.3: Projection of Annual Industrial Water Demand for Time Horizon, 2013–2030

Industry Region	Projection of Average Annual Water Demand (m^3/s)				
	2013	2015	2020	2025	2030
Java	10.3	11.6	14.8	17.9	21.1
Sumatera	2.4	2.6	3.4	4.1	4.8
Sulawesi	1.1	1.2	1.6	1.9	2.2
Indonesia[a]	**14.0**	**15.8**	**20.1**	**24.4**	**28.7**

m^3/s = cubic meter per second.

Note: Extrapolation based on an expected annual GDP growth of 6.15%.

[a] Without Bali, Nusa Tenggara, and Maluku–Papua.

Source: Asian Development Bank.

C. Electrical Power Water Demand Development

Electricity Demand and Development Projections

The National Electricity Firm (*Perusahaan Listrik Negara*) has developed a strategy for the future power mix for Indonesia. This is the Electricity Supply Business Plan.[47] According to this plan, the following additional capacity is needed to reach the government's 2021 goals of 57.3 gigawatt (GW) extra capacity:

(i) 37.7 GW coal-fired plants,

(ii) 4.9 GW geothermal energy,

(iii) 7.3 GW hydropower,

(iv) 4.1 GW gas-fired plants,

(v) 2.5 GW combined cycle plants, and

(vi) 0.9 GW others (solar, biomass).

[47] National Electricity Firm (PT PLN Persero). 2013. *Rencana Usaha Penyediaan Tenaga Listrik 2013–2022* (Plan for Electricity Provision Development 2013–2022). Jakarta.

Hydropower Future Scenario

A hydropower potential study clearly puts the focus on hydropower development in Sumatera (4,408 MW), Java (4,595 MW), and Sulawesi (3,240 MW), which is in line with the actual development of the hydropower industry. These three islands cover 95% of the (feasible) hydropower potential.

The potential for mini/micro hydropower is about 770 MW with about 30% already developed. Micro hydro (<1 MW) and small hydro (1–10 MW) mostly target rural electrification with the largest potential in Papua and Sumatera. Some developers develop a small cluster of mini hydro.

Water Demand for Energy

The energy mix changes from 2013 to 2050. For the long-term prognosis of the water demand for energy, the following assumptions are made.[48]

(i) The electricity generation capacity by 2030 will be about 400 GW (10 times that in 2010). With this projection, the consumption per capita by 2030 will equal the world average and by 2050 will equal the present average for Organisation for Economic Co-operation and Development countries.

(ii) The renewable energy potential that can be exploited up to 2050 is about 3,300 terawatt-hours (TWh) per year. This can contribute up to 20% of the total.

(iii) The energy mix policy in Indonesia will be developed as follows:
  (a) maximize renewable energy for electricity generation,
  (b) minimize the use of oil and diesel,
  (c) optimize the use of biodiesel for transport,
  (d) optimize the use of gas, and
  (e) balance the rest with coal or nuclear power.

(vi) Assume that by 2025, 100% of the population will have access to electricity (80% in 2013).

(vii) The 2050 situation is projected to be as follows:
  (a) energy demand: 3,368 TWh (from 215 TWh),
  (b) installed capacity is 625.9 GW (from 41 GW), and
  (c) water for energy demand is 23,405 MCM (from 23,405 MCM).

As a result of the mix changes and the other indicated changes, it is anticipated that the "water for energy" demand will increase by a factor of about 8 in the next 36 years (Table 6.4).

[48] H.D. Ibrahim, N.M. Thaib, and L.M. Abdul Wahid. 2010. Indonesian Energy Scenario to 2050: Projection of Consumption, Supply Options and Primary Energy Mix Scenarios. Paper presented at the Joint Symposium within APEC project "Energy Links Between Russia and East Asia: Development Strategies for the XXI Century" held in Irkutsk, Russian Federation, 30 August–2 September 2010.

Table 6.4: Water for Energy Demand Projection

Scenario		2012	2020	2030	2040	2050
Population	Million	238.4	261.5	284.4	299.2	307
Total energy demand	KWh/capita/year	4,768	8,839	15,701	25,702	35,820
Electricity as % of total		14.1	16.9	20.0	23.8	30.0
Electricity demand	KWh/capita/year	672	1,494	3,140	6,117	10,746
Installed electricity capacity total energy demand	GW	41	95	198	400	626
Electricity demand	TWh per year	216	405	929	1,915	3,471
Water demand intensity	m^3/MWh	13	11	9	7.5	6.7
Water demand	m^3/s	90	141	265	455	737

GW = gigawatt, KWh = megawatt-hour, m^3 = cubic meter, s = second, TWh = terawatt-hour.

Source: Asian Development Bank.

D. Agricultural Water Demand Development

Regarding agricultural water demand, there are two conflicting trends. The ever increasing population needs more rice and other crops to assure its food security, whereas, at the same time, the expanding population encroaches on agricultural land for urban expansion and economic development. This phenomenon is most notable in Java.

On Java, the urban area is predicted to expand by about 40% by 2030, whereas the irrigated paddy fields will reduce in area by 13%. As Java is the most efficient rice producer, producing about 58% of the national output, this will have a significant impact on food security. The area of irrigated paddy fields in Java in 2011 was 2.5 million ha and that of nonirrigated paddy fields was 0.8 million ha. By 2030, the area of irrigated paddy fields will be reduced to around 2.1 million ha.

The main activities to increase rice production in Java are focused on (i) increasing cropping intensity through irrigation improvement, rehabilitation, and development; irrigation and water management; agricultural infrastructure and improvement of facilities and services; (ii) application of water-saving technology such as System of Rice Intensification (SRI), decrease of flood height; and (iii) agricultural innovation and technology applications.

In 2011, total area of paddy fields on Sumatera was 2.2 million ha consisting of 0.9 million ha of irrigated and 1.3 million ha of nonirrigated paddy fields. Assuming that water requirement for paddy fields was 5,750 m^3/ha, it is estimated that water demand for paddy fields was 9,000 MCM per crop season.

It is estimated that during the next 5 years around 30,000 ha of new paddy fields will be developed in Sumatera in areas already equipped with irrigation (using more water than the existing fields) for which 1.08 MCM/year of water would be required.

Sulawesi is expected to develop new paddy field areas to support food security in eastern Indonesia. The total area of paddy fields in Sulawesi was 0.92 million ha, consisting of 0.66 million ha of irrigated paddy field land and 0.27 million ha of nonirrigated land. The paddy fields of Sulawesi are predominantly (60%) in South Sulawesi.[49] Water demand of the existing irrigated paddy fields in Sulawesi EC is about 6,600 MCM per crop season.

The proposed activities to help accelerate irrigation development and food crops production in Sulawesi are (i) managing existing paddy fields by improving irrigation system and water management, (ii) strengthening and increasing agricultural development based on regional policy with regard to existing commodities, (iii) integrating planning and development of irrigation and newly developed paddy fields, and (iv) improving good food crop practices.

Box 6.1: Overview of Future Scenario

Water for domestic, municipal, and industrial use: The urban domestic demand is predicted to increase from about 190 cubic meters per second (m^3/s) in 2015 to 260 m^3/s by 2030, whereas the rural demand will decline from 110 m^3/s to 100 m^3/s.

The industrial demand is predicted to double from about 14 m^3/s in 2013 to 29 m^3/s by 2030.

Sanitation demand growth is directly related to population growth. Figure 6.1 therefore provides a perfect prediction of the growth in sanitation needs in urban and rural areas.

Water for agriculture: The future water requirement of agriculture in Indonesia is mainly determined by the increase in irrigation water demand (mainly from rice production). With an estimated potential increase of 2 million hectares in harvested area through improved infrastructure and maintenance of existing irrigation areas, and an extension of irrigated area by about 1 million hectares (about 1.7 million hectares harvested area), the water demands for irrigation will increase by about 1,500 m^3/s to about 6,000 m^3/s, if water use efficiency is not increased.

Water for energy: The energy mix changes from 2013 to 2050. As a result of the mix changes and the other indicated changes, it is anticipated that the "water for energy" demand will increase by a factor of about 8 in the next 36 years, from about 90 m^3/s in 2012 to 737 m^3/s by 2050. Growth factors vary between 7 (Central Java) and 11 (West Papua), with the highest growth in the areas with the lowest populations (Papua, Kalimantan). The highest absolute growth is focused in the densely populated areas on Java.

Source: Asian Development Bank.

49 Personal communication. Ministry of Agriculture, 2013.

chapter seven

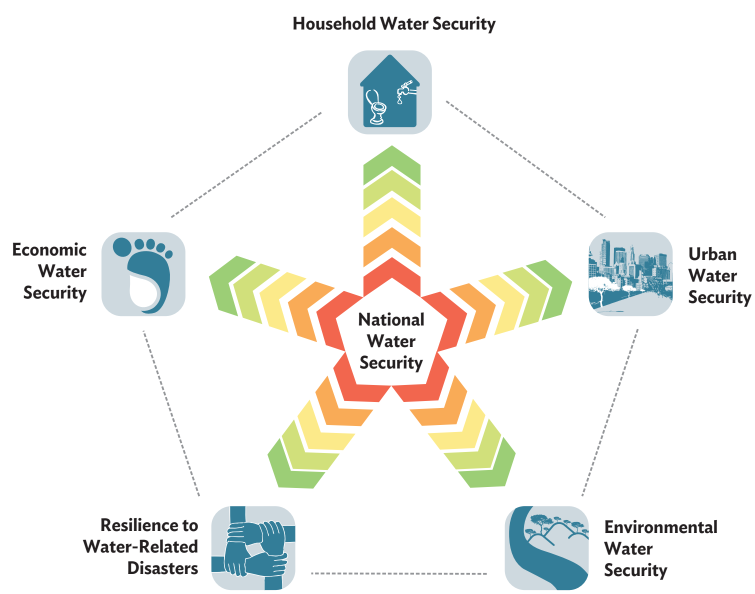
INDONESIA WATER DEVELOPMENT OUTLOOK

A comprehensive framework for national water security was developed and presented in the *Asian Water Development Outlook 2013* (AWDO 2013). The assessment was prepared over a period of 5 years by a team of 10 water knowledge partner institutions led by the Asia-Pacific Water Forum and the Asian Development Bank. The team adopted an outcome-based approach by crafting a comprehensive vision of water security for the benefit of societies, recognizing the need for water security in households, economies, cities, the environment, and resilient communities. This vision was then transformed into a quantitative assessment of water security in five key dimensions: Household Water Security, Urban Water Security, Environmental Water Security, Resilience to Water-Related Disasters, and Economic Water Security (Box 7.1).

Box 7.1: Water Security Vision

Societies can enjoy water security when they successfully manage their water resources and services to

(i) satisfy household water and sanitation needs in all communities;
(ii) support productive economies in agriculture and industry;
(iii) develop vibrant, livable cities and towns;
(iv) restore healthy rivers and ecosystems; and
(v) build resilient communities that can adapt to change.



Source: ADB. 2013. *Asian Water Development Outlook 2013: Measuring Water Security in Asia and the Pacific.* Manila.

The AWDO 2013[50] underlined that these key dimensions of water security “are related and interdependent, and should not be treated in isolation of each other.” (p. 12) Measuring water security as an aggregate of indicators for these key dimensions recognizes their interdependent nature. Increasing water security in one dimension “may affect security in another dimension while simultaneously increasing or decreasing the indicated overall national water security.” (p. 10) Increases in water security will be achieved by governments that “break the traditional sector silos” and “find the ways and means to manage the linkages, synergies, and trade-offs among the dimensions.” (p. 12)

In this country water assessment report, we follow the AWDO 2013 dimensions to a certain extent for formulating the outlook. The following sections describe the main water-related issues from the AWDO 2013 dimensions.

Gap Analysis

For the economic assessment, a gap (between existing and needed capacity or service level) analysis is performed for each province. In the analysis, data from Statistics Indonesia are used to assess the current status of a sector. As not all developments of Indonesia are described in a way that allows a gap analysis for all relevant sectors, additionally data from other sources are also used. The gap for the different sectors is determined on the data available from Statistics Indonesia. Data on water availability are based on the work done in preparation of this report. The gap analysis is discussed in detail in Annex 1 of the extended version of this report.

A. Household and Urban Water Security

Water Supply

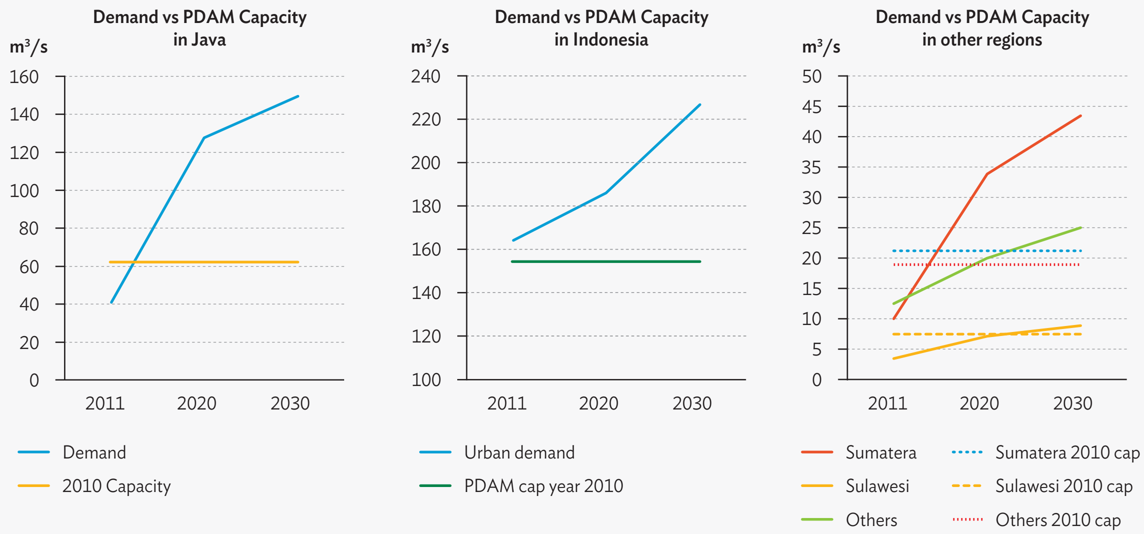
In the coming 20 years, the urban population of Indonesia is predicted to grow with about 90 million people (Figure 7.1) with the cities in Kalimantan and Sumatera more than doubling in size. Currently, the government aims to provide access to piped water supply to the entire population by 2019, following which, in the next 15 years, all regions will have to continue expanding the urban water supply services further by 30%–50% so as to keep pace with the growth in urban population.

The water supply system in the cities is managed by the regional government through water utilities (PDAMs). But the PDAMs so far are unable to catch up with the pace of urban growth and depreciation of the water supply system, as evidenced by low coverage of the water supply system. In 2011, the PDAMs covered only 30%–40% of their service area.

The large discrepancy between the current available capacity of the PDAM and the projected demand of clean water in urban areas emphasizes the need for urgent improvements. Considering the total available water resources in the basins and the priority given in water allocation, the availability of water is not a main issue, except in certain small islands. The main issues are relevant to the management and

50 ADB. 2013. *Asian Water Development Outlook 2013: Measuring Water Security in Asia and the Pacific.* Manila. pp. 10–12.

Figure 7.1: Present and Future Coverage of Perusahaan Daerah Air Minum (without Expansion)



	Coverage of Service Area Population (%)	Coverage of Administrative Area Population (%)
Java	31.9	17.6
Sumatera	34.0	22.7
Sulawesi	37.7	24.6
Others	45.2	32.2

m^3/s = cubic meter per second, PDAM = Perusahaan Daerah Air Minum (water utility).

Source: Support Agency for the Development of Drinking Water Supply Systems (BPPSPAM). 2012. *PDAM Performance Report 2011*. Ministry of Public Works, Jakarta.

"health" of the PDAM, debt restructuring and adoption of cost recovery tariffs, and a sound public–private partnership (PPP) framework to mobilize the huge investments needed for the development and maintenance of appropriate infrastructure and distribution network.

In many of the PDAMs, especially the ones in large cities, the reduction of nonrevenue water (NRW) becomes a short-term priority to potentially increase the water availability. If the NRW is reduced to an average of 20%, an additional capacity of 5,328 liters per second (l/s) can be achieved (Table 7.1).

Table 7.1: Nonrevenue Water in Java, Sumatera, and Sulawesi

	2011 Average NRW (%)	Water Saved if NRW is Reduced to 20% (m^3/s)
Java	34.0	0.181
Sumatera	52.5	0.127
Sulawesi	40.9	1.487
Others	32.7	2.374

NRW = nonrevenue water.

Source: Support Agency for the Development of Drinking Water Supply Systems (BPPSPAM). 2012. *PDAM Performance Report 2011*. Ministry of Public Works, Jakarta.

Groundwater is the main water resource, especially for those who are not served by the PDAM. It is the appropriate stable source of good quality water for domestic use, but overextraction in urban areas and water pollution threatens its sustainable use. Urban areas generally develop in coastal areas and large basins (e.g., Bandung). These urban areas are vulnerable to subsidence. Also, the poor sanitation facilities, especially dysfunctional septic tanks, are a major threat to the quality of the shallow groundwater.

Measures

The exploitation of groundwater, especially in the deep layers (>20 meters), by the community for domestic or nondomestic uses should be monitored and controlled, as the overexploitation of this groundwater decreases its quality and quantity and affects the community welfare. Land subsidence occurs in areas where groundwater abstraction is very intensive, and the overextraction of groundwater also causes seawater intrusion.

To reduce the deterioration of groundwater quality, the following actions are to be taken:

(i) Connect people who are dependent on groundwater to the PDAM network.

(ii) Reduce the groundwater abstraction as regulated in PP 48 year 2008 on Groundwater.

(iii) Set up regulation at all local governments to control groundwater abstraction.

(iv) Tighten the requirements for groundwater licensing.

(v) Close unlicensed wells.

(vi) Ensure effective coordination among stakeholders.

(vii) Provide community education on groundwater conservation.

(viii) Reduce the per capita demand by promoting the use of water-efficient fixtures in the houses and educating the low-water-use life style, such as recycling and rainwater harvesting.

(ix) Strengthen the local government commitment to support proper tariff setting. Currently, the PDAM increases the tariff only once in every 5–6 years, whereas their business plans are based on increases every 2 years.

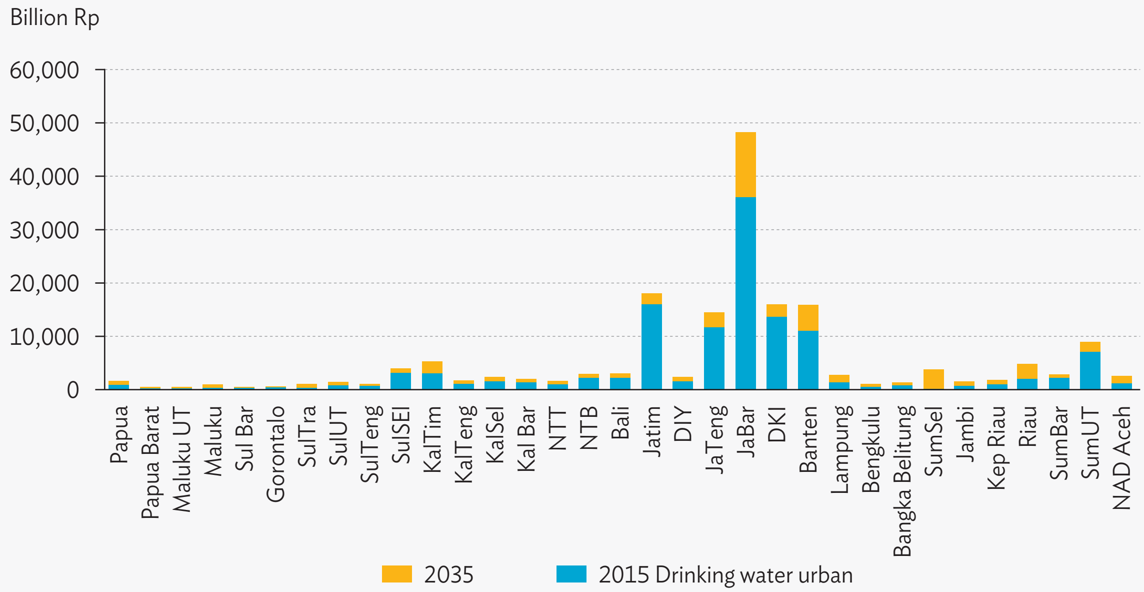
(x) Encourage private sector participation in the development of water supply and sanitation systems. Several areas have already been identified for private sector participation, as discussed in the *Public–Private Partnership (PPP) Handbook 2013*.

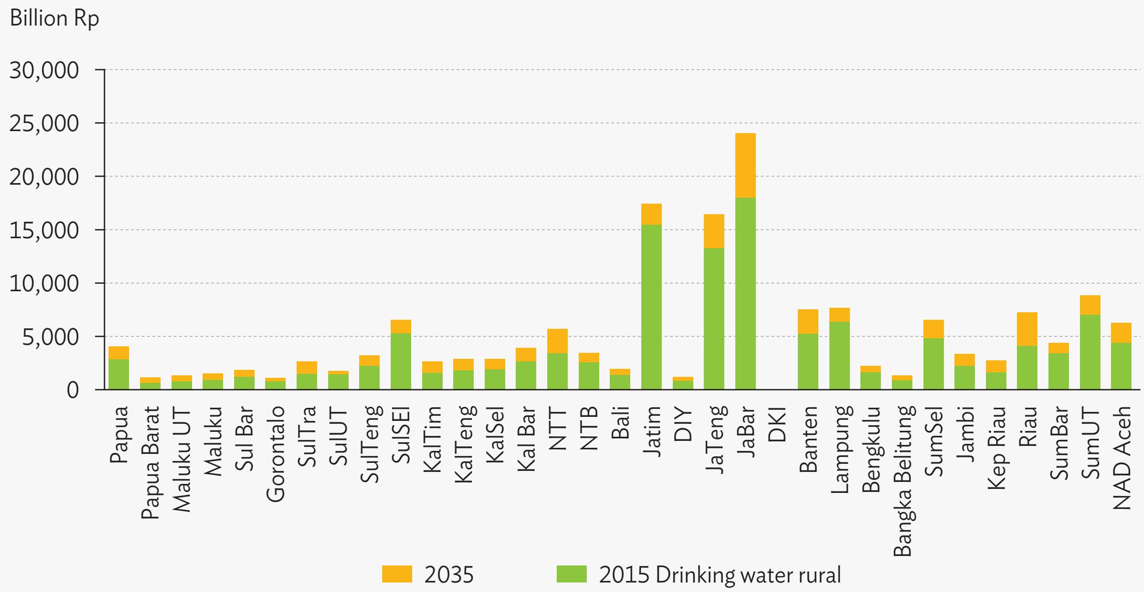
(xi) Continue the Water Hibah program as the national government's participation in local programs.

Priorities

Assessment of the gap in available urban drinking water supply and the present need and the projected need in 2035 (Figure 7.2) shows that the cities in the highly populated provinces of Java need more water supply compared with other regions. A more detailed assessment of the 50 largest cities in Indonesia is provided in Annex 2 of the extended version of the country water assessment report. These 50 cities but also the other cities in the provinces are included in the provincial assessment made in this chapter. The detailed assessment shows that the JaBoTaBek region has the highest gap between the presently available and the future needed capacity.

Figure 7.2: Investment Needed in Drinking Water Supply to Fill the Present and 2035 Gap per Province





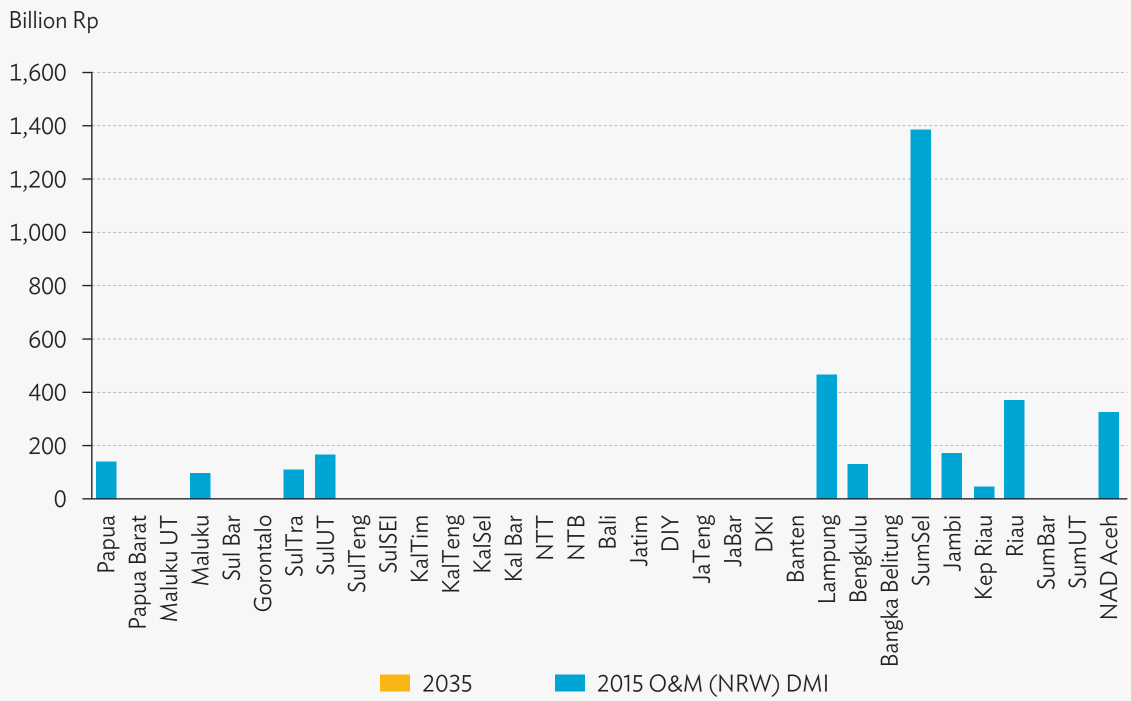
Rp = rupiah.

Note: Estimates in the present study are based on the urban population that is not served in 2015, and urban growth as projected by Statistics Indonesia.

Source: Asian Development Bank.

Regarding operation and maintenance (O&M), all regions can benefit from the improvement of services and the reduction of losses. The high-priority areas that require high investments to reduce the NRW are South Sumatera (NRW 81%), Lampung (NRW 61%), Riau (NRW 70%), and Aceh (NRW 56%) (Figure 7.3). As no prediction can be made regarding O&M needs in 2035, this is not included in the analysis.

Figure 7.3: Investment Needed in Operation and Maintenance in Provinces with the Present Nonrevenue Water Level Higher than 45%



Rp = rupiah.

Note: Estimate in the present study assume the NRW is reduced from present levels to 33%.

Source: Asian Development Bank.

Sanitation

More than 70% of urban households have on-site sanitation, mostly in the form of septic tanks, some of which are poorly constructed, dysfunctional, and rarely emptied and allow untreated or partially treated wastewater to seep into groundwater, the incidence of which is high in many locations, or into open drains and watercourses. Only less than 25% of human waste delivered to on-site systems is dealt with properly. About 80% of bathroom, kitchen, and laundry wastes are passed directly into the surface water drains. In rural areas, less than 30% of households have toilet facilities, and only about 20% have septic tanks. The lack of adequate sewerage systems, combined with inadequate solid waste management, is causing widespread contamination of both surface water and groundwater.

With only 4% of the septage actually being treated, the present improved approach on sanitation aimed at health priorities needs to be expanded further to include the water quality of the receiving system.

Because of the high urbanization, the demand for communal and central sanitation facilities will increase even further, requiring proper management, cost recovery tariffs, and institutional embedding to enable to generate the huge investments needed.

Priority should be given to large inland urban areas located upstream from other users (e.g., Bandung basin) and areas where high pollution levels are impeding priority developments (e.g., Jakarta Great Garuda project is only feasible if the water quality improves).

Measures

Actions needed to close the gap in sanitation services are as follows:

(i) Strengthen the central and local government commitment to finance and implement the development of sanitation facilities and the local government commitment to establish institutional arrangements for the management of sanitation facilities.

(ii) Ensure community empowerment, and regular community education on the importance of sanitation to health. Involving women in the planning of sanitation facilities ensures their suitability and sustainability.

(iii) Develop adaptive master plans dealing with sanitation using a stepwise approach encouraging communal systems that can effectively reduce sanitary pollution in densely populated areas, and that include house septage systems and their emptying. Allow for growth to semicentralized systems where that provides added value. In all steps prioritizing sanitation, but mainstreaming the reduction of pollution discharges to the groundwater and river systems.

(iv) Collect user charges to cover O&M costs in the communal sanitation facilities.

(v) Develop policies and regulations for wastewater services covering the management, financial, and environmental aspects.

(vi) Train personnel for the proper management of sanitation facilities.

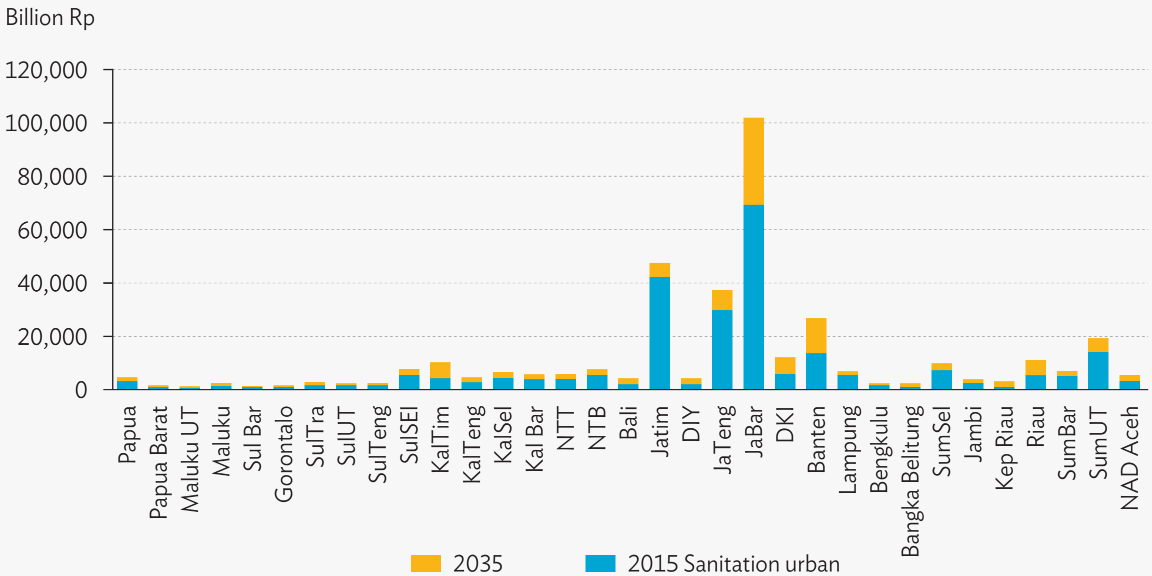
Priorities

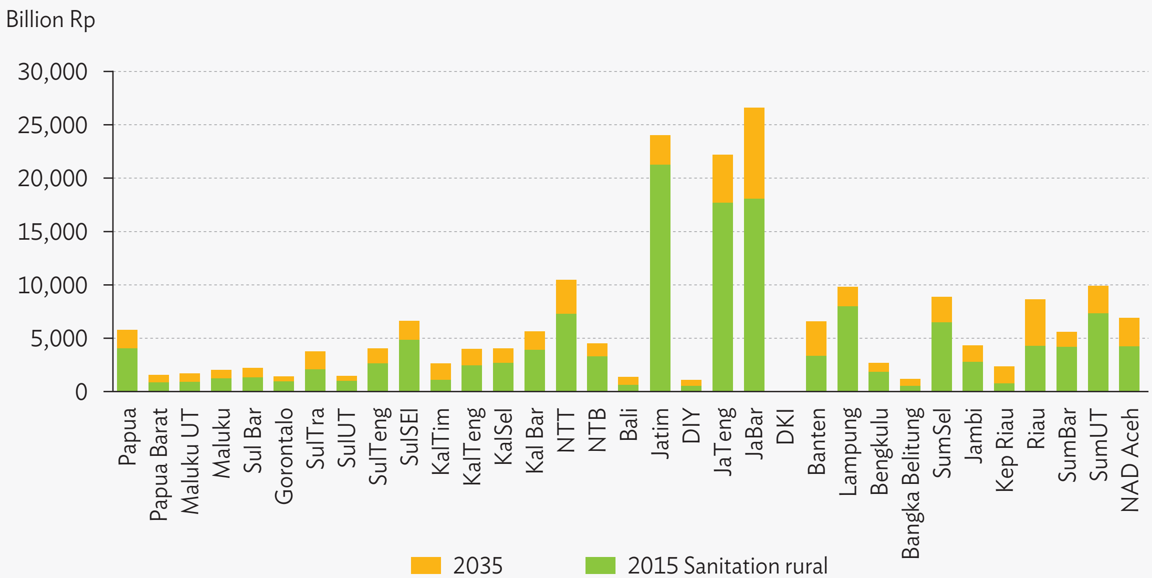
Urban sanitation needs are highest in the provinces with major cities in Java, Sulawesi, and Sumatera, where also the largest impact of urbanization is found (Figure 7.4). Impacts of the large untreated effluent flows on the groundwater, rivers, and marine environment are highest near the mega cities. The inland cities (such as Bandung) deserve special attention because the pollution impacts all uses of the water downstream of the city.

Urban Drainage

Many households are located in areas that do not have adequate drainage facilities, and in some towns there is regular flooding. The presence of large quantities of sewage and uncollected garbage exacerbates the already existing problems of inadequate drainage networks.

Figure 7.4: Investment Needed in Urban and Rural Sanitation to Fill the Present and 2035 Gap per Province





Rp = rupiah.

Source: Asian Development Bank.

Flood incidences are perennial and have been increasing in severity during the past decade, especially in Jakarta where the multiple threats of rapid and poorly controlled urbanization, combined with severe watershed degradation, have increased the runoff substantially. A combination of inadequate retention basins, an undersized drainage network, increase in nonabsorptive surfaces, and land subsidence has created the conditions for prolonged and extensive flooding during high-rainfall events.

As a result of studies of several large cities prone to flooding such as Semarang, Palembang, Bandung, and Makassar, some flood prevention measures have been adopted: (i) construction and extension of secondary and tertiary drainage networks; (ii) "normalization" of rivers and human-made drainage channels to restore the original carrying capacity; (iii) building of retention basins, polders, seawall defenses, weirs, dams, and pump stations; (iv) implementation of urban drainage master plan; (v) urban flood risk mapping; and (vi) implementation of regular O&M schedules to clear the drains of sediment and the solid waste that is disposed of in the drainage network by local communities.

The main factors influencing the occurrence of urban drainage problems or deterioration of the urban drainage network in the future would be

(i) lack of effective city-wide drainage network and assessment of impacts of individual projects on drainage;

(ii) subsidence, which alters the drainage pattern and decreases the discharge capacity; and

(iii) lack of effective solid waste management.

Measures

In general, reducing the frequency of flood requires the following measures:

(i) Effective drainage master planning, which includes identification of the main drivers of flooding (such as subsidence), and effective urban flood risk mapping, which produces urban flood hazard and risk maps, critical for a preliminary flood risk assessment of urban areas where significant flood risks exist or are likely to occur.

(ii) Commitment of local governments to improve their urban drainage network and to initiate steps to tackle the basic causes of urban flooding This includes financing continuous O&M as a major component.

(iii) Identification of nonstructural measures, such as zoning, warning, adapted electricity, adapted housing, alternative traffic routing, etc., to reduce flood damage.

(iv) Recognition by the local government of the need to tackle the legal, institutional, and social issues that are an integral part of any flood prevention strategy, including coordination and cooperation between related agencies.

(v) Provision of good solid waste collection and disposal services and following that, stronger implementation of local permit regulations (Perda and Perwal) and the predilection of many people to throw rubbish (*sampah*) into both the natural and human-made drainage channels.

(vi) Regular public awareness and "socialization" campaigns, as well as strengthening institutional capacity and organization.

Priorities

No overall data are available on the severity of drainage issues. Situations can change rapidly when maintenance or even simple cleaning is performed. However, subsidence is a structural issue that aggravates the drainage problem. The cities of Medan, Jakarta, Cirebon, Semarang, and Surabaya (located on the northern shore of Sumatera, Java, and the Bali island range) are particularly vulnerable to drainage problems. The geology of this zone is very prone to subsiding, which is exacerbated in case of groundwater extraction.

B. Economic Water Security

Water is used in productive economies mainly in the agriculture, industry, and energy sectors. Industrial demand is generally included in the assessment of domestic demands as industrial areas are almost always located in the vicinity of towns and rely on the water supply system of towns.

When the projected demands are compared with available water resources, it is evident that the available water resources exceed the demands. However, local and temporal differences exist. This will be discussed in more detail for Java, Sumatera, and Sulawesi.

Figure 7.5 presents the river basins (for Java divided into subbasins) where 2030/2035 demands for irrigation; domestic, municipal, and industrial use; livestock; and fisheries exceed the 80% assured river flow in any month. The available flow is corrected for existing and planned reservoirs, and for Java it is corrected also for interbasin transfers identified in the Java Water Resources Strategic Study. Water shortages are concentrated in the eastern part of Java and the southern part of Sulawesi.

However, the analysis of demand curves show that in Java water demand is maximized for all months with surplus water. This is not yet the case in Sumatera and Sulawesi, indicating the lack of infrastructure or connection between irrigated areas and available resources resulting in a lower cropping intensity. To assess the potential additional rice harvested rice area if additional water storage would be made available (using existing paddy field area), the highest monthly water demand is used for the whole year. In Sulawesi, the existing paddy field areas could potentially increase their harvested area with 840,000 hectares, or almost a factor of 2. In Sumatera, more than 1.1 million hectares could be harvested, an increase of approximately 1.8. The highest potential additional harvested area (Figure 7.6) can be achieved in the Saddang, Jeneberang, and Walanae-Cenranae river basins of South Sulawesi. In South Sumatera, the highest gains can be achieved in Seputih-Sekampung and Musi–Sugihan–Banyuasin basins.

Measures

Improvements in economic water security can be achieved by effective water resource allocation prioritizing industry at the same level as that of domestic use. The contribution of industry to both gross domestic product and employment per cubic meter of water used is higher than that of agriculture, and industries can generally use the same infrastructure as the domestic water utility.

Figure 7.5: Areas with Shortage in Dry Season for 2030 (Java) and 2035 Taking Planned Reservoirs into Account

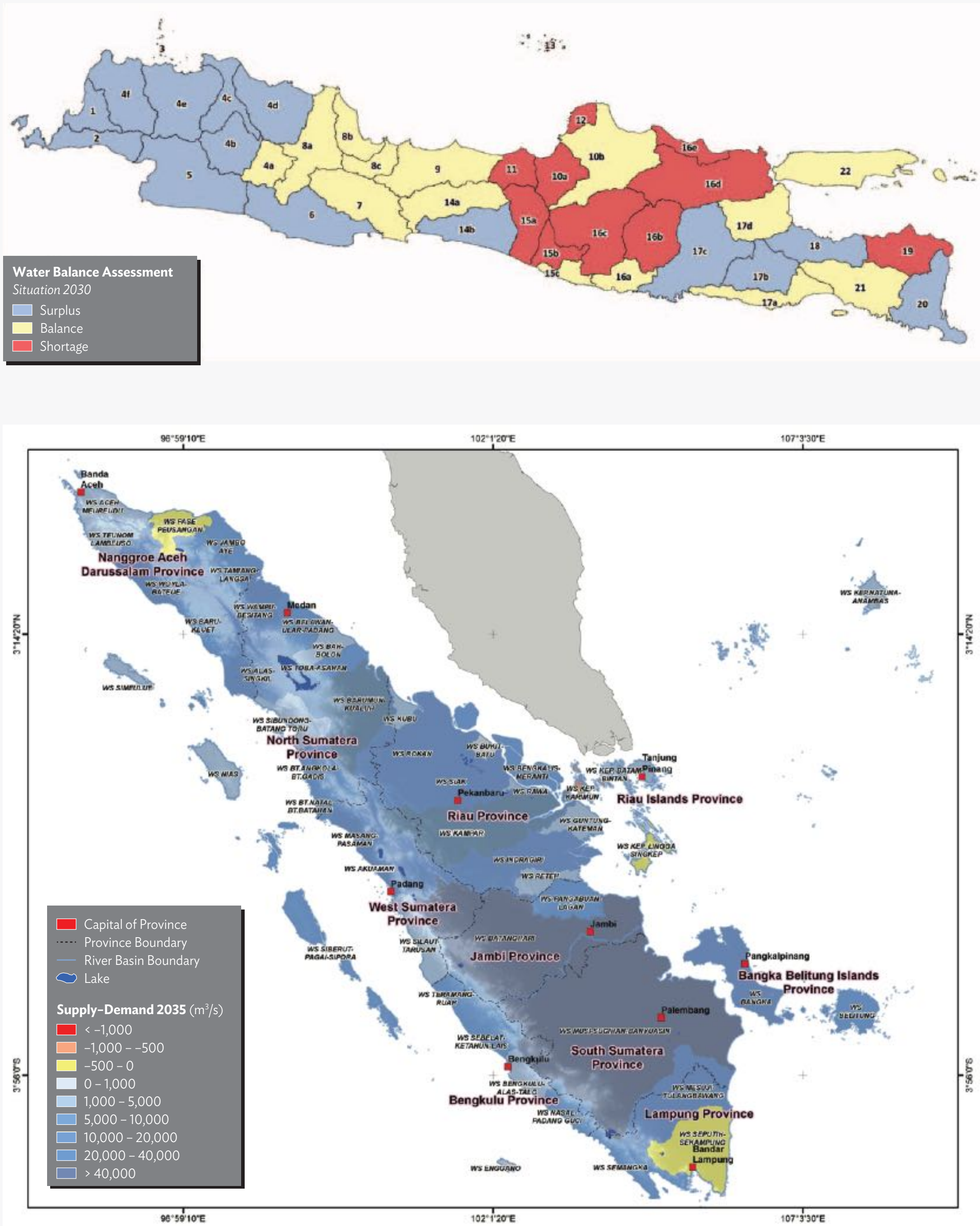


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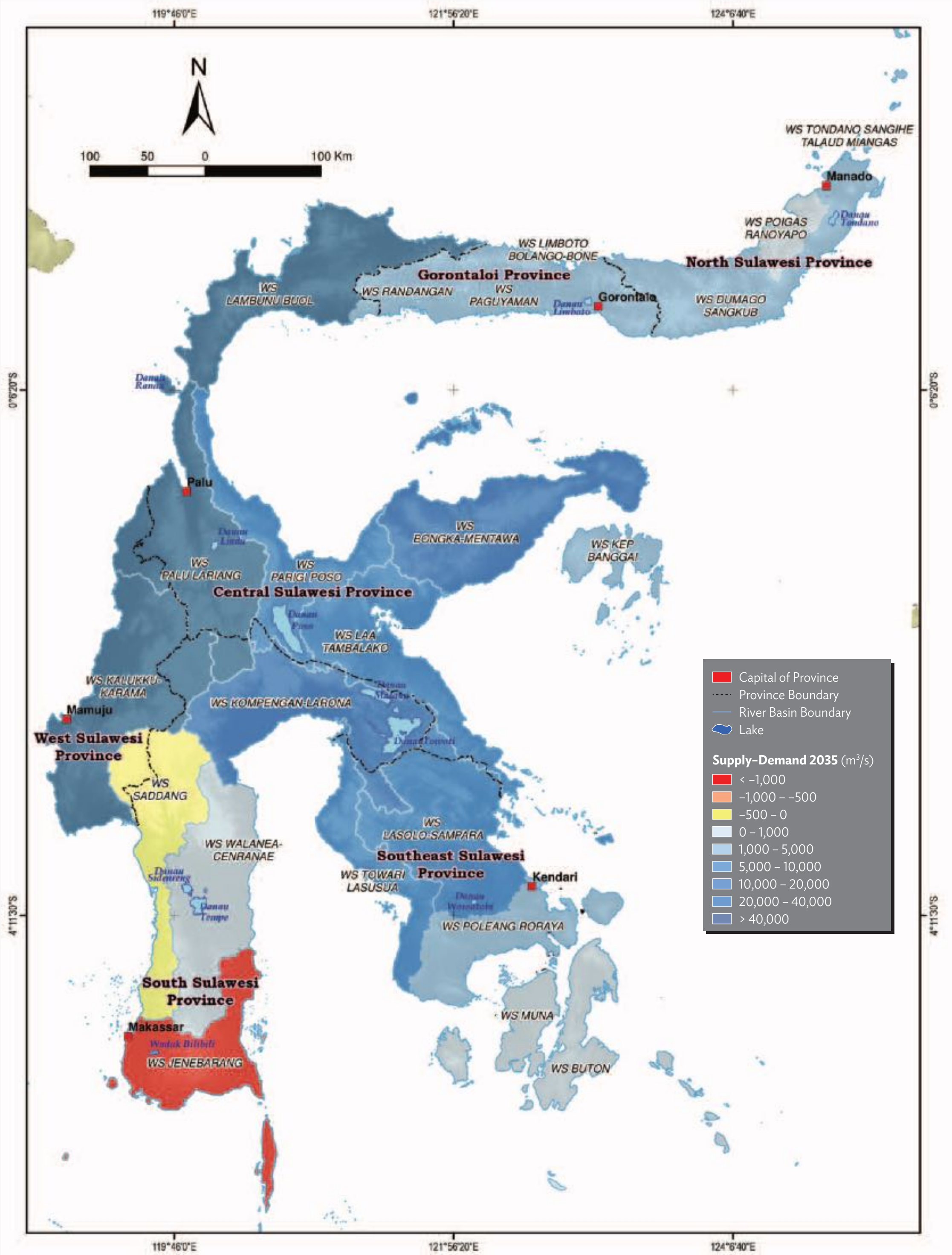
Figure 7.5: Continued



DMI = domestic, municipal, and industrial; m^3/s = cubic meter per second.

Note: Shortages reflect sum of months where the demand for agriculture, DMI use, and livestock/fishery exceeds the 80% water availability in rivers. Where no shortage occurs, value indicates yearly excess flow (m^3/s).

Sources: Statistics Indonesia. 2014. *Statistical Yearbook 2013.* Jakarta; Ministry of Agriculture (Peta Audit Baku Sawah), and PusAir, Neraca Air.

Figure 7.6: Estimate of Potential Additional Harvested Area with Improved Infrastructure

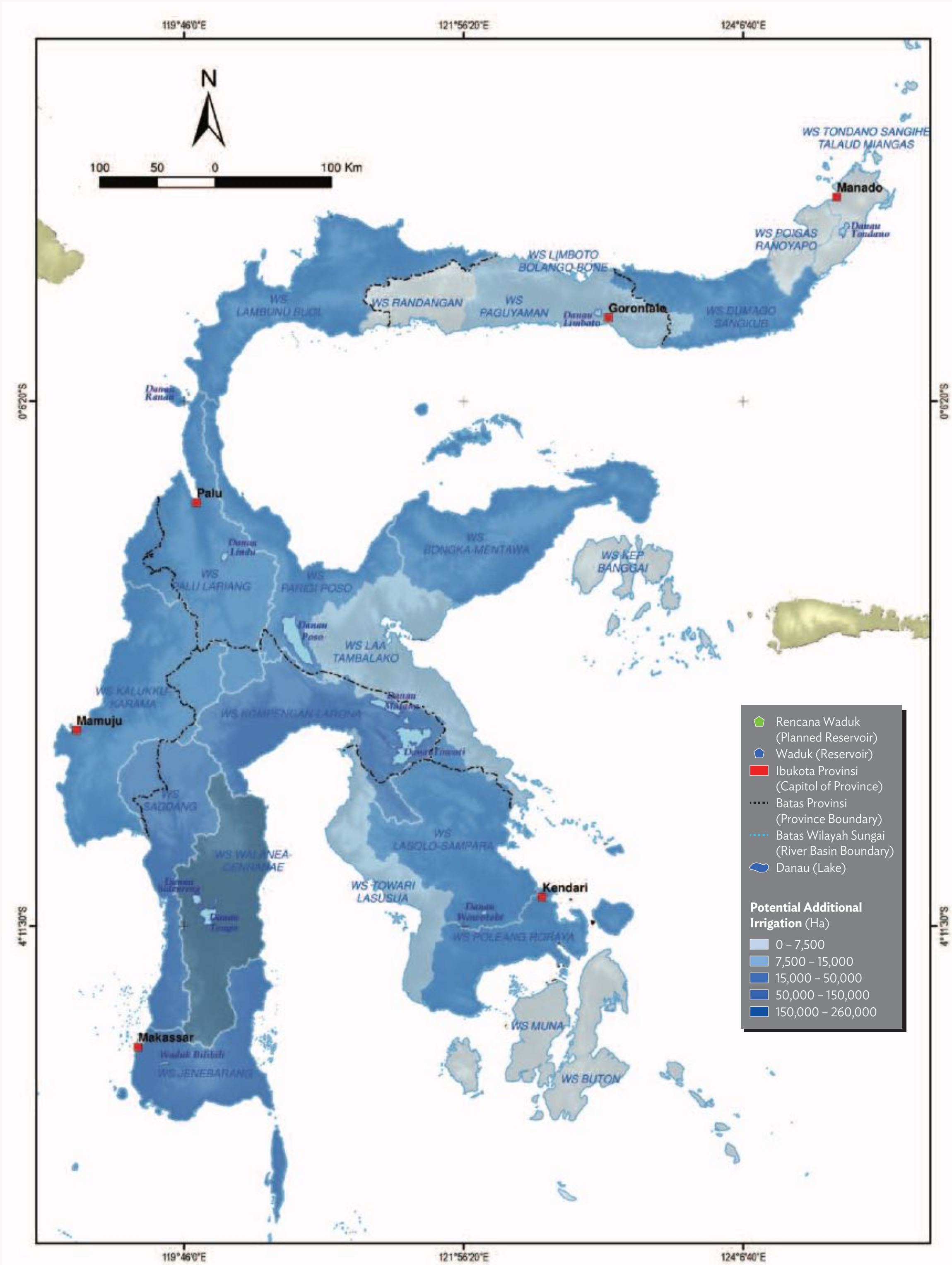


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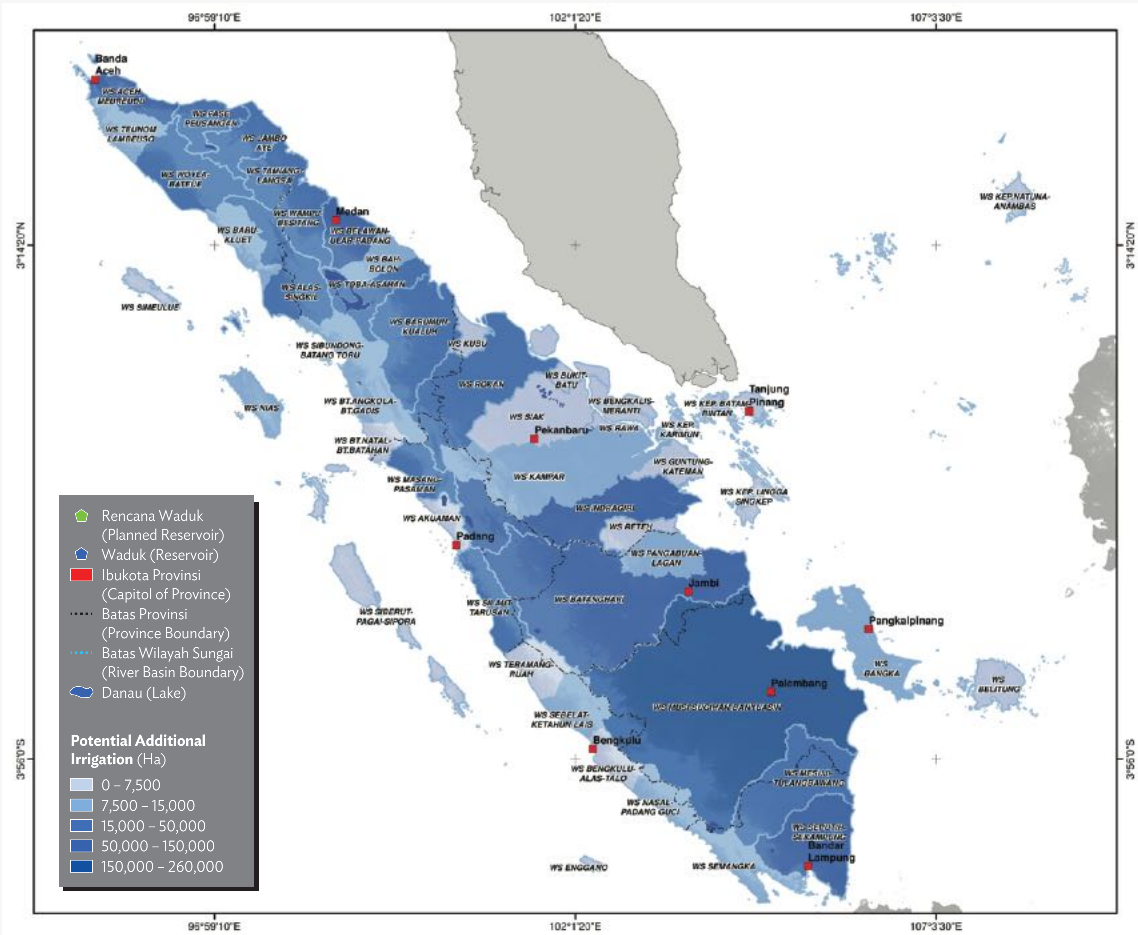
Figure 7.6: **Continued**



ha = hectare.

Note: Estimates were generated by comparing the actual versus potential cropping intensity.

Source: Asian Development Bank.

All water allocations, from reservoirs, but also using river diversions and piped connections, whether for domestic or for irrigation use, must be explored for (run of the river type) hydropower generation.

In all sectors, including domestic water use, nonrevenue water, energy use, and water use in agriculture, opportunities for demand management should be explored and stimulated with incentives (progressive pricing, benchmarking, tax deductions, consumer education, etc.) enhancing self-regulation.

To support food security, agricultural production, especially rice production, can be enhanced by rehabilitating deteriorated irrigation schemes and reservoirs and ensuring that full required O&M is conducted on all schemes. In this respect, special emphasis and support need to be given to Kabupaten or Kota and selected provincial government departments to raise awareness and increase the available water capacity. Funding arrangements need to be reviewed to ensure that regions are self-sustained to fund the activities under their responsibility.

Developing additional storage and connecting existing irrigated areas to additional resources are the most effective ways to increase the harvested area when targeting existing irrigated areas where irrigation schemes are not implemented effectively. Southern Sulawesi and South Sumatera are most promising in this respect. However, it still remains to be explored whether geographically suitable locations actually exist.

Priorities

Priority should be given to those areas where a higher economic production can be achieved without developing new irrigation areas (Figure 7.6) and, if possible, without developing new reservoirs.

South and North Sumatera and Aceh are areas where the most can be achieved in terms of increasing the harvested area on existing irrigated areas through rehabilitation, O&M, and connections, not necessarily through developing additional reservoirs (Figure 7.7).

For Java and South Sulawesi and Lampung, additional reservoirs can provide additional potential to existing irrigated areas. For Java, the Java Water Resources Strategic Study identified additional potential for water conservation through dams as follows:

(i) Citarum (raising Cirata Dam), Citanduy (Matenggeng). Pemali Comal, (Ki Gede Sebayu), Jratunseluna (Panohan, Dolok), Lukulo-Bogowonto (Bener, for interbasin transfer to Yogyakarta), and Bengawan Solo.

(ii) Jragung Dam could be potential if catchment conservation (especially improved agriculture management) results in less erosion. Jipang needs careful assessment, especially concerning social and environmental issues.

(iii) Other dams especially in Jratunseluna and Bengawan Solo.

For the development of water for energy, areas with relatively low connection to the electricity network and/or high water potential and high expected demands (Figure 7.8) are most promising. In this respect, Papua, Riau, North Sumatera, and provinces on Java show most potential.

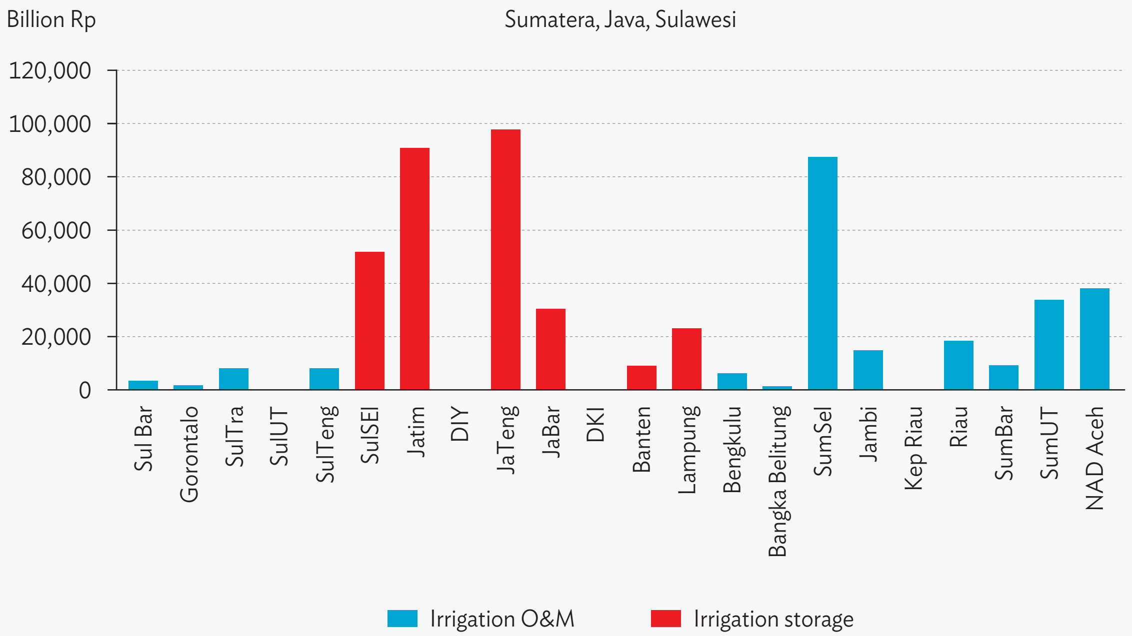
C. Environmental Water Security

The aquatic environment in Indonesia is under serious threat, especially in the highly populated islands, where almost all major rivers are heavily polluted. Indonesia has the questionable honor of having two sites among the top 10 most polluted places in the world: the Citarum River and the rivers in Kalimantan polluted by mining activities. In addition, Indonesia is one among the top 10 greenhouse gas emitters due to forest clearing and peatland degradation.

Costs to society are huge as intakes for drinking water are affected, but also drinking water itself in areas where unprotected sources are used.

This situation will deteriorate further with population increase unless a major improvement in sanitation is achieved. With most urban centers located near the coast, the highest increases will be concentrated in coastal areas.

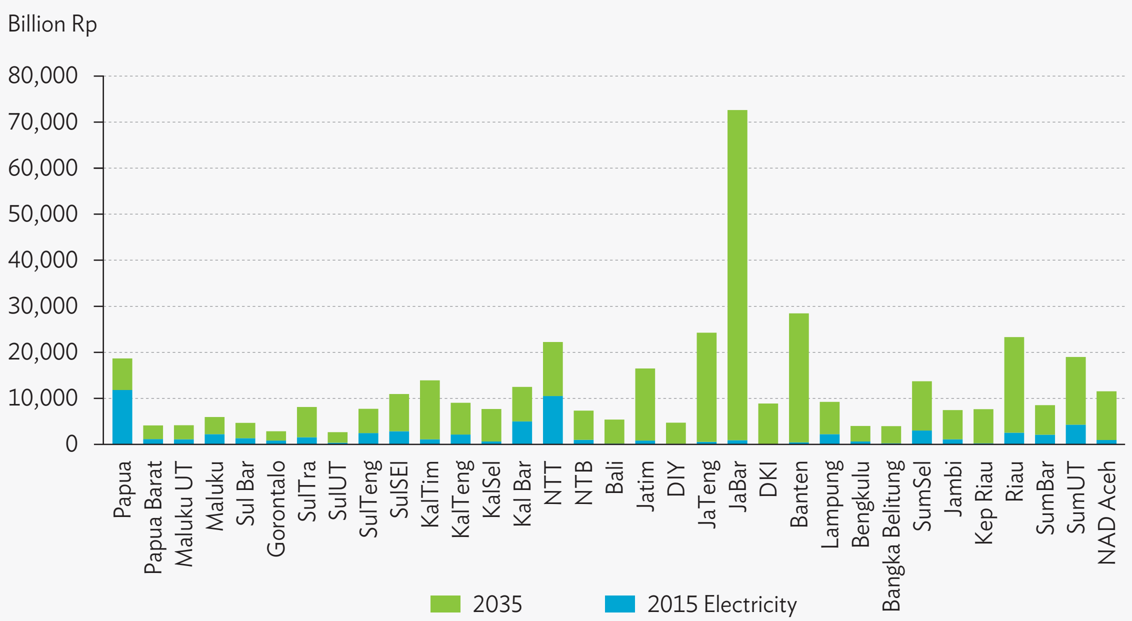
Figure 7.7: Minimum Investments Needed in Irrigation Based on Potential Increase of the Harvested Area on Present Irrigated Areas through Improved O&M (Blue) **or Additional Storage or Interbasin Transfer Measures** (Red)



Note: Investment needs based on O&M costs only. Actual investments in the red-marked areas will be higher depending on the type of intervention needed.

Source: Asian Development Bank.

Figure 7.8: Investments Needed to Fill the Present and 2035 Gap in Electricity Needs



Note: Analysis in present project based on population and energy requirements, which increase over time.

Source: Asian Development Bank.

Priority areas for water quality are the groundwater basins located in all major cities; the rivers draining larger cities with limited or no septage treatment; and the rivers draining (illegal) mining areas, especially in Sumatera, Kalimantan, and Papua.

Unchecked environmental degradation of upland and forest areas may result in serious problems on the sustainability of water resources. Erosion and sedimentation limit the life span of reservoirs and damage irrigation and drainage systems, leading to reduced use and increased flooding.

Measures

Correcting measures can be grouped into three categories:

Prevent, mitigate, and monitor pollution: Pollution prevention measures are the first priority as they are almost always the cheapest, easiest, and the most effective way to protect water quality. In line with the policy and strategies of the Government of Indonesia, there are some measures to reduce or eliminate (quantity) the pollutants and/or contaminants as well as to reduce (quality) their hazard to the environment. Pollution prevention measures to be considered and applied as regulations and best practices are enumerated below:

(i) Enhance, improve, and apply an integrated environmental safeguard as a prerequisite ("readiness criteria") for any development initiative, from overall planning/programming level (i.e., SEA or KLHS; strategic environmental assessment) to specific project implementation level (EIA or AMDAL; environmental impacts assessment), including its compliance with regional spatial planning. Treating the KLHS/AMDAL as an operational document, rather than as an administrative document, is urgently required.

(ii) Apply currently enacted zoning regulation for specific development activities, including industrial zones/clustering. The clustering (agglomeration) for easy monitoring and localized impacts is not only proposed for large-scale industries but also or small- and medium-scale industries and home industries, at least in the long term.

(iii) Map aquifer zoning and enforce strict limitation with regard to groundwater abstraction for nondomestic use, including disincentives with higher progressive tariff and alternatives for conjunctive use with surface water (piped and nonpiped water supply).

(iv) Encourage and expand application of cleaner production (green chemistry) through material substitution (ban of ozone-depleting substances, substitutes of persistent/nonbiodegradable pesticides, etc.); process improvement (e.g., from wet sanding to dry/modified sanding in automotive industry, etc.); and recycling (including by-products, wastes, and wastewater recycling). This requires "triple helix" cooperation of research and development (R&D) among R&D institutions run by government (PusAir, Pusarpedal, Indonesia Institute of Sciences, the Agency for Assessment and Implementation Technology [BPPT], etc.), the private sector, and universities.

(v) Enforce, improve, and expand regulation related to hazardous chemicals/substances trade, use, and its restriction in industry (e.g., ozone-depleting substances); agriculture/plantation (e.g., persistent pesticides); fishery (e.g., explosives and chemicals for fishing, as being drafted in its regulation); and mining (e.g., mercury).

(vi) Adopt best practices in respective sector/industry, for example, Roundtable for Sustainable Palm Oil for sustainable palm oil plantation/industry, the environmental guidelines of the International Finance Corporation for general industries, and Good Agricultural Practices. The measure also includes application of best available technologies that generate less wastes and pollutants/contaminants.

(vii) Apply, improve, and expand environmental monitoring (i.e., water quality monitoring) for collecting adequate and reliable data required for proper evaluation and planning, including use of Water Resources Information System for the decision support system.

(viii) The press and media can be tapped as watchdogs for the Ministry of Environment's Program for Pollution Control, Evaluation, and Rating (PROPER) to encourage better environmental management practices and award high achievers.

(ix) Encourage corporate actions and participation for sustainable and clean production by adopting voluntary internationally recognized management system (Environmental Management System [EMS] or Health Safety and Environment [HSE], Water Footprint, Water Audit).

Expand and improve sanitation facilities: Provision and improvement of wastewater and sanitation facilities (e.g., waste water treatment plants, landfill, sewerage) also contribute to good water quality. More efforts as enumerated below are required to expand and improve sanitation facilities to deal with the tremendous amount of untreated wastes entering into waterways, among others:

(i) Provide, improve, and expand coverage (greater access) of sanitation services (solid waste management, sanitation, water supply, and sewerage), especially for poor people in slum areas and riparian areas in both urban and peri-urban settings.

(ii) Enhance public awareness and community participation, especially among women, for better sanitation practices and hygienic and healthy behavior change.

(iii) Provide "green infrastructure" (supporting infrastructure to support environmental/water preservation and conservation) among others environmental laboratory, monitoring stations and instrumentation.

Restore, manage, and protect ecosystem: Healthy ecosystems provide important water quality functions by filtering and cleaning contaminated water; therefore, ecosystem protection and restoration will be the basic element of sustainable water quality efforts. Conservation focusing on watersheds can have high impact on "hot spots" through the application of a mix of measures as listed below.

(i) Delineate protected areas in spatial plans and law enforcement of spatial planning and zoning regulation for overall river basin (including watersheds, riparian corridors, and floodplains).

(ii) Enhance and expand forest rehabilitation and conservation through current initiatives such as National Action for Forest and Land Rehabilitation; National Action for Water Preservation Partnership; Reducing Emissions from Deforestation and Forest Degradation; Land Use, Land Use Change and Forestry; as well as future plans (eco-labeling and timber certification).

(iii) Enhance and expand practices of agroforestry (sustainable agriculture practices), which combines forest conservation and livelihood program under community-based development scheme.

(iv) Expand and replicate success stories of payment for environmental services as means for upstream and downstream mutual cooperation in water preservation and conservation. It could be expanded not only between spatially dependent areas but also for technically and/or physically dependent entities.

(v) Apply economic and/or financial approaches and instruments (incentive and/or disincentive), including effective use of fine and/or charge ("polluter pays" principle) for wastewater discharge and competitive-performance-based special fund allocation for provinces and/or districts in water quality monitoring.

(vi) Enhance and expand environmental minimum requirement standard for environmental monitoring by province or district government, as part of overall monitoring by the eco-region management centers of the Ministry of Environment.

(vii) Enhance functionality and independence of Indonesia ecoregion centers (PPE) as part of the Ministry of Environment in environmental management in main islands and/or regions in Indonesia

(viii) Establish effective communication and education for greater public participation in land and forest conservation, in combination with private-sponsored corporate social responsibility activities and involvement of nongovernment organizations.

(ix) Establish effective application and enforcement of legal and institutional arrangements (see also Section VII-E: Water Governance).

Priorities

The Ministry of Environment and Forestry monitors the environmental conditions in Indonesia and presents the results in the form of an environmental quality index. The monitored basins are distributed all over Indonesia (Figure 7.9). The results show that the environmental status varies from province to province (Table 7.2). Based on the environmental index, nine basins are identified as priority catchments: Bengawan Solo, Brantas, Ciliwung, Cisadane, Cimanuk, Citarum, Citanduy, Progo, and Serayu.

Figure 7.9: Basins Monitored for the Environmental Quality Index

Source: Ministry of Environment. 2012. Indeks Kualitas Lingkungan Hidup Indonesia 2011 (Indonesia Enviroment Index 2011). Jakarta.

Table 7.2: Environmental Quality Index per Province

Province	IKLH_2011	IKLH_2010	IKLH_2009	Rank_2011	Rank_2010	Rank_2009
Gorontalo	98.89	97.93	*	1	2	*
Sulawesi Tengah	98.53	97.58	68.51	2	3	14
Bengkulu	96.77	96.89	79.58	3	4	4
Lampung	86.57	86.95	73.64	4	7	9
Bali	85.3	99.65	85.5	5	1	3
Sulawesi Utara	84.59	84.18	88.21	6	8	1
NTB	84.3	90.15	73.69	7	5	8
Sumatera Selatan	77.5	75.7	69.3	8	13	12
Sumatera Barat	77	81.46	87.04	9	9	2
Kalimantan Barat	74.27	76.39	71.92	10	12	11
Maluku and Malluku Utara	73.09	79.72	78.8	11	10	5
Sumatera Utara	72.21	87.17	62.48	12	6	17
Kalimantan Timur	70.75	62.22	68.63	13	19	13
DIY	68.89	71.91	53.52	14	14	21
Sulawesi Barat	67.85	*	*	15	*	*
Aceh	66.74	77.3	72.47	16	11	10
Bangka Belitung	64.99	64.92	52.15	17	15	22
Jambi	64.92	62.82	75.04	18	17	7
Kalimantan Tengah	63.98	50.38	45.7	19	26	27
Sulawesi Selatan	62.64	62.89	67.62	20	16	15
Kalimantan Selatan	60.29	58.24	48.25	21	21	26
Papua and Papua Barat	68.51	59.56	75.3	22	20	6
NTT	59.01	50.72	66.61	23	24	16
Riau and Kep Riau	56.23	54.86	51.65	24	22	23
Jawa Timur	54.49	49.49	59.01	25	27	19
Sulawesi Tenggara	52.79	62.23	60.53	26	18	18
Jawa Barat	50.9	53.44	49.69	27	23	25
Jawa Tengah	49.82	50.48	55.4	28	25	20
Banten	48.98	48.98	50.86	29	28	24
DKI Jakarta	41.31	41.81	41.73	30	29	28
Indonesia	**60.25**	**61.07**	**59.79**			

Note: Provinces marked with an asterix (*) were not yet established in that year.

Source: Asian Development Bank.

The economic analysis shows that costs of land restoration amounted to about Rp12.75 million per hectare. Benefits are about Rp15.64 million per hectare. Most investments for water quality are dependent on sanitation facilities for rural and urban areas (Table 7.2).

D. Resilience to Water-Related Disasters

Results of water-related disaster management are not up to community expectations (protecting the public from the hazard of disasters); in fact, there are still many districts and cities at high risk for disasters.

The main problems related to society's resilience with respect to water-related disasters are as follows:

(i) Lack of attention and commitment of the government (national, provincial, district or city) in providing resources and funds needed for the O&M of irrigation infrastructure (causing drought problems) and flood prevention infrastructure (causing flood problems)

(ii) Dam operation does not include risk assessment downstream.

(iii) Lack of monitoring and weak law enforcement. These relate to
   (a) the communities and industries located in disaster-prone areas;
   (b) excessive groundwater abstraction leading to land subsidence; and
   (c) illegal water use, creating drought affecting one and all.

(iv) The decline in the availability of water source in the dry season, and increase in the runoff in the wet season as a result of environmental degradation, especially after 1998.

(v) Lack of water resources information and communications system.

(vi) Lack of early warning system.

(vii) Inadequate evacuation infrastructures and facilities.

(viii) Lack of awareness and community participation in disaster management.

Forewarned is forearmed

Implementing integrated structural and nonstructural approaches for disaster risk management improves preparedness and significantly reduces the cost of rehabilitation after disasters. Investing in flood forecasting and early warning systems that reach down to individuals who could be affected helps save lives. It also reduces economic impacts when supported by modern technology and information sharing.

Indonesia is experiencing increasingly frequent and severe water-related disasters that cause loss of life and disrupt economies. Fostering communities that can better cope with such events by being better prepared, through a combination of appropriate infrastructure, effective early warning systems, and community-based responses, will reduce the cost counted in lost lives, damaged property, and interrupted economic activities.

Although investment in flood protection works and channel improvements can reduce the effects of extreme events, an important strategy for the immediate future is to make long-overdue investments in the development and maintenance of up-to-date, comprehensive disaster risk assessments, with supporting database systems for the basins, communities, and industries at risk. Linking these databases to efficient forecasting, early warning, and disaster management systems, and with well-practiced institutional responses and teams of disaster management specialists, will reduce the risk of catastrophic events and associated losses.

These systems require adequate funding, continued political support, and frequent training and simulation exercises to ensure effective forecasts, dissemination of timely warnings, and implementation of risk mitigation strategies. Where necessary, these systems must operate across jurisdictional boundaries within countries or between riparian countries. Sharing real-time hydrological and meteorological data is key to success. Warning messages must be conveyed to communities and people in a timely fashion and must be disseminated all the way to the individual at the end of the system.

Create insurance mechanisms to minimize reliance on disaster relief

Creating insurance facilities to provide immediate funding after disasters can help countries jump-start the rehabilitation and recovery process.

Postdisaster humanitarian aid can provide much-needed relief in the immediate aftermath of a disaster. However, risk management programs established before a disaster occurs can combine prevention and risk transfer. Increased access to international reinsurance markets will help diversify and offset risk. These approaches can enable governments to rapidly access the additional liquidity required after a disaster occurs, in order to combine this with humanitarian relief resources. For example, since 2007, the Caribbean Catastrophe Risk Insurance Facility has provided participating governments with rapid access to funds following hurricanes and earthquakes. A similar initiative for the Pacific is being considered as a sovereign risk facility to meet governments' postdisaster liquidity requirements. Having funds immediately available to jump-start the rehabilitation and recovery process will reduce the potential for disasters to derail development progress.

Measures

Remedial actions can be grouped into the preparation phase, the response phase, and the recovery phase.

The preparation phase includes the following proactive measures:

(i) Preparation of disaster management plans or emergency action plans, including dam break analysis required to take the necessary action if dam failure occurs.

(ii) Disaster risk reduction:
  - (a) developing community awareness and capacity and
  - (b) increasing commitment to disaster management actors especially government officials (central, provincial, district, and city)

(iii) Prevention of water-related disaster:
  - (a) identifying and recognizing the source of disaster hazard and
  - (b) strengthening social resilience.

(iv) Improvement in coordination within the framework of an integrated water-related disaster management through segregation of the elements involved into national, regional, and local development plans.

(v) Implementation and enforcement of spatial planning.

(vi) Implementation of education and training.

(vii) Provision and dissemination of technical standard requirements of disaster management.

Reactively, the following measures should be undertaken during the preparation phase:

(i) Preparedness
    (a) providing and disseminating evacuation routes and shelter,
    (b) maintaining and improving the function of information and communication systems during water-related disasters, and
    (c) developing early warning systems and local wisdom.

(ii) Implementation of an early warning system

(iii) Disaster mitigation
    (a) ensuring law enforcement and supervision of the water-related disaster management;
    (b) improving the licensing system;
    (c) improving the quality of water resources conservation;
    (d) covering all aspects of watershed management: protection of water sources, water preservation, the water quality management, and water pollution control; and
    (e) construction, operation, and maintenance of water resources infrastructure (river infrastructure, irrigation infrastructure, water supply infrastructure, and coastal protection infrastructure).

The response phase covers the following actions:

(i) Search and rescue for victims of water-related disasters.

(ii) Immediate restoration of vital water resources infrastructure and facilities.

(iii) Restoration of water supply and delivery of logistics to the communities affected by water-related disasters.

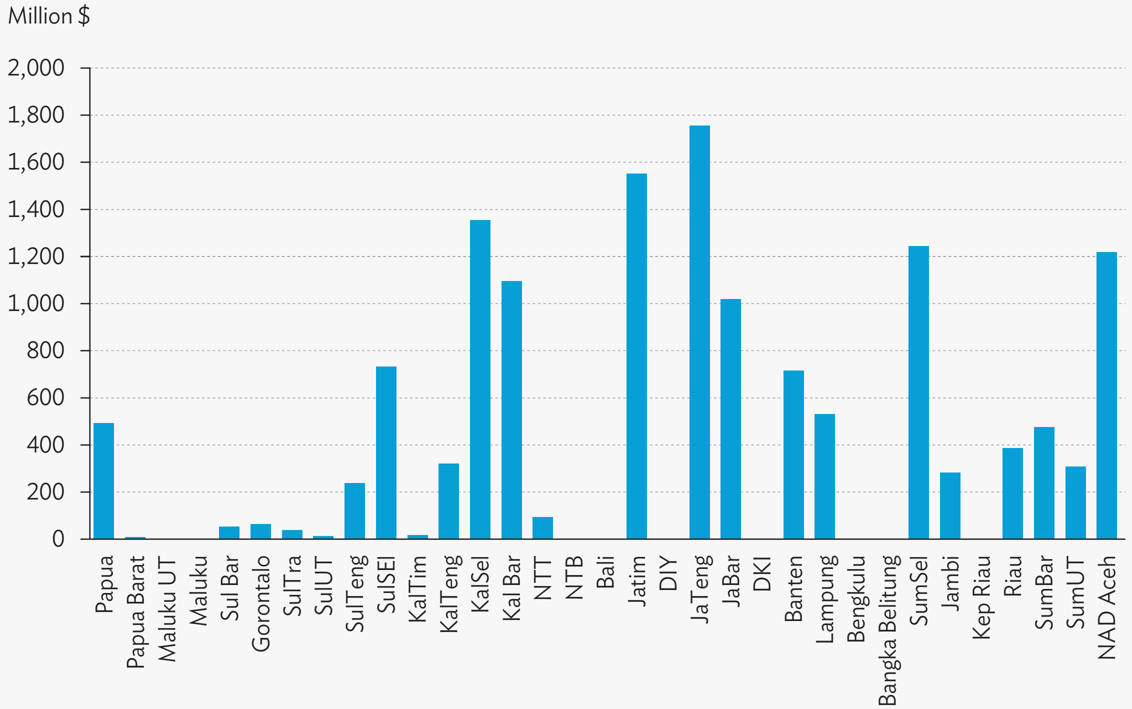
(iv) Preparation of damage and loss assessment of water resources infrastructure and facilities.

Finally, the recovery phase involves rehabilitation and reconstruction of water resources infrastructure and facilities.

Priorities

Flood damage is highest where rivers reach (low-lying) densely populated areas. Very little data are available on actual flood protection levels. Figure 7.10 presents an approximation of the annual damage from river floods in case the protection level would be designed on a flood with a probability of occurrence of once in 25 years. Most vulnerable areas are Java, South Sumatera, Aceh, South and West Kalimantan, and South Sulawesi.

Figure 7.10: Estimated Annual River Flood Damage at a Once-in-25-Year Protection Level



Note: The special districts of Jakarta and Yogyakarta are not reflected.

Sources: World Resources Institute. 2015. www.wri.org/floods; H.C. Winsemius et al. 2013. A Framework for Global River Flood Risk Assessments. *Hydrology and Earth System Sciences.* 17:1871–1892; P.J. Ward. 2013. Assessing Flood Risk at the Global Scale: Model Setup, Results, and Sensitivity. *Environmental Research Letters.* 8:044019.

In areas that are presently protected by storage reservoirs, priority should be given to O&M of the reservoir and channels as well as land restoration upstream of the reservoirs, ensuring maximum capacity and life span of the reservoirs.

E. Water Governance

Government Capacity

Following the Grand Design of the Bureaucratic Reform 2010–2025 and the implementation of the Mental Revolution put forth by Joko Widodo, the President of Indonesia, through intensive public and media monitoring, it is expected that the government apparatus will improve its integrity, neutrality, competency, and professional performance.

The central government and/or regional and local government officials involved in the implementation of water resources management should have a good knowledge base and a coherent perception of integrated water resources management (IWRM).

Following up on the legislature on IWRM, members of the Parliament are responsible for providing political support to the allocation of appropriate budgets for the implementation of IWRM plans and strategies.

Through a community and business development program, the community and businesses will have an active role as operator or service provider serving the various needs of the community, in line with the government's role as the regulator and facilitator.

Institutional Organization

According to the 2005–2025 long-term vision (Undang-Undang 17/2007), the role of the government is manifested as a facilitator, regulator, and development catalyst, who increases the efficiency and effectiveness of public services.

Water resource management activities are to be entrusted with state-owned and locally owned enterprises, as well as cooperatives. To achieve this, the government will endeavor to further develop *Perum Jasa Tirta* by increasing the work area of the existing *Perum Jasa Tirta I* to cover more basins; and enhance transformation of river basin organizations into corporate river basin organizations.

To strengthen decentralization and regional autonomy, efforts are needed to make decentralization consistent. The central government needs to follow up with the provision of adequate resources and funds to the regions. In addition, the complexity of the system should be reduced. This will improve interaction between resource operators and the retail operators. The central government remains responsible for wholesale services, whereas the provincial and district governments are responsible for retail services.

Coordination and Networking

In the short and medium term, the government will have to develop role-sharing agreements to eliminate duplication of activities and funds.

In the longer term, the government needs to build synergies and integration of major programs (such as the plan to develop new dams and additional irrigated area) with sector and regional strategic management plans (Pola). The basin councils, including their secretariats, as well as the legal annual water allocation plans, need to be strengthened.

Policies and Regulations

The repair of Water Law 7/2004 and the development of a new water law with derivative regulations on standard, guidelines, and procedures should be completed on a fast track. Furthermore, all of the existing regulations related to water resources management need to be harmonized to ensure that the revision of Law 7/2004 leads to an improved law. The preparation and the establishment of the law and regulations should be completed in 2024 to contribute to the implementation of the Grand Design of the Bureaucratic Reform 2010–2025.

F. Private Sector Participation

Progress in engaging the private sector in the delivery of infrastructure services in the water and sanitation sector has been slow. Factors that constrain public–private partnerships (PPPs) include institutional coordination and leadership issues, land clearance problems, poor project identification and preparation, and continuing regulatory uncertainty.[51]

In Indonesia, the tendency of contracting agencies to place numerous restrictions, conditions, and expectations of risk transfer on the private sector makes it difficult to structure financially feasible deals. A key factor contributing to the problem of risk overload is the common perception within Indonesia that PPPs are simply financing instruments. Opportunities for private sector investment through PPPs are typically only conceived of within the context of the funding gap, that is, the gap between infrastructure needs and the financing capacity of the government. Hence, if the PPP modality is being considered, the default setting is to assume a full concession model, with most, if not all, demand and other risks being transferred to the private sector.

The opportunity to use PPP to obtain a higher value for money through more efficient or higher-quality services has not received much emphasis in Indonesia as yet, although the use of PJT can be considered as one.

PPP is, in principle, possible at every phase of development (construction, operation, service delivery) and for a widescope of activities. Presidential Regulation 67 and its amendments govern the PPP process related to water supply projects; Decree No. 16/2008 facilitates PPP for the development of domestic wastewater management. Presidential Decree 38/2015 creates a mechanism for performance-based annuity schemes. Key success factors for Indonesia's water sector PPP are the following:

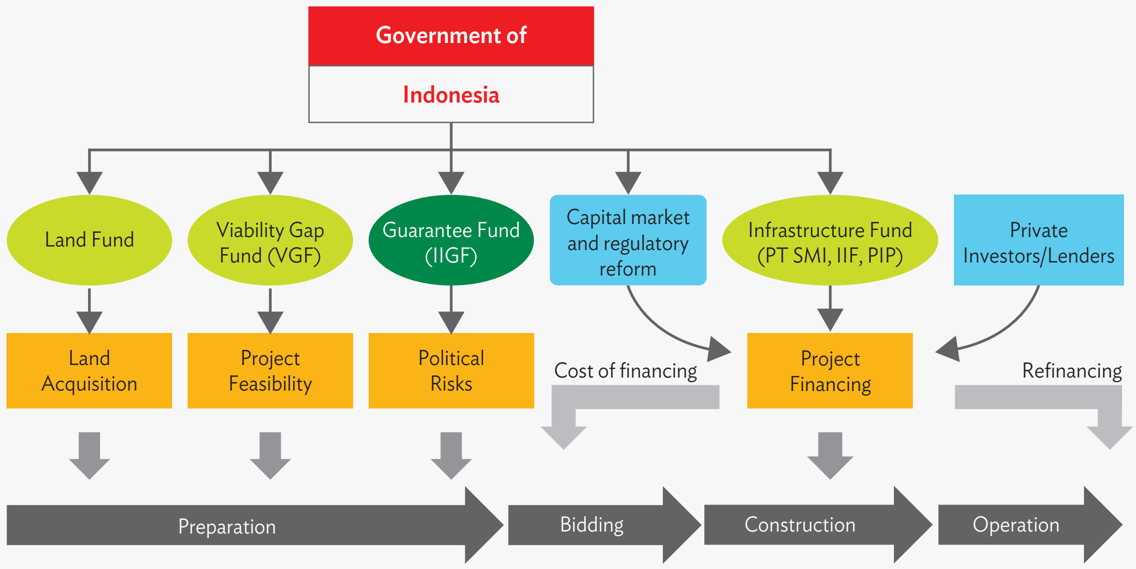
(i) **Strong commitment from contracting agency.** Strong support from Parliament is needed for priority projects as well as those considered as strategically important in the development plan. Commitment on tariff and capability to gain traction from public is essential. Fiscal commitment is sometimes required to address residual risks. Short-sighted interests should not disrupt objective policy and project decisions.

(ii) **Robust project preparation.** A technical viability analysis of raw water is required including demand, needs, and options analysis; as well as legal, environmental, and social analysis. Suitable PPP modalities should be selected (Build-Operate-Transfer, concession, or other?).

(iii) **Coherent plan and policy at all levels.** Consistency between central, provincial, and local plans are needed, facilitated by an effective coordination forum.

[51] Ray et al. 2013. Indonesian Infrastructure—Five Years and Beyond: Key Themes and Priorities for the 2015–19 Development Plan. *Indonesia Infrastructure Initiative (IndII) Technical Report.* Jakarta.

Figure 7.11: Initiatives of the Government of Indonesia to Support Infrastructure Development



Source: S. Roesly. Public–Private Partnership Models in Indonesia—A Focus on Water Sector PPP. PowerPoint presentation. Jakarta. 4 June 2014.

(iv) **Sound implementation plan.** Presidential Regulation 13/2010 Article 4(1) enables PPP, among others, to support the power, water, waste, and irrigation sectors through the Indonesia Infrastructure Guarantee Fund (Figure 7.11), the role of which is to

(a) drive quality project preparation and bankable PPP agreement;
(b) encourage clear, transparent transaction execution process;
(c) indicate the need for sectoral regulatory improvement; and
(d) increase certainty of PPPs transaction delivery.

G. Prioritization Within and Between Sectors

In this chapter, costs and benefits are discussed. The calculations make use of a number of uniform conditions, such as discount rate, economic growth rate, and period of evaluation. Most investments for the different sectors are evaluated on the basis of a discount rate of 10% and an economic growth rate of 5%. The period of evaluation is 25 years for most sectors, unless indicated otherwise. Investments are evaluated on the basis of unit of surface (hectare) or person (per capita).

Although some prices are quoted in US dollar ($), the cost–benefit calculations are made in Indonesian rupiah (Rp). Official exchange rates are used to convert $ (or euro [€]) prices into Rp: $1 = Rp12,400 and €1 = Rp13,050. The key numbers on costs and benefits as used are presented in Table 7.3. A more detailed account of assumptions and rationale of the economic assessment is given in Annex 1 of the extended country water assessment report.

Table 7.3: Unit Costs and Benefits of Measures Used in this Study (Rp million)

	Unit	Costs (2014)	Benefits	NPV	IRR (%)
Electricity (no escalation)	Capita	6.88	8.36	1.48	15
Electricity (with escalation)	Capita	6.88	13.35	6.47	21
Land conservation/rehabilitation	Hectare	12.75	15.64	2.89	13
Urban sanitation	Capita	4.76	5.54	0.78	13
Rural sanitation	Capita	2.38	2.64	0.26	12
Urban DMI supply	Capita	1.77	2.31	0.54	14
Rural DMI supply	Capita	1.69	1.89	0.19	12
O&M DMI supply	Capita	0.94	1.38	0.44	16
Irrigation—new development	Hectare	177	157	(20)	6.33
Irrigation—heavy rehabilitation	Hectare	117	157	40	33
Irrigation—moderate rehabilitation	Hectare	107	157	50	63

DMI = domestic, municipal, and industrial; IRR = internal rate of return; NPV = net present value; O&M = operation and maintenance; Rp = rupiah.

Source: Asian Development Bank.

Internal Rate of Return

Time value of money dictates that time has an impact on the value of cash flows. In other words, a lender may give you 90 cents for the promise of receiving $1.00 in a month's time from now (resulting in an interest of 10% a month), but the promise to receive that same $1.00 20 years into the future (resulting in an interest of 10% over 20 years) would be of much less worth then to that same person.

To make future cash flows comparable, these payments are discounted (on the basis of a minimum required interest rate) to their *present value*. The *net present value* is defined as the sum of the present values of incoming and outgoing cash flows over a period of time (benefit and cost cash flows).

The (economic) *internal rate of return* is the interest rate (or discount rate) for which the net present value equals 0; that is, the present economic value of all cost and benefits are equal.

The relative importance of investments in different provinces per sector has been established earlier. The strategy proposed by this study to develop water resources in river basins cannot be done without assessment of the detailed basin situation as well as consultation with the relevant stakeholders. This strategy has four main elements: infrastructure investments, demand management, intersectoral coordination, and O&M.

Infrastructure investments received most emphasis in the recent mid-terms plans and in the Pola and Rencana. They are perceived as the most important strategic components to achieve sustainable water resources for the development of Indonesia. Also, in the plans of the new government, the item related to the number of new dams receives most attention. As described earlier, the development of water storage has been lagging behind population growth since independence.

Demand management has not been at the forefront of government plans until recently, but possibilities for intensifying cultivation of rice are being explored. The previous assessment has shown that efficiency in this regard is not yet very high.

Intersectoral coordination refers to whether efforts of different ministries or levels of government are synchronized to achieve optimal results. Horizontal coordination has always been a challenge due to unsynchronized targets and budgets, but more so after the decentralization of the vertical coordination between central, provincial, and *kabupaten/kota* level ministries/governments.

The manner in which strategic objectives of governments are formulated has a direct impact on the selection of priority measures. If the government emphasizes the measure, for example, development of new dams (as the present government does), rather than the outcome, for example, improved food security, the resulting strategy will be affected.

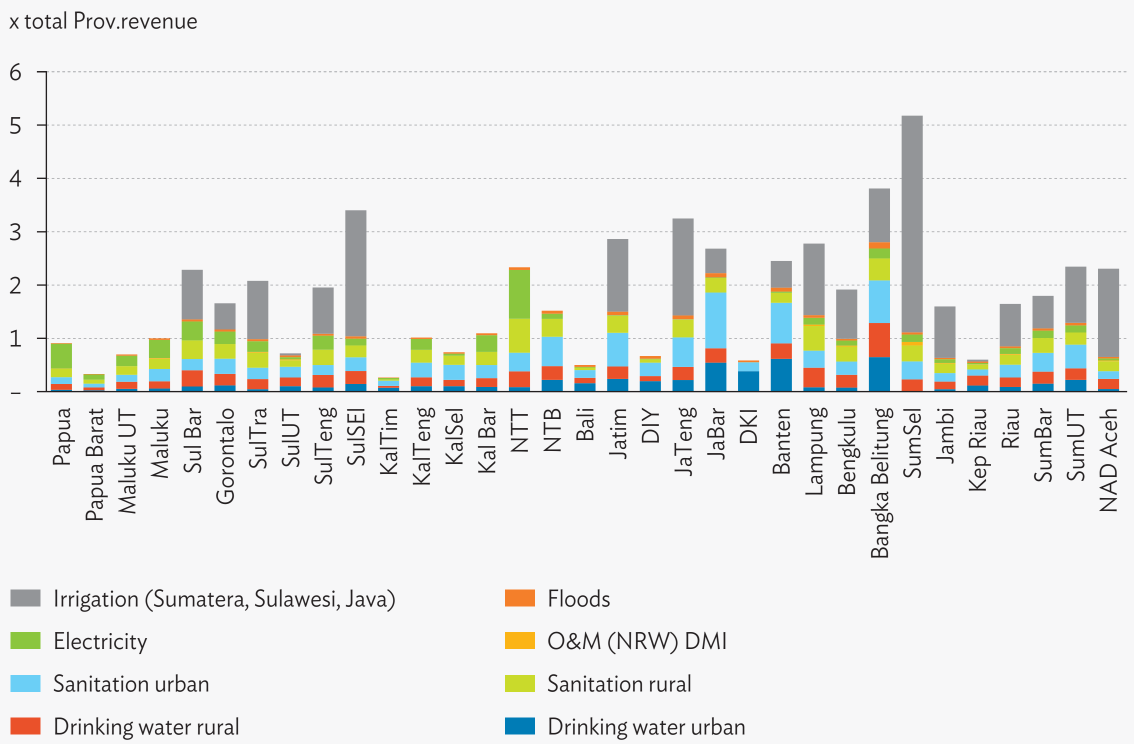
An optimal selection of interventions requires an outcome-based log frame with selection criteria to guide the individual measures. Regarding the midterm development plan (National Medium Term Development Plan, *Rencana Pembangunan Jangka Menengah Nasional*), it is strongly recommended to use outcome-related indicators. This will not only guide the most efficient interventions but also allow monitoring as to whether objectives are achieved, whereas the present input-oriented indicators only show whether the decided number of dams has been built, without indicating the impact on food security.

Operation and maintenance has not received the needed priority and funding resulting in deterioration of infrastructure and loss of functionality or reduction in the life span of infrastructure requiring high investments for rehabilitation of the existing or purchase of new structures. At present, the *kabupaten* and provincial levels underperform in terms of O&M. PDAM performance also shows undervaluation of O&M.

When the harvested area is used as an indicator for irrigation production, interventions such as rehabilitation of existing irrigation schemes, system of rice intensification (SRI) and other demand management approaches, and proper O&M become much more attractive than merely building new dams as can be seen from the internal rate of return (IRR) to develop 1 hectare. The IRR of new development is 6.3%, whereas moderate rehabilitation has an IRR of 63%. Similarly, O&M of domestic, municipal, and industrial infrastructure has a higher IRR than the development of new resources.

After the decentralization in Indonesia, many of the interventions require investments by regional governments. When the interventions discussed in previous paragraphs are compared with the revenues of these provinces (Figure 7.12), it is clear that certain provinces face a much heavier burden than the

Figure 7.12: Sum of Investments Relative to Total Provincial Revenues, 2015



Note: Total revenues of provinces include taxes, retribution, profit sharing of local, state-owned enterprises, government allocations (tax sharing, special fund allocation, general fund allocation), grants and emergency funds, and revenues of its districts and cities. If the column reaches 1, it means that the total investments needed to overcome the 2015 identified gap is equal to the total yearly revenue of this province.

Source: Ministry of Finance. http://www.djpk.kemenkeu.go.id/data-series/data-keuangan-daerah (accessed March 2015).

others. It must be realized that this assessment only includes water and energy investments, whereas in reality provinces are faced with other investment needs as well. Obviously, the investments will not be paid for directly in a year from these revenues, but the comparison gives an indication of the capacity of the provinces to fund part of the investments. Also, there is a disparity between the different types of investments. Actual gaps that will need to be filled one way or the other, such as drinking water and sanitation, are not the same as the more politically motivated objective of food security.

The involvement of the central government in funding of infrastructure should consider the willingness and capacity of regional governments to fulfill their share, especially regarding O&M, which is often a regional responsibility.

The central obstacles to financing infrastructure are management and guarantee of cost recovery through tariffs. These obstacles are overcome with time through pressure of praising and exposing, greater transparency, accountability, monitoring, benchmarking, and tariff–payer involvement.

Box 7.2: Outlook Summary

Using the facts and analyses in the preceding sections, we formulate a vision of how national water security may be achieved or maintained for the future, balancing the competing needs for food and energy.

The main components of this vision are as follows:

Implement **demand management** in all water-related sectors to reduce the exponential growth in water demand related to population growth and increased economic wealth. The cost to save a cubic meter of water is much less than the costs related to generating a cubic meter of additional water resource.

Optimize the use and life span of existing systems and infrastructure providing or regulating water resources. Ineffective or inefficient use of existing systems reduces the amount of water actually used for beneficial purposes. The cost of properly managed operation and maintenance per cubic meter of water is much less than the costs related to rehabilitation of or rebuilding the same facility. Still, rehabilitation is much more cost and time effective than developing a new infrastructure.

Develop new resources where the added investment will create net added value. Life cycle costs and benefits should be considered including operation and maintenance, not only of the facility or infrastructure itself but also of all related measures. In case of dam development, for instance, social and environmental considerations and adaptations are not only part of the equation but also are needed for upstream catchment restoration or conservation to assure the long life of the reservoir with little sedimentation.

Move toward **transparency** in data and information. The population, who pays for all costs directly either through a tariff or through the tax system, is the ultimate stakeholder and has a right to have an insight into how his or her money is being spent. At the same time, a transparent sharing of data will reduce the costs of monitoring by eliminating the many redundant systems and at the same time constitutes one of the best methods to ensure an honest and corruption-free management.

Revitalize the institutional setting to transform it from a theoretical system into a system focused on practicality working coherently and efficiently for the optimal development and provision of services to the population while at the same time protecting the natural system for generations to come. The annulment of the water law creates an opportunity to harmonize legal instruments in line with bureaucratic reforms.

Source: Asian Development Bank.

Indonesia Country Water Assessment

The Country Water Assessment (CWA) evaluates the balance between reliable and available water supplies and future demands for sustainable economic development in Indonesia. Articulated around the water, food, and energy nexus, the CWA explores technical, institutional, and policy options to improve planning, management, and development of water resources. The 2015–2019 midterm government development policy guides the priorities covered under the CWA. This assessment intends to provide a platform for dialogue to advance water reforms across Indonesia, focusing on Java, Sumatera, and Sulawesi—the country's three main economic regions.

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