Foreword

CLIMATE CHANGE is undoubtedly the biggest challenge the Philippines faces today, and the vulnerability of our water resources to this phenomenon is a reality that can no longer be ignored. But while water scarcity is perhaps one of the most alarming projected effects of climate change on water resources, two recent typhoons in the Philippines—Ketsana and Parma—have driven home the message that over-abundance can be equally devastating. Both typhoons, along with several others in the past few years, have shown how the country is sorely ill-prepared to handle the impacts brought on by a warming world. Indeed, climate change and the ensuing extreme weather events which have brought too little—or too much—water, have caused periods of water crisis that have destroyed thousands of lives and billions of pesos worth of property and agricultural crops.

At the same time, water resources in the country are already confronted with many persistent problems: widespread pollution, over-extraction, and the degradation of watersheds. The present situation, set against the backdrop of climate change, is far from promising. While climate change will affect all sectors, it is its effects on freshwater—society's, and the Earth's, life support system—which will be most seriously felt. Water insecurity cuts across all other sectors and will negatively affect agriculture, health, and the economy.

But the country's water systems are still far from being climate-proofed, and current climate change adaptation plans lack the necessary emphasis on addressing impacts on water. This report therefore puts forward the case for the improved management of water resources as a key climate change adaptation strategy. Ensuring the sustainability of our freshwater resources now, particularly by addressing water pollution, and planning for changes that will enable current water systems to be resilient in the face of extreme weather and other climate impacts, should be the first step.

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Introduction

EVEN BEFORE the onset of climate change, access to a steady supply of clean, potable water has been a persistent problem in the Philippines. The country, however, does not lack freshwater resources. The archipelago is surrounded by the ocean and seas which supply the moisture for its abundant renewable freshwater resource—rainfall—which flows into its 421 major river basins, 59 inland lakes, swamps and marshes and ample groundwater sources which serve as natural catchments and reservoirs throughout the year.

A Greenpeace volunteer collects water samples from a well in Atok, Benguet. © Greenpeace

Yet, clean freshwater is becoming a scarce resource for more and more Filipinos. Despite the abundance of water supply, the country is vulnerable to episodes of water scarcity. Increasing population and urbanization, coupled with the lack of new water supply and waste treatment facilities, as well as insufficient and incompetent waste management and pollution control systems, has led to the over-extraction of ground water, an increase in polluted freshwater sources, salt-water incursion into low lying areas like Metro Manila and Cebu, and a decrease in the amount of available clean freshwater nationwide[1].

Scientists warn that, if unchecked, pollution and population pressure on freshwater sources could lead to a water crisis in less than 20 years[2]. Studies further show that unless the Philippines takes steps to protect and conserve its freshwater sources now, the amount of freshwater available for each person by 2025 will decrease dramatically by 65% of the current per capita availability[3], potentially making the Philippines second to the lowest among Southeast Asian countries with regard to freshwater availability per person, and bringing the country to the brink of a water crisis.

Climate change presents an additional challenge—one that is tremendously significant since its effects are felt on a scale beyond the country's coping capacity. It should thus be considered together with all the other stresses impinging on our water resources, particularly since impacts on water resources have far-reaching social consequences: water quality and availability directly affects lives, food security and health.

Although it is difficult to accurately quantify the exact effects of climate change on freshwater, it is undeniable that occurrences of extreme climactic events such as droughts and floods have serious negative implications for major water resources. The expected impacts of climate change on rainfall distribution will ultimately affect runoff to rivers and lakes. Extreme weather and climate events in the form of heavy rains which cause floods and landslides, intense tropical cyclones which cause casualty and damage to property, and strong El Niño which causes drought, have been observed in the Philippines and have affected local freshwater resources in varying degrees.

Indeed, climate change and the extreme weather systems it brings, as well as rising sea levels, are already exacerbating—and will continue to exacerbate—the country's water problems and will make access to clean water increasingly difficult. Super typhoons, once rare, now occur every monsoon season, and wreak havoc upon the country's freshwater systems, dams, dikes, levees and irrigation. On the other hand, unusually long periods of El Niño, that bring warm, dry weather to the Philippines, cause severe droughts in many areas of the country.

This report looks at freshwater sources and supply systems in the Philippines and their vulnerability to observed and future impacts of global warming. The imminent threat of the potential water crisis predicted by experts, as well as the looming specter of climate change, should provide impetus for government agencies to put in place appropriate preparedness, prevention and adaptation measures that would promote freshwater sustainability, alleviate water scarcity, and respond to future water-related challenges brought on by a changing climate.

Background: Global and Regional Perspectives

Water Availability and Use

If all the freshwater on the planet were divided equally among the global population, there would be 5,000 to 6,000 cubic meters (m^3) of water available for everyone, every year[4]. That's a lot of water for everybody, considering that water scarcity threshold is only about 1,700 m^3 (1 cubic meter of water = 1000 liters) per person per year, according to some experts. However, the world's freshwater resources are at times not available where they are needed most. Their distributions are as uneven as the world's population (Figures 1 and 2).

FIGURE 1 – NATIONAL WATER FOOTPRINTS AROUND THE WORLD.
(UN-Water, 2008. Status Report on IWRM and Water Efficiency Plans for CSD16.)

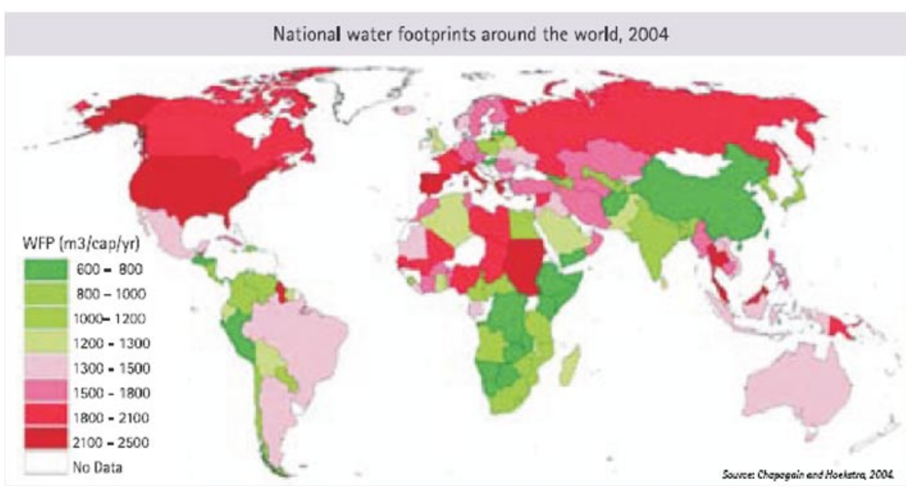

FIGURE 2 — DISPARITY IN WORLDWIDE FRESHWATER AVAILABILITY AND POPULATION
(United Nations Development Program, 2006)

Factors such as population growth and economic development, water pollution, over-harvesting and exploitation, wasteful and inefficient use of water, denudation of forest cover, and land conversion, exert pressure on water resource availability[5]. The specter of climate change and the accompanying extreme weather/climate events will put even greater pressure on freshwater availability world-wide. Extremes in water availability, i.e., over-abundance of precipitation, may cause floods, landslides, etc., and lack of or absence of precipitation usually cause drought, forest fires, and the like.

Although about 75% of the earth's surface is covered with water, only about 2.5 % is freshwater, the rest is saltwater found in the vast seas and oceans. Rainwater and snow are the primary sources of freshwater. About 1% of this freshwater are in rivers, lakes, swamps, aquifers, reservoirs, etc., the rest is locked up in glaciers and in permanent snow cover[6].

Worldwide, 70% of total water use is for agriculture, 8% is for domestic use i.e., clean water for basic human needs, and about 22% for industry. For low- and middle-income countries 82% of freshwater is used for agriculture, 8% for domestic use, and 10% for industry. Industrial use of water can be as much as 59% for high-income countries[7].

As consistent with the effects of climate change in general, those who would be most greatly affected by the problem of water scarcity and unavailability on a day to day basis are the poor in developing countries.

Extremes in Water Availability

Too much or too little of anything is usually dangerous, as the common saying goes. Such is the case for extremes in water availability. Over-abundance of precipitation (rain) results in floods, flashfloods and landslides, while lack of or absence of precipitation results in drought. In the tropics, the generators of such extremes in water availability are usually intense weather/climate systems such as active low pressure areas, tropical cyclones, monsoon rains, El Niño/La Niña, and climate variability/change.

Water scarcity, defined as "the point at which the aggregate impact of all users impinges on the supply or quality of water under prevailing institutional arrangements to the extent that the demand by all sectors, including the environment, cannot be satisfied fully"[8], is also a question of water quality. Freshwater bodies have a limited capacity to process the pollutant charges of effluents from expanding urban, industrial and agricultural uses. Water quality degradation can therefore be a major cause of water scarcity.

According to the United Nations (UN), around 1.2 billion people, or almost one-fifth of the world's population, live in areas of physical scarcity, a situation that can soon be experienced by 500 million more. Another 1.6 billion people, or almost one quarter of the world's population, face economic water shortage (or lack the necessary infrastructure to take water from rivers and aquifers)[9].

Regional Aspects of Freshwater Availability

There is worldwide wide disparity between water availability and population (Figure 2). In the Americas, for example, there appears to be a greater share of available freshwater vis-à-vis the percentage of population worldwide, whereas Asia which supports 60% of the world's population has only 36% of the world's water resources[10].

Table 1 shows that there is wide disparity between annual water resources and annual and sectoral withdrawals of water among the listed countries in tropical Asia and even among Southeast Asian countries. For example, Indonesia has the highest annual water resource of 2,530 cubic kilometers (km^3) per year, while tiny Singapore has only 0.6 km^3 per year. Cambodia and Myanmar withdraw minimal amounts from their huge water resource, mostly for agriculture. The Philippines and Vietnam have comparable annual water resource and almost the same annual percentage of water withdrawal for agriculture.

TABLE 1 — WATER RESOURCES AND USE IN TROPICAL ASIA

Country	Annual Internal Renewable (km3)	Annual Withdrawal (km3)	% of Water Resources	Sectoral Withdrawal (%)		
				Domestic	Industry	Agriculture
Bangladesh	2,357.0	22.50	1	3	1	96
Bhutan	95.5	0.02	0	36	10	54
Cambodia	496.1	0.52	0	5	1	94
India	2,085.0	380.00	18	3	4	93
Indonesia	2,530.0	16.59	1	13	11	76
Laos	270.0	0.99	0	8	10	82
Malaysia	456.0	9.42	2	23	30	47
Myanmar	1,082.0	3.96	0	7	3	90
Nepal	170.0	2.68	2	4	1	96
Philippines	323.0*	29.50	9	18	21	61
Singapore	0.6	0.19	32	45	51	4
Sri Lanka	43.2	6.30	15	2	2	96
Thailand	179.0	31.90	18	4	6	90
Viet Nam	376.0	28.90	8	13	9	78
Source: WRI, 1996-Data Table 13.1.				= *479 km3 (AQUASTAT, 2007.)		

Climate Change and the Region

Freshwater systems are highly sensitive to the effects of climate change: climate and water systems are very closely interconnected. Experts say that climate change is expected to increase global water scarcity by 20%, with countries that already suffer from water shortages being hit hardest. Notably, the incidence of water scarcity will increase even if the water impacts of climate change are neutral or even to augment the world's hydrological budget. Climate change is projected to affect not only bulk water availability but is seen to also worsen the extremes of droughts and floods[11].

It is difficult to quantify the exact effects of climate change on water resources: even with the increasing sophistication of global climate (circulation) models, the prediction of rainfall, particularly at national and regional levels, still leaves much to be desired. However, the certainty of the IPCC's (Intergovernmental Panel on Climate Change) projections that some extreme events will become more frequent, more widespread and/or more intense during the 21st century[12] ranges from *likely* to *virtually certain* to happen:

- It is virtually certain that there will be more frequent hot days and nights and fewer cold days and nights. This will result in increased water demand by an ever-growing population and increased evapo-transpiration rates from water surfaces that may contribute to water scarcity and decrease in water quality. Increased evaporation of water surfaces may, however, accelerate the hydrologic cycle, resulting in more cloudiness and a wetter condition.
- It is very likely that heavy precipitation events will increase in frequency over most areas, resulting in temporary increase in water supply but increased risk of floods and flash floods, landslides and soil erosion, inability to cultivate land due to water logging of soils, damage to crops, etc. Endemic morbidity and mortality due to diarrheal disease primarily associated with floods and droughts are expected to rise in East, South and Southeast Asia due to projected changes in hydrological cycle.
- It is likely that intense tropical cyclone activity will increase. Heavy precipitation caused by intense tropical cyclones may increase the availability of freshwater but will likewise augment flood risk and damage to property. Power outages may cause disruption of public water supply; damage to crops and uprooting of trees due to high winds; increased risk of deaths, injuries, water- and food-borne diseases and post-traumatic stress disorders.
- It is likely that areas affected by drought will increase. Drought or rainfall deficiency will result in decreased freshwater supply that could lead to land degradation, lower crop yields, crop damage and failure; increased livestock deaths; increased risk of wildfire, etc.[13]

Climate change is likely to have a significant impact on water resources in Tropical Asia. The climactic factors that will likely affect water resources in the region are temperature rise, precipitation intensity, tropical cyclone occurrences, and sea level rise. Temperature rise will result in increased evaporation. The expected changes in regional precipitation due to increased frequency of extreme weather events have potential effects on mean runoff, frequency, and intensity of floods and droughts, soil moisture, and water availability for irrigation and hydropower. Sea level rise may result in saltwater intrusion in coastal regions where most mega-cities and population centers in the Southeast Asian states are located. Water resources in the region are also vulnerable to increasing demand resulting from population growth, urbanization, industrialization, and agriculture.

The Asian Development Bank (ADB) views climate change as both an environmental and an economic issue:

> The Asia and Pacific region's water sector feels the impact of climate change in both environmental and economic ways. The subtle and significant evidences of climate change—such as mere variances in the frequency of rains to the onslaught of torrential rains, flash floods, and rising sea levels—demonstrate water's force on the landscape and on people's lives. Climate change affects the quality and availability of water supply from both ground and surface sources, which are the very lifeline to economic productivity of households, industries, and entire cities. When the climate acts up, the inconsistency in water supplies brings more economic uncertainty in the Asia and Pacific region[14].

The table below details observed climate change impacts on freshwater resources in Southeast Asia.

TABLE 2 – SUMMARY OF OBSERVED IMPACTS OF CLIMATE CHANGE ON THE WATER RESOURCES SECTOR IN SOUTHEAST ASIA
(ADB, Economics of Climate Change, April 2009)

Increasing temperature	– Increased evapo-transpiration in rivers, dams, and other water reservoirs leading to decreased water availability for human consumption, agricultural irrigation, and hydropower generation
Variability in precipitation (including El Niño Southern Oscillation)	– Decreased river flows and water level in many dams and water reservoirs, particularly during El Niño years, leading to decreased water availability; increased populations under water stress – Increased stream flow particularly during La Niña years leading to increased water availability in some parts of the region – Increased runoff, soil erosion, and flooding, which affected the quality of surface water and groundwater
Sea level rise	– Advancing saltwater intrusion into aquifer and groundwater resources leading to decreased freshwater availability
Sources: Boer and Dewi (2008), Cuong (2008), Ho (2008), Jesdapipat (2008), Perez (2008).	

The Philippines

Freshwater Resources, Water Availability and Use

Rainfall is the only direct source of freshwater in the Philippines. Being an archipelago, the country has no common boundary with any other state where freshwater may flow into or from. The average annual precipitation is about 2,400 millimeters (mm), or approximately, 704 m^3/year in volume.

Weather and Rainfall in the Philippines

The Philippine climate is typically tropical and maritime, characterized by high temperature and high humidity. The mean annual temperature values range from 19.5°C in the mountain areas to 28.2°C in small islands. January is the coolest month and May the warmest.

The country is favored by substantial amounts of annual rain, caused by various rain-bearing tropical weather systems. Average annual rainfall is about 2,400 millimeters (mm), ranging from 965 mm to 4,064 mm, with the Eastern part of the country receiving the most rainfall and southernmost Mindanao, the least. Severe storms (thunderstorms, squalls, cloudbursts, etc.), active low pressure areas, tropical cyclones (typhoons), the Northeast and Southwest monsoons, Easterly waves, the inter-tropical convergence zone (ITCZ), cold fronts, and others are common weather systems that bring substantial rains into the country almost year round. Thunderstorms occur almost throughout the year, except perhaps in January and February. The tropical cyclone season usually lasts from June to November; the Northeast monsoon from October to March and the Southwest monsoon from June to September. The ITCZ and Easterly waves occur almost year round but are most pronounced during the boreal summer months; and the so-called 'tail end of the cold front' during the Northern winter season. The irregularly seasonal El Niño and La Niña phenomena respectively bring below normal and above normal rainfall into the country.

Topography and wind direction are the most significant factors controlling the rainfall regimes of the country. From late May to September, when the wind generally blows from the Southwest (Southwest monsoon season), the Western part of the Philippines is rainy and wet, as influenced by the Caraballo and Zambales mountain ranges. From October to early April (Northeast monsoon season), when the wind is from the Northeast, the Western part of the Philippines is generally dry, because it is shielded from the Cordillera-Sierra mountain ranges in the eastern part of the Philippines. It is the Eastern part of the country which experiences rainy and wet weather because it is exposed directly to the moist Northeastern wind. The other parts of the country have uniformly distributed rainfall with no pronounced maximum rainfall periods, some with short dry seasons, depending on their exposure to the monsoon winds, high mountain barriers, and effects of tropical cyclones.

Annual rainfall trends have been either constant or slightly increasing during the past 20-30 years. About 38% of the average annual rainfall of the country is due to tropical cyclones, which are the largest contributors to rainfall in the Philippines.* An annual average of 19 tropical cyclones enter the Philippine Area of Responsibility (PAR), with about eight or nine of them crossing the Philippines. A tropical cyclone may not necessarily cross the country to contribute to its total rainfall.

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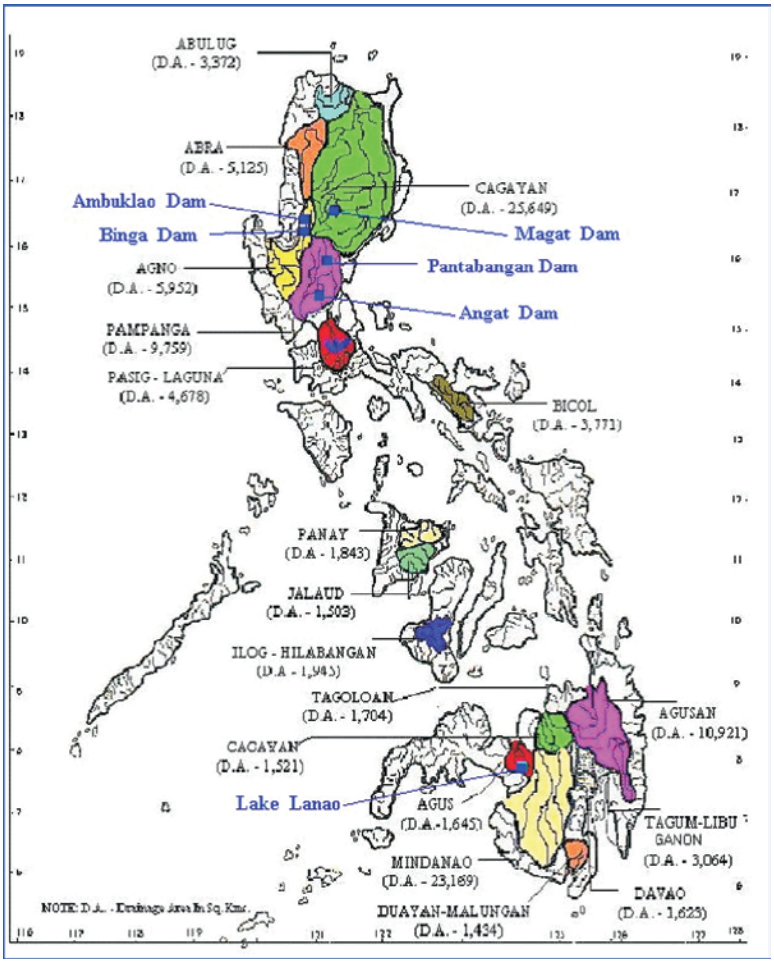
*CAB T.P. No. 2001-5.

The total freshwater supply of the country consists of surface water (runoff, or the portion of the rainfall that flows into streams), and groundwater (the portion which penetrates into the groundwater reservoir).

Surface freshwater supply is sourced mainly from the country's 421 river basins (Figure 3), each with a drainage area of at least 40 square kilometers (km^2). Twenty of them are considered major river basins with drainage areas of at least 990 km^2, not counting small mountain streams that sometimes swell to three times their size during rainy months. The five principal river basins (larger than 5,000 km^2) are the Cagayan River Basin (25,469 km^2) in North Luzon, the Mindanao River Basin (23,169 km^2) and Agusan River Basin (10,921 km^2), both in Mindanao Island, the Pampanga River Basin (9,759 km^2) and the Agno River Basin (5,952 km^2) both in Luzon Island. Only 18 river basins have an area greater than 1,000 km^2, eight of them are in Mindanao Island, seven in Luzon Island, two in Panay Island and one in Negros Island. The smallest river basins are frequently under 50 km^2.

FIGURE 3 – MAJOR RIVER BASINS OF THE PHILIPPINES
(National Water Resources Board)



Other surface freshwater supply sources are 59 natural, inland lakes with an aggregate area of about 2029 km^2. The biggest are Laguna de Bay in Luzon and Lake Lanao in Mindanao. There are also freshwater swamps and marshes, such as the Candaba and San Antonio swamps in Central Luzon and Ligusan marsh in Southern Mindanao with an aggregate area of about 5,290 km^2 [15].

Groundwater resources are likewise extensive. They are estimated at 180 cubic kilometers per year (km^3/year), of which 80% (145 km^3/year) would constitute the base flow of the river systems. There are four major groundwater reservoirs (Cagayan, 10,000 km^2; Central Luzon, 9,000 km^2; Agusan, 8,500 km^2; Cotobato, 6,000 km^2) which, when combined with smaller reservoirs, would aggregate to an area of about 50,000 km^2.

Total dam capacity was 4,753 million cubic meters (m^3) in 2000, consisting of 54 small dams (for a total capacity of 80 million m^3) and six large dams.

The country's total renewable water resource (TRWR, or the total amount of available freshwater from rivers, streams, lakes and underground aquifers) is estimated at 479 km^3/year, on the average, consisting of surface water (444 km^3/year) and groundwater (180 km^3/year), with an overlap of 145 km^3/year[16].

TABLE 3 – TOTAL RENEWABLE WATER RESOURCE PER CAPITA/DAY

Year	Population	Total water resource	Per capita withdrawal
1975	42,070,660	31,191 liters/ person/day	
1990	60,703,206	21,616 liters/ person/day	
1995	68,616,536	19,125 liters/ person/day	1,106 l/p/d
2000	76,506,928	17,154 liters/ person/day	1,020 l/p/d
2005	85,261,000	15,800 liters/ person/day	1,102 l/p/d
2007	88,574,614	14,816 liters/ person/day	

Total renewable water resources per capita (m^3/inhabitants/yr) however shows a decreasing trend: 10,788 in 1975, 7,486 in 1990, down to 5,767 in 2005.

Table 3 shows the decline in total water resource per capita from 31,191 liters per person per day in 1975 to less than half that amount in 2007, primarily in direct proportion to population increase during the same period. The total water per capita withdrawal though, remains almost constant at 1,100 liters per person per day.

There is an appreciable increase in total freshwater withdrawal from 5.9% of total water resources in 2000 to 7.1% in 2005, compared to the 1995 (5.7%) to 2000 (5.9%) period. Consistent with trends on the use of water in developing countries, yearly average agricultural water withdrawal in the Philippines accounts for about 75% of total withdrawal, while about 16% is for domestic use.

TABLE 4 – TRENDS IN FRESHWATER WITHDRAWAL IN THE PHILIPPINES
(AQUASTAT, 2007)

	1995	2000	2005
Agricultural water withdrawal (km^3/yr)	21.1	21.1	25.4
Domestic water withdrawal (km^3/yr)	4.27	4.73	5.70
Industrial water withdrawal (km^3/yr)	2.30	2.69	3.20
Total water withdrawal (summed by sector) (km^3/yr)	27.7	28.5	34.3
Percent of total water resource (479 km^3)	5.7%	5.9%	7.1%

Note that "withdrawal" typically refers to water taken from a water source for use. It does not refer to water "consumed" in that use. The domestic sector typically includes household and municipal uses as well as commercial and governmental water use. The industrial sector includes water used for power plant cooling and industrial production. The agricultural sector includes water for irrigation, fishery and livestock.

Estimated water withdrawals as of 2003, based on water rights issued by the NWRB is 77,456 m^3/year of which 84% (64,774 m^3) was by the agricultural sector, 9% (6,935 m^3) by the industrial sector, and 7% (5,515 m^3) by the domestic sector. Other water withdrawal (non-consumptive use of water) include hydropower (102,579 m^3), fisheries (747 m^3) and recreation (232 m^3)[17].

Competing uses of water

Typical of a developing country, the biggest user of freshwater in the Philippines is the agricultural sector. Irrigation, the important factor underlying agricultural growth in the Philippines over the past two decades, comprises the bulk of agricultural use of freshwater.

Clean water for basic human needs such as for drinking and general household use, health, sanitation and hygiene, may be comparatively small in terms of volume, but needs to be constantly available in the home or, at the very least, close by. The unstoppable growth of cities, with large numbers of people concentrated in small areas, is an added complexity to the problem of providing water for domestic use locally.

The average domestic water consumption, based on 17% of total water withdrawal for the Philippines is 180 liters per person per day (see Table 5).

TABLE 5 – TOTAL RENEWABLE WATER RESOURCES, WATER FOR DOMESTIC USE, PHILIPPINES

	Total renewable Water resource* (liters/inhab/day)	Total Renewable Water withdrawal (liters/inhab/day)	Domestic use Resource (liters/inhab/day)	Per Capita Consumption (liters/inhab/day)
1990	21,616	—	3,674	—
1995	19,125	1060	3,251	188
2000	17,154	1020	2,916	173
2005	15,391	1102	2,616	187
2007	14,816	—	2,518	—

*Based on the total renewable water resource (TRWR) of 479 km^3/yr and on population figures of NSO. Water scarcity threshold is about 1,700 m^3/person/yr (4,657 L/P/D).

Pressures on local water resources

Many human activities, whether on freshwater or terrestrial environments, directly or indirectly affect—sometimes permanently—the integrity of freshwater resources. Pollution, population growth and related over-extraction, deforestation and changes in land use, as well as infrastructure development are factors that contribute to water stress. Climate change is an additional pressure which also exacerbates the existing problems. Along with incompetent and poorly funded water and environmental management, as well as impotent environmental laws, these have led to the rapid deterioration of the Philippines freshwater resources.

Population

The ADB and the Philippines' NWRB studies show that, more than any other factor, population and the corresponding growth in consumption (food, services, shelter) and its resulting pollution, is straining, and will continue to strain, the country's freshwater resources to near crisis levels.

Population and consumption growth increase the demand for water. More people means more water abstraction. A modest growth of 10 million people in five years would mean an additional domestic water use of at least 1,000 million liters per day if each individual were to use only 100 liters of water every day. Urbanization will mean demand for more water by more concentrated populations. As communities become more developed, the amount of water that each person uses (per capita consumption) is also expected to increase.

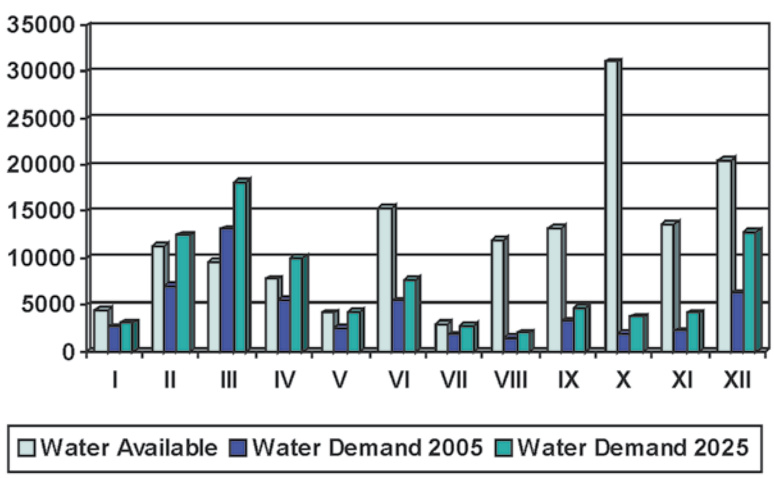
There are an estimated 92.23 million Filipinos this 2009, an increase of over 2% or almost four million people, from the 88.57 million figure in 2008[18]. But while there is still more than enough water for every Filipino, the total amount of water available for each person has declined since 1975, and has declined in direct proportion to an increase in the country's population. Note that while the amount of water available has been on the decline, the amount of water withdrawn or used by each person per day has remained almost the same, at 1,100 liters per person per day. At the same time, while a reported 85% of Filipino households now have access to a steady supply of water, two out of three people in rural areas do not[19].

Given the country's already poor water supply systems, where many people still do not have regular access to clean water, ADB projects that by 2025, if the country's population hits 120.22 million, or by 2040 if it hits 141.669 million, water availability will be "marginal" in most major cities[20].

Experts already predict that by year 2025, water availability deficit will take place in several river basins such as in Pampanga and Agno, in Pasig-Laguna, in Cagayan Valley, all other regions in Luzon, in Jalaur and Ilog Hilabangan, and in the island of Cebu in Visayas[21].

Agricultural production must also be enhanced to support such a burgeoning population. Increased agricultural production in turn requires increased water supply.

FIGURE 4 – PROJECTED REGIONAL SUPPLY/DEMAND SITUATION: 2005-2025 (in thousand cubic meters)
(Alikpala, R.B., NWRB, 2009)



Pollution

Pollution is mainly a man-made pressure on water resources. Domestic sewage, municipal wastes, industrial effluents and the heavy use of fertilizers and agro-chemicals pollute streams and waterways at an alarming rate. The Department of Environment and Natural Resources (DENR) has identified that of the more than 400 principal rivers in the country, 40 are biologically dead[22]. Sixty-seven percent of the country's rivers have been declared too polluted for domestic

Greenpeace Water Patrol activists place a signpost with the words "Our trash. Our water. Protect our water sources!" after obtaining water samples from an illegal dump site in Angono, Rizal Province, 30km east of Manila in the eve of Earth Day 2008. © Greenpeace

use, while nearly 60% of the country's groundwater is contaminated with fecal coliform and industrial pollutants[23].

Much of the pollution comes from the unregulated and untreated effluents from the hundreds of manufacturing industries located along or near rivers, as well as from municipal waste dumps and agricultural runoff (pesticides and fertilizers). Chemical pollution of surface waters, mainly by industry and agricultural runoff, and biological pollutants pose major health and environmental hazards.

Unfortunately, government agencies in charge of protecting and conserving water sources and supplies such as the DENR, Department of Health (DOH), Metropolitan Waterworks and Sewerage System (MWSS), and NWRB, along with regional and provincial water districts, lack the resources and people to monitor pollution from the thousands of industries who dump their waste into water sources.

Appendix A lists a sampling of recent water pollution cases in the Philippines.

Deforestation and land conversion

Land-use and land-use change, especially deforestation and agricultural intensification also pose major pressures to local water supply.

Many agricultural lands are converted into housing subdivisions, and some forest lands to agricultural lands. *Kaingin,* the local slash and burn farming practice, and other forms of land conversion and intrusion, have deleterious effects on local water resources. Similar practice "eliminates key components of aquatic environment; [causes] loss of functions; integrity; habitat and biodiversity; alters runoff patterns; inhibits natural recharge, [and] fills water bodies with silt"[24]. Extensive soil erosion in the upland areas has caused the siltation of rivers, thus reducing their carrying capacities. The degradation of watershed areas is also responsible for causing floods and prolonged drought.

Forests play a critical role in maintaining and preserving the quantity and quality of freshwater resources. Studies by the American Water Works Association found that costs for water treatment decreased as the forest cover in and around the freshwater sources increased[25]. In particular, for every 10% to 60% increase in forest cover, costs for water treatment went down from 19% to 20%. The study also found that protecting forests, wetlands (such as marshes and swamps), as well as the banks of freshwater sources (rivers, streams and lakes) that serve as natural filters against pollution, help preserve the quality of freshwater sources as well as hold the soil and prevent water runoff and the siltation of reservoirs such as dams[26].

However, Philippine forest cover, particularly those that are supposed to serve as watersheds for water reservoirs, have already been denuded. While forests used to cover over 70% of the country in the late 1800's (or an estimated 21 million hectares), now only 24% (or about 7 million hectares) of the country is forested, of which only 11% (or 1.4 million hectares), is classified as primary old growth forest[27]. Despite a ban on logging in 1990, corruption by government agencies has allowed logging to continue reducing forests by 2% per year. Between 1990 to 2005, an additional 32% of forest was lost to logging, equal to 3.412 million hectares[28].

Government statistics also show a more than 3% decrease in the number of farmlands since 1997, as more farms were being converted into real estate or subdivisions and shopping malls. As more and more poor farmers cannot make a living from producing food, they are forced to sell the land to developers, who in turn alter the land and destroy any plant cover that serve as both anchors of the soil, and filters for water. Although a ban on further land conversion was instituted by the government in 2004, corruption and neglect has allowed more farmlands to be sold off and converted[29].

Infrastructure development (dams, dikes, levees, diversions)

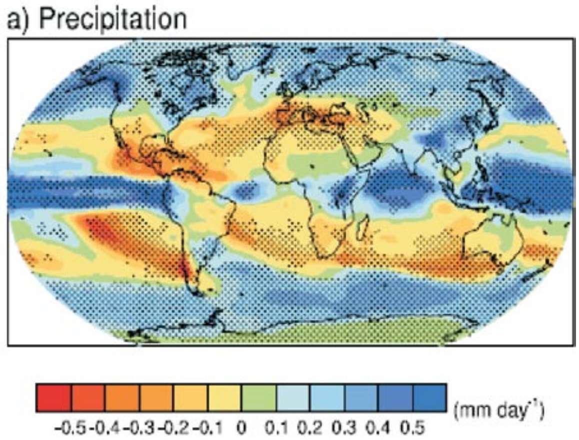
Dams are built for the storage of freshwater. Together with dikes, levees, diversions, etc. they are also designed for regulating water flow and flood protection. The downside, however, is loss of integrity. According to the IPCC, such activities "can alter water temperatures, recreation, pollution dilution, hydropower, transportation, and the timing and quantity of river flows; lower water levels; destroy the hydrologic connection between the river and the river floodplain; reduce natural flood control, nutrient and sediment transport, and delta replenishment; eliminate key components of aquatic environments; and block fish migration"[30].

A global study on river flow status has demonstrated the increasing fragmentation of river basins as a result of damming and other flow impediments. Waterfalls, rapids, riparian vegetation and wetlands can all disappear when river flow is altered by damming[31].

Climate change

Since the Philippines is located in the "wet tropics" it is likely to experience a general increase in precipitation by mid-century as predicted by the IPCC. Rainfall in the country is influenced to a great extent by the monsoons, the Intertropical Convergence Zone (ITCZ), tropical cyclones and active low pressure systems. A shift in the location, timing (onset) and intensity of these weather systems due to climate change will greatly affect the rainfall regime of the Philippines and the Asian region. So far, global circulation (climate) models do not have common findings on the future characteristics of these weather systems. Recent extreme events, however, may be viewed as a response, or as adjustments of these systems, to changes in climate parameters, such as global temperature rise.

FIGURE 5 – PREDICTED RAINFALL WORLDWIDE, 2050
(IPCC, 2007)



Recent trends in extreme weather and climate events worldwide seem to support the IPCC projection of increased heavy precipitation and intense tropical cyclone events (Figure 5). There are indications of increasing incidence of extreme weather events, such as intense precipitation events and tropical cyclone occurrences during the last two decades in the country, causing flashfloods and landslides and damage to property and loss of lives.

As mentioned earlier, extreme weather events such as heavy precipitation and tropical cyclone intensity (both in wind strength and intensity of precipitation) are expected as an inevitable consequence of a changing climate. The effect of such extreme weather events, including La Niña, will be temporary and transient increase in local freshwater resources. These extremes in rainfall events will likely lead to water-induced disasters, such as floods or flashfloods and landslides.

On the other hand, El Niño usually results in lack of precipitation. Drought or near-drought conditions resulting from below normal rainfall conditions in the country will affect not only agriculture but all other users of freshwater resources, notably water for domestic use. The frequency of occurrence of this extreme climate event is expected to remain almost the same over the years, but its intensity is expected to increase.

Climate change, therefore, particularly extreme weather events, poses an additional significant pressure—aside from exacerbating the impacts of other existing pressures. However, compared to other factors exerting pressure on water availability as enumerated in the previous section, the scale of the impacts of climate change are likely to be beyond the Philippines' coping range and will require additional adaptation efforts over and above efforts addressing other pressures.

Generally, demand for water increases while temperatures increase, this is true for domestic use as well as for irrigation where water demand decreases with precipitation. Such a situation, against the backdrop of a growing population, puts further strain on water resources and systems.

Climate change also intensifies water pollution with higher temperatures, increased precipitation intensity, and longer periods of low flows[32]. Increase in temperature affects the self-purification capacity of rivers due to reduced dissolved oxygen levels, and promote algal blooms and fungi. More intense rainfall leads to turbidity in lakes and reservoirs, and to the increasing higher runoff of pollutants from the soil (such as fertilizer or pesticide residues and heavy metals) to water bodies. Heavy rainfall also leads to greater pollutant loads due to increased infiltration rates to aquifers. The lowering of water levels in rivers and lakes lead to greater concentrations of pollutants and the suspension of bottom sediments.

Extreme weather events, particularly, droughts, present even greater strains on water sources. During the 1997 to 1998 El Niño, the drought wreaked havoc on 68% of the country, and forced the government to make painful decisions on water allocations, giving priority to domestic consumption and depriving farms of much needed irrigation, with long term implications on the country's food security.

Climate change-related but non-extreme weather events-related effects on freshwater resources include sea level rise which usually also results in salt water intrusion, aside from massive flooding of low-lying coastal areas. The salinization of freshwater systems, especially groundwater, irrigation water and estuaries will result in decreased freshwater quality and availability. Saltwater intrusion of estuaries would affect upriver freshwater plants, brackish-water fisheries and agriculture.

Sea level rise also exacerbates the occurrence of storm surges, which can result in the salinization of estuaries and freshwater systems and its quality, increased risk of deaths due to water contamination and by drowning in floods.

Weather disasters and episodes of water crisis

Due to its geographical location and geological setting, the Philippines is prone to a wide spectrum of natural disasters caused by tropical cyclones (typhoons), heavy monsoon rains, earthquakes, volcanic eruptions and the like. Water-related natural disasters are by and large associated with extreme weather events: those caused by too much rains (floods, flashfloods, landslides) and those due to lack of rain (drought, forest fire).

As discussed above, the IPCC predicts, and evidence has proven so far, that climate change will cause an increase in precipitation, stronger monsoons and more violent typhoons, in the Philippines and in Southeast Asia in general. Tropical cyclones (including tropical depressions, storms and typhoons), which now account for about 38% of the country's rainfall, will bring even more rain, raise the average river run-off and water availability by 10 to 40%, and cause more devastating floods.

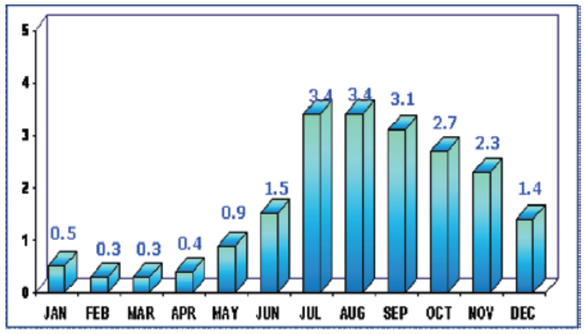
Filipino scientists have observed that the amount of rainfall in the Philippines has been increasing in the past 30 years[33], while some of the most destructive typhoons hit the country from 1991 to 2000, during the world's warmest decade. A total of 29 violent and wet typhoons hit the Philippines from 1986 to 2000, compared to only ten from 1971 to 1980 (13 from 1991-95, eight each in both the 1986-90 and the 1996-2000 periods, compared to only five from 1971-76 and four during the 1976-80 period)[34]. While typhoons bring rain, they can also contaminate water sources.

At the same time, the El Niño, or warm periods that bring less rain and cause intense droughts, is also expected to become more intense. Low water levels in rivers and streams may also bring down water quality by increasing the concentration of pollutants, making clean water even more scarce[35].

Tropical cyclones (typhoons)

An annual average of 19 tropical cyclones enter the Philippine Area of Responsibility (PAR), with about eight or nine of them crossing the Philippines. At least one tropical cyclone per year may not make its landfall but still inflict damage and casualties in the country. A tropical cyclone may occur any time of the year, but the months from June to December may be considered as the typhoon season, with its peak during the months of July and August (Figure 6).

FIGURE 6 – AVERAGE MONTHLY TROPICAL CYCLONE OCCURRENCE
(Philippine Atmospheric Geophysical and Astronomical Services Administration.)



Loss of human lives and damage to property depends to a large extent on the severity of a tropical cyclone, i.e., wind strength, rainfall intensity, and storm surge occurrence. Surface winds of tropical cyclones can reach speeds of 200 km/h or more (super-typhoons). Damage to property is generally due to strong winds and storm surges, human casualties are mainly due to drowning in floods and flashfloods, in storm surges and in the high, stormy seas.

A storm surge is characterized by a sudden rise of water (sea) level along the coast or near the place of landfall of a typhoon. The rise in water level could be as high as five meters or even more. The strong winds, the swift current of an ebbing surge, together with the wave action due to big sea swells, could sweep away rows and rows of houses and other structures along the coast. Loss of human lives is usually high when the storm surge occurs at nighttime and the affected community fails to evacuate to higher and safer grounds. In the Philippines it has been observed that a typhoon accompanied by a storm surge usually causes more than 100 casualties. Rising storm-surge levels also erode coastlines and cause landward saline intrusion.

The amount of rain that an average tropical cyclone generates could be awesome and can cause instantaneous flashfloods, widespread floods, landslides or mudflows which in turn negatively impact freshwater systems.

Floods and flash floods

Floods can occur anywhere after heavy rain events. All floodplains are vulnerable and heavy storms can cause flash flooding in any part of the world. Floods come in all sorts of forms, from small flash floods to sheets of water covering huge areas of land. They can be triggered by severe thunderstorms, tropical cyclones (many of which can be exacerbated by the La Niña phenomenon), and monsoons. In coastal areas, storm surges caused by tropical cyclones, tsunamis, or rivers swollen by exceptionally high tides can cause flooding. Dam breaks or sudden regulatory operations can also cause catastrophic flooding.

Floods have tremendous socio-economic impacts. Aside from deaths, mostly due to drowning, water-borne diseases usually follow. Damage to structures, public works, and to agriculture, especially to rice and corn crops, vegetables, etc. could be enormous. Floods, even in their aftermath, disrupt daily socio-economic activities, including trade and industry. The social and emotional trauma inflicted on the victims may have a short-term inhibiting effect on the community's drive.

Flash floods can also occur after a period of drought when heavy rain falls onto very dry, hard ground that the water cannot penetrate. Flash floods and/or landslides caused by heavy, continuous rains due to tropical cyclones, intensified monsoons, and other rain-causing weather systems are common yearly occurrences in the Philippines.

Excessive flooding affects water quality, dumps mud and debris on rivers, streams and lakes, contaminates groundwater sources, and damages water supply systems, making the water undrinkable and causing outbreaks of diseases at a time when clean water is needed the most.

Landslides, mudslides or mudflows

Mudslides and landslides are local events and are usually unexpected. They occur when heavy rain or an overflowing crater lake sends large amounts of earth, rock, sand or mud flowing swiftly down mountain slopes, especially if these are bare or burnt by forest or brush fires.

Examples of land- or mudslide events that caused considerable casualty and damage to property were the Payatas landslide (2000), Camiguin landslide/flashflood (2001), Southern Leyte landslide (2003), the Albay landslide/mudflow (2006), and the Guinsaugon landslide (2006).

Similar to floods, landslides, mudslides and mudflow inhibit access to clean water particularly if water sources and systems become buried in mud.

Drought or rainfall deficiency

The primary cause of drought is deficiency of rainfall. Drought is different from other hazards in that it develops slowly, sometimes over years, and its onset can be masked by a number of factors. Drought can be very devastating: water supplies dry up, crops fail to grow, animals die and malnutrition and ill health become widespread.

Between 1982 to 1998, four strong El Niños caused a dramatic drop in rainfall in the Philippines, resulting in some of the most intense droughts ever experienced in 50 years. Billions of pesos were lost in agriculture (7% drop in agricultural production in 1997 El Niño) and industry, as irrigation and power came to a halt[36].

A man walks in a cornfield damaged by severe drought, Surallah, Cotabato, 2005. Since the extreme drought struck farmers report that the harvest is less than one third the normal yield. The country's worst drought in 50 years has affected around 700,000 people. ©Greenpeace/Jose Enrique Soriano/ Silverlens

The following is a list of recent major weather disasters in the country and their effects on water systems.

A delivery truck turned upside down, after typhoon Ondoy caused heavy flooding in Barangay Sto. Nino in Marikina. Located in a valley, Marikina City was one of the hardest hit by the said typhoon. Greenpeace is calling on industrialized nations to put up an adaptation and mitigation fund for countries like the Philippines that are most vulnerable and least prepared to deal with the impacts of climate change. © Greenpeace/Gigie Cruz-Sy

Typhoon Ondoy (Ketsana)

From September 26 to 28, 2009, Typhoon Ondoy (international code name Ketsana) hit Luzon's eastern and central provinces, drowning Metro Manila and the provinces of Bulacan and Laguna in floods from two to ten feet deep.

In less than 12 hours, Ondoy brought as much as 455 millimeters of rainfall in Metro Manila, the highest amount of rainfall recorded in the capital in 42 years, or the equivalent of one month's worth of rainfall in Manila during the monsoon season[37]. Within nine hours, 80% of Metro Manila was flooded. Worst hit were the cities of Marikina, Pasig and Cainta, all flood plains (once home to extensive rice farms and fish ponds, but now home to subdivisions, malls and manufacturing plants) in the path of the swollen Marikina River, which had spilled over and breached the dikes along its banks[38].

Municipalities downstream from Metro Manila and along the Laguna Lake in the provinces of Rizal and Laguna, received the spill-over from the Lake's 21 river tributaries, including the Marikina River, and were submerged in over ten feet of water. Scientists estimate it will take over six months for the waters to subside along the shores of the Lake[39].

The speed with which the waters rose caught local governments, national disaster agencies, and the tens of thousands of unprepared residents who were trapped in their homes, unable to move to higher ground. Most were forced to wait for rescue on the roofs of their houses and almost all were caught without food or water[40].

Water pumping stations throughout the Metropolis, many over 30 years old, proved useless in pumping flood waters out into Manila Bay, as all were built to handle only up to 100 mm of rainfall per hour, and not the 294 mm per hour that Ondoy's rains brought onto the capital[41].

On September 29, as Ondoy left the country, over 400 lay dead from drowning or landslides, most of whom were from Metro Manila and the provinces of Rizal[42].

As of October 2009, damage from Ondoy is estimated to be at PHP (Philippine Pesos) 10.8 billion, of which 63% or almost PHP 7 billion is in agriculture. More than PHP 820 million worth of irrigation facilities, including dikes and canals, servicing over 53,000 hectares of farmland in Central Luzon were likewise damaged by the floods[43].

Over four million people were affected by the floods, one million of whom were forced to leave homes that were damaged or washed away. More than 700,000 took refuge in the over 550 public schools, gyms and public buildings, which served as makeshift evacuation centers all over Metro Manila, straining the sanitation and water supply facilities of all of the hardest hit cities and municipalities[44].

Water and electrical utilities were likewise damaged. Metro Manila's power concessionaire was forced to shut down power in many of the flood hit areas, not only because of damaged lines, but to avoid further harm from possible electrocution and fires[45].

Power outages and flood waters also shut down major water pumping stations of the Metro's two water concessionaires so that while much of the capital was head deep in water, many had no access to clean water. Two days after Ondoy left the country, Manila Water Company reported water supply capability down by 92%, and Maynilad Water Services Inc. down by 25%, leaving over 100,000 households-customers without piped-in water[46].

Both concessionaires reported damage to major water pumping stations in Rizal province, and in the cities of Taguig and in Muntinlupa (to the south of Metro Manila), all of which service five municipalities in Rizal (west of Metro Manila) and almost all cities and municipalities in the southern part of the Metropolis. Eight out of 19 pumping stations and water treatment facilities of Manila Water were inundated and damaged by flood waters. Damaged water pipes also forced the concessionaires to reduce water production in many more areas around Metro Manila. Maynilad Water was forced to use their deep wells, many of which are contaminated with domestic waste. Two weeks after Ondoy, the two concessionaires were still trucking water into waterless communities of Rizal province, as well as to cities and municipalities in the south of Metro Manila, and to the over 500 evacuation centers in flood affected areas[47].

Hundreds of millions of pesos went to supplying and servicing flooded waterless communities and evacuation centers with several hundred chemical toilets, makeshift showers, water bladders, tens of thousands of jerry cans, crates of bottled water and water purifying kits, while hundreds of water tanks trucked hundreds of thousands of gallons of water to affected communities and evacuation centers everyday[48].

Three weeks after Ondoy, the Philippine Department of Health, the United Nations Children's Fund (UNICEF) and the World Health Organization (WHO), reported a spike in cases of leptospirosis. In Metro Manila, nearly 2,000 incidences of leptospirosis infections been reported, with 148 deaths traced to the disease[49].

Spikes in cases eczema and other fungal infections, and of colds and coughs, as well as of diarrhea have also been reported in and among flooded communities and evacuation centers that lack clean water and toilets. In Marilao, Bulacan for instance, 75% of the 8,000 families staying in evacuation centers have been infected by water borne bacterial diarrhea[50].

Water reservoirs like Angat Dam in Bulacan and Pantabangan Dam in Nueva Ecija were also caught flatfooted by Ondoy's rains. On September 29, Angat Dam, which supplies Metro Manila and Bulacan province with raw water, was forced to release over 500 cubic meters of excess water that had accumulated during Ondoy, exacerbating the floods in seven of Bulacan's rice and vegetable producing municipalities[51].

Pantabangan Dam was likewise forced to release excess water on September 29, as its safe level was breached by five meters during Ondoy's rains. Pantabangan administrators had already begun to release water even before Ondoy as a precaution, but were forced to open their flood gates after heavy rains caused the three rivers that feed Pantabangan Dam to swell[52]. The spill increased water levels in the already flooded communities downstream of the Pantabangan, including six municipalities and three cities in Nueva Ecija and the municipality of Candaba in Pampanga province, all major farming communities in Central Luzon[53].

Super Typhoon Pepeng (Parma) and the dams of Luzon

Five days after Ondoy while the country's capital and primary rice producing regions were still trying to recover from the floods, Typhoon Pepeng (international code name Parma) hit Philippine waters on October 3.

Pepeng swung back and forth for six days, making landfall three times, and leaving a path of death and destruction across 5,200 villages, 360 municipalities, 36 cities in 27 provinces in Northern and extreme Northern Luzon, affecting over four million people and leaving at least 438 dead and 51 missing from the ensuing floods and landslides[54].

As of October 2009, damage was estimated to be at PHP 16.553 billion, and as with Typhoon Ondoy, agriculture sustained the biggest losses at PHP 11.69 billion or over 70% of the damage[55]. The total cost of assistance as of October 19, 2009 is PHP 111.7 million from Philippine government (not counting foreign assistance). Pepeng also damaged 178,000 tons of rice crops making the total loss of rice harvest from Ondoy and Pepeng about 478,000 metric tons or 7% of the national rice production target for the planting season[56].

A Category Four typhoon, Pepeng's winds of 195 to 240 kph (kilometers per hour) slowed down as the typhoon lingered over land, but dumped from 200 to 300 mm of rain every 12 hours[57]. In 24 hours, a recorded 675 mm of rain was dumped over Northern Luzon, over three times the normal level of rainfall of 180mm for the region during the monsoon season[58]. The effect of just two days of continuous rain was devastating, overloading the already saturated soil in the mountains of Northern Luzon and caused already swollen rivers to spill over, breach their dikes, and inundate communities downstream of the Cordillera mountains, including the rice, sugar, vegetable and fish producing provinces of La Union, Pangasinan, Tarlac and Bulacan.

Water was released from all seven multi-purpose dams in Northern and Central Luzon, built for flood control, irrigation and power generation, when rain waters had reached near spilling points. Ambuklao and Binga Dams in Northern Luzon, San Roque Dam in Pangasinan, Pantabangan Dam in Nueva Ecija, Magat Dam in Isabela, Angat and Ipo Dams in Bulacan, all released most of their waters on the morning of October 6, two days after Pepeng's torrential rains had hit Northern Luzon. The dams serve as catchments for rain and river water from the Cordillera mountains and river systems from Northern and Central Luzon. Thus, the release of water acted to exacerbate the flooding in all areas downstream, from the provinces of La Union and Pangasinan in Northern Luzon, to as far as Central Luzon in Pampanga and Bulacan[59].

Dam officials later admitted none of the dams were built to take in so much water in such a short period, all at the same time[60]. Floods caused by the rains and exacerbated by the spill waters from the dams in Northern Luzon submerged eight municipalities in Bulacan[61], 80% of Pangasinan Province, including 38 towns, the city of Dagupan and thousands of hectares of rice and vegetable farms and fishponds, as well as several towns and hundreds of farms in the nearby province of Tarlac[62], and 24 out of Nueva Ecija's 32 towns. In Isabela Province, spill water from Magat Dam saturated its over 4,000 hectare watershed and the swollen Magat River, destroying thousands of hectares of rice fields and rice crop in the province as well as in neighboring Cagayan[63].

Four to five days after Pepeng had left the country, all seven dams were still spilling water, as all of them still held water in excess of their safe spill levels, and continued to spill water a week after Pepeng, as a precaution against possible torrential rains from Typhoon Ramil, (international code name Lupit)[64].

As with typhoon Ondoy/Ketsana, water services and supply systems in almost all areas affected by Pepeng's floods suffered damage and contamination. In the almost all major cities and towns in Pangasinan, water utilities were inundated and unable to service the thousands of people whose homes were damaged or totally destroyed by the floods. In Dagupan City, water services were out for over a week as ten out of the city's 18 pumping stations were flooded. Throughout Pangasinan, the Local Water Utilities Administration (LWUA) along with the local fire departments resorted to trucking in 1.6 million gallons of clean water everyday to all affected communities and evacuation centers[65]. The Red Cross, National Disaster Coordinating Council (NDCC) and private companies all helped to provide flooded communities throughout the province with water bladders (which provided about 15,000 liters of clean water per day), tens of thousands of jerry cans and bottles of potable water, water sanitation kits, as well as set up makeshift water testing and treatment plants[66].

Typhoon Frank (Fengshen)

In 2008 alone, 14 typhoons and their resulting floods affected over 7.6 million people. The worst among them was Typhoon Frank (international code name Fengshen) which hit the Philippines from June 20 to 23. Not a super typhoon, Frank (Category 3 typhoon, with winds of only from 165 to 205 kilometers per hour), poured so much rain on the provinces of Panay, Iloilo, Antique, Capiz and Negros, as well as portions of Eastern and Western Samar, that floods of up to two meters were reported in 2,000 barangays, killing over 600, and damaging the homes of over one million people[67]. Damage to infrastructure was pegged at over PHP 3 billion, while agriculture took the worst beating at PHP 7 billion, including irrigation systems, dams and local agricultural reservoirs at over PHP 1.2 billion[68].

Hardest hit were the provinces of Iloilo and Aklan, where flood waters and mud of up to two stories high inundated entire towns, and destroyed their water systems. Water had to be shipped in and trucked to affected communities, along with storage tanks and smaller water containers for residences[69]. Iloilo City's water supply was cut off for several months, as its main water pipe was destroyed when it was hit by a bridge that had collapsed from rampaging flood waters. Moreover, the few water utilities and deep wells left untouched by mud and floodwaters, were rendered useless, as the electric generators and water pumps that powered them were either flooded or buried in mud[70].

The DOH reported outbreaks of typhoid fever and deaths from diarrhea in many towns as people were forced to rely on shallow wells and contaminated streams and rivers[71]. Municipal governments went into debt as millions of pesos in bottled water had to be bought from suppliers outside the province[72].

Water districts utilities of Aklan and Iloilo, along with their filtration and sanitation facilities were so badly damaged, that it took over six months before they were repaired[73]. To this day, the floods and mudslides that came with Typhoon Frank have left the Aklan River silted and prone to spillovers with each heavy rain, while many towns in the provinces of Aklan and Iloilo are left with drainage systems and water utilities that await repair, as local governments were left cash strapped after spending most of their funds on relief and rescue operations.

Typhoon Reming (Durian)

Houses lie in shambles in a collapsed riverbank after strong winds and rain from Typhoon Reming battered Legazpi in Albay. ©Greenpeace/Ivan Sarenas

From November 28 to 30, 2006, Super typhoon Reming, (international code name Durian), hit Albay province in Southern Luzon with 230 kilometers per hour winds, killing over 1,300 people, most of whom were buried in the landslides triggered by the strong winds and heavy rains dumped by Reming and the three super typhoons that came before it--typhoons Milenyo (Xangsane), Category 4, in late September; Paeng (Cimaron), Category 5, in late October; Queenie (Chebi), Category 4, in early November 2006[74].

Indeed the amount of rain that fell over Albay was unprecedented, 466 mm or 18 inches in just two days, the highest amount of rainfall recorded in the province since 1967[75], or over 6,400 million liters of water, enough to fill 275 Olympic sized pools in just 80 minutes. Ironically, while Typhoon Reming dumped tons of water on the province, it also left most of Albay's freshwater sources (deep wells, streams and rivers) as well as water supply systems damaged and buried under tons of mud and rocks, and contaminated with debris and dead bodies.

Twenty-two water districts were damaged, along with filtration and sanitation utilities, costing the province over PHP 80 million. Distribution pipelines, service connections and pumping stations were completely destroyed from the mudflows and debris. Legazpi City, Tabaco and Daraga water districts, near the foot of Mayon Volcano, reported difficulty re-connecting water pipelines because of shallow and clogged river flows, and the loss of underground springs, which were buried in the landslide[76].

Many municipalities resorted to digging new shallow water wells, along with shallow latrines, which became breeding grounds for diarrhea, cholera and typhoid[77]. Eleven major hospitals in Camarines Sur, including all government hospitals and its tertiary hospital in Albay, had to refer patients to hospitals outside the province, for lack of potable safe water[78].

For nearly three months, potable water had to be trucked in from nearby provinces and Metro Manila, while the provinces' over one million residents had to bathe or launder in rainwater or contaminated river water[79]. The DOH, along with the Red Cross, Department of Social Welfare and Development (DSWD), and the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA), were forced to find ways to provide water tanks for Albay's 719 barangays and the hundreds of evacuation centers where the homeless were staying[80].

Indeed, two years after Reming, public water utilities of Albay were still in the process of re-establishing lost water sources from rivers and groundwater springs, as well as rebuilding water utility systems[81].

Bicol was not the only province to suffer damage to its water utilities. The National Irrigation Administration reported damage to irrigation systems, including dams in Quezon and Laguna provinces. One year after Reming, many of the irrigation systems were still in need of repair.

Unding, Violeta, Winnie and Yoyong, and the Umiray incident

From November 14 to December 4, 2004, four weather events visited the Philippines, killing about 1,800 people in flash floods and landslides in Aurora and Quezon provinces, and parts of Bicol and Eastern Visayas[82]. While only one of the weather disturbances, Yoyong, was a typhoon, it was the combined torrential rainfall from tropical storm Unding, and tropical depressions Violeta and Winnie, that set off the landslides in the towns of Real, Infanta and General Nakar on the coast of Quezon province[83].

The four storms damaged crops and infrastructure worth over PHP 7 billion, and disrupted water and sanitation systems not only in the provinces hardest hit, but also threatened the water supply of Metro Manila[84]. Overall damage by the storms was at PHP 11.3 billion.

Tropical Depression Winnie in particular, caused landslides in Quezon that damaged over 100 water sources in schools, health centers and barangay halls, depriving the thousands of refugees with potable water and sanitary facilities[85]. Water districts reported damages of up to PHP 2 million, including damages to the National Irrigation Administration (NIA) Dam in Dingalan, Aurora, along with several other smaller dams and irrigation facilities[86]. Water facilities of the MWSS along with the two private water concessionaires for Metro Manila (whose tunnels and reservoirs traverse rivers along Aurora and Quezon provinces) also reported damages to facilities of up to PHP 3.446 million[87].

But the most costly damage to a single water facility that had devastating consequences for the capital Metro Manila, was inflicted on the13-kilometer Umiray Conveyance Tunnel of the MWSS, whose water intake section was blocked by big boulders, logs and other debris, washed in from the floods, rendering it totally useless[88]. The Umiray Tunnel brings water from the Umiray River in General Nakar Quezon, to the Angat Dam, which supplies 90% of Metro Manila's water. Damage to Umiray Tunnel, along with its supporting facilities (connecting bridge bunkhouses and maintenance equipment), was estimated to be at PHP 1.5 billion, while the cost to Metro Manila residents was six months of decreased water pressure as repairs were being undertaken on the tunnel[89].

Tropical depression Uring and the Ormoc foods 1991

Tropical Depression Uring struck Negros and Leyte provinces on November 5, 1991. Hardest hit were Ormoc City and the Ormoc watershed in Leyte, which were inundated by land- and mudslides from heavily denuded hillsides, and flood waters from the Antilao and Malbasag Rivers[90]. Over 6,000 drowned in the mudslides and floods which crashed into the city for over four hours[91].

Uring's wind strength was relatively weak, 55 kph, but the rainfall intensity was abnormally strong, measuring from 140mm to 580.5mm within 36 hours. Indeed, the rain was so strong, that within five hours, soil on the hillsides of the Ormoc watershed became totally saturated and weak, eroding at up to three meters in many places, and was carried down to the rivers by the water[92].

The flood waters, along with soil and debris, rose from seven to 15 meters, or from two to five stories, in just 4 hours. The total volume of water that flooded Ormoc City is estimated to be about 22,500,000 cubic meters, the equivalent of 22.5 billion liters, or enough water to fill 9,000 Olympic sized swimming pools[93].

The huge amount of debris and dead bodies contaminated the rivers and ground water, and completely destroyed Ormoc City's water supply and sanitation system. Potable water had to be shipped in from Cebu, and trucked to affected areas in water tanks for nearly two months[94]. It would take another four years to completely repair the city's water supply and sanitation system[95]. The heavy rainfall also changed the nature of the city's streams and rivers. The downpours that eroded the banks of many streams brought more sediment and debris to the Antilao and Malbasag Rivers, making them shallower downstream, nearest to the more populated areas of Ormoc City. The increased volume of sediments in both rivers makes them less capable of carrying water, and more prone to spillovers and flooding during heavy rains[96].

El Niño, droughts and the water crisis of 1997 to 1998

The El Niño (or warm episodes), in the Philippines and Southeast Asia, is marked by no rain, or very little rain, late and weak monsoons (at times delayed by over a month), and fewer tropical cyclones. Droughts follow intense El Niños, with devastating effects. While El Niño events

Observed Impacts of El Niño and La Niña on Water Reservoirs

An assessment of the impacts of extreme climate events (ECEs) on water resources was performed by relating rainfall with hydrological indicators (inflow, water level) of five major reservoirs, namely, the Angat, Pantabangan, Magat, Binga and Ambuklao dams in Luzon and Lake Lanao in Mindanao.*

Annual rainfall trends at the watersheds are either constant or slightly increasing/decreasing during the past 20-30 years but the trend of the annual inflow curves for all the catchments is generally decreasing. This implies that the capacity of the watershed to absorb moisture decreased considerably, likely attributed to degradation of forest cover due to land conversions, deforestation and other human activities; erosion and heavy siltation in the case of Binga-Ambuklao.

The 1980's and the 90's were characterized by the occurrence of four strong El Niños (warm periods), i.e. in 1982-83, 1986-87, 1992-93 and 1997-98 causing consistent negative anomalies of rainfall and inflow. The El Niño events of 1997-98, the most intense, as well as the 1982-83 warm episode, had dramatic effects on the water availability of the country. The effects of El Niño on the major reservoirs are consistent with the observed low annual rainfall. Majority of the lowest annual rainfall and inflow were experienced during El Niño years. On the average, there was a corresponding decrease in the reservoir water levels (RWL) of major reservoirs. During such extreme climate events, all the reservoirs in Luzon exhibit a delay of one month, i.e. starts in May instead of April.

Another impact of the warm episode is on irrigation. In the event of an El Niño, elevated areas which are not serviced by water impounding reservoirs were mostly affected. The impacts on power generation are less dramatic than those of domestic water supply and irrigation in Luzon as the decrease in hydropower generation could be augmented from other sources of energy. However, for Mindanao island, power comes mainly from a series of hydro-electric power plants from the Agus River that emanates from Lake Lanao. The prolonged drought of 1992 that brought the water in the lake to its lowest level reduced the power production to a point where National Power Corporation (NPC) had to impose power curtailment in the entire island of ten to 15 hours daily. This power shortage caused enormous economic losses of several billion pesos on unrealized revenues and economic opportunities of 32 national and multinational corporations within the island.

The response of the catchments (reservoirs) to La Niña is not very distinct and the impacts during La Niña and normal years are more or less similar except for Magat and Lake Lanao. In general, there is an increase rainfall during La Niña (cold episodes). During La Niña events, the above normal rainfall usually inundates low-lying areas thereby decreasing the benefited areas.

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*CAB T.P. No. 2001-5.

normally occur every three to five years, Philippine scientists have observed that these warm episodes have become more intense in the past 20 years[97]. The El Niño episodes of 1982 to 1983, 1992 to 1993, and 1997 to 1998 caused some of the worst droughts in the country's history.

The droughts of 1992 to 1993, and 1997 to 1998, were so intense that irrigation was severely rationed in Central Luzon, and in some provinces was stopped altogether as water levels in rivers that fed the Angat and Ipo Dams dropped. Rice farmers were hardest hit. Many farmers in Central Luzon and Mindanao chose not to plant or simply planted less water dependent crops[98]. The 1992 to 1993 El Niño induced a drought so severe that Mindanao's hydro-electric power plant, dependent on the nearly dry Agus River and Lake Lanao, came to a near standstill. Power cuts of from ten to 15 hours were imposed, causing billions of pesos in losses for many industries and businesses on the Island[99].

Figure 7 below shows the moisture deficit at various places in the Philippines during the El Niño years of 1973, 1982-83 and 1997-98. Note that Mindanao has been adversely affected during all these El Niño episodes (January-February-March, JFM).

The El Niño of 1997 to 1998 was especially devastating, affecting 68% of the country, and inducing a severe drought that lasted for six months, from June to October 1997, and a very weak monsoon until June 1998 where rainfalls fell to 87% of normal levels[100].

Government agencies in charge of water supply and distribution are the first to admit that most of the Philippines' water utilities, reservoirs, and supply systems are not prepared to cope with emergencies, much less extreme weather events and accompanying disasters on the scale of the Ormoc City flood of 1991, or of the Legazpi mudslide of 2006[1]. Lack of funds, and comprehensive research and planning have led to an inability to effectively deal with and prepare for extreme weather events, floods, landslides and drought[2].

National government agencies such as the DENR (Department of Environment and Natural Resources), DOH (Department of Health) , MWSS (Metropolitan Waterworks and Sewerage System) and LWUA (Local Water Utilities Administration), lack human and financial resources to do comprehensive research, surveys, or monitor water quality for each and every water utility and water district nationwide. For example, when cholera or typhoid outbreaks occur and water supply is suspect, it takes a while to find out where and why the outbreaks happened, and even more time to correct the problem. At the same time, local governments charged with the administration of water utilities in the provinces need more technical know how and funds to maintain quality standards, or undertake research and planning on how to prepare for and deal with climate change events[3].

The fact that the Philippines' thousands of water utilities are run by a confusing number of government and private entities only adds to the problem, especially since all operate using different water allocation criteria, regulations, quality standards and pricing schemes[4]. Metro Manila is covered by two private companies, while other regions are supplied either by one of the 500 water districts, or one of the over thousand local government water utilities, or one of the hundreds of small independent water companies that operate in areas not covered by any of the water utilities[5].

After the Legazpi mudslide in Bicol, water utilities of Legazpi City, Tabaco and Daraga did not know how to deal with the change in river flows and loss of springs from which they sourced their water[6], while almost all provincial water districts and water utilities hit by floods, landslides and mud did not have backup systems for water treatment, filtration and sanitation. Neither did they plan for possible losses of water mains, aquifers and water pumping equipment[7].

The situation for the country's dams is equally alarming. Many dams, built 40 to 50 years ago are heavily silted and have either been

Water levels in reservoirs like the Angat Dam, the Pantabangan, Magat, Binga and Ambuklao Dams in Luzon fell considerably as the rains failed, and the rivers that fed them turned dry[101]. Water levels at the Angat Dam, which supplies Metro Manila with 97% of its raw water[102], dropped by 89% as water inflows went down to 86% below average inflow levels[103]. Low water levels in the Angat reservoir resulted to a high concentration of manganese content in the water.

As the drought became more severe, Angat Dam stopped water allocations for irrigation altogether, and imposed a 30% cut on water rations for domestic use. Water was made available to Metro Manila households for only four hours a day[104]. Long lines of housewives and children armed with pails and water barrels, awaiting the arrival of fire trucks and water tanks became a common sight during the drought. Many households in Metro Manila resorted to use of groundwater sources, digging hundreds of deep wells and using pumps to extract the groundwater, and contributing to the depletion of Manila's aquifers, which had already resulted in salt-water intrusion decades before in the cities of Muntinlupa, Las Piñas and Parañaque[105].

The Maasin River irrigation system in Bulacan, which depended on the Angat Dam for water, had to limit water allocations for thousands of farms. Some 27,000 hectares of rice and corn lands, planted by over 15,000 farmer households, went without water for two cropping seasons, resulting in the loss of about 100,000 metric tons of rice for Luzon[106].

abandoned, or are in danger of being closed, as the forests and watersheds that are supposed to protect the rivers and streams that feed the reservoirs have disappeared. For example, the Binga and Ambuklao Dams in Northern Luzon, had to be abandoned, and are only now being restored after deforestation of the surrounding watersheds in Benguet and Ilocos, led to heavy soil run-offs and siltation. The more recently built San Roque Dam (built in 1998, completed in 2003) is in danger of siltation, as it now catches the silted spill from the older Binga and Ambuklao Dams. The San Roque Power Corporation, in charge of San Roque Dam, fear that the life of the dam could be cut by 20 years, unless something is done to renew the watersheds and stop the run-off of silt[8]. The damage to Umiray tunnel in 2004 from flashfloods, is a foretaste of what can happen to all water reservoirs and supply systems because of extreme weather events, and abuse of watersheds.

The situation for private deep wells is even more chaotic. While the LWUA and NIA are supposed to monitor and regulate the drilling and construction of deep wells in order to safeguard water quality and preserve the country's aquifers, in truth the two agencies are not sure of just how many deep wells there are in the country. Unregulated construction of deep wells have already led to subsidence or the sinking of land, and subsequent salt-water intrusion in many of the country's' coastal cities. Many parts of Metro Manila and Cebu have been experiencing subsidence and salt-water intrusion for over 20 years now[9].

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Nationwide, a total of 166,000 hectares of irrigated rice lands were affected by the drought, or 26% of the country's rice land[107]. By the time the drought ended mid 1998, agricultural production reported a drop of 7.15%, the lowest in 20 years. Rice and corn production were hardest hit, rice production fell by 44%, corn 27%, while coconut production by 10%[108]. Fishery production reported a loss of PHP 7.24 billion by November 1998, as fish ponds dried up and water quality went down. Indeed the heat forced fishpond owners to either stop production, or cope with poor harvests, as fish became sick and stunted from heat stress and lack of clean water[109]. Cases of acute malnutrition among small indigenous rain dependent farming communities were reported in Mindanao by 1998, along with outbreaks of cholera, diarrhea and food poisoning, and pockets of malaria and dengue. Seventy-two reportedly died because of the food shortage, including 42 who died after eating poisonous wild root crops[110].

Small hydro electric plants were also severely affected by the drought, contributing only 1% of total electrical power generated for 1998, much lower than the 19% share they were able to generate in 1997. Many small power suppliers resorted to using diesel fired plants, as water became scarce. Indeed the petroleum imports for power jumped from 300,000 barrels in 1997, to 440,000 barrels in 1998[111].

Between January and March of 1998, the lack of rain also began to take its toll on forests. Over 200,000 hectares of forests and grasslands burned between 1997 and 1998. Palawan lost over 15,000 hectares of forest, while fires also hit forests in the provinces of Isabela, Quirino, Nueva Ecija, Cagayan and Iloilo, Cotabato and Bukidnon. Forest rangers and firefighters were virtually helpless against the fires, without any water to douse the flames[112].

The 2007 dry spell and the Central Luzon and Southern Mindanao water shortage

The Philippines went through another dry spell in 2007, as the effects of an El Niño that began in late 2006 started to take hold. From June to July in 2007, only one tropical cyclone had entered the country, when from four to five tropical cyclones normally enter the country during the southwest monsoon[113].

Low rainfalls caused water levels of the Angat Dam to drop, and left thousands of hectares of rice and vegetable fields in Northern and Central Luzon dry. The Cordillera Administrative Region, and Pangasinan, Ilocos Sur, and Ilocos Norte provinces were much affected, as were the provinces of Bulacan and Pampanga as the Angat Dam reduced water rations for irrigation.

Agricultural production went down to 3.5% in affected provinces, from a high of over 5.4% the previous year. About PHP 1.14 billion in agricultural crops were lost as farmers chose to delay or stop planting all together, this included an estimated 500,000 metric tons of unplanted rice, and some 1 million metric tons of corn[114].

The dry spell began to be felt in several provinces in Mindanao by September 2007, and lasted until June 2008. Thousands of hectares agricultural crops, including rice and corn, were destroyed as the rains failed to come, and the drought dried up rivers and irrigation systems in South Cotabato and Maguindanao[115]. The dry spell ended with the very late entry of Typhoon Chedeng (international code name Pabuk) in August 5, 2007. The same year saw fewer typhoons for all of Southeast Asia than previous years.

Impacts and Vulnerabilities

Freshwater resources

TROPICAL CYCLONES (tropical depressions, tropical storms and typhoons) account for about 38% of the total rainfall of the Philippines. Heavy precipitation events, the La Niña phenomenon, more frequent and more intense tropical cyclones in terms of more rainfall will therefore have a positive effect on the quantity of freshwater resources in the country, contributing to surface water supply as well as groundwater recharge.

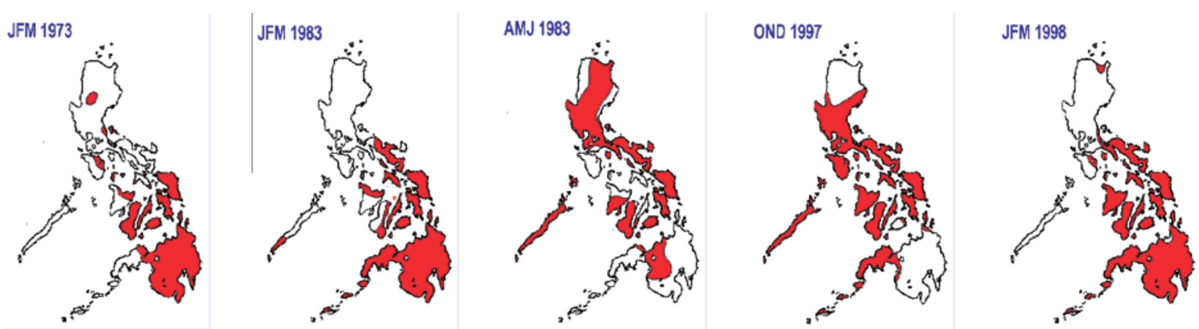
But, while changes in climate may lead to more precipitation rainfall, the increase in the frequency and intensity of extreme precipitation events will also likely increase the incidence of floods, flash floods and landslides. Intense downpours will increase runoff, and at the same time reduce the ability of the water to infiltrate the soil, that may lead to the question of how much soil is retained in the aquifers. Siltation in bodies of water from erosion from floods and landslides will reduce the carrying capacity of water bodies.

Landslides also add silt to rivers and streams, and alter their capacity to hold and transport water, increasing chances of spillovers and floods on outlying communities with every succeeding heavy rain and typhoon. Areas hit by massive land and mudslides have also reported changes in the flow of rivers and streams, as well as fluctuating amounts of water from springs and aquifers, making the repair of damaged water supply systems even more difficult[116].

On the other hand, the El Niño phenomenon generally results in below average rainfall throughout the Philippines, as exemplified by the El Niño of 1982-83 and 1997-98. Drought or rainfall deficiency will result in decreased freshwater supply and will adversely affect the local health and sanitation conditions. More widespread water stress will result in increased risk of food and water shortage; increased risk of water- and food-borne diseases; water shortages for settlements, industry and societies; reduced hydropower generation potentials; potential for

FIGURE 7 – RAINFALL EXTREME INDEX (MOISTURE DEFICIT) DURING EL NIÑO YEARS

(A.M. Jose, Extreme Climate Events in the Philippines, 2001)



population migration. The quality of surface and groundwater may also be adversely affected, including contamination of local water supply.

Extreme variability in weather conditions will also aggravate disparities between water supply and demand. Despite abundant water resources in the Philippines, distribution of these resources varies widely in time and place as a result of the different geographic and climate conditions prevailing in different parts of the country. Water resources are unevenly distributed throughout the country, often resulting in water shortages in highly populated areas, especially during the dry season. Periods of extreme rainfall that lead to the increase in water resources do not necessarily alleviate conditions of water stress nor directly address dry season problems as extra water is not stored in such a way that it can augment supply during times of scarcity.

Water supply infrastructure

Climate change has impacts on the function and operation of water infrastructure as well as on water management. This is because water infrastructure and management systems were in the past designed for less variable climate conditions. Current water management practices are therefore very likely to be inadequate in reducing the negative impacts of climate change on water supply reliability[117]. New uncertainties related to climate change impair the reliability of these systems and limit access of water users. Poorly managed water systems and infrastructure are among the most vulnerable to climate change.

The impact of extreme weather events on freshwater supply and access and the resulting damage to water supply systems is notable as seen in section 3.4. Water infrastructure are prone to malfunction during floods and are vulnerable to landslides and mudslides and extreme forces of nature. Damage to water supply systems also have consequences far beyond just the province or region hit by disasters, as seen in the case of the Umiray Tunnel.

The damage to water systems has cost the Philippines billions of pesos, and has hindered the economic development of many regions, as national and local government units are forced to spend the money on relief and rehabilitation efforts, including the purchase of clean and potable water, and the repair of water systems damaged by floods and landslides.

Aside from being vulnerable to forces of nature, the country's present water infrastructure are also not built to deal with extreme weather occurrences. The country's dams have not been designed to contain above normal precipitation which climate experts predict will occur more frequently in the future and the only contingency plan in place for water reservoirs to deal with increased precipitation is through the release of spill waters which in turn aggravates flooding in nearby communities.

Sea level rise and salt water intrusion

The predicted sea level rise due to climate change, although not considered an extreme weather/climate event, will affect freshwater resources especially in coastal areas through saltwater intrusion into groundwater and incursion into estuaries. Sea level rise may pollute coastal freshwater aquifers through saline intrusion as salty groundwater rises. The movement of the saltwater front up-estuaries would affect upriver freshwater-pumping plants, brackish-water fisheries and agriculture.

Sea level rise due to sea temperature increase alone (i.e. discounting the melting of permafrost and ice caps) is a slow-onset phenomenon. Hence, the expected salt-water intrusion into coastal areas and estuaries may follow that trend. The negative effects on freshwater resources, however, may not just be long lasting but widespread as well.

The Philippines stands to lose almost 80 kilometers of coastline to rises in sea levels. Sea level rise will affect 64 of the country's 81 provinces, covering at least 703 municipalities and flooding the homes of at least 1.5 million Filipinos[118]. Studies already show slight sea level increases in the country's major coastal cities, with Manila showing the highest increase, followed by the cities of Davao, Legazpi, Jolo and Cebu.

And while land subsidence caused by over-extraction of groundwater, may yet be the main reasons for salt water intrusion into the groundwater of some cities in Metro Manila, Cebu and Davao, residents of these cities have already been getting a taste of what a sea level rise can do to the taste of their drinking water. In Metro Manila, the cities of Malabon, Navotas, Paranaque, Muntinlupa and Las Piñas, many groundwater aquifers cannot be used for drinking because of salt water intrusion and pollution[119].

Meanwhile, sea water has encroached into large areas of Cebu City's aquifer, threatening the entire groundwater system, as well as nearby agricultural communities[120]. Unlicensed and uncontrolled water extraction, by industries and residences, as well as deforestation of the city's watershed has led to subsidence and sea water encroachment.

Water quality

Implications of climate change on water quality are considerable. However, further research into this issue is cited by the IPCC as a priority because the impacts are as yet poorly understood[121].

The IPCC reports with high confidence that "[h]igher water temperatures and changes in extremes, including floods and droughts, are projected to affect water quality and exacerbate many forms of water pollution—from sediments, nutrients, dissolved organic carbon, pathogens, pesticides and salt, as well as thermal pollution, with possible negative impacts on ecosystems, human health, and water system reliability and operating costs"[122]. Increase in areas of salinization of groundwater and estuaries, caused by sea-level rise is also predicted to diminish freshwater quality.

As in examples cited in the section above, while previous flooding incidents in the country have led to more water, these have also negatively affected water quality. Floods in urban areas in the Philippines not just sweep rubbish into waterways, but also pump toxic chemical leachate and bacteria from waste dumps into freshwater bodies. A considerable number of waste dumps in Metro Manila are located near water sources, reservoirs, or watersheds, particularly those located around Angat Dam, and Laguna Lake. Agricultural pollutants also find their way into water bodies, such as cases in Bulacan and Benguet where excessive fertilizer use has contaminated groundwater with nitrates. Extreme rains and floods moreover overload wastewater treatment plants and mine tailings ponds and cause the overflow of toxic substances into bodies of water. Excessive precipitation and flooding therefore lead to greater pollutant loads due to increased infiltration rates to aquifers or higher runoff to surface waters. Raging floods also dump mud and debris on rivers and streams and lead to increased amounts of polluted storm water, while rains increase turbidity of water bodies. In evacuation centers, shallow wells and groundwater sources can be corrupted with human waste, as people create an increased demand on already decimated and inadequate sanitary facilities.

Floods spread pollution, aside from aggravating it. Flood experiences in the country have generally led to the increased incidences of water-borne diseases, particularly because of already poor water quality. Flood waters near heavily polluted water bodies, for example in Marilao and Meycauayan in Bulacan province whose rivers have been declared biologically dead due to considerable heavy metal content, are particularly dangerous.

On the other hand, incidents of decreased rainfall which lead to lower water levels also reduce water quality, increasing the concentrations of both biological and chemical contaminants. Nineteen major rivers in the Philippines are already biologically dead during the summer months[123], a time when water supply is relatively lower. Occurrences of drought are likely to aggravate the current situation.

Social and Economic Aspects of Current and Projected Impacts

WATER QUANTITY AND QUALITY affect not just the environment but also all social and economic sectors. Activities and sectors that depend on high water abstraction, such as agriculture, will be affected most by the impacts of extreme climate conditions on water bodies. Changes in water availability and integrity brought on by climate change has implications on health and food security. Costs can include social costs aside from costs of damages and adaptation.

Water is a major determinant of human health. Healthy living conditions depend on access to clean freshwater systems, safe drinking water, and adeqaute sanitation. Floods and drought adversely affect local health and sanitation conditions and increase the burden of water borne diseases such as diarrhea and leptospirosis, and can abet the spread of other diseases such as dengue, malaria, cholera and typhoid which are already on the rise due to changing patterns of rainfall.

More than 80% of water withdrawals in the Philippines is for agriculture, particularly for irrigation. Lack of water therefore has grave repercussions on the country's agricultural sector (as during the extreme El Niño events in the 1990s). But while too little water leads threatens crop production, too much water also has harmful effects on agriculture mainly due to flooding and strong rains as seen in crop damage caused by the recent typhoons Ketsana and Parma which inundated the country's key agricultural areas.

According to the IPCC, freshwater ecosystems will have the highest proportion of species threatened with extinction due to climate change[124]. This will affect sectors which rely on the economic benefits that these ecosystems bring them, aside from affecting the balance of the ecosystem itself.

Still, accurately quantifying the economic impacts of climate change-related impacts on water resources is difficult due to lack of data and varied assumptions used regarding changes in water availability across the different types of water uses such as agricultural, urban or instream uses. But the costs of climate change impacts on water will likely outweigh benefits[125], primarily due to the damages that floods and droughts inflict on infrastructure, agriculture, etc. Climate change will also have impacts on the costs for water supply sector (with regard to water infrastructure and distribution) and can increase the costs of water supply as demand on a stressed resource increases.

Conclusions and Recommendations

WATER IS THE PRIMARY MEDIUM through which the impacts of climate change will affect people, the environment, and consequently the economy. The state of water resources and water availability directly affects other major sectors such as agriculture, health and sanitation, and industry. At the same time, water is one of the sectors most vulnerable to climate change. Freshwater sources as well as water infrastructure are highly at risk from its impacts. Management of water resources should therefore be a deliberate and important focus in any national climate change strategy. Adaptation and mitigation strategies must also permeate across the different water-dependent sectors because of the impact of water management on varied policy areas[126]. Indeed, climate change and the vulnerability of our freshwater resources to this phenomenon cannot be ignored and should be a major consideration both for long-term policy directions and in programs that directly and indirectly affect the protection, allocation and control of water resources.

Recommendations

On institutional reforms and water management:

Adoption of the Public Water Supply Sector (PWSS) plan to combat problems and issues concerning water supply, (i.e., institutional fragmentation, inadequate support for service providers, weak access to sector investment and financing, and lack of reliable and updated sector information needed for sector planning, etc.), namely: strengthening water supply and wastewater management institutions; developing of key agencies, water supply providers and other major stakeholders; and building strategic alliances between legislative and executive champions in government, the public and private sectors and communities. Such strategies should be mainstreamed into the institutions' plans and programs.

Effective adoption of the Integrated Water Resource Management (IWRM) concept which will enable the integration of the water supply sector to the overall social and economic agenda of the nation. IWRM is defined as the coordinated development and management of water, land and related resources within hydrological boundaries, to optimize economic and social welfare, without compromising the sustainability of vital ecosystems.

On increased water production and availability:

Identification and development of alternative new water sources specifically surface water; and upgrading and climate-proofing of existing infrastructure.

On pressures against water resources and water sustainability:

Reduction of pollution in the river systems through wastewater management for the protection of rivers; management of groundwater sources through extraction regulations; protection and rehabilitation of priority watersheds through community-based development and management are among the desirable measures to improve local water management operations and governance.

In particular, drastic action must be taken to reduce the release of hazardous chemicals from industrial origin into water resources with a view towards elimination of these chemicals within one generation. A robust regulatory and political framework should also be instituted to ensure public reporting of hazardous contaminants released to water sources, with a commitment to increasingly reduce and eliminate such releases to water bodies.

Population growth and economic development, urbanization and industrial development, water pollution, over-harvesting and exploitation, wasteful and inefficient use of water, denudation of forest cover, land conversion, and other factors exerting pressures on water resources availability should also be looked into in relation to freshwater sustainability.

Promotion of water conservation measures, such as rain water harvesting, water recycling, water impounding, etc., are examples of local or traditional solutions which should be encouraged. Other adaptation measures can include protecting waterside vegetation, restoring river channels to their natural form, etc.

On disaster risk reduction in anticipation of climate change:

Disaster preparedness, mitigation and prevention (PMP) capabilities and measures should be further strengthened to combat impacts of climate change, not only to prevent or alleviate water shortage in case of drought conditions but to minimize casualty and damage to property and infrastructure in case of too much rain resulting in widespread flooding and/or flashflood-triggered landslides; and strong winds, heavy rains, and storm surges caused by intense typhoons.

A periodic or continuous review of the typhoon warning and climate change monitoring systems should be conducted. More effort should be exerted towards narrowing the forecast area being warned as the typhoon nears landfall or of an ENSO (El Niño-Southern Oscillation) event's likely occurrence. With the increasing incidence of flash floods and landslides due to excessive rains even though the tropical cyclone is far from the locality, there is a need to incorporate rainfall intensity into the forecast and warnings. It is also necessary that the typhoon warnings and climate bulletins should be fully understood so that the individual and the community may properly respond to the impending threat. Innovative approaches in public information and education through the multi-media and the educational system could undoubtedly contribute to the better understanding of the warning/bulletin. In anticipation of increases in the frequency and intensity of extreme weather and climate events brought about by climate change it is necessary to further improve the existing capabilities to monitor, forecast and warn decision makers and the general public of impending excessive rains or lack of rains that may result in drought conditions and scarcity of freshwater availability.

On vulnerability assessment and adaptation measures:

"All-purpose" adaptation measures are in abundance, but more climate change-oriented measures are needed. In this connection, a municipal-level, GIS (geographic information system) -based vulnerability assessments on sea level rise, agriculture, water resources, health and coastal and marine resources should be conducted nationwide following the Common Methodology of the IPCC. From here, more focused and realistic adaptation measures can be formulated.

While it is notable that the Philippine government has shown much effort in attempting to address climate change, the government's adoption of the above strategies still vary as the consideration of the uncertainties brought on by climate change have only been recently taken into account in water resources management. Recent efforts have seen the launch of the Philippines' IWRM framework which incorporates climate change adaptation as a strategic theme. However, more concrete efforts to prioritize of impacts on water are needed.

The water sector should be among the top priorities for climate change adaptation, and should be mainstreamed in all national and local climate change adaptation strategies. Improved water management—from the protection of water sources, to water management systems, to demand side adaptation—should be a key approach, particularly for the Philippines which counts among those most vulnerable to climate change impacts and which relies solely on rainfall for freshwater. Such strategies must also be flexible and robust given the many uncertainties that climate change poses.

Finally, underpinning all water management strategies must be a strong, coordinated and immediate effort to protect the country's freshwater sources from pollution and degradation: the first step must be to ensure that clean freshwater will be available for generations to come.

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APPENDIX A
Water Pollution in the Philippines: Case Studies

Lack of sewage affecting rivers, streams and lakes

The lack of sanitary toilets and the facilities to treat human waste is one of the main reasons why many of the country's rivers, streams, lakes and groundwater aquifers are polluted.

Four out of ten people in rural areas, still do not have access to sanitary toilets, while only 7% of urban households, and 2% of rural households are connected to sewer networks[1]. Even in the city of Manila, the country's capital, only 4% of residents are connected to the sewer network, while 40% of households make do with communal or public toilets[2]. Indeed, what serve as sewage for more than half of Metro Manila's 20 million residents are the National Capital Region's major rivers, namely Pasig, San Juan, Parañaque, and the Navotas-Malabon-Tullahan-Tenejeros Rivers[3]. Untreated human waste and makes up 70% of the Pasig River's pollution load[4], while 58% of the city's groundwater sources have tested positive for fecal coliform and domestic liquid waste.

Laguna de Bay, the country's largest freshwater lake, and a potential source of drinking water for Metro Manila's residents, also serves as sewage for the nearly 4 million people who live along its shores and tributaries. Untreated domestic waste makes up 70% of Laguna de Bay's pollution load[5].

Nitrates in vegetable fields and in drinking water

In a survey of groundwater from artesian wells in Benguet and Bulacan, two provinces known for intensive vegetable production and fertilizer use, 30% of the wells tested showed nitrate contamination levels higher than 50 milligrams per liter of water, the "safe level" set by the World Health Organization (WHO)[6].

While plants need nitrogen to grow properly, farmers often apply too much nitrate (a form of nitrogen contained in most fertilizers) for the crops to absorb. Excess and unused nitrates are washed by rain water into streams, rivers and groundwater, contaminating drinking water.

High levels of nitrate interfere with and can destroy the ability of red blood cells to absorb oxygen causing a condition called methemoglobinemia. Babies are especially susceptible to methemoglobinemia (or blue-baby syndrome) because of lack of oxygen. Lack of oxygen in the blood causes headaches, fatigue, difficulty in breathing, and in severe cases, can cause seizures, coma and death. Nitrate poisoning can also cause gastroenteritis and sepsis.

Industrial pollution

Industry is the third biggest polluter of Philippine freshwater sources, it accounts for 27% of the pollutants in freshwater sources. Industrial pollution is responsible for most heavy metal pollution of surface and groundwater sources, as well as pollution from toxic chemicals such as chlorine and petroleum[7].

There are about 15,000 registered manufacturing industries nationwide, 69% of which are in Metro Manila and surrounding provinces. It should be of no surprise then that among the country's worst polluted rivers are those located in Metro Manila and outlying provinces[8].

Water intensive industries, like food and dairy, pulp and paper, textiles and dyes, plastics and consumer goods, metals and glass manufacturers, as well as electronics and microchip industries, use and release large amounts of wastewater into rivers and creeks, which eventually reach groundwater sources[9]. Every year, in Metro Manila alone, industries release about 2,000 tons of solvents, 22,000 tons of heavy metals, infectious wastes and biological sludge, lubricants and intractable wastes (wastes that need special technologies and facilities for safe disposal), and 25 million tons of acid/alkaline wastes[10].

The Clean Water Act of 2004 includes laws to regulate industrial pollution, in addition to over 20 Memorandum Circulars and Regulatory Rules that give the Department of Environment and Natural Resources (DENR), the Environmental Management Bureau (EMB), and the Department of Science and Technology (DOST) the power to monitor, regulate and punish manufacturers found violating the law. However, despite the slew of laws on industrial pollution, industries continue to pollute surface and groundwater sources[11].

Marilao, Pasig, Meycauayan and Bocaue Rivers

Tests conducted on major Luzon rivers, including the Marilao, Pasig, Meycauayan and Bocaue Rivers, show dangerous levels of chromium, cadmium and lead[12]. Much of the pollution comes from the unregulated and untreated effluents from the hundreds of manufacturing industries located along or near the rivers, such as tanneries, textiles, electronics and batteries recyclers, and smelting plants[13].

Cavite groundwater

While groundwater sources near industrial areas still have to be systematically tested nationwide, studies by Greenpeace of groundwater in and around three micro-chip manufacturing plants at the Cavite Export Processing Zone showed contamination from several toxic cancer-causing chemicals, at levels that exceeded maximum safe levels set by the WHO and the United States Environmental Protection Agency (US EPA).

VOCs or volatile organic chemicals were found at each site, including chlorinated chemicals known to cause damage to the human central nervous system, causing headaches, dizziness, sleepiness, confusion and difficulty in speaking and walking. High doses can cause unconsciousness and death. It is also cancerous, and can damage both the kidney and liver.

In three samples, the levels of chlorinated chemicals exceeded the maximum recommended levels set by the WHO and US EPA. For one sample, the chlorinated chemical tetrachloroethene, exceeded WHO safe levels for exposure by nine times, and US EPA safe levels for drinking by 70 times[14]. One other water sample showed high levels of heavy metals, particularly of zinc. High doses of zinc in humans can cause damage to the pancreas, anemia, gastro intestinal distress and diarrhea.

Mine tailings

Mines, coal and diesel fired power plants, are also heavy polluters of both surface and groundwater sources. Many having already killed major rivers in Luzon, Mindoro and Mindanao, leaving heavy metals like mercury, nickel, copper and sludge to continue polluting and killing, long after the facilities have already been closed.

Rapu-Rapu Gold, Copper and Zinc Mining Project

On October 2006, the Rapu-Rapu Gold, Copper and Zinc Mining Project, then owned by Lafayette Mining Inc., an Australian mining company which had been granted mining leases for over 80% of Rapu-Rapu island by the DENR and the local government unit of Albay, spilled mine tailings, including cyanide, into the creeks and sea surrounding Rapu-Rapu Island in the province of Albay, Bicol.

Fish kills resulted almost immediately after the spill and residents complained of yellow acid mine tailings at the lower portions of Mirikpitik Creek, one of several creeks that lead out of the facility. Tests by Greenpeace several months after the spill showed that the creeks still contained particularly high concentrations of cadmium, copper and zinc, along with some amounts of cobalt, iron and manganese.

Rapu-Rapu Island is home to 29,000 people, most of whom are fishermen who depend on the rich fishing grounds and coral reefs in the surrounding gulfs of Albay and Lagonoy, as well as the Pacific Ocean, for a living.

Cadmium is highly toxic to humans, animals including fish, and plants. Large amounts of cadmium can destroy the human kidney, liver and bones, and cause cancer. In fish, cadmium destroys the gills, kidneys and liver. Large amounts of copper can damage the human kidney, bile, and damage the brain. Small amounts of copper can kill fish, especially freshwater fish, as it also damages their gills, liver and kidneys. Even small amounts of zinc has been known to kill fish and other small marine animals, while high levels of zinc can damage the nerve receptors of the human nose, cause lethargy and destroy muscle control. Cyanide destroys the body's ability to use oxygen. People and animals who ingest cyanide have difficulty breathing, excessive sleepiness, shortness of breath, headaches, dizziness, irregular heartbeat, seizures and coma.

In 2008, Lafayette was forced to declare bankruptcy after community campaigns pushed the prices of its stocks down. However, in May 2009, despite protests from residents and environmental groups, Malaysian and Korean mining firms took control of the mines, and resumed operations[15].

Marcopper Mining Disaster

On March 24,1996, four million tons of mine tailings from the Marcopper Mining Corporation in Boac, Marinduque Island, spilled from one of its old tunnels, which it had earlier plugged with cement and had used as a catchment pit for tailings.

The tailings spilled into the Boac and Makulapnit Rivers, and rushed down into the coastal areas, Calancan Bay and the sea around Marinduque. The volume of the spill was so massive that the rivers spilled over, flooding towns and farmlands in its wake. Rice, vegetable fields and farm animals were poisoned, while all animal and plant life in the rivers were killed as the waters of the Boac and Makulapnit Rivers became poisonous.

Residents along the two rivers and coastal towns hit by the mine spill tested positive for copper and zinc poisoning, at levels of over 200% above WHO safe levels, while water samples from the rivers showed copper and zinc levels of 1,300% above WHO safe standards.

Investigations into Marcopper's environmental record showed that the 1996 spill was not the Canadian mining firm's first "accident" in Marinduque. Between 1975 and 1988, Marcopper had allowed mine tailings from the Mount Tapian mining complex (the very same mine tunnel they had later plugged and used as a catchment for tailings and that would fracture and leak in 1996), to discharge into the shallow Calancan Bay, which over the years had filled with over 200 million tons of mine tailings. Indeed, the deposits of tailings are now so thick, that when they dry, winds carry them over farms, streams, wells, and residences. Many residents, especially children, have suffered from or have died of heavy metal poisoning.

After the 1996 disaster, Placer Dome closed their mines, but refused to clean up the rivers, fields, and communities. Nor did the mining company compensate the thousands of victims poisoned by the spills, only donating PHP 1,000.00 for every child who had died from the toxic tailings.

Placer Dome Mining was sold to Barrick Gold Corporation, another Canadian mining firm in 2006, and to this day Placer Dome officials deny any responsibility for the disaster.

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