

Climate-Responsive Integrated Master Plan for Ago River Basin

Volume I – Executive Summary



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EXECUTIVE SUMMARY

1 Rationale

In compliance with Executive Order 510, the River Basin Control Office (RBCO) of the Department of Environment and Natural Resources (DENR) crafted an Integrated River Basin Management and Development Master Plan for the 18 major river basins. With this, most of the river basin masterplans had been formulated and approved by the late 2000's. With the passage of the Climate Change Act of 2009 and the Disaster Risk Reduction Law of 2010, the significance of integrating potential climate impacts in development planning had become recognized. Furthermore, the Cabinet Cluster on Climate Change Adaptation and Mitigation had also adopted the river basins as priority areas of the government.

The Agno River Basin is one of the 18 major river basins. However, its master plan predated the establishment of the RBCO and the passage of the Climate Change Act and the Disaster Risk Reduction Law. Thus, there is a need to review and update the master plans not only to make it more relevant to the present conditions of the river basin, but also to incorporate and adopt climate change adaptation and mitigation, and disaster risk reduction and management into the planning framework in order to address the evolving needs and challenges in the river basin.

2 Project Objectives

The objective of this project is to update the Integrated River Basin Master Plan for the Agno River Basin and to incorporate the implications of the new climate normals in addressing the concerns of the river basin on:

1. Water resources management;
2. Watershed management;
3. Disaster risk reduction and management;
4. Wetland management;
5. Economic development; and
6. Institutional linkages and organizational structure for river basin management.

3 Scope and Limitation

The project updated update the Integrated Management and Development Master Plan of the Agno River Basin, taking into consideration potential climate change impacts to provide a sound basis for management decisions in the sustainable management of the resources therein. The project consisted of two phases, the scope of which includes:

1. Updating of river basin profile;
2. Revision of vision, missions, and goals;
3. Identification of strategies, programs and projects;
4. Evaluation of strategies, programs and projects; and
5. Investment and implementation planning.

4 Methodology

The project adopted the following methods and approaches to accomplish the objectives (Figure 1). The following tasks were undertaken during the implementation of the project:

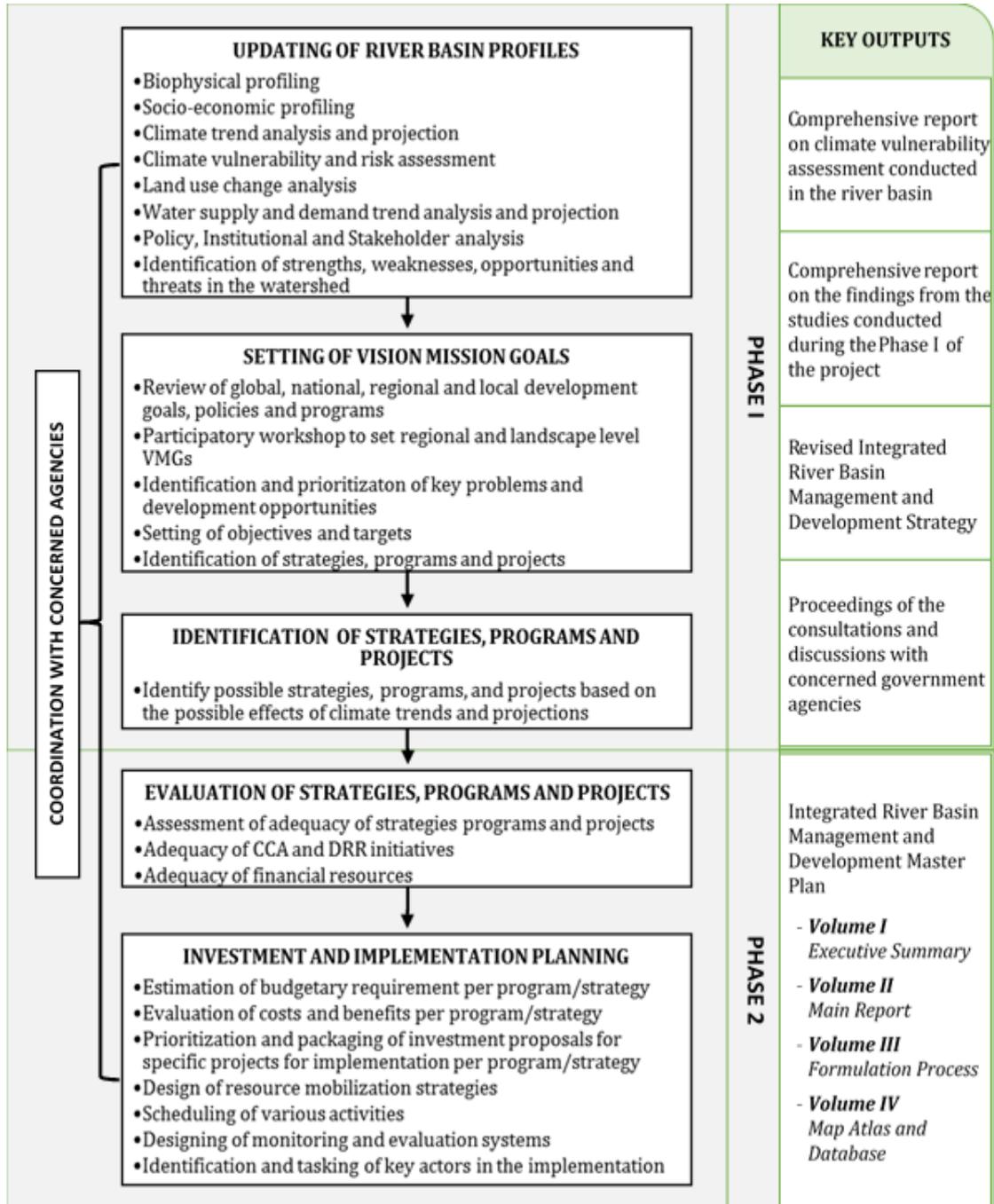


Figure 1. Flow of activities in the formulation of master plan for the Agno River Basin.

5 Assessment Reports

5.1 Geophysical Profile

Geographic Location

The Agno River Basin is located along western Luzon, draining into Lingayen Bay. It spans four regions, covering 9 provinces, 73 municipalities, and a total of 1,232 barangays. It is the fifth largest river basin in the Philippines, covering an area of around 6,219.65 km², straddling the provinces of Benguet, Ifugao, Mountain Province, Nueva Ecija, Nueva Vizcaya, Pangasinan, Tarlac, Zambales, and Pampanga.

Climate Trends

Agno falls under the Type I climate of the Modified Corona Climate Classification System, with two pronounced seasons throughout the year. It is typically dry from November to April and wet during the rest of the year, with the months of June to September generally receiving the most amount of rainfall. It has an annual average rainfall of 3,111.2 mm and about 144 rainy days a year. The mean annual temperature is around 23.7 °C with January reaching 22.0 °C and May 25.2 °C. By 2050, rainfall is projected to increase by as much as 200 mm; seasonally, it is expected to decrease by 15% during the summer months and increase by 40% at the peak of the rainy season. Temperature is projected to increase by 2.5 °C by 2050. Furthermore, the number of days with extremely high temperatures (>35 °C) is projected to increase two-fold, while the number of days with extremely high rainfall (>300 mm) is projected to increase by 57% in 2050.

Topography

The Agno River Basin has an average elevation of 248.98 meters above sea level (masl), with a standard deviation of 571.58 masl. Most of the river basin (51%) is located in relatively low elevations, including all of Nueva Ecija, most of Pangasinan, and parts of Tarlac. Its highest point is 2,926.42 masl at the peak of Mt. Pulag. The ARB has a mean slope of 24.3%, which is classified as steeply sloping. The most frequent slope class is 3%-8%, covering 26.9% of the area.

Soils and Geology

The soils in the Agno River Basin are diverse and represent a wide range of development stages. There are about 50 different types of soil from 29 different soil series in the river basin, with soil textures ranging from moderately coarse to fine. Similarly, the geological complexity of the area is evident in the seven distinct geologic formations underlying the area, the four fault systems traversing it, and the thirteen volcanoes it contains. Owing to such conditions, the river basin is rich in both metallic and non-metallic mineral resources which include some of the principal gold and copper deposits in the country.

Water Resources

The river basin encompasses around eight critical watersheds and three major hydroelectric dams, which are key sources of water and energy in the region. With about 4,024 kilometers of rivers and tributaries, 3,297 hectares of lakes and reservoirs, and extensive aquifers underlying the river basin, the area is abundant with surface water and groundwater resources. Generally, the freshwater storage capacity and the high rate of precipitation would have assured the river basin with an adequate source of water to meet demands for multiple uses (i.e. domestic, industrial, agricultural, commercial).

However, as early as the 1990's, the Japan International Cooperation Agency (JICA) has projected that increasing demand may begin to outpace available water supply by 2025. A total of 634 abstraction permits had been granted by the NWRB in the Agno River Basin, 59.8% for surface water extraction, 40.2% for groundwater. However, groundwater extraction can be as high as 63% of illegal abstractees are included. Irrigation and domestic demand are the largest consumers of water in the area, each comprising 63% and 23% of the total water use respectively.

Results of the simulation water balance simulation indicated a total water yield of about 2,357.4 mm year⁻¹ or 77% of annual rainfall. The annual mean runoff of the Agno River Basin is about 1,855.3 mm, representing a 0.60 runoff coefficient; total groundwater recharge is 437.7 mm year⁻¹, of which 20.8 mm year⁻¹ is recharge to deep aquifers. The simulated impact of projected climate scenarios on the water balance showed annual rainfall in 2020 and 2050 will result to increase in water yield and surface runoff. However, a slight decrease in water yield will occur during the summer months due to shifts in rainfall distribution patterns. Similarly, the groundwater recharge also likely to increase in 2020 and 2050.

Land Classification and Land Cover

Most of the river basin area (52%) is classified as forest lands (i.e. forest reserves, reservations, national parks, unclassified public forest), with only 48% of the area classified as alienable and disposable. The dominant land covers are annual crops, encompassing 39% of the river basin. This is followed by wooded grasslands (20%), open forests (14%), grasslands (7%), and shrublands (6%). Land cover change analysis from 2003 to 2010 indicated the increasing urbanization of agricultural areas in the ARB and the shifting of farming preference to perennial crops. The area of annual crops decreased by 10%; about 26% of the decrease can be attributed to land conversion to built-up areas and another 26% is converted to perennial crops. Built-up areas increased by 163% during this period, and over 87% of this increase is from the conversion of annual croplands. Likewise, the area of perennial crops increased by almost 590%, with 74% of that increase due to conversion of areas cultivated for annual crops to perennial crops.

Natural Hazards

Majority (76%) of the river basin is highly susceptible to drought. Four of the provinces within the ARB (Pampanga, Pangasinan, Zambales, and Nueva Ecija) are also highly susceptible to droughts. About 23% of the river basin have low drought susceptibility, which includes the provinces of Benguet and Nueva Vizcaya; and only 1% of the river basin is moderately susceptible to droughts (Mountain Province and Ifugao).

Most of the river basin have no present risk for earthquake hazard, which covers most of the central valley in Nueva Ecija, Pangasinan, and Tarlac. Low danger zones are located in the northern midstream in Pangasinan. High danger zones for earthquake hazards are mostly located in the northern and southern headwaters which have higher elevation and steeper slopes. Among the provinces in the high danger zones are Zambales, Benguet, Mountain Province, Ifugao, Nueva Vizcaya, Zambales, and selected upland barangays of Pangasinan and Tarlac.

Flooding is the most common and most destructive natural hazard in the area. About 121,588 hectares of the river basin is highly susceptible to floods and 109,868 hectares have moderate to low susceptibility. Pangasinan is the most susceptible to flooding, having about 61% of the high flood susceptible areas and 47% of low to moderate susceptible areas in the river basin. Tarlac is the second most susceptible with 29% of

high flood hazard and 39% of the total low to moderate hazard areas; followed by Nueva Ecija with 7.6% and 15.1% of high and moderate to low flood prone areas in the basin.

Highly landslide susceptible provinces include Zambales, Benguet, Mountain Province, Ifugao, Nueva Vizcaya, and parts of Tarlac. However, the area is more susceptible to rain-induced rather than earthquake-induced landslides. Overall, there are 47% more areas susceptible to rain-induced landslides compared to earthquake-induced. There are also no highly susceptible areas to earthquake-induced landslides in the area, whereas there are more than 238,000 hectares of land highly susceptible to rain-induced landslides.

Liquefaction susceptible areas occur in the central valley of the river basin near major tributaries underlain by sandy soils. Pangasinan is the most liquefaction prone, covering about 60% of all the liquefaction prone areas; followed by Tarlac with roughly 39% of liquefaction areas; and Nueva Ecija with only about 1%.

There are more than 368,800 hectares in the river basin with perceptible soil erosion. About 45% of this have slight erosion, 41% have moderate, and 24% have severe erosion. Benguet has the largest perceptibly eroding land area (31%) in the river basin followed by Tarlac (27%) and Pangasinan (26%). However, unlike Benguet and Tarlac where only 16% and 13% had severe erosion, 48% of erosion in Pangasinan is classified as severe – more than half of the severely eroding areas in the river basin.

5.2 Demographic Profile

As of the 2015 census, there are about 2.38 million individuals residing in the river basin. Most (77%) of which reside in the provinces Pangasinan and Tarlac. About 20% reside in Benguet and Nueva Ecija. The annual population growth rate has been decreasing since 1990, from 1.85% to 1.4% in 2015. This is much lower than the national average growth rate of 2.3% and 1.9% for the same time periods. The population density for the entire river basin is 2.56 persons per hectare, which is lower than the national population density of 3.08. With increasing population, the population density in the ARB is also expected to increase.

Over the past one and a half decade, the rate of birth in the ARB was found to be decreasing from an average of 27.8 births per thousand population to 25.1 even though the number of live births in the ARB was increasing. Similarly, the crude death rate was decreasing from an average of 7.0 deaths per thousand population per year to 6.0. Thus, from 2000 to 2015, the crude rate of natural increase was decreasing from an average of 20.7 per thousand population per year to 19.1. This coincides and confirms the decreasing growth rate observed during the period. Currently, the total fertility rate is 3.04, which is 13% lower than the 3.5 in 2000. This may imply that current families have begun to prefer lesser children compared to families one and a half decade ago.

As evident by the aforementioned metrics and the relatively high total dependency ratio of 59.1%, the age distribution of the river basin has started to shift from an expansive age structure where the population pyramid had a very wide base tapering to a very narrow peak which is indicative of lower life expectancy and high birth rates, to a more stable age structure where tapering is becoming less evident in the population pyramid.

5.3 Socio-economic Profile

Settlement Pattern

The Agno River Basin is still largely rural. In 2007, only 26.0% of the total population resided in urban areas. However, migration to urban areas within the same province or municipality may have started to take hold in 2010 where 29.4% of the basin population had resided in urban areas. This migration may be due to urban areas generally having better access to government services like health and education.

Indigenous Peoples

There are more than 20 distinct indigenous peoples present throughout the ARB. However, most belong to two general indigenous groups, the Igorot and the Negrito. There are also around 32 Certificate of Ancestral Domain Title (CADT) in the provinces of the ARB.

5.4 Bioecological Profile

Due to its unique biogeographic position, the Agno River Basin is rich in both floristic and faunal diversity. The river basin is part of the Greater Luzon Terrestrial Biogeographic Region and straddles three terrestrial biogeographic sub-regions (i.e. Central Cordillera, Central Luzon Lowlands, and the Zambales-Bataan). It is also bounded by two biodiversity corridors – Cordillera Terrestrial Biodiversity Corridor and the Bataan-Zambales Terrestrial Biodiversity Corridor.

There are more than 500 species of bryophytes, pteridophytes, gymnosperms, and angiosperms have been identified in the Agno River Basin in at least 8 different vegetation types. This includes numerous indigenous species; Northern Asiatic floristic species; and endemic species, some of which are Luzon-restricted, regionally-restricted, or locally-restricted species. Locally, endemism estimates for flora in the river basin typically range and high as 46%. Although faunal assessments in the river basin were not as extensive as flora, at least 150 migratory and resident species of birds, amphibians, reptiles, and mammals were identified in the Agno River Basin. This includes numerous vulnerable species, some of which are site-restricted. Local estimate of faunal endemism rates is as high as 55%.

The biological diversity of the Agno River Basin is also evidenced by the presence of numerous conservation and special interest areas. This includes four Conservation Priority Areas, two National Parks, a Resource Reserve, two Watershed Forest Reserves, a Protected Landscape, two Key Biodiversity Areas and two Important Bird Areas.

The river basin also has numerous wetlands that need to be further studied. This includes 14 inland wetlands and one coastal wetland, which supports the major fishery and aquaculture industries of the region.

Land and House Tenure

In view of household land ownership, agricultural land 64% of the total, of which 3% were acquired through the Comprehensive Agrarian Reform Program. Residential land comprised around 29% of the total. Majority (84%) of the households owns or amortizes their current housing unit. Renter households make up 6% of the total and the rest live rent free in their current housing unit. Around 58% of house owners in the ARB had acquired their home by purchase and 32% inherited their home.

Energy Consumption

Majority (90%) of the communities rely on electricity for lighting. Roughly 8.4% depends on kerosene while the rest (<1%) dependent on other sources such as oil and liquefied petroleum gas (LPG). However, 49% of the households depend on wood and

charcoal for cooking. On the other hand, about 47% of the households indicated LPG as their main source of energy for cooking.

Health

There were 1,369 infant deaths and 406 fetal deaths in the ARB in 2012. The maternal death rate in the ARB is relatively low at 0.5% and Tarlac had the lowest rate among provinces 0.1%. Overall, the provinces of the Agno River Basin have relatively high levels of health service coverage as indicated by the high total number households with access to safe water supply and sanitary toilets. Also, there are about 222,000 immunized children between 9 to 11 months old.

Literacy and Education

The ARB has a relatively high literacy rate of 92.68% (Table 89). Zambales is the most literate, with 95.82% literacy. Mountain province has the least literacy rate (86.34) in the ARB. The ARB also has a high level of education, with more than 90% of the population finishing elementary and 60% finishing high school

Poverty and Subsistence

The poverty rate of the Agno River Basin ranges from 3% in Benguet to 36% in Ifugao; while subsistence incidence ranged from 22% in Ifugao and 1% in Benguet. Increasing poverty incidence was observed in the provinces of Ifugao and Nueva Vizcaya from 2006-2012.

Human Development Index

Human Development Index (HDI) was highest in Benguet (85%) and was lowest in Mt. Province (43%). A generally decreasing HDI trend was observed from 2006-2012 for most of the provinces in the river basin. This, therefore, implies the need for the government to further improve the delivery of basic services in order to improve the quality of life in these areas.

Employment and Labor

The current employment rate in the river basin is relatively high (93%). Among the provinces, the highest mark was observed in Mt. Province with 99.6%, which is closely followed by Nueva Vizcaya with 97.6%. Lowest rate was observed in Tarlac with 87.1%. However, the labor force participation rate is only (67%). Among the provinces, Mt. Province has the highest rate (86%), followed by Ifugao (80%).

Natural Resource Dependent Livelihood

Over the past half-decade, rice production was increasing from 3.22 to 4.03 million tons yr⁻¹ for irrigated rice farms, and 0.45 to 0.58 million tons yr⁻¹ for rainfed rice production areas. Corn production is also increasing, with production rate of yellow corn and white corn at 0.50 million tons yr⁻¹ (in 2010) and 0.68 million tons yr⁻¹. Among the livestock, hog raising is the most popular with 187 kilotons of hog meat produced in 2014. Other major livestock grown within include cattle, carabao and goat, where production was collectively less than 60 kilotons yr⁻¹. Aquaculture is also a major natural resource-based income source of downstream communities. The value of aquaculture production was found increasing from 2010 (PhP25.6 B) to 2014 (PhP 35.4 B). Moreover, the marine and inland fisheries also generated about PhP 2 billion and PhP 1.1 billion worth of income. The ARB provinces collectively produced 5,743 cubic meters of log and 1,310 cubic meters of lumber in 2014. Around 52% of the logs produced in the ARB originate from Tarlac, the largest producer in the river basin. Similarly, Nueva Vizcaya is the largest producer of lumber, producing over 65% of the lumber in the area.

Commercial and Industrial Establishments

Most number of establishments in the river basin is the wholesale and retail trade businesses which comprises 46% of the total establishments, followed by the manufacturing sector (14%). Almost 92% of the establishments in the river basin are microenterprises that employ less than ten employees. Small enterprises make up 8% of the establishments, and medium to large enterprises only comprise less than one percent of the total.

5.5 Infrastructure

Educational Facilities

There are around 2,366 public schools in the river basin that collectively enrolled 897,203 students for the academic year 2014-2015. About 82.3% of these are public elementary schools that enroll around 70.2% of the students in the river basin (Table 94). This is consistent with the demography of the river basin, which indicates a relatively high proportion of the population under the age of 15.

Health Facilities

There are 115 hospitals in the river basin that are licensed by the Department of Health. Majority, or 53.0%, of these hospitals are privately owned, and 30.4% is located in Pangasinan. In total, 63.5% of the hospitals are classified by the DOH as Level 1 service capability hospitals, 33.9% are Level 2 service capability, and three are Level 3 service capability. Furthermore, there are 2,161 Barangay Health Stations and 27,154 Barangay Health Workers in the river basin.

Road and Bridges

There are around 766 km of national roads in the river basin, with around 97% of the roads are paved. Majority (62%) are paved with concrete, 35% have an asphalt surface, and 3% are gravel and earth roads. About 50% of the road network is in good condition, 27% is in fair condition, 12% are in poor condition, 10% are in bad condition, and 3% are yet to be assessed. There are also 168 bridges in the ARB collectively spanning 11,586 meters, around 90% are made of concrete.

Dam and Irrigation

There are 30 completed, one on-going, and 30 proposed dams in the river basin. Of these, 60% are diversion dams, 24% are small water impounding systems, and 16% are water impounding systems. There are also 10 national irrigation systems servicing 25,377 hectares of agricultural lands in the river basin. A national irrigation project is currently being implemented in Tarlac (i.e. Water Resources Development Project-Camiling).

Waste and Sanitation

More than 70% of the ARB households use a water-sealed septic tank. Approximately 60% of the households have individual water-sealed septic tanks, while 11% are using shared water-sealed septic tanks. 20% use other forms of water sealed depository systems. The remaining 10% of the ARB households have non-sanitary and non-water-sealed toilet facilities. Only a third of the households have their wastes picked up by a waste collection system. Majority of residents (45%) still rely on burning to dispose their wastes.

Communications

There are more than 120,000 telephone lines installed in the ARB provinces. However, due to the popularity of mobile telecommunications, there are only about 66,000 telephone subscribers which means only 55% of the installed capacity is utilized. More than 77% of the households in the ARB do not have access to the internet and only 7% have access to the internet at home.

Financial Institutions

There are about 2990 individual financial institutions, consisting of thrift banks (138), rural banks (445), pawnshops (1991), and other banks (416) in the ARB provinces. Pampanga, Pangasinan, and Nueva Ecija have the most number of financial institutions, with 812, 727, and 544 institutions respectively. Ifugao and Mountain Province have the least, with 9 and 10 respectively.

Energy

The rate of electrification of barangays and local communities in the ARB is very high. In fact, almost all of the households have ready access to electricity. The extent of electrical service is almost universal since all ARB barangays are classified as electrified or energized. There are three hydroelectric power plants in the ARB. These are the Ambuklao, Binga, and San Roque hydroelectric plants.

Transportation

There are almost 950,000 motor vehicles registered in the river basin. Most of which are located in Pampanga, Pangasinan, and Nueva Ecija. More than 75% of these motor vehicles are privately owned, 15% are for hire, and about 10% are government vehicles.

5.6 Land Capability Assessment

The Universal Soil Loss Equation is the commonly used formula in determining soil erosion processes. The factors considered in this formula are rainfall erosivity, soil erodibility, slope length, slope gradient, cover and the existing erosion control practice ($SEP = RKLS$). Soil erosion is considered as a good indicator of land capability. Using the USLE, the soil erosion potential was estimated, wherein rainfall, erodibility, slope length and gradient were factored in.

Three rainfall scenarios were under the study of the river basin's Soil Erosion Potential. This enables the evaluation of the impacts of rainfall activities present in the study area. This will essentially lead to land capability classification of the river basin. With the rainfall data from PAGASA, past records as well as the projected were included in coming up with the three rainfall scenarios.

The land capability classification was developed as a more effective and responsive approach towards land use allocation. The major biophysical factors included were rainfall, soil, topography, land cover and hazards. The classification then resulted to two major zones, namely Protection Zones and Production Zones. While there are four subzones under the Production zones (a) Agroforest Production (b) Unlimited Production (c) Limited Production and (d) Production Buffer; Protection zone is composed of two subzones, (a) Strict Protection and (b) Protection Buffer.

5.7 Stakeholder Analysis

There are at least 67 major stakeholders in the Agno River Basin. Of these, around 42% are user groups, 42% are mediating institutions, and 16% are external economic interest groups.

There are six identified general categories of issues or motives that create and cement stakeholder alliances in the river basin. These are resource access; power generation and distribution; water extraction and distribution; agriculture, forestry, and fisheries; economic purposes; natural resource conservation and environmental protection. Sources of conflicts among stakeholders include administrative conflicts, economic conflicts, conflicting resource use, resource access, pollution, and illegal activities. Illegal activities are identified as the most common source of conflict among stakeholders within the watershed.

In terms of importance and influence, 20 stakeholders were rated as important and influential in watershed management. The basin management should try to include these stakeholders in the implementation of river basin interventions to not only increase its chances of success but also increase its impacts. In the other end of the spectrum, about eight stakeholders were classified as less important and less influential in the river basin. This entails that these stakeholders are marginalized in terms of river basin knowledge and participation in river basin management.

5.8 Policy and Institutional Assessment

Many policies encompass the management of the river basin, including the Sustainable Development Goal (2015-2030), Philippine Development Plan (2011-2016), Sustainable National Action Plan (2009-2019), National Climate Change Action Plan (2011-2028), Philippine Strategy for Sustainable Development (1999), etc. These policies have a single goal—to improve the quality of life through poverty alleviation, sustainable development, capacity building, disaster risk reduction, and climate change adaptation.

These frameworks basically evolved from the Water and environment summits and principles such as the Dublin Principle for water scarcity, Earth Summit in 1992, Agenda 21 and the adoption of Integrated Water Resources Management by Global Water Partnership whose main objective is to promote sustainable development of water resources at all levels and sectors. Was further expanded to the Integrated River Basin Development and Management (IRBDM), which is the focus of this project.

Various key government agencies from national and subnational levels play important roles in river basin management and development. The institutional arrangements of these agencies possess differing relationship in terms of mandates and functions. Nevertheless, they have pertinent roles to carry out under the components of river basin management and development framework, namely; water resource management, watershed management, wetland management, flood management and institutional development.

To implement these management strategies and as a solution to further eliminate the issue of fragmentation, lack of coordination, inefficiency, overlaps, there must be a coordinating mechanism that would harmonize the initiatives in the river basin. Also, there should be a coordinating body to facilitate delivery of goods and services by the stakeholders as well as provide mechanisms for conflict resolution among stakeholders.

The lessons learned from Philippine experiences and the assessments from the comparison of cases of river basin management accent the indispensable characteristics of a river basin organization that we must refer and tailor fit to the context of the river basin in focus. The three main points in river basin governance: a) organizational structure of River Basin Organizations, b) decentralization, relation of government units and ownership, and c) financing of River Basin Organizations must be regarded as requirements in their institutionalization.

5.9 Vulnerability Assessment

Flooding

Flooding is considered as the most destructive hazard in the river basin exposing numerous communities to high disaster risk, so it is very necessary to develop plans to prevent and mitigate it. With rainfall expected to increase, river outflow and flooding are also projected to have an increasing trend. As a whole, the effects of climate change based on downscaled A1B climate scenario, flooding for the Agno River Basin 2020 and 2050 climate change scenario for the scenarios, the inundated areas are expected to increase by at least 5,700 hectares in 2020 and at most 16,600 hectares in 2050. Similarly, the flood inundation depths are also projected to increase by at least 0.62 m in 2020 and at most 2m in 2050.

Seismically-induced Landslides

It was assessed that the slopes are stable with regards to sliding. Considering only the weight of the sliding mass, it can be said that the area has a low to medium susceptibility to seismic-induced landslides. Considering both factor of safety and critical accelerations, the southwestern and the northern portion of the river basin is susceptible to seismic-induced landslides. The slopes in the middle are relatively flat in some area, therefore, the factor of safety and critical accelerations in those areas are very large. The Newmark displacements are very small for most of the river basin except for parts of Benguet near the Jan Jose Fault of the Philippine Fault Zone which ranges from 5 to 9 cm. Displacements of 5 cm to 10 cm can cause the ground to crack and can make the shear strength of soil lose and end up in weakened or residual-strength condition. The results of this study can be further verified by conducting geotechnical investigation reports in the river basin.

Rain-induced Landslide

The assessment indicate that the upper reaches of the basin are the most susceptible to mass wasting. This falls mostly in the Ambuklao and Binga areas, primarily due the steep slopes in these upstream zones that gradually opens up to gentler morphologies towards the central parts of basin. The southwestern part of the basin, along the foothills of the eastern Zambales range is characterized by variable susceptibility but mostly in the moderate range. In comparison, when the different factors are given only equal weights, most of the northern region of the ARB is ranked as moderately susceptible to mass wasting, and the southern region as low susceptibility to wasting. High susceptibility areas are those closest to streams and rivers.

Water Supply

The groundwater potential of each sub-basin in the river basin is dependent on its relative surface area, its hydrogeology and the amount of precipitation each receives. Surface water supply is expected to increase from 2,515.36 mm yr⁻¹ [15,638.04 MCM yr⁻¹ (million cubic meter yr⁻¹)] in 2020 to 2,836.49 mm yr⁻¹ (17,634.51 MCM yr⁻¹) in 2050. Groundwater recharge also is expected to increase from 441.50 mm yr⁻¹ (2,744.81 MCM yr⁻¹) to 450.91 mm yr⁻¹ (2,803.32 MCM yr⁻¹) which is 13.62% and 12.62% of annual rainfall, respectively.

Participatory Risk and Vulnerability Assessment

The general risk estimates for the whole river basin was arrived at by assigning a numerical value for the degree of likelihood and consequences (i.e., very low = 1; low = 2; moderate = 3; high = 4; and very high = 5). Using these values, the degree of likelihood and consequences for each risk event was assessed. Results showed that flood poses the

highest risk in Agno River Basin, followed by drought and landslide. Flood was assessed to be an extreme risk event, where immediate actions are required. On the other hand, drought and landslide fall under high-risk events, which calls for high priority control measures.

6 Management and Development Plan

6.1 Vision

Several focus group discussions with stakeholders from multiple government agencies, peoples' organization, academe, regional and local government units were conducted to affirm the previously crafted vision, mission, and goals of the Agno River Basin (ARB). The vision statement for ARB was made in accordance to the context of Integrated River Basin Management Strategy and was revised during the inter-agency focus group discussion. The stakeholders agreed to the following vision statement:

“ The Agno River Basin is envisioned to be a haven for its populace under God's divine guidance radiating in the diversity and industry of its people, each charting one's own and sharing for everyone's well-being towards a pristine, diverse, and disaster resilient environment. ”

6.2 Mission

Similar to the updating of the vision, the mission statement for the Agno River Basin was made in accordance to the context of Integrated River Basin Management Strategy and was revised during the inter-agency focus group discussion. The stakeholders agreed to the following mission statement:

To protect, conserve, sustainably develop, and restore the quality and beneficial uses of water, land, flora and fauna, habitats, and other natural resources for the upliftment of the living conditions of the communities within the Agno River Basin through:

- a. the adoption and integration of appropriate local and global best practices;*
- b. institutionalization of partnership between and among concerned stakeholders;*
- c. ensuring welfare and rights of the people with purposive regard for the indigenous peoples; and*
- d. the practice of participatory, accountability, responsibility and transparency principles.*

6.3 Integrated River Basin Management and Development

Formulated by RBCO in 2007, the Integrated River Basin Management and Development (IRBMD) Framework is the basic system for all strategies in the Philippines for sustainable river basin ecosystem management. **Error! Reference source not found.** Figure 2 shows the four principal frameworks and development strategies: Integrated Water Resources Management, Integrated Watershed Management, Wetland Management, and Flood Mitigation

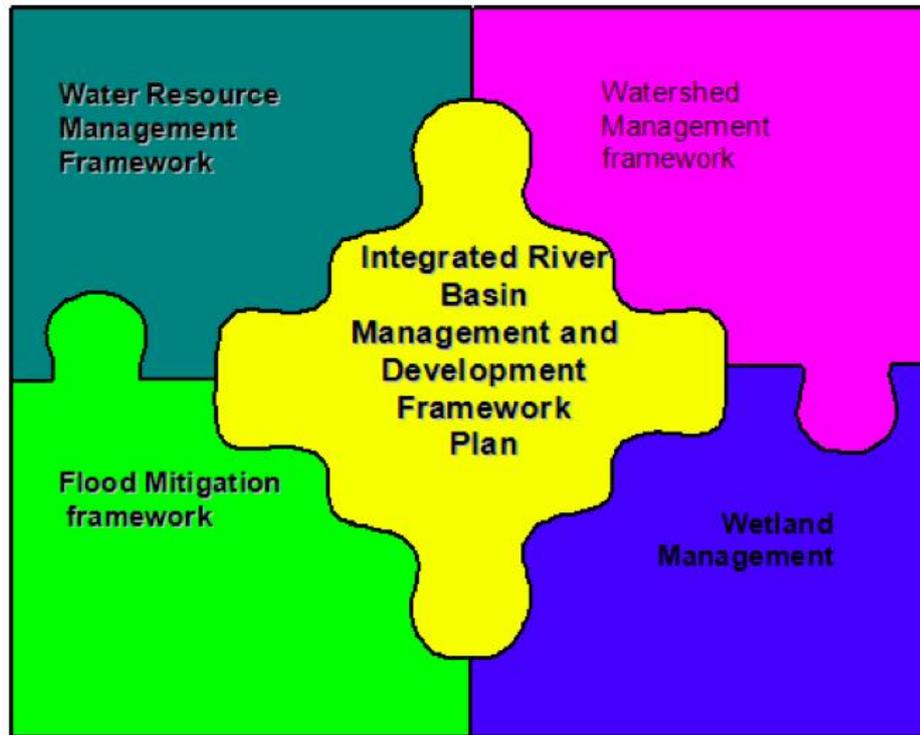


Figure 2. Relationships of Four Major Ecosystems

1. Integrated Water Resources Management – manages fresh water as an economic and public good while recognizing its vulnerability and limited supply.
2. Integrated Watershed Management – organizes land, people, and other resources in the watershed to provide goods and services without harming the soil and water.
3. Wetland Management – manages areas that are submerged or soaked by enough surface or groundwater to support ecosystems such as mangroves, coral reefs, swamps, rice paddies, estuaries, lakes and reservoirs
4. Flood Mitigation – protects and enhances coping capacities of communities and the environment against water-induced hazards

6.4 Development Issues and Challenges

Water Resources

Highly variable water supply is the major issue for water resources in the Agno River Basin. This is due to the disparity between the spatial and temporal distribution of water supply to its actual demand. This results to local shortages in water supply during the dry months, with demand often exceeding supply especially in highly urbanized areas. These shortages are often exacerbated by El Nino-induced droughts and dry spells. The seasonal variation is (between wet season and dry season water supply) is becoming greater, causing floods during the rainy season and droughts during the dry season. This is mainly because of the Type I climate of the region and exacerbated by shorter El Niño Southern Oscillation Cycles, with corresponding increased temperatures, causing decreased rainfall especially if El Nino occurred during the dry season.

Watershed Management

Watershed degradation is the overarching issue that needs to be addressed in watershed management. Unabated, this may lead to the decrease in soil productivity, decrease in ecosystem resilience, the reduction of ecosystem services, and the increased in basin vulnerability to climate variability and extremes. Immediate causes of watershed degradation in the ARB include environmental pollution caused by improper waste management; deforestation caused by unsustainable livelihood practices and mining and quarrying operations; land conversion fueled by inadequate land use zoning; and illegal resource extraction activities like treasure hunting, timber poaching, and agricultural intrusion into protected areas driven by the lax implementation of environmental laws and upland migration due to increasing population and inadequate livelihood opportunities.

Wetland Management

The core problem of wetlands in the Agno River Basin is wetland degradation. Two main drivers (water degradation and land conversion) and one institutional factor (lack of institutional arrangement for wetland management) were identified as the primary causes of wetland degradation. Water degradation is probably the biggest problem for wetlands in the since most local wastes are inadequately disposed or treated. Land conversion is driven by the pressure to use wetlands for more profitable land uses, and indefinite institutional arrangements related to wetland management.

Disaster Risk Reduction and Management

Flooding is the core issue for disaster and risk reduction and management in the ARB. The central valley of the ARB is especially susceptible to floods during the rainy season. This is due to streamflow from the northern and southern headwaters of the river basin converging into the relatively level terrain with the natural floodplains of the Agno River and its tributaries extending across the valley. These flood events often result to negative impacts in the ARB communities. Unmitigated and aggravated by the projected increase in total annual rainfall and rainfall intensity, this may lead to further loss of life, property, and livelihood; damage to infrastructure; and increased incidence of waterborne diseases.

Economic Development

Poverty is the core issue of economic development in the river basin. Sustaining such condition in the long-term may result to increased vulnerability of marginalized sectors in the Agno River Basin to climate change. This is caused primarily by insufficient infrastructure to support economic growth, low agricultural income, low fishery income, increasing climate risks, limited employment and livelihood opportunities, limited access to public goods and services, and heavy reliance on natural resource-dependent economic activities.

6.5 Implementation Plan

The implementation plan recommends relevant programs and projects for the Agno River Basin. These are crafted based on the issues and problems that are currently faced by the river basin and congruent to the vision, mission, and goals. The suggested programs and projects aim to make the river basin climate-resilient. Six thematic areas are taken into consideration, the water resources management, the watershed management, wetland management, economic development, disaster risk reduction management and institutional development. There are also projects that cut across the different thematic areas.

Table 1. Different projects identified for each thematic area

Goal	Objective	Strategy	Program/Project
Water Resources Management			
Well-managed water resources	Sustain water sources for water demand	Improve water supply of the river basin	Water Supply Development Program Water Source Development Project Water Distribution Project Strategic Irrigation Development Project Groundwater Conservation and Protection
	Improve water quality in the river basin	Proper Waste Management	Ecological Waste Management Program Water Quality Monitoring System Development of Local Government ESWM Plan Construction of MRFs and SLFs Waste-to-Energy Project Development of Wastewater Treatment Facilities
Watershed Management			
Well-conserved, protected and managed Basin and its natural resources not only to sustain the needs of the growing population, but also to prevent further basin degradation and hazards	Restore the river basin's denuded areas Improve habitat and biodiversity	Watershed Restoration	Watershed Conservation Program Forest Landscape Program Conservation Forest Villages Project River Basin Protection and Conservation Project Comprehensive Natural Resources Assessment and Monitoring Project
Wetland Management			
Well-managed inland wetland	Conserve inland and coastal	Wetland rehabilitation and	Wetland Enhancement Program

Goal	Objective	Strategy	Program/Project
and coastal ecosystems to sustain aquatic resources	wetland resources Protect aquatic and wetland associated species and habitat	conservation	Riparian Area Management and Restoration Project Integrated Coastal Zone Management Project Wetland Resources Assessment, Mapping, and Monitoring Project
Disaster Risk Reduction and Management			
Improved resiliency and adaptive capacities of communities against natural and anthropogenic disasters, and impacts of climate change.	Enhance coping capacities of communities against climate-induced disasters Reduce impacts and risks of hazards on basin communities Provide dependable hazard mitigation infrastructures Reduce soil erosion and sedimentation	Enhance the resiliency of basin communities to adverse climate impacts	Disaster Risk Management Program Hazards Forecasting and Warning Systems Project Local Disaster Preparedness Project Disaster-Prone Communities Relocation Project
		Mitigate disaster risk in disaster prone areas	Climate-Adaptive Hazard Mitigation Infrastructure Program Flood Control Project Slope Stabilization Project Sediment Control Project
Economic Development			
A sustainable, climate-resilient, and inclusive economy with ample opportunities for livelihood and entrepreneurship	Develop the river basin's potential for trade and commerce Foster sustainable and climate-resilient economic growth and development Ensure reliable, efficient, and equitable provision of infrastructure	Increase livelihood opportunities and access to public services	Inclusive Development Support Program Industry and Enterprise Development Project Cooperative Development for Natural Resource-Based Enterprises Project Livelihood Development for Minority and Marginalized Sectors Ancestral Domain Enhancement Project
		Promote climate-resilient livelihood	Sustainable Climate-Resilient Livelihood

Goal	Objective	Strategy	Program/Project
	services Reduce poverty	program	Program Climate-Smart Agriculture Project Sustainable Fisheries Project Community-based Ecotourism Development Project Payment for Ecosystem Services System
		Stimulate and optimize integrated infrastructure development	Infrastructure Development Program Construction, Retrofitting, and Rehabilitation of Key Facilities and Transportation Systems Renewable Energy Project
Institutional Development			
Strengthened river basin governance mechanism devoted to the upliftment of the quality of life of its people, enhancement of its ecological/environment integrity and able to provide, regulate, ensure cultural and support services.	Promote Integrative Planning and Development in the ARB Ensure science-and-evidenced based management of the ARB Heighten the participation of stakeholders in river basin management	Integration of Plans and Policies in the ARB	Legislative Policy and Institutionalization Program Creation and Institutionalization of the ARBMC and ARBMO Development and Harmonization of Environmental Policies and Land Use Plans
		Improve information management in the ARB	Watershed Information Program Research and Development Project Real-Time Watershed Monitoring Project Integrated Management Information and Decision Support System
		Empower ARB Stakeholders in Watershed	Participatory Development Program

Goal	Objective	Strategy	Program/Project
		Management	Social Mobilization and Development Project Gender Equity and Social Inclusion Project Agno River Basin Master Plan Caravan/Roadshow Project Feasibility Assessment of the Agno River Basin Master Plan

6.6 Investment Plan

The investment plan indicates the budgetary requirements of the various programs and projects that were developed under the climate-responsive Integrated Master Plan for the Agno River Basin. To pursue the objectives set forth in the Master Plan, five (5) component programs were developed: Water Resources, Watershed Management, Wetland Management, Disaster Risk Reduction and Management, Economic Development. In addition to these five programs are 10 other projects that are considered crosscutting in nature as they address concerns of more than one program.

The total investment requirement of the Plan over a 15-year period is PHP52.811 billion, as shown in Table 1. The economic management programs and projects has the highest funding requirement among the six themes at PHP18.117 billion (34.3% of the total), followed by Watershed management (27.4%), Disaster Risk Reduction and Management (21.5%), Water Resources (15.7%), Institutional Development (0.65%) and Wetland Management (0.4%). Table 2 shows the total cost of each project for the Agno River Basin.

Table 2. Total cost of projects proposed for the Agno River Basin

Program/Project	Total
<u>WATER RESOURCES</u>	-
<i>Water Supply Development Program</i>	
Water Source Development Project	1,650,000,000
Water Distribution Project	1,500,000,000
Strategic Irrigation Development for the Agno River Basin	3,656,000,000
Groundwater Management and Protection for the Agno River Basin	15,000,000
<i>Subtotal</i>	<i>6,821,000,000</i>
<i>Ecological Waste Management Program</i>	
Water Quality Monitoring System	40,000,000
Development of Local Government Ecological Solid Waste Management Plan	102,000,000
Construction of Material Recovery (MRF) and Sanitary Landfill Facilities (SLF)	490,000,000
Establishment of Wastewater Treatment Facilities	160,000,000
Waste-to-Energy Project	700,000,000
<i>Subtotal</i>	<i>1,492,000,000</i>

Program/Project	Total
<u>WATERSHED MANAGEMENT</u>	-
<i>Watershed Conservation Program</i>	
Forest Landscape Restoration Project	13,463,800,000
Conservation Forest Villages Project	919,570,000
Comprehensive Natural Resources Assessment and Monitoring	30,000,000
River Basin Protection and Conservation Project	50,000,000
<i>Subtotal</i>	<i>14,463,370,000</i>
<u>WETLAND MANAGEMENT</u>	-
<i>Wetland Enhancement Program</i>	
Riparian Area Management and Restoration Project	105,000,000
Integrated Coastal Zone Management Project	84,000,000
Wetland Resources Assessment, Mapping, and Monitoring Project	20,000,000
<i>Subtotal</i>	<i>209,000,000</i>
<u>DISASTER RISK REDUCTION AND MANAGEMENT</u>	-
<i>Disaster Risk Management Program</i>	
Hazards Forecasting and Warning Systems Project	40,000,000
Local Disaster Preparedness Project	365,000,000
Disaster-Prone Communities Relocation Project	1,260,000,000
<i>Subtotal</i>	<i>1,665,000,000</i>
<i>Climate-Adaptive Hazard Mitigation Infrastructure Program</i>	
Flood Control Project	6,600,000,000
Slope Stabilization Project	550,000,000
Sediment Control Project	2,550,000,000
<i>Subtotal</i>	<i>9,700,000,000</i>
<u>ECONOMIC DEVELOPMENT</u>	-
<i>Inclusive Development Support Program</i>	
Industry and Enterprise Development Project	250,000,000
Cooperative Development among NR-based Enterprises	20,000,000
Livelihood Development for Minority and Marginalized Sectors	10,000,000
Ancestral Domain Enhancement Project	32,000,000
<i>Subtotal</i>	<i>312,000,000</i>
<i>Sustainable Climate-Resilient Livelihood Program</i>	
Climate-Resilient Agriculture Project	10,000,000
Sustainable Fisheries Project	10,000,000
Community-Based Ecotourism Development Project	100,000,000
Payment for Ecosystem Services System	20,000,000
<i>Subtotal</i>	<i>140,000,000</i>
<i>Infrastructure Development Program</i>	
Construction, Retrofitting, and Rehabilitation of Key Facilities and Transportation Systems	17,200,000,000
Renewable Energy Project	465,000,000
<i>Subtotal</i>	<i>17,665,000,000</i>
<u>INSTITUTIONAL DEVELOPMENT</u>	-

Program/Project	Total
<i>Legislative Policy and Institutionalization Program</i>	
Creation and Institutionalization of the ARBC and the ARBMO	40,000,000
Development and Harmonization of Environmental Policies and Land Use Plans	14,000,000
<i>Subtotal</i>	<i>54,000,000</i>
<i>Watershed Information Program</i>	
Research and Development Project	45,000,000
Real-time Watershed Monitoring System	110,000,000
Integrated Management Information and Decision Support System	50,000,000
<i>Subtotal</i>	<i>205,000,000</i>
<i>Participatory Development Program</i>	
Social Mobilization and Development Project	40,000,000
Gender Equity and Social Inclusion Project	8,500,000
Agno River Master Plan Caravan/Roadshow Project	12,000,000
<i>Subtotal</i>	<i>60,500,000</i>
<i>Pre-implementation Project</i>	
Feasibility Assessment of the Agno River Basin Master Plan	25,000,000
<i>Subtotal</i>	<i>25,000,000</i>
GRAND TOTAL	52,811,870,000