INTERSESSIONAL PANEL OF THE UNITED NATIONS COMMISSION ON SCIENCE AND TECHNOLOGY FOR DEVELOPMENT (CSTD)

Geneva, Switzerland
25-26 October 2022

Contribution by Philippines

to the CSTD 2022-2023 priority theme on "Ensuring safe water and sanitation for all: a solution by science, technology and innovation"

Inputs from the Department of Science and Technology | Philippines

PRIORITY THEME 2: Ensuring safe water and sanitation for all: a solution by science, technology and innovation

1. What are the concrete challenges that your country has encountered in managing water and sanitation and providing access for all to these services?

   In the Philippines, 14.5% or a total of 22.7 million families have no access to safe water supply based on the Philippine Development Plan (2017-2022). Around 332 municipalities, mostly located in the nation's poorest provinces and urban poor spaces, are still considered waterless. Despite being surrounded by ocean, source of potable water in different regions of the Philippines, especially in small islands or in geographically isolated and disadvantaged areas (GIDA) is a major concern.

   There are several sources (commonly deep wells, streams and wells) which are contaminated and are unsafe for human consumption. There are 79,934 or 36% households who have no access to safe water out of the 221,325 poor households based on government statistics. Residents from geographically isolated and disadvantaged areas travel by boat for an hour to fetch water in neighboring communities. There are people who travel long distances (more than ten kilometers) using motorcycles or tricycles to fetch water. Some walk distances just to collect water for their daily needs. There are also places in Metro Manila experiencing shortages, hence the need for water resources management studies to supply the increasing demand for water.

   Multiple decision-makers at the national, watershed and local levels constrain the planning and decision-making of the water resource. Another challenge in terms of planning programs in managing water and sanitation is the availability of sufficient relevant data/information to conduct a more comprehensive water resource assessment.

   Specifically, in the agriculture, aquatic, and natural resources sector, the following challenges are needed to be addressed:
   a) Continued degradation of water resources reduces the quality and capacity to provide environmental services, such as water for irrigation, thereby threatening food security
   b) Inadequate and inefficient water impounding/harvesting strategies resulting in significant water supply shortage in various locations
   c) Poor and inefficient distribution system resulting in irrigation water shortage in various locations
   d) Poor management of and adaptation to natural phenomena (ENSO) manifesting into an ironic state of acute scarcity amid abundance

   Through assessments, it was also found that research efforts on resources are fragmented and data for the water status from upstream to downstream like, BOD, DO, sediments for heavy metals are not readily accessible to the public except for monthly data gathering and monitoring done by Laguna Lake Development Authority (LLDA) for Laguna Lake. Requirements for treatment and standards from regulating agencies also need to be harmonized, compartmentalized, and have focus on strategies.

Focusing on some of the major water resources of the country:

For Laguna Lake: there are three (3) concrete challenges faced by Laguna Lake Development Authority (LLDA) within the Laguna de Bay Basin: (i) environment and health risks that are posed to the citizens living in the basin particularly that segment of the population that are highly vulnerable to poor environmental quality; (ii) institutional capacity challenges in balancing the wide range of demanding interests and the water supplying capacities; and (iii) lack of mechanisms and capacities for development of environmental and water-related infrastructure that are imperatives for sustainable water resources development.

For Manila Bay: In 2019, the Environment and Natural Resources Secretary officially declared the start of the Manila Rehabilitation at the Baywalk in Manila. This is due to the deteriorating state of the bay caused by the following but is not limited to the following:

Manila Bay is among the most important bodies of water in the Philippines in terms of economic and environmental significance. Strategically situated adjacent to the center of urban activity Metro Manila, Manila Bay is the focal point of national development efforts for its vast potential for multi-purpose use. The Bay provides a variety of environmental goods and services to the surrounding communities that extend to other stakeholders inside and outside the basin.

Considered one of the finest harbors in the world, Manila Bay facilitates the country's international trade and commerce, and offers numerous livelihood opportunities to millions which include fisheries, aquaculture, agriculture, business, manufacturing, mining and quarrying among others. It is home to a rich biodiversity and a wealth of biological resource. Mismanagement and overexploitation due to urbanization and population growth however have taken toll on their ecological integrity and economic value. Incidences of hypoxia and anoxia, harmful algal blooms and associated fish kills have become regular occurrences. The country's fish industry is in jeopardy with alarming rates of decline in production. These problems may be due to the following with other factors involved:
1. Only 15% (2.4M/16.3M) of the water-served population in the NCR are connected to a sewerage system and about 3.84% (187,000/4,863,938) of water served population outside the NCR are provided with sanitation services;
2. Almost 233,000 informal settler families (ISFs) are residing along the waterways of the Manila Bay area, directly discharging their wastes to the water;
3. Only about 76% (135/178) of LGUs have approved 10-Year Solid Waste Management Plans

2. What projects/policies has your country implemented to use the above-mentioned range of technologies and innovations or other STI, including frontier technologies (e.g., AI and drones) to address these challenges? What are the main outcomes? What are the main difficulties confronted while trying to implement these projects/policies? Pls. include the gender dimension.

The **Harmonized National R&D Agenda (HNRDA) of the DOST** highlighted the research priorities for Environmental Pollution Control and Management on water and wastewater management including but not limited to the following, whereas the SDG 2030 will be focusing on SDG 6 - Clean Water and Sanitation:
   a. Cleaner and safer technologies for application to industrial wastewater/wastewater remediation, removal of heavy metals, nitrates and phosphates

b. Safe and potable drinking water
c. New wastewater purification technologies (Forward Osmosis and Capacitive Deionization)
d. Field-testing/application of cleaner technologies for the benefit of the industry, domestic households and general public
e. Storm water and storage and rainwater technologies
f. Alternative materials and processes that will reduce or eliminate hazardous substances in the environment and manufacturing sites
g. Reuse of wastewater purification technologies and wastewater treatment/rehabilitation technologies
h. Treatment, control, and monitoring sensors and systems

These priority research agenda fall under the program entitled "Support to Water Environment R&D Program" with the objective of developing a national research and development program on the following: prevention and control of water pollution; development of compact wastewater treatment technologies; and provision of potable water for water security. This is in collaboration with the National Government Agencies (NGAs), academe, private sector, non-government organization and other stakeholders. Two (2) sub-programs were prioritized i.e. (1) Programs for Water Security and Sufficiency and (2) Program for Wastewater Treatment and Management.

Under the Sustainable Development Goals (SDGs) specifically on SDG6. Clean Water and Sanitation), the Department's projects are also focused on the development of **technologies for treating wastewater** e.g. ballast water and emerging pollutants and provide access to potable water.

In 2004, the **Philippine Clean Water Act or RA 9274** was enacted to protect the country's water resources, abate pollution from land-based sources, and improve water quality through the formulation of better water quality management. Under the law's section 24. "Pollution Research Development Programs, in coordination with the DOST and other concerned agencies and academic research institutions shall establish a National Research and Development Program for the prevention and control of water pollution." As part of the said program, DOST shall conduct and promote the coordination and acceleration of research, investigation, experiments, training, surveys and studies relating to the causes, extent, prevention and control of pollution among concerned government agencies and research institutions.

Most of the programs and projects funded were specifically addressing environment and pollution control i.e. providing access to potable water; developing cleaner, safer and compact technologies for application to industrial wastewater, materials that detoxify harmful substances in water, wastewater remediation and the like. On water technologies, most of the studies included earth clay materials for the development of ceramic water filters at different scales and designs. The University of Northern Philippines (UNP) and the Baluyut Pottery were also distributors/producers of ceramic water filters. In addition, low-cost modular-type rainwater collection system was also developed by ITDI in collaboration with Manly Plastics, Inc. to help. Fifty-four units (54) of rainwater collection systems were deployed in different barangays as beneficiaries of the project. Some issues and concerns were on sustainability, product quality and resource verification/characterization of clays in other parts of the region and water resource management.

On wastewater treatment, some of the programs and projects were focused on the development of technologies in treating industrial and domestic wastewater using different processes: biological, physico-chemical, advanced treatment using membrane technologies, and advanced oxidation process.

More specifically, the projects being implemented and/or supported by DOST are:

- The DOST-Advanced Science and Technology Institute (DOST-ASTI) partnered with Laguna Lake Development Authority (LLDA) for a research endeavour for the monitoring of Laguna de Bay watershed and its basin. The joint project is coined as the **AI4LaWA Project or Artificial Intelligence for Land and Water Applications in Laguna de Bay** (Context: "lawa" is the Filipino word for "lakes"). Both agencies have entered into an agreement to address the watershed monitoring of LLDA using earth observation data and AI.

- DOST-ASTI through the Remote Sensing and Data Science (**DATOS**) Project developed a GIS-plugin to train and implement AI models in extracting features from satellite imagery. The technology uses the agency's High-Performance Computing which can be used by public users from academic institutions as well as government agencies.

    Since the DOST-ASTI also distributes commercial satellite imageries of various resolutions, it is imperative to develop a robust way to process these datasets. Manually processing these kinds of images require highly technical and specialized skills and software. To eliminate the technical barrier and computing barrier, pre-processing algorithms are embedded into the GIS plugin. This enables any GIS practitioner to access AI technologies and apply them into their mandates.

    Building on the partnerships that DOST-ASTI is currently forging and has already forged with Laguna Lake Development Authority as well as Libmanan Water District, the DOST-ASTI's target is to gather knowledge, capacitate more resource managers and planners from appropriate agencies by providing the necessary support and technology for them to be able to continue improving their operations using space assets and advanced image processing techniques. However, the intermittent – if not unavailability of – internet connectivity as well as ample computing facility of its partner agencies sometimes delay the process of coming up with relevant information and datasets to address and sustain the research endeavour. Hence, the DOST-ASTI offered its available science and technology infrastructure and datasets to enable the operationalization of this research and development project.

- The **Manila Bay Rehabilitation** was launched last January 27, 2019 which was participated by various agencies. After that, a series of meetings with Mandamus agencies and other concerned agencies were conducted to come up with a holistic approach/strategies for the clean-up, rehabilitation and sustainment of Manila Bay area. In response to the need of technological interventions concerning this issue, the PCIEERD initiated the plan of action as tasked by the Department to handle the issue. The Council, in collaboration with the academe/researchers and experts sit together to come up with a doable action plan and was able to conceptualize the program **"IM4ManilaBay"**. The Manila Bay Rehabilitation Program requires a comprehensive assessment not only of the bay itself but all connected systems including watersheds, tributaries including Pasig River and Laguna Lake. As one impacts another in this interconnected system, any changes or development in one component must be evaluated and impacts "simulated" prior to approval and implementation. It can be said

that environmental degradation in partly because of implementation of "developments" without first fully assessing their potential impacts in an integrated manner. IM4ManilaBay Program envisions the institutionalization and operationalization of a multi-scale integrated system for mapping, monitoring, modelling, and managing the Manila Bay, Pasig River, Laguna de Bay, and all watersheds and tributaries. IM4ManilaBay **utilized citizen science** (**including volunteered geographic information**), **space technologies** (**e.g., satellites, drones, GIS**), numerical models, and decision support system in continuously assessing the environment; providing early warning for possible environmental degradation; and evaluating proposed courses of actions

- The DOST National Capital Region office transferred the **DOST-developed the Upgraded Emergency Water Disinfection System (UPEDS)** to a community in Metro Manila where the local water line is still inaccessible. UPEDS is a semi-continuous type, portable, and ready-to-use water treatment facility that can treat 170 liters of surface water per tank/cycle. The system was developed with the goal of addressing the shortage of potable drinking water within communities, especially in times of disaster.

- The DOST's Collaborative Research and Development to Leverage Philippine Economy (CRADLE) Program has funded a project led by researchers from the Asian Institute of Management (AIM). They are harnessing the power of artificial intelligence (AI) and machine learning to help curb water shortages in the east service area of Metro Manila. The research team developed simulation modelling software to enhance Manila Water Company's (MWC) capability in forecasting the water supply system of Angat-Ipo-La Mesa Dams and its treatment plants and storage reservoir. Their modeling software can also forecast the water supply of other dams in the Philippines, providing more opportunities for other agencies to benefit from this tool.

- The 2017 Philippine National Standards for Drinking Water (PNSDW) guides DOST-Industrial Technology Development Institute (DOST-ITDI) in identifying its research and development activities. The DOST-ITDI has developed a **water treatment system** that may be adopted for existing conditions, especially for disadvantaged communities. Soon for deployment is the upgraded emergency disinfection system to communities affected by volcanic eruptions, settlements of indigenous people, and poor urban communities. The system developer recommends declaring such technology as a public good to support this endeavor further. At the moment, though, the gender dimension has not yet been fully considered, and a gender and development scoring mechanism is available at DOST to measure such an extent. In addition, the ITDI-Materials Science Division (MSD) spearheaded projects on the development of **ceramic water filters with anti-microbial nanocoating for households, the development of household and community-based filters for metals in water, and the development of a portable filtration membrane module for remote areas ("Mabuhay Straw").**

- The DOST-PCIEERD funded a project of Adamson University (private university) on efficient sanitation management to address the vulnerability and risks caused by sanitation problems, particularly in temporary shelters. They developed an **Eco-Friendly Septic System (Eco-Sep),** a self-sustaining and portable/movable wastewater treatment system that uses an innovative combination of bio-stimulation and filtration. It is a low-cost and deployable method for immediate installation of domestic wastewater clean-up in disaster-affected areas anywhere in the country.

Being enhanced with organominerals makes the Eco-Sep appropriate in disaster-stricken areas. The project deployed and field-tested three Eco-Sep Systems for 522 residents in temporary shelters in Palo, Leyte, with 61 latrines and 30 bathing cubicles.

- The DOST, through its Councils, has supported almost a hundred of implementation of projects, establishment of **Niche Centers in the Regions through R&D** projects or NICER and academic-industry partnerships under the Science for Change Program. DOST has deployed technologies that address water concerns in areas with high socio-economic importance. Some of the water technologies deployed and/or supported by DOST in water R&D are the Enhanced Forecasting Model for Complex Water Supply Systems, Mountain Engineering R&D Center, Philippine Groundwater Outlook, Post-Treatment of Food Processing Wastewater Effluent for Nutrient Removal, Evapotranspiration-based Irrigation Scheduler and Calculator (ETCal), Water Advisory for Irrigation Scheduling System (WAISS), Philippine Groundwater Health Index for Agricultural Area, and Enhanced Forecasting Model for Complex Water Supply Systems.

- The DOST Region IVB has implemented a total of 15 projects which provided units of **water pumping system with treatment facility, water pumping systems, water purification systems, rainwater collector with filtration systems, water filtration systems and water desalination technology**. To ensure that these technologies are optimized to provide the best water service while saving utility costs, the agency equipped the water technologies with solar power systems. These STI water technologies have benefitted 2,081 households or at least 10,400 persons from diverse sectors such as women and the indigenous peoples. The communities were also able to save a total of around 500,000 pesos (US$ 9,800) of water and transportation costs per month which they can use for other important things such as food. There was also a decrease in the incidence of water-borne diseases, especially among children. The residents do not need to travel long distances as the technologies were installed in facilities closer to their homes. These interventions promoted inclusivity especially among members of the indigenous peoples, one of the marginalized sectors in the Philippine setting, as these STI initiatives paved the way to provide them access to water and live normally as part of the rest of the society.

3. Can your country provide examples of policies/projects/initiatives aimed at strengthening national STI capabilities in managing water and sanitation for ensuring their access by all population in your country? One example is what institutional and regulatory arrangements are in place to stimulate R & D and innovation in managing water and sanitation for access by all.

The country has developed the **Philippine Water Supply and Sanitation Master Plan** to serve as the national action plan to achieve universal access to safe, sufficient, affordable and sustainable water supply, hygiene, and sanitation. The plan includes activities, responsible agencies, and budget necessary to support the water supply and sanitation sector in addressing the needs of the country. In May 2022, led by the National Economic Development Authority in partnership with the World Bank and different Regional Development Councils (RDCs) across the country came up with the Philippine Water Supply and Sanitation Master Plan. For MIMAROPA Region, in June 2022, a resolution on "Adopting The Philippine Water Supply and Sanitation Master Plan, and The Databook and Roadmap for the MIMAROPA Region (Region IVB) was passed.

The updated **S&T Water Environment Roadmap** which set the direction of the water sector was aligned with the different national programs such as the DOST's Harmonized

National Research and Development Agenda (HNRDA 2017-2022) and the Philippine Development Plan (PDP) to complement the SDG 2030 Agenda. Participatory approach was used in the conduct of roadmapping activities of the S&T Water Environment Roadmap through a series of stakeholders' meeting. The DOST-PCIEERD, in consultation with the different agency institutions which mandates are related to this water sector, service provisions, regulatory functions, and experts / researchers, was able to lay down the needs/gaps to be addressed in terms of technological interventions and priority programs and plans of actions. The vision of the roadmap which covered the year 2018-2022, "Sustained ecological functions & services of water ecosystems", was adopted from the previous Roadmap. The missions formulated were as follow: 1) to provide S & T support for the enforcement of guidelines and standards under Philippine environmental laws; 2) to strengthen the R & D of cost-effective waste management, treatment options and cleaner production options to reduce water pollution of various industries; 3) to build capacity for good environmental governance. The composition of the Technical Panel and Review Committee (TPRC) that drafted the S&T Water Environment Roadmap (now called Technical Working Group) was also reviewed to include other representatives from the private sector e.g., Maynilad, Manila Water, and Philippine Chamber of Commerce and Industry. The group also requested to invite other participants to provide additional inputs. Resource persons were also invited in some of the meetings. Key stakeholders from the following agencies were also included as part of the TWG were industry partners, academe, and the government.

On R&D, there are initiatives on water resources management which are listed in an article published by the DOST last August 2, 2021 titled "DOST Makes R&D Programs on Sustainable Water Resources a Major Priority". Said article can be accessed here: https://www.dost.gov.ph/knowledge-resources/news/72-2021-news/2373-dost-makes-r-d-programs-on-sustainable-water-resources-a-major-priority.html.

More specific to the DOST's efforts in advanced science and technology, the DOST-ASTI has long been providing support to government agencies by enhancing their operational capabilities through advanced science and technology. For mapping applications and resource management in the Philippine setting, **localized training data** is of importance as the ability to retain the **geographic information** after the datasets goes into different layers of the neural network is vital for this method to work. The agency proliferates this effort and the technologies that come with it through signing of Memoranda of Agreement with partner agencies. Most of DOST-ASTI's methods and efforts are based on developments in **information communications technology and computing**. These infrastructures that DOST-ASTI already has in place offer huge computing and storage capacities that can shoulder the surge of earth observation data through the emergence of cloud computing and High-Performance Computing from different providers.

As such, below are some efforts, initiatives, and methods that the DOST-ASTI employs:
- Gathering of historical maps to be used as training data. These maps may be available from the archive of partner agencies or past and current DOST-funded projects.
- Training of Artificial Intelligence model for land cover, individual trees that are not allowed in watersheds, and fish pens. This will substantially help the team verify the emergence of forest clearance.
- Flood extent mapping on downstream areas.
- Development of GIS-based interface for temporal processing and change estimation and visualization. This will help forest and water managers and planners to maximize the wide range of multisectoral forest and watershed benefits without detriment to water resources and ecosystem function.

For laws and policies, the Philippines has the following implemented:
- Presidential Decree No. 1067 - Water Code of the Philippines
- Republic Act No. 9275 - Philippine Clean Water Act of 2004
- Presidential Decree No. 856 - Code on Sanitation of the Philippines
- The Clean Water Act or RA 9274
- Philippine Biodiversity Strategy and Action Plan 2015-2028
- Philippine Water Supply and Sanitation Master Plan (2019-2030), prepared by NEDA

4. Could you share case studies of regional and international cooperation that have helped your country in strengthening STI capacities? Can you provide success stories in this regard?

In strengthening STI capacities, the DOST provides opportunities for funding R&D, capacity building activities through regional Consortia management, human resource development scholarship programs for building formal education, as well as outright transfer of technologies for human resource development.

The Integrated Water Resources Management (IWRM) conducted a workshop on Best Practices, Norms, and their Implementation within the APEC Region. In the said workshop, different best practices were presented by the different participating countries. For the Philippines, two (2) case studies were presented from NWRB and BSWM:

- Comprehensive Water Resources Assessment for Major River Basins as a science-based decision support tool for planning and policy formulation - This case illustrates the processes and results of the conduct of water resources assessment for major river basins in the Philippines.
- Enhancing multi-functionality of agriculture through rainwater harvesting system - This case study looks into the multifunctionality of rainwater harvesting systems particularly small water impounding projects (SWIPs) located in the barangays of Maasin and Buted, Nueva Ecija, in recharging the groundwater through collected surface runoff, rainfall, and mitigating soil erosion through trapped sediments while providing irrigation water in the downstream rice paddy service areas. Furthermore, the study showed that rainfall-runoff analysis within the sub-watershed is essential in the rainwater harvesting planning and management and paves the way to improve current methodologies for rainwater harvesting scheme development.

The DOST-PCIEERD has partnered with the UKRI-Natural Environment Research Council (NERC) of the United Kingdom of Great Britain and Northern Ireland for the implementation of PH-UK Newton Agham Joint S&T Cooperation Program on Understanding the Impacts of Hydrometeorological Hazards in the Philippines. One of the projects under this is the development of Philippine Groundwater Outlook which aims to determine and quantify the susceptibility of groundwater to future hydrometeorological and urbanization extremes, improve predictions of risk and to quantify pathways for cascading impacts. The project involves real-time observational data and modelling.

The DOST, through DOST PCIEERD and Technology Application and Promotion Institute, in collaboration with the Philippine Trade and Investment Center in Dubai, as part of the business program of the Philippine participation in Expo 2020 Dubai, organized an Online Science and Technology Business Forum and Business Matching Event held via Zoom, where innovations of Filipino tech start-ups and businesses on Artificial Intelligence, Smart Energy Management, Water Management, Smart City and Textiles were showcased to investors in the MEA region. The AI for Water Management technology was one of the technologies presented.

Lastly, with the great impact of these water technologies such as water desalination, it was replicated in other areas in the country, especially in Region IVB. These water-related technologies are successfully institutionalized and replicated with the proper coordination and strong support of relevant partners/stakeholders. A case in point, the Provincial Government of Marinduque already signified interest in pursuing another water desalination project. Several Local Government Units are also collaborating with the DOST, through its MIMAROPA Regional Office for water desalination projects and solar-powered water filtration systems.

Other DOST regional offices also did benchmarking to provide water-related interventions in their respective communities.

Contact details:

- DOST Office of the Secretary – osec@dost.gov.ph
- Dr. Leah J. Buendia, DOST Assistant Secretary for International Cooperation – leahbuendia@yahoo.com; oasec.ic@dost.gov.ph

DOST Inputs to CSTD26 Priority Theme 2: Ensuring safe water and sanitation for all: a solution by science, technology and innovation

Annex 1. Some of the projects funded and/or supported by DOST-PCAARRD on water resources management (agriculture, aquatic, and natural resources sector)

Program/Project Title	Brief Description	Outcomes	Impacts
Smart Water Management Strategies for Sugarcane	Water deficit is one of the major limiting factors for the production of sugarcane. This challenge has been addressed by the completed project which aimed to increase sugarcane yield by 30% through the use of smart irrigation technologies. The project was able to improve sugarcane production efficiency through the optimum irrigation scheduling schemes using soil moisture sensors and weather monitoring systems and the use of subsurface drip irrigation (SDI) and furrow irrigation (FI) methods	- Increased yield of sugarcane by more than 30% with the use of furrow irrigation and subsurface drip irrigation (SDI). - Water savings of 61.78 % from the use of SDI over that of FI. - A water productivity of 63.27 kg/m3 and 28.99 kg/m3 for the plant crop was calculated for SDI and FI, respectively. - The projected bags (50-kilogram/bag) of sugar produce per hectare was 338 bags in FI and 295 bags in SDI plots. These are significantly higher than the farmers' practice of total dependence on rainfall for irrigation. The farmers' practice	Increased yield means more profit for sugarcane planters

Program/Project Title	Brief Description	Outcomes	Impacts
		yielded an average of only 75 tons cane per hectare (tc/ha) and 130 bags/ha of sugar. - In sugarcane areas where water is limited to allow expansion of production area, SDI is recommended. Varieties with longer ratoon life may justify the use of drip irrigation. With the use of moisture sensors, furrow irrigation was able to minimize the excessive application of water. Furrow irrigation remains the most attractive option when water charges are low.	
S&T Based Soil, Nutrient and Water Management for Coffee in the Philippines	The project aimed to develop science-based water management practices and formulate/update fertilizer recommendations for coffee production. Applying the right amount of water at the right time means more efficient use of resources. In the long term, the adoption of the	More efficient use of resources; increase in yield and income	Decrease grap between the demand and supply of coffee in the country

Program/Project Title	Brief Description	Outcomes	Impacts
	technology would address the increasing demand for coffee in the country. The project also aimed to initially design a mobile NIR instrument for in situ assessment of the soil and water status of coffee farms.		
Enhancing Peanut Production Through Innovative Water Management Strategies	The project main objective was to increase the productivity of peanut by 30% through the application of drip irrigation technology. The technology utilizes drip irrigation (DI) with the developed best irrigation scheme for peanut Using this developed scheme, dry pod yield can be increased to as much as 31.45%. It is profitable through yield improvement with an ROI of 0.25.	• Validated irrigation management strategy for peanut • Pilot test farms showcasing the DI technology • Increase in yield by 30% • Increase water productivity by 60%	• Increased profitability of peanut production • Improved seed quality
Component Projects: Project 1. Application of Nuclear Analytical Techniques for Efficient Nutrient & Irrigation for Rice Production Project 2. Application of Nuclear Analytical Techniques for Efficient Nutrient & Water Management in Corn Production	To address and improve the use of precision and smart farming systems for integrated nutrient management for rice and corn production, respectively, the program focused on developing precision and efficient technologies such as the use of nuclear isotopic techniques known to be an effective tool for nutrients, soils, and	Efficient use of farm resources; higher yield and higher income	Impact: Potential improvement in the national irrigation policies, Findings were the basis for current research. Potential increase in rice and corn when the developed iFarm application is used

Program/Project Title	Brief Description	Outcomes	Impacts
Project 3. Water Balance and Loss Assessment of Upper Pampanga River Integrated Irrigation Systems (UPRIIS) and Magat River Integrated Irrigation Systems (MARIIS) Project 4. Enhancement of Nutrient and Water Use Efficiency Through Standardization of Engineering Support Systems	water resource determination and management, the development and application of high efficiency and precise fertigation systems, use of automated and controlled crop production systems, and the development and formulation of agricultural production technology standards for precision and smart farming systems, specifically for soil and water resources management. The program was able to produce several adopted standards, input to national irrigation master plan, and findings that were the basis of current research. Through the developed manuals, agricultural technicians, farmers, and other stakeholders benefitted from the locally-developed integrated nutrient and water management system and technologies,		and followed. More efficient use of fertilizer and water, resulting in an increase in yield and higher income for rice and corn farmers
Smarter Technologies for Crop-Water Management	A tool for smarter water management by providing its end-users with practical information	WAISS can assist in smart irrigation (using the right amount of water at	Improvement in farmers' irrigation practices and

Program/Project Title	Brief Description	Outcomes	Impacts
	on irrigation scheduling and recommendations. It is comprised of two components: a field unit and software that processes the data from the field to generate irrigation advisories that will be sent to end-users via text message. It can send text messages to the user/farmer on the status of soil moisture and provides recommendations such as whether to irrigate or not.	the right time) through proper monitoring and scheduling; assist in the irrigation of fields smartly and address the lack/absence of field staff/laborers	management

Mainstreaming of using smart technologies for more sustainable crop water management |
| Community-Level SARAI-Enhanced Agricultural Monitoring System (SEAMS) and Dissemination of Crop Advisories | Utilizes satellite information which is built on a platform of free and open source Geographic Information System (GIS) and Remote Sensing (RS) to monitor the growth of crops and provides weather monitoring and forecasting using satellite remote sensing, provides flood monitoring and crop damage assessment and pest infestation information. | CL-SEAMS can assist in the monitoring of areas affected by extreme weather events such as flooding; can be utilized in disaster risk assessment and response; provide information on the extent of damage incurred by particular regions, farms, etc.; and provide information to assist in the planting calendar with crop components | Promotes timely crop monitoring for LGUs and DA Regional Offices which will result to savings on time and resources of the LGUs and DA technicians (Zamora, Espaldon, Predo & Dorado, 2019) (e.g. Dumangas Municipality, Iloilo Province used SEAMS already for reporting crop status)

Promotes estimation of |

Program/Project Title	Brief Description	Outcomes	Impacts
			expected crop yields for decision-makers. Promotes efficient allocation of resources after extreme events like droughts and floods.
Drought and Crop Assessment and Forecasting (DCAF) Phase 2	Detects, monitors and forecasts drought events and stress in a certain agricultural area. DCAF generates maps that can be used to generate drought index suitable for Philippine condition. With this drought index, drought occurrences can be predicted six months ahead, assess crop yield, and mitigate severe effects of drought site-specifically;	DCAF can provide agricultural drought forecast which provinces are affected and will be affected by moisture stress; provide information on specific areas based on projected availability of water for crops; assist in the monitoring of areas affected by extreme weather events such as drought; can be utilized in disaster risk assessment and response; provide information on the extent of damage incurred by particular regions, farms, etc.; and provide	predicting an ENSO event will help farmers in adjusting cropping patterns and/or crop mix. provides policy makers in their decision to better manage the associated risks.

Program/Project Title	Brief Description	Outcomes	Impacts
		information to assist in the planting calendar with crop components	
Hydroponic System as Smart Farming Technique for Vegetable Crops Production	A hydroponics production system is a soilless culture. It protects crops from soil-borne pests and diseases; minimizes and efficiently utilizes inputs such as land, labor, water, and chemicals per unit of output, thus making farming profitable and possible even in urban areas; minimizes risks of changing climatic conditions; can be automated which allows precise water and nutrient supply to the crops; allows the production of off-season crops; and provide high quality products.	High-quality produce; increase in income	Food self-sufficiency

Program/Project Title	Brief Description	Outcomes	Impacts
Improving Production Efficiency and Cane Yield in a Sugarcane Block Farm Using an Automated Furrow Irrigation System	Furrow irrigation is the predominant method of irrigating sugarcane farms and

widely used in the Philippines. Over–irrigation incurs water losses in terms of deep

percolation and high runoff resulting in low irrigation efficiencies. Under-irrigation

provides inadequate water for crops resulting in water stress and lower yield. To avoid

over-irrigation and under-irrigation, this research dealt with the development of a

platform that integrates crop production models, irrigation management strategies, soil

and crop sensors, and control systems. The main objective of the research work was to

introduce to farmers a robust, alternative option to facilitate precision irrigation in

sugarcane production for a 20% increase in water application efficiency and productivity

through the aid of the | • Developed a flexible design package for the automated furrow irrigation systems for varying combinations of furrow lengths and furrow intake rates.

• Produce better yield (tc/ha) compared to farmer's irrigation practice

• Number of bags of sugar produced per hectare increased by more than 20% using an AutoFurrow system

• Increase value of recovery (Lkg/tc) of sugarcane ranging compared to traditional furrow irrigation | • increased yield

• better water productivity

• reduced labor requirement

• increased irrigation efficiencies |

Program/Project Title	Brief Description	Outcomes	Impacts
	Automated Furrow Irrigation System (AutoFurrow).		
Utilization of Modified Drip Irrigation for Production of High-Quality Onion and Garlic	To ensure viability and profitability of the onion and garlic industries and considering current farm practices, the project aimed to increase the yield of onion and garlic by 30% as well as water-use efficiency by 30% through the application of modified drip irrigation	Higher marketable yield compared to onions grown under open field environment; Efficient use of resources The marketable yield of drip irrigated onion grown in open field and greenhouse were more than 30% higher compared to the national average of 8.7 t/ha. Water productivity	Increased yield of onion and garlic means more profit for the individual farmer and a bigger contribution of the industry to the national economy. The developed modified drip irrigation system will reduce time and labor requirements and will help in the conservation of scarce water resources.

Program/Project Title	Brief Description	Outcomes	Impacts
		was found to be highest when plots were irrigated when soil moisture reaches 50% TAW (9 to 11.4 kg/m3 for onion and 5.64 to 6.72 kg/m3 for garlic) as compared to flood irrigation (1.23 to 1.89 kg/m3 for onion and 0.33 to 0.56 kg/m3 for garlic).	Water savings in using the system can open opportunities to expand production areas of onion and garlic. Under protected cultivation, off-season production of onion and garlic is possible; it also allows early seedling production for early transplanting and harvesting resulting to a premium price of produce. More competitive onion industry.
Biodiversity and Vulnerable Ecosystems Research Program (BiVER)	Increasing demand for groundwater has put pressure on water agencies worldwide to monitor and assess the water quality of this resource. In the Philippines, the projected groundwater demand from the agricultural sector is at 84% in 2025. Yet, the country lacks guidelines and tools for groundwater water	1. Training module on monitoring PGHI developed. 2. National and local agencies involved in routine monitoring of groundwater quality trained on the use of PGHI. 3. Scientific	•Healthy groundwater for agriculture •Reduce economic loss due to water pollution

Program/Project Title	Brief Description	Outcomes	Impacts
	quality monitoring and assessment. To address this gap, the project aims to develop a Philippine groundwater health index (PGHI) for monitoring and assessing groundwater resources, which can be considered a first in the Asian region. This proposed PGHI is a more holistic approach to managing groundwater resources as it uses a combination of microbial, biological, water chemistry, and environmental indicators.	reports published. 4. Policy briefs and inputs prepared and presented to key stakeholders.	
Biodiversity and Vulnerable Ecosystems Research Program (BiVER)	The BiVER Program was implemented to provide updated biodiversity information on the vulnerable ecosystems in Eastern Visayas. Particularly, this program aimed to document the diversity of seagrasses, river and mangrove vegetation, and the beneficial fungi that are mutually living with the plants. This program also assessed the water quality of selected ecosystems. It also aimed to create a model that can predict the susceptibility of the Binahaan River to flooding through the correlation of data on geomorphological	The BiVER program provided baseline information on the biodiversity of the vulnerable ecosystems (fresh and marine systems) that can be used by the DENR and LGUs in their policy-making endeavors as well as in the creation of evidence-based management programs. It also provided PSHS scholars with a training ground for the development of their skills.	Through this BiVER program, the importance of conserving vulnerable ecosystems was communicated to the surrounding community

Program/Project Title	Brief Description	Outcomes	Impacts
	characteristics and species population. Furthermore, it aimed to develop a database and a website that can provide all the information gathered in this R&D program.		
Soil erosion management in the Taganibong watershed in Musuan, Bukidnon	Giant bamboo reduces soil losses by 75%. Sediment yield which is a major cause of siltation and flooding in lowland areas also decreases. Bamboo foliage also helps in intercepting raindrops and minimizing the impact on the soil surface. Bamboo litter also shield the soil from the impacts of raindrops as decomposed litter improves soil structure and promotes water entry by 40%. This further reduces surface flow, translating to minimized soil erosion and landslides.	Significance difference of erosion rates between giant bamboo stand (12.66 Ton Ha/Yr) and without bamboo (92.12 Ton/ha/yr). The discharge and sediment yield were comparatively lower in an area with bamboo than in an open area.	Giant bamboo minimizes soil erosion and soil degradation.
UP's Emerging InterDisciplinary Research (EIDR) Program:Ten Years After the Millenium Ecosystem Assessment of Laguna de Bay: Towards a	With concerns of protecting the lake from further degradation, it is necessary to identify the characteristics of the lake and the areas surrounding it and to	Project 1, entitled "Assessment of geophysical hazards in urban lacustrine systems" focuses on the	This program generally aims to come up with recommendations that will support sustainable management of

Program/Project Title	Brief Description	Outcomes	Impacts
Sustainable Future	compare its current status with baseline values derived by previous works. This comparative operation will help in establishing the rates by which the lake ecosystem has been changing and provide critical inputs towards better management schemes. This program specifically covers the city of Calamba, Laguna and municipalities of Los Baños and Bay in Laguna. Three watersheds, namely Tigbi, Molawin-Dampalit and Cambantoc also serve as sites for land use change and land cover. In order to provide a thorough assessment, this program is composed of 4 independent but complementing researches.	geophysical hazards and understanding impacts to communities and developmental plans. Project 2, entitled "Exploring pollution monitoring proxies for characterizing urban lake environments" looks into the pollutant signatures within the lake system through analyses of water and sediment pollution, as well as heavy metal concentration using paleomagnetism. Project 3, entitled "Land use change and impacts on watersheds of large urban lakes" characterizes the biophysical aspects of the watershed, evaluates land use change and identifies critical areas through watershed vulnerability assessments. Project 4, entitled	the Laguna Lake through the integration of information from different disciplines. This program aims to be a platform for intelligent decision-making in the development planning and up-keep of one of the most important water resources of the country by integrating knowledge from the biophysical (chemistry, geology, forestry, geography, environmental science) and social sciences

Program/Project Title	Brief Description	Outcomes	Impacts
		"Assessing Socio-Ecological Systems: Visioning sustainable future of Laguna de Bay" is conducting a socio-ecological systems (SES) assessment of the Laguna de Bay ecosystems. This project is generating new baselines and indicative factors for visioning and scenario-building exercises, as well as companion modelling.	
National Research & Development Project for Watershed Management in the Philippines (Phase 2)	The National Research and Development Project for Watershed Management was implemented to set up a Philippine Network of Learning Watersheds to develop empirical databases for watershed management in the Philippines. The project includes mainly the characterization of learning watersheds in terms of their physical, biological, and socio-economic attributes and the regular monitoring of watershed resources and services.	Established wireless sensor networks that generate real-time information • Installation of Automated Water Level Stations (AWLMS) - Phase 1 (old sites) - 6 - Phase 2 (new sites) - 6 • Installation of Automated Weather Stations (AWS) - Phase 1 (old	Founded on the vision of enhancing science and technology-based watershed and ecosystem management. The project generated data and information through a network of Learning Watersheds that would be useful in guiding policy decisions on the kind and the extent to which various land uses and land use

Program/Project Title	Brief Description	Outcomes	Impacts
		sites) - 3 - Phase 2 (new sites) - 6 Established networks of permanent biodiversity monitoring plots • Establishment of 2-hectares permanent biodiversity monitoring sites - Phase 1 (old sites) - 6 - Phase 2 (new sites) - 6 Assessed the interrelations of watershed and ecosystem services with human and natural factors • Socio-economic and Resource Use Profile of the Watershed (4) • Power Relations and Roles of Stakeholders in the Watershed (2) • Climate Change and Watershed	practices could be allowed in the watershed without impairing the sustainability of surface and groundwater resources. This could also provide fresh information for a better understanding of the responsiveness of policies such as the withdrawal of critical watersheds and watershed reservations from agriculture and other uses. The outputs of this project are expected to help promote secured water supply for domestic, agriculture, energy, and other uses, food security, enhance resilience and stability of ecosystems and local communities, promote more sustainable livelihoods, reduced risks due to climate change,

Program/Project Title	Brief Description	Outcomes	Impacts
		Management Literacy (1) • Assessment of livelihood capital of watershed communities (1) • Relationship of the level of environmental awareness of households on resource use and participation in watershed management (3) • Impacts of major development interventions in the watershed (govt projects, infra, private sector investment, etc.) (1) • Watershed Health Index (1) Developed and/or validated models and tools on hydrology and land allocation • SWAT Model (6) • Erosion-based Land Capability (2) • FRAGSTATS (6) • Vulnerability	and the reversal of pervasive watershed degradation in the country.

Program/Project Title	Brief Description	Outcomes	Impacts
		assessment (3)	
		• Artificial Neural Network (ANN) (1)	
		• RUSLE (1)	
		Developed an information-management system that synthesizes data into real-time spatial estimates	
		• Watershed Health Index	
		• Water Balance Scenario Builder	
		• PES Calculator	
		• Carbon Neutrality	
		• INWARD OpenData	
		• Climate	
		• Streamflow	
		Identified priority studies in the watersheds utilizing the generated data	
		• Physical, Biological, and Socio-economic studies - 31 studies	

Program/Project Title	Brief Description	Outcomes	Impacts
		Developed a culture of research among graduate and undergraduate students	
		• Student Fellowship Program	
		- Phase 1 - 11 students	
		- Phase 2 - 57 students	
		• Laboratory Activities	
		- Phase 1 - 150 students	
		- Phase 2 - 47 students	
		Build capacity of local government units, schools, and other stakeholders for watershed monitoring	
		• Stakeholder's forum	
		- Phase 1 - 4	
		- Phase 2 - 6	
		• Seminar-Training	

Program/Project Title	Brief Description	Outcomes	Impacts
		Workshop	
		- Phase 1 - 8	
		- Phase 2 - 6	
		• Policy Forum	
		- Phase 1 - 2	
		- Phase 2 - 1	
		• Courtesy meetings	
		- Phase 2 - 3	
		Generated data and information that will feed into the SARAI project and other related projects	
		• Biodiversity plots used by LIDAR for validation	
		• Site characteristics useful for NGP sites	
		• Climate data for SARAI and LDP	
		• Protocols for characterization and monitoring for River Basin planning	
		• Land cap and vulnerability maps for land use planning	

Program/Project Title	Brief Description	Outcomes	Impacts
		• Biodiversity data for protected area management • Streamflow data for irrigation, domestic water supply, and risk reduction • Socio econ data for risk and vulnerability assessment • Water quality and quantity data for land use planning	
National Research and Development Project for Watershed Management	The National Research and Development Project for Watershed Management was implemented to set up a Philippine Network of Learning Watersheds with the aim of developing empirical databases for watershed management in the Philippines. The project include mainly the characterization of learning watersheds in terms of its physical, biological, and socio-economic attributes and the regular monitoring of watershed resources and services.		Founded on the vision of enhancing science and technology-based watershed and ecosystem management. The project generated data and information through a network of Learning Watersheds that would be useful in guiding policy decisions on the kind and the extent to which various land uses and land use practices could be allowed in the watershed without

Program/Project Title	Brief Description	Outcomes	Impacts
			impairing the sustainability of surface and ground water resources. This could also provide fresh information for a better understanding on the responsiveness of policies such as on the withdrawal of critical watersheds and watershed reservations from agriculture and other uses. The outputs of this project are expected to help promote secured water supply for domestic, agriculture, energy and other uses, food security, enhance resilience and stability of ecosystems and local communities, promote more sustainable livelihoods, reduced risks due to climate change, and the reversal of pervasive watershed

Program/Project Title	Brief Description	Outcomes	Impacts
			degradation in the country.