SCIENCE FOR THE PEOPLE

# SCIENCE FOR CHANGE

ROWENA CRISTINA L. GUEVARA
FORTUNATO T. DE LA PEÑA

SCIENCE FOR THE PEOPLE

# SCIENCE FOR CHANGE

ROWENA CRISTINA L. GUEVARA
FORTUNATO T. DE LA PEÑA

Science for Change



National Library of the Philippines

ISBN 978-621-96393-2-3 (Paperback)

ISBN 978-621-96393-3-0 (PDF)

ISBN 978-621-96393-1-6 (ePub)

Published by the Department of Science and Technology

Gen. Santos Avenue, Bicutan, Taguig City, Metro Manila, Philippines 1631

Produced by CAN Creative Capital www.can.ph

OTHER BOOKS IN THIS SERIES

***SCIENCE FOR SCALE***

*Winston Damarillo*

***SCIENCE FOR SUCCESS***

*Maret Follosco-Bautista*
*Robina Gokongwei-Pe*

***SCIENCE FOR SOCIAL CHANGE***

*Segundo Joaquin E. Romero Jr.*

***SCIENCE FOR INNOVATION***

*Maret Follosco-Bautista*
*Robina Gokongwei-Pe*
*Fortunato T. de la Peña*

***SCIENCE FOR COOPERATION***

*Leah J. Buendia*
*Fortunato T. de la Peña*

***SCIENCE FOR HUMAN CAPITAL***

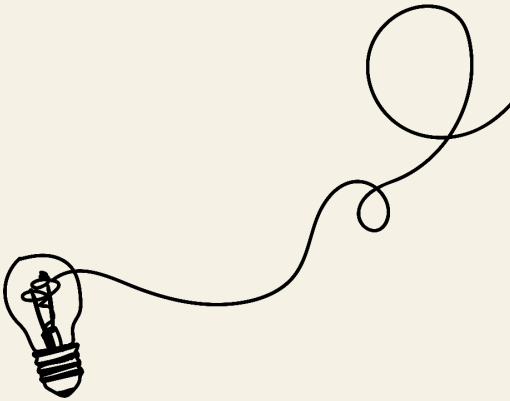
*Fortunato T. de la Peña*
*Josette T. Biyo*

***SCIENCE FOR COMMUNITIES***

*Fortunato T. de la Peña*
*Ernesto M. Granada*

TABLE OF CONTENTS

SCIENCE FOR CHANGE



CHAPTER I

# SCIENCE FOR CHANGE

## Science for Inclusive and Sustainable Development

"At the heart of our programs is the commitment to attain a more inclusive and sustainable development through S&T partnerships and linkages. We want to strengthen R&D capacity building and encourage our enterprises particularly the MSMEs to do R&D."

— Secretary Fortunato T. de la Peña

For the past six years, the Department of Science and Technology (DOST) endeavored to significantly accelerate science, technology, and innovation in the country through a massive increase in investment in Science and Technology Human Resource Development (S&T HRD) and Research and Development (R&D). The country's latest performance in the Global Innovation Index (GII) demonstrates its continuous commitment to innovation. From 100th place in 2014, it ranked 50th in 2020.

The Philippines moved up by 50 notches in just six years, despite the relatively low investments given to science, technology, and innovation initiatives in the country.

While the government recognizes the role of science, technology and innovation in the economic and social development of the country, the percentage of R&D expenditure to the Philippine Gross Domestic Product (GDP)—from 0.11% in 2009 to 0.15% in 2015—is still low. This is still far below the global average of 2.04% and UNESCO's recommendation of 1% for developing countries.

In 2014, about 93% of R&D funding was concentrated in the National Capital Region (NCR), Region III, and Region IV-A (CALABARZON), and only 7% was distributed among the other 14 regions of the country. The bulk of R&D spending in the Philippines came from the public sector with 53% of total expenditures.

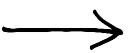
The country also has limited science, technology, and innovation infrastructure such as laboratories, testing facilities, and R&D centers. Those that exist mostly need upgrading. To add to that, the working industry-academe collaborations for R&D are also few.

In 2016, the DOST recognized these challenges and initiated the implementation of the Science for Change Program (S4CP) that aims to promote inclusive innovation by addressing the disparity in R&D funding distribution in the regions. It provides an enabling platform

where government, academe, and industry in the country collectively pursue market-oriented research. It aims to accelerate the development and adoption of science, technology, and innovation by spreading R&D funding across all regions and securing partnerships between and among academe and industry members.

The S4CP outlines how our nation's R&D investments will be spent through expansion of 17 R&D programs, introduction of new programs in areas of defense and security, space science and technology, artificial intelligence, strengthening of R&D and S&T services in the regions through infrastructure and human resource development, technologies for creative, tourism and services industries, and new and emerging technologies.

Part of the major strategies of the S4CP is focused on the Accelerated R&D Program for Capacity Building of R&D Institutions and Industrial Competitiveness through its sub-programs which we will tackle in this book:



### NICHE CENTERS IN THE REGIONS FOR R&D (NICER) PROGRAM

establishes research and development centers and collaborations among higher education institutions as well as hospitals across regions; this is a strategy towards science for inclusive and sustainable development.

### R&D LEADERSHIP (RDLead) PROGRAM

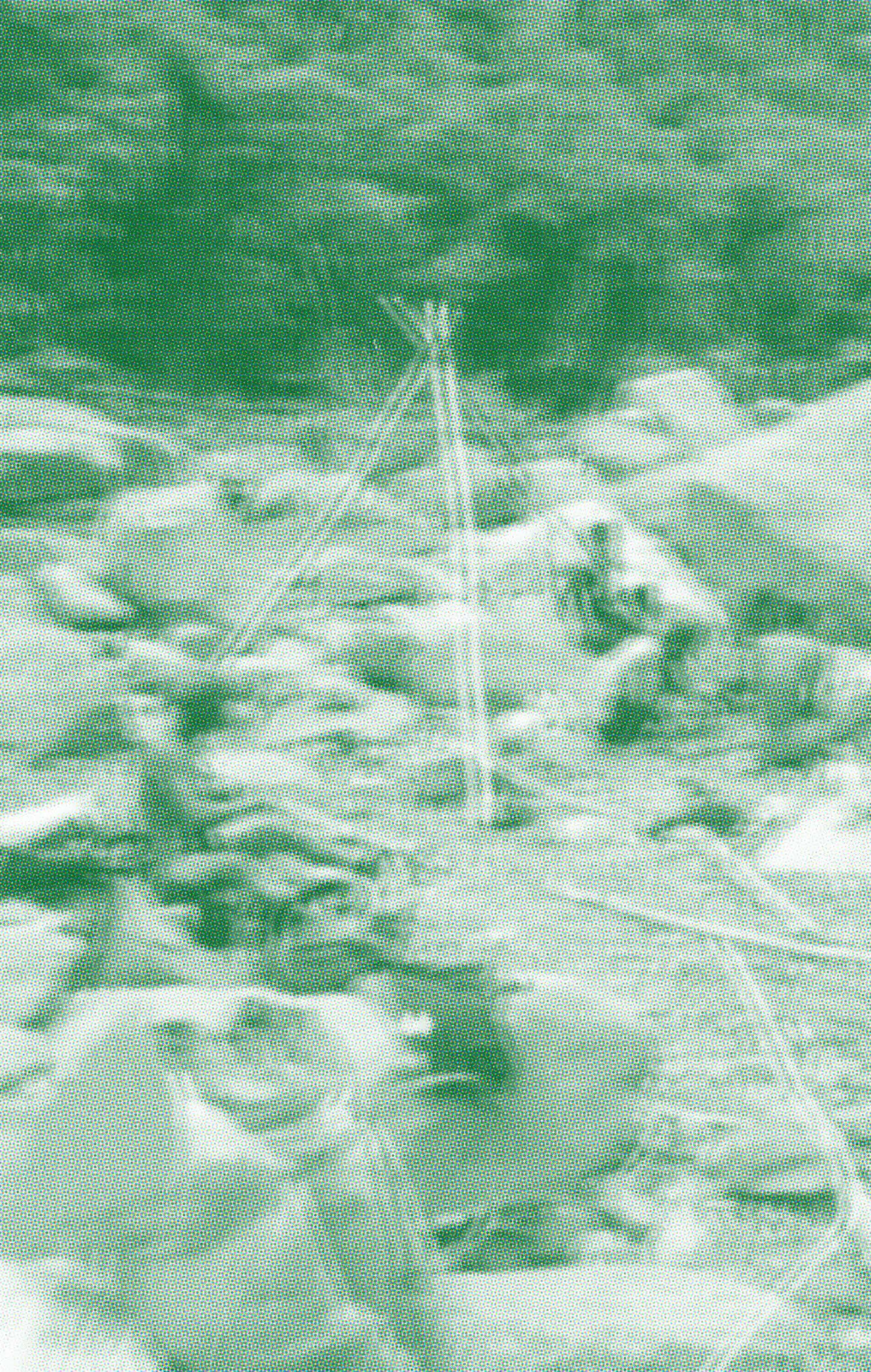
experts lend their skills to strengthen the research capabilities of higher education institutions, research and development institutes and national government agencies; this is a strategy for capacitating R&D organizations.

### COLLABORATIVE R&D TO LEVERAGE PHILIPPINE ECONOMY (CRADLE) PROGRAM

creates a synergistic relationship between the academe, government, and industry with the goal of invigorating R&D; this is the strategy to push linkages and collaboration.

### BUSINESS INNOVATION THROUGH S&T (BIST) FOR INDUSTRY PROGRAM

helps Filipino companies acquire and incorporate relevant technologies for their R&D activities; this is the strategy to address the need of SMEs for internal R&D.



CHAPTER II

# NICER PROGRAM:

## Equity in Science and Technology for Development

Niche Centers in the Regions for R&D

Keeping in mind the development inequality across the country (in 2016, 85% of the DOST R&D funding went to NCR, CALABARZON, and Central Luzon), the NICER, or the Niche Centers in the Regions for R&D Program, was established to address the disparity in access to R&D funding across all regions in the Philippines.

Duly endorsed by the Regional Development Council (RDC), the program provides grants for Higher Education Institutions (HEIs) in the regions to undertake collaborative quality research, promote regional development, and encourage industrial competitiveness.

To achieve this, the program provided an institutional grant to HEIs for R&D capacity building to improve their S&T infrastructure and enable collaborative R&D activities specific to the needs of each region, making sure to increase the number not just of developed but transferred technologies, i.e., those that are actually put into use to benefit the research community and local industries.

In doing this, the NICER Program enhanced the level of intellectual property (IP) management and protection, deployed technologies for the public good, and generated revenues for its stakeholders through licensing and commercialization.

The NICER Program profoundly promotes inclusive growth and sustainable development. State Universities and Colleges (SUCs), Private Higher Education Institutions (HEIs), and Medical Centers all over the country were able to propose their own niche centers to the Department of Science and Technology (DOST). So much so that within four years of the NICER Program's implementation, there were apparent increases noted in the number of researchers, the scale of research undertaken, accessibility

of research facilities, and industry-academia research collaborations. HEIs engaged in R&D increased from 85 in 2016 to over 168 in 2021. R&D funding to regions outside of Metro Manila also increased. While these are not achievements of the NICER Program alone but the whole of DOST, the NICER Program is highly contributory to these accomplishments.

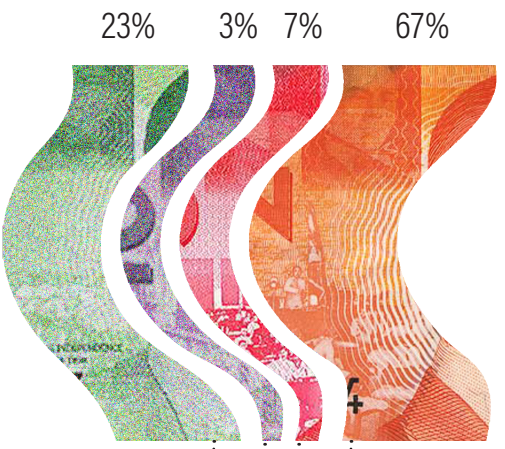
While this book features five NICER Programs only, there are many more not just in the agri-aqua biodiversity area, but in the industry, energy, health, disaster risk reduction, and emerging sectors such as data science and environmental informatics.

## PRESENT DISTRIBUTION OF NICER PROGRAM FUNDS


YEAR 2020 **62*** **HEIs**

** HEIs (Higher Education Institutions)*

Currently, the NICER Program has established 35 Centers across 17 regions in the country, with 111 projects approved and a total funding of PHP 1.7B. Of the total NICER Program funds, 67% are for the regions outside Metro Manila, CALABARZON, and Central Luzon.




PRESENT (2021)

**76***
**HEIs**

** HEIs (Higher Education Institutions)*

TOTAL BUDGET
**₱ 1,707,286,022**

(as of June 2021)

# NICHE CENTERS IN THE REGIONS FOR R&D

POTATO
BSU,CAR

CRUSTACEAN
SSU, R-VIII

GARLIC & OTHER
AGRI-FOOD
CONDIMENTS
MMSU, R-I

DRRM-HEALTH
UPM, NCR



SEA CUCUMBER
MSUN, R-X

QUEEN
PINEAPPLE
CNSC, R-V

ASTRONOMY
RTU,NCR

RENEWABLE
ENERGY
AdDU, R-XI

MOUNTAIN
ENGINEERING
UC, CAR

CITRUS
NYSU, R-II

INDUSTRIAL TREE
PLANTATION
CSU, CARAGA

ADVANCED MATERIALS
FOR ENERGY
UST, NCR

FRESHWATER
FISHERIES
ISU, R-II

HALAL GOAT
SKSU,
SOCCSKSARGEN

CAVE
ECOSYSTEM
UPLB, R-IVA

SWEET POTATO
TAU, R-III

BIODIVERSITY
CTU, R-VII

SEAWEED
MSU TCTO,
BARMM

TAMARIND
PSAU, R-III

ENVI, TECH.
PUP, NCR

SUSTAINABLE
POLYMERS
MSU-IIT, R-X

NATIVE PIG
MSC, R-IVB

ADVANCED
BATTERIES FOR
ENERGY
UST, NCR

CoastER
MMSU, R-I

PILI
BU, R-V

LAKES
LSPU, R-IVA

ELECTROMOBILITY
CSU, R-II

MOLLUSK
UPV, R-VI

CACAO
USM, SOCCSKSARGEN

SMART WATER
ISU, R-II

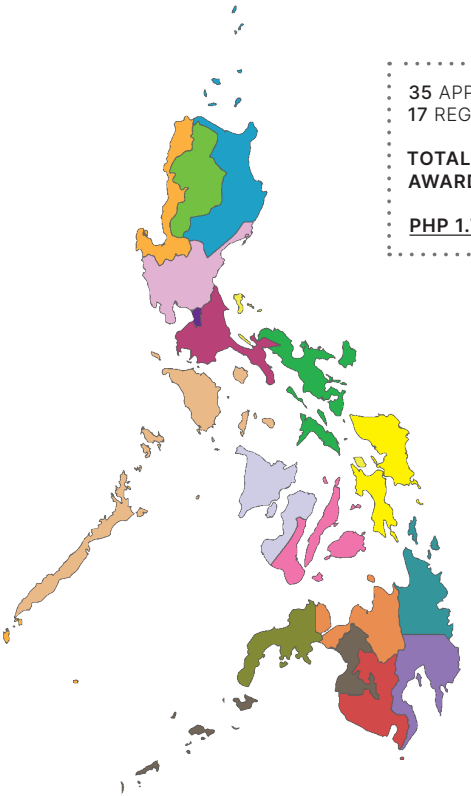
ENVIRONMENTAL
INFORMATICS
UPC, R-VIII

APPLIED MODELING,
DATA ANALYTICS &
BIOINFORMATICS IN
HEALTH
UP MINDANAO, R-XI

CENTER FOR
VECTOR OF
DISEASES
DLSU-Lag, R-IVA

BAMBOO
CMU R-X

NATIVE CHICKEN
WMSU, R-IX



**35** APPROVED NICERs
**17** REGIONS

**TOTAL GRANTS AWARDED**

**PHP 1.70B**

CAR
R-I
R-II
R-III
NCR
R-IVA
MIMAROPA
R-V
R-VI
R-VII
R-VIII
R-IX
R-X
R-XI
SOCCSKSARGEN
CARAGA
BARMM

1. Potato R&D Center at Benguet State University
2. DRRM-Health R&D Center at UP Manila
3. Astronomy R&D Center at Rizal Technological University
4. Citrus R&D Center at Nueva Vizcaya State University
5. Freshwater Fisheries R&D Center at Isabela State University
6. Sweet Potato R&D Center at Tarlac Agricultural University
7. Tamarind R&D Center at Pampanga State Agricultural University
8. Native Pig R&D Center at Marinduque State College
9. Pili R&D Center at Bicol University
10. Mollusk R&D Center at UP Visayas
11. Biodiversity R&D Center at Cebu Technological University
12. Environmental Informatics R&D Center at UP Cebu
13. Crustaceans R&D Center at Samar State University
14. Sea Cucumber R&D Center at MSU–Naawan
15. Renewable Energy R&D Center at Ateneo de Davao University
16. Industrial Tree Plantations Species R&D Center at Caraga State University
17. Halal Goat R&D Center at Sultan Kudarat State University
18. Seaweed R&D Center at MSU Tawi-Tawi College of Technology and Oceanography
19. Garlic and Other Agri-Food Condiments R&D Center at Mariano Marcos State University
20. Queen Pineapple R&D Center at Camarines Norte State College
21. Mountain Engineering R&D Center at University of the Cordilleras
22. Advanced Materials for Energy R&D Center at University of Sto. Tomas
23. Cave Ecosystem R&D Center at UP Los Baños
24. Applied Modeling, Data Analytics, and Bioinformatics in Health R&D Center at UP Mindanao
25. Bamboo R&D Center at Central Mindanao University
26. Electromobility R&D Center at Cagayan State University
27. Cacao R&D Center at University of Southern Mindanao
28. Native Chicken R&D Center at Western Mindanao State University
29. Vector of Diseases of Public Health R&D Center at De La Salle University Laguna
30. Advanced Batteries R&D Center at Technological Institute of the Philippines
31. Sustainable Polymers R&D Center at MSU–Iligan Institute of Technology
32. Smart Water Infrastructure and Management (SWIM) R&D Center at Isabela State University
33. Coastal Engineering Research (CoastER) R&D Center at Mariano Marcos State University
34. Environmental Technologies and Compliance R&D Center at Polytechnic University of the Philippines-Manila
35. Lakes Sustainable Development R&D Center at Laguna State Polytechnic University

# Freshwater Fisheries R&D Center

## Isabela State University

The “president’s fish” or lobed river mullet, known locally as "*ludong*" or "*banak*." Photo courtesy of Freshwater Fisheries R&D Center.

The Cagayan River is teeming with rare fish.

These include the *ludong* or "president's fish" claimed to be found only in Cagayan River, as well as the *igat* and *palos*, or freshwater eel, which can also be found in Japan, South Korea, and China.

Commanding a high price in the market (the *ludong* goes for PHP 7,000 a kilogram), both species are also endangered, said Dr. Isagani Angeles.

Dr. Angeles is a professor at Isabela State University, he was appointed the Program Leader for the NICER Freshwater Fisheries Center (FFC) established to research the best ways to manage both the *ludong* and *igat*.

The program he leads supports the "*Oplan Sagip Ludong*" but also aims to cultivate them for the market, Dr. Angeles explained. "We want to address the concerns on the endangered status of the fishes, especially of *ludong*, since it can only be fished in Cagayan River, [and] at the same time, produce and have more high-value products for the fishpond operations in the Cagayan Valley Area (Region II)."

## PROGRAM SPECIFICS

In order to help fishermen and the fishing industry in Region II, the Center runs two component projects:

- **Project 1**

  Conservation and artificial spawning of '*ludong*' Lobed River Mullet (*Cestraeus sp.*)

The research program is focused on developing artificial breeding and culture techniques, and gathering information on their natural habitats so as to better manage the fish.

- **Project 2**

  Utilization of aquatic plants as immunostimulants for freshwater eel culture

The Center aims to improve the fish's resistance against pathogenic bacteria, thereby having its population multiply by studying immunity-boosting food for the fishes like azolla and water spinach for the *igat* and duckweed for the *ludong*.

The Center is ensuring the involvement of the local fish farmers in the process, as well as the indigenous Aetas, who surveyed possible fishing grounds of *ludong* in Blue River, Isabela.

## ACCOMPLISHMENTS AFTER THREE YEARS

Research-wise, Project 1 identified 11 municipalities that could be fishing grounds for *ludong*, concluding that it could be reared in captivity—in circular tanks appointed with water filtration and UV system.

*Igat*, the freshwater eel. Photo courtesy of the Freshwater Fisheries R&D Center.

This is good news for fish farmers like Melchor Domingo from Ramon, Isabela, who shared the challenges of cultivating in open environments.

***"Ang mga pagsubok na aming nararanasan sa freshwater fish farming ay ang pabago-bagong klima na nagdudulot ng pagkamatay at pagkakaroon ng sakit ng mga alagang isda. Maliban dito, nararanasan din namin ang pagkasira ng aming mga palaisdaan dahil sa mga kalamidad na dumarating.***

[The challenges we are experiencing in freshwater fish farming is the frequent changes in weather that results in the death and illness to our fishes. Besides this, we also experience the destruction of our fishing grounds due to the calamities]," he said.

Since marine water is one of the requirements for the induced spawning of *ludong*, the breeders are currently reared at Multi High Value Species hatchery (MHVSH) in Barangay Taggat Norte, Claveria, Cagayan. They have also gained weight, an additional 32% to 79%, from being fed with an alternative diet of commercial food and natural duckweed every other day.

Meanwhile, Project 2 concluded that two aquatic plants—azolla and *kangkong*—contain metabolites, which provide antioxidant effects that are good for the freshwater eel. Specifically, azolla has high amounts

## ELEVEN MUNICIPALITIES' RIVERS IDENTIFIED AS FISHING GROUNDS OF LUDONG

- Ilagan (Abuan River in Cabisera 10 and Ilagis River)
- Maconacon (Blues River in Reina Mercedes)
- Palanan (Dialaoyao, Pinacanauan River in Didiuan and Ilaya)
- Tumauini (Lapogan)
- Cabbaroguis (Eden)
- Nagtipunan (Siitan River)
- Alcala (Afusing Batu)
- Amulong (Dugayung)
- Gattaran (Nassiping)
- Lallo (Catayuan)
- Santo Niño (Dungao and Matalao)

The collection of azolla, an aquatic plant with high amounts of tannins and saponins. Photo courtesy of Freshwater Fisheries R&D Center.

of tannins and saponins, while *kangkong* has appreciable amounts of tannins, alkaloids, flavonoids, terpenoids, steroids, and traceable amounts of saponins.

Researchers reported that azolla and *kangkong* inhibited the growth of *Vibrio cholerae* (bacteria that naturally live in brackish or saltwater), *V. harveyii* (a serious pathogen of marine fish and invertebrates) and *V. parahaemolyticus* (a bacterium in the same family as those that cause cholera that lives in brackish saltwater), though both azolla and *kangkong* extracts were more effective in inhibiting *V. harveyii* and *V. parahaemolyticus* than *V. cholerae*.

## IMPACT ON INDIGENOUS PEOPLES AND FISH FARMERS

The indigenous peoples (IPs) joined the Center's fishing expeditions for which they were compensated and during which the FFC team could observe their culture and traditions. They found out that the IPs are happy people and are content with their lives. They demonstrated remarkable determination and persistence.

The FFC trained fish farmers in the production of freshwater fish and *kuroko* (young eel) in tanks, as well as assisted them in obtaining grants or loans to fund their setup. Photos courtesy of the Freshwater Fisheries R&D Center.

Dr. Angeles said: "The FFC team established a good working relationship with the IPs. Keeping their credibility and loyalty are important for the success of the fishing expedition."

The IPs are the experts in terms of catching live *ludong*, he pointed out. "They have the ability to catch live ludong using a scoop net and a flashlight. Indeed, *ludong* expedition is not possible without the help of the IPs."

When it comes to the fish farmers, it was actually the Center that encouraged them to organize as the aquaculture cooperative, Cagayan Valley Aquaculture Producers Cooperative (CVAPCo).

They are now recognized by the Cooperative Development Authority, with 60 members and a Board of Directors that plan and propose programs for funding.

Dr. Angeles, together with the Research Manager of the Bureau of Fisheries and Aquatic Resources-Region 2 (BFAR-R02) Dr. Evelyn C. Ame, visited different fish farming sites to distribute free glass eels to the members of the Cagayan Valley Aquaculture Producers Cooperative (CVAPCo). Photo courtesy of the Freshwater Fisheries R&D Center.

Mr. Domingo, a fish farmer, also stated that eel farming offers good opportunities because it can be sold in local and international markets at a high price.

He added that the Freshwater Fisheries Center gave them confidence in their venture.

***"Bukod sa mas gumanda at umayos ang pag-aalaga namin ng eel, tinulungan din kami ng FFC na makapasok sa Cagayan Valley Aquaculture Producers Cooperative. Natulungan din kaming mag-avail ng grants o loans sa iba't ibang funding agencies.***

[Besides helping us improve our eel farming, FFC also helped us join the Cagayan Valley Aquaculture Producers Cooperative. We were also assisted in availing grants or loans from different funding agencies]," he said.

Glass eel. Photo courtesy of the Freshwater Fisheries R&D Center.

In a feeding experiment in both aquariums and hapa or nets, the glass eels' average weight increased by 204%, and an average of 94% of the eels survived after one month. Photo courtesy of the Freshwater Fisheries R&D Center.

Program Leader Dr. Angeles is proud of the Freshwater Fisheries Center's R&D that could enable livelihoods. "This will be reflected in the successful eel culture and availability of *ludong* fingerlings in the region."


Because of the NICER Program, a building at Isabela State University was successfully renovated and equipped. It now has two laboratory rooms and 23 concrete tanks, 24 plastic tanks, one water recirculating system, one multimedia room, and one water filtration system set up, available to students and other researchers. Photos courtesy of the Freshwater Fisheries R&D Center.

# POINTS OF VIEW

Melchor Domingo,
Fish farmer

General Aguinaldo,
Ramon, Isabela

*"Dahil sa laging handa ang FFC at ang CVAPCo sa pagtulong sa kagaya naming mga fish farmers, nakikita namin na malaki ang magiging pagbabago ng aming produksyon sa fish farming. Bukod sa lalawak ang aming kaalaman sa pag-aalaga ng isda lalo na sa igat, makakatulong rin kami sa kapwa naming fish farmers. Mas lalaki ang posibilidad na tumaas at umunlad ang industriya ng pangisdaan sa ating rehiyon."*

[Because FFC and CVAPCo are always ready to help fish farmers like us, we see that there will be a big change in our fish production. Besides broadening our knowledge in taking care of fish, especially eel, we could also help the other fish farmers. There is the possibility that the fishing industry in the region will become bigger and develop.]

# Sea Cucumber R&D Center

## Mindanao State University-Naawan

Sea cucumber or bêche-de-mer is a delicacy in French cuisine. Photo courtesy of the Sea Cucumber R&D Center.

Boiled and dried for use in Asian or French cuisine, sea cucumbers sell at a whopping PHP 4,000 to PHP 8,000 a kilogram. The rarer the sea cucumber species, the more expensive it gets. However, the majority of the sea cucumbers traded globally are caught from the wild and have caused a decline in the natural stocks.

At the Mindanao State University at Naawan (MSU-Naawan), an R&D center has been established to study vulnerable and endangered species like *H. fuscogilva* and *H. scabra*. Part of the goal is to replenish their natural stocks, said Program Leader Dr. Wilfredo Uy.

Prior to the establishment of the Sea Cucumber R&D Center, the MSU-Naawan had already been conducting sea cucumber research since 2011. It received funding from the Commission on Higher Education (CHED) on sea cucumber biodiversity assessment, together with different higher education institutions (HEIs) in the Philippines.

The research project was followed by a two-year grant from the DOST's Philippine Council for Agriculture, Aquatic, and Natural Resources Research and Development (DOST-PCAARRD) on the biology and ecology of *H. fuscogilva*, which is known for its high commercial value. It was also able to pilot a hatchery in 2014 in partnership with University of

The Sea Cucumber R&D Center is focusing on the two species: the *H. scabra* or sandfish (locally known as *balat kagisan* or *mangadlay*); and *H. fuscogilva* or white teatfish (locally known as *susuan* or *sus-an*). Photo courtesy of the Sea Cucumber R&D Center.

the Philippines Marine Science Institute (UP-MSI) and Southeast Asian Fisheries Development Center (SEAFDEC) through funding from the Australian Centre for International Agricultural Research (ACIAR).

Through the pilot hatchery, they were able to produce sandfish juveniles and provide enough seed materials to members of coastal communities who would like to grow sea cucumbers as a livelihood.

## PROGRAM SPECIFICS

The program has four component projects:

- **Project 1**
  "Fisheries Assessment of Sea Cucumbers in Mindanao" focuses on assessing stocks of sea cucumbers in Mindanao fisheries supplemented by socio-economic profiling and value chain analysis.

- **Project 2**
  "Ecology, Biology and Population Genetic Diversity of the White Teatfish, *Holothuria fuscogilva* (Cherbonnier, 1980) in Selected Sites of Mindanao" aims to provide vital information on the

ecology, biology and genetic diversity of *Holothuria fuscogilva* in support of conservation, sustainable utilization, and mariculture of the high-value sea cucumber.

Establishing the genetic and connectivity profiles of geographically separated stocks of *H. fuscogilva* is important to identify potential sources of broodstock or a group of mature individuals used for breeding purposes.

- **Project 3**

  "Development on Mariculture Technology and Stock Enhancement Protocol for the White Teatfish *Holothuria fuscogilva* (Cherbonnier, 1980)" aims to develop viable mariculture technology for stock enhancement, protocols for broodstock maturation in both the hatchery and natural habitat, refinement of captive breeding techniques and protocols, and development of juvenile production techniques for stock enhancement and sea ranching: when juveniles are released into the sea to grow on their own until the farmer harvests them.

The NICER Program has helped fund the improvement of MSU-Naawan's facilities. Building on the existing pilot hatchery, the Center supported its expansion and the improvement of its life support system. The program is also planning to rehabilitate an anoxic old pond fronting the Research Building into a learning center to pilot large scale production in a controlled environment. Photo courtesy of the Sea Cucumber R&D Center.

The program engaged a powerhouse of research collaborators from MSU-Lanao del Norte Agricultural College, MSU-Maigo School of Arts and Trades, MSU-Tawi-Tawi College of Technology and Oceanography, University of Science and Technology of Southern Philippines-Panaon Campus, Camiguin Polytechnic State College, and MSU-Naawan Foundation for Science and Technology Development Inc., who signed a Collaborative Research Agreement for the NICER Sea Cucumber R&D Center. Additionally, a MOA was signed with local government units and the Bureau of Fisheries and Aquatic Resources. Photo courtesy of the Sea Cucumber R&D Center.

In every production at the hatchery, 20% of the juveniles will be given to the LGU, which will be the source of broodstock for stock enhancement and sea ranching. The remaining 80% will be used for experimental studies and the development of broodstock.

- **Project 4**

  "Refinement of Culture Production of Sandfish *Holothuria scabra* (Jaeger, 1833) in Mindanao" aims for the mass production of sandfish using ocean nursery systems, sea ranching, and pen grow-out systems in partnership with the local community in selected sites in northern Mindanao. It likewise promotes responsible restocking practices.

## ACHIEVEMENTS

The Center made sure to include stakeholders in all the activities, from data collection to sea cucumber rearing. The Center deployed some of its


Turning over of sandfish, *Holothuria scabra* for pen grow-out to local beneficiaries was done in two Project Sites (Mahinog, Camiguin, and Lopez Jaena, Misamis Occidental) to provide alternative livelihoods to the beneficiaries. A similar activity was done for the white teatfish, *Holothuria fuscogilva.* Photos courtesy of Sea Cucumber R&D Center.

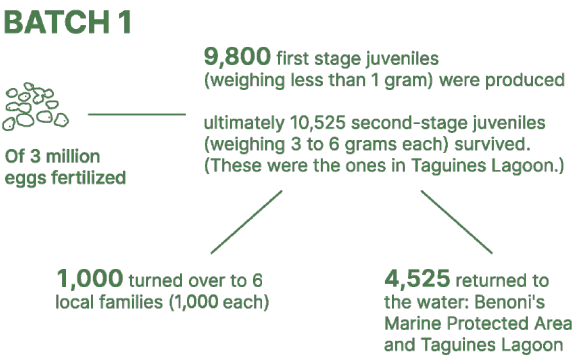
staff to immerse with the community, and local fishers and gatherers were always invited during project presentations.

What is unique to this program is that a whole family, not just an individual, is selected as a beneficiary.

A particularly enthusiastic community is that of Mahinog in Camiguin, also known as the "island born of fire."

During the program staff's reconnaissance trips to Camiguin's rich coastlines, they found out that the municipality of Mahinog has a lagoon that presented to be a potential source of *H. scabra* and an optimal setting for hapa nets in rearing sea cucumber juveniles with the presence of a field station of the Bureau of Fisheries and Aquatic Resources (BFAR).

Many local fisherfolks in Camiguin have been gathering sea cucumbers mostly for their own consumption, though only a few sell them fresh in the local markets. As such, the program started test processing *H. scabra* to bêche-de-mer or trepang, which will be later taught to local communities to further supplement local alternative livelihoods. Looking forward, the Center will develop modules to make it easier to train the communities in how to process sea cucumbers.




Sea cucumbers are first reared at MSU-Naawan's hatchery for two months before they are placed in an ocean nursery system for another two months. Photo courtesy of the Sea Cucumber R&D Center.


Workshops were conducted, including one on "Handling and Tissue Collection of Sandfish for Genetic Analysis," led by resource speaker, Dr. Rachel Gotanco, from University of the Philippines Marine Science Institute (UP-MSI). Photo courtesy of the Sea Cucumber R&D Center.

On the cultivation side, the program is refining hatchery protocols. To date, the program has had two batches of hatchery operations of broodstock from Camiguin.

Learning from the first round, the second batch of operations yielded a total of 5.42 million eggs producing 121,350 first-stage juveniles. Approximately 64,000 juveniles were transferred to Taguines Lagoon, Camiguin, into a floating hapa nursery, while the rest of the juveniles were kept in the hatchery for experimental purposes.

Due to travel restrictions from COVID-19, the program was only able to operate for six months (from October 2019 to March 2020) in Camiguin. However, the program was able to operate from rearing in the hatchery to growing out in sea pens, which is a big achievement.

Additionally, the fisherfolk kept constant communication through online messaging applications and the BFAR-Camiguin undertook the checking

and cleaning of the floating hapa nets stationed in Taguines Lagoon when staff could not enter the area, which showed the enthusiasm of the community.

Finally, since human activities were greatly limited, wild sea cucumber populations may have been undisturbed, or at best, improved.

The sea cucumbers' presence alone plays a vital role in the marine ecosystem: they clean sediments, prevent algal bloom and protect coral reefs through their alkalinity. Aside from that, the calcium carbonate released in their waste is a building block of the corals.

On the second floor of the existing algal culture laboratory previously enhanced through the assistance of the DOST-PCAARRD, a museum is also in the works to house specimens and learning materials. Photos courtesy of the Sea Cucumber R&D Center.


A project member diving deep at 30 meters to gather sediment information on the white teatfish. Photo courtesy of the Sea Cucumber R&D Center.

# Seaweed R&D Center

## MSU Tawi-Tawi College of Technology and Oceanography

What do the following have in common: toothpaste, shampoo, ice cream, salad dressings, air fresheners, diet sodas, soy milk, and shoe polish?

They all have carrageenan as an ingredient.

Carrageenan, which is extracted from seaweeds, is widely used in the food, medical and personal-care industries for its gelling, thickening, and stabilizing properties.

It was reported that the first commercial cultivation of the species of seaweeds *Eucheuma* spp., commonly known as *guso*, and *Kappaphycus spp*., also known as *guso* or *agar-agar*, for carrageenan, was developed in the Philippines since the early 1970s. It is now a major source of livelihood for thousands of coastal communities in the country. Another top producer is Indonesia.

High-quality and food-grade, about 70% of Philippine carrageenan exports are refined, while about 27% are semi-refined. According to the Department of Trade's Board of Investments DTI-BOI, from 2004 to 2013, Philippine carrageenan exports averaged USD 101.5 million, or about 13,100 tons, per year.

With a global market size of USD 615.9 million or 50,400 tons in 2013, the Philippines stands to gain a bigger share if it is able to increase its production or even get into processed carrageenan.

The MSU Tawi-Tawi College of Technology and Oceanography has the world's richest collection of over 1,000 seaweed specimens. Photo courtesy of the Seaweed R&D Center.

However, the country's seaweed production has been decreasing due to a lack of high-quality seed stocks, epiphytes (a plant that grows on another), poor farm management and post-harvest practices, and a disease called “ice-ice."

Mobin Hassan, a seaweed farmer in Tawi-Tawi, the highest seaweed producing province in the Bangsamoro Autonomous Region of Muslim Mindanao (BARMM), shared: "*Ang problema namin ay ang ice-ice disease, malakas na alon na nakakasira sa mga seaweeds, sereng-sereng na tumutubo sa seaweeds at mababang presyo ng seaweeds."* [Our problem is the ice-ice disease, strong waves that destroy the seaweeds, *sereng-sereng* that grow on the seaweeds and low price.]

Caused by changes in salinity, ocean temperature, and light intensity, ice-ice stresses seaweeds, making them produce a moist organic substance that attracts bacteria and induces the "whitening" and hardening of the seaweed's tissues.

There are some unhealthy cycles: The repeated propagation of the same seaweed plants has led to a loss of genetic diversity and with it, slow growth of poor quality seed stocks, a decrease in carrageenan yield and quality, and susceptibility to disease.

At the same time, farmers usually select the best-growing plants from one harvest for the next crop, inadvertently selecting a seed stock that is not acclimated to seasonal changes in the environment.

In order to address the issues—including the downward trend in the country's carrageenan exports—the Seaweed Research and Development Center (SeaRDeC) was established at the Mindanao State University-Tawi-Tawi College of Technology and Oceanography (MSU-TCTO). Dr. Sitti Zayda Halun is its Center Head and Program Leader, while Professors Karen Joy Serag and Richard Dumilag are leading their own projects under the Center.

What is the best part of being the SeaRDeC Program Leader? Dr. Halun replied: It is "inspiring the researchers in MSU-Tawi-Tawi in improving the lives of seaweed farmers through science and technology." Photo courtesy of the Seaweed R&D Center.

Since the four major seaweed production areas in the country are in the BARMM, Palawan, Luzon, Western Mindanao, and Bohol, Central Visayas, SeaRDeC is working closely with the local government units of Tawi-Tawi and Sulu, farmers' associations, BARMM-Ministry of Agriculture, Fisheries and Agrarian Reform, MSU-Sulu, and MSU-Naawan. It is being monitored by the Philippine Council for Agriculture, Aquatic, and Natural Resources Research and Development (DOST-PCAARRD).

Tawi-Tawi has a total production of 368,795 metric tons in 2019, contributing 53% of the regional production and 24% of the national production. In order to increase seaweed production in Tawi-Tawi and meet national standards, the Center will produce quality seed stocks, promote seaweed health and good farm management. Photo courtesy of the Seaweed R&D Center.

## RIPPLE EFFECT
## EXPECTED OUTPUTS BY 2023

By providing continuous technical support and high-quality seed stocks to farmers, it is expected that the seaweed R&D will help promote a sustainable seaweed industry and, in turn, produce a healthier population, reduce malnutrition, increase income and job opportunities (especially for women), leading to better access to education and better quality of life.

- **Products:** five tons of seed stocks to be produced for distribution to farmers, one seaweed dryer that has been pilot tested. Increase seaweed production in BARMM by 15% (and increase annual income of farmers by 35%)

- **Patents:** around protocols on improved laboratory culture of eucheumatoids, improved outdoor/land-based nursery culture, and seaweed post-harvest handling

## RIPPLE EFFECT
## EXPECTED OUTPUTS BY 2023

- **Papers:** six published papers in peer reviewed journals, nine Technical papers presented in national and international conferences plus handbooks on laboratory and land-based nursery culture of eucheumatoids, on farm management, and on post-harvest handling protocols (this eventually creates a pool of seaweed researchers and technical support at the farm level)

- **Personnel:** 100 seaweed farmers, and 40 faculty, researchers, students from different universities or colleges in BARMM-MAFAR trained on farm management and post-harvest handling of eucheumatoids; about 25 faculty, researchers, and students from different universities and colleges in BARMM trained on laboratory culture, and land-based nursery culture of eucheumatoids

- **Partnerships:** Memoranda of agreements and understanding with seaweed farmer organizations, higher education institutions, BARMM-MAFAR, Department of Trade and Industry, Seaweed Industry Association of the Philippines and LGUs; plus a research agreement with the University of the Philippines Los Baños Biomech to pilot test a seaweed drying facility

- **Policy:** Briefs on the distribution of economically important seaweeds, farm management, and post-harvest handling of eucheumatoids to improve the quality of raw dried seaweeds for LGUs, BARMM-MAFAR, DTI, Seaweed Industry Association of the Philippines.

**THESE 6 P'S CAN BE A FRAMEWORK FOR EVALUATING SUCCESS OF ANY R&D PROJECT.**

In BARMM, home to thousands of families whose primary source of income is seaweed farming, job opportunities are limited, especially for women. As the women play a significant role in seaweed farming and are not credited for their contribution, Dr. Halun pointed out that "supporting the seaweed industry through S&T will create more jobs for women and empower them." Photo courtesy of the Seaweed R&D Center.

## ACCOMPLISHMENTS

In its first year, the Center collected more than a thousand eucheumatoid specimens from six municipalities—Panglima Sugala, Sapa-Sapa, Sibutu, Sitangkai, South Ubian, and Tandubas—in Tawi-Tawi.

"This has been the richest collection of eucheumatoid specimens by far known for any research endeavor," Dr. Halun proudly announced. "This suggests that Tawi-Tawi has the most number of sites where wild seaweed populations thrive... These sites have a potential for 'seed-sourcing' and in-situ conservation."

---

**EUCHEUMATOID**

of or relating to eucheuma, a seaweed algae that may be brown, red, or green in color.

---

Farmer drying seaweed using bamboo structures. Photo courtesy of the Seaweed R&D Center.

In fact, the team has started GIS mapping the distribution of economically important seaweeds in order to provide relevant information to policy-makers on which marine areas should be protected.

## GIS MAPPING SOFTWARE

A Geographic Information System (GIS Software) represents data on maps, in order to show geographic or spatial distribution.

The team also conducted meetings with farmers, traders and local government officials about the problems and challenges they are facing.

The seaweed farmer, Mr. Hassan, wished for fast growing seedlings and a dryer in their community. *"Ang mabigyan kami ng seedlings na mabilis tumubo at hindi nagkakasakit ng ice-ice disease, at maturuan kami ng mas maayos na paraan ng pagtatanim ng seaweed agal-agal para hindi sila magkasakit o mamatay. At [magkaroon kami] ng seaweed dryer para mas tuyo at malinis, at mas mataas ang presyo ng bilihan ng aming raw dried seaweeds."* [That we will be given seedlings that grow fast and without disease, and we will be trained in planting seaweeds that do not get sick or die. Plus, a dryer so the seaweeds can be cleaner and command a higher price.]

For this purpose, a collaboration has been discussed with UPLB Center for Agri-Fisheries and Biosystems Mechanization (BIOMECH). to pilot test a seaweed drying facility. Eventually, the goal is for SeaRDeC to be licensed to certify the quality of raw dried seaweeds, as well as link farmers with industry players and entrepreneurs that can help them process their yield and develop products throughout the seaweed value chain. Dr. Halun pointed out: “Carrageenan is a billion-dollar industry. Thus, increasing production to meet the market demand would increase the income of farmers and boost the local and regional economy.”

For now, the Center's game plan is to collect and profile the morphological, genetic, physiological and chemical characteristics of seaweeds in the selected areas, notably for their survival, growth rate, carrageenan yield, and quality.

From here, superior strains will be cultivated by the scientists then distributed to seaweed farmers, similar to the program of the Sea Cucumber R&D Center also in Mindanao State University. But instead of a hatchery, the propagation will take place in the lab using tissue culture techniques such as branch culture and micropropagation. The R&D team will propagate the seed stocks using spores.

Through the NICER Program, SeaRDeC has the opportunity to combine laboratory, hatchery and farming technologies that include morphological, genetic, and chemical analyses of farmed and wild eucheumatoid seaweed varieties across the Sulu Archipelago. Photos courtesy of the Seaweed R&D Center.

Seaweed collection. Photo courtesy of the Seaweed R&D Center.

# Tamarind R&D Center

## Pampanga State Agricultural University

"If Guimaras in the Visayas is very popular for its mangoes, and Anao town in Tarlac for its *ylang-ylang* trees, this project proposes to make the municipality of Magalang the town of tamarind."

So says the former municipal mayor and current administrator, Lyndon Cunanan, about the town's long-term strategies to produce, process, and promote tamarind varieties based on consultations with farmers and entrepreneurs in the area.

With the help of the Tamarind R&D Center established in the Pampanga Agricultural State University (PSAU), the municipality is aiming to improve the quality of sour and sweet tamarind production through science and technology interventions.

PSAU, an agricultural university occupying nearly 700 hectares in Magalang, is strategically located on the slopes of the majestic Mt. Arayat. Besides the Tamarind R&D Center, it has Centers under the R&D for Laboratory Works of Students that include the Bamboo and Rattan R&D Center, Alternative Low Input Agricultural System Center, and the Mushroom Production Center.

This has made the scientists at the university very knowledgeable about the traits they are looking for in a crop.

Program Leader Dr. Virgilio Gonzales described tamarind as a low-input crop—very resistant to climatic stresses and does not need water and fertilizer.

In particular, he emphasized that they would be working with a reforestation species. "We are hitting two targets in one bullet: reforestation of denuded hillsides and additional income for the surrounding communities."

## PROJECT SPECIFICS

To increase the production and quality of tamarind in order to become globally competitive, the program has three project components:

- **Project 1**
  The Genomic Characterization for Improvement of Sour and Sweet Tamarind Varieties, led by Mr. Jacob Anderson Sanchez;

- **Project 2**
  The Development of S&T-based Production Management Strategies for Tamarind, led by Dr. Gonzales himself;

The town of Magalang with its 27 barangays, is a consistent awardee as the cleanest and greenest municipality in Pampanga in 2001 to 2007. It is an agriculture-based municipality with a total land area of 973,100 hectares, strategically located near economic zones and business centers, such as Clark Field, SM Mall in Clark and Marquee Mall in Angeles City, among others, which makes it easy to move products economically. Photo courtesy of the Tamarind R&D Center.

• **Project 3**

Value Chain Analysis and Marketing of Tamarind, led by Dr. Emelita Kempis.

* **The Genomic Characterization** involves S&T interventions such as the identification and selection of superior sour and sweet tamarinds required by consumers and processors; morphological and genomic characteristics to identify superior clones required by growers and processors (with thick peel and at least three segments per pod); application for registration of sweet and sour varieties with the National Seed Industry Council (NSIC); and the development of policy recommendations for the accreditation of seedling nurseries. Its intended beneficiaries are the clonal seedling nurseries, investors who intend to establish plantations for either sour or sweet types, and processors of food and non-food products.

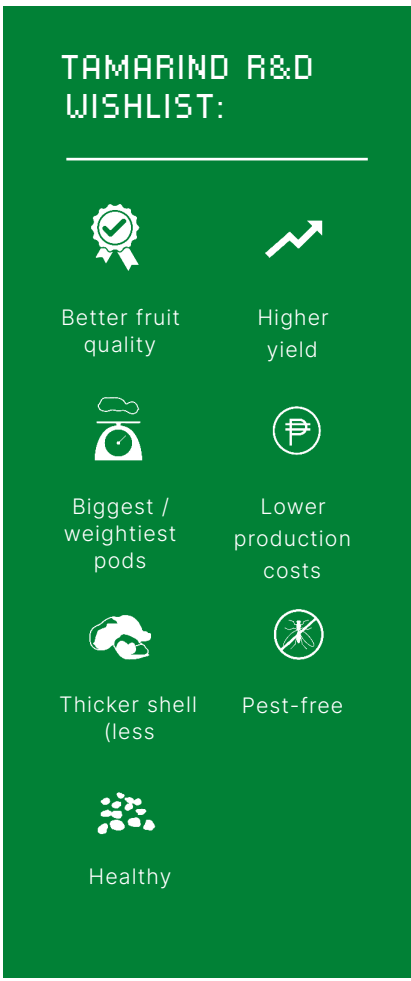
Mr. Sanchez explained that if growers would just look at the seedlings, it is difficult to differentiate whether they are of sweet or sour tamarind because they look similar: Their leaves look the same and they are not flowering yet. This might have economic implications later. Hypothetically, Mr. Sanchez said, a returning overseas Filipino worker might procure PHP 300,000 worth of seedlings from an orchard at PHP 300 to PHP 400 a piece, hoping that it will be sweet tamarind. Little did he know that after three to five years some fruits are sour. Sweet tamarind commands a different market price.

* **The Development of S&T-based Production Management Strategies** experiments with S&T interventions such as the identification or selection of dwarfing interstock genotypes to generate small tree plantations to address the high harvesting and picking cost in areas with limited skilled climbers. (High labor cost for picking—from PHP 2 to PHP 9 per kilo of harvest depending on the height of the tree—has been a major issue limiting the growth of the tamarind industry.)

It also entails the generation of technologies to control flowering dates that should not coincide with high-rainfall months; technologies expected to increase peel thickness with the post-harvest application; development of integrated pest management with emphasis on biocontrol agents, as food

processors require raw materials free of chemical pesticides; and trainings on market-driven production systems, processing, and marketing of tamarind. The beneficiaries of these strategies are the tamarind growers, and food and non-food product processors.

* In the **Value Chain Analysis and Marketing** component, the S&T interventions involve market data and information for policy recommendations and implementation of change or extension strategies; and linkage services between tamarind producers and market or processing entities. For example, the demand is already known for powdered sour tamarind (for *sinigang* broth), tamarind paste (for Worcestershire sauce), extracts (for pharmaceuticals), as well as ripened wet pods (or the fruit itself). This analysis aims to develop tamarind suited for those requirements, benefiting growers, processors, and sellers.




## ACCOMPLISHMENTS AND CHALLENGES

After a year of study, Program Leader Dr. Gonzales said that they could identify the sweet seedlings or trees from sour ones based on looking at the flower petals and buds.

At the same time, an ongoing study is set to determine the genomic distinction among sour and sweet tamarind genotypes. This will be the basis of policy recommendations to identify and accredit tamarind nurseries.

Dr. Gonzales disclosed that they have already identified genotypes or tree selections—one

By setting up a Soil and Plant Tissue Analytics Lab, and Genomic Laboratory, the Center has enhanced its R&D capabilities that can be utilized by the university's faculty researchers and students. Photos courtesy of the Tamarind R&D Center.

for sour type, one line for sweet type—with superior characteristics.

The selection "PAC Sour 2" was found to exhibit a higher pulp-to-pod ratio, while the selected "Golden Sweet" tamarind was found to have the thickest pod shell with the largest pod size and the highest individual pod weight of all the sweet lines. These superior selections will be applied for registration to the NSIC.

In the lab, Dr. Gonzales and the team also analyzed what nutrients are responsible for certain varieties' thick shells, desirable for their resistance to pests, diseases and breakage during harvesting, protecting the pods inside. From here, they should be able to identify which fertilizer element—whether nitrogen, phosphorus, potassium, or calcium—should be applied in the orchards.

Making DNA analyses of the genetic material of different tamarind lines across the Philippines, Mr. Sanchez explained that his project on genomic characterization has to do with checking the different tamarind types. "Some are big, some are small, some are flat, some are rounded, some have flowers that are colored red, while others are yellowish or others are light," he said.

This information, taken together with the morphological or physical features of the fruits, flowers, or leaves, is meant to help the tamarind industry, particularly the Bureau of

Plant Industry and NSIC to have improved standards in certifying sweet and sour tamarinds.

When it comes to improving yield, the program established 70 hectares of sour tamarind in Pampanga and Zambales.

These plantations have the minimum potential yield of 15 tons per hectare, or 1,000 tons in four years to five years, to supplement the raw material requirement of the industry. An additional 30 hectares will be established at the onset of the wet season from May to September 2021.

It should be noted that the supply volume of raw tamarind materials for processing in the Philippines at 7,436 tons (Crops Statistics of the Philippines 2015-2017, Philippine Statistics Authority) was not even enough to meet the annual requirement of one major broth processing company at 8,000 tons. Dr. Gonzales cited the processing capacity of Marygold Manufacturing Corp. as an example, at 5,300 kilograms per day during its processing months from October to December.

Crucially, the R&D generated valuable data, leading to the insight that small but closely spaced trees can reduce harvesting costs.

As such, there are plans in motion to identify dwarf varieties that are close to the ground, as well as maintain horizontal branches and suppress vertical growth through pruning and girdling, to make it cheaper to harvest, as well as potentially improve flowering and fruiting.

These and other best practices have been cascaded through media campaigns, webinars and community-based trainings of 66 farmers from organizations, such as the New Maria Sinukuan Upland Farmers Association of Arayat Inc.; Ayala-San Agustin Farmers Association; Samahan ng mga Magsasaka at Maggugulay ng Tukod; Tukod Farmers and Vegetable Growers Association; and Alyansa ng Magsasaka at Maggugulay ng Tukod. On the lighter side of things, two "*Sampalok*" folk songs in Filipino and Pampango versions were created to highlight the advantages of establishing tamarind plantations and the crop's health and wellness benefits.

Companies producing tamarind powder require pods to be free from synthetic chemicals. To meet this requirement, the project has identified two beneficial organisms that were found effective against tamarind diseases: *Trichorderma harzianum*, found effective against *Podosphaera sp.* (92%) *Fusarium sp.* (70.43%) and *Aspergillus niger* (55.30%); and *Trichoderma viride* as potential biocon agent to Fusarium sp. (49.65%). Photos courtesy of the Tamarind R&D Center.

Ruel Nucup, Chairman of Maria Sinukuan Upland Farmers Association in San Juan Baño, Arayat, Pampanga said: "*Isa sa mga challenges namin ay yung pagtaas nang pagtaas ng [puno ng] sampalok; pangalawa, yung kulang sa pagdadalhan ng produktong sampalok; pangatlo, kung minsan ang tanim matagal ang hinihintay bago mamunga."* [One of the challenges we experience in farming tamarind is that the tree is getting taller and taller; second, lack of market; and third, sometimes it takes long for the plant to bear fruit.]

He added: "*Naituro ng NICER na kailangan i-prune ang puno ng sampalok para hindi tumaas nang tumaas at mapaaga pa ang pagbunga nito. Nagbigay din sila ng mapapagbagsakan ng produktong sampalok o buyer; at mabilis magbunga na ang tanim na sampalok dahil grafted na at garantisado pang maraming bunga dahil mabunga ang mother tree na pinakuhanan. Sa bagong teknolohiya, nakatutulong ang DOST-NICER."* [DOST-NICER taught us the need to prune the tamarind tree so that it will not grow taller and have its fruits earlier. They also gave us buyers to whom we bring our products;

and our plants grow fruits faster because they are grafted that guaranties more fruits like the mother tree. DOST-NICER provides support through new technology.]

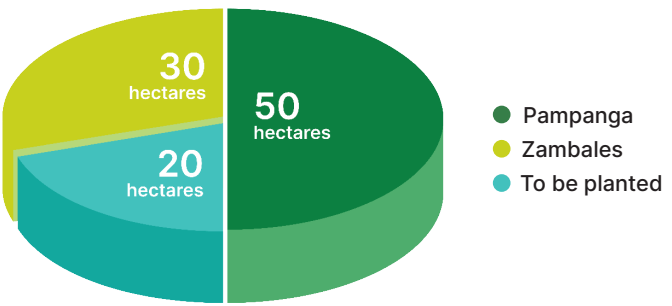
Having designed the project prior to the pandemic, Dr. Gonzales shared that it was quite a struggle to collect the samples of sour tamarind flowers, fruits, and leaves from all regions nationwide because of travel restrictions and the requirements for travel documents.

However, he called it a good accomplishment to have collected samples from seven of 14 regions. Partners from state universities and colleges also stepped up, and the team sought alternative logistics services.

## COMBINING PRODUCTION AND MARKETING

Most notably, the Tamarind R&D Center regularly links tamarind producers with the market.

A total of 81 tamarind producers were assisted from Pampanga, Bulacan, Nueva Ecija and Tarlac, while four tamarind entrepreneurs were assisted in Bataan, Nueva Ecija, Metro Manila and Laguna.




The Center has committed to plant 100 hectares of tamarind in three years time. As of October 2020, the Center has established a maximum of 70 hectares of tamarind plantations predominated by sour types through the "Plant Now Pay Later" scheme. The remaining 30 hectares will be planted in the next wet season, which lasts from May to October.

To bring their products to market, the Center has been coordinating with processing entities, like the Sunrich Manufacturing Corp. in Canlubang, Laguna, which can process up to 60 tons per day, as well as Marygold Manufacturing in Pasig City that can process 5,300 kilograms a day.

Dr. Gonzales said it was an accomplishment to make the households aware of the overwhelming raw material requirements of the tamarind processing facilities of at least six tons a day: an opportunity.

He added, "With the advent of social media, we intend to remove the participation of market intermediaries [middlemen] in the tamarind trade."

Today, farmers are able to pick the fruits faster because the tamarind trees no longer grow very tall. What's more, the quality of the fruits has improved and the trees bear more fruits.

Next, they are aiming for the export market. "In 2019, I still remember when we received an email from an importer from Japan requesting us to facilitate the supply of 1,000 kilograms of tamarind pulp per month for export," Dr. Gonzalez recalled.

Aware of the Center's capabilities, he said it will support the transformation of unproductive marginal lands—the drought-prone infertile areas and denuded hillsides—into tamarind plantations. "The NICER Tamarind R&D Center shall be the central hub serving to facilitate the linkage and collaboration among stakeholders of the tamarind industry [producers, processors, exporters] both national and international levels," Dr. Gonzales said with pride. He also wanted to inspire confidence in farmers, that the tamarind seedlings they will buy from the center are "true to type."

To illustrate, he used as example the PSAU Sour Tamarind No. 2 as having the highest yield or the best qualities. If a farmer would buy that variety, a certification from the center—which he envisions as the premier tamarind center in the country—will give the farmer a sort of guarantee that his or her investment will bear the fruits he wanted to have after three to five years: big, healthy, and have good weight.

Beyond being a backyard crop, Jacob Sanchez sees the tamarind industry growing in five to ten years. Budget from national funds and tapping DOST agencies like TAPI (Technology Application and Promotion Institute) and PCHRD (Philippine Council for Health Research and Development) for product development and commercialization will be key. "The tamarind research expertise is now in Pampanga. But we want to bring this technology to different parts of the country, so we have collaborations in Luzon, Visayas and Mindanao." Photo courtesy of the Tamarind R&D Center.

Farm owner Rafael Nopre of Barangay Cadmang, Cabanggan, Zambales said: "*Isang paraan ito upang maiangat ang aming pamumuhay. Ito ang kailangang programa lalo na sa kanayunan. Bukod sa pagsasaka, ang bagong industriya na ito ay panibagong source of income namin."* [The program is a big help to us. It is a mechanism that helps improve our lives. This program is needed especially in the countryside. Besides farming, this new industry is our new source of income.]

"*Una, dahil ito [tamarind] ay bagong pananim para sa amin, hindi pa namin gaanong kabisado ang mga pangangailangan nito. Pangalawa, ang problema, lalo na sa probinsya ng Zambales ay mainit na panahon, kaya tubig ang kailangan. Dahil bukal lamang ang source ng tubig sa lugar namin, kailangan ang water system. Pangatlo, ay ang makapagpagawa kami ng maayos na daan para marating ng sasakyan ang lugar ng taniman para sa mabilis na pag-transport ng produkto."* [First, since the tamarind is a new crop, we have no knowledge on its requirements. Second, the problem in Zambales is hot weather, which requires water. Since our water source is the spring, we

The municipal administrator Mr. Cunanan foresees a tamarind-based cottage industry, providing jobs to farmers, mothers, and out-of-school. So far, he is betting on the success of a sweet variety, the Aglibut Sweet Tamarind. Photo courtesy of the Tamarind R&D Center.

need a water system. Third, is the building of a good road so the vehicles could reach the farms for fast transportation of the farm produce.]

"*Umaasa ako na kapag nasunod namin ang lahat na alituntunin, ng tamang protocol sa pag-aalaga ng tamarind, naniniwala ako na may magandang kinabukasan lalo na in terms of income. Simula nang nag-umpisa ako sa pagtatanim ng fruit trees at mga punungkahoy sa Cabanggan, unang programa ko ay ang makatulong sa community lalo na sa baryo ng Cadmang. Ibig ko na makapagbigay ng hanapbuhay sa mga tao dito lalo pa at ang majority sa kanila ay indigenous people. Malaki ang hangarin ko na maiangat ang kanilang pamumuhay sa pamamagitan ng pagbibigay ng mapapagkakitaan.*"[I am hoping that if we follow all the rules of the protocol in taking care of the tamarind, I believe there will be a beautiful future for us, especially in terms of income. Since I started planting fruit trees and other trees in Cabanggan, my first program is to help the community, especially in Cadmang barrio. I want to give jobs to people, especially since the majority of them are indigenous people. It is my utmost desire to raise their standard of living by giving them a source of livelihood.]

Through the trainings, Mr. Nopre is now well aware of the concept of adding value. On his wishlist is a processing plant: "*Para sa added value to the product hindi lang sa tamarind kundi sa mga ibang pananim gaya ng sili, kawayan at iba pa.* [To add value to the product, not only to the tamarind but also to other crops, such as chili, bamboo shoots and others]," he said.

Pruning techniques create lower trees that make it easier to pick tamarind. Photo courtesy of Tamarind R&D Center.

Mr. Remin Sardo, Municipal Agriculturist
from San Marcelino, Zambales said:

***"Ang NICER, malaking tulong to deliver to our farmers the result of R&D, dahil sila naman talaga ang end users. Malaki po ang maitutulong ng PSAU since diyan po na-develop ang mga technology sa tamarind farming and I believe na nandiyan ang mga tamarind experts."***

[NICER is a big help to deliver to our farmers the result of R&D since they [farmers] are the real end users. PSAU can provide a big help since the technologies in tamarind are developed there and the tamarind experts are there.]

Collecting pests for identification of possible sources of disease for sour and sweet tamarind trees at Baculong, Victoria, Tarlac. Photo from Tamarind Community PSAU's Facebook page.

# Biodiversity R&D Center

## Cebu Technological University (CTU)

The Philippines is one of the world's megadiverse countries, owing to its geographical isolation, diverse habitats, and high rates of endemism—fifth in terms of plant species and fourth in terms of birds. Unfortunately, the Philippines also has one of the world's highest numbers of endangered and threatened species, making it one of the priority areas for global conservation.

According to the Cebu Technological University (CTU) Argao team led by Dr. Archiebald Malaki, biodiversity loss is a "behavioral" issue that can be addressed by proper education coupled with an enabling environment.

**The first step is discovery.**

The CTU-Argao team is aware of the power of spreading knowledge. They believe that as more and more endemic species are discovered through field surveys, the appreciation and understanding of the unique and priceless biodiversity in the area will eventually lead to the desire to protect it.

## KEY METHOD

The field surveys have been identified as a key method in a program to protect the biodiversity in Cebu, home to many endemic species, especially birds. Cebu's forests are home to 15 endemic flyers. But with only 1% of forest cover left compared to 1987, it has become a critical area.


Flora and Fauna Assessment Using Permanent Biodiversity Monitoring System (PBMS) in Cebu Island Key Biodiversity. Photo courtesy of the Biodiversity R&D Center.

Massive deforestation and rapid urbanization and population growth caused the extinction of several endemic Cebu species, such as the Philippine Cockatoo (*Cacatua haematuropygia*) and the Philippine Leafbird (*Chloropsis flavipennis*), and threats to four species, namely the critically endangered Cebu Flowerpecker (*Dicaeum quadricolor*), the endangered Black Shama (*Copsychus cebuensis*), the endangered Cebu Hawk-Owl (*Ninox rumseyi*) and the Cebu Brown Dove (*Phapitreron frontalis*). Mammalian species, such as the Visayan Spotted Deer, Visayan Warty Pig, and the Cebu Pygmy Buffalo, and a species of goby (*Sicyopus cebuensis*) fish, have also become extinct.

In 2006, the Department of Environment and Natural Resources (DENR) identified key biodiversity areas (KBAs): Nug-as and Mt. Lantoy; Mt. Lanaya-Mt. Kambulagsing; Tabunan Forests; Mactan, Kalawisan and Cansaga Bays; and Olango Island Wildlife Sanctuary.

Leading the charge to establish conservation priorities and programs is the Central Visayas Research and Development (R&D) Center for Biodiversity in CTU led by Dr. Malaki.

## PROJECT SPECIFICS

Aiming to clarify the biological inventory and ways forward for the local government units and conservators, the program has three component projects.

Project 1's general objective is to create a more effective and localized natural resource management system on Mt. Kangbulagsing and Lanaya, Mt. Lantoy, and Mt. Kapayas. Specifically, it seeks to assess the flora and fauna diversity, habitat types, and composition of KBAs through permanent biodiversity monitoring systems (PBMS). It also wants to further improve the information available for decision-makers in each area through regular data collection of natural biological resources, as well as develop a plant and animal database, establish visible conservation landmarks in the municipalities covered by the KBAs, and promote forest restoration and rehabilitation through the establishment of demonstration areas like plantations.

For Project 2 and 3, the general objectives are to determine the current status of mangroves and seagrass communities on Camotes Islands in Cebu, find

From top to bottom: Cebu Flowerpecker (*Dicaeum quadricolor*), the endangered Black Shama (*Copsychus cebuensis*), the endangered Cebu Hawk-Owl (*Ninox rumseyi*) and the Cebu Brown Dove (*Phapitreron frontalis*). Photos courtesy of the Biodiversity R&D Center.

enterprising activities related to such, and recommend policies for conservation and management. Specifically, Project 2 targets to determine the species diversity of mangrove communities, and explore the changes in land-use patterns, such as turning an eco-park into a residential or industrial area, among others. Meanwhile, Project 3's general objective is to determine the diversity of seagrasses in terms of their species, family, and genus, as well as to profile the habitat itself in terms of soil type, physicochemical parameters, and water depth.

Strong community participation is key. Locals were invited to do environmental profiling and vulnerability assessment, as well as in long-term planning of rehabilitation strategies and forest management practices to be turned into ordinances.

## PANDEMIC, PAIN POINTS, AND PROGRESS

The Project 1 on Flora and Fauna Assessment was supposed to end last December 31, 2020. However, due to the COVID-19 pandemic restrictions, some activities were not fully implemented on time. Among them are the geotagging of mother trees, putting up landmarks on flat corners, and establishing forest nurseries and plantations in three KBAs.

Despite the drawbacks, Professor Malaki proudly disclosed that they had recorded potential new species of orchids and snails whose slime can be used for their antibacterial properties. Jaime Getaruelas, vice president of

### BY THE NUMBERS

To share the knowledge with more people, the program published:

**9** papers in journals

**6** guidebooks (three each for floral species and fauna species—for which the center has applied for copyright)

The program has also established:

**3** Memorandums of Agreement with LGUs to manage the key biodiversity areas (and suggested one policy input to the LGU in Barangay Canbantug, Argao)

KMYNPNA people's organization, who volunteered for the participatory mapping in Nug-as, Alcoy, said *"Dati, kaming mga volunteers hindi namin kilala kung ano yung nandoon sa gubat. Kapag may bisita... wala kaming maisagot sa tanong nila kung "Ano 'to?" sa mga bagay na nakikita nila kahit mga snails or plants... hindi namin kilala."* [Before, we volunteers could not identify the natural resources in the forest. When we have visitors... we could not answer their questions of 'What is this?' to the items they see even the snails or plants... we could not identify them.]

Among the Center's "first island records" were a north Philippine Temple Pit Viper (*Tropidolaemus subannulatus*), and 16 species of trees and ten species of snails.

When it comes to flora, 5,201 trees were classified into 86 families, 237 genera and 471 species in the four KBAs of Cebu. The distribution of 16 trees was newly recorded, along with the ten threatened (according to the Department of Environment and Natural Resources' list) and ten endemic tree species.

A total of 278 mother trees were geotagged, representing 115 species in 64 families in

From top to bottom: Mt. Lantoy KBA-Argao, Mt. Lanaya KBA-Malabuyoc, Mt. Kapayas KBA, Catmon, Nug-as Forest KBA, Alcoy. Photos courtesy of the Biodiversity R&D Center.

38 of the permanent biodiversity monitoring plots which could serve as sources of good quality seeds and planting stock.

For Project 2, the program recorded a total of 30 mangroves and associated species, greater than what was reported during the previous assessment. On Camotes Islands, data was collected from the three municipalities of San Francisco, Poro, and Tudela. And more will be mapped.

Professor Malaki said, "It may be a new Center. However, it is being manned by very competent biodiversity research practitioners. All of the Center's staff were trained under the guidance of renowned scientists/ professors at UPLB."

At least 75 persons, including tree farmers, eco-tourism guides, undergraduates, and graduate forestry students were trained in how to identify flora and fauna, as well as in a tool called basic GIS (Geographic Information System) mapping. Not only were they able to properly identify and collect the right wildlings for propagation, but they were also able to visualize the information they collected by laying out maps on computer platforms.

Jonathan Panerio Alcaria, Municipal Environment and Natural Resources Officer (MENRO) in Alcoy, Cebu, hoped there would be opportunities to learn new tools and technologies. "We lack knowledge on biodiversity... We are taking care of forests, but we have no expertise on what is in the forests... We are blessed for this opportunity."

## BY THE NUMBERS

To share the knowledge with more people, the program published:

**1** greenhouse for wildling propagation

**1** R&D office (converted from a stock room)

**2** hectares of native forest tree plantations on Mt. Lantoy in Argao

**2** growth chambers and 0.5 hectare plantation area for native tree wildlings on Mt. Capayas in Catmon

**0.5** hectare area for Cebu cinnamon (*Cinnamomum cebuense*) at Nug-as Forest

Some of the identified land snail specimens in Nug-as Forest and Mt. Kapayas, Cebu Island KBA

(Top) Left to right: *Chloraea fibula, Liptopoma woodfordi, Liptopoma nitidium, Ryssota oweniana, Helicostyla daphnis, Calacochlia bruguieriana.* (Bottom) Left to right: *Moulinsia fusca, Rhinocochlis nasuta, Helicina clappi, Trochomorpha sp.1, Euplecta sp., Trochomorpha sp.2.* Photos courtesy of the Biodiversity R&D Center.

He continued: "*I am hoping na mayroong technology transfer or information transfer na maibibigay sa amin mula sa results ng researches and studies conducted by different [universities and] organizations... Para maging tools... for our planning purposes, for future purposes. Ganoon siya ka-importante.*" [I am hoping there would be technology transfer, or information transfer to us from the results of the research and studies conducted by different universities and organizations... So that they could become tools for our planning purposes, for future purposes. That is how important it is.]

"*Minsan wala kaming data para sa mga pagpaplano sa mga initiatives dito.*" [Sometimes we lack data for the planning of our initiatives.]

## MORE INFORMED GUIDES, AND SUSTAINABLE TOURISM

To ensure that conservation efforts are upheld despite Cebu's focus on tourism, field guides were hired to conduct the program tasks with the added benefit of giving them income during the pandemic when travel slowed down. The DOST-NRCP sees this Program as a key contributor to sustainable tourism efforts in Cebu and the entire country. As a result, the

tour guides themselves have become environmental frontliners, aware of clear guidelines to follow. Some harmful practices that the locals are being made aware of include hunting, small-scale mining, bird's nest collection, release of exotic species, use of harmful chemicals in agriculture, and lack of waste management.

Mr. Getaruelas said, *"Ngayon may guidelines na kami kung paano ito i-protekta, kung anong gagawin namin para mas mapabuti pa ito."* [There are big changes because we now have guidelines on how we could protect the (flora and fauna).]

Carling Colipano Pautan, a resident and volunteer from Mt. Kapayas affirmed, "The birds are now being protected and more trees are being planted."

# FLORA AND FAUNA ASSESSMENT USING PERMANENT BIODIVERSITY MONITORING SYSTEM (PBMS) IN CEBU ISLAND KEY BIODIVERSITY AREAS

*Shorea contorta S. Vidal*
(Lauan)

*Diospyrus longiciliata*
(Itom-itom)

*Agathis philippinenses*
(Almasiga)

Photos courtesy of the Biodiversity R&D Center.

# POTENTIAL NEW FLORA SPECIES

Top to bottom:
*Raphiolepis, Ulaian, White Lauan*

Top to bottom:
New species 1- Nug-as Forest KBA
*Dascymaschalon lantoyense*
New species 1 - Mt. Kapayas KBA






Photos courtesy of the Biodiversity R&D Center.

# Center for Environmental Informatics

## UP Cebu (UP-CENVI)

Over-exploitation and competing demands have placed the Philippines' natural resources under immense pressure. This has translated into aquatic and agricultural resources that are under-maximized, more frequent occurrences of natural disasters, and the degradation of the country's unique biodiversity, among others. To sustainably manage its environmental resources, the country will need to invest in environmental informatics. This is critical in collecting and analyzing data, as well as developing tools and systems to make informed decisions and shape relevant programs.

To help build the Visayas region's capacity to address environmental and other issues through technology, the Department of Science and Technology's (DOST) Niche Centers in the Regions for R&D (NICER) Program is supporting UP Cebu's Center for Environmental Informatics (UP-CENVI). The three-year partnership is expected to help "maintain the region's leadership in the ICT industry, particularly in the fields of data science, remote sensing, and artificial intelligence by contributing to environmental conservation, research, and development," said Program Leader Dr. Mary Joyce Flores.

The program aims to establish a NICER Center on Environmental Informatics for Central Visayas in UP Cebu that conducts research and development, expands academic partnerships, provides technical services, and makes climate resiliency information accessible.

The UP-CENVI's two priority sectors are 1) agriculture, aquatic and natural resources, and 2) disaster risk reduction and climate adaptation. The program also intends to contribute to the growth drivers of Central

Visayas which include travel and tourism, information technology and business process management (IT-BPM) through R&D, Dr. Flores added

To date, UP-CENVI's work has been instrumental in creating thoughtful and tangible solutions to some of the region's pressing concerns.

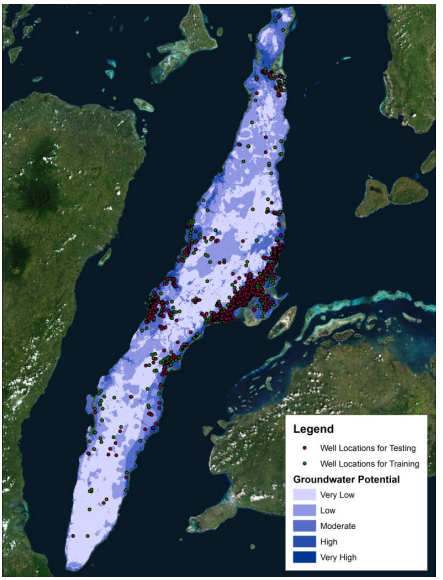
## CEBU GROUNDWATER MAPPED TO AVERT POTENTIAL WATER CRISIS

In 2017, the Department of Environment and Natural Resources (DENR) in Region 7 forecasted a serious water crisis on the island by 2025, or earlier, if corrective measures are not put in place. In addition, salty seawater has been seeping into inland water because aquifers are getting empty due to the overpumping of groundwater.

To help address this, UP-CENVI has developed a map of potential groundwater sources that can be tapped across Cebu. The map "would actually help guide policymakers or lawmakers in identifying areas for water regulation, and also for areas for development in terms of extraction," said Chito Patiño, UP-CENVI's supervising science research specialist.

A monthly groundwater well monitoring in Metro Cebu is conducted by the University of San Carlos - Water Resources Center Foundation, Inc. Photo courtesy of UP Cebu Center for Environmental Informatics (UP-CENVI).

"Instead of just searching blindly for possible water sources, they are now guided by maps that could point them to a good water source," he said. Mr. Patiño added that local government units (LGUs) have expressed interest




A groundwater potential map with Cebu as the study area. Photo courtesy of UP Cebu Center for Environmental Informatics (UP-CENVI).

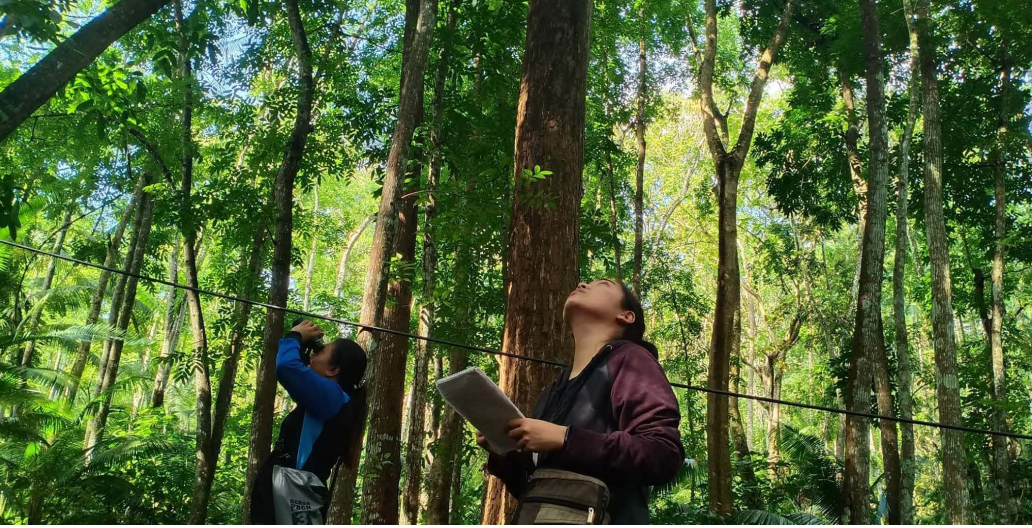
in the maps, noting that UP-CENVI's initial output was already tapped by the LGU of Alegria in Southern Cebu, which is quickly industrializing due to the discovery of offshore natural gas, to ensure a reliable supply of water in their locality.

Meanwhile, in Metro Cebu, the LGU of Mandaue is awaiting the Center's report on vulnerability to water contamination for the revision of their comprehensive land-use plan.

Beyond water extraction, the maps are equally important in protecting groundwater supply, especially to cushion booms in tourism, which is heavily water extractive.

## ENDEMIC SPECIES MAPPED TO AID CONSERVATION PLANS

Cebu is home to many endemic plant and animal species, several of whom may face extinction due to deforestation. To aid conservationists' work, UP-CENVI has produced around 90 to 100 species distribution maps



UP-CENVI volunteered in the Central Cebu Protected Landscape to do a simultaneous siloy (black shama) count. Photo courtesy of UP Cebu Center for Environmental Informatics (UP-CENVI).

which will be important in raising public awareness of these species as well as helping decision-makers prioritize areas in most need.

"This involves different species that are native and/or endemic to Cebu. From there, though, we're still [completing] the output; we will be able to provide guidance on how the province would [apply this] across their conservation plan," said Mr. Patiño. In addition, the city's tourism office in the region is excited about using the data to boost eco-tourism.

"Since we were able to identify which species would probably live in a certain area, they could make plans on how eco-tourism sites would be somewhat helpful to certain communities. [They would] be able to craft policies that would ensure that eco-tourism would not disrupt the current habitat," he explained.

## MAXIMIZING MANGO PRODUCTION

Mangos are responsible for about PHP 500 million worth of sales in Guimaras, yet millions are potentially lost due to pests and disease. With the increasing interest in mango production in Guimaras, the Center will

look into mango disease and pest monitoring to strengthen the industry. Though the project was delayed due to the pandemic, initial results have been promising.

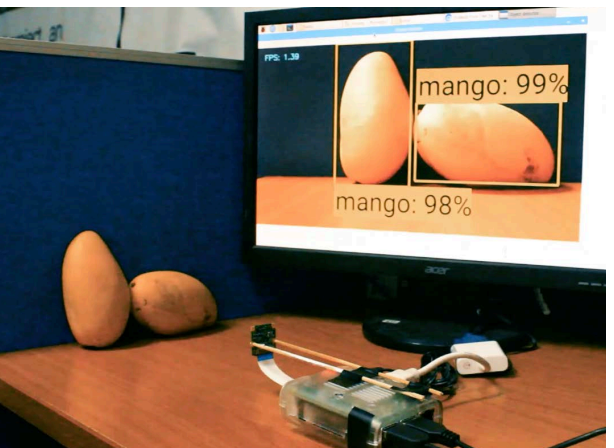
"In terms of its essential output, which is to identify certain pests and diseases of mangoes through its leaves, *kuha naman* [we have results]. [We are] doing a good performance already," Mr. Patiño said.

He added that the Center expects to get patents for the devices they are developing for mango pest and disease monitoring. This would be valuable in helping the Department of Agriculture protect mango and, potentially, other crops while contributing to more strategic business decisions.

"Crop and aquaculture businesses can make informed decisions and increase production once collaborative research goes on full swing at the center," the Program Leader said.

## SUPPORTING DEVELOPMENT PLANNING AND COMMUNITY-CENTERED PROJECTS

The partnership has also played a major role in supporting the work of civic-minded organizations and non-government organizations, particularly in mitigating potential disasters and planning projects benefiting local communities.




UP-CENVI demonstrates a device they have been developing to detect pest and disease that can degrade the value of Cebu mangoes. Photo courtesy of UP Cebu Center for Environmental Informatics (UP-CENVI).

UP-CENVI uses its FireCheck project to assist rescue teams and locate buried houses and victims after the 2018 landslide in Naga City. Photo courtesy of UP Cebu Center for Environmental Informatics (UP-CENVI).

Marivic Codiñera, Technical Development Support Officer at the Philippine Augustinians Development Office (PADO), which creates "Climate Smart Villages" for people without homes and farmer tenants said they tapped UP-CENVI's expertise to help identify potentially hazardous areas and locate those which are suitable for development, as well as provide recommendations on how to optimize their project property according to environmentally acceptable standards.

"PADO wanted to make sure that the planned developments are built on areas that pose zero or minimal risks to people and investments, and something that will also give justice to the environment," Ms. Codiñera said.

To ensure the safety and sustainability of PADO's 42-hectare project property in Barangay Kang-Actol, Dumanjug, Cebu, UP-CENVI conducted a suitability mapping that took a closer look at the possible hydro-meteorological hazards brought about by floods and rain-induced landslides. As a result, five hectares were identified as having low risks of landslides or flooding and where development could take place.

"We were made to consider carefully that the new developments in these areas should comply with the guidelines and regulations with respect to the natural hazard," she said.

In addition, nine hectares were identified as vulnerable to landslides and floods due to steep slopes. Using the mapping as a guide, she said they have

In 2019, UP-CENVI joined the property planning workshop for the Dumanjug Climate Smart Village of the Philippine Augustinians Development Office. Photo courtesy of UP Cebu Center for Environmental Informatics (UP-CENVI).

opted to slowly turn unsafe areas to eco-farm sites by planting endemic trees like narra, tic, tugas, etc. to slopey areas as well as vegetable gardens in hilly areas.

"The suitability mapping has also helped organizers introduce new technologies to the farmers in the community, who had previously relied on unsustainable slash-and-burn practices. Now, they use alternative organic farming practices of inter-cropping of vegetation to yield the maximum productivity of soil for vegetation, as well as vermi-composting," Ms. Codiñera said.

"The community members themselves are now supportive of the tree growing efforts of church and civic-minded organizations who regularly go there for this purpose. Monitoring of the trees grown is now being done with the active participation of the community having learned of the results of the suitability mapping of UP-CENVI," she said.

## ENHANCING RESILIENCE TO CLIMATE CHANGE

In Mandaue, UP-CENVI has also worked with Cordaid, an international emergency relief and development organization, to develop projects

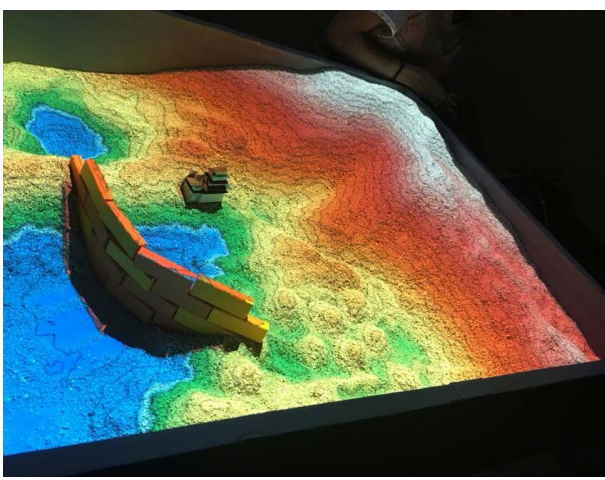
around integrated risk management, urban farming, and small-scale economic activities for low-income households in response to the effects of climate change.

In March 2020, the Mandaue resilience network was launched online, and in August 2020, an adaptation approach for vulnerable groups was developed. Both relied heavily on UP-CENVI's inputs in terms of generating maps to identify priority areas as well as laymanizing the data to for communities and other non-technical groups.

"UP-CENVI's distinct role was being able to support data consolidation across the entire city, being able to make a linkage with community information that we were collecting, i.e. what are the hazards, what are the vulnerabilities, what were the local capacities to cope with the risks identified, geographical perspective as well as social capital," said former Country Director for Cordaid Philippines, Ms. Anat Prag.

She added that through UP-CENVI, Cordaid was able to access valuable data, such as updated figures on water salinization, and the conditions and populations of informal settlements, as well as data to project storm surges.

"That was a very, very crucial part of being able to draw out a picture of different hazards, different vulnerabilities, different capacities across Mandaue, across the broader landscape," she said.



UP-CENVI presented their augmented reality (AR) sandbox in 2018. This AR sandbox is an educational tool that helps users understand concepts such as topography and mapping. Photo courtesy of UP Cebu Center for Environmental Informatics (UP-CENVI).

A drone is used for vegetation cover mapping in Barangay Tangbo, Samboan, Cebu. Photo courtesy of UP Cebu Center for Environmental Informatics (UP-CENVI).

"Those base maps... like all the climate projections, you got the different hazards, you got the vulnerabilities, different layers. What it means is that you can see a really clear picture of risks in Mandaue as a nontechnical person. And I think that that was really a terribly important part of the contribution that UP-CENVI made—that they were able to make complex information accessible to regular people. I think that that is a very, very important skill," she added.

Beyond creating maps and collecting data, the UP-CENVI team was also heavily involved in engaging and training stakeholders, which increased their participation in the project.

## IMPROVING DISASTER RELIEF EFFORTS

In Naga City, rescuers were able to enhance their skills and knowledge to respond more efficiently to disasters, including by using geographic information systems (GIS).

Mr. Patiño relayed that during a landslide in the city in 2018, which killed 78 people, the Center was asked to loan their equipment to the city rescuers. However, they realized that people doing the search and rescue operation did not know how to use the equipment with GPS.

"Prior to our intervention, the search and rescue was somewhat random. They just pick a location and then if they find certain signs of possible victims, everyone in the field of a huge area would concentrate on that point. *Matatagalan talaga yung* [That will prolong the] search and rescue, [because] everyone wants to have an output," he explained.

"When we went there, we provided them with the history of the location of the houses. Based on the locations, we told them that within a few meters around a five-meter radius, you could possibly find houses *na natabunan ng* landslide [covered by landslide]."

"I think just on their first attempt they were able to find one. It gave them confidence that maps would actually work. On the next excavations, we were able to analyze more exactly where the possible victims were. So in a matter of a week or two, the search was already. I think it is one of the fastest searches that was able to find the victims. Though sadly, it was not fast enough to be able to find survivors," he said.


The search team for the 2018 Naga landslide made use of UP-CENVI's maps to pinpoint possible victim locations. Photo courtesy of UP Cebu Center for Environmental Informatics (UP-CENVI).

Groundwater validation surveys continue in Toledo City, Cebu. The groundwater potential map created using these surveys can be used by local governments for water source prospecting, conservation, and regulation. Photo courtesy of UP Cebu Center for Environmental Informatics (UP-CENVI).

## BEYOND ENVIRONMENTAL MANAGEMENT: ENVIRONMENTAL INFORMATICS FOR ECONOMIC GROWTH AND HEALTH

From biodiversity studies to hazard mapping to crop monitoring, UP-CENVI and other partners' efforts have demonstrated the potential of environmental informatics to move the needle across a range of pressing issues and sustainably manage the country's natural resources. Beyond environmental management though, strengthening the UP-CENVI can also lead to economic and health gains.

Through the DOST's support of the Center, UP Cebu's faculty and researchers will be well-positioned to assist Central Visayas in its efforts to bolster human capital through graduates who are immersed in real-world research in ICT and sustainable tourism.

While the highly urbanized cities of Cebu and Dumaguete have been considered top global destinations for ICT and outsourcing businesses (Cebu placed 7th and Dumaguete, 93rd, based on Tholons 2016 ranking of Top 100 Outsourcing Destinations), their rankings have dipped as the cities have fallen behind in innovativeness, startup ecosystems, and digitalization.

UP-CENVI said that its use of "increased environmental informatics research and development [R&D] will hopefully increase and improve ICT workforce, inspire innovations and startup ideas, and transform our processes towards digitalization."

Amid the COVID-19 pandemic, the Center has also contributed to information and maps reflecting the prevalence of cases in specific areas.

## POSITIONING UP CEBU AS A LEADER

Since it was granted autonomy, UP Cebu has aggressively and successfully aligned itself with the growth trajectory and needs of Metro Cebu in the fields of ICT, product design, and environmental protection.

A member of UP-CENVI uses tools to collect data for their Mango Spectral Library Collection. Photo courtesy of UP Cebu Center for Environmental Informatics (UP-CENVI).

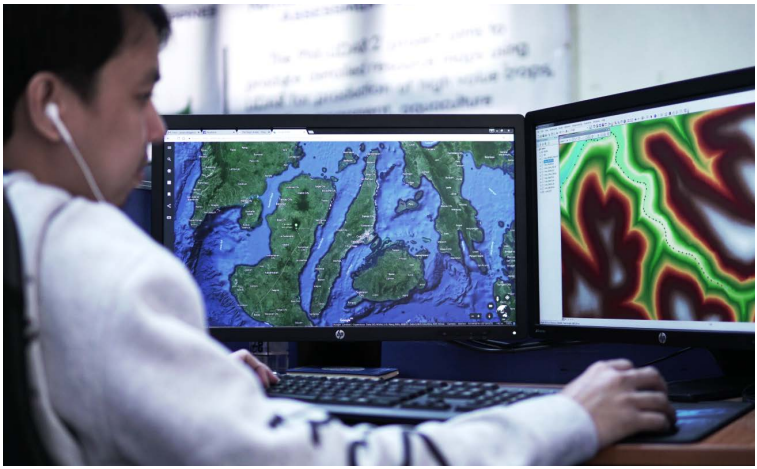
"The NICER grant will enhance UP Cebu's standing as a research university, improve its current inventory of scientific equipment, and facilitate collaborative research among its faculty and partner institutions in the academe, government and industry," Dr. Flores said.

Given the growing need of Central Visayas to maintain ecological integrity while sustaining its growing ICT and tourism-bolstered economy, supporting the UP-CENVI is a strong move toward propping the university as a leader in environmental informatics, and ultimately the region as a model in data-driven and impactful solutions.

UP Cebu intends to achieve a self-sustaining Center for Environmental Informatics similar to the success of its DOST-funded technology business incubator, Dr. Flores said.

Currently, UP Cebu is in different stages of talks with the local governments of Victorias City in Negros Occidental, Mandaue City, Lapu-Lapu City, and the provincial governments of Cebu and Negros Occidental to craft memoranda of agreement for more multi-hazard studies and information system developments in the future.

The testing of UP-CENVI's tree mapping app was done with the cooperation of the Municipal Environment and Natural Resources Office in Lumpan, Alegria. Photo courtesy of UP Cebu Center for Environmental Informatics (UP-CENVI).



UP-CENVI's scholarly research includes converting collected data into easily understood visual maps.

The UP-CENVI team participated in its first ever synchronised Siloy Watch last March, 2019. This was the biggest citizen science event during its time. Photos courtesy of UP Cebu Center for Environmental Informatics (UP-CENVI).

A geo-resistivity survey for groundwater assessment and exploration involves the use of electrical measurements carried out on the ground's surface. A method that determines the depth and thickness of the underlying resistivity layers. Photo courtesy of UP Cebu Center for Environmental Informatics (UP-CENVI).

CHAPTER III

# RDLead:

## Capacitating R&D Organizations

Research
and
Development
Leadership


Focused on developing human capital, Research and Development Leadership (RDLead) Program engages experts, called RD Leaders, with strong leadership, management, and innovative policy-making to assist in strengthening the research capabilities of Higher Education Institutions (HEIs), Research and Development Institutes (RDIs), and National Government Agencies (NGAs).

The role of the RD Leaders in their host institutions revolve around four (4) key functions namely:

1. Lead in establishing and/or upgrading of research and development centers;
2. Train and capacitate local researchers, faculty, laboratory heads, and staff;
3. Provide policy recommendations for the continuous development and sustainability of R&D centers; and
4. Develop and/or update manuals, modules, guidelines, and other related documents.

Since it started on July 2018, until September 2021, the RDLead Program has engaged 49 RD Leaders, of which 13 are females (26%) and 36 are males (74%). These RD Leaders were engaged for 46 institutions across all 17 regions of the country. The RD Leaders engaged have helped in different research-related areas like proposal development, manuscript writing and submission, technical training in various fields such as food technology, renewable energy, and agricultural engineering, among others. These fields of learning were deemed key in the research aspirations of the institutions that the RD Leaders are assisting.

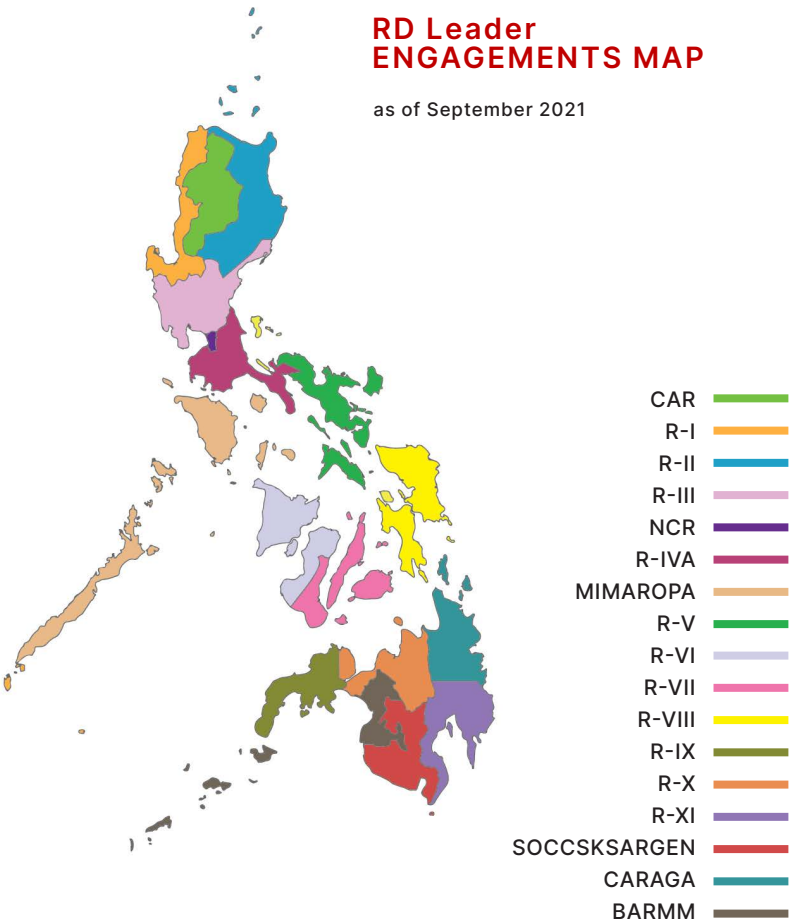
The RDLead Program has proven instrumental in the establishment of some of the Niche Centers in the Regions (NICERs) through the assistance and expertise that the RD Leaders extended to their hosts during the proposal development and revision phases of these NICERs when they were still "promising ideas on paper". These RDLead-assisted NICERs are the Sea Cucumber Research and Development Center of the Mindanao State University Naawan; the Seaweed Research and Development Center of the Mindanao State University Tawi Tawi; the Halal Goat Research and Development Center of the Sultan Kudarat State University; and the Queen Pineapple Research and Development Center of the Camarines Norte State College.

The program has likewise assisted the following NICERs in their implementation:

1. University of the Philippines Manila's Center for Innovations for Disaster Risk Response and Management in Health (UPM CDRRM-H);
2. Samar State University's Eastern Visayas Center for Crustacean Research and Development (SSU-EVCCRD);
3. University of the Philippines Cebu's Center for Environmental Informatics (UP Cebu-CENVI);
4. Cebu Technological University Argao's Biodiversity Research and Development Center;
5. University of the Philippines Visayas Miagao' s Center for Mollusk Research and Development (UPV-CMRD);
6. Rizal Technological University's Center for Astronomy Research and Development (RTU-CARD); and
7. Ateneo De Davao University's Mindanao Renewable Energy Center (ADDU-MREC).

The assistance and mentoring that the RD Leaders provided to their host institutions faced different challenges from the start, especially when the pandemic hit the country resulting in lockdowns and travel restrictions. Even though activities and travel to host institutions were affected, the RD Leaders and their host institutions pressed on and pursued the engagement

together. Some of the notable institutions that braved the different challenges with their RD Leaders include the following: Camarines Norte State College (CNSC), Biliran Province State University (BiPSU), Ateneo de Davao University's Mindanao's Renewable Energy Center (MREC), and the University of the Philippines-Visayas. We spoke to some the RD Leaders and their host institutions and asked them to reveal valuable insights when it comes to shaping R&D.



**CORDILLERA ADMINISTRATIVE REGION (CAR)**
- Mountain Province Polytechnic State College
- Philippine Military Academy

**ILOCOS REGION (R-I)**
- Northern Luzon Adventist College
- Don Mariano Marcos Memorial State University
- Ilocos Sur Polytechnic State College

**CAGAYAN VALLEY (R-II)**
- Batanes State College
- Isabela State University-SWIM R&D Center

**CENTRAL REGION (R-III)**
- Tarlac State University
- Nueva Ecija University of Science and Technology

**NATIONAL CAPITAL REGION (NCR)**
- UP Manila - CDRRM-H
- Industrial Technology Development Institute
- Rizal Technological University - CARD
- Universidad de Manila

**CALABARZON (R-IVA)**
- University of Rizal System
- Cavite State University
- Southern Luzon State University
- University of Perpetual Help System-DJGTMU
- Philippine Air Force - AETDC & ALEN
- Pamantasan ng Cabuyao

**MIMAROPA (R-IVB)**
- Mindoro State University

**BICOL REGION (R-V)**
- Camarines Norte State College
- Partido State University
- Sorsogon State College

**WESTERN VISAYAS (R-VI)**
- UP Visayas - CMRD
- Northern Iloilo Polytechnic State College
- West Visayas State University
- Capiz State University

**EASTERN VISAYAS (R-VIII)**
- Biliran Province State University
- Samar State University-EVCCRD
- Eastern Visayas State University
- University of Eastern Philippines

**ZAMBOANGA PENINSULA (R-IX)**
- Ateneo De Zamboanga University

**NORTHERN MINDANAO (R-X)**
- Mindanao State University-Nawaan
- University of Science and Technology of Southern Philippines

**DAVAO REGION (R-XI)**
- Ateneo De Davao University–MREC
- Davao del Norte State College
- University of Immaculate Concepcion

**SOCCSKSARGEN**
- Sultan Kudarat State University
- Mindanao State University General Santos

**CARAGA**
- Surigao State College of Technology
- Caraga State University

**BANGSAMORO AUTONOMOUS REGION IN MUSLIM MINDANAO (BARMM)**
- Mindanao State University-Tawi-Tawi
- Tawi-Tawi Regional Agricultural College
- Mindanao State University Maguindanao

## RD Leader ENGAGEMENTS

| | |
|---|---|
| FEMALES | 13 |
| MALES | 36 |

| RD Leader | Host Institution |
|---|---|
| Dr. Aristotle T. Ubando | Ateneo De Davao University-MREC |
| Dr. Nilo T. Bugtai | Ateneo De Zamboanga University |
| Dr. Roberto S. Clemente | Batanes State College |
| Dr. Floirendo P. Flores | Biliran Province State University |
| Dr. Teresita U. Dalisay | Camarines Norte State College |
| Dr. Ricardo P. Babaran | Capiz State University |
| Dr. Mudjekeewis D. Santos | Caraga State University |
| Dr. Luis F. Razon | Cavite State University |
| Dr. Inocencio E. Buot Jr. | Cebu Technological University Argao-Biodiversity R&D Center |
| Dr. Emmanuel P. Leaño | Cebu Technological University Argao-Biodiversity R&D Center |
| Dr. Alejandro F. Tongco | Davao del Norte State College |
| Dr. Laurence A. Gan Lim | Don Mariano Marcos Memorial State University |
| Dr. Argel A. Bandala | Eastern Visayas State University |
| Dr. Tonette P. Laude | Ilocos Sur Polytechnic State College |
| Dr. Maria Patricia V. Azanza | Industrial Technology Development Institute (Food Processing Division) |
| Dr. Blessie A. Basilia | Industrial Technology Development Institute (Material Science Division) |
| Dr. Guillermo Q. Tabios III | Isabela State University |
| Dr. Asuncion B. De Guzman | Mindanao State University-Naawan |
| Dr. Floredel D. Galon | Mindanao State University-Tawi-Tawi |
| Dr. Elmer P. Dadios | Mindanao State University General Santos |
| Dr. Emilia T. Quinitio | Mindanao State University Maguindanao |
| Dr. Mark Angelo O. Balendres | Mindoro State University |
| Dr. Daniel C. Peckley Jr. | Mountain Province State Polytechnic College |
| Dr. Gerald F. Quinitio | Northern Iloilo Polytechnic State College |
| Dr. Lorcelie B. Taclan | Northern Luzon Adventist College |
| Dr. Eulito U. Bautista | Nueva Ecija University of Science and Technology |
| Dr. Edwin Sybingco | Pamantasan ng Cabuyao |
| Dr. Thomas Edison E. dela Cruz | Partido State University |

| RD Leader | Host Institution |
|---|---|
| Dr. Franco G. Teves | Philippine Air Force, Air Education Training Doctine Command (AETDC) & Aviation Leadership and Excellence Nexus (ALEN) |
| Dr. Santos Jose O. Dacanay III | Philippine Military Academy |
| Dr. Ernest P. Macalalad | Rizal Technological University-CARD |
| Dr. Francis N. Baleta | Samar State University - EVCCRD |
| Elviro A. Cinco, M.Sc. | Samar State University-EVCCRD |
| Dr. Shirley T. Palisoc | Sorsogon State College |
| Dr. Cynthia Grace C. Gregorio | Southern Luzon State University |
| Dr. Reynaldo L. Intong | Sultan Kudarat State University |
| Dr. Ryan Rhay P. Vicerra | Surigao State College of Technology |
| Dr. Dennis V. Cantre | Tarlac State University |
| Dr. Eureka Teresa M. Ocampo | Tawi-Tawi Regional Agricultural College |
| Dr. Edison A. Roxas | Universidad de Manila |
| Dr. Rey Donne S. Papa | University of Eastern Philippines |
| Dr. Mario V. Capanzana | University of the Immaculate Concepcion |
| Ms. Maria Nilda M. Muñoz, M.Sc. | University of Perpetual Help System-DJGTMU |
| Engr. Isidro Antonio V. Marfori III | University of Rizal System |
| Dr. Wilma A. Hurtada | University of Science and Technology of Southern Philippines Claveria |
| Dr. Drandreb Earl O. Juanico | UP Cebu-CENVI |
| Dr. Michael Joseph S. Diño | UP Manila-CDRRM-H |
| Dr. Marco Nemesio E. Montaño | UP Visayas-CMRD |
| Dr. Jonel P. Saludes | West Visayas State University |

**DR. TERESITA U. DALISAY**

Queen Pineapple
R&D Center

*On kicking off an R&D Project*

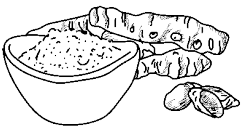
"The 'take-off' meeting held at the Camarines Norte State College (CNSC) was successfully conducted and the workshop started right after. Researchable areas to operationalize the center were identified, followed by the setting up of groups to deliberate and eventually come up with 'what, why, and how' to do the projects covered by the center. The workshop continued the following day, during which, each group presented their output. There was no training conducted to come up with good proposals. The two-day workshop was just enough to have triggered their interest, excitement, and 'brain cells' to work efficiently and come up with proposals. An RD Leader has a big role to play in guiding the proponents in the program they aspire to be implemented. They are the ones that have that dream [they want to] become a reality. [An RD Leader is] simply instrumental, 'a small branch from a big trunk.' It is mainly the proponents that get the 'big chunks or slices,' meaning the big credit to the success of the program's approval. There are identified projects comprising the program, but they [the proponents] will not stop making more project proposals along its implementation period. It will be a never-ending process of asking the whats, whys, and hows."

The Camarines Norte State College (CNSC) felt the need to save the distinctly sweet queen pineapple that added a gem to Camarines Norte's crown as the "queen pineapple country." Being the only college of agriculture in the province, CNSC deemed that the establishment of a queen pineapple research and development (R&D) center would best help the farmers and the industry in the province. Thus, maintain the sweetness the fruit has been giving to the lives of the farmers and to the industry. Photo courtesy of Camarines Norte State College.


Dr. Teresita U. Dalisay as she led an analysis of strengths, weaknesses, opportunities, and threats (SWOT) that led to interesting research questions during the writeshop at CNSC. Photo courtesy of the National Research Council of the Philippines (DOST-NRCP).

The CNSC researchers attended a two-day proposal writing workshop or "writeshop" assisted by RD Leader Dr. Teresita U. Dalisay in April 2019. Throughout the workshop, Dr. Dalisay acted as a hands-on mentor in guiding the participants as she went around and talked to each group to give them assistance or suggestions. She shared with them her rich experience in the field when she was starting similar projects, and as a professor at the Institute of Weed Science, Entomology and Plant Pathology at the College of Agriculture and Food Science in University of the Philippines Los Baños. Photo courtesy of the DOST-NRCP.

As an RD Leader Dr. Dalisay explained that she assisted the program leader (Dr. Alegre) through a "constant 'kumustahan' [asking of developments]." "The concept and reasons behind the program are all their own work. It is the role of the RD Leader to guide or assist them in what researchable areas will be included in the program, those areas that will hone the Queen Pineapple industry in the region," she pointed out. Photo courtesy of the DOST-NRCP.



**DR. FLOIRENDO FLORES**

Turmeric Crop Farming and Food Production

*On working with natural resources*

"We believe that Biliran province was chosen [to spearhead this kind of research] because turmeric can be not just grown there, but integrated into an agri-tourism development project. Sometimes, we can get stymied by bureaucracy, so I really appreciated how the RDLead Program created the linkage between me and BiPSU so that we were able to discuss our roles and responsibilities. The turmeric research in the Philippines is a little unwieldy because there are sporadic farmers and sporadic usages in turmeric. One commendable thing about turmeric farming in the Eastern Visayas region is that we are doing this already. Agronomically, the red soil in Eastern Visayas is really suited to turmeric. When I went there and talked about different possibilities and research directions, I think it made sense to them to not just focus on the scientific aspect of turmeric processing into food products, but to think about turmeric as a way for them to get leverage, with other funding agencies and the national government. I'd like to think that, in the next five to ten years, the Philippines will be in a position to have a greater share in processing and promoting turmeric products, including but not limited to the bioactive components."

According to the research pitch by the Biliran Province State University (BiPSU), turmeric thrives in six locations in the Eastern Visayas Region. Three of the top locations for turmeric farming are Brgy. Calerokan in Gandara, the municipality of Calbiga, and Ormoc City, Leyte. This region also has active farmers associations across its different municipalities and cities. The highest estimated yield for turmeric is 635 kilograms per harvest and it is commonly sold raw or processed into a powder. Photo courtesy of DOSTv: Science For The People.

The DOST's Regional Research, Development and Innovation Committee (RRDIC) identified turmeric as the priority for the NICER project since Eastern Visayas' red soil is suited for the crop and there are sporadic turmeric farmers in the region. It could be grown for domestic consumption and exported to Western countries where turmeric has gained popularity as a spice and colorant. Dr. Flores believes that Biliran province was chosen because aside from growing turmeric, the land can be integrated into an agri-tourism development project. Photo courtesy of DOSTv: Science For The People.


In the research process, Dr. Flores points out that securing the farmer communities and the LGUs' consent was crucial. Additionally, Dr. Flores was surprised to see that BiPSU's research team recognized this and applied it into their most recent version of the research proposal. "The turmeric farmers really fend for themselves. For BiPSU to talk to them and not just use them as instruments for their research proposal [...] To talk to them as collaborators—I think [the communities] appreciated that," he said. Photo courtesy of the DOST-NRCP.


Dr. Flores says that the Philippines has strong state colleges and universities that are able to come together and be confident in what they do. That said, he believes that BiPSU can also recognize its capabilities to undertake a bigger project in the future. In their most recent version of the research pitch, BiPSU's research team hopes to help farmers financially gain from turmeric production. By leading the promotion of the turmeric industry, they can contribute to reducing poverty and aiding the economic growth of the region. Photo courtesy of the DOST-NRCP.

**DR. ARISTOTLE T. UBANDO**

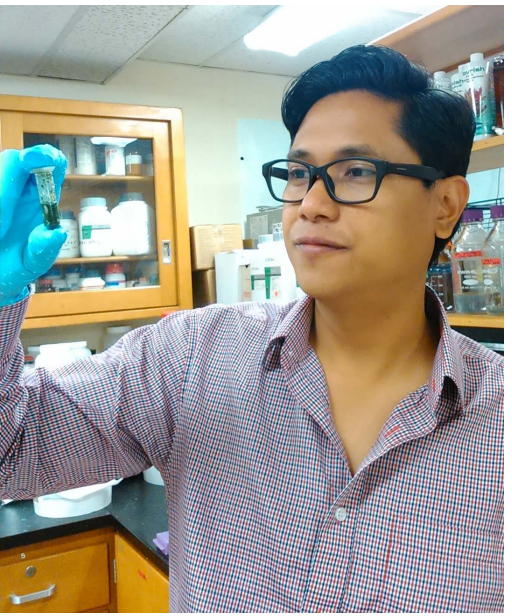
Mindanao Renewable
Energy Center

*On preparing a proper framework*

"The initial activity that they actually needed was the Computational Fluid Dynamics or CFD modeling training. It is a computational methodology wherein you use software to design turbines. That initial activity led us to develop what we call the "Renewable Energy Research Ecosystem Framework," and in this framework, we were able to map out how each of these stakeholders, each of these Mindanao universities, would be able to connect [to] Mindanao Renewable Energy Center or MREC in terms of research. The RDLead Program was able to connect the need as well as the expertise. Since I am more capable of being one of the experts in CFD, I think [the research] would be very successful since we already have developed the Renewable Energy Research Ecosystem Framework. At the same time, through the RDLead Program, we would be preparing a sustainable plan for MREC, and the sustainability plan would itemize step-by-step procedures on how MREC can proceed with the research even after the funding of DOST. So you have the sustainability plan, and we have the Renewable Energy Research Ecosystem Framework to match the sustainability plan."

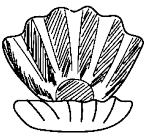
Dr. Aristotle Ubando is a Full Professor and Research Fellow at the Mechanical Engineering Department of De La Salle University whose research includes computational fluid dynamics (CFD). It is his expertise in this field which aided in his work as the RD Leader of Ateneo de Davao University's (AdDU) NICER – Mindanao Renewable Energy Center (MREC) Program. The AdDU researchers needed training that could enable them to do computational fluid dynamics for designing an ocean turbine that could provide renewable energy. Photo courtesy of Dr. Aristotle Ubando.

Since the AdDU invited other Mindanao universities to attend the training sessions, Dr. Ubando says that the talks became a conglomerating event for stakeholders. This resulted in the development of the "Renewable Energy Research Ecosystem Framework," with MREC serving as a research hub for renewable energy. It serves as a starting point for other collaborations and allows the people involved to see the capacity in which the government and the private sector can assist in the future. Photo courtesy of Dr. Aristotle Ubando.



According to one of Dr. Ubando's presentations, their study in renewable energy is motivated by several global factors: the flattening of global carbon dioxide emissions in advanced economies due to the expanded role of renewable energy sources and recent movements to shift into renewable energy due to lowered energy demands amid COVID-19 pandemic lockdowns. Overall, Dr. Ubando's team is focusing on solar and ocean/wave energy which can be harnessed in various areas in the Philippines, as proven by other Filipino researchers in the past. Photo courtesy of Dr. Aristotle Ubando.

Dr. Ubando believes that he and the research team have a "matching of strengths" as his expertise is on the modeling component of the study and the AdDU team excels in the experimental component. The researchers are very supportive of him because of this. In five to ten years, he looks forward to the success of the project. Through the RDLead Program, they would also be able to prepare a sustainable plan that can outline a step-by-step procedure that allows MREC to do independent research even after the DOST's grant for the program is completed. Photo courtesy of Dr. Aristotle Ubando.



**DR. MARCO NEMESIO MONTAÑO**

UP Visayas Miagao Center for Mollusk Research and Development Center

*On utilizing waste materials*

"The UPV Miagao people already know the work, so my approach was [to] introduce to them [to] do research to serve for a utility, to serve the people. What can others do with your substance? Because of [an] activity we had, we were able to get in contact with the pearl farm. The golden pearl farm. When they collected the pearl shells, they only collected the pearl. They threw away the meat of the shells. Our proposal to them was to utilize those. My recommendation to DOST [was] basically [that] if we have a project like that, [it] should lead towards the community. You also have to tie up [with] the industry and also the local government. [In five to ten years], I think there will be more research. Because of the pandemic, *natigil yung activities* [the activities were stopped], but there will be more, I think, project proposals. One of them is the expanding into the food of the mollusks, squids, and micro-algae. The pearl farmers were telling me about their longtime problems with how to dispose of the meat, the shells. And then, I guided the researchers there to make a proposal. You have to value the shells, you have to value the meat."

Dr. Marco Nemesio E. Montaño is a retired professor of the UP Marine Science Institute, a consultant for various DOST councils and regions, and has been involved in noteworthy international programs across Asia. When he first observed the Research and Development capabilities of UP Visayas Miagao Center for Mollusk Research and Development (CMRD), he believed that they needed a reorientation of their outlook in the NICER research. “My approach was [to] introduce them [to] do research, basically, to serve for a utility, to serve the people." Photo courtesy of UP Visayas Miagao CMRD.

As an RD Leader, Dr. Montaño emphasizes the need for both theory and application in research. He specifically cites the French Chemist Louis Pasteur as an example of a person who has done academic research with utility. His support for the researchers was guided by the question: “What can others do with your substance?” This, he says, helps them realize that research should also have a utilization through the community of their region. These researchers can publish their work and apply their knowledge to the people at the same time. Photo courtesy of UP Visayas Miagao CMRD.

Currently, Dr. Montaño's assistance as the RD Leader in UP Visayas CMRD has resulted in over ten different research program proposals—all related to finding value in products from mollusks. Some of these include programs in the Sulu archipelago, as well as the Asid and Ragay Gulf. Photo courtesy of UP Visayas Miagao CMRD.

Dr. Montaño says that the mollusk farmers have talked to him about their long-standing problems with the disposal of the oyster meat and shells. So, he guided the researchers to make a proposal for them. "You have to value the shells, you have to value the meat," he says. With that, he gave a tip to look into making oyster sauce for cooking purposes or using oyster pearls in skincare products. Photo courtesy of UP Visayas Miagao CMRD.

CHAPTER IV

# CRADLE:

## Industry-Academe-Government Linkage

## Collaborative Research and Development to Leverage Philippine Economy

In the Philippines, the majority of the research done by the academe is not used by the industry. The Collaborative Research and Development to Leverage Philippine Economy (CRADLE) Program aims to change that by shifting research practice from being publication-centric to being local company-driven.

Designed to create collaborative projects in the short term and synergistic relationships in the long term, the CRADLE Program allows a local company to determine its problem/need, which requires an R&D solution while the partner academe or research and development institution (RDI) undertakes the R&D to solve the identified problem/need.

Enabling all this is the DOST's funding support for up to PHP 5 million, across a period of one to three years. In return, the partner company provides at least 20% counterpart funding and commits to adopting the technology. With this framework, both the academe and company benefit from collaboration through the following: (1) Higher chances of success for the project because research is done by experts; (2) Financial risks for R&D are reduced; and (3) Readily adoptable research outputs for the company are developed. Since the program's implementation in 2017 until September 2021, it has funded 73 collaborative R&D projects across the country, with a total R&D budget of PHP 335 million. The projects are being implemented by 32 HEIs/RDIs and 74 partner companies.

# Building a sustainable water supply through SOFTWARE

In 2019, Manila experienced a shortage in water supply when the El Niño went on for longer than usual, a headline-making indication of global warming.

Angat Dam, from which utility companies get the bulk of the water they pump to Metro Manila's households in the East Service Area, was running dangerously low.

The team of Mark Orbos, Head of Corporate Strategy at Manila Water, carefully monitors the dam water levels. They pump water from this dam through their treatment plants in Balara La Mesa and finally into one million Metro Manila households consuming an estimated 1,600 million liters of water daily. Watching the dam through data loggers was always part of Mr. Orbos' team's regular routine. For years, they could predict water levels for as far as two weeks ahead. But this time, they didn't.

"Because of how the water infrastructure has not developed to the pace of the development of Metro Manila, that margin or that buffer that the dam affords us is so thin," Mr. Orbos elaborated. In order to ensure they had enough water supply, they had to wait for rain to come—a risky precaution with no guarantee.

It dawned on them: while the population in Metro Manila had continued to grow through the years, its water infrastructure was not able to keep up. Taguig is a primary demonstration of this dynamic—a city that was virtually non-existent 20 years ago but is now one of the most important central business districts.

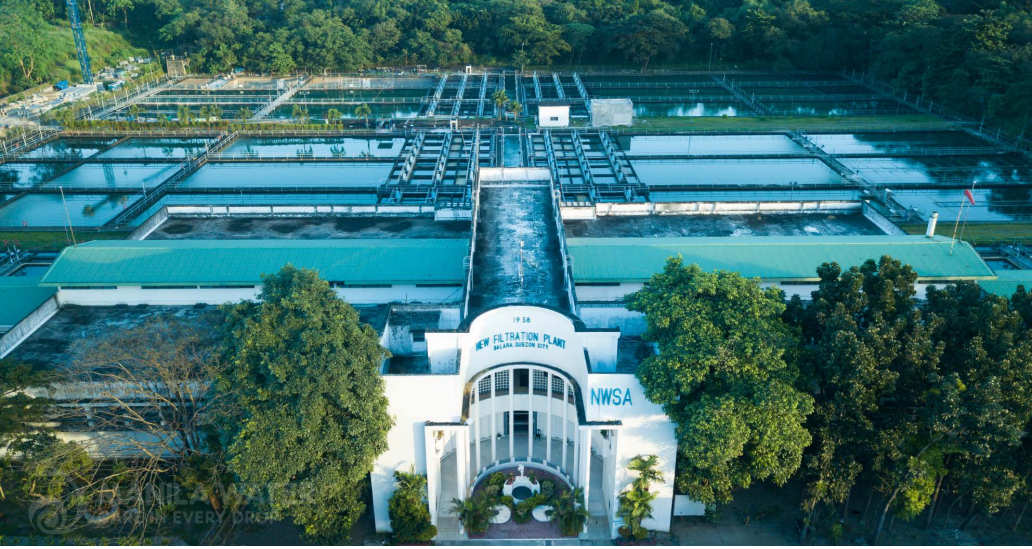
**Meanwhile, the Angat Dam has undergone no changes since it was built in the 1960s.**

This was compounded by the El Niño situation that summer of 2019. The water levels to the East zone of Manila fell short by about 8%, which was equivalent to 500-600 thousand Filipinos left without any water to use.

Mr. Orbos and his team had to do something. He started working together with Dr. Christopher Monterola of Asian Institute of Management's (AIM's) Data Science Laboratory. Prof. Chris, as everyone calls him, wears several hats. Apart from being the head of the Aboitiz School of Innovation, Technology, and Entrepreneurship, he is also leading ACCeSs@AIM—Analytics, Computing, and Complex Systems Laboratory. What is easily noticeable about Prof. Chris is how much he lights up when he talks about science in the Philippines. He attributes his strong sense of nationalism to holding the lifetime honor of being an academician of the National Academy of Science and Technology under the DOST.

The two met at an innovation conference in Singapore back in 2017, where Prof. Chris was presenting transport simulations of what would be the world's first smart city found in Singapore. A group from Manila Water was in the audience. When Prof. Chris returned to the Philippines in 2019, just in time, the two institutions started working together, playing to each of their strengths: Manila Water for their knowledge of water service and AIM for their ability to come up with a sophisticated technology solution.

Their goal was simple: To have enough water for people to use uninterruptedly. Apart from water used for bathing, washing the dishes, doing the laundry (which has grown as people work from home), there is also water used for farming and power generation. Not to mention drinking water, which at present, Manila Water is legally obligated to supply subject to the hygiene condition of a house's pipes, following DOH standards.




Manila Water's Balara Filtration Plant filters an equivalent of almost seven billion glasses of water each day (approximately 1,600 million liters of drinking water per day). Photo courtesy of Manila Water Company, Inc.

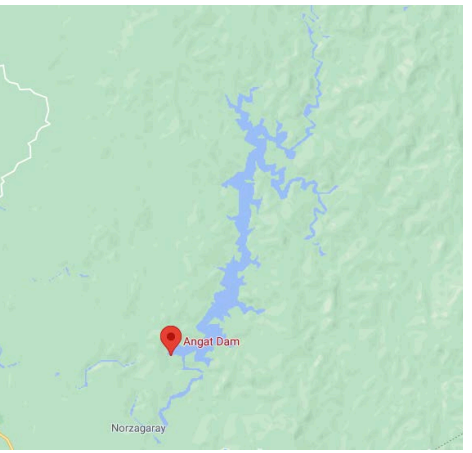
This means that water from Angat dam is distributed not just to Manila Water and Maynilad under the supervision of Metropolitan Waterworks and Sewerage System (MWSS), but also to the National Irrigation Agency (NIA) and the National Power Corporation (NPC).

To figure out the split, an agency sits to convene this discussion. The National Water Resources Board oversees the proper allocation to 1) domestic use (Manila Water and Maynilad), 2) irrigation to farmers in Bulacan (NIA), and 3) discharge to generate power to run through the turbines (NPC). While what takes precedence is domestic use given its essentiality to day-to-day life, there have been a great number of conversations on revisiting how water is being distributed."That's why it's very important to have the project we have now as it provides the conversation with some empirical data to base decisions on," Mr. Orbos said.

To ensure that the water shortage experienced in 2019 will not recur, the AIM team of data scientists thought of developing four forecasting models: three to predict the water supply levels of Angat Dam, Ipo Dam, and La Mesa Dam, respectively, and a fourth to predict the supply allocation for Manila Water treatment plants.

This was done through machine learning and statistical modeling.

In its simplest form, a machine learns and mimics how humans think. Its job is to process a set of input one possesses in order to yield the output one wants to extract.




The Angat Dam, which supplies 98% of Metro Manila's water needs, is located 38 kilometers north of Metro Manila at the Angat River in San Lorenzo, Norzagaray, Bulacan. Image from

Prof. Chris explained that a person's weakness is normally only being capable of seeing two to three dimensions. Any more than that, humans will find it difficult to understand and nearly impossible to process. Machines, on the other hand, can handle hundreds or thousands of variables at any point in time. The main idea behind machine learning is that there is input and output—and the machine finds a way to map it.

With a laboratory that houses the fastest AI supercomputer in the country and among the top three in ASEAN that operates at a whopping 1.2 Petaflops, AIM and its data scientists are equipped with the most cutting-edge tools to digest and process vast amounts of data, namely: rainfall history, historical water level of the different dams, the release of water, and where, and consumer seasonality and behavior. These were in turn provided by the Manila Water's team of system engineers, who collected data from what they gathered on-site, learning what type of information was useful or not, and even installing new sensors for data they hadn't been collecting yet. For example, the initial quantitative variables provided by Manila Water were originally bound to a daily basis. But once more sensors were installed, the granularity of the data they could give AIM could be in hours and even minutes.

Angat-Ipo-La Mesa water system is carefully monitored by Manila Water to prevent both deficit and surplus. Photo courtesy of Manila Water Company, Inc.

To the AIM team,
the data revealed that rainfall is one of
the strongest water level predictors.

Then through sophisticated machine-learning tools, the AIM team attempted to figure out what the data is trying to convey without the bias of any pre-existing hypothesis in mind.

In addition, it interpreted the influence of seasonality both in terms of what can be forecasted given the year and with respect to what's been observed in the previous weeks. The AIM team explained that seasonality for Manila Water pertains to the balance between what they suspect will happen this month and what actually took place in the past two months.

In as early as two to three weeks, the AIM team were able to extract results and present their findings to Manila Water to ask if they're sensible results. The weekly alignment meetings between both collaborators granted a continuous

discussion on meaningful measurements of errors and targets for Manila Water and ceaseless access to new and relevant emerging data for AIM to use in order to successfully produce them.

After some time, the AIM team realized that a more accurate forecasting model required external data beyond what Manila Water was initially able to provide such as figures and numbers pertinent to the growth of population per area. Incorporating these factors allowed them to recalibrate the model to account for the factors that influenced the water shortage in 2019. By taking readings by the minute, for example, they were able to further improve the prediction accuracy of the dam's level and extend their forecast to a longer period–from two weeks–which was the case in 2019–to six months. "That is very valuable because [with] six months, you get to span an entire weather season," Mr. Orbos elaborated. "So, if you know how that is going to turn out, you at least know how much water do we need to save, how much adjustments in the network do we need to do, how many pipes do we need to fix so the leaks go down."

Eventually, the goal is to transfer the tools developed by AIM to Manila Water and train their personnel to use them on their own.

The challenge always lies in how constant change is. In lockdown, Mr. Orbos and his team observed a 5% shift in consumption from the non-domestic areas namely Makati, Taguig, parts of Mandaluyong to domestic cities, as well as an overall 3% increase in total water consumption. Mr. Orbos joked, "The most difficult time for our pump station operator is Saturday morning because [that is when] all of the husbands have to wash the clothes of the household."

Luckily, the deep learning model developed by the AIM team operates on LSTM (long short-term memory), which looks at both long-term dynamics and short-term factors.

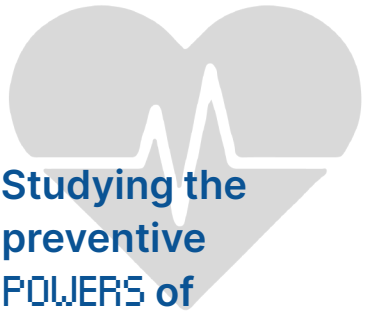
Finally, both collaborators are optimistic about how their findings can augment policy when it comes to the distribution of the nation's water supply between farming, consumer use, and even power.

"If you have the information that is objective and empirical, it makes for good policy," Prof. Chris said.

"Imagine the life blood of a city is always its water supply," Mr. Orbos noted. "So once you are able to fix that, it opens a lot of doors for all other sectors to thrive."

Manila Water's team worked with AIM to figure out what data they had and still needed to acquire in order to properly predict water supply. Photo courtesy of Manila Water Company, Inc.


Data scientists hard at work discussing the water crisis. Photo courtesy of Manila Water Company, Inc.



# Studying the preventive POWERS of pineapple

Over the last decade, 120,800 Filipinos died of coronary heart disease.

To look for a preventive measure, a joint research project by Del Monte Philippines Inc. and the University of San Agustin in Iloilo City looked at pineapples' ability to prevent cholesterol build-up in the heart and arteries.

Originally co-authored by Dr. Jonel Saludes and Dr. Doralyn Dalisay, it was packaged to fit the CRADLE Program's goals of addressing one of the leading health problems in the country. (At present, the most commonly used commercial drug against high cholesterol is Lipitor, priced at USD 63.65 or PHP 3,041 a pop.)

Dr. Saludes' team focused on finding, if present, the exact location of a compound in Del Monte's pineapples that modified a protein called HMG-CoA reductase, which is directly responsible for the high cholesterol in our bodies. Dr. Saludes said: "HMG-CoA reductase is one of the enzymes in the mevalonate metabolic pathway that produces cholesterol. It functions by transforming HMG-CoA into mevalonate that becomes the precursor for cholesterol synthesis in the body. If HMG-CoA reductase enzyme comes in contact with cholesterol-lowering medicines like Lipitor, it is inactivated and can not produce mevalonate, with the consequential reduction in blood cholesterol level. However, this inactivation is only temporary (reversible binding), hence the need for continuous use of HMG-CoA reductase inhibitors, such as statin drugs, to maintain the desired effect." He clarified that HMG-CoA reductase enzyme is not the

Photo courtesy of the University of San Agustin

precursor to cholesterol synthesis, it is the enzyme that transforms HMG-CoA into mevalonate, the cholesterol precursor. Blocking the HMG-CoA reductase enzyme blocks the production of cholesterol in our bodies, which in effect, lowers the body's cholesterol levels.

"How did we find it? Of course, it is a long technical process," he explained.

The process began with Del Monte's pineapples. A variety exclusive to the company, the pineapples' quality is kept consistent in their plantation-based in the country's fruit basket, Bukidnon. Research manager Dr. Joey Orajay is one of the people responsible for maintaining the quality of Del Monte pineapples, free from pests and diseases.

"Pineapples are susceptible, but the environment is something that we can influence as growers," Dr. Orajay explained. One form of prevention is what Dr. Orajay, referred to as "culture control" by constructing canals in the areas where they grow pineapples in order to drain the soil of excess moisture where disease can thrive.

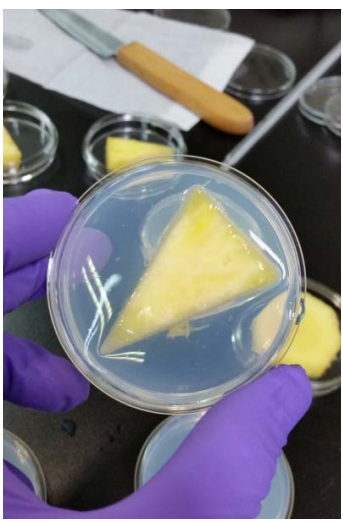
Part of the prerequisites of research is controlling certain factors to repeatedly test one specific result. Because Dr. Saludes and his team were testing for one compound, it proved convenient for them to work with Del Monte's pineapples with research managers like Dr. Orajay who works to control any inconsistencies in quality. "They shipped the pineapples to us here in Iloilo, and we performed different testing - there are purification processes, there is testing directly against this enzyme, this protein," Dr. Saludes explained.

Through the support of the DOST's CRADLE Program, they had access to in vitro kits from the German multinational science and technology company, Merck, which allowed them to test for the presence of the HMG-CoA reductase protein. They tested juice extract from fresh pineapples—not processed—through a process called size exclusion chromatography. Using crude extract from freeze-dried pineapple juice, they dissolved the powder into water and added it into the kits to test for the presence of the compound and its subsequent activity. "We found that the crude extract has the activity, and then we were sure that we were going to have a compound that could inhibit HMG-CoA reductase." Dr. Saludes confirmed. The chromatography process is, essentially, a way to narrow down the number of components per fractions. "Those fractions were tested again so that we will know which fraction has the compound that contains the desired property of pineapple." The total mass of a molecule plays a key role in determining this. Just like our

Preparing pineapple extracts. Photo courtesy of the University of San Agustin.

body weight, molecular weight is very specific for every compound. "That mass is like the fingerprint of the compound." Because these kits mimic what happens within the human body, they were able to refer to this and the molecular weight of the compound to quantify how many pineapples we'd need to consume for the protein to take effect.

They also tested this compound using a different but similar in vitro kit. This time, it was to see whether it could also prevent the absorption of dietary fat. "It is the same compound," he said, describing how this one property has many benefits to the human body. Part of the pervasive health concern leading 35% of Filipinos to die from coronary heart disease is caused by obesity—a direct product of too much dietary fats. The more fats you eat, the more it is absorbed into your body, which, in turn, also increases the risk of cardiovascular diseases. These diseases are usually treated using *Orlistat lipase* inhibitors-based medicine. "Orlistat could be prescribed to reduce the absorption of dietary fat to help them lose weight." It is a drug typically prescribed to overweight people with comorbidities like high blood pressure, diabetes, high cholesterol, and heart disease.


Isolating compounds. Photos courtesy of the University of San Agustin.

Testing using kits procured through the help of the CRADLE Program. Photo courtesy of the University of San Agustin.

Testing using kits procured through the help of the CRADLE Program. Photo courtesy of the University of San Agustin.

"Pineapple also does the same thing. It will reduce the fat that your body will absorb," Dr. Saludes confirmed.

Because the methods are still undergoing intellectual property approval, Dr. Saludes could not go into any specifics but said that the amount needed every day is, surprisingly, far below one slice of an average pineapple. Further clinical trials will still have to be conducted, which would require more funding. Those clinical trials will also zoom in on the behavior of the inhibitor and how much should be consumed to get the preventive effect.

Dr. Saludes explained that these clinical trials will also be able to identify if this compound is found in different varieties of pineapples, and where within their structures. He likened a plant's internal nutritional ecosystem to human organs—how each organ is located at a different part of the body, and each plays a different role in maintaining bodily functions. "Plants compartmentalize their nutrition," he said.

Through the instrument, they learned that the compound was only found in that specific part of the pineapple, and not found anywhere else.

Despite all of his discoveries and the subsequent benefits he listed, Dr. Saludes emphasized that their findings should not be a replacement for prescription medication, which contains the compound in its purest form. Instead, he compared eating pineapples for cholesterol reduction to the act of drinking tea. "You don't drink tea for medication purposes, but teas are recommended to be taken on a regular basis to improve health and well-being."

# Electrifying lumad communities; taking solar home systems to the CLOUD

Somewhere in the highest points of Talaingod are Davao del Norte's Ata Manobo tribe—one of seven indigenous communities in Davao del Norte. Situated three hours away from the city, the Talaingod Manobo tribe live in off-grid houses with no nearby sources for signal and electricity—leaving them to depend on kerosene for light.

A great number of native lumad communities in Davao del Norte still follow this traditional way of illumination. Each month, they use up to four liters of kerosene as fuel for their lamps. The shortage of electricity sources results in a severe lack of resources available to the indigenous people, such as charging outlets, electronic devices (computers), and the internet. Without access to the internet, members of these indigenous communities are limited in terms of news sources, wider access to information, and the platforms to engage and connect with others.

The irony is, even without the access to high-powered electricity, indigenous tribes still incur expensive costs to traditionally power their homes.

An average indigenous household spends over PHP 500 monthly on energy allocated across kerosene, batteries for their AM radios, and renting charging stations for their cellphones. For years, project leader Engr.

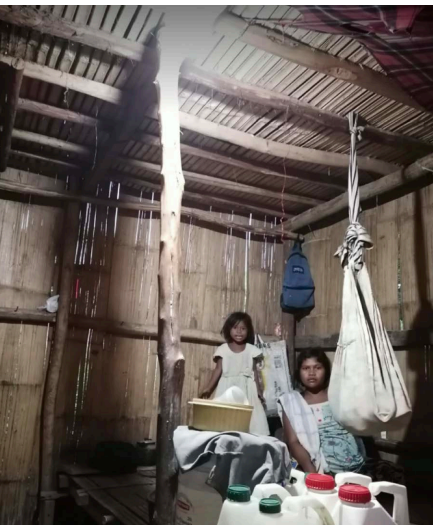
With no nearby sources for signal and electricity, the Ata Manobo residents of Talaingod depend on expensive sources of power and light. Photo courtesy of Engr. Filmann Simpao from the University of Southeastern Philippines.

Filmann Simpao often traveled to these areas and watched first-hand how the lack of electricity fosters financial challenges and hinders economic activities among indigenous people from flourishing.

He observed how the people living in the mountainous areas were left with no choice but to shoulder high costs in place of a sustainable source for electricity in their homes. As an electronics engineer, Engr. Simpao was quick to think that there must be a more lasting and durable way for these indigenous households to utilize and secure energy for their homes.

When he first met fellow electronics engineer Reyman Zamora on a church community trip to the mountains, he found someone with the same commitment to helping indigenous people. Engr. Zamora, who is also the president of renewable energy provider LEADTECH, shared his idea for a sustainable energy solution for remote areas—a solar home kit—but the ones he had come across were priced somewhere between PHP 10,000 and PHP 15,000, an unimaginable expense for families who barely earn enough money to eat breakfast, lunch, and dinner every day.

Acknowledging the financial limitations reported by Engr. Zamora, Engr. Simpao was quick to offer his expertise and a number of suggestions on the most feasible approach to building an affordable solar home kit. It did not take long until Engr. Simpao proposed the idea of partnering with Engr. Zamora and applying to the CRADLE Program to fund their research and development. They called their initiative PISOLAR.



Electrification of 32 Households in Sitio Salapion, Sto. Nino, Talaingod, Davao del Norte. Installations of PISOLAR and its beneficiaries. Photo courtesy of Engr. Filmann Simpao from the University of Southeastern Philippines.

PISOLAR stands for Payment Innovation of Solar Home System (SHS) Ownership through a Law-away Routine. In other words, rather than forcing the costs of the product down, they innovated on the payment side, introducing a scheme where residents pay as they go, a little bit every month, until they reach the total cost of the solar kit installed in their household.

With only seven functioning solar home systems but 19 homes to service, Engr. Simpao and Engr. Zamora found it impossible to determine which households were most qualified to receive electricity first. In the mountain areas of Talaingod, the households are spaced about three to five meters apart. The dispersed structure of the lumads' homes challenged an idea Engr. Simpao had of connecting more than one home to each solar home system to drive down costs even further. And yet, Engr. Zamora went out to source for long wires that could extend the reach of the solar home systems—enough for it to start servicing three households each.

A principle of the combinatorial approach and empathy in general, this wider perspective on the lives of end-users enabled Engr. Simpao's team to better analyze and make design decisions for their solar home system.

First, they inspected the size and measurements of existing solar home systems and checked if they could fit in any area of the lumad households. The homes of the Ata Manobo tribe have compact spaces with walls made of a combination of wood and bamboo. With no robust mat to support their floors, the soil of the mountainland substitutes as their flooring. It was also important to Engr. Simpao that the PISOLAR SHS be placed in an area where it was not exposed to breaking or unintentional tampering of the children when left alone at home.

Second, the members of the community did not have access to Short Message Service (SMS), which urged Engr. Simpao to find a way to incorporate more pay-as-you-go modes of electricity. He thus added other pre-existing technologies: a Wireless Sensor Network (WSN) that requires no cellular coverage and the Conditional Access Modules (CAM), which operate the same way as RFID.

Engr. Simpao has extensive knowledge of such components, having worked on installations of solar systems in other rural communities, as well as over 20 years of service as an electronics engineer.

The initiative at Sitio Salapion is also part of LEADTECH, Inc.'s commitment with Northern Davao Electric Cooperative (Nordeco) to energized the off-grid areas. The 56th Army Battalion led by Lt. Col. Norman Valdez has organized the area by providing livelihood and agricultural training. Photo courtesy of Engr. Filmann Simpao from the University of Southeastern Philippines.

Engr. Simpao quips, his three advocacies all fit into the acronym of IP—indigenous people, internet protocol, and intellectual property. "I may sound patriotic," he said, "but I just wanted to help achieve the total electrification effort of the government, especially in energizing this area which is generally off-grid." Photo courtesy of Engr. Filmann Simpao from the University of Southeastern Philippines.

In addition to attending to his duties as an Engineering professor at the University of Southeastern Philippines (USeP), Engr. Simpao is the director of Knowledge and Technology Transfer under the school's Office of the Vice President for Research, Development, and Extension (OVPRDE). He currently teaches engineering courses focused on Data Communications, Networking and Embedded Systems and Programming.

To monitor customer payments, Engr. Simpao developed a cloud-based software system. It functions as both a monitor—tracking the solar-powered system's battery life and photovoltaic (PV) modules generating direct current electricity from sunlight—as well as a database of all user and client information, including how much they've already paid.

PISOLAR offers three base packages—in the most affordable one, users who avail of one solar home kit pay PHP 300 "energy credits" to authorized village local entrepreneurs or VLEs every month for three years, and this

already goes towards paying off the PHP 10,000 for the system. With Engr. Simpao's pursuit of his idea, each solar home system can now service three households each, so three families can split and share the monthly costs for energy credit at just PHP 100 each. Once the users have fully paid for the system, they unlock lesser subsequent payments which can also be used for maintenance, battery replacement, and system upgrading.

Engr. Simpao shared that this inter-community sharing of electricity gave the lumads a stronger sense of responsibility for other members of their community when it came to paying their dues.

Ensuring continuity, the VLEs are trained to support the technical and administrative components of the operations and maintenance of the system.

This part is where Engr. Zamora comes in. Through connecting and engaging with tribe leaders, he was able to better understand the needs of the community and assess which ones he could provide solutions for. For Engr. Zamora, the long-term solution is for the members of the community themselves to help one another—leading him to initiate and organize a solar community association."We have to capacitate the community for them to learn how to fix things without us," Engr. Zamora said.

In order to nudge the community members towards making their monthly payments, Engr. Zamora has linked farmers in the areas they electrify with buyers. In Cardava, he helped residents whose livelihood came from selling Cardava bananas establish ties with Hijo Resources Corporation, a pioneering exporter of the thick moon-shaped and sweet Cardava bananas.

Engr. Zamora has a background in helping indigenous communities in Davao create economic value from readily available resources found within their area. Apart from fresh produce, other indigenous tribes and communities hope to sell higher-earning items such as pre-processed products (e.g. coco syrup, dressed chicken, chili sauce) through the use of processing centers that Engr. Zamora connects them within the urban area of Davao.

Demo of PISOLAR in Talingod.

Pilot sites during the demo. Photos courtesy of the University of Southeastern Philippines. Photos courtesy of Engr. Filmann Simpao from the University of Southeastern Philippines.


PISOLAR Package

Previously an Engineering professor at Ateneo de Davao University, Engr. Zamora is now at the helm of LEADTECH, which stands for Learning by Doing Technologies. Driven by wanting to stand on his own two feet, he founded and established LEADTECH so his work wouldn't have to depend on any third-party funding. "I have to give what I have," he said. He summarized the nature of his work as job creation by helping people help themselves. In addition to teaching and mentoring out-of-school-youth, he looks for solar, hydro, and biomass projects that require the specific skill sets he teaches his students in order to secure jobs for them.

For both collaborators, the project's biggest challenge was procuring the right materials and resources. The component materials and supplies needed to build the solar home system were hard to come by. To ensure the affordability of the device, Engr. Simpao was specific on the electronic technologies that went into it. He found that no single supplier in Davao could provide the volume of materials he required for the project.

Through reconnecting with a former graduate of USeP, he was able to resolve this problem and locate a material provider that matched his needs. The USeP alumnus had started his own company that supplied electronic equipment and machinery. When Engr. Simpao explained the project and the situation he found himself in, the USeP graduate was more than happy to extend a helping hand in acquiring the necessary materials

internationally (a large majority of it coming from China), in spite of the importing challenges posed by the COVID-19 pandemic. Second to sourcing out materials, Engr. Simpao and Engr. Zamora find liaising and cooperating with the tribe people an equally difficult obstacle. Given the proximity and demands of traveling to the testing sites, regular and constant communication was hard to organize.

In 2020, Engr. Simpao and his team carried out continuous laboratory trials to discover the most efficient and sustainable technological model that could smoothly operate in indigenous households. When they had built a prototype they were confident in, his team organized pilot testing in three target communities: Marilog, Panabo, and Sta. Cruz.

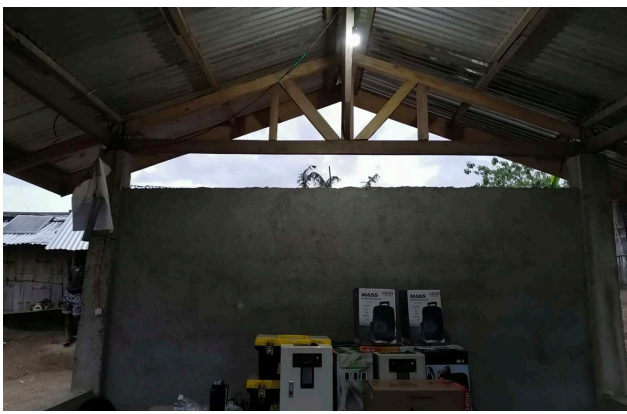
"You need to partner with the actual user to validate your idea," Engr. Simpao said.

During the first pilot testing session in Davao del Norte last December 2020, Engr. Simpao was able to witness his technology successfully take effect. The community where the first prototype was deployed became fully electrified and a teary-eyed elderly local came up to him, *"Sir, sa buong buhay ko, ngayon lang ako nakakita ng ilaw."* [Sir, all my life, this is the first time that I saw light.]

Engr. Simpao explained that the industry-academe partnership born out of the CRADLE Program granted him a desirable approach to research and development. The dedicated involvement of the industry did not only provide his technology with an immediate adapter (the Igang community in Talaingod, Davao del Norte) but also additional input coming from the point-of-view of the end-user. To ensure the technology would go to the community it could best service, LEADTECH pre-identified the community of Igang. Company partner LEADTECH realized the limitations of its pre-existing solar power generator being only suitable for clustered households, which was not an effective option for the Igang community whose households were scattered. With the insights of LEADTECH, Engr. Simpao and his team as USeP could take into consideration the structure of dispersed households when building PISOLAR SHS.

Engr. Zamora believes that while the project of electrification is a valuable infrastructure, the key to uplifting these communities in the long term is still education. He argued that electricity provides indigenous communities a platform for education, not just through traditional methods such as attending online classes. “I think the best way is to generate a learning-by-doing method [and] that has something to do with appropriate technology in the locality,” he explained.

The long-term goal of the project is to find more communities to energize. Both collaborators dream of powering countless more indigenous homes in all of Davao—particularly Davao de Oro, Davao City, and Davao del Sur.



Through the combined efforts of government agencies and private sectors, beneficiaries are finally able to avail of energy services. Photos courtesy of Engr. Filmann Simpao from the University of Southeastern Philippines.

# Protecting bananas against blight, with a patent-pending TECHNOLOGY

Banana is the leading fruit export worldwide. The Philippines is among the major exporters, competing with Cambodia, Vietnam and Ecuador.

However, a sharp decline in the country's banana production occurred in 2012, when Typhoon Pablo hit Mindanao, where the big banana production areas are located. This significantly affected banana exports as it dwindled from 237 million boxes exported in 2011 to only 187 million boxes shipped in 2016—a 21% decline in volume within just five years. According to a report by the Department of Agriculture High Crops Development Program, the average price of a box was USD 6. These translated to a USD 300 million loss to Mindanao's economy.

While the country was trying to recover, South American bananas were able to increase their market share in the traditional Philippines markets in Asia and the Middle East.

In 2017, the Philippines was able to regain its No. 2 rank as a banana exporter thanks to the banana producers' hard work. However, despite its recovery, small banana farmers in the country are still affected by many concerns. According to data from the Philippine Statistics Authority, the country's ranking in the banana world market slipped from No. 2 to No. 6 in recent years. On top of the current issues are diseases, such as the sigatoka caused by fungus and bunchy top virus, among others. These diseases cause lower yields but require higher production costs due to the need for more pesticides and agricultural chemicals, especially in large monocrop plantations of Cavendish bananas.

Ms. Tuason-Fores, CEO of Hijo Resources Corporation said: "Collaboration with the academe is very good. I would encourage private companies to work with the academe. But hopefully, for a bigger purpose. It's not for a selfish purpose. We could share these research results to other small plantations so that our industry is strengthened." Photo courtesy of the University of Southeastern Philippines.

Cavendish banana, which is for export, accounts for more than half of the total production, followed by lakatan and saba or the cardaba varieties for domestic consumption.

The University of Southeastern Philippines (USeP) in Davao Region, through its Research Division, has been communicating with the executives of the banana plantation, Hijo Resources Corporation (HRC), regarding the company's concerns on the prevalence of sigatoka and bunchy top diseases.

HRC is one of the small-and-medium banana plantations in Mindanao and one of the oldest producers of export-quality Cavendish bananas in the industry. Based in Tagum City, Davao del Norte, HRC has more than 450 hectares of plantation area.

"Although, [the HRC executives] have been trying their best to mitigate the diseases [in the banana plantation], they just want to know if there could be other interventions," said Project Leader Dr. Val A. Quimno from USeP.

Small and medium banana plantations do not usually have access to the same cutting-edge research as big corporations. This makes the smaller plantations, including HRC, dependent on service providers who spray their farms with insecticides and other agricultural chemicals against the diseases in order to have good yields.

For 52 weeks a year, the plantations receive 60 cycles of insecticide spraying.

Unfortunately, the spraying "was not believed to be dynamic," said Dr. Quimno. Being too dependent on service providers," [the HRC management] do not know when to spray and when not to spray. [Since there is a] schedule in spraying, *hinahayaan nila kasi nakakontrata* [they just allow it because that was stipulated in the contract.]"

He said that HRC wanted "some mechanism for them to detect the real situation in the field so that they can provide interventions." Aside from that, they want to minimize dependence on aerial spraying, in the process, lowering their costs.

HRC CEO Rosanna Tuason-Fores agreed. "*Ang problema, ang programa na 'yan [spraying by service providers] ay hindi gaanong ka-responsive in terms of disease control and management* [The problem with this program (spraying by service providers) it is not as responsive in terms of control and management of the banana plants diseases]," she told DOSTv's Science for the People program.

"We wanted to find a way to have our own research and development and look for solutions in addressing our farm-specific problems, and start to veer away from being reliant on the multinationals," Ms. Tuason-Fores said in a recent interview.

She adds that there is a big gap between the exchange of information and how it is affecting HRC farms and the future state of farms. She also raised the concern of pests becoming more immune to pesticides.

"[A]s you know, once you use more and more pesticides, your pests become immune to those pesticides," she said. "Are we addressing it sustainably? I said no, we are not. So let's find a solution."

Ms. Tuason-Fores acknowledged that the solution came from the academe, through USeP.

## PROGRAM OBJECTIVES

USeP and HRC partnered to develop the ROSANNA: Mobile Banana Disease Surveillance System. It is under the "Synergize Academe-Industry Research Undertakings to Improve Productivity through the Development of a Banana Diseases Surveillance System" project proposal by HRC.

The project's goal was to minimize the frequency of spraying pesticides and provide viable disease-control alternatives backed by data through a better understanding of pests, plant selection, harvest monitoring, and other key factors.


To do so, a surveillance system was designed to monitor the disease prevalence in the field. It utilizes a mobile application as a sentinel or a data collection device.

Operated by a "banana disease spotter," the mobile app is connected to a database that could generate information-like visualization for decision options. It could help the farm manager and supervisor determine the interventions needed in the field, such as spraying or leaf cutting.

The data could then be used to determine the schedule of spraying as well as the amount of spray needed based on the real situation on the field, "rather than just being dependent on the spraying schedule of the service provider."

## RESULTS OF THE ROSANNA PROJECT

Dr. Quimno was amazed by the achievements of the research project.

At the outset, they just intended to reduce the cost of banana production by 13%, to improve the production by approximately between 13% to 20%, and the disease control by about 13%.

"True enough, the results in our experiment gave a substantial cost reduction," Dr. Quimno said.

Studying four treatment cycles, Dr. Quimno explained: "We tried the spraying schedule as the normal one like the four cycles in a month using our system to save them about 7% [in cost]. The next treatment is about three cycles per month with the savings of around 24%. But the most interesting part was the 61% to 77% savings if we reduce the spraying cycle to just one cycle per month."

"However, because the banana plantation is about 450 hectares, aiming for 77% savings was risky with one cycle per month only. It could result in disease prevalence or disease infestation," he said.

In the end, HRC decided to follow the treatment of 1.7 spray cycles a month that resulted in 61% savings in production costs, "which is really very good compared to our initial promise of about 20% cost reduction."

Dr. Quimno pointed out that besides their aim in saving costs, the study resulted in other unintended outcomes. "Try to imagine [that] we've done this on a 10-hectare experimental site. But because of the promising result that we had. HRC implemented the system and improved the system further to the entire banana plantation. That is very, very wonderful and a very amazing achievement," he exclaimed, noting that the people's perception at the start of the project was that it would only be good during the project's cycle.

The ROSANNA project developed by the USeP and HRC allows the company to minimize the frequency of spraying pesticides. The mobile app provides data that helps farm managers and supervisors in assessing their field's needs. Photos courtesy of the University of Southeastern Philippines.

"But beyond the project period, HRC continued and improved on it from our initial results. We are very happy with that," he said.

The USeP Research Department agreed, adding that HRC's greater use of the mobile app leads its practices towards precision, and smart agriculture—the term for the use of technologies like sensors, robots, and artificial intelligence on one's farm. Some call these components of the "Internet of Things."

"Another unintended outcome was that HRC hired the programmers of the university in the project to continue its implementation. As a result, the plantation developed and made improvements in the system, and made consultations and discussions with USeP," Dr. Quimno said.

Program Leader Dr. Quimno recognized that because of the CRADLE Program, USeP became "popular" in the banana industry and beyond. "Some of the big players in the banana industry in Davao Region, arranged meetings with us. [The CRADLE project] became an eye-opener. They started asking, '*Paano ba ginagawa 'yan* [How do you do that]?'" One of the country's biggest banana plantations, Tagum Agricultural Development Company Inc. (TADECO), and other companies in cacao and coconut production as well as mining and consulting submitted a proposal to USeP to manage other diseases in its plantation. Photo courtesy of the University of Southeastern Philippines.

"Meanwhile, the positive effect of the new technology to the environment could not yet be quantified as a result of the reduced application of pesticides," the USeP Research Department said.

"We are actually looking [to see] that it has an impact on the environment. *Kasi hindi na masyadong maraming chemicals ang napupunta sa mga neighboring areas, lalo na doon sa mga populated areas, yung chemical residues na pumupunta doon sa waterways, hindi pa namin na-account* [Because there are lesser chemicals carried by air to the neighboring areas especially to the populated areas, the chemical residues carried to the waterways, but we have not accounted it yet]," the researchers said.

The researchers added that it was an expected outcome that the reduction in the use of pesticides, besides lower cost, was the ultimate impact of reduced chemical pollution.

The project is using drones in spraying insecticides to smaller targeted areas, which is more efficient, compared to the previous use of airplanes that spread chemicals to large areas. Thus, the use of drones is more environmentally friendly.

However, the occurrence of the COVID-19 pandemic hindered the use of more drones in spraying insecticides. The researchers said the country's drone industry still does not have the capacity to supply services to big areas.

As for the original intention of the system to combat disease, USeP's Research Department said that in the next five years, most probably there will be a paradigm shift in the banana industry in controlling the sigatoka disease.

It said that the current traditional use of airplanes in spraying and the constant use of chemicals of around 62 to 75 times a year is very expensive. It cited that with the use of the ROSANNA technology around PHP 1.2 billion per year will be saved.

## BENEFITS TO HRC

Ms. Tuason-Fores called the results of the research extraordinary and credited the good relationship between HRC and USeP.

"For me, it was actually a manna from heaven," she said in a recent interview.

She explained that the results of the research was based on the openness of HRC with the academe (USeP) and trust.

She told the DOSTv program that the positive results of the HRC and USeP collaboration encouraged the company to continue and apply the results to a large area of the plantation.

She added that during the duration of the CRADLE Program, HRC brought along USeP's staff of two faculty members and one student to their trip to Israel about smart agriculture technologies.

Based on HRC's experience, Ms. Tuason-Fores said she would like to encourage the private sector to collaborate with the academe to find solutions for their concerns.

Besides this, the USeP researchers are also hoping that the players in the industry will have an academic partner who can help them with their industry problems and prevent the ill effects of the "secretive" multinational companies' not sharing their technology with smaller banana plantations.

"If smart and precision agriculture will be adopted by our multinational and small growers, [maybe] it would lead toward better productivity not only for banana growers but also doon sa mga maliliit nating farmers [but also among our small farmers]," the USeP Research Department said.

They also said that this would lead to a "more science-based" decision-making.

HRC has tapped a consulting firm in Singapore to facilitate its international patent application for its banana surveillance system (pictured), which was lodged in various intellectual property agencies worldwide. Photo courtesy of the University of Southeastern Philippines.

They explained that the use of smart and precision agriculture would lead to more productivity, lesser cost and minimum effect of lesser radius in the use of synthetic chemicals to the environment.

Today, USeP has become known for its research capabilities.

Engaged with "16 industries" in Regions XI and XII, it has generated more than PHP 25 million for research and has involved its 100 or more faculty, students, and staff from 2017 to 2019. As of 2020, the university had about PHP 200 million in research funding from different sources. At the same time, the university coordinates closely with the DOST Regional Office that has been linking USeP with other industry players.

Dr. Quimno attributed the success of the project to both parties' commitment. "After the project, *tinuloy pa rin nila* [they continued with it]. And they have invested so much. In fact they have facilitated the international patent application," he said.

The University of Southeastern Philippines' assistance to Hijo Resources Corporation allowed them to come up with solutions to the banana plantation's agricultural problems. This sets an example for other players in the industry to partner with other academic institutions as well. Photos courtesy of the University of Southeastern Philippines.

## RESEARCH TREND: SMART AGRICULTURE

HRC has been adding a traceability function to the surveillance system in order to determine the particular block in the plantation that would give a good yield or has produced a good amount of quality bananas.

This gives them an edge of having traceability in the supply chain, as the ethics in production and food safety have become increasingly important to consumers. For example, a Cavendish banana buyer would be able to determine the farm that produced it and the farm practices so that the consumer would know if it is safe to eat.

Finally, the system could be expanded to include market intelligence so farmers would know the buying prices for bananas abroad like in China, South Korea, Japan, the Middle East, or the US. They could then produce in time for when the price of the product is high, and most importantly, determine a fair price when they sell to distributors—knowing what their crop is worth.

Dr. Val Quimno (left) shared that through the CRADLE Program, the grant went to the research and development of the disease model and surveillance system for HRC. Photo courtesy of the University of Southeastern Philippines.

# Turning undervalued EGGS into innovative products

In San Jose, Batangas, the "Egg Basket of the Philippines," the members of the Batangas Egg Producers Multipurpose Cooperative (BEPCO) produce 10 million fresh chicken eggs a day.

But out of these, there are always undervalued eggs that are considered cracked, soft-shelled, or with an unacceptable level of extraneous materials—about 1% to 2% or approximately 82,000 per day.

Considered "off-specification" or non-compliant to table egg specifications by the Philippine National Standards for table eggs, these undervalued eggs, sold at best at 1/3 of the price of good eggs, if at all, hit the income of BEPCO's 54 members, some of them small backyard farmers who are dependent on daily sales for their livelihood.

There are also periods when the cooperative faces a surplus of eggs, such as during the bird flu infestation in 2017, which extended up to mid-2019, when demand was low.

BEPCO Managing Director Cecille Aldueza-Virtucio recalled: "Millions of eggs piled up in our town. So, we needed to figure out what could be done with the surplus of eggs to make the most out of them."

Ms. Virtucio was the former product head of an international bank and is now a social entrepreneur and agri-coop volunteer. Her father, Mr. Leo Aldueza, a poultry farmer, founded BEPCO and asked her to help the cooperative in its concerns.


When freshly farmed chicken eggs were at a surplus in 2018, BEPCO pushes through with creating an egg-powder facility to solve the problem. Photo courtesy of the Batangas Egg Producers Multipurpose Cooperative (BEPCO).

By 2014, BEPCO plotted a product roadmap to make use of low-value and surplus eggs—most notably, powdered and granulated eggs used for commercial baking. She became a member of BEPCO in 2014 and has plotted a product roadmap. In 2018, a clear plan was made to make use of low-value and surplus eggs—most notably, powdered and granulated eggs used for commercial baking.

## KICKOFF

As a full-time Director of BEPCO, Ms. Virtucio was tasked to talk to industry players at an agriculture trade fair in Thailand in 2017 and floated the idea of an egg-powder facility. Their assessment: it was not viable owing to high production cost and "not enough eggs in the Philippines."

But that didn't stop the coop.

They formed a core team:

- BEPCO's Cooperative Manager, Ms. Judit Alday-Mangmang, a Food Technology graduate at the UP College of Home Economics,
- Dr. Ma. Patricia Azanza, a professor at the University of the

Philippines Diliman College of Home Economics (UP-CHE), Department of Food Science and Nutrition,

- and Ms. Virtucio, a graduate of Business Administration and Accountancy at UP Diliman, a Certified Public Accountant and experienced Product Development and Information Management professional.

They prepared a project proposal titled "Development of Dried Chicken Egg White Powder and Granules from Low Value Edible Shell Eggs."

They were specific in what they wanted to achieve and why. For example, the egg yolk was not included in the project because it already had a market.

As for the choice to develop powder and granules, they spotted a gap from the fact that these ingredients are usually imported by commercial bakers. Meanwhile, Dr. Azanza said the powder and granules had an added benefit of having a long shelf life.

After successfully applying to and receiving funding from the CRADLE Program, the project was implemented with the DOST-National Capital Region Food Innovation Facility at the UP Diliman's Department of Food Science and Nutrition, the DOST Industrial Technology Development Institute (DOST-ITDI), and the DOST OneLab providing the facilities.

It was determined that eggs with extraneous materials were considered the most ideal and suitable to be developed as granules and powder because of the internal egg quality of these eggs is very close to that of good eggs. The extraneous material, anyway, can be subject to washing and sanitation to prevent any risk in using these undervalued eggs.

## RULES OF THUMB ON WRITING A PROPOSAL FOR FUNDING

1. Articulate the need.
2. Consult an expert on the topic.
3. State the industry problem in a way that can be solved.

Dr. Azanza spoke about turning a problem into an opportunity. "CRADLE is about looking at the problem of the industry. We 'cradle' the industry... for them to be able to continue with their industry or their business." Photo courtesy of Dr. Azanza.

Ms. Fatima Ibarreta of the Philippine Council for Industry, Energy and Emerging Technology Research and Development (DOST-PCIEERD), the monitoring agency, said that the project was the first to execute a Collaborative Research Agreement (CRA) between the implementing agency, i.e., the researcher's institution, and the industry partner. The CRA details the terms of agreement with respect to intellectual property ownership and any licensing of technology.

Ms. Ana Espigol also of the DOST-PCIEERD added, "*Ang maganda sa partnership na ito, as early as may results na sina Dr. Azanza, naiko-communicate na nila agad sa BEPCO team, so nagagamit na agad nila, especially nung kalagitnaan pa lang."* [What is good with this partnership, as soon as the team of Dr. Azanza produces a result, they communicate it right way to BEPCO team, which uses it, especially during the middle part of the Project.]


The CRADLE Program aims to create synergistic relationships between the academe and the industry with the goal of invigorating Philippine R&D. Photos courtesy of Batangas Egg Producers Multipurpose Cooperative (BEPCO) and College of Home Economics, UP Diliman.

## ACCOMPLISHMENTS AND CHALLENGES

After 18 months, the spray-drying technology at the DOST-ITDI produced several formulations of powdered egg white for baking, cooking, and food preparation. The egg white powder can be used as an alternative to fresh egg whites in recipes such as cakes, bread, mayonnaise, meringue, pavlova, chiffon cakes, and pancakes among others.

Packaged samples have been sent to the coop's clients, including snack providers, and those importing egg powder, for testing in their recipes and other applications.

"So, if they accept, it is just a matter of putting them into a commercial scale," Ms. Virtucio said.

What's more, the learnings from the Project led the cooperative to the department of several other products, like powdered egg yolks and powdered whole eggs.

"The development of egg white granules is a little bit extended from spray-dried processing," according to Dr Azanza. Granulation results in larger particles, which are more soluble than the powder.

Dr. Azanza added that in the first year of research, they developed a protocol in washing and sanitizing of the undervalued eggs with extraneous materials on the eggshell, which they trained the BEPCO members in.

The project team from UP Diliman is also developing virtual courses on processing and handling of raw materials.

Production-wise, the goal is to hit a commercial scale of around 2,000 kilograms of egg powder a day. Since building their own facility would take more time and resources, BEPCO is considering employing toll manufacturing or having another company manufacture the products so that they can proceed with the registration with the Food and Drug Administration.

Cooperative members of BEPCO and farmers in nearby provinces will directly benefit from the results of the R&D and experience the change that science can bring to their livelihood. Photo courtesy of Batangas Egg Producers Multipurpose Cooperative (BEPCO).

The project faced some challenges throughout the project implementation.

Dr. Azanza had to spearhead the implementation of two additional methodologies to determine the shelf life of the product. While it was additional work and beyond the project deliverables, the project team decided to go the extra mile as they knew it would benefit their industry partner, BEPCO. Meanwhile, Ms. Virtucio also said that the quarantine protocols brought about by the COVID-19 pandemic affected the cooperative's schedule of production at their chosen toll manufacturing facility, which has been moved several times. "If we have more access to a facility, we are looking at perhaps the fourth quarter of this year [to start manufacturing]," she said.

The BEPCO members would be the biggest beneficiaries of this future space. "When the egg production is big and the sales are down, the members just have to go to the facility," Ms. Virtucio pointed out.

For the BEPCO members to fully benefit from the S&T intervention, a change in some of the egg producers' handling of off-specification eggs is needed as some members purposely crack these eggs for disposal.

BEPCO is educating its members about turning these undervalued eggs to profitable products through spray-drying.

That's the beauty of collaboration and having different skill sets involved: addressing issues, planning for commercial scale, and expanding the research can all happen at the same time. While Ms. Virtucio works on a business proposal to pitch to an investor or agency, Dr. Azanza is advising on the pertinent effect of washing and sanitizing conditions on the identified raw materials, and Ms. Mangmang is thinking of how to hire more people and help more families.

As of the moment, BEPCO's commercial production is already ongoing via toll manufacturing. They have also repackaged their product for supplemental feeding of geographically-isolated areas aligned with their vision of reaching far to nourishing families today and tomorrow.


Through the CRADLE Program, the private industry partner identifies their problem and the R&D Institution undertakes the R&D to solve said problem. Photo courtesy of Batangas Egg Producers Multipurpose Cooperative (BEPCO).

FOR THE COMPLETE LIST OF PROJECTS UNDER THE CRADLE PROGRAM, TURN TO PAGE 183 OF INDEX ▶

CHAPTER V

# BIST:

## SMEs Need R&D

Business Innovation through Science and Technology for Industry

The Business Innovation through S&T (BIST) for Industry Program assists Filipino-owned companies or the consortium or organization to which they belong in order to acquire state-of-the-art equipment, machinery, and technology licenses for immediate incorporation in their research and development activities. Each technology acquisition project leads to corresponding research for a total period of three to five years, and each company can avail of 70% of the total eligible cost of the needed technology, paying the government back at zero interest starting on the third year of the project implementation. Meanwhile, the amount of financial assistance for the company's R&D is determined by the revenue and assets of the company based on their financial/tax report submitted. In keeping with the Harmonized National R&D Agenda, all the project proposals for technology acquisition must be in line with the priority industries identified, including:

a. Agri-processing
b. Agriculture, Fishery and Forestry
c. Drug and herbal development
d. Integrated Circuit (IC) Design
e. Semiconductor and Electronics
f. Creative Industries/Knowledge-based Services
g. Renewable Energy
h. Industrial Waste Treatment
i. Information and Communication Technology (includes Artificial Intelligence)
j. Food and Nutrition
k. Infrastructure and Logistics
l. Environment and Climate Change
m. Manufacturing

Among the four strategy programs under the Science for Change Program, the BIST Program was the most challenging to implement. There are two reasons why. First, it is because 99.5% of the total businesses in the Philippines are micro, small, and medium scale enterprises (MSMEs). While they contribute 62% of the total workforce in the country according to the Department of Trade and Industry (DTI) in February 2020, our MSMEs are focused more on increasing their productivity, branding, and market expansion. Second, the remaining 0.5%, the large businesses, are into Service, Manufacturing, and Construction Sectors. Very few of the country's businesses are doing R&D.

That said, the DOST's commitment to level up the innovation capacity of Filipino-owned companies while promoting R&D-based industry led the department to seek out interested companies. Within three years of implementing the program, the DOST received a total of 38 proposals and approved three (as of 15 September 2021).

| TITLE | COMPANY | APPROVED BUDGET |
|---|---|---|
| Semi-purification of crude plant extracts: an initial step for the production of pharmaceutical grade ingredients | herbanext Laboratories | PHP 11.7 M |
| BRIDGES: A Brisk Response through In-location Diagnostics and Genome Sequencing | BioAssets | PHP 15.9 M |
| Development of a Fully Advanced and Highly Sustainable Packaing Material using Advanced and Nanotech Materials from Indigenous Plants | NANOTRONICS YOUR SOLUTIONS PARTNER | PHP 5.0 M |

In November 2019, the DOST approved the very first financial assistance under the BIST Program. The discussion that follows involves the firm Herbanext Laboratories, Inc., which is based in Bago City, Negros Occidental. It specializes in the manufacture of herbal drugs.

## Herbanext Laboratories, Inc.

In Negros Occidental, a company that pioneered a spray-dried format of a native medicinal mushroom expanding into other Philippine botanicals has launched the country's first ever scale-up facility for research on herbal extracts. Here, researchers can do everything from analyzing the feasibility of a new herbal product to processing raw materials, standardizing and manufacturing active ingredients, packaging, and even assistance with intellectual property applications and registration to the Philippine Food and Drug Administration (FDA).

Called the Applied Research and Innovation Laboratory (ARIL), it houses various pilot-scale equipment such as extractors, concentrators, homogenizing equipment, spray dryers, tableting and capsulizing machines, and a pharmaceutical laboratory for quality control acquired through an interest-free loan from the BIST Program.

### TAWA-TAWA

Herbanext is currently known as the manufacturer of the Philippine Food and Drug Administration (FDA)-registered standardized *tawa-tawa* (*Euphorbia hirta*) supplement against dengue, one of around 20 medicinal herbs being farmed and processed by the company.

Currently working to have it developed and registered as an anti-dengue medicine, the company has come a long way from being a small agricultural enterprise that started cultivating and processing the medicinal mushroom *Ganoderma tropicum* to address diabetes, high cholesterol, and hypertension in the year 2001.

The Applied Research and Innovation Laboratory (ARIL) contains a mix of existing equipment accumulated from previous DOST Small Enterprise Technology Upgrading Program (DOST-SETUP)-funded projects of Herbanext, projects funded under the Tuklas Lunas Program and Department of Health's Philippine Institute for Traditional and Alternative Health Care (DOH-PITAHC), and new equipment, worth PHP 11.7 million acquired through the BIST Program. Photo courtesy of Herbanext Laboratories, Inc.

In just 20 years, the Bago City-based enterprise has blossomed into the country's leader in the production of spray-dried herbal extracts. Founded by Mr. Philip Cruz, a multi-awarded agri/aqua-entrepreneur and a 2005 Ten Outstanding Young Men (TOYM) Awardee, Herbanext expanded in 2006 by processing other medicinal plants into nutraceutical products, functional foods and beverages, herbal drugs, and animal health products. The company is able to make instant granulated beverages, loose teas and tea bags, tablets in strip foil, capsules in familiar blister packs, and herbal syrups, having established Good Manufacturing Practice (GMP)-certified production lines. It has also expanded into herbal cosmetic products, including creams, ointments, massage oils, soaps, and shampoos.

It further expanded and modernized its manufacturing plant in 2011 by putting up the country's first purpose-built extraction and spray-drying facility for botanicals with the assistance of the Department of Science and Technology (DOST).

Among the spray-dried ingredients that Herbanext pioneered are *banaba* (Queen's flower or *Lagerstroemia speciosa*), *luyang dilaw* (turmeric),

Herbanext research on the cultivation of *tawa-tawa*. Photo courtesy of Herbanext Laboratories, Inc.

*ampalaya* (bitter gourd), *balbas pusa* (cat's whiskers), mangosteen, *tsaang gubat* (forest tea), *sambong* (*Blumea balsamifera*), *lagundi* (*Vitex negundo*), and recently *bignay* (wild cherry or *Antidesma bunius*) and *batuan* (*Garcinia binucao*). The company is also the first to introduce standardized extracts for important phytochemical marker compounds, such as curcumin in turmeric, corosolic acid in *banaba*, and alpha-mangostin in mangosteen.

Often, the process starts with working with locals in the community, like Mr. Mario Segovia, a farmer. *"Kung mayroon po sila ipakuha na gamot, binabayaran po nila ako, [tulad ng] tawa-tawa at saka sampaliya."* [If they ask me to get herbal plants for them, like *tawa-tawa* (*Euphorbia hirta*) and wild *ampalaya* (wild bitter gourd), they pay me.]

From here, the company develops the product with the aim to commercialize or produce it at a large scale.

Depending on the supply of the raw material, Herbanext's extraction facility currently can process up to a maximum of 1,500 kilos of fresh herbs per week, which will produce around 8,000 to 12,000 bottles of finished dosage form per month depending on the type of medicinal plant.

## HIGHER QUALITY

By being able to provide a loan to purchase new equipment, the BIST Program allowed Herbanext to semi-purify the *tawa-tawa* extract, shared Mr. Phil Aidan Cruz, Herbanext's Research and Extension Head and son of the company's president, Mr. Philip Cruz. The new extraction machine they were able to purchase through the BIST Program is able to remove unwanted plant oils or starch from extracts without needing to use toxic solvents.

"You can remove oil, that is the dead weight in the extract, and have more of the purified extract left," the younger Mr. Cruz quipped.

To further explain the process, he said that the recommended dosage in a powdered herbal medicine would be two grams, three times a day. "So, you can imagine that like for Vitamin C, a 1,000 milligram tablet is really big and difficult to swallow. If you have to take two grams three times a day... that is six big tablets in a day... A large portion of those two grams is actually just nuisance compounds or they do not have any medicinal benefit [like starch and oil]," he explained.

He added that if 70% or 80% of the extract is removed the two grams would have 400 milligrams left, which can fit into a single capsule. "It does not even have to be a tablet anymore; it can be a smaller capsule," he said, and a person only has to take three capsules instead of six capsules.

### The product commercialization process generally involves:

→ Sourcing of raw materials and scale-up of post-harvest process

→ Scale-up, optimization, and standardization of ingredient manufacturing process

→ Scale-up of product manufacturing process

→ Pilot-scale characterization and validation run

→ Stability study, laboratory tests and other regulatory requirements of the Food and Drug Administration

Tannins, which are bitter or astringent compounds with some being toxic, are also removed if they don't contribute to the bioactivity of the extract. There are also organic acids, like sugar, which make extracts gather water or moisture really quickly.

Using the 3-in-1 coffee as example, he explained: "Leave [its] powder out in the open for a day, you might just see after it is gonna be like a cake. It is gonna be hard because it contains a lot of sugar. So, the sugar makes these extracts sticky."

Some plants, he said, generally have a lot of sugars like fruits, citing the calamansi extract. "If you remove some of these sugars, they can actually make your extracts more stable as well. They last longer without caking," he noted.

Herbanext also acquired a semi-preparative high-performance liquid chromatography (HPLC), which is like a chromatography system that separates some of the compounds in an extract. The equipment can

People interviewed by the DOST for the DOSTv: Science for the People Program said that the patients' fever subsided after drinking the water from boiled *tawa-tawa* leaves for three to five days. Photo courtesy of Herbanext Laboratories, Inc.



Available in Metro Manila, Bacolod, Batangas, Cebu, Iloilo, Davao and General Santos, Daily Apple brand Tawa-Tawa capsules are registered with the FDA as an herbal supplement and sold for PHP 15 each. The recommended dosage is one to two capsules at three times per day, for five days. Photos courtesy of Herbanext Laboratories, Inc.

further purify extracts and is an important tool in separating compounds, identifying them, and finding out which ones are the most active ones. Another is a filtration system for removing large particles from extracts that cause them to become cloudy, especially if dissolved in water to make a beverage.

"It can branch out to any of the different methods we've developed to remove the nuisance compounds from the [extracts]. After that, we get the semi-purified extract which we can characterize using the HPLC system. And then we can compare how much of the compounds in the crude extract were reduced if we semi-purified them," he explained.

Expense-wise, he said the process is cheaper because it allows the manufacturer to concentrate extracts. Considering the whole production cost of making a tablet, "the price really increases greatly if you have to

Herbanext conducts research on purifying herbal extracts to make them more concentrated. Photo courtesy of Herbanext Laboratories, Inc.

take more tablets in a single dose. It is really beneficial in that sense to have more purified extracts. It helps to fit more of the extract as well in a single dosage," he noted.

At the same time, the project enabled Herbanext to coordinate with local farmers to develop supply chains for some herbs with good potential for scale up.

## VIRTUOUS CYCLE

In Negros Island, where most of the agricultural resources are directed toward sugarcane, the BIST Program provides an alternate source of livelihood, he said.

Ms. Rosally Mallorca, a farmer, received *sambong* and *balbas-pusa* seeds to plant, as well as *alingatong* or stinging nettle. Planting the latter, she said, "*Nakatulong talaga yoon sa pangangailangan namin. Lalo nitong dumating tong pandemya."* [The benefit we received from Herbanext was the planting of *alingatong* (nettle tree or *Dendrocnide meyeniana*). It was able to help us during the pandemic.]

Besides this, the BIST Program has upped the demand for turmeric which is being purchased at a rate of one to two tons per month from farmers like Mr. Nole Belando. "*Ang aming product, sila po ang kumukuha, kaya hindi kami nahirapan sa pag benta. Maganda po ang presyo nila kaysa sa mga middleman."* [Herbanext buys our products, so we do not have a hard time finding someone to purchase. They have a better price than middlemen.]

By planting in their own backyards, indigenous peoples or farmers like Mr. Mario Segovia do not need to enter forested protected areas to harvest [medicinal herb] resources in the future, thereby easing their work and protecting the forests, said Mr. Philip Cruz, President of Herbanext Laboratories, Inc.

The elder Mr. Cruz shared his own change in mindset when it comes to sharing resources. "...When I took the BIST [Business Innovation through S&T for Industry] Program [of the Department of Science and Technology], my first idea was to use the money to acquire research equipment for the benefit of our company. But I realized that these advanced technologies that we are acquiring through the BIST Program will not only benefit myself but the entire industry."


Mr. Philip Cruz with the Ati community in Sitio Marikudo, Kabankalan. Photo courtesy of Herbanext Laboratories, Inc.

Production of herbal extracts follows good manufacturing practices. Photo courtesy of Herbanext Laboratories, Inc.

Knowledge and technologies around herbal extracts will be shared with other companies and researchers who visit the laboratory. Photo courtesy of Herbanext Laboratories, Inc.

By improving the quality of herbal extracts, Herbanext can further standardize the development of local herbal drugs, making reliance on western pharmaceuticals less.

Mr. Phil Aidan Cruz disclosed that Herbanext is opening its facility to university partners, including the University of the Philippines Diliman, the University of San Agustin in Iloilo, Ateneo de Manila University, and the University of Santo Tomas. People from different businesses or industries who are interested in new products can then come and look at the different portfolios of products and be matched with a research team. “Our dream would be for these people to just look at our portfolio and say, ‘Oh I want to commercialize this one," he said.

It is a virtuous cycle, one where the Herbanext Product Development Team will share their knowledge and assist their partners in evaluating the commercial viability of their intended product or process.

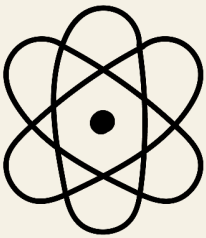
In turn, the laboratory’s state-of-the-art equipment will continue to help Herbanext innovate and keep growing as a company. Newest in their product lines are botanical oils from roselle, moringa, ginger, turmeric, holy basil, calamansi, *dalandan* (sweet orange), eucalyptus, lemongrass, and Manila Elemi resin.

Recently, two more projects were approved for funding under the BIST Program. The project proposed by BioAssets Corporation aims to establish a Point-of-Need Diagnostics system that will address the country’s need in animal disease diagnostics. While Nanotronics Inc., a startup company based in Laguna, will develop a fully sustainable advanced packaging material (FSAPM) using advanced and nanotechnology material leveraging our indigenous plants.

To date, we have provided a total of PHP 32.6M financial assistance to these companies to support their respective research and development activities.

CHAPTER VI

# FUTURE LANDSCAPE OF RESEARCH AND DEVELOPMENT



As the NICERs mature, they will become national centers and may even link with each other for national programs or projects. Eventually, HEIs that hosted RD Leaders will be sending their local experts to other HEIs, RDIs, and NGAs that need the assistance. The CRADLE Program budget will balloon for the next five to ten years to about PHP 250 million per year and gradually increase its budget and cater to both firm-level R&D collaboration to industry-level R&D collaboration. After five years, it will start to level off as companies and industries take the initiative to allocate funding for R&D and collaborate with HEIs. The BIST Program, which had a quiet (calculated) start, will require companies to include R&D activities in their operations, from short-term incremental improvement in their products, processes, and services, to a long-term innovation roadmap guided by R&D.

In the next five to ten years, the DOST's R&D Programs would be expected to feature the following:

1. Institutionalization of Science for Change Program and graduation of several NICER Programs into National Centers;
2. Implementation of long-term R&D programs;
3. Significant increase in the technology transfer and adoption of DOST-funded R&D projects.
4. Synergy between R&D and Human Resource Development programs in S&T

Institutionalizing the Science for Change Program will ensure the gradual increase of R&D funding until it reaches the UNESCO recommendation of 1% of the country's GDP. It is with the gradual increase in the R&D investment that these programs see their fruition. One example is the Genomics R&D Program that started the Philippine Genome Center (PGC) in Diliman, Visayas and Mindanao. The first investment in PGC was made in 2009. Who would have thought that more than ten years after, the researchers, their experiences, and the research programs would play a key role in our fight against COVID-19? Without those years of investments, it would have been almost impossible to develop GenAmplify,

a locally made detection kit test for the presence of SARS-CoV-2, in the short time that Manila HealthTek did.

Those who are in charge of funding in the government rarely appreciate the fact that R&D investment is long-term. Yearly defending the R&D budget will lead to short-term R&D programs that will have little or no impact on society and the economy.

Long-term R&D programs are key to maximizing the benefits of science, technology, and innovation for the Filipino people. In the last five years, the DOST has put in place the Harmonized National R&D Agenda, held the annual National R&D Conference, exponentially increased the IP protection applications from R&D, made inroads in levelling the playing field for R&D across the country, and steadily increased the number of R&D outputs that are transferred to the target users. These are the long-term R&D programs that will be put in place from July 2021 to June 2022.

Related to this, R&D in the Philippines will have the following priority areas:

1. Health Self Sufficiency and Responsiveness to Public Health Emergencies, including Virology Science and Technology Institute of the Philippines (VIP)
2. Defense and Security R&D
3. Nuclear Science for Energy, Health, Agriculture and Industry
4. S&T for Creative, Tourism, and Services Industry
5. CRADLE Program for Industry (rather than firm level)

The Science for Change Program has changed mindsets of academe, industry, and government, and even lawmakers; capacitated higher education institutions (HEIs), Research and Development Institutes (RDIs), and industries; and changed the landscape of R&D in the country towards equitable, science-based decision making and development.

The future with the approved and implemented Science for Change Program shall provide continuing support from government, industry, and academe to science, technology, and innovation for inclusive, equitable, and sustainable development. There will be more national centers of excellence in R&D that are at par with international counterparts. There will be continuing increase in technology-based and value-adding business investments, both foreign and domestic, due to a conducive STI-supported economic environment. The Philippines will be more self-reliant because of more capable and more confident technology stakeholders, and there will be an optimal use of R&D budgets allocated to different government departments and agencies.

# INDEX

# COMPLETE LIST OF CRADLE PROJECTS

| PROJECT TITLE | IMPLEMENTING AGENCY | COMPANY PARTNER |
|---|---|---|
| 1. PCOPEIA Predictive Chromatography of Organic Plant Extracts with Intelligent Agents | Technological Institute of the Philippines (TIP) - Manila | Pascual Pharma Corp. |
| 2. Metabolomics as Tool for the Discovery of Hypocholesterolemic Natural Products from Pineapple | University of San Agustin (USA) - Iloilo | Del Monte Philippines Inc. |
| 3. Synergize Academe-Industry Research Undertaking to Improve Productivity through Development of Banana Diseases Surveillance System | University of Southeastern Philippines (USeP) | HIJO Resources Corporation |
| 4. Development of a Cost-Competitive Aquafeed from Lab-lab | De La Salle University (DLSU) | SANTEH Feed Corporation |
| 5. Reinventing Ice Cream into a Functional Food Matrix | University of the Philippines Los Baños (UPLB) | Sugar and Ice Confections Inc. |
| 6. Development of Chicken Egg White Powder and Granules from Low Value Edible Shell Eggs | University of the Philippines Diliman (UPD) | Batangas Egg Producers Cooperative (BEPCO) |
| 7. PISOLAR: Payment Innovation for SHS Ownership by Lay Away Routine | University of Southeastern Philippines (USeP) | Learning By Doing Technologies, Inc (LEADTECH) |
| 8. Enhancement and Market Validation of Plasma Enhanced Chemical Vapor Deposition Industrial Prototype for Nitride Based Coating | University of the Philippines Diliman (UPD) | Asian Semiconductor Electronics Corporation (ASET Corp) |
| 9. Post-Treatment of Food Processing Wastewater Effluent for Nutrient Removal | Industrial Technology Development Institute (DOST-ITDI) | Central Macaroni Co. Inc., (CENMACO) |

| PROJECT TITLE | IMPLEMENTING AGENCY | COMPANY PARTNER |
|---|---|---|
| 10. Fermentation and Purification Research to Produce Food Grade, Pharmaceutical-Grade and Polymer Grade Lactic Acid | University of the Philippines Mindanao (UPMin) | Monde Nissin Corporation |
| 11. Micropropagation of selected genetically-verified, superior bamboo to protect the environment and develop an alternative wood industry | University of the Philippines Los Baños (UPLB) | Carolina Bamboo Garden |
| 12. Development of a Design Guideline Using Finite Element Analysis (FEA) for Semiconductor Packages | De La Salle University - Laguna (DLSU-Laguna) | Integrated Micro-Electronics Inc. (IMI) |
| 13. Development of Novel Radiopharmaceuticals for Management and Detection of Early Stage Prostate Cancer | Philippine Nuclear Research Institute (PNRI) | Rocket Health Inc. |
| 14. ZURFACE: Surface Modification of Natural Zeolite for the Adsorption of Textile Dye Waste | De La Salle University (DLSU) | Saile Industries |
| 15. Demeter's Eye: An Embedded System for Detection and Mapping of Witchbroom's Disease on Cassava | Isabela State University (ISU) | EDCOR Development Cooperative |
| 16. Machinery for Decontaminating Rice Hull as Litter Floor for Broiler Breeder Production | Central Luzon State University (CLSU) | Cobb-Vantress Philippines Inc. |
| 17. Protein Hydrolysates from Marine Fisheries Species | University of the Philippines Visayas (UPV) | Pascual Pharma Corp. |
| 18. Development and Pilot Testing of Tree Climbing-Harvesting and Mobile Mechanical Dehusker for Coconut | University of Southeastern Philippines (USeP) | Franklin-Baker and Coco-link |

| PROJECT TITLE | IMPLEMENTING AGENCY | COMPANY PARTNER |
|---|---|---|
| 19. Development of a System that Can Determine and Classify the Layout Correctness of Integrated Circuit Layout Blocks using Machine Learning | University of Perpetual Help System - DALTA | Center for Applied Microelectronics and Programming, Inc (CAMP) |
| 20. Design and Development of a Mechanical Garlic and Cashew Chipper | Holy Angel University (HAU) | Edelyn's Homemade Nuts |
| 21. Development of De-oiling Equipment for Deep Fried Peanuts and Garlic | Bataan Peninsula State University (BPSU) | Terio's Food Products |
| 22. Development of Wastewater Treatment Equipment for Wet-Type Finishing Spray Booth | Forest Products Research and Development Institute (FPRDI) | RSU Rattan Furnitures |
| 23. Enhanced Forecasting Model for Complex Water Supply Systems of the East Service Area of Metro Manila | Asian Institute of Management (AIM) | Manila Water Company, Inc. |
| 24. Non-intrusive Sensor-based Prescriptive Maintenance Platform for Wire Manufacturing Factory (IISA - Integrated Intelligent Sensors and Actuators) | Ateneo de Manila University (AdMU) | Associated Wire Corporation of the Philippines |
| 25. Runruno (DOST-PCIEERD funded, CRADLE tagged) | Ateneo de Manila University (AdMU) | FCF Minerals Corp. |
| 26. Development of Efficient Semiochemical Management Method for Banana Flower Thrips | Cagayan State University (CSU) | Tagum Agricultural Development Company, Inc. |
| 27. Design and Prototyping of Salt Harvesting Equipment | Industrial Technology Development Institute (DOST-ITDI) | JALD Industries |

| PROJECT TITLE | IMPLEMENTING AGENCY | COMPANY PARTNER |
|---|---|---|
| 28. Management of Unified Control and Automated System for Smarter Hydroponics Greenhouse | Iloilo Science and Technology University (ISAT-U) | Ephrathah Farms |
| 29. Reworking of Processed Meat Using a Combined Acidification-Heat Treatment Process | Eastern Visayas State University (EVSU) | Tacloban City Litson Industry Association |
| 30. Standardized and Safe Tawa-tawa: Filling in the Final Gaps for a Clinically-proven Nutraceutical Product | University of San Agustin (USA) - Iloilo | Herbanext Industries |
| 31. Valorization of Mature Coconut Water through Beverage Development | University of the Philippines Diliman (UPD) | Aegina's Organic Farm Products (AOFP) |
| 32. Formulation, Quality Control and Immediate-Release Tablets of Fixed-Dose Combinations of Aspirin and Cilostazol | Adamson University (AdU) | Compact Pharmaceutical Corporation |
| 33. CARRAGEEN RESEARCH & DEVELOPMENT LAB (CR&De-L): Developing Cold-Soluble Powders, Bioplastic Sheets, and Bioactive Hydrogels from Nano-Structured Carrageenans | University of San Carlos (USC) | MCPI Corporation |
| 34. Integration of Machine Learning Inference on Home Energy Storage System (HESS) to Deliver Long-term Optimized Self-Consumption with Low Probability of Power Loss | Holy Angel University (HAU) | Edge-systems Engineering Services and Techno Philippines Innovation Corporation |
| 35. Integrated Flywheel Energy Management | De La Salle University - Laguna (DLSU-Laguna) | Amber Kinetics Philippines |
| 36. Development of a Liner-Enhanced Curing Vessel for Salted Egg Production for Eggciting Traditions | Batangas State University (BatSU) | Eggciting Traditions Processed Food Manufacturing |

| PROJECT TITLE | IMPLEMENTING AGENCY | COMPANY PARTNER |
|---|---|---|
| 37. Production of Dietary Fiber using Sugarcane Bagasse from Raw Sugar Manufacturing | Industrial Technology Development Institute (DOST-ITDI) | Raw Brown Sugar Milling Corp. |
| 38. DRIVER. PH- Drivers Roadworthiness Improvement Verification Education & Readiness for the Philippine logistics industry | Technological Institute of the Philippines (TIP) - Manila | Quicktrans Cargo Moving Inc. |
| 39. Development of a Gamma Computed Tomography Imaging Device for Industrial Applications (GAIA) Project | Philippine Nuclear Research Institute (PNRI) | Energy Development Corp. |
| 40. Application of Natural Antioxidants Derived from Sugarcane for Food, Food Supplement and Cosmetics Production Formulations | University of the Philippines Los Baños (UPLB) | Forever Nutriliving Corp. |
| 41. Development of a Design Guideline Using Finite Element Analysis (FEA) for Semiconductor and Electronics Packaging Systems for Automotive Applications - FEA Phase 2 (Automotive Applications) | De La Salle University - Laguna (DLSU-Laguna) | Integrated Micro-Electronics Inc. (IMI) |
| 42. Development of Plasma Coating Processes for the Furniture Industry | University of the Philippines Diliman (UPD) | Chamber of Furniture Industries of the Philippines |
| 43. Pilot Testing of Packaging Technology Developed For Frozen Durian Using Locally Produced Packaging Materials | Industrial Technology Development Institute (DOST-ITDI) | Rosario's Food Products and Farmers' Market, Calinan, Davao |
| 44. Smart Parcel Locker | Technological Institute of the Philippines (TIP) - Manila | iTrack Solutions Inc. |
| 45. Enhancement of housing management and breeding program in multiplier farm of Itik Pinas in Central Luzon | Central Luzon State University (CLSU) | R.C.R Egg Dealer and Balut Industry |

| PROJECT TITLE | IMPLEMENTING AGENCY | COMPANY PARTNER |
|---|---|---|
| 46. Biofloc-based Nursery Tank Production of Shrimp for Quality and Sustainable Supply of Aquaculture Products in Urban Areas | University of San Agustin (USA) - Iloilo | Marmi Agricultural Corporation |
| 47. Development of Low Temperature Dryer (LTD) for Specialty Coffee in Nueva Vizcaya | Isabela State University (ISU) | Bugkalot Coffee Growers MPC |
| 48. Development and Quality of Soysage using Okara | University of Sto Tomas (UST) | Banawe Soybean Corporation |
| 49. Extension of Shelf Life of Rice Meal in Microwaveable Container | University of the Philippines Diliman (UPD) | Jolliant |
| 50. Systematized Mining Operations using Automation and Real-Time Telematics Platform towards a Paradigm Shift in Surface Mines of Caraga Region (SMART Mines) | Caraga State University (CarSU) | Cagdianao Mining Corp. (CMC) |
| 51. SMART MINE: Development of Sediment Monitoring and Analysis for Rehabilitation Tool in a surface MINE area | Central Mindanao University (CMU) | Agata Mining Ventures, Inc. |
| 52. Upgrading the Philippine Lateritic Bauxite Through Potential Ore Beneficiation Processes | University of the PhIlippines Diliman (UPD) | Marcventures Holdings Inc. |
| 53. Mine Tailings Utilization for Socioeconomic and Environmental Sustainability | Caraga State University (CarSU) | Sarnimian Small Scale Mining Corporation |
| 54. Drive Air ni Juan-Aluminosilicate Technology for Compact Air Purification | University of the Philippines Diliman (UPD) | SLI, MC Home Depot, Manly Plastics, Inc. GOSSI |

| PROJECT TITLE | IMPLEMENTING AGENCY | COMPANY PARTNER |
|---|---|---|
| 55. baTID: RFID-band for Personalized Body Temperature Monitoring | Ateneo de Manila University (AdMU) | SparkSoft Inc. |
| 56. Community-level Functionalization of Handwoven Cordillera and Mindoro Textiles for Creative Protective Clothing | Philippine Textile Research Institute (PTRI) | Custom Made Crafts Center Inc. |
| 57. CYANanobot: Miniaturized Boat-assisted Data Acquisition for Automated Cyanide Monitoring in Wastewater using Optical Nano-sensor | Caraga State University (CarSU) | Apex Mining Co. Inc. |
| 58. Technology Intervention to Provide an Alternative Market for Sampaguita (Jasminum sambac) as Raw Material for Jasmine Oil Production | Mapua University | Secura International Corporation |
| 59. Development of Immunoactive and Growth Promoting Aquafeed Additive from Ulva Seaweed | University of the Philippines Visayas (UPV) | Obi's Trading Room, Inc. |
| 60. Internet of Tubig (IOT): Development of Smart Water Meter Wireless Network | University of the Philippines Diliman (UPD) | Jhaymarts Industries, Inc. |
| 61. Valorization of Carabao's Milk | University of the Philippines Visayas (UPV) | Waffle Time Inc. |
| 62. Moringa oleifera-based developed (MOD) Nutraceutical Product: Nutritional and Metabolome Profiling | University of the Philippines Los Baños (UPLB) | Herbanext Laboratories Inc., and Pascual Pharma Corp. |
| 63. Diachronic Representation and Linguistic Study of Filipino Word Senses Across Social and Digital Media Contexts | De La Salle University (DLSU) | Senti Tech Labs |

| PROJECT TITLE | IMPLEMENTING AGENCY | COMPANY PARTNER |
|---|---|---|
| 64. Site Characterization and Implementation of Innovative Sustainable Oyster (SCI2SOS) | University of the Philippines Diliman (UPD) | Agricultural Sustainability Initiatives for Nature, Inc. |
| 65. ChicIoT: An IoT-Based Smart Poultry Building Environment and Growth and Health Status Monitoring and Modelling | University of Southeastern Philippines (USeP) | Tetra Consulting Company |
| 66. Building Bonds between Academe and Industry: Formulation of Vitrified Bonding Materials for Locally Manufactured Aluminum Oxide and Silicon Carbide Grinding Wheels | Ateneo de Manila University (AdMU) | GICA Grinding Wheel Corporation |
| 67. SPARCS: System for Plasma-assisted Ablation of Residues and Cleaning of Surfaces | University of the Philippines Diliman (UPD) | Filipinas Oro de Cacao, Inc. |
| 68. Constructed Wetland for Wastewater Treatment of Effluent from a Water Provider | Technological Institute of the Philippines (TIP) - Arlegui | Subicwater Technology |
| 69. Sustainable Bangus Fry Production of ALT Hatchery, Panabo City Davao del Norte | University of the Philippines Visayas (UPV) | ALT Hatchery |
| 70. i-DRIP (IoT-Based Dispenser for Real-time Intelligent Pour) an IoT-Based Real-Time Control and Monitoring System for Smart Beverage Dispenser | Bulacan State University (BulSU) | Purenectar Company |
| 71. Black Soldier Fly (BSF) Farming for Agricultural Productivity and Waste Management | University of the Philippines Cebu (UP Cebu) | Chesed Quail Supplier |
| 72. Maritime Energy Demand Information and Analysis Software (MEDIAnS) | University of the Philippines Diliman (UPD) | SeaShore Transport Supplies and Services (SeaShore) |
| 73. Nanotexturing of Stainless Steel 316L by Electrochemical Etching for Biological Implants | Industrial Technology Development Institute (ITDI) | Arthrologic Inc. |

# REFERENCES AND FURTHER READING


ABS-CBN DZMM Teleradyo Live Interview. (2019, November 23). *Lakas ng Siyensya: Season 2 The DOST Innovation Landscape and the NICER program* [Transcript].

Agripreneur. (2020, September 24). *Agripreneur Live! Kasama si Pampanga State Agricultural University President, Dr. Honorio Soriano* [Video]. YouTube.https://www.youtube.com/watch?v=thI4IGECJAg

Aldama, K. R. (2019, July 11). *Cebu's KBAs: Assessed using Permanent Biodiversity Monitoring System* [Article]. http://www.pcaarrd.dost.gov.ph/home/portal/index.php/quick-information-dispatch/3508-cebu-s-kbas-assessed-using-permanent-biodiversity-monitoring-system

ANC 24/7. (2019, August 7). *Future Perfect: Tawa-tawa herbal capsule to help alleviate dengue symptoms.* [Video]. YouTube. https://www.youtube.com/watch?v=3HuHKOLB0Qs

Angeles, I. (2019, November 8.). *Freshwater Fisheries Center Accomplishment Report* [PDF]. Isabela State University Echague, Isabela.

Angeles, I. (n.d.). *Salient Accomplishments and Socio-Economic Impacts of FFC* [Document].

Bureau of Agricultural Research. (2005, September 9). *Agro-ecological Studies on Farming Systems and Value Chain Analysis of Turmeric and Turmeric Production in Eastern Visayas* [PDF]. Department of Agriculture.

Camarines Norte State College. (2019, May 8). *CNSC, NRCP partners for the establishment of QP RDE Center in CN* [Article]. https://cnsc.edu.ph/cnsc-website/homepage/news-and-updates/92-cnsc-nrcp-partners-for-the-establishment-of-qp-rde-center-in-cn

Camarines Norte State College. (n.d.). *Major Programs on Research and Development* [PDF]. Retrieved from https://cnsc.edu.ph/wp-content/uploads/2016/pm/MPRD.pdf

Camarines Norte State College. (n.d.). *DOST-PCAARRD evaluates Queen Pineapple 5* [PDF]. https://main.cnsc.edu.ph/images/2020%20Documentation/02112020%20-%20DOST-PCAARRD.pdf

Cebu Technological University Biodiversity, Environment, and Natural Resources Research Center. Facebook page. https://www.facebook.com/ctubenrc/

Commission on Higher Education Region 1. (2019, December 13). *The Science for Change (S4C) Program: Research Innovations Contributory to National Development* [Powerpoint].

Darvin, L. (2018, March 2). *DOST and PCAARRD jointly kick off NICER Program at Isabela State University* [Article]. http://www.pcaarrd.dost.gov.ph/home/portal/index.php/quick-information-dispatch/3134-dost-and-pcaarrd-jointly-kick-off-nicer-program-at-isabela-state-university

De la Peña, F. (2020). *Filipinnovation: Financing Science for the People. The Global Innovation Index 2020* [PDF]. Retrieved from https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2020-chapter10.pdf

Department of Agriculture: Philippine Rural Development Project. (2019, October 24). Better Lives through Convergence [Article]. http://prdp.da.gov.ph/better-lives-through-convergence/

Department of Science and Technology. (2019, July 12). *Of Ecology, Coffee Entrepreneurs, and Biodiversity: PCAARRD Steps Up Scientific Response* [Article]. Scitech And Digital News. https://scitechanddigital.news/2019/07/12/of-ecology-coffee-entrepreneurs-and-biodiversity-pcaarrd-steps-up-scientific-response/

DOST-National Research Council of the Philippines Research Pod. (2020, July 17). *Meet our RD Leaders* [Video]. Facebook. https://www.facebook.com/watch/?v=282551896186289

DOST-NRDC. (2021, January 21). *NICER – Flora and Fauna Assessment in Cebu Island Key (Dr. Archiebald Baltazar B. Malaki)* [Video]. YouTube. https://www.youtube.com/watch?v=gOtliPSNcuw

DOST-NRDC. (2021, January 11). *Tuklas Lunas Program: Drug Discovery and Development from Philippine Biodiversity (Mr. Philip Cruz)* [Video]. YouTube. https://www.youtube.com/watch?v=VnbI4OTrC0s

DOST-Philippine Council for Health Research and Development Applied Research Innovation Laboratory. (2021, April 13). *Making Your Labscale Research Industry-Ready* [Webinar].

DOST Report. (2020, August 7). *Secretary's DOST Report and CRADLE Program* [Transcript].

DOSTv: Science for the People. (2020, July 24). *DOSTv Esp. 13 Nicer and RD final* [Video]. YouTube. https://www.youtube.com/watch?v=jLYGp_fNw4U

DOSTv: Science for the People. (2020, July 17). DOSTv Esp. 132 RDLead Programs of DOST [Video]. YouTube. https://www.youtube.com/watch?v=0WpCIAsh1UA

DOSTv: Science for the People. (2020, August 7). *DOSTv Esp. 15 CRADLE program* [Video]. YouTube. https://www.youtube.com/watch?v=9Jvqprt88sY

DOSTv: Science for the People. (2020, August 14). *DOSTv Esp. 16 CRADLE program* [Video]. YouTube.com. https://www.youtube.com/watch?v=vOMpRr7X5-E

DOSTv: Science for the People. (2019, November 8). *Tawa-Tawa Capsule* [Video]. YouTube.com. https://www.youtube.com/watch?v=FwZDvvKZyp4

Estremera, S. (2017, December 5). *Making R&D Available to All* [Article]. Sunstar Davao. Retrieved from https://www.hijoresources.com/making-rd-available-to-all/

Freshwater Fisheries Center. Facebook page. https://www.facebook.com/freshwaterfisheriescenter/

Global Links MP Events International. (2020, November 5). *Science for Change Program: Accelerated R&D program for Capacity Building Research and Development Institutions* [Video]. YouTube. https://www.youtube.com/watch?v=sPQpVijjJLk

Gonzales, V. (2020). *Annual Report 2020: NICER Tamarind Y2 Renewal-GC* [PDF]. Tamarind R&D Center. Pampanga State Agricultural University.

Gonzales, V. (2020). *Accomplishment Report: Tamarind R&D Center [PDF]. Tamarind R&D Center.* Pampanga State Agricultural University.

Halun, S. (n.d.). *MRRD-SeaRDeC- Salient Accomplishments and Socio-Economic Impact* [Document]. Mindanao State University-Tawi-Tawi College of Technology and Oceanography.

Halun, S. (n.d.). *SeaRDeC Accomplishments* [Document]. Mindanao State University-Tawi-Tawi College of Technology and Oceanography.

Halun, S. (2021, January). *Executive Brief for DOST-GIA* (NICER) [PDF]. Mindanao State University-Tawi-Tawi College of Technology and Oceanography

Halun, S. (2021, January) *Seaweed Narrative Report* [PDF]. Mindanao State University-Tawi-Tawi College of Technology and Oceanography

Herbanext. (n.d.). *Company Profile* https://www.herbanext.com/

Isabela State University. (n.d.). *Vision, Mission, and Goal.* https://isu.edu.ph/cagayan-valley-freshwater-fisheries-center/

Laguda, M., et al. (2005, September 9). *Proposal for the Effectiveness of Different Modalities of Mollusk Product Promotion* [PDF]. Department of Agriculture of Agricultural Research.

Leaders in Innovation Fellowship. (n.d.). *QP Technologies Products* [Brochure]. https://www.aim.edu/sites/default/files/2019-08/AIM-LIF-QP-Tech-One-15-01.pdf

Letigio, D. (2018, November 28). Cebu Daily News. *Cebu's Smallest Snails* [Article]. https://cebudailynews.inquirer.net/205669/cebus-smallest-snails

Lilio, E., et al. (n.d.). *Flora of Mount Lantoy Key Biodiversity Area: An Introductory Guide* [Document]. Cebu Technological University-Argao.

Lubang, S. and Panaligan, K. (2018, April 11). P*CAARRD's program on Queen Pineapple to help marginalized farmers in Bicol and Eastern Visayas* [Article]. DOST-PCAARRD S&T Media Services. http://www.pcaarrd.dost.gov.ph/home/portal/index.php/quick-information-dispatch/3177-pcaarrd-s-program-on-queen-pineapple-to-help-marginalized-farmers-in-bicol-and-eastern-visayas

Magno, M. and Uy, W. (n.d.). *Sea Cucumber Storyline* [Document]. NICER Sea Cucumber R&D Center.

Malaki, A. (2017, August 31). *Program Proposal: Biodiversity Environment and Natural Resources R&D in Central Visayas* [Document]. Cebu Technological University.

Malaki, A., et al. (2020 January). *Diversity and distribution of ferns in forest over limestone in Cebu Island Key Biodiversity Areas (KBAs), Philippines* [PDF]. http://www.pcaarrd.dost.gov.ph/home/portal/index.php/quick-information-dispatch/3508-cebu-s-kbas-assessed-using-permanent-biodiversity-monitoring-system

Malaki, A. (n.d.). *CTU DOST-NICER storyline* [Document]. Cebu Technological University-Argao

Malaki, A. (2021 January). *CTU Executive Brief* [Document]. Cebu Technological University-Argao

Malaki, A. (n.d.). *Flora and Fauna Assessment Using Permanent Biodiversity Monitoring System (PBMS) in Cebu Island Key Biodiversity Areas* [Presentation]. Cebu Technological University-Argao

Mauro, A. B. (2020, August 12). *DOST links University Researchers to Local Industries* [Article]. DOST-STII. https://www.dost.gov.ph/knowledge-resources/news/67-2020-news/1908-dost-links-university-researchers-to-local-industries.html

Mindanao Renewable Energy Center. (n.d.) *CSP Modelling* [Webinar].

Niche Center for Sea Cucumber. Facebook. https://www.facebook.com/NICERforSeaCucumber/

Noderama, R., et al. (2005, September 9). *Municipal Ordinance for Mollusks Habitat* [Document]. Department of Agriculture of Agricultural Research.

Pampanga State Agricultural University. (2017, March 8). *About PSAU and their R&D programs* [PDF]. https://files.seameo.org/19_SEAMEO-China%20TVET%20Cultural%20Twinning%20Programme/25_30Aug_Pampagang%20State%20Agriculture%20University%20Philippines_Resize.pdf

PRDP InFOCUS Mindanao. (October 2019). *Better Lives through Convergence* [Journal]. https://issuu.com/prdpmindanao/docs/october_layout

Science for Change. (2021, April 8). *S4CP Weblaunch featured projects SEAWEED, BSC, PISOLAR & HERBANEXT* [Video]. YouTube. https://www.youtube.com/watch?v=3ba6bHGvy7c

Science for Change. (2021, January 20). *NRCP RDLEAD 2020* [Video]. YouTube. https://www.youtube.com/watch?v=TWkXkSR0eos

Science for Change Program Website. (n.d.). https://s4cp.dost.gov.ph

Science for Change Program Website (n.d.). *BIST: Complete list.* https://s4cp.dost.gov.ph/programs/bist/bist-projects/

Science for Change Program Website (n.d.). *CRADLE: Complete list.* https://s4cp.dost.gov.ph/programs/cradle/cradle-projects/

Science for Change Program Website. (n.d.). *NICER projects.* https://s4cp.dost.gov.ph/programs/nicer/nicer-projects/

Science for Change Program Website (n.d.). *RD Leaders: Complete list.* https://s4cp.dost.gov.ph/programs/rdlead/

Seaweed Research and Development Center. Facebook. https://www.facebook.com/seaweedRDcenter/

The Worldbank. (n.d.). *Research and development expenditure* (% of GDP)-Philippines. https://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS?end=2015&locations=PH&start=2002

Ubando, A. (2020, July 10). *Computation Fluid Dynamics Training* [Document]. DOST-NRCP Philippines.

# IMAGE CREDITS

Azanza, P. (n.d.). *Dr. Patricia Azanza* [Digital image].

Batangas Egg Producers Multipurpose Cooperative (BEPCO). (n.d.). *BEPCO products* [Digital images].

Bernabe, J. (2020). *Sampalok Bonsai Lovers Group* [Online image]. Tamarind Community PSAU Facebook. https://www.facebook.com/TamarindCommunityPSAU/photos/a.115898760129657/139902297729303

Biodiversity R&D Center, Cebu Technological University. [n.d.]. [Digital images].

Department of Science and Technology (n.d.). *Herbanext Laboratories, Inc.* [Digital image].

Department of Science and Technology. (n.d.). *Dr. Teresita Dalisay* [Digital image].

Department of Science and Technology. (n.d.). *Dr. Floirendo Flores* [Digital image].

Department of Science and Technology. (n.d.). *Dr. Aristotle Ubando* [Digital image].

Department of Science and Technology. (n.d.). *Dr. Marco Nemesio Montaño* [Digital image].

Department of Science and Technology. (n.d.). *Science for Change Program* [Digital images]. https://s4cp.dost.gov.ph

Dorweiler, S. (2017). *The beauty of nature* [Digital image]. Unsplash. https://unsplash.com/photos/9Z1KRIfpBTM

Freshwater Fisheries Center, Isabela State University. (n.d.). *Conservation and Artificial Spawning of Ludong* [Digital images].

Freshwater Fisheries Center, Isabela State University. (n.d.). *Freshwater Fisheries Center Building* [Digital image].

Freshwater Fisheries Center, Isabela State University. (n.d.). *Salient Accomplishments and Socio-Economic Impact* [Digital images].

Freshwater Fisheries Center, Isabela State University. (n.d.). *Utilization of Aquatic Plants as Immunostimulants for Freshwater Eel Culture* [Digital images].

Google. (n.d.). [Google map for Angat Dam]. Retrieved June 2021, from https://goo.gl/maps/cuSCx5CtKrjcuzQi6

Google. (n.d.). [Google map for Cabantug, Argao Cebu]. Retrieved June 2021, from https://goo.gl/maps/TqQ4KtMqH1JAmQPDA

Herbanext Laboratories, Inc. (n.d.). *Herbanext facilities* [Digital images].

Herbanext Laboratories, Inc. (n.d.). *Tawa-Tawa Herbal Food Supplement* [Digital images].

Malaki, A. (n.d.). *Flora and Fauna Assessment Using Permanent Biodiversity Monitoring System (PBMS) in Cebu Island Key Biodiversity Areas* [Digital images].

Manila Water Company Inc. (n.d.). [Digital images]. https://www.manilawater.com

Mindanao Renewable R&D Center, Ateneo de Davao University. (n.d.). [Digital images].

National Research Council of the Philippines. (n.d.). *DOST RDLead Program* [Digital images].

Niche Center for Sea Cucumber, Mindanao University-Naawan. (2020). *A look inside the genetics laboratory* [Online image]. Facebook. https://www.facebook.com/NICERforSeaCucumber/photos/a.105947334350831/158068612472036

Niche Center for Sea Cucumber, Mindanao University-Naawan. (2020). *H. scabra juveniles grown in the MSUN fishpond yielded good results* [Online image]. Facebook. https://www.facebook.com/NICERforSeaCucumber/photos/217198719892358

Niche Center for Sea Cucumber, Mindanao University-Naawan. (2020). *I spy with my little eye something that begins with an S!* [Online image]. Facebook. https://www.facebook.com/NICERforSeaCucumber/photos/121575889454642

Niche Center for Sea Cucumber, Mindanao University-Naawan. (2020). *Processing H.scabra to trepang* [Online image]. Facebook. https://www.facebook.com/NICERforSeaCucumber/photos/217198523225711

Tamarind Community Pampanga State Agricultural University. (2020). [Online images]. Facebook. https://www.facebook.com/TamarindCommunityPSAU/?ref=page_internal

Sea Cucumber Research and Development Center, MSU-Naawan. (n.d.). [Digital images].

Seaweed Research and Development Center, Mindanao State University Tawi-Tawi. (n.d.). *Dr. Zayda Halun* [Digital image].

Seaweed Research and Development Center, Mindanao State University Tawi-Tawi. (n.d.). *Professor Serag with seaweed cultivars* [Digital image].

Seaweed Research and Development Center, Mindanao State University-Tawi-Tawi College of Technology and Oceanography. (n.d.). [Online images]. Facebook. https://www.facebook.com/seaweedRDcenter/?ref=page_internal

Seaweed Research and Development Center, Mindanao State University Tawi-Tawi. (n.d.). [Digital images].

Simpao, F. (n.d.). [Digital images].

Simpao, F. (n.d.). *Payment Innovation of SHS Ownership through a Lay-Away Routine* (PISOLAR) [Digital images].

University of the Philippines Cebu Center for Environmental Informatics. (n.d.). *UP CENVI Field Photos* [Digital images].

University of the Philippines Visayas Miagao Center for Mollusk Research and Development. (n.d.). [Digital images].

University of San Agustin, Iloilo. (n.d.). *Metabolomics as Tool for the Discovery of Hypocholesterolemic Natural Products from Pineapple* [Digital images].

University of of Southeastern Philippines, Davao. [n.d.]. [Digital images].

# INTERVIEWS

Abrea, R. (2021, April 29). Phone interview.
Alaban, M. (2021, March 29). Email interview.
Alcaria, J. (2021, April 5). Phone interview.
Alday-Mangmang, J. (2021, May 3). Online interview.
Aldueza-Virtucio, C. (2021, May 3). Online interview.
Alegre, A. (2021, May 31). Phone interview.
America, L. (2021, March 24). Email interview.
Amil, F. (2021, April 19). Email interview.
Ancheta, R. (2021, May 5). Phone interview.
Angeles, I. (2021, March). Email interview.
Angeles, I. (2021, April 27). Email interview.
Arriesgado, D. (2021, April 29). Email interview.
Arriesgado, E. (2021, April 29). Email interview.
Awail, R. (2021, April 20). Phone interview.
Azanza, P. (2021, April 19). Online interview.
Bais, A. (2021, April 30). Email interview.
Belando, N. (2021, April). Phone interview.
Cabansag, J. (2021, April 27). Email interview.
Concepcion, T. (2021, April 19). Email interview.
Cordiñera, M. (2021, May 3). Email interview.
Cruz, P. (2021, April). Email interview.
Cruz, P. (2021, April 27). Phone interview.
Cunanan, L. (2021, April 21). Email interview.
Dalisay, T. (2021, May 3). Email interview.
De Guzman, A. (2021, April 28). Phone interview.
Domingo, M. (2021, March). Email interview.
Dumilag, R. (2021, April 19). Email interview.
Espigol, A. (2021, April 22). Online interview.
Flores, F. (2021, April 21). Phone interview.
Getaruelas, J. (2021, March 25). Phone interview.
Gonzales, V. (2021, March 22). Phone interview.
Gonzales, V. (2021, March). Email interview.
Halun, S. (2021, May 3). Email interview.
Ibarreta, F. (2021, April 22). Online interview.
Importante, G. (2021, May 3). Phone interview.
Leopardas, V. (2021, April 28). Email interview.
Malaki, A. (2021, April 5). Phone interview.
Mallorca, R. (2021, April). Phone interview.
Marfy, L. (2021, March 22). Email interview.
Masahud, T. (2021, April 21). Phone interview.
Matba, H. (2021, April 20). Phone interview.

Mendez, C. (2021, April 28). Phone interview
Meñez, A. (2021, April 28). Email interview.
Montaño, M. (2021, April 28). Phone interview.
Monterola, C. (2021, April 25). Phone interview.
Morados, A. (2021, April 28). Phone interview.
Mualil, I. (2021, May 6). Phone interview.
Nahul, A. (2021, May 5). Phone interview.
Nopre, R. (2021, February 11). Email interview
Nucup, R. (2021, February 11). Email interview.
Nuryakin, J. (2021, April 19). Phone interview.
Oguis, M. (2021, April 28). Email interview.
Orajay, J. (2021, April 19). Phone interview.
Orbos, M. (2021, April 25). Phone interview.
Ortigo, A. (2021, April 28). Phone interview.
Pautan, C. (2021, March 24). Phone interview.
Piedad, L. (2021, April 28). Email interview.
Quimno, V. (2021, April 12). Phone interview.
Recente, C. (2021, April 28). Email interview.
Saludes, J. (2021, May 6). Phone interview.
Sanchez, J. (2021, March 23). Phone interview.
Sardido, E. (2021, April 19). Phone interview.
Sardo, R. (2021, February 11). Email interview.
Segovia, M. (2021, April). Phone interview.
Serag, K. (2021, May 1). Email interview.
Simpao, F. (2021, April 25). Phone interview.
Tuason-Fores, R. (2021, April 26). Online interview.
Ubando, A. (2021, April 28). Phone interview.
Uy, W. ( 2021, April 29). Phone interview.
Zamora, R. (2021, April 24). Phone interview.

# ACKNOWLEDGMENTS

The Department of Science and Technology (DOST) wishes to show its appreciation to all the individuals and the institutions supporting the Science for Change Program. This program would not have been possible without all their assistance.

The book would not have been complete without the unique contributions of the project leaders, beneficiaries, business leaders, private institutions, and educational institutions such as the Ateneo de Davao University, Biliran Province State University, Camarines Norte State College, Cebu Technological University, Isabela State University, Mindanao State University-Naawan. MSU Tawi-Tawi College of Technology and Oceanography, Pampanga State Agricultural University, University of San Agustin, University of Southeastern Philippines, University of the Philippines Cebu, University of the Philippines Diliman, Asian Institute of Management, and the University of the Philippines Visayas who shared their time and wisdom with us. We also greatly value the contributions from companies such as the Batangas Egg Producers Multipurpose Cooperative (BEPCO), Del Monte Philippines Inc., Herbanext Laboratories, Inc., Hijo Resources Corporation, Learning by Doing Technologies, Inc. (LEADTECH), and the Manila Water Company, Inc.

The DOST also wishes to show its appreciation for all the colleges, universities, and private institutions integral to the Science for Change Program. They also greatly appreciate the steadfast support from the government and non-government agencies, the private sector, media, researchers, as well as the Department of Science and Technology's regional offices, councils, and agencies.

We wish to recognize the support of the lawmakers to the Science for Change Program Bill both in Senate and House of Representatives: Sen. Panfilo Lacson, who authored House Bill No. 4581; Hon. Joey Sarte Salceda, District Representative of Albay (2nd District), who introduced and served as one of the principal authors of House Bill No. 4581; and Hon. Sharon S. Garin from the Party List of AAMBIS-OWA, who introduced House Bill No. 7193, which institutionalized the Science for Change Program as a national strategy to accelerate the appropriation of funds and the development of science and technology, and innovation in the country.

Lastly—the DOST extends a heartfelt thank you to the Science for Change Program Management Team under the Office of the Undersecretary for Research and Development for their valuable time and effort in developing this book. With this book that highlights the Science for Change Program's impact and potential, we truly hope to inspire future scientists, research institutions, and industries that science, technology, and innovation can make positive changes happen.



For more information on the Science for Change Program, you may visit our website at https://s4cp.dost.gov.ph or contact us at:


| | |
|---|---|
| Phone: | (02) 8837-2943 or (02) 8837-2930 |
| Email: | s4c.ousecrd@dost.gov.ph |
| Address: | 2nd Floor ADMATEL Bldg., DOST Compound, General Santos Avenue, Bicutan, Taguig City |

Follow us on

| | |
|---|---|
| Facebook : | https://www.facebook.com/dost.s4cp/ |
| Instagram: | @dost.s4c |
| YouTube: | Science for Change |



Science for the People is a publication of the Department of Science and Technology. The implementation of this book project was monitored by the National Research Council of the Philippines.

For more information about the Department of Science and Technology and their programs:

Website: www.dost.gov.ph
Facebook: www.facebook.com/DOSTph

DOST Building
General Santos Avenue Bicutan, Taguig City
Metro Manila, Philippines 1631
Phone: (632) 8837-2071 to 82 or (632) 8837-2937
Email: osec@dost.gov.ph

# ABOUT THE AUTHORS

**DR. ROWENA CRISTINA L. GUEVARA** is the Undersecretary for Research and Development of the Department of Science and Technology (DOST) and a Professor of Electrical and Electronics Engineering at UP Diliman. She has a Bachelor of Science and a Master of Electrical Engineering from UP Diliman and a Doctorate in Electrical Engineering from the University of Michigan in Ann Arbor. She was the proponent and the first program leader of the Engineering R&D for Technology, a consortium for the graduate engineering scholarship program of the DOST since 2007. She is an expert in speech and audio signal processing, time-frequency analysis, and synthesis. Undersecretary Guevara was the youngest and first female Dean of the UP College of Engineering and has received several awards, including the Metrobank Foundation Search for Outstanding Teachers of the Philippines.

**FORTUNATO "BOY" T. DE LA PEÑA** is the Secretary of the Department of Science and Technology (DOST). He has a Bachelor of Science degree in Chemical Engineering, a Master of Science in Industrial Engineering, and a Doctorate in Business Administration from UP Diliman, and further studies in Industrial Quality Control from Bouwcentrum International Education in Rotterdam, Netherlands, and Operations Research at the New York University Tandon School of Engineering. Secretary de la Peña started his career as a faculty at the UP College of Engineering and the first editor of the Philippine Engineering Journal. He also held key positions as the director of the UP's Institute for Small Scale Industries and as vice president for planning and development of the entire UP System, receiving an Outstanding Achievement Award from the university in 1999. He served as executive director of the Congressional Commission on Science, Technology and Engineering (COMSTE), co-chaired the National Innovation Network (Filipinnovation), and chaired the United Nations Commission on Science and Technology for Development (UNCSTD).

---

This book was made possible through researchers, staff writers, and contributors who, in the spirit of collaboration, brought in perspectives from multiple disciplines, from science to communications.

Science for Change




| | |
|---|---|
| Executive Editor | Anna Canlas |
| Editor in Chief | Anna Canlas |
| Publisher | Bam Besa |
| Managing Editor | Jenny Aguilar |
| Program Director | Danielle Canlas-Torres |
| Art Director | Zoe Sabandal |
| Illustrator | Zoe Sabandal |
| Researcher-Writers | Maia Puyat, Lyn Resurreccion, Julianne Suazo |
| Research Assistants | Ticia Almazan, Micah Guiao, Patricia Villoria |
| Contributors | Bernadette T. Baer |
| | Ernilyn B. Brown |
| | Melvin P. Jusi |
| | Marfy H. Lita |
| | Maradika Maravilla |
| | Gilbert M. Poralan Jr. |
| | Nikko B. Delos Reyes |
| | Ma. Anya Yasmin A. Roslin |
| | Monica Blaise B. Saniel |
| | Reina Kris D. Villaluna |

Breaking down four key programs that promote R&D expertise, applications and collaborations between academe and the industry, **SCIENCE FOR CHANGE** fleshes out how innovation can be used for the benefit of the country.