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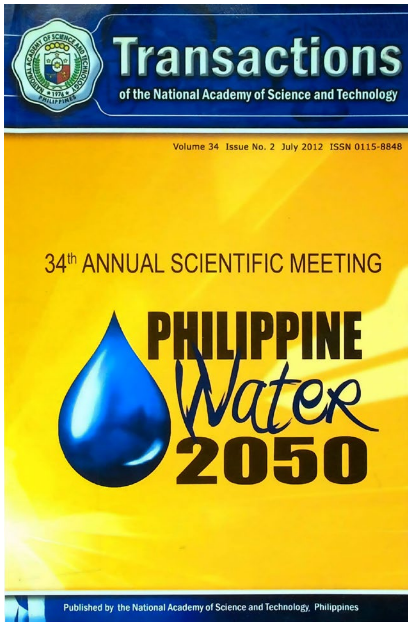

Water for Food Security in the Philippines

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WATER FOR FOOD SECURITY IN THE PHILIPPINES

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Abstract

Over the years, sectoral approach was used in ensuring the sufficiency of water supply for agriculture. In the Philippines, agriculture serves as the main consumer of freshwater resources. However, efforts in enhancing agricultural production were not linked with watershed protection. This paper uses the Ridge-to-Reef approach in establishing the link with watersheds and agriculture. It argues that the management of irrigation waters should consider watershed conservation to ensure the sufficiency of water supply. The paper presented several interventions that could be adopted by supply-side management through watershed conservation, and demand-side management through efficient use of irrigation waters. The information presented in this paper could help in crafting water-related policies or programs in the country.

Keywords: agriculture, food security, ridge-to-reef approach, water withdrawal, watershed

Overview of the Problem

Water is vital in all areas of the world as it provides a myriad of ecosystem services essential in meeting human needs. It plays a critical role in sustaining life and supporting economic and cultural activities. Despite the countless services it provides, freshwater resources only constitute for 2.53%

of the total water in the world wherein 67% is locked up in glaciers and permanent snow cover (WWAP, 2003). These resources are also unevenly distributed and most of which are far from human population (UNEP, 2008). At present, over one billion people are experiencing water scarcity (NWP, 2011). By 2025, almost two-thirds of the world's population will be exposed in water-related stress; and the shortage will be severe and socially disruptive for one billion of them (NWP, 2011).

Scarcity of water resources, aside from population pressures, could be aggravated by climate change. According to the Intergovernmental Panel on Climate Change (IPCC), water availability and quality will be the pressing issues for societies under climate change (WWAP, 2012). Despite the uncertainty on its precise impact, the projected change in annual runoff will amplify the situation. Stern (2007) argues that climate change will be felt more by people due to temporal and spatial changes in water distribution (as cited in WWAP, 2012). It is projected that about 20% of the increase in global water scarcity will be a consequence of climate change (WWAP, 2003).

Freshwater resources are threatened by several problems such as pollution, multiple competing demands for water, climate change and other complex environmental issues. At present, water demand for agriculture is one of the greatest pressures on freshwater resources. About 70% of freshwater withdrawals are utilized for irrigation and food (WWAP, 2012). It even reaches up to 90% in some fast-growing economies. Although water withdrawal is higher in developing world than industrialized nations, both of their water resources are mostly withdrawn for agricultural purposes (Lansigan *et al.*, 2006; WWAP, 2012).

The inaccessibility, uneven distribution, and increasing demand for freshwater resources to sustain economic activities might lead to water scarcity in the future. Moreover, climate change could worsen the picture. To continuously attain food security, conservation of freshwater resources and implementation of technological interventions to maintain the quality and sufficient supply of water is urgently needed.

Introduction

Water is the key to food security (WWAP, 2012). Agriculture requires large amount of water to meet the sufficiency of food. In Asia, the highest percentage of irrigation water is used for the production of rice which is considered as the staple food in the region. Asia's food security depends largely on about 80 million hectaresof irrigated rice, which account for 75% of the annual world rice supply (Tabbal, 2002). Due to high demand on rice, about 34-43% of the total world's irrigation water is allotted for its production (Bouman *et al.*, 2007). However, its water use has low efficiency and large amounts of water are needed for its growing (Hafeez *et al.*, 2008). In fact, rice grown under flooded conditions is one of the biggest users of freshwater resources (Tuong and Bouman, 2003). According to Tuong *et al.* (2005), irrigated rice is a major target for the development of water-saving technologies since it consumes 2-3 times more water at the field level than other cereals (as cited in Maraseni *et al.*, 2010).

In the Philippines, agriculture serves as the main consumer of freshwater resources. The performance of agriculture sector serves as a significant determinant of overall economic growth of the country (ADB, 2008). In 2006, about 19.1% of gross domestic products and 36.7% of employment for the labor force were generated by this sector (ADB, 2008). However, this sector is faced with several challenges such as diminishing water supply and slow irrigation development.

The Philippines is rich in water resources. The country has 421 principal river basins with drainage area varying from 41 to 27,280 km^2. Out of these principal river basins, 20 are considered as major river basins, with each one having at least 990 km^2 basin area. These major river basins cover a total area of 111,269 km^2 equivalent to 37.1% of the total land area of the Philippines. River basins provide agricultural lands with irrigation waters; hence degradation of these areas would affect its supply. It was observed that water resources in the Philippines declined from 1970-2005, as well as water availability per capita.

Climate variability and extremes could exacerbate the situation of agricultural production in the country. With the changing seasons, resource-constrained farmers cannot solely rely on rainfall to irrigate their crops.

According to Department of Agriculture (DA), farming sector is vulnerable to the unpredictability of nature (Cainglet, 2010). The early or delayed onset of rain and occurrence of droughts, floods, and typhoons would adversely affect their harvest, hence disturbing their livelihood and income. From 1995-2004, 4.1 million hectares of prime rice and corn farmlands were damaged due to climate anomalies (Cainglet, 2010).

Rijsberman (2006) argues that the increasing water scarcity, coupled with malfunctioning irrigation systems, threaten the viability and sustainability of rice production (as cited in Maraseni *et al.*, 2010). Moreover, rapid increase in population entails higher presssure on attainment of food security, which also implies higher demand for freshwater resources.This situation, if not properly addressed, might lead to food insecurity in the future.

Ridge to reef framework (R2R) is becoming well-known and wide-used at present. It acknowledges the interconnectivity of uplands, lowlands, and coastal areas. In simple terms, it explains that whatever you do in the upland has a ripple effect on low lying areas. The framework for analysis presented in Figure 1 was formulated under this principle. It was used to explain the complex relationship between irrigation waters and food security in the Philippines. River basins or watershed, as the source of freshwater resources, supplies the agricultural lands with irrigation waters. The increasing demand for agricultural products requires watershed protection to maintain the sufficient supply of water. The amount and quality of water supply, as a result of healthy relationship between watershed and agricultural lands, influences the attainment of food security. The goal of achieving food security, on the other hand, puts pressure on irrigation development and watershed protection of the country.

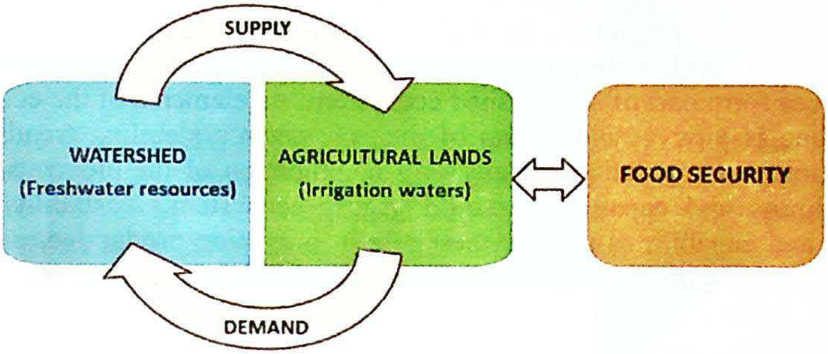

Figure 1. Framework for analysis

This paper provides a brief description of the current performance of Philippine irrigation development including supply-side management or watershed conservation for enhanced water supply, and demand-side management or agricultural land enhancement towards water use efficiency which are both necessary in attaining and maintaining food security in the country.

Supply-Side Management

Watershed is "a basin-like geographical structure bounded by surrounding ridges" (PCARRD, 1991). It has a network of stream tributaries that leads to a common mouth or drainage channel. The Revised Forestry Code simply defined it as "a land area drained by a stream or fixed body of water and tributaries having a common outlet for surface runoff" (P.D. 705). It is also defined as "the continuum of interrelated ecosystems from headwaters in the forestlands, the downstream areas or lowlands, to the coastal base and adjacent bays" (IEMSD, 1997). Aside from upland or mountainous landform, watershed may occur in lowlands which may be a residential, agricultural, industrial, educational, or experimental site. Watershed has a discrete geographical unit capable of providing water, timber and non-timber products, as well as intangible goods and services such as aesthetics and leisure.

Watersheds vary greatly in size and extent often straddling over one or more political administrative units. A watershed can include various living and non-living resources, as well as man-made. Among others, these resources are soil, water, range, timber, wildlife, mineral, and people. These resources form part of a watershed ecosystem. As elements of the ecosystem, each one is vital as indicator/s of the ecosystem's stability, trends and/or conditions. Manipulations of any or a combination of the elements beyond their limits and capabilities would trigger ecosystem's instability. These limits and capabilities include their role in providing productive, protective and aesthetic values. Proper understanding of the linkages and relationships of the various watershed resources is necessary for an effective and sustainable use of the resources.

In terms of classification, the largest type of watershed is classified as river basin with size greater than 1,000 km^2. As presented in Table 1, second largest watershed is called large watershed which ranges from 500 to 1,000 km^2. The smallest watershed is classified as micro-watershed with size below 10 km^2.

Table 1. Watershed typology

Type	Areal extent (km^2)	Administrative coverage
River basin	more than 1000	The topographic boundaries include land occurring within 3 or more provinces and 2 or more regions
Large watershed	500 to 1000	The topographic boundaries include land occurring within 3 or more provinces and at least 1 but not more than 2 regions
Medium watershed	100 to 500	The topographic boundaries include land occurring within at least one but not more than 2 provinces
Small watershed	10 to 100	The topographic boundaries fall within one province and include land occurring within 1 or more municipalities
Micro-watershed	below 10	The topographic boundaries fall within one municipality and include land occurring within 1 or at most 2 barangays

Watershed forest reserves in the country are about 1.5 million hectares (DENR-FMB, 2006). There are 125 watershed forest reserves, wherein 60-75% is located in Luzon while the rest are found in Visayas and Mindanao. There are 23 watershed forest reserves with an aggregate area of 0.281 million hectares in Region III, which also has the highest number of watershed forest reserves among the different regions. As shown in Figure 2, Region 12 and ARMM have the least number of watershed forest reserves.

State of Watershed Management in the Philippines

In the Philippines, watersheds are under the jurisdiction of the Department of Environment and Natural Resources (DENR). But due to inadequate resources, the control and administration of some watersheds were transferred to other agencies such as National Power Corporation (NPC), Energy Development Corporation - Philippine National Oil Company (EDC-PNOC), and Local Government Units (LGUs).

Nowadays, watershed degradation in the Philippines is becoming severe and alarming. This condition invariably affects livelihoods especially for those who depend on farming and forestry activities. With the increasing population, the pressure on watershed resources is also rising which commonly leads to deforestation, soil erosion, poor water quality and low water supply. Compounding the human induced watershed degradation is the added stress on watershed resources and functions arising from climate change and the associated extreme events and climate variability. Many watersheds today are in varying state of degradation characterized by soil erosion, erratic streamflow, diminishing groundwater resources, micro-climate deterioration, and declining land productivity.

Soil erosion, ranging from 56 to 130 million tons of soil being lost annually, is considered to be the worst problem in different regions (FAO, undated). 13 of the country's 80 provinces have over half of their area affected by moderate to severe erosion (PCARRD, 1991; FAO, undated). Sedimentation has reduced the storage capacity of the country's major reservoirs affecting water supplies for domestic, industrial, irrigation and power-generation purposes. In over a 40-year period, an estimated 30-40% reduction occurred in the area irrigated in the dry season in a significant number of irrigation systems. Soil erosion also causes siltation in rivers, lakes, and seas. Excessive siltation pollutes rivers and lakes, and damages freshwater fish and organisms by causing eutrophication, and limiting sunlight penetration to the bottom where green plants thrive. In seas, excessive siltation can damage the corals.

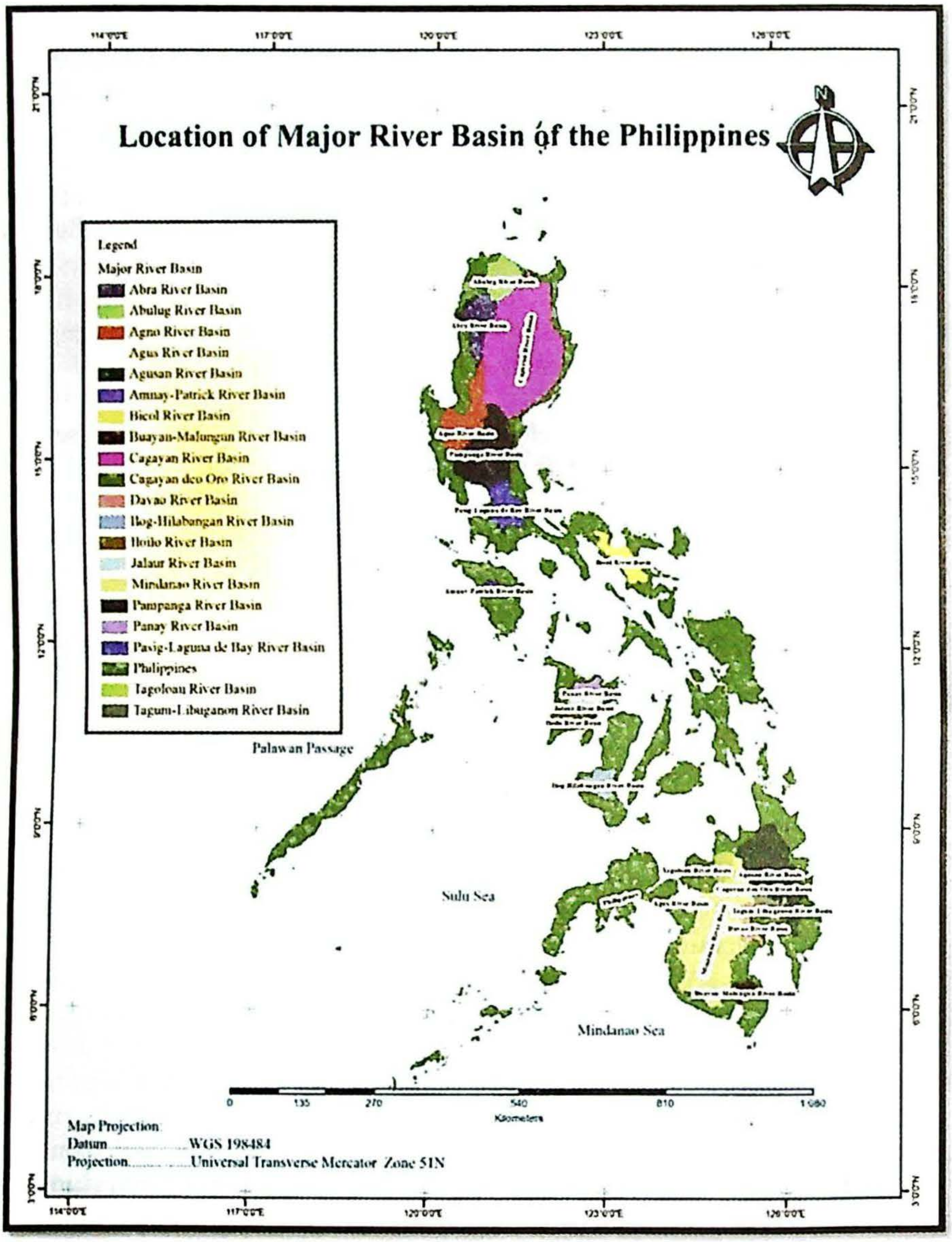

Figure 2. The major river basins in the Philippines

The country has vast water resources owing to the abundance of rainfall estimated at 2,400 mm annually. The country also boasts of an extensive groundwater resource covering an estimated area of 5 million hectares and storage of about 251,158 million cubic meters. The safe yield is estimated at 31,554 million cubic meters per annum. The dependable yield of the total water resources of the country adds up to a total of 975 million cubic meters per day coming from surface runoff (833 million cubic meters per day) and groundwater safe yield (142 million cubic meters per day).

Direct Causes of Watershed Degradation

Given the ecological importance of our watersheds and the extent of human dependence on its services, watershed degradation has potentially enormous environmental and socio-economic costs. Efforts to develop and use the provided services have not really been well integrated with protecting and managing watershed ecosystems. For instance, vital economic resources like water are usually managed with policies, institutions, and practices that are conflicting or disconnected from those designed to protect forests and other watershed resources. This situation leads to higher risk of watershed degradation, hence jeopardizing water supplies and other vital ecosystem services beneficial to human societies. The direct drivers of watershed degradation in the Philippines are briefly described below.

1. Deforestation and removal of natural vegetation

   The latest forestry statistics (DENR-FMB, 2009) revealed that large portion of our forest cover comprising 4,030,588 hectares or 56.23% are classified as open forest. Referring to Figure 3, a closed forest has the second highest coverage with 35.72% or 2,560,872 hectares of the total forest cover. Meanwhile, plantation has the lowest area accounting for only 5%. Large areas of former forested lands are now dominated by low-value fire climax grasslands.

   Forest cover in most watersheds in the Philippines have dwindled so much that only watersheds in Regions 2, 4, 8 and 11 have more than 30% of land area covered with forests. Referring to Figure 4, Regions 5 and 7 have the least forest cover. Over exploitation of the forest resources and inappropriate land use practices have disrupted the hydrologic condition of watersheds, resulting in accelerated soil erosion, siltation of rivers and valuable reservoirs, increased incidence and severity of flooding, and decreasing supply of water.

2. Upland agriculture

These include a wide variety of practices, such as absence or poor maintenance of erosion control measures, improper crop rotations, shortening of the fallow period in *kaingin* cultivation, insufficient or excessive use of fertilizers, and overuse of irrigation water. The expansion of cultivation into the uplands that are usually of inferior productivity potential and/or high vulnerability to soil erosion often leads to nutrient loss, water pollution (by sediment, pesticides, fertilizers) and general decline in the income from the use of land.

As shown in Figure 5, the ratio of forest cover to irrigated and irrigable lands is generally quite low. This could indicate serious implications on soil erosion and availability and quality of water for irrigation.

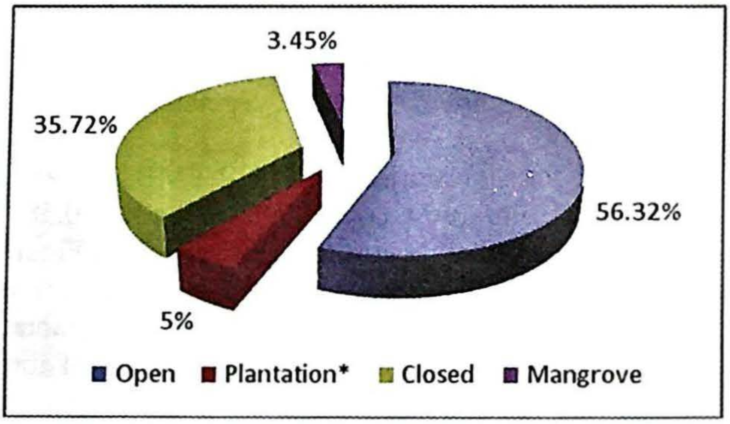

Figure 3. Forest Cover (ha) in the Philippines (FMB, 2009).
* Plantation data are not yet complete.

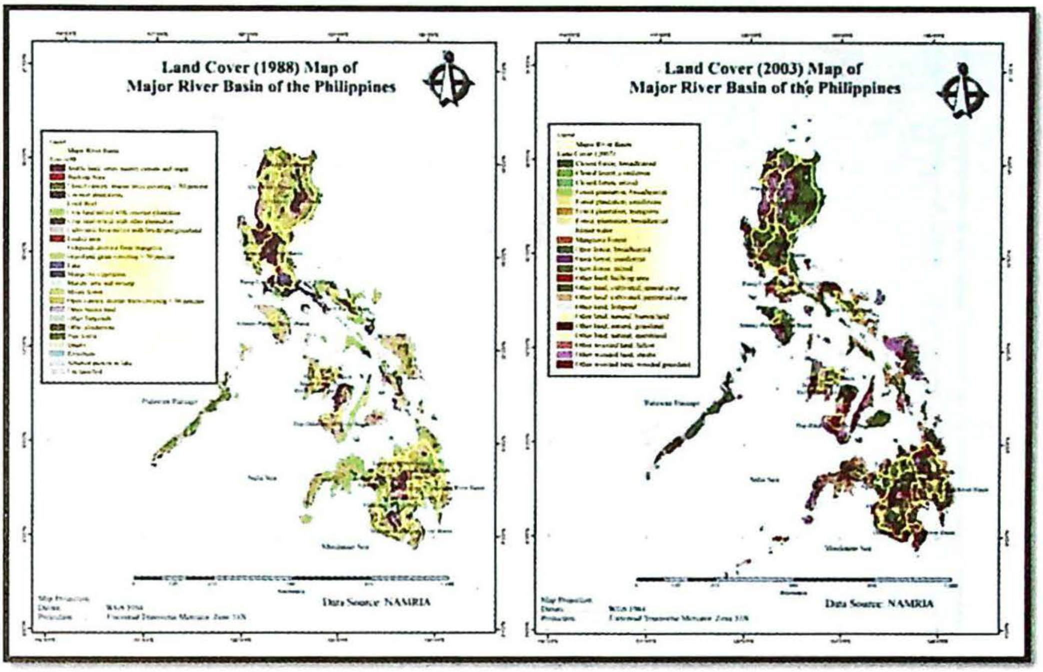

Figure 4. Distribution of forest cover by regions and river basins

3. Forest resources utilization

Illegal logging continues to thrive in the Philippines because of poverty and weak enforcement of forestry laws. Hundreds of thousands of people in/near forest areas rely on illegal logging, *kaingin* or forestland conversion, firewood gathering and charcoal making for lack of alternative means of livelihood. Illegal loggers, along with *kaingineros*, firewood gatherers, charcoal makers and upland settlers, account for 80-90% of forest depletion. Normally, trees cut indiscriminately, harvesting immature stands and making no provision for reforestation.

Table 2 shows that the country needs a total of 39.774 million cubic meters of fuelwood to satisfy the demands of rural households. Looking at each region, Region 4 has the greatest needs with 10.5 million cubic meters while Region 12 has the least fuelwood requirement of 1.72 million cubic meters.

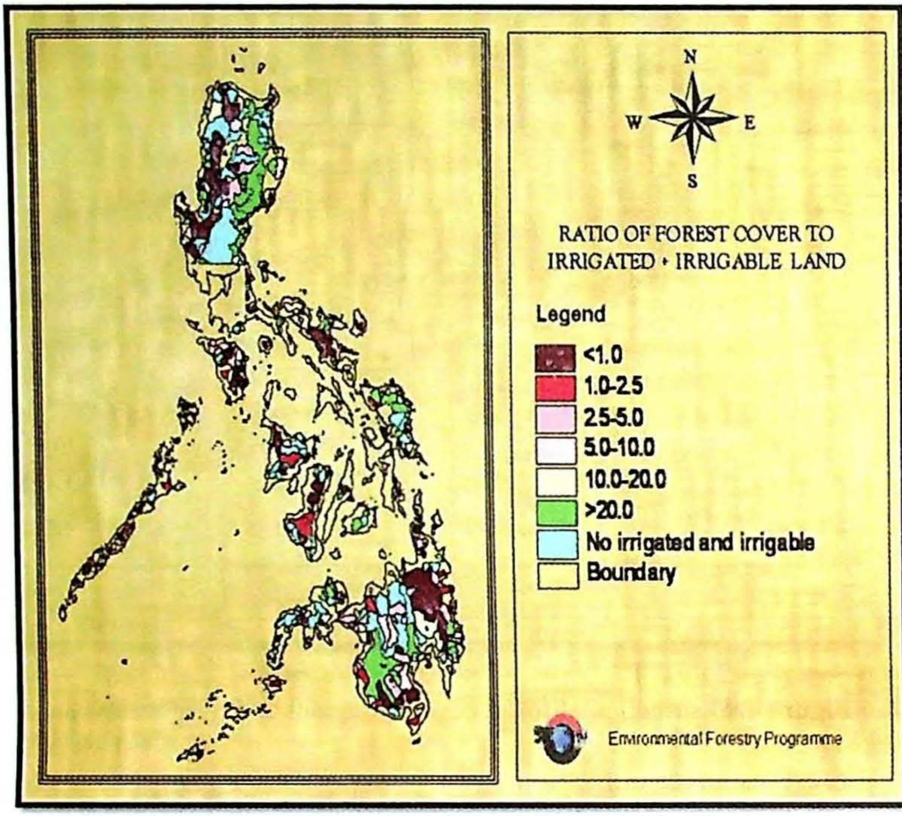

Figure 5. Ratio of forest cover to irrigated and irrigable land

Table 2. Summary of fuelwood consumption (million cubic meters) by region

REGION	FUELWOOD CONSUMPTION/DEMAND (Sub-totals)			
	1985	1990	1995	2000
I	3.085	3.253	3.396	3.513
II	1.509	1.656	1.796	1.919
III	3.096	3.389	3.604	3.907
IV	7.840	8.800	9.689	10.509
V	2.199	2.348	2.456	2.527
VI	3.027	3.279	3.499	3.649
VII	2.442	2.630	2.796	2.937
VIII	1.784	1.929	2.057	2.149
IX	1.593	1.744	1.885	2.005
X	1.930	2.163	2.387	2.597
XI	2.281	2.534	2.883	3.163
XII	1.467	1.569	1.655	1.725
PHILIPPINES	**31,522**	**34,584**	**37,358**	**39,774**

Source: excerpt from the FDC report (Misajon *et al.*, 1989)

4. Inefficient water resource management

Over extraction of water from rivers and other surface waters for irrigation, urban, and industrial use has led to reduced downstream availability. Areas where water is returned after use may have a higher salt content and/or be polluted from agro/industrial-chemicals and human wastes. Inefficient irrigation practices, wasteful urban/industrial water use and leakages from water delivery systems all contribute to water shortage problems, as well as over-pumping of the aquifers. In many lower watershed areas, the intensive use of tube wells has led to abstraction of water in excess of natural recharge by rainfall and river seepage and a progressive lowering of the water table. In coastal areas, over-extraction of groundwater has resulted in salt water intrusion into the freshwater aquifer. This is a growing problem in parts of Cebu.

5. Unregulated land conversion

Uncontrolled land development for agricultural, residential, commercial and/or industrial purposes may contribute to degradation if the management practices for such land uses are unsustainable. Farm households affected by the conversion of agricultural lands to other purposes may be forced to seek land elsewhere. In the country, this would mean moving into marginal uplands areas.

6. Pollution

As presented in Figure 6, pollution coming from residential, commercial, industrial and agricultural areas has degraded the quality of water resources in many rivers in the country. The total BOD generation of the country reaches 2,236,750 mt/year. Due to excessive pollution, 16 rivers are usually biologically dead during summer months.

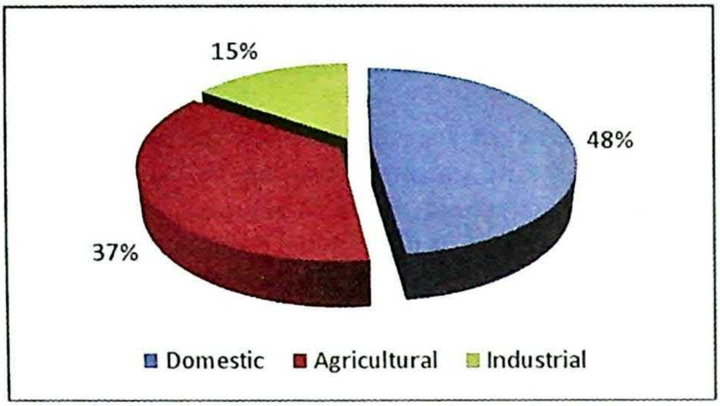

Figure 6. Share of domestic, industrial, and agricultural BOD in the Philippines.

Indirect Causes of Watershed Degradation

Indirect causes of watershed degradation are the underlying reasons for inappropriate practice of land use management. These are usually related to the socio-economic circumstances of the land users and the social, cultural, economic and policy environment in which they operate. The following are of particular importance in the Philippines:

1. Population growth and development

A growing population in the lowlands with its needs for increased urbanization and industrial development leads to an ever-expanding demand for water, electricity, timber, agricultural crops, and recreation facilities. These may lead to over-exploitation of watershed resources in the uplands. Table 3 presents the total population by major river basins in the Philippines.

While many watersheds continue to deteriorate, the population that relies on the goods and services watersheds provide steadily grows creating more pressure for the already overburdened natural resources in the watersheds. Watersheds continue to be the sole sources of water for domestic, agriculture, industrial and commercial uses in the country. The finite area of the watersheds however sets the limit to its capacity to meet the growing needs for water of an ever growing population. Table 4 indicates that around 975 million cubic meters of water are estimated to be available daily to meet the demands from various sectors. It is shown in Table 5 that some areas including major cities are bound to experience water scarcity if the present pattern and rate of consumption do not change and that no increase in the present supply of available water happens. To guarantee the sustainability and availability of water, the mode of watershed management must improve. This must focus on strategies that will protect and enhance the sustained ability of the watersheds to capture and store more rainwater, as well as to promote more effective use of water resources. It is projected that there will be more regions in the country that will experience water supply deficit by 2020.

Table 3. Total population by major river basins

Major River Basin	Total Population			
	1980	1990	2000	2010
Data Source	*NSO*	*NSO*	*NSO*	*WorldBank*
Abra River Basin	1,677,027	2,016,273	2,059,658	2,367,676
Abulug River Basin	1,333,021	1,550,991	1,814,441	1,954,441
Agno River Basin	5,870,117	7,374,856	8,214,206	12,950,139
Agus River Basin	1,430,619	1,977,724	2,231,867	1,121,974
Agusan River Basin	3,394,848	4,498,259	4,841,521	4,744,221
Amnay-Patrick River Basin	669,369	832,642	1,062,068	1,157,721
Bicol River Basin	2,216,530	2,600,686	3,101,296	3,398,429
Buayan-Malungun River Basin	1,904,072	2,022,203	1,860,151	1,633,615
Cagayan de Oro River Basin	2,187,686	2,922,671	2,997,827	2,087,830
Cagayan River Basin	4,037,692	4,959,699	5,743,206	6,446,016
Davao River Basin	3,054,985	4,146,932	3,521,520	2,312,258
Ilog-Hilabangan River Basin	2,749,700	3,182,180	3,262,708	4,834,077
Iloilo River Basin	1,778,520	2,053,847	2,030,270	3,608,638
Jalaur River Basin	1,925,872	2,231,577	2,213,338	3,795,037
Mindanao River Basin	5,335,789	6,900,434	7,123,160	5,935,157
Pampanga River Basin	13,269,102	17,583,566	22,187,339	29,612,557
Panay River Basin	2,250,435	2,612,074	2,664,652	4,290,159
Pasig-Laguna de Bay River Basin	11,625,365	15,800,747	21,291,204	26,050,683
Tagoloan River Basin	1,321,666	1,708,942	1,724,603	2,087,830
Tagum-Libuganon River Basin	1,621,817	2,320,955	2,943,614	2,437,097

Source: except from NSO (National Statistics Office) data and WorldBank (www.worldbank.org).

Note: The population count is by province and then cross-tabulated by major river basins. There could be overlap among river basins (i.e. a province may belong to one or more river basins).

2. Land tenure

Confusion among tenure holders on the legal uses of land and resources are caused by the absence of long-term security of tenure for major stakeholders in the forestlands and the conflicts in the coverage and entitlements of various tenure instruments. Aggravating these problems are policies with inconsistent provisions on land classification allocation and use. In particular, the provisions of PD 705 Mining Act of 1997, IPRA and NIPAS Law on jurisdiction and uses of watershed areas clash with one another leading to confusion in strategies and programs being undertaken. The multiplicity of land tenure instruments being issued such as IFMA, SIFMA, CCFS, CSC, CBFMA, CADT, CALT and CLOA under RA 7881 and 7950 also add to the confusion of land-use within many watersheds.

Table 4. Daily water availability by water resources region

Region	Available Supply/ Day			Daily Demand		Surplus/Deficit	
	Surface Water (MCM)	Ground Water (MCM)	Total	1995 (MCM)	2000 (MCM)	1995 (MCM)	2000 (MCM)
Ilocos	42	7	49	13	24	36	25
Cagayan Valley	130	28	158	23	47	135	111
Central Luzon	52	16	68	41	72	27	-4
Southern Luzon	139	15	154	45	81	109	73
Bicol	46	9	55	24	36	31	19
Western Visayas	33	11	44	23	33	21	11
Central Visayas	28	3	31	11	21	20	10
Eastern Visayas	101	13	114	17	25	97	89
SW Mindanao	53	5	58	17	22	41	36
N Mindanao	74	16	90	22	41	68	49
SE Mindanao	63	10	73	28	48	45	25
S Mindanao	72	9	81	24	54	57	27
Philippines	**833**	**142**	**975**	**288**	**504**	**687**	**471**

Source: excerpt from the NWRB report. Note: MCM = million cubic meters.

Table 5. Projected water (m^3/year) availability in major cities in the Philippines

City	1995	2025	Groundwater availability	Surplus/(Deficit) in percent	
				1995	2025
Metro Manila	1,068	2,883	191	(82)	(93)
Metro Cebu	59	342	60	2	(82)
Davao	50	153	84	69	(45)
Baguio City	12	87	15	21	(83)
Angeles City	11	31	137	1,148	343
Bacolod City	37	111	103	179	(7)
Iloilo City	9	47	80	788	70
Cagayan de Oro City	29	98	34	18	(65)
Zamboanga City	28	203	54	92	(73)

Source: excerpt from the NWRB report

3. Poverty and absence of viable livelihoods

Poverty is the underlying cause of much watershed degradation in the Philippines. Table 6 presents the poverty incidence and population density by river basins in the country. The upland and mountain areas comprising large portions of the watersheds in the country are generally the poorest and least developed. Consequently, the on-site users of watershed resources are predominantly rural. The lack of alternative income- generating activities causes the upland dwellers to depend on unregulated farming and forestry activities for their survival.

4. Poor access to markets

Geographic isolation and the lack of a well-developed market infrastructure in most upland areas imply that their agriculture and forestry activities have remained predominantly for subsistence. Lack of good roads and markets restrains the opportunities for increasing cash income to a small number of commodities that keep well, have high value or are easily transported. For as long as the upland dwellers are subsistence farmers, they will continue to rely heavily on upland resources leading to higher pressure on resource sustainability.

Table 6. Poverty incidence and population density by river basins

Major River Basin	Area	Poverty Index	Population Density			
			1980	1990	2000	2010
Abra River Basin	495,634	0.35	0.75	0.90	0.90	1.04
Abulug River Basin	372,416	0.31	0.51	0.59	0.68	0.74
Agno River Basin	664,699	0.30	1.70	2.15	2.31	4.11
Agus River Basin	188,459	0.27	0.89	1.23	1.31	0.45
Agusan River Basin	1,194,720	0.40	0.88	1.16	1.14	1.14
Amnay-Patrick River Basin	50,096	0.37	0.48	0.59	0.75	0.82
Bicol River Basin	312,455	0.34	1.69	1.98	2.36	2.59
Buayan-Malungun River Basin	116,095	0.31	0.91	0.92	1.03	1.03
Cagayan deo Oro River Basin	146,936	0.37	1.09	1.45	1.38	0.80
Cagayan River Basin	2,761,266	0.40	0.69	0.86	0.94	1.08
Davao River Basin	172,518	0.21	1.11	1.52	1.21	0.62
Ilog-Hilabangan River Basin	209,896	0.31	1.37	1.58	1.66	2.36
Iloilo River Basin	24,387	0.29	1.44	1.66	1.68	2.82
Jalaur River Basin	101,997	0.45	2.45	2.85	2.89	4.61
Mindanao River Basin	1,998,315	0.38	1.05	1.34	1.37	1.04
Pampanga River Basin	1,091,188	0.21	10.95	14.75	18.70	23.17
Panay River Basin	209,435	0.34	1.71	2.00	2.12	3.05
Pasig-Laguna de Bay River Basin	416,602	0.17	16.12	21.95	28.82	34.50
Tagoloan River Basin	176,261	0.25	0.92	1.17	1.05	1.33
Tagum-Libuganon River Basin	243,506	0.37	0.62	0.89	1.06	0.70
Others	18,640,636					
Grand Total	**29,587,516**	**0.35**	**3.07**	**4.01**	**4.92**	**5.92**

Source: excerpt from NSO (National Statistics Office) and WorldBank (2010) data and then cross tabulated by river basin.

5. Lack of access to capital resources

One of the reasons for failure of watershed users to adopt conservation effective technologies is the difficulty of access to financial and technical resources. Financing institutions are usually unwilling to open windows for lending money to the poor such as watershed upland users who do not have the ability to put up guarantees for their ability to pay.

6. Conflicting institutional mandates

More than 30 government agencies are invariably mandated to be responsible for limited aspect of water resources development and management. As a result, the programs and thrusts of these agencies that include DENR, DA, DAR and the LGUs are usually independent of each other and uncoordinated. Hence, there is a need to clarify the jurisdiction and scope of responsibilities among the various agencies as provided for in various legislations such as PDs 705, 1159, EOs 192, 223 and 224 of 1987, 258 of 1995, RAs 4850 amended by PD 813, RA 8371, LOIs 845 and 1002, and the Provincial Water Utilities Act of 1973.

Executive Order 216 of July 6, 2009 declared that the River Basin Control Office (RBCO) under the DENR is the lead government agency for the integrated planning, management, rehabilitation and development of the country's river basins. Under the leadership of RBCO, it is hoped that the independent and uncoordinated programs of the more than 30 government agencies can be harmonized into a concerted effort with long lasting impacts on the sustainability of watershed and water resources.

7. Underpricing of watershed resources

Several studies had been conducted on the valuation and pricing of water and other watershed resources (Cruz *et al.*, 1997; Calderon *et al.* 2000; and Francisco *et al.*, 2000). There is now a need to test which of the pricing and valuation systems work and which ones do not under certain set of conditions.

8. Absence of land use and management plans

The use and management of many watersheds in the country commonly do not benefit from integrated land use and management plans. The success of existing limited watershed management plans are usually constrained by lack of holistic and integrated framework and more importantly by absence of political will to implement plans. In most instances, existing plans suffer from lethargic support from major stakeholders such as the LGUs and other line government agencies due to the absence of integration of watershed plans to those of LGUs and other agencies.

Formulation of land use and management plans is also hampered by the absence of management decision support systems particularly watershed information system. Poor plans are attributable to the absence of good maps and other information that are foundationally essential to making sound decisions on what land uses and management strategies are most appropriate for deriving the optimum benefits from the use of watershed resources. The absence of information system also makes it difficult to keep track of the various uses of the land and other watershed resources and its impacts, and of the state and condition of various ecosystem services emanating from the watersheds.

Implications to Water Supply and Quality for Agriculture

The role of forests in sustaining water supplies, protecting the soils of important watersheds, and minimizing the effects of catastrophic floods and landslides is comprehensively discussed in the FAO and CIFOR (2005) publication on "Forest and floods". The booklet deals on the complexity of the hydrologic processes, separating fact from fiction on issues related to forests and water, and deciphering some of the commonly held misconceptions about the role of forests in flooding.

Basically, the conventional wisdom suggests that forests act as giant sponges, soaking up water during heavy rainfall and releasing freshwater slowly when it is mostly needed. The upland-lowland relationships, as well as forest and flood interactions, are frequently perceived based on this myth than on science. Identifying the causes of disasters is usually associated with hydrologic processes based on observations and assumptions from one place to another, which often have quite different environmental characteristics. In reality, all floods cannot and should not be completely prevented. Flooding is important for maintaining biodiversity, fish stocks and fertility of floodplain soils. However, steps can be taken to limit the adverse impacts of floods and to ensure effective responses to flooding events.

FAO and CIFOR (2005) further emphasized that it requires a far better understanding of the interactions between human activities and floods, the limitations of watershed management and the role of floodplain or river-basin management in reducing flood-related impacts. An improved approach to watershed and floodplain management integrates land management in the uplands with land-use planning, engineering solutions, flood preparedness and emergency management in the lowlands. This requires good understanding of all the physical processes involved, as well as the social behavior and culture of local residents. Furthermore, this approach should draw upon the best available scientific knowledge about the environmental, social and economic impacts of floods and the environmental, social and economic effects of these interventions.

In the Philippines, the watershed management implications are attributable to a wide range of physical and socio-economic factors that are often complex and localized in nature. Figure 7 shows a typical problem tree of many watersheds in the country depicting the relationship of various drivers and its impacts. Climate change and deforestation are large multipliers of the watershed degradation which are typically blamed for flooding and water shortage in the downstream and agricultural lands.

Climate change and variability, in hydrologic views, directly alter the water cycle as well as the type and abundance of vegetation, which may change the behavior of lakes and watercourses (Sircoulon *et al.*, 1999). Changes in the climate regime can influence natural processes of a watershed ecosystem (Band *et al.*, 1996; IPCC, 2001a) and have long-term implications on economic and ecological processes (USEPA, 2004). More recently, the United Nations address the leadership challenge on climate change, particularly on adverse changes in the hydrologic cycle, which accelerates due to rising temperature (UNEP, 2007). A warmer atmosphere holds more moisture, becomes less stable and produces more precipitation, particularly in the form of heavy rain bursts. Greater heat also speeds up evaporation. The net effect of these changes in the cycling of water will result to the decline of the quantity and quality of freshwater supplies. Wind patterns and storm tracks are likely to change. The intensity (but not the frequency) of tropical cyclones is expected to increase, with larger peak wind speeds and heavier rains.

Effects and impacts of climate variability and land use changes have already been damaging the agriculture, fishery, environment, and human survival. The weather conditions of the country are often experiencing erratic and extreme events. Being within the northwest Pacific basin, the country is frequently visited by typhoons or cyclones (Moog, 2005). The country is now experiencing more or less 15 typhoons a year on an average. Tropical cyclones and the resulting floods and storm surges are the most destructive of all weather-related disasters.

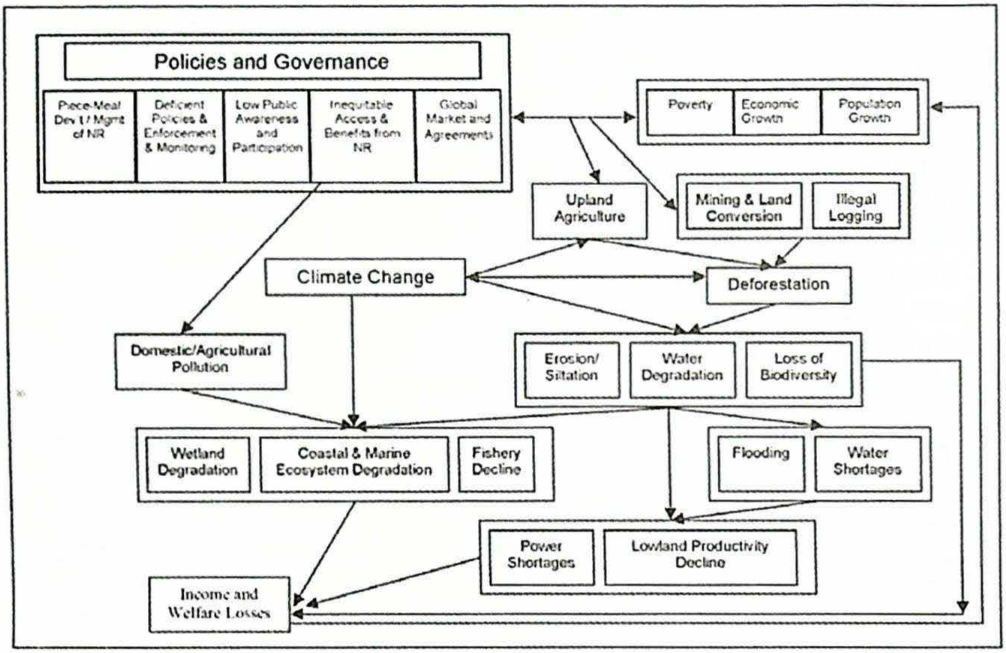

Figure 7. Interconnected drivers and impacts of watershed degradation in the Philippines

During the last few decades, watershed degradation was seen as a serious threat not only to the environment but also to the well-being and survival of millions of people living in watershed and downstream areas. Recognizing the vital role of the watershed ecosystem as a landscape unit, a detailed hydrologic impacts of the changing climate and land use are overwhelming concerns and issues in the country. For instance, investigations revealed that the hydrologic processes of the country's forest watersheds are greatly affected by changing climate and land cover types (Combalicer *et al.*, 2010). Distribution of hydrologic processes would be altered with disproportionate patterns and changes. These conditions can be associated to the likelihood of extreme occurrences or vulnerability to various climate and environmental hazards. More intense hydrologic events, such as excessive rainfalls, erratic streamflow magnitudes, high evaporation losses, and moderate seepages, will be expected to take place more frequently. As a result, these situations could place severe damage on agricultural production, livelihood, infrastructure, and environment in and around the watershed.

DeFries and Eshleman (2004) also described that these consequences include changes in water demands from changing land use practices, changes in water supply from altered hydrological processes of infiltration, groundwater recharge and runoff; and changes in water quality from agricultural runoff and suburban development. Essentially, understanding these consequences requires transcending traditional boundaries among disciplines, such as hydrology, ecology, geography and even social sciences.

The constant challenge for watershed management in the Philippines is finding ways on how to provide quality water from both surface and groundwater sources on a sustainable basis, to meet the needs of different water users within the downstream of the watershed, and to provide increased protection from flood and sedimentation damage for the downstream areas. In some instances, watershed management will require total protection of some areas (e.g., for biodiversity preservation or wildlife protection).

Overall, the ultimate goal of any watershed management program is to promote the use of natural resources within a watershed for economically productive purposes and at the same time to protect the environment. This should meet the requirements for sustainable water production and, to a practical extent, flood protection for communities downstream. This will require the development and adoption of improved management practices (i.e. watershed and floodplain management integrates land management with land-use planning, engineering solutions, flood preparedness and emergency management in the lowlands) that are not only productive but also conservation effective. Such practices should enable the users of the watersheds resources to increase tree, crop and/or livestock production in ways that would enhance and sustain, rather than degrade, the natural resource base.

Interventions Needed for Watershed Conservation

Given the state of watersheds in the country and the various drivers and impacts of watershed degradation previously discussed, the key interventions presented in Figure 8 (among the wide range of potential interventions) are recommended to improve the conditions of most of our watersheds and the quality of functions and services these watersheds provide.

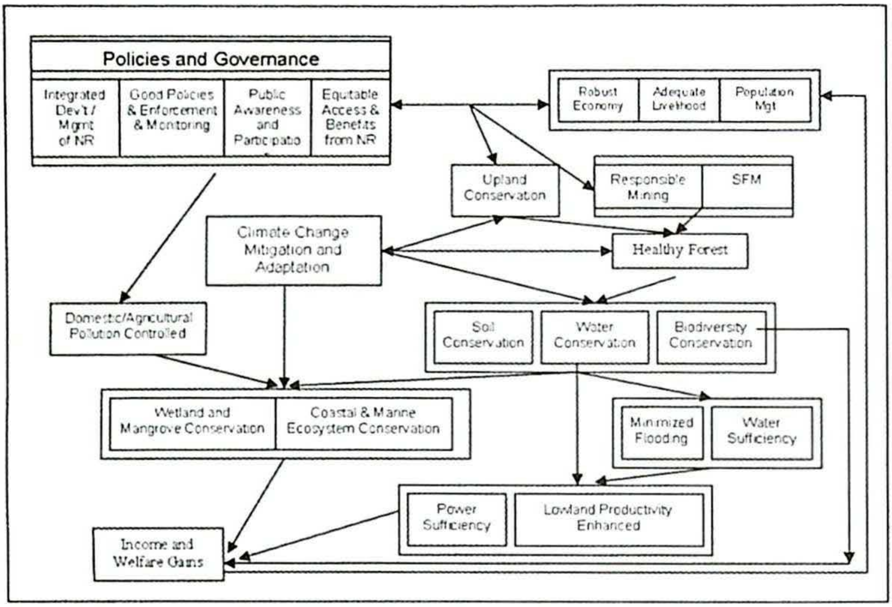

Figure 8. Interconnected potential solutions to watershed degradation

a. Increase the ability of watershed managers and planners in sound decision-making by improving the current understanding of the watershed behavior. Research on watershed should allow watershed manages and planners understand much better the link and interaction between the different functions, components and processes of the watershed;

b. Rationalize the research, development and technology transfer programs that will promote the conservation of soil, water, and other watershed resources without constraining adversely the use of watershed resources in meeting the needs for sustainable community development in particular and socioeconomic development in general;

c. Establish network of learning watersheds in strategic locations that will serve as regional focal research venues and capability building programs;

d. Enhance policy studies and development that will facilitate state driven and non-state driven modes of watershed governance such as watershed governance led by LGUs, local communities, water districts, government and private corporation;

e. Rationalize the policy and institutional climate to promote science-based management of watersheds;

f. Establish an appropriate operational mechanism for monitoring, accounting, evaluation and valuation of watershed resources and services for sustainability purposes;

g. Enhance information, education and communication to increase knowledge, appreciation and awareness of the users regarding watershed including its principles, concepts and practices;

h. Require mandatory formulation of integrated watershed management plan for all priority watersheds in the country; and

i. Vigorous restoration of degraded forests in watersheds. The implementation of the National Greening Program by virtue of Executive Order 26 will contribute to the restoration and rehabilitation of the country's watersheds. The program seeks to plant and develop some 1.5 million hectares of open and idle forest lands between 2011 and 2016 to address the problem of soil erosion, secure a sustainable supply of water and provide additional livelihood for farmers through agroforestry. Through the greening program, the government pursues to improve the vegetative cover of watersheds nationwide that could supply much of the freshwater requirement.

Prior to this greening program, UPLB-CFNR-AKECOP (2005) conducted a review of research and development initiatives of forest restoration in the Philippines. In forest plantations, the gaps and research agenda for restoration include the following:

- The identification of priority forest tree species for use in national planting programs, especially in industrial tree plantations, and smallholder tree farms in the different regions. At the time of the review, only the so-called popular species, normally with very little scientific basis, have been chosen for planting in the various regions of the country. It is only when these priority tree species are identified that the other aspects of tree seed technology could be properly addressed.

- Identification of appropriate sources (superior sources, plus tree) and genetic variations of the priority species. This will also include ways to ensure the genetic diversity of the sources to prevent the narrow genetic base of the selected species.

- Establishment of seed production areas of the priority species, and seed orchards of species that are highly in demand.

- If there are dormant seeds among the priority species identified, and lack of treatments are available, then intensive efforts are also needed to develop dormancy breaking treatments that are simple and economical.

- Establishment of seed testing procedures for the priority species which should include appropriate infrastructure (capital outlay and human resources) development.

- Enactment of a tree seed law that will regulate the production, use and marketing of quality seeds of the priority tree species.

- Expansion of the species base and species prioritization for forest revegetation activities.

- Formulation and implementation of a national comprehensive forest tree improvement program for the Philippines

- Improvement of forest tree seed technologies

- Production of improved quality planting stocks

- Increased protection of plantations from fires, pests and diseases
- Enhanced management and administration of forest plantations.

Technological Approaches to Increase Supply

Rijsberman (2006) suggested that water scarcity problem can be addressed through improved water productivity (Maraseni *et al.*, 2010). Hence, various technological approaches are being developed in order to increase supply of water.

A. Rainwater Harvesting

IPCC (2007) projected that rainfall events will become more intense due to changing rainfall patterns and amounts (as cited in Salas, 2009). With the occurrence of droughts and flooding, supply of freshwater ecosystem services will be more unreliable (Salas, 2009). Moreover, watershed degradation will result to increase in runoff and flooding during rainy months and water deficits in dry season. Hence, structures that could collect and store rainfall and run-off during its abundance are very crucial. Rainwater harvesting offers a steady supply of water in the face of the increased seasonal variability. This method is used for collecting and storing rainwater and surface runoff for more productive applications. It is found to be effective in adapting to increased changes in water supply and rainfall (Salas, 2009). It contributes to the improvement of water use efficiency within a watershed by reducing unproductive losses and unstable run-off (Contreras, 2007).

In the country, rainwater harvesting has long been implemented by Department of Agriculture (DA) through establishment of small water impounding projects (SWIPs) of not more than 15 meters in height (Contreras, 2007). The average storage capacity for SWIPs having a structural height of 5–15 meters reaches approximately 0.30 million cubic meters (Contreras, 2007). The major facilities of SWIPs include a dam and reservoir, outlet works, emergency spillway, irrigation distribution system, and access roads. It can be constructed in the middle portions of the watershed where the topography is predominantly rolling to hilly. It is beneficial for runoff management, soil and water conservation for supplemental irrigation, inland fish production, livestock watering, domestic purposes, groundwater recharge, and flood mitigation. One of the successful stories of community-managed SWIPs in the country is the Maasin SWIP in Talugtog, Nueva Ecija.

In Ilocos Norte, there is also an upland rainwater harvesting network which was established in Magnuang SWIP, Batac. A small water impoundment was established upstream and was reinforced by network of downstream water retention reservoirs. This is proved to be more efficient for collection and storage of rainwater. Moreover, it promotes optimum utilization and more efficient distribution of stored water.

Establishment of small farm reservoirs or ponds is also being encouraged in the country for sufficient supply of water. It is also a rainwater harvesting structure designed for trapping, collecting and storing water and runoff. It is beneficial in alleviating drought in rainfed farmlands. It is usually small and intended for use of a single farm making it easier to manage. As alternative source of income, it is sometimes being utilized as a fish pond. Small farm ponds or reservoirs are also helpful for farm level flood control, water augmentation, and livelihood diversification.

Salas (2009) reported that the use of rainwater collected in ponds for rainfed areas has caused the farmers to increase their production yields from an average of 2.2 - 3.3 tons/hectare with 4.68 tons/ hectare as the highest. This is higher compared with the yield from irrigated lands averaging 3.3 tons/hectare (Salas, 2009).

B. Water supply augmentation thru regulated shallow tube well (STW)

Water supply augmentation through regulated shallow tube well (STW) is one of the strategies being done to maintain the supply of water for farmlands. STW is a tube or pipe vertically set into the ground at depth of 20 to 60 feet. This is used for suction lifting of water from shallow aquifer. To ensure that groundwater quality is not being compromised, inventory and mapping of STWs within a basin/sub-basin are undertaken for proper monitoring. This program suggests that total groundwater extraction should not exceed recharge (i.e. with sufficient

GW discharge at the coastal to prevent saline water intrusion in coastal aquifers).

C. Excess water management

Improvement of drainage system can help to manage excess water. For instance, in areas with flooding problem, drainage facilities that will facilitate the timely release of storm water during rainy season should be prioritized. Moreover, drainage facilities and structures should form part of any irrigation systems that will be established.

D. Wastewater re-use for agriculture purposes

Water re-use has significant contribution to water productivity (Maraseni *et al.*, 2010). Water inputs to a field which was lost through percolation can be reused downstream. Hence, not necessarily leading to water depletion. DAO 26, Series of 2007 provides guidelines on the procedures and technical requirements for the issuance of a certification allowing the safe re-use of wastewater for irrigation and other agricultural purposes. Examples of regulated wastewater re-use can include use of liqud fertilizer, sprinkler irrigation, and establishment of fish pond. However, increasing water productivity through water reuse could contribute to rise in greenhouse gas (GHG) emissions. As show in Table 7, it is estimated that water reuse through pumping irrigation generates 1.47 times higher GHG emission compared with gravity-fed canal irrigation (Maraseni *et al.*, 2010).

According to Guarnieri *et al.* (2005), the salinity problem of sodic soils characterized by low permeability to water and air may be aggavated by water pumping and reuse leading to higher energy requirement for tillage (Maraseni *et al.*, 2010). Fossil fuel is used to meet the demand for energy resulting to higher GHG emission, hence contributing to climate change.

E. Utilization of Renewable Energy

Studies showed that energy consumption in agriculture has a direct relationship with the development of technology and the level of production (Maraseni *et al.*, 2010). To increase agricultural productivity, efficient use of water should be done simultaneously with efficient use of energy (Maraseni *et al.*, 2010).

The use of technologies for improving the supply of irrigation water entails high consumption of energy. Irrigation requires large amount of fossil energy for pumping and delivering crops (Maraseni *et al.*, 2010). For instance, pump irrigation is a common practice in meeting the agricultural demand for water. In the study of Gleick *et al.* (2002), energy required for pumping groundwater from a depth of 100 m increases 23-fold to 28,500 kWh (as cited in Maraseni *et a*l., 2010). The development of pump irrigation systems are hindered by high cost of energy. Utilization of renewable energy offers can help in meeting the energy demand for the purpose. At present, solar power water pump, ram pump and wind power pump are being used to sustain the supply of water in farmlands. This is cost-efficient compared with the convetional pumps which rely on fuel. Moreover, the use of renewable energy would lessen the contribution of agriculture sector to climate change.

Table 7. GHG emissions (kgCO_2e/hectare/season) from different farm inputs in rice farming from pump and canal irrigation systems.

Sources	Pump irrigation (with water reuse)	Canal irrigation (without water reuse)
Pumps, pipes, fuels and oils	338.7	NA
Tractors, accessories, fuels and oils	471.8	454.1
Agrochemicals	432.2	390.4
Total	**1,242.7**	**844.5**

Source: Maraseni *et al.* (2010)

Demand-Side Management

The Philippines is predominantly agriculture-dependent country. In 2009, about 40.1% of the total land area of the Philippines was devoted for agriculture (World Bank, 2012). As defined by World Bank, agricultural land refers to the portion of land area that is arable, under permanent crops, and under permanent pastures. Agriculture dominates the country's land use since it usually serves as primary source of income of the people residing in rural areas.

Agriculture, specifically, irrigated agriculture is considered as the greatest water user as it accounts for about 79% of the total water use. Most of the water coming from various irrigation systems originates from watersheds. In 2003, the total irrigated area of the country is about 1.4 M hectares, which is only 43% of the total potential irrigable area of 3.3 M hectares (i.e., NIA estimates). Three years later, slight increase of irrigation facilities was achieved with the total area of 1,515,347 hectares representing only 48.47 % of the total irrigable area (NWRB, 2006). Of the irrigated lands, 0.7 M hectares are served by NIA, 0.5 M hectares by Communal Irrigation Systems (CIS) and 0.2 M hectares by private irrigation systems (PIS) with a total of more than 1.1 M farmer beneficiaries. At the end of 2011, 50% irrigation development was reached resulting to total service area of 1,566,591 hectares (NIA, 2011). Areas primarily devoted to rice and corn and is characterized by up to 3% slope comprised the estimated potential irrigable area of the country (NIA, 2011).

As shown in Table 8, although there is generally an increasing trend on irrigation development for the past four decades, it hardly moved and has not even reached 50% in 2009 (Cainglet, 2010). This can be attributed to decline in public investment and conversion of agricultural lands to industrial use (Cainglet, 2010). According to Asian Development Bank (ADB), the country was rice self-sufficient in 1970s primarily due to steady investment in irrigation. Beginning 1980s, implementation of several programs has limited the government intervention in the agricultural sector and promoted planting of export crops at the expense of food production (Cainglet, 2010). These programs include SAP (Structural Adjustment Programs), BAIDS (Balanced Agro-Industrial Development Strategy), ABIDS (Agro-Based Industrial Development Strategy), and KPAs (Key Production Areas) Program.

Table 8. Irrigation development in the Philippines

Year	Potential Irrigable Area (hectare)	Service Area (hectare)	Irrigation Development (%)
1979	3.126 million	1.17 million	37%
1989	3.126 million	1.46 million	46%
1999	3.126 million	1.35 million	43%
2009	3.126 million	1.54 million	49%

Source: National Irrigation Authority (NIA) as cited in Cainglet (2010)

Irrigated agriculture is the main focus of food security projects in the country considering that it provides 76% of annual rice production of the country (ADB, 2008). Rice serves as the basic food staple for the Filipinos. Ironically, Philippines is considered as one of the largest importers of rice in the world (ABD, 2008) despite its vast water resources and potential agriculture lands.

According to Philippine Institute for Policy Studies (PIDS), irrigation can improve the productivity of land in two ways (as cited in Cainglet, 2010). First, the sufficiency of water supply can raise the yield per hectare per crop. Likewise, irrigation allows a second crop to grow during the dry season when yields are potentially higher.

State of Irrigation Development of the Philippines

Studies revealed that the irrigation system performance of the country is characterized by declining public investment, operation and maintenance which typically fails to distribute water efficiently and equitably, and rapidly deteriorating irrigation systems (Cainglet, 2010). Specifically, the irrigation sector is faced by five interrelated problems (Araral, 2005) presented in Figure 9 below.

Most of the irrigation facilities of the country are in need of rehabilitation and/or improvement as indicated in Table 9. It is estimated that approximately 80% of the country's 196 national irrigation systems (NIS) should be rehabilitated. This problem indicates that the country has chronic underinvestment in irrigation maintenance. Moreover, the poor water delivery can be attributed to deterioration of physical facilities. It was recorded that in the last 10 years, 30% of the total irrigation service area was inadequately served with irrigation water. This same situation contributes to farmer dissatisfaction resulting to reduced willingness to pay for irrigation fees. Poor collection of fees will lead to chronic underinvestment in irrigation maintenance. Poor water service, in turn, will adversely affect the productivity of farmlands causing lower income of farmers.

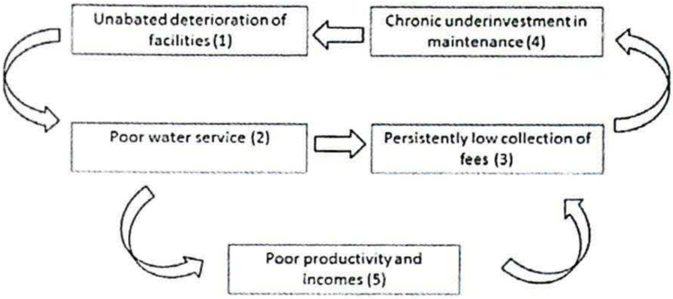

Figure 9. The vicious cycle problem of public irrigation in the Philippines.
Source: Araral (2005)

Although the government has been investing on irrigation to meet food security, the performance of irrigation investments have often fallen short of expectations created during project design. According to ADB (2008), the issues in irrigation systems in the country can be categorized into three—(1) overoptimistic system development assumptions, (2) inadequate operation and maintenance, and limited farmer participation, and (3) system deterioration.

Table 9. Condition of physical facilities (as of 2002)

Type of facility	Total	Percent needing rehabilitation (%)
Headworks	145 units	34
Main canal	3,917 km	61
Control structures, main canal	11,423 units	53
Lateral canal	10,299 km	63
Control structures, lateral canal	39,949 units	56
Service/access roads	13,967 km	74

Source: NIA Archival Data as cited in Araral (2005).

1. Overoptimistic system development assumptions
The assumptions followed in system development are usually overoptimistic. The service areas designed for the purpose tend to be larger than available water resources. Moreover, hydrological records are limited, hence, data-based hydrological analysis on water availability seems hard to achieve. Usually, establishment of service area requires

farmers to convert land. However, due to shortage of resources and the value of existing crops, such lands are not developed.

2. Inadequate operation and maintenance, and limited farmer participation
   The inadequacy of operation and maintenance (O&M), and limited farmer participation results to deteriorating canals and structures, and silted and defective diversion works. O&M costs are expected to be covered by irrigation service fees. However, collection efficiency is very low. Meanwhile, most O&M funding is utilized for NIA personnel and little remains for actual O&M. To address this issue, the irrigation management transfer (IMT) program was established. It aims to transfer system management to the implementing agencies and thus reduce O&M costs.

3. System deterioration
   System deterioration is one of the major challenges in the performance of irrigation investment. After the creation of NIA in 1963, irrigation development accelerated. However, many of the schemes developed are now aging and have accumulated damage through natural calamities, hence reducing their efficiency in fulfilling the expected functions. At present, many systems now require comprehensive and systematic upgrading to bring them to full operating status.

The current problems of public irrigation in the country stemmed from its irrigation development path (Araral, 2005). Vermillion (2002) argued that this path is characterized by the government playing a central role in irrigation development, large irrigation bureaucracies biased towards construction, dependence upon foreign loans, and the promotion of farmer participation with patronage (as cited in Araral, 2005).

Irrigation Operation Constraints

The irrigation performance of the country, as shown in Figure 10, is affected by two major factors. Aside from the dysfunction of irrigation system, it is also influenced by climate change. More efficient irrigation systems are required to maintain or increase agricultural productivity in the face of extreme and skewed rainfall. Meanwhile, irrigation system dysfunction is a result of natural wear or tear and calamity devastation. According to World Bank, if the repair and rehabilitation of typhoon-damaged irrigation facilities will not be addressed, it would result to an estimated PhP 30 billion to PhP 47.5 billion losses for farmers (Cainglet, 2010).

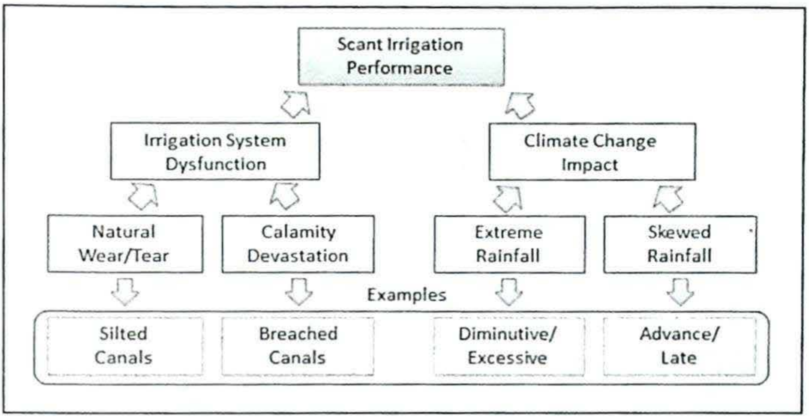

Figure 10. Factors affecting scant irrigation performance of the Philippines

Some interventions, as presented in Table 10, are installed to address water scarcity as a result of diminutive rainfall. On the other hand, Table 11 presents some interventions being installed to address excessive rainfall which results to inundation, erosion, scouring and sedimentation.

Measures in Improving Irrigation Performance

Irrigation operation enhancement is undertaken to sustain food security using resource- based and technology-based interventions as shown in Figure 11. Responding to the goals of the Food Staple Self-Sufficiency Program 2011-2016 (FSSP), NIA embarks to expand irrigation area and optimize irrigation performance forthwith. Hence, investments are made both for resource-based and technology based intervention. Expanding irrigation area, gauged in higher irrigation development level, is achievable through more investment in construction projects—a resource-based intervention.

Optimizing irrigation performance, gauged in higher irrigated area, cropping intensity, crop yield and farm income, depends on technology-based interventions.

Table 10. Interventions to Water Scarcity

Water Augmentation	Type	Usage	Water Conservation	Type	Usage
Drainage Reuse System (DRS)	PI^s	High	Rotational Water Distribution (RWD)	OI	Medium
Transitory Reservoir System (TRS)	PI^s	Low	Sustainable Irrigated Agriculture (SIA) (AWD)	OI	Medium
Shallow Tubewell System (STW)	PI	High	Concrete Canal Lining (CCL)	PI^s	High
Additional Stream Tapping (AST)	PI^s	High	Canal Offtake Retrofitting (COR) (W^2OR)	PI^s	High
Small Reservoir Scheme (SRS)	PI	High	Controlled Irrigation Application (CIA) (e.g. AWD)	OI	Medium
			Modified Cropping Pattern (MCP) (e.g. R^3CP, 5in1 CP)	PI	Medium

Note. PI=physical intervention, OI=operational intervention, PI^s= subsumed in projects

Table 11. Interventions to Excessive Rainfall

Intervention	Type	Usage	Intervention	Type	Usage
Pre-Emptive Spill (Inundation Control)	OI	High	Watershed Replanting (Erosion Control)	PI^s	Low
Drainage Rehabilitation (Inundation Control)	PI^s	High	Slope Protection (Erosion Control)	PI^s	High
Afflux Dike (Inundation Control)	PI^s	High	Silt Extrusion (Sedimentation Control)	PI^s	High
Drainage Pumping (Inundation Control)	PI^s	Low	Farming System, SIA (Carbon Sequestration)	OI	Medium
Spur Dike (Scouring Control)	PI^s	High			
Flood Protection Dike (Inundation Control)	PI^s	High			

Note: PI=physical intervention, OI=operational intervention, PI^s= subsumed in projects.

Technology-based interventions comprise physical measures as well as operational schemes—aimed to quell operations constraints and boost irrigation benefits. This means that irrigation system rehabilitation can be relevant in just restoring functionality by rectifying dysfunction caused by natural deterioration and flood damages. It can also be relevant in just improving performance by enhancing system configuration to address water scarcity, canal siltation, flood devastation, and wasteful diversions. Table 12 presents different technology-interventions that can be undertaken to enhance the operation of irrigation systems.

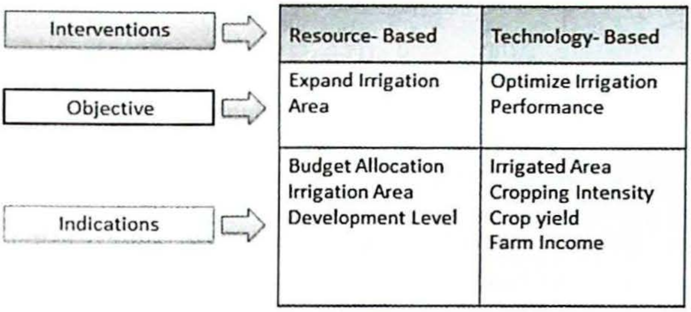

Figure 11. Irrigation Operation Enhancement Interventions

Table 12. Technology- Based Intervention for Irrigation Operation Enhancement

Objective	Technology- Based Intervention	Description
Increase Irrigated Area	Canal Offtake Retrofitting (COR)	Alleviate water distribution inequitableness
Increase cropping intensity	Cropping pattern optimization (CPO)	Increase 1 to 2 more rice crops in 2 years
Increase Palay yield	Sustainable Irrigated Agriculture (SIA)	More crops realized at less water/ production input

On increasing irrigated area (per cropping season), the technology-based operational intervention is canal offtake retrofitting (COR)—putting a cap to water diversion level. Advocated COR is the use of straight overshot weir as canal cross-regulator paired with a notched-weir as offtake intake, with the gate shutter maintained for more flexibility. COR intends to resolve inequitableness in water distribution, i.e. to expunge the prevalence of water wasting, water deficit and water deprived zones in irrigation areas.

On increasing cropping intensity (per agricultural year), the technology-based intervention is cropping pattern optimization (CPO)—one or two rice crops more in two years. This policy reform pushes a shift from 2 rice crops in a year (2 in 1 or 4 in 2) to 5 rice crops in 2 years (5 in 2) or 6 rice crops in 2 years (6 in 2) cropping patterns. In climate types I, III and IV, target irrigated area in the 3rd crop season in a year could be utmost 35% because of scarce rainfall and streamflow (except in reservoir irrigation systems).

On increasing palay yield (per cropping season), NIA promotes sustainable irrigated agriculture (SIA)—a farming system with component practices already familiar to farmers. SIA, dubbed the Philippine variant of the System of Rice Intensification (SRI), has alternate wetting and drying (AWD) as a component—a water saving intervention. On improving irrigation performance, technology-based interventions (Table 13) focus at water availability, planning database, operating skill, silt extrusion, and flood control.

These interventions, focused at water shortage, flood devastation, reservoir sedimentation, and canal siltation exist even before climate change had become a buzzword. This means that NIA's interventions to improve functionality and performance of irrigation systems match the necessary mitigation and adaptation measures to climate change. These interventions make-up the components of irrigation construction and rehabilitation projects, with the cost for climate change measures subsumed in project cost.

Table 13. Strategies and Interventions in Improving Irrigation Performance

Strategy	Intervention
Water Supply Augmentation	Dam heightening, drainage reuse, interim water reservoirs, reservoir irrigation systems
Water Supply Conservation	Canal lining, intermittent irrigation, offtake retrofitting, irrigation delivery suspension
Planning Database Improvement	Parcellary map upgrading, hydro-meteorological stations establishment
Operating Skill Enhancement	Technology module piloting, seminar-workshop execution, technology module packaging
Silt Intrusion Control	Silt stilling basins, proper dam operations, slope stabilization, watershed reforestation
Flood Devastation Control	Flood protection dikes, drainage way clearing, flood diversion ponds, afflux dikes, spur dikes

Technological Approaches in Reducing Demand

To reduce the consumption of water in agriculture while maintaining yield per crop, various methods are being implemented. These strategies are mostly employed in rice paddies which have the highest consumption among cereals. For rice production systems, there are two challenges in developing water-efficient strategies (Bouman, 2001). These include reducing water inputs and maintaining yields at the same level as under flooded condition. To realize this goals, the following methods are being employed:

A. Sustainable Water Management

Sustainable system of irrigated agriculture (SSIA) encourages the use of less irrigation water while ensuring higher yields. It contains a combination of farming practices beneficial in raising the productivity of rice and other crops from planting, watering, soil aeration to nutrient applications (Kikuchi *et al.*, 2008). SSIA are guided by six key elements: (1) leveling and preparing the field, (2) preparing the nursery, (3) innovative transplanting, (4) irrigating intermittently, (5) applying organic fertilizer, and (6) rotary weeding and tillage. Intermittent irrigation (i.e. Alternate Wetting and Drying (AWD)) in combination with good cultural management is a good practice to increase yield (i.e. fertility management) and reduce cost.

Kikuchi and Xie (2008) differentiated SSIA with conventional method in terms of their water use. During land preparation in SSIA, the field is soaked for 5 days before plowing or rototilling and is flooded 2-3 days before harrowing or puddling. This is in contrast with conventional practice in which soaking of field is done before plowing or rototilling and flooding is undertaken between harrowings or puddlings. In addition, paddies are drained after leveling in SSIA unlike in conventional method which only reduces paddy water depth to 5-7 cm. For irrigation, SSIA uses 3-day on and 7-day off irrigation scheme and starts intermittent irrigation at 10 days after transplanting. Moreover, less standing water (+2 cm) is used in wet period and continuous irrigating is done during panicle initiation and heading stages. In conventional method, continuous flooding at 5-10 cm paddy water depth is employed throughout the growing season, except during terminal drainage. For these three stages, SSIA exceeds the water efficiency of conventional method, hence saving much water.

According to Kikuchi and Xie (2008), SSIA has potential impact on three major issues in the irrigation sector:

1. Water savings – this is especially an advantage where there is water stress and shortage, where pumping is used for irrigation; and where water charges are based on volume. Given climate change and its increasing variability, the water-saving feature of SSIA is of particular importance.
2. Increasing farm productivity – this becomes significant given the need for more food production to feed the increasing population and the need to alleviate poverty.
3. O&M of irrigation infrastructure – SSIA calls for improved irrigation water management. Increased farm incomes facilitate increased collection of irrigation service fees (ISF), which in turn improves farmers' ability to pay and the financial sustainability of irrigation systems.

B. Water-saving technologies

Alternate Wetting and Drying (AWD) is a water-saving technology that can be applied by lowland (paddy) rice farmers in reducing water use in irrigated fields (IRRI, 2009). In this method, rice field is alternately flooded and non-flooded. Flooding is done for a certain number of days after the disappearance of ponded water. Meanwhile, the number of days of non-flooded soil between irrigations can vary from 1 day to more than 10 days.

Studies pertaining to soil water threshold of rice revealed that water level can be allowed to drop below ground surface at 15 cm during dry season and 20 cm during wet season. According to the report of IRRI, irrigation should be applied to re-flood the field with 5 cm of ponded water once it dropped to 15 cm below the surface of the soil. Moreover, ponded water should be kept at 5 cm depth from one week before up to one week after flowering. During grain filling and ripening, the water level can drop again to 15 cm below the surface before reirrigation.

AWD, particularly the 'safe AWD' variant, reduces the hours of irrigation use (by about 38%), without a statistically significant reduction in yields and profits (Rejesus *et al.*, 2011). This reduction in irrigation time translates into corresponding savings in the amount of irrigation water and pumping energy used. This water-saving technology is usually implemented 20-30 day after direct wet seeding or transplanting continuous flooding method. It can generate about 15-30% water savings compared to continuous flooding method. However, current impact results have to be interpreted with caution and further data collection is needed.

C. Improved irrigation methods for high value commercial crops

Overhead irrigation is one of the methods used for watering high value commercial crops. It applies water in form of spray, hence simulating rain. It has a nominal discharge of 40 liters/hour – 20 m^3/hr. In this method, water flows under pressure through a nozzle. It is highly efficient as water is conveyed through a pipe system. It operated well in steep slopes and erodible soils; and undulating land too costly to level. It also allows interference with farming operations.

Another method is localized irrigation (drip irrigation) in which water is applied by wetting only a part of the soil in the field through emitter. The same with overhead irrigation, it is highly efficient as water is conveyed through a pipe system. Water is applied directly to each plant such that only the soil near each plant is wetted. This method facilitates fertigation and thus, could increase yield by 20% to 70%. It is also suitable in steep and undulating slopes, and sandy soils.

D. Cropping patterns and Calendar Adjustment in Irrigated Agriculture

Cropping patterns and calendar adjustment can be undertaken to allow rice ecosystem to perform flood water detention function and improve soil fertility and stocks of natural biodiversity. This is also beneficial in coping with the seasonal changes in our climate.

E. Organic farming system

Organic farming system involves soil management for the improvement of soil water holding capacity and water and nutrients availability and uptake. There are two kinds of soil management; these are organic-based agriculture fertilizer program (modified rapid composting (MRC) production farms) and Community-based Composting Facility for farm waste management.

Proper mix of farm enterprises in the uplands such as agroforestry, natural vegetation strip, and contour farming can also be done to improve soil condition. Upland soil conservation farming system include contour farming and establishment of hedge rows of close-growing crops, composting of farm waste and residues, mulching and establishment of brush dams across gully.

F. Plant Breeding

Plant breeding can indirectly increase water productivity by raising the yield per crop without additional water consumption. It is done to increase the tolerance of plants for drought conditions and salinity. Plant resistance to water deficit may arise from three factors—drought escape, drought avoidance, and drought tolerance.

1. Drought (or dehydration) escape relies on successful reproduction before the onset of severe drought stress. The plants combine short life cycles with high rates of growth and gas exchange, using maximum available resources while moisture in the soil lasts.

2. Drought avoidance involves the following factors:
   (a) minimizing water loss (through closing stomata, reducing light absorbance through leaf rolling, decreasing canopy leaf area, non-permeable leaf cuticle to reduce transpiration; other physiological traits such as stomatal conductance, leaf water potential, leaf relative water content, water loss rate, canopy temperature) and
   (b) maximizing water uptake (through increasing investment in the root [large, shallow, deep penetrating], reallocation of nutrients stored in older leaves, higher rates of photosynthesis)

3. Drought tolerance is a result of coordination of physiological and biochemical alteration at the cellular and molecular levels (osmotic adjustment, more rigid cell walls or smaller cells, changes in mRNA and protein levels)

G. Submergence tolerant variables

The projected impacts of climate change such as increased floods threaten the viability of sufficient rice production in the country. Flood prone areas in the country are challenged with increasing productivity even in the face of extreme climate events. In just a period of four years, a total of 77 tropical cyclones visited the country from 2008-2011. As shown in Table 14, an average of 19 typhoons is passing across the country. Moreover, Table 15 shows the areas which are prone to flooding.

Table 14. Number of Tropical Cyclones in the Philippines from 2008-2011

Particulars	2008		2009		2010		2011		Across year	
	Total	Average	Total	Average	Total	Average	Total	Average	Total	Average
Tropical cyclones	23	3	22	2	11	2	21	3	77	19
No. of days	86	10	69	8	42	8	151	22	348	87

Table 15. Submergence-prone (October 2009, Regional)

Region	Hectare	Region	Hectare
CAR	6,618	VII	1,439
I	58,233	VIII	21,507
II	24,485	IX	6,440
III	76,887	X	2,386
IVA	2,759	XI	6,127
IVB	20,729	XII	12,797
V	9,434	XIII	13,593
VI	29,868	ARMM	29,146
TOTAL		**322,448**	

Submergence tolerant rice is used to ensure that flooding will not result to reduced production. It can survive complete submergence under murky and turbid water for up to 2 weeks unlike intolerant rice which can only last for 3-4 days when submerged. Under complete submergence, shoot elongation of tolerant varieties is inhibited, conserving carbohydrate reserves and allowing survival under water and growth resumption after desubmergence.

H. Governance

Irrigation management transfer (IMT) is an important strategy among donors and governments to strengthen farmer control. It is formulated from the idea of decentralization which assumes that resource users will act collectively to advance their interests if they will be given the right to decide and manage the resources (Araral, 2011). Moreover, decentralization highlight the importance of credible enforcement since decentralized subsystems are more likely to solve collective action problems such as free-riding, conflict resolution and rule enforcement (Araral, 2011). Without participation of beneficiaries, upgrading irrigation infrastructure and operations is not likely to be successful and/or sustainable (ADB, 2008). Users' accountability, collaborative effort, and reduce costs for operation and maintenance of irrigation systems are the rationale behind the implementation of IMT.

The construction of irrigation facilities remains the focus of government projects. However, the insufficiency of funds has impaired operation and maintenance (O&M) activities. Hence, implementation of irrigation management transfer (IMT) would not just increase farmers' participation, but will also improve O&M activities by mainstreaming the process. IMT is in line with government strategy of empowering communities through decentralization, increasing accountability and quality of public sector services, and streamlining the public sector (Bandyopadhyay *et al.*, 2007). However, some critics suggest that reducing the state's financial burden has become the focus of irrigation reform instead of the original objective of improving the livelihoods of poor farmers (Bandyopadhyay *et al.*, 2007).

In the study of Bandyopadhyay *et al.* (2007) wherein a survey of 68 irrigator associations and 1,020 farm households were undertaken in the Philippines, the following three main results were derived:

1. The presence of irrigation management transfer is associated with an increase in maintenance activities undertaken by irrigation associations.

2. By increasing local control over water delivery, the presence of irrigation management transfer is associated with a 2-6 percent increase in farm yields.
3. Irrigation management transfer is, at a minimum, poverty-neutral, and may even give the asset-poor a small boost in terms of rice yields.

IMT contributes to increased productivity as a result of expansion of cropping area, an increase in cropping intensities, and crop diversification. Through IMT, monitoring of water consumption at the farm and basin level can be easily done by the farmers. Moreover, they can easily adopt and practice water conserving technologies since they have direct management of the irrigation system. (Araral, 2011). Hence, IMT could lead to poverty reduction, improved irrigation operation, and participatory conservation of water resources (Araral, 2011).

Conclusions

Water is vital in achieving food security. Agriculture heavily depends on freshwater resources in enhancing its production; making it as the largest consumer of water. With the increasing trend of water withdrawal, agriculture must meet the challenge of increasing water productivity. It should maintain more water-efficient production system and ensure water security as a pathway toward food security. The guiding principle lies in the concept that freshwater is a finite and vulnerable resource. Hence, the development and utilization of water resources should be properly regulated, and accountability and self-regulation should be adopted by water users.

Management of irrigation waters should consider watershed conservation to ensure the sufficiency of supply. Good farming practices, water re-use and recycling will increase water use efficiency within a watershed. Moreover, strengthening institutional linkages within a watershed will also facilitate better collaboration and partnership for more coherent program on water conservation and water use efficiency.

The big challenge for the agriculture sector is to reduce its "water footprints" by increasing water efficiency on farms. Hence, there is a need for an enabling environment in terms of a unified water-related policies, institutional arrangements, and financing mechanisms to address the threat of present and future water insecurity.

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