Chapter 2
Water Supply and Demand and the Drivers of Change

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Abstract This chapter synthesizes the existing information and knowledge on the state of water resources in the Philippines by providing a general overview on water supply, demand and uses at the national level. The major sources of water, namely surface and ground water, will be examined in terms of its adequacy considering present and future supply based available studies and projections. Similarly, the demand side will be analyzed considering the sectoral needs and priorities in relation to the present and projected future water supply. Major drivers of change that are likely to shape the water supply and demand scenarios such as demographic shifts, urbanization, and climate change will be highlighted in the analysis. The chapter concludes with the analysis of the gap in the water supply and demand and its implications on the water governance of the country.

Keywords Water supply and demand • Water sustainability • Demographic processes • Urbanization • Climate change

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2.1 Introduction

The Philippines is well-endowed with abundant water resources, both surface and underground, to meet its water requirements. However, as in many parts of the world, water resources in the Philippines are facing increasing pressure from a combination of naturally occurring conditions and people's actions (UNESCO 2006). Considering water availability against increasing demand, as well as the worsening quality of both surface and underground water, such precious resources are now precariously approaching the critical limit. Even within a low economic development scenario, projections on water availability indicate that water stress will worsen in the future.

More recent literature analyzed the various drivers of change that influence the supply, demand, and long-term sustainability of water resources (Gleick 2013; Chang et al. 2013; Schnoor 2015). Among the major drivers that directly affect water stress and sustainability (these also apply in the Philippines) are demographic factors, which include population growth and rural-urban migration; urbanization and increasing economic activities; land use change; and climate change (Gleick 2013; Chang et al. 2013; Schnoor 2015). Their impacts have a significant bearing on the balance between water demand and supply–usually in uncertain ways–thereby creating new risks for water managers and users (UNESCO 2006, 2012). They also pose a greater challenge for achieving water sustainability.

This chapter synthesizes the current state of knowledge in terms of present and future demand and supply of water resources in the Philippines in the context of the changing times. More than reviewing available literature and project documents, it also attempts to provide updated data and information from various government sources, which are not yet currently available as published materials, in order to have a clearer picture of the water resource situation in the country. Based on water demand and supply assessment, the chapter analyzes the major factors that drive the demand-supply dynamics, which, in turn, shapes the achievement (or non-achievement) of the country's water sustainability goal. It concludes with a brief statement on how to ensure that water supply will meet long-term demand by focusing on the need to better align scientific understanding with management of water resources, specifically in addressing the environmental and socioeconomic stressors that determine water availability and sustainability.

2.2 State of Water Supply and Demand in the Philippines

At the outset, the Philippines' water resources are abundant, considering the current volume of actual renewable water resources, both surface and underground. However, looking at water availability in the face of increasing demand, as well as noting the deteriorating quality of both surface and underground water resources, one may surmise that such resources are persistently approaching their critical limit.

Table 2.1 Groundwater and surface water potential of water-resource regions in the Philippines (million m^3)

Region	Groundwater potential	Surface water potential	Total water resource potential	Percent groundwater to total potential
X Northern Mindanao	2116	29,000	31,116	6.8
VI Western Visayas	1144	14,200	15,344	7.45
IX Western Mindanao	1082	12,100	13,182	8.21
XII Southern Mindanao	1758	18,700	20,458	8.59
XI Southeastern Mindanao	2375	11,300	13,675	17.37
III Central Luzon	1721	7890	9611	17.91
IV Southern Tagalog	1410	6370	7780	18.12
VIII Eastern Visayas	2557	9350	11,907	21.47
II Cagayan Valley	2825	8510	11,335	24.92
V Bicol	1085	3060	4145	26.18
I Ilocos	1248	3250	4498	27.75
VII Central Visayas	879	2060	2939	29.91
Total	20,200	125,790	145,990	13.84

Sources: Ancheta et al. (2003), Data from NWRB (2003)

2.2.1 *Water Sources and Supply*

The major sources of water in the Philippines include rainfall, surface water resources (rivers, lakes, and reservoirs), and groundwater resources. Annual rainfall in the country ranges from 1000 mm to 4000 mm, of which 1000–2000 mm are captured as runoff by natural topography consisting of rivers, lakes, and swamps (NWRB 2003). Tropical cyclones contribute 38% of the annual rainfall in the country, while monsoon rains from the southwest and northeast account for the remainder. Average rainfall is 2348 mm/year. (AQUASTAT 2012) with huge variations: from about 960 mm in General Santos City in southeast Mindanao to more than 4050 mm in the municipality of Infanta in Central Luzon.

The Philippines' actual renewable water resource is estimated to be about 145,990 million m^3 (Table 2.1). Of these, 125,790 million m^3 are surface water, which constitutes around 86% of the country's total water resource potential. Its reliable surface water supply is estimated at 833 million m^3 per day, with only about 28% being consumed (AQUASTAT 2012). In terms of volume, Northern Mindanao has the highest potential source of surface water, whereas Central Visayas has the least.

On the other hand, total groundwater potential for all water resource regions in the country is around 20,200 million m^3 per year, which accounts for about 14% of water resource potential. Groundwater is replenished or recharged by rain and seepage from rivers, making it a renewable resource. The values in Table 2.1 are arranged from lowest to highest percentage of groundwater potential to total potential.

The country's reliable surface water supply is estimated at 833 million m^3 per day, of which only 28% is consumed (AQUASTAT 2012). Surface water supply comes mainly from major watersheds or river basins and lakes. At least 70% of the country's land area is considered as watershed areas. There are 421 principal river basins, 146 of which are proclaimed watershed forest reserves covering a total area of 2,675,687 ha (FMB 2014). From among the principal river basins, 18 are regarded as major river basins with drainage areas of at least 1400 km^2 (Kho and Agsaoay-Saño 2006). They have an aggregate area of around 11.62 million ha (about 36% of the country's total land area).

In spite of this seeming abundance, both surface and groundwater resources of the Philippines are under threat. The 2010 land use and land cover map of the Philippines reflects the critical condition of the major river basins of the country, which poses a great danger to its surface water potential.[1] Barely 25% of these basins are covered with forest vegetation. Six river basins, particularly Bicol, Buayan-Malungan, Ilog-Hilabangan, Jalaur, Panay, and Pasig-Laguna, have less than 10% forest cover. Similarly, significant portions of the total area of the basins are under cultivation (33.45%), which implies that soil and water conservation is a challenge, particularly those in sloping areas and high elevation. The Bicol, Jalaur, Panay, Pampanga, and Mindanao river basins have the largest cultivated land, more than 40% of the basin area. Moreover, about 20% of the total basin area is covered with shrubs, while another 7% is either barren or covered with grass and hence are very prone to forest fires, especially during summer months.

On the other hand, supply of groundwater has been declining through time (NSCB 2004). This may be attributed to unregulated groundwater extraction in many parts of the country. The 2003 Philippine Environmental Monitor published by the World Bank reported the absence of water-right permits in about 60% of groundwater extraction, resulting in indiscriminate withdrawal (Ancheta et al. 2003). This endangers the future supply of a high percentage (86%) of piped water systems that use groundwater as a source. More importantly, it threatens the very well-being of about half the country's population who depend on groundwater for drinking.

[1] Please see Chap. 9, Table 9.3 for details of land use and land cover in river basins in 2010.

Table 2.2 Water demand (million m^3), by sector, 1988–2016

Year	Demand						Total demand
	Domestic	% of Total demand	Agricultural	% of Total demand	Industrial	% of Total demand	
1988	5199.62	12.00	35,736.63	82.45	2404.94	5.55	43,341.19
1989	5318.80	12.01	36,453.76	82.34	2501.96	5.65	44,274.52
1990	5560.06	12.63	36,031.91	81.84	2435.45	5.53	44,027.42
1991	5811.88	13.09	36,030.53	81.16	2549.98	5.74	44,392.39
1992	5949.12	14.59	32,210.34	78.97	2626.15	6.44	40,785.61
1993	6112.07	13.47	36,453.26	80.35	2800.63	6.17	45,365.96
1994	6235.91	13.71	36,314.14	79.83	2941.16	6.47	45,491.21
1995	6411.86	16.04	30,030.82	75.12	3535.37	8.84	39,978.05
1996	6560.80	16.43	29,853.00	74.78	3506.82	8.78	39,920.62
1997	6709.34	16.57	30,228.52	74.64	3559.73	8.79	40,497.59
1998	6857.87	16.31	31,483.35	74.87	3711.81	8.83	42,053.03
1999	7006.41	16.41	31,974.20	74.87	3722.98	8.72	42,703.59
2000	6936.96	16.15	32,236.79	75.03	3789.34	8.82	42,963.09
2016	7073.27	5.3	92,266.59	69.1	34,214.04	25.61	133,581.96

Sources: NSCB (2004), DENR-Compendium of Philippine Environment Statistics (2014), NWRB (2016)

2.2.2 Water Uses and Demand

Based on the *2004 Compendium of Philippine Environmental Statistics* (NSCB 2004), the agricultural sector has the highest demand for water resources in the country, ranging from around 31,974 to 36,453 million m^3 annually or about 75–82%, respectively, of the country's total water demand within the 1988 to 2000 period (Table 2.2). This is followed by domestic demand, which constitutes 12–17%. The industrial sector has the lowest demand, only about 6–9% within the same period. In terms of trend, however, a comparative analysis across the three sectors indicates that both domestic and industrial sectors have increasing water demand, while that of agriculture is declining through time. The latest available figures (2016) show that the proportion of agricultural demand has declined and that of industrial demand has increased tremendously, which reveals the high rate of industrialization in the country. The latter may be attributed to continuous conversion of agricultural areas into settlements and diversion to other land uses.

Future projections, however, indicate that water demand in all three sectors will significantly increase by the year 2025 under scenarios of both low and high economic growth (Table 2.3). Even assuming a low–economic-development scenario, only 32% of the anticipated demand by 2025 will be met by the groundwater recharge.

On the other hand, gauged from the volume of water allocated by the National Water Resources Board (NWRB) in terms of water-right permits issued to different users, sectoral water demand has been continuously increasing through time.

Table 2.3 Water demand in the Philippines (million m^3/year)

Water demand	1996	2025		% of Total (1996)
		Low	High	
Municipalities	2178	7430	8573	7.27
Industrial	2233	3310	4997	7.46
Agriculture	25,533	51,920	72,973	85.27
Irrigation	18,527	38,769	53,546	61.87
Livestock	107	224	309	0.36
Fishery	6899	14,437	19,939	23.04
Total demand	**29,944**	**62,660**	**86,543**	**100.00**
Groundwater (GW)				
Recharge	20,200	20,200	20,200	
%GW Potential/				
Total Demand	67.46	32.24	23.34	

Sources: NWRB (2003) and JICA, Master Plan Study on Water Resources Management in the Republic of the Philippines (1998)

From a total of 135,313 million m^3 allocated to various users (19,190 permits issued in 2006), the allocation increased to 199,706 million m^3 issued to 21,459 permit holders in 2014. This represents an 8% increase in 8 years (Fig. 2.1a).

Recent records from the Department of Environment and Natural Resources (DENR) indicate that the power sector has the highest volume of water allocation, representing 57.72% of the total allocation in 2014, which is equivalent to 115,275 million m^3 (Fig. 2.1b).[2] This is followed by the irrigation sector, which receives 33.55% (67,005 million m^3). The industrial (4.55%) and municipal (3.34%) sectors are the two other sectors with relatively small percentage allocation. The remaining 0.84% is shared by other sectors that include recreational, fisheries, and livestock.

Similarly, viewed from the perspective of demand and supply, total demand for groundwater has increased from 1998 to 2001 by 3197 million m^3, while supply has decreased by 76,573 million m^3 in the same period (NSCB 2004). This dual pressure from both demand and supply is important since groundwater, as mentioned earlier, is used for drinking by about 50% of the country's population. On the other hand, the demand for surface water declined in the same period, but it was more than compensated for by a decline in its potential supply. Overall, the national annual water demand is catching up with potential supply as gleaned from the increasing percentage of demand over supply, which implies that more and more water resources of desired quality are needed through time.

[2] Although the power sector has the highest volume of water allocation, it is generally non-consumptive and recycled to irrigation and other uses. The data for the power sector therefore overlap with those of irrigation and other water uses.

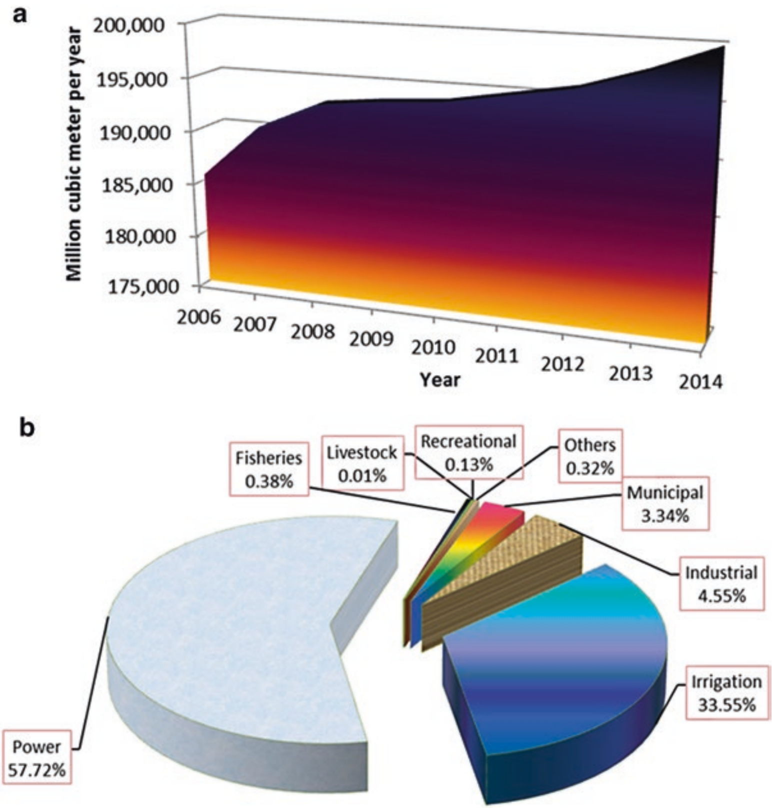


Fig. 2.1 (**a**) Volume of water allocated: 2006–2014. (**b**) Volume of water allocated, by water use, 2014 (DENR 2014)

2.2.3 Water Availability

The country has an estimated annual average runoff of 444 km^3. In 9 out of 10 years, annual runoff exceeds 257 km^3. With an annual average rainfall of more than 2400 mm, there are sufficient surface runoff and groundwater resources (FAO 2012; Kho and Agsaoay-Saño 2006). Theoretically, the high rate of precipitation assures the country of adequate water supply for agricultural, industrial, and domestic uses (Greenpeace 2007). However, due to climate variability and geography, rainfall in the country is highly unevenly distributed across time and space, often resulting in water shortages in densely populated areas, especially during the dry season (Greenpeace 2009).

The Philippines ranks second to Thailand in terms of lowest per capita water availability per year among Southeast Asian countries. It has only 1907 m^3, which is roughly half of the Southeast Asian per capita of 3668 m^3 or close to one-third of the 7045 m^3 global average for the year 2000 (Ancheta et al. 2003). The Lao People's

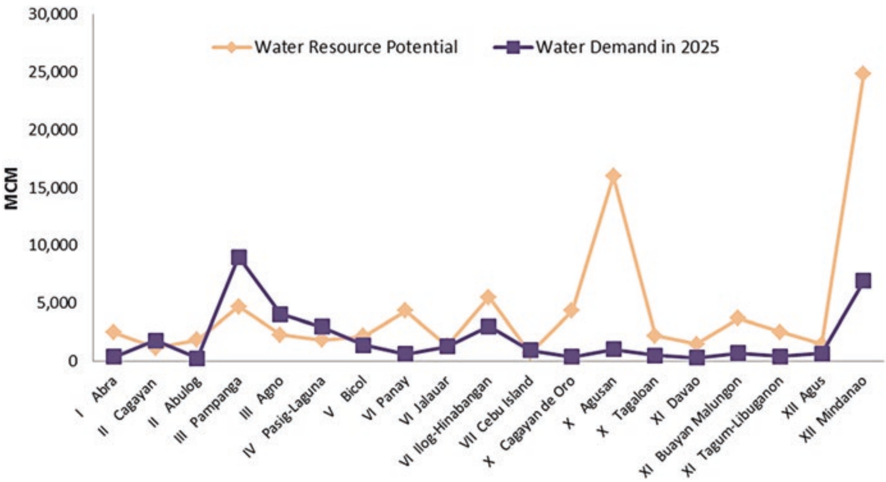


Fig. 2.2 Water potential and demand, by river basin (Ancheta et al. 2003)

Democratic Republic has the highest per capita water availability at 35,049 m^3, more than 18 times higher than the Philippines'.

According to the World Resources Institute (2000–2001), water stress is experienced in areas where per capita water supply drops below 1700 m^3/year, while water scarcity is experienced in areas with per capita water supply below 1000 m^3/year. This means that the Philippines, as a whole, is already close to experiencing water stress. In fact, the 2003 Philippine Environmental Monitor categorizes four river basins in the country as already water-scarce: Pampanga, Agno, Pasig-Laguna, and the island of Cebu (Ancheta et al. 2003). Indeed, the stability and integrity of most river basins are under increasing stress associated with a growing population, poverty, and inefficient governance. These stresses manifest as loss of forest cover, expansion of agricultural areas, prevalence of erosive and pollutive farming practices, unregulated land use conversion, poor solid waste and wastewater management, and excessive surface soil erosion (Cruz 2014).

Future projections pose a major challenge in terms of making water available to meet the increasing demands of the different sectors. In the 1998 Master Plan Study on Water Resource Management in the Philippines conducted by the Japan International Cooperation Agency (JICA), it is projected that, by 2025, even under a low-economic-growth scenario, there will be a deficit in water availability in major river basins in at least six water-resource regions (WRR). These are (1) Pasig-Laguna (WRR IV); (2) Pampanga and Agno (WRR III); (3) Bicol (WRR V); (4) Cagayan (WRR II); (5) Jalaur and Ilog-Hilabangan (WRR VI); and (6) the island of Cebu (WRR VII) in the Visayas (Fig. 2.2). Moreover, seven (7) of nine (9) major cities of the Philippines will experience groundwater supply deficit in 2025—Metro Manila, Metro Cebu, Davao, Baguio, Bacolod, Cagayan de Oro, and Zamboanga. Only Angeles and Iloilo City are not expected to experience such a deficit, although seasonality of sustained supply, particularly in the latter, may be a problem.

2.2.4 Water Demand and Supply

The latest available data show that the amount of groundwater granted to the various sectors is about 19% of total groundwater potential (Table 2.4). Almost all regions still have high groundwater potential. The surface water source, however, is a different story. The total amount of surface water available has reached the negative mark, as demand has surpassed supply, nationally. Five of the 12 WRRs already have negative supply (Table 2.5). Most water for irrigation, industry, and power rely on surface water source.

2.2.5 Water Quality Assessment[3]

The Philippines classifies its water bodies according to uses for easy monitoring. This classification aims to maintain safe quality and satisfactory condition according to best usage. Most existing and future beneficial use of said bodies of water and the land bordering them includes residential, agricultural, aquaculture, commercial, industrial, navigational, recreational, wildlife conservation, and aesthetic purposes.

Water bodies under fresh surface waters (rivers, lakes, reservoir, etc.) are classified into five types based on their best usage (DENR – EMB 2008): (1) Class AA or waters that require only approved disinfection in order to meet the Philippine national standards for drinking water (PNSDW); (2) Class A or waters that require complete treatment (coagulation, sedimentation, filtration, and disinfection) in order to meet the PNSDW; (3) Class B or waters that can be used for primary recreation such as bathing and swimming, skin diving, etc.; (4) Class C or fishery water for propagation and growth of fish and other aquatic resources; and (5) Class D or waters allowed for use in agriculture, irrigation, livestock watering and cooling in industrial facilities.

The coastal and marine water group (coastal, offshore, and estuarine) is classified into: (1) Class SA or waters suitable for propagation, survival, and harvesting of shellfish for commercial purposes and designated as marine parks and reserves; (2) Class SB or waters suitable for bathing, swimming, and skin diving; (3) Class SC described as Recreational Water Class II suited for boating and commercial sustenance fishing; and (4) Class SD waters rated as Industrial Water Supply Class II for cooling purposes in industrial facilities.

Among those classified in 2008 were 283 principal rivers (67.22% of the total 421 principal rivers nationwide) and 340 lakes/small rivers/bays. Class AA, which is the most potable, is found only in very small percentage in six regions. Of the 623 water bodies classified, 36% were in Class C for fisheries and 33% were in Class A

[3] Data drawn from DENR (2000–2008), Compendium of Basic Environment and Natural Resources (ENR) Statistics for Operations and Management (Second Edition).

Table 2.4 Groundwater assessment by region, 2016

Water-resource region	Groundwater potential (million m^3)	Amount of water granted (million m^3)				Total amount of water granted		Amount of water available (million m^3)
		Domestic	Irrigation	Industrial	Power	(million m^3)	(%)	
I	1248	215.167	73.292	6.780	0.073	295.312	24	952.688
II	2825	33.269	30.213	4.347		67.829	2	2757.171
III	1721	362.795	220.875	94.642		678.312	39	1042.688
IV	1410	456.260	102.432	189.035	4.415	752.141	53	657.859
V	1085	122.131	39.504	3.842		165.477	15	919.523
VI	1141	121.119	91.697	42.586		255.402	22	885.598
VII	879	344.220	87.239	36.196		467.654	53	411.346
VIII	2557	369.143	16.122	14.318		399.583	16	2157.417
IX	1082	27.274	2.656	3.952	3.564	37.445	3	1044.555
X	2116	125.986	44.184	54.675		224.845	11	1891.155
XI	2375	184.538	151.236	9.712		345.486	15	2029.514
XII	1758	108.023	69.316	14.891		192.231	11	1565.769
Total	**20197**	**2469.925**	**928.766**	**474.976**	**8.051**	**3881.718**	**19**	**16315.282**

Source: NWRB (2016)

Table 2.5 Surface water assessment by region, 2016

Water-resource region	Surface water (80% dependable flow) in million m³	Amount of water granted (million m3)				Total amount of water granted (with Power)		Total amount of water granted (w/o power)		Amount of water available (million m³)
		Domestic	Irrigation	Industrial	Power (Non-consumptive)	(million m³)	(%)	(million m³)	(%)	
I	3250	172.828	3447.254	78.102	6123.385	9821.569	302	3698.184	114	−448.184
II	8510	7.090	9361.782	24.642	34150.148	43543.662	512	9393.514	110	−883.514
III	7890	1121.158	16781.985	3816.842	14240.166	35960.151	456	21719.985	275	−13829.985
IV	6370	3068.142	7463.938	3643.232	18974.894	33150.206	520	14175.312	223	−7805.312
V	3060	35.099	2925.161	37.494	805.266	3803.021	124	2997.754	98	62.246
VI	14,200	105.274	5845.925	606.090	3662.461	10219.750	72	6557.289	46	7642.711
VII	2060	9.717	26288.046	24989.543	1854.406	53141.712	2580	51287.306	2490	−49227.306
VIII	9350	23.732	2517.598	195.028	107.794	2844.151	30	2736.358	29	6613.642
IX	12100	25.584	1179.561	4.707	340.072	1549.924	13	1209.852	10	10890.148
X	29000	4.745	4683.802	54.675	21288.420	26031.642	90	4743.222	16	24256.778
XI	11300	34.830	4126.486	199.776	2273.745	6634.837	59	4361.092	39	6938.908
XII	18700	15.151	6716.288	88.936	12315.375	19135.750	102	6820.375	36	11879.625
Total	**125790**	**4623.349**	**91337.827**	**33739.068**	**116136.131**	**245836.375**	**195**	**129700.244**	**103**	**−3910.244**

Source: NWRB (2016)

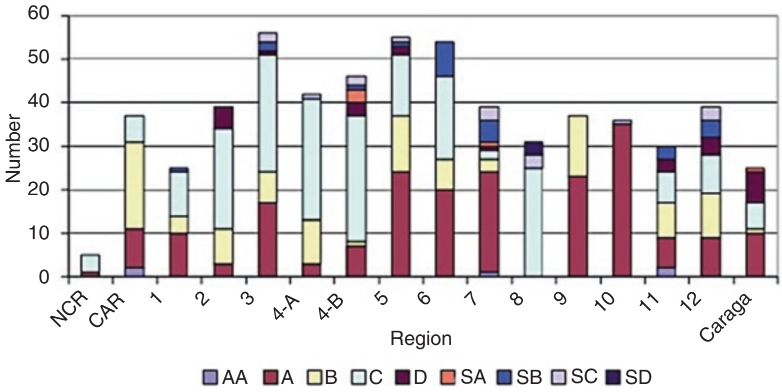


Fig. 2.3 Number of classified water bodies (Including principal and small rivers), CY 2007

(need complete water treatment to be potable) (Fig. 2.3). These figures are a far cry from the situation 50 years ago where river water everywhere is potable and where fishes in these rivers abound.

Biochemical oxygen demand (BOD) and dissolved oxygen (DO) are the main parameters used in assessing water quality. BOD is a measure of the amount of oxygen used by microorganisms to decompose organic waste. The BOD criterion standard is 5.0 mg/L (maximum) for classes A and B, 7.0 mg/L (maximum) for Class C, and 10.0 mg/L (maximum) for Class D. DO is an indicator of how well the water can support aquatic life. The DO criterion standard is 5.0 mg/L (minimum) for Classes AA to C and 2.0 mg/L (minimum) for Class D per DENR Administrative Order 2016–08.

For BOD and DO, regular water quality monitoring is mainly focused on the 19 priority rivers identified under the *Sagip- Ilog* (Save the River) Program. Assessment results revealed that all 19 priority rivers have improved significantly from 2003 to 2008 in terms of DO level. Two rivers seen to have exceeded the BOD standards are found in urbanizing areas, implying that the higher the population density, the lower the quality of river water. This is mainly caused by solid wastes being poured into the body of water and the failure of government to regulate these actions.

Moreover, water quality monitoring of the Pasig River that crosses Metro Manila was also done. For the 2004–2008 period, general water quality was poor, consistently failing to meet BOD and DO criteria for Class C waters. The most polluted parts of this river system are located downstream of the San Juan and Marikina rivers (DENR-EMB 2008; Naz 2012/2013), which are also highly populated areas.

Two other major bodies of water near the metropolis are the Manila Bay and the Laguna Lake. For the Manila Bay area, regular monitoring of the quality of the coastal waters is based on fecal coliform (FC) count. Available data show that the FC counts exceeded the maximum limit; high values are consistently registered, among others, near Luneta Park, a popular tourist attraction in the Philippines. On the other hand, BOD and DO levels of Laguna Lake showed that the lake water is still appropriate for propagation and growth of fish and other aquatic resources (DENR-EMB 2008).

Pollution of groundwater occurs when contaminants coming from domestic wastewater, agricultural runoffs, and industrial effluents reach the aquifer or water table in the form of leachates (Ancheta et al. 2003). Of these, domestic wastewater is the main contributor of bacterial contamination to groundwater supply. Waterborne diseases such as diarrhea, cholera, dysentery, hepatitis A, and others can be caused by the presence of coliform bacteria in drinking water. Based on limited data compiled from various feasibility studies of water districts, LWUA (1990–1997), and the NWRB-NWIN Project, up to 58% of groundwater intended for drinking water supplies (75 out of 129 wells) are contaminated with FC and would need treatment (Ancheta et al. 2003).

Saline water intrusion has likewise emerged as a problem in some areas, thereby reducing the availability of groundwater supply. This is caused by overexploitation or excessive withdrawal of groundwater in coastal areas. As salt water enters into the water table, water availability for domestic (including drinking) and agricultural usage, is reduced. Metro Manila, Cebu, Bulacan, Pampanga, Capiz, and Sorsogon are considered representative areas where a range of problems related to deterioration of water quality in wells yielding saline water is present (NEPC 1987 as cited in PWR 2000, p. 182).

2.3 Drivers of Change in Water Demand and Supply

A study conducted by the World Resources Institute predicts that the Philippines will experience a "high" degree of water shortage in 2040 (WRI 2015). By this time, it would rank 57th (out of 167) in a list of the most water stressed countries in the world. The study defined water stress as "the ratio between total water withdrawals and available renewable surface water at a sub-catchment level"(WRI 2015, p. 3). The sector that will have the worst impact of water shortage by that year is agriculture, a major component of the Philippine economy. Water stress will also be experienced in the industrial and domestic sectors. The study, however, does not reflect future water scarcity for smaller localities. Thus, although overall water stress projection for the country is "high," specific regions such as Mindanao could experience more extreme cases of water shortage than the national average.

Water sustainability is one of the crucial challenges that confront many societies, including the Philippines. It has been defined as *the continual supply of clean water for human uses and for the use of all other living organisms* (Schnoor 2015). Such a definition refers to a sufficient quantity of quality water for the foreseeable future for humans and all biota. Water sustainability is therefore mainly concerned with ensuring that water supply meets changing demand through time. The combined effects of demographic factors, urbanization, land use conversion, and climate change drive many regions of the world to face issues of water scarcity and water pollution, which threaten the long-term sustainability of water resources (Gleick 2003). In the Philippines, four major factors drive water demand and supply that impact on the long-term sustainability of water.

2.3.1 Demographic Factors

Demographic processes such as population growth and migration create some of the greatest pressures on water resource quantity and quality (UNESCO 2009). These processes directly affect water availability and quality through increased water demand and consumption and through pollution resulting from water use. In addition, demographic processes affect water resources indirectly through changes in land use and water use patterns, with significant implications at the local, regional, and global levels.

The demographics of the global population are changing, with important implications for water resources (UNESCO 2009). Asia-Pacific countries now have more working-age people and fewer dependents than at any point in history, providing a springboard for growth (UNDP 2016). Region-wide, 68% of the people are of working age and only 32% are dependents. The Philippine population has been steadily growing for many years (World Population Prospects 2016). It is listed as the 12th most populated country in the world, between Mexico and Ethiopia, at a population of 100,981,437 (World Population Prospects 2016). This is higher by 8.64 million compared with the population of 92.34 million in 2010 and by 24.47 million compared with the population of 76.51 million in 2000. Philippine population increased by an annual average of 1.72% from 2010 to 2015. By comparison, the rate at which the country's population grew during the 2000 to 2010 period was higher at 1.90%.

The country's fertility rate, which pertains to the number of children that a woman wants to have in her lifetime, had historically been going down (Crisostomo 2016). From 1.9 in 2010, it went down to 1.7 in 2015, meaning people are choosing to have fewer children. The increase in the population is driven primarily by 23 million women (ages 15 to 49) who are of reproductive age. In 5–10 years, the country is presumed to have the biggest number of women of reproductive age in history at 25–30 million. This is because there are many 5- to 10-year-old girls who are going to reach reproductive stage in the next 5 years.

A relationship exists between age structure and consumption and production patterns with increasing longevity. This means that with people living longer, there is greater provision for medicine, medical facilities and health care providers (UNESCO 2009). The interaction, however, between age structure and demand and supply on water resources has been inconclusive since there are other factors, such as population density, land degradation or improvement, that can influence the production and consumption of water (Sherbinin et al. 2007).

In terms of mortality, the country ranked 72nd in under-five mortality when the estimated global figure of UNICEF shows that 2000 children under the age of 5 die every day from diarrheal diseases. Of these 2000, some 1800 deaths are linked to water, sanitation, and hygiene (UNICEF-WHO 2012). Moreover, access to water and sanitation systems is a key health issue. Those who have less access tend to have higher rates of disease due to poor drinking water quality and reduced availability of water for hand washing (Giles and Brown 1997). Water-borne diseases are spread when drinking water is contaminated with pathogens from waste matters from infected humans or animals and then ingested by humans. Safe drinking water and good sanitation are effective tools to fight water-borne diseases (Boberg 2005, p. 58).

The same UNICEF-WHO report mentions that the Philippines has an almost 90% of child deaths that are due to diarrheal diseases caused by contaminated water, lack of sanitation, or inadequate hygiene (UNICEF-WHO 2012). An estimated 26% of Filipinos do not have improved sanitation, translating into more than 24 million people. Almost 8 million Filipinos are openly defecating, which is the third highest total in the Asia-Pacific region. Over the last 20 years, the poorest 20% of the rural population went from 36% to 48% open defecation (Matilla 2013). Those in urban areas have better access to water services and toilets than those in rural areas, with the rural poor four times more likely to practice open defecation than those in urban areas. The poor provinces of Masbate and Maguindanao have sanitation coverage that is as low as 38% and 30%, respectively (FIES 2009 as cited in Matilla 2013).

2.3.2 Urbanization

Urbanization is an important population trend that affects water resources (Boberg 2005). The process of urbanization has been used in several ways. These include migration from rural areas to urban areas, absolute growth in the urban population (urban growth), and urban growth that is faster than rural growth (UN-DESA 2015).

The level of urbanization affects the level of water use within a country (Boberg 2005). It can influence levels of per-capita use, overtax water resources by concentrating demand in a small area, and overwhelm existing infrastructure. The redistribution of population by migration can also shift pressures on water resources, primarily as a major contributor to urbanization.

In 2014, the urban population accounted for 54% of the total global population, up from 34% in 1960; it is expected to increase to 66% by 2050 (WHO 2016). The urban population growth is concentrated in the developing regions of the world and it is estimated that, by 2017, a majority of people will be living in urban areas. Global urban population is thus expected to grow approximately 1.84% per year between 2015 and 2020, 1.63% per year between 2020 and 2025, and 1.44% per year between 2025 and 2030. This rapid urbanization is caused by an interplay of natural increase, high levels of rural-urban migration and the transformation of rural settlements into cities (Boberg 2005).

Table 2.6 Urban population and level of urbanization, by region, 2007 and 2010

Region	Urban population (million)		Level of urbanization (%)	
	2007	2010	2007	2010
Philippines	35.580	41.856	42.4	45.3
NCR	11.566	11.856	100	100
CAR	0.298	0.425	19.6	26.3
Region 1-Ilocos Region	0.520	0.601	11.4	12.7
Region 2-Cagayan Valley	0.268	0.373	8.8	11.6
Region 3-Central Luzon	4.685	5.233	48.3	51.6
Region 4A-CALABARZON	6.404	7.527	54.5	59.7
Region 4B-MIMAROPA	0.465	0.613	18.2	22.3
Region 5-Bicol Region	0.648	0.831	12.7	15.3
Region 6-Western Visayas	2.206	2.246	32.2	34.7
Region 7-Central Visayas	2.556	2.969	39.9	43.7
Region 8-Eastern Visayas	0.223	0.358	5.7	8.7
Region 9-Zamboanga Peninsula	1.026	1.157	31.8	33.9
Region 10-Northern Mindanao	1.512	1.773	38.3	41.3
Region 11-Davao Region	2.255	2.649	54.2	59.3
Region 12-SOCKSARGEN	1.645	1.911	43	46.5
ARMM	0.731	0.466	17.7	13.7
CARAGA	0.569	0.667	24.8	27.5

Source: PSA (2013)

Urbanization and overall growth of the world's population could add another 2.5 billion people to urban populations by 2050, with about 90% of the increase concentrated in Asia and Africa (UN-DESA 2015). The largest urban growth will take place in India, China, and Nigeria which will account for 37% of the projected growth of the world's urban population between 2014 and 2050.

In 2014, 17 countries in Asia were more than 75% urban, including several of the region's most populous countries, such as Japan (93% urban), Republic of Korea (82% urban), and Saudi Arabia (83% urban) (UN-DESA 2015). China's population has grown to 1.4 billion people in 2014, 54% of whom resided in urban settlements. Indonesia has surpassed the 50% mark where 53% of its 253 million inhabitants resided in urban settlements in 2014.

In the Philippines, the level of urbanization or proportion of urban population to total population was 45.3% in 2010 (PSA 2013). This means that, of the 92.3 million people in the Philippines in 2010, 41.856 million lived in areas classified as urban (Table 2.6). The rural population or those who live in areas classified as rural numbered 50.5 million, accounting for 54.7% of the total population.

Secondary cities, which are growing fast, are putting pressure on urban infrastructure (Navarro 2014), increasing the need to establish more water system facilities to meet the rising water demand of industries and urban population. Of the 17 regions in the Philippines, the CALABARZON corridor (comprising the urban areas of Cavite, Laguna, Batangas, Rizal, and Quezon that are adjacent to Metro Manila) is the most populated area in the country with 12.61 million inhabitants. The population of CALABARZON has surpassed that of the National Capital Region (NCR), which is composed of Metro Manila (11.86 million), and Central Luzon (10.14 million). Further, 33 cities, including all 16 cities in the NCR, are now classified as “highly urbanized cities,” four of these being home to more than 1 million inhabitants. These four HUCs include three located in the NCR (Caloocan City [1.49 million], the City of Manila [1.65 million], and Quezon City [2.76 million]), as well as Davao City (1.45 million) in the southern island of Mindanao. Cities in the Philippines are contending with urban problems such as congestion, overcrowding, poor quality of life, and rapidly growing urban poor communities.

While the annual population growth rate has declined over a period of 25 years, the urban growth rate remains higher than the national growth rate due to a high birth rate, in-migration, and, to some degree, the income reclassification of local government units (Navarro 2014). Compared with other countries, the Philippines ranks 11th among countries or areas with declining percentage of urban residents between 1990 and 2014 (UN-DESA 2015).

Rapid urban growth can also affect water quality when formerly vegetation-covered land is changed into pavements and buildings (Boberg 2005). These infrastructure developments can increase the volume of runoff and pollution levels, degrading or eliminating the ability of the land to absorb rainwater and possibly infecting water systems with human wastes.

A report on the Philippines indicated worsening water quality caused by rapid urbanization (ADB 2007). Only about 33% of its river systems are classified as suitable public water supply sources and up to 58% of groundwater is contaminated. Further, water availability will be unsatisfactory in eight of the 19 major river basins and in most major cities before 2025. The depletion of groundwater resources is an increasing problem in Metro Manila and Cebu, and the ability of groundwater to meet future demand is also very limited, amounting to only 20% of the total water requirement of the country’s nine main urban centers by 2025. Water quality is poorest in urban areas, the main sources of pollution being untreated discharges of industrial and municipal wastewater.

Although groundwater resources are generally abundant, downstream water courses and aquifers have been polluted by over abstraction and poor environmental management of extractive resource industries such as mining and forestry (ADB 2007). This has caused siltation and lowered water tables. In addition, water pollution, wasteful and inefficient use of water, saltwater intrusion, high non-revenue water levels due to leaks and illegal connections, and denudation of forest cover are placing major strains on water resources, making it more difficult to provide basic water services.

Domestic waste is responsible for 48% of pollutants (ADB 2007). Thirty-seven percent comes from agricultural waste, while 15% comes from industrial waste. Metro Manila is estimated to generate 5345 tons of solid waste per day and only 65–75% is collected and a measly 13% is recycled. Meanwhile, 700 industrial establishments in the country generate about 273,000 tons of hazardous waste annually. The Philippines, however, has no integrated treatment facility to deal with it, although there are around 95 small to medium-scale facilities. Due to lack of proper treatment and landfill facilities, about 50,000 tons of hazardous waste is stored on- or off-site.

Urbanization also affects the level of water use within a country (Boberg 2005). This is particularly true for the domestic and municipal sector, where urbanization—and the infrastructure that often accompanies it—can make a significant difference in per capita use. While domestic water use in many countries is a relatively small part of the freshwater demand burden, densities of urban areas can mean that local demand can be extremely high, outstripping the resources available locally, and localized water shortages.

Rural to urban migration is a major component of urban population growth in developing nations (Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat 2001). Natural disasters, insurgency, and perceived lack of economic opportunities are just some of the negative factors that make people leave an area. In developed nations, the underlying factor for the process of urbanization is industrialization. Migration from rural to urban areas poses a major challenge for city planners. The provision of basic drinking water and sanitation services to peri-urban and slum areas to reach the poorest people is important to prevent outbreaks of cholera and water-related diseases in these often overcrowded places (WHO-UNICEF 2006).

This rural-to-urban migration pattern remains the main migration stream in the Philippines (Tirona 2013). The 2000 census of population and housing showed that about 48% of the Filipinos live in urban areas compared with 37% over two decades ago. The urban population grew rapidly at an annual rate of about 5% from 1960 to 1995, albeit showing a decline of about 3% annually from 1995 to 2000. It is estimated that, by 2030, about eight out of 10 Filipinos will be living in cities and urban areas. Rural-to-rural and urban-to-rural migration flows and counterflows are also evident, giving rise to urban sprawls. Peripheral rural areas receive the spillovers of population from the highly urbanized cities. This is observable in Central Luzon and the CALABARZON regions where rural-urban or "rurban" communities accommodate relocating residents from Metro Manila.

A two-way relationship exists between water and migration. Water stressors influence migration and migration contributes to water stress (UNESCO 2009). Water stressors, such as water scarcity and flooding, can trigger migration decisions. The social, economic, and political contexts in which water stresses occur will influence the migration response. That is, if the natural environment becomes inhospitable, people may move to areas where their locally specific knowledge may no longer apply.

The arrival of more people requires that their places of destination must provide them with water resources (UNESCO 2009). Migration can strain the capacity of the urban infrastructure and aggravate water-related conflicts. It can also upset the fragile balance of human populations and water resources. Climate change, which is predicted to lead to greater frequency and intensity of extreme weather events, is likely to result in an overall increase in the displacement of people in the future.

2.3.3 Land Use Change

Land use changes contribute to water resource conditions (FAO 2000). Between 1988 and 2010, changes in land use and land cover have been largely unregulated as the use of land in major river basins in the Philippines shifted from one major use to other major uses—i.e., forest land, cultivated land, shrub and grassland (Table 2.7). For instance, from a total area of 3,262,407 ha in 1988, forest cover was reduced to 2,913,627 ha in 2010. This represents a total loss of 348,780 ha of forest cover or an annual loss of 15,854 ha in 22 years. On the other hand, barren and grassland more than doubled in the same period from 1,057,856 ha in 1988 to 2,623,210 ha in 2010. Continuous land use conversion to non-forest uses and the degradation of the watersheds will have adverse impacts on the quantity, quality, and water regime, which will, in turn, threaten the sustainability of water supply.

Changes in land use patterns (e.g., conversion of watersheds, rapid urbanization) and increasing discharges of untreated wastes and various pollutants affect the availability of water for human consumption. For example, some rivers in Metro Manila are already heavily polluted and are fit only for navigation. Their potential as sources of water supply is lost. As a result, the Metropolitan Waterworks and Sewerage System (MWSS) has to get its water supply from Angat River, which is located in another river basin.

Land use changes, apart from pollution and increasing siltation, also influence the change in the quality of lakes, rivers, and reservoirs (PWR 2000, p. 196). On a regional basis, the critical problem in the NCR is the poor quality of its surface water, which further widens the gap between increasing demand and declining supply.

2.3.4 Climate Change

Climate change has adverse impacts on the water sector. The Asian chapter of the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report states that water scarcity will be a major challenge for most of the region, including the Philippines, due to the combined impacts of increased water demand and lack of

Table 2.7 Land use and land cover change between 1988 and 2010 in the major river basins in the Philippines (in ha)

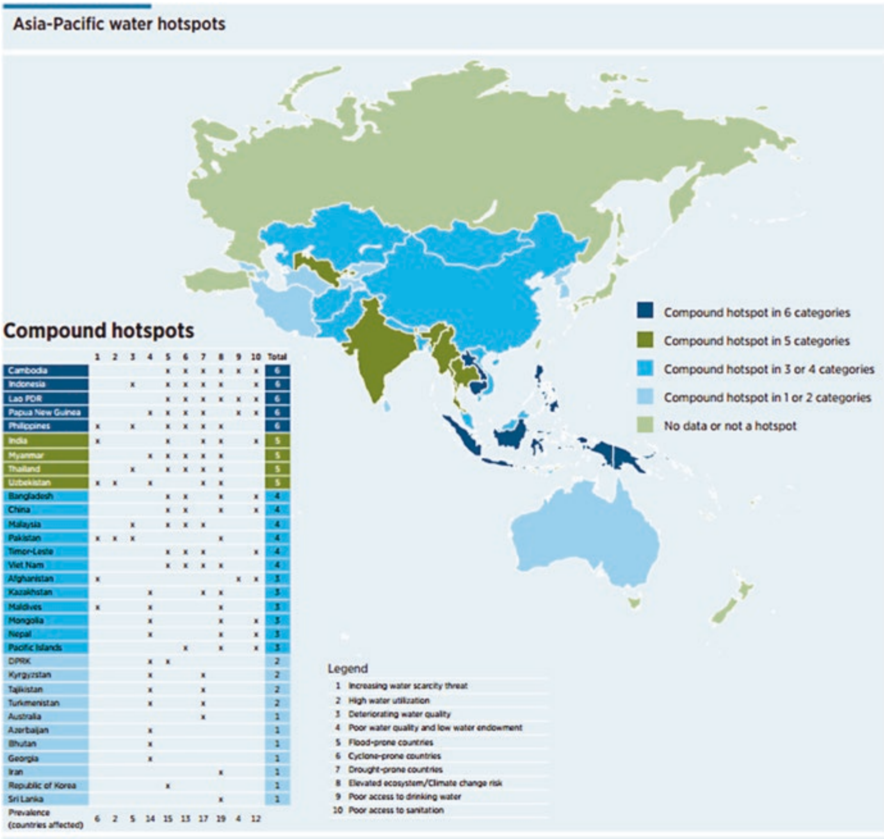
Land Cover	1988	2010	Percent change	Remarks
Forest	3,262,407	2,913,627	−10.69	Decline in forest cover mainly attributed to increase in barren areas and grassland (10.63%), shrubs (9.32%), and cultivated areas (4.94%)
Plantation	150,964	38,260	−74.66	Decrease in plantation areas mainly due to increase or conversion to cultivated areas (71.49%), shrubs (11.45%), barren areas and grassland (8.55%), forests (4.95%), and mangrove (1.24)
Cultivated	6,753,565	4,494,350	−33.45	Reduction in cultivated areas mainly due to increase in barren areas (23.6%), shrubs (9.38%), and forests (6.8%)
Shrubs	0	1,024,386		Shrubs mostly came from cultivated and forested areas
Barren and grassland	1,057,856	2,623,210	147.97	Increase in barren and grassland areas (61.04%) mainly from cultivated areas (25.9%), shrubs (6.2%), and forests (5%)
Mangrove	10,452	13,843	32.44	Increase in mangrove areas (47.13%) mainly from inland water (26.12%), cultivated (18%), barren areas and grassland (6.14%), forests (1.3%), and shrubs (1.15%)
Marshland	99,825	126,930	27.15	Increase in marshland (73.49%) mainly from cultivated (19.4%), inland water (5.83%), and shrubs (1.08%)
Inland water	283,971	384,433	35.38	Increase in inland water (79.46%) mainly from cultivated (9%), barren areas and grassland (8.05), and marshland (1.46%)
Total	**11,619,040.00**	**11,619,039**		

good management (Hijioka et al. 2014). The anticipated drier summer season and wetter rainy season brought about by climate change would have profound effects on stream flow, dam operation and water allocation, domestic water supply, irrigation, hydropower generation, depth and recharge of aquifers, water quality (e.g., salt-water intrusion), and even on water infrastructure and management systems (Pulhin and Tapia 2015). There is a grave threat of water scarcity during summer and too much precipitation during the rainy season, which can trigger more floods and landslides.

The vulnerability of the country's water sector to natural hazards associated with climate change is already evident in the recent extreme weather events like typhoons and droughts (Pulhin and Tapia 2015). For instance, Tropical Storm Ketsana (Ondoy) exposed the deficiencies in water infrastructure and management systems in the country, catching the sector off-guard to extreme climate variability. Pumping facilities to ease floodwaters in Metro Manila were unable to handle beyond 100 mm of rainfall per hour, leaving the greater part of the area and adjacent municipalities submerged in floodwaters. More than US$18.7 M (PhP 820 M) worth of irrigation facilities, including dikes and canals that serviced 53,000 ha of farmland in Central Luzon, were also destroyed by the same extreme event. Moreover, water supply in the city was affected and halted, affecting more than 100,000 households without piped-in water (Climate Change Commission n.d.). Further, the situation submerged more than 500 barangays or communities in Region III because the National Irrigation Administration (NIA) was forced to open the gates of some water reservoirs, such as La Mesa Dam, Ipo Dam, Ambuklao Dam, and Binga Dam, as water levels already reached critical status (NDCC 2009).

On the other hand, droughts usually caused by a strong El Niño produced significant dips in water inflows of major water reservoirs, which led to shortages in domestic water and irrigation supply (Jose 2002). The 1997–1998 El Niño in the country significantly reduced the water level of Angat Dam (from 37 to 22 m^3/s), which supplies more than 90% of domestic water in Metro Manila. As a result, the MWSS had to augment water supply through rationing; water supply was limited only to 4 h a day to contain the shortage. To address agricultural needs, the Bureau of Soils and Water Management had to resort to cloud seeding, spending an additional US$0.83 M (PhP 36.7 M) (Pulhin and Tapia 2015). Moreover, many people had to use water wells indiscriminately, contributing to groundwater depletion and salt-water intrusion (Juanillo 2011).

The many threats to water resources brought about by climate change interact with other factors in a complex manner. To better focus and prioritize regional action, **United Nations Economic and Social Commission** for Asia and the Pacific (ESCAP) has identified hotspots of multiple challenges. Hotspots are countries, areas, or ecosystems with overlapping challenges of poor access to water and sanitation, deteriorating water quality, limited water availability, and increased exposure to climate change and water-related disasters. Many of these challenges directly relate to the Philippines. The Philippines is among five countries in the Asia-Pacific region with compound hotspots in six categories (Fig. 2.4). These are (1) water utilization level, (2) water quality, (3) frequency of floods, (4) frequency of cyclones, (5) frequency of droughts, and (6) climate change pattern. These challenges need to be addressed if the country is to move forward with its quest of reducing poverty and achieving sustainable development.



	1	2	3	4	5	6	7	8	9	10	Total
Cambodia					x	x	x	x	x	x	6
Indonesia			x		x	x	x	x		x	6
Lao PDR					x	x	x	x	x	x	6
Papua New Guinea				x	x	x	x		x	x	6
Philippines	x		x		x	x	x	x			6
India	x				x		x	x		x	5
Myanmar				x	x	x	x	x			5
Thailand			x		x	x	x	x			5
Uzbekistan	x	x		x			x	x			5
Bangladesh					x	x		x		x	4
China					x	x		x		x	4
Malaysia			x		x	x	x				4
Pakistan	x	x	x					x			4
Timor-Leste					x	x	x			x	4
Viet Nam					x	x	x	x			4
Afghanistan	x								x	x	3
Kazakhstan				x			x	x			3
Maldives	x			x				x			3
Mongolia				x				x		x	3
Nepal				x				x		x	3
Pacific Islands						x		x		x	3
DPRK				x	x						2
Kyrgyzstan				x			x				2
Tajikistan				x			x				2
Turkmenistan				x			x				2
Australia							x				1
Azerbaijan				x							1
Bhutan				x							1
Georgia				x							1
Iran								x			1
Republic of Korea					x						1
Sri Lanka								x			1
Prevalence (countries affected)	6	2	5	14	15	13	17	19	4	12	

Fig. 2.4 Asia-Pacific hotspots (UNESCO 2012, p. 683)

2.4 Conclusion: Ensuring That Water Supply Meets Long-Term Demand

Water sustainability is one of the great challenges facing society in the twenty-first century (Falkenmark 2008). With ongoing land use conversion driven by population growth and urbanization and the anticipated impacts of climate change, many countries of the world, including the Philippines, face issues of water scarcity and pollution, which threaten the long-term sustainability of water resources (Gleick 2003). Considering the Philippines' water availability as against increasing demand, as well as the degenerating quality of both surface and underground water resources, such precious resources are now approaching critical limits. Projections on water availability indicate that water stress will worsen in the future, brought about by limited supply amidst higher demand and worsening water quality.

The paucity of more updated data and reliable information on water supply and demand is one of the major constraints that limit the effectiveness and efficiency of water management in the Philippines. Such information is crucial for policy and decision-making both at the national and local levels to develop more appropriate and strategic policies and programs to advance water resource management and sustainability. Water governance needs to better align scientific understanding with the management of water resources, specifically in addressing the environmental and socioeconomic stressors that shape water availability and sustainability (Falloon and Betts 2010). Unless the country can overcome or adapt to these driving forces, future generations will inherit a legacy of declining and degraded water resources that threaten their livelihoods and well-being, particularly those of the poorer sector of society. In the next chapter, we discuss water governance, which is one of the important pillars for pursuing water sustainability.

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