NIMP

National Irrigation Master Plan

2020-2030

Abridged Version

The National Irrigation Master Plan (NIMP) 2020-2030
Abridged Version

National Economic Development Authority (NEDA)
National Irrigation Administration (NIA)
University of the Philippines Los Baños Foundation Inc. (UPLBFI)

December 2020

TABLE OF CONTENTS

LIST OF ACRONYMS

A&D	Alienable and Disposable
ADB	Asian Development Bank
ADSDPP	Ancestral Domain Sustainable Development and Protection Plan
AFMA	Agriculture and Fisheries Modernization Act
AFMP	Agriculture and Fisheries Modernization Plan
AHP	Analytic Hierarchy Process
AMS	Asset Management System
AO	Administrative Order
ARDL	Autoregressive Distributed Lag Model
ARMM	Autonomous Region in Muslim Mindanao
ASEAN	Association of Southeast Asian Nations
ATI	Agricultural Training Institute
AWD	Alternate Wetting and Drying
AWP	Agency-Wide Programs
BBB	Build, Build, Build
BCA	Benefit Cost Analysis
BCM	Billion Cubic Meter
BCR	Benefit-Cost Ratio
BDRRMC	Barangay Disaster Risk Reduction Management Committee
BIIS	Bohol Integrated Irrigation System
BMB	Biodiversity Management Bureau
CADT	Certificate of Ancestral Domain Title
CAF	Census of Agriculture and Fisheries
CAR	Cordillera Administrative Region
CC	Climate Change
CCA	Climate Change Adaptation
CCC	Climate Change Commission
CDM	Clean Development Mechanism
CER	Certified Emissions Reduction
CHED-PCARI	Commission on Higher Education – Philippine-California Advanced Research Institutes
CI	Controlled Irrigation

CIP	Communal Irrigation Project
CIRDUP	Comprehensive Irrigation Research and Development Umbrella Program
CIS	Communal Irrigation System
CLIRAM	Climate Information Risk Analysis Matrix
CO	Central Office
CorPlan	Office of the Corporate Planning Services
CSA	Climate Smart-Agriculture
CU	Coefficient Uniformity
CWR	Crop Water Requirements
DA	Department of Agriculture
DA-AMIA	Department of Agriculture - Adaptation and Mitigation Initiatives in Agriculture
DA-AO	DA - Administrative Order
DA-ATI	Department of Agriculture-Agricultural Training Institute
DA-BAR	Department of Agriculture-Bureau of Agricultural Research
DA-BAFE	DA - Bureau of Agricultural and Fisheries Engineering
DA-BAFS	DA - Bureau of Agriculture and Fisheries Standards
DA-BFAR	DA - Bureau of Fisheries and Aquatic Resources
DA-BSWM	DA - Bureau of Soils and Water Management
DA-CAFED	DA - Central Agriculture and Fishery Engineering Division
DA-CARP	DA - Comprehensive Agrarian Reform Program
DA-FPOPD	DA - Field Programs Operational Planning Division
DA-HVCDP	DA - High Value Crops Development Program
DA-NOAP	DA - National Organic Agriculture Program
DA-RFO	DA - Regional Field Offices RFO
DAO	Department Administrative Order
DBM	Department of Budget and Management
DBP	Development Bank of the Philippines
DCIEP	Diversified Crops Irrigation Engineering Project
DEM	Data Elevation Model
DENR	Department of Environment and Natural Resources
DENR-EMB	DENR - Environmental Management Bureau

DENR-ERDB	DENR - Ecosystems Research and Development Bureau
DENR-FMB	DENR - Forest Management Bureau
DENR-LMB	DENR - Land Management Bureau
DENR-MGB	DENR - Mines and Geosciences Bureau
DENR-NWRB	DENR - National Water Resources Board
DENR-NWRC	DENR - National Water Resources Council
DENR-PAMB	DENR - Protected Area Management Board
DepEd	Department of Education
DGCS	Design Guidelines Criteria Standards
DIME	Digital Imaging for Monitoring and Evaluation
DOE	Department of Energy
DOH	Department of Health
DOST	Department of Science and Technology
DOST-PAES	DOST - Philippine Agricultural Engineering Standards
DOST-PCAARRD	DOST - Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development
DPWH	Department of Public Works and Highways
DPWH-BOD	DPWH - Bureau of Design
DPWH-BRS	DPWH - Bureau of Research and Standards
DRRM	Disaster Risk Reduction and Management
DRS	Drainage Reuse System
DS-GU	Downstream Start-Going Upstream
DSIM	Dry Season Irrigation Management
DSWD	Department of Social Welfare and Development
DSWD-MSWDO	DSWD - Municipal Social Welfare Development Office
DU	Distribution Uniformity
DWR	Diversion Water Requirement
EC	Efficiency Change
ECC	Environmental Compliance Certificate
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EMS	Environmental Management System
EMMP	Environmental Management and Mitigation Plans
EO	Executive Order
EPMR	External Program and Management Review
EPRMP	Environmental Performance Report and Management Plan
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management/Mitigation Plans
ESRI	Environmental Systems Research Institute
EU	Environmental Unit
FAO	Food and Agriculture Organization

FAS	Farm Administration System
FAP	Foreign-Assisted Project
FGD	Focus Group Discussion
FGIS	Farmland Geographic Information System
FIR	Field Irrigation Requirement
FISA	Free Irrigation Service Act
FMR	Farm-to-Market Road
FS	Feasibility Study
FSDE	Feasibility Study and Detailed Engineering
FUSA	Firmed-Up Service Area
FWR	Farm Water Requirement
GAA	General Appropriations Act
GAME	GIS-Based Assessment, Monitoring and Evaluation
GAP	Gender Action Plan
GCG	Governance Commission for Government-Owned and Controlled Corporation
GHG	Greenhouse Gas
GIS	Geographic Information System
GPS	Global Positioning System
GVA	Gross Value Added
HEC-RAS	Hydrologic Engineering Center - River Analysis System
HRM	Human Resource Management
HVC	High Value Crops
IA	Irrigators Association
ICC	Indigenous Cultural Communities
ICID	International Commission on Irrigation and Drainage
ICT	Information and Communications Technology
IDD	Institutional Development Division
IDE	International Development Enterprises
IDMP	Irrigation Development Master Plan
IDO	Institutional Development Officer
IEC	Information Education, and Communication
IEE	Initial Environmental Examination/Evaluation
IFC	International Finance Corporation
IFSAR	Interferometric Synthetic Aperture Radar
II	Irrigability Index
IMMS	Irrigation Management Monitoring System
IMO	Irrigation Management Office
IMT	Irrigation Management Transfer
INM	Integrated Nutrient Management
IP	Indigenous People
IPDP	Indigenous People Development Plan
IPM	Integrated Pest Management
IPRA	Indigenous Peoples' Right Act

IRA	Internal Revenue Allotment
IRR	Internal Rate of Return
IRRI	International Rice Research Institute
ISC	Irrigation Service Cooperatives
ISO	Irrigation Systems Office
ITRC	Irrigation Training and Research Centre
IWRM	Integrated Water Resources Management
JICA	Japan International Cooperation Agency
JSS	Job Satisfaction Survey
KII	Key Informant Interview
LAN	Local Area Network
LBP	Land Bank of the Philippines
LFP	Locally-Funded Project
LGU	Local Government Unit
LWUA	Local Water Utilities Administration
M&E	Monitoring and Evaluation
MAR	Managed Aquifer Recharge
MARIIS	Magat River Integrated Irrigation System
MASSCOTE	Mapping System and Services for Canal Operation Techniques
MCM	Million Cubic Meter
MHO	Municipal Health Office
MID	Management Information Division
MOA	Memorandum of Agreement
MP	Multipurpose Project
NAMRIA	National Mapping and Resource Information Authority
NCCA	National Commission for Culture and the Arts
NCEA	Netherlands Commission for Environmental Assessment
NCIP	National Commission on Indigenous People
NCR	National Capital Region
NDCC	National Disaster Coordinating Council
NDRRMC	National Disaster Risk Reduction and Management Council
NEDA	National Economic and Development Authority
NFA	National Food Authority
NG	National Government
NGA	National Government Agency
NGO	Non-Government Organization
NHCP	National Historical Commission of the Philippines
NIA	National Irrigation Administration
NIMP	National Irrigation Master Plan
NIP	National Irrigation Project
NIPAS	National Integrated Protection Area System
NIPO	National Irrigation Project Office
NIPP	National Irrigation Proposed Project

NIS	National Irrigation System
NPAAAD	Network of Protected Areas for Agriculture and Agro-Industrial Development
NPM	New Public Management
NPV	Net Present Value
NRLP	National River Linking Project
NRP	National Rice Program
O&M	Operation and Maintenance
ODA	Official Development Assistance
OECF	Overseas Economic Cooperation Fund
OGA	Other Government Agency
OMB	Optical Media Board
OSM	Open Street Map
PA	Protected Area
PAES	Philippine Agricultural Engineering Standards
PAF	Project Affected Families
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration
PAPs	Programs, Activities and Projects
PCB	Private Commercial Bank
PCG	Philippine Coast Guard
PD	Presidential Decree
PDAF	Priority Development Assistance Fund
PDIME	Project Digital Imaging for Monitoring and Evaluation
PDIP	Participatory Irrigation Development Project
PDP	Philippine Development Plan
PhilCCAP	Philippines Climate Change Adaptation Project
PhilMech	Philippine Center for Postharvest Development and Mechanization
PhilRice	Philippine Rice Research Institute
PHIVOLCS	Philippine Institute of Volcanology and Seismology
PIA	Potential Irrigable Area
PIDS	Philippine Institute for Development Studies
PIP	Public Investment Program
PIS	Private Irrigation System/Pump Irrigation System
PISOS	Pump Irrigation System from Open Sources
PMU	Project Management Unit
PNS	Philippine National Standards
PO	Peoples Organization
PPD	Project Planning Division
PPP	Public-Private Partnership
PRIR	Philippine Rice Industry Roadmap
PRISM	Philippine Rice Information System
PRS	Philippine Reference System
PSA	Philippine Statistics Authority
PV	Present Value

PVS	Participatory Varietal Selection
QC/QA	Quality Control/Quality Assurance
QGIS	Quantum GIS
R&D	Research and Development
RA	Republic Act
RAP	Rapid Appraisal Procedure
RatPlan	Rationalization Plan
RBs	Rural Banks
RBCO	River Basin Control Office
RBME	Results-Based Monitoring and Evaluation
RCA	Revealed Comparative Advantage
RCEF	Rice Competitiveness Enhancement Fund
RCM	Rice Crop Manager
RCP	Representative Concentration Pathway
RDE	Research, Development and Extension
RFU	Regional Field Unit
RIS	River Irrigation System
RO	Regional Office
ROW	Right of Way
RTA	Rice Tariffication Act
S&E	Situational and Environmental
SANREM	Sustainable Agriculture and Natural Resource Management
SCHEMA	Schema Konsult Inc.
SD	Spring Development
SDC	Swiss Agency for Development and Cooperation
SDP	Social Development Plan
SEC	Securities and Exchange Commission
SFR	Small Farm Reservoir
SIP	Small Irrigation Project
SIS	Small Irrigation System
SMD	Systems Management Division
SMS	Short Messaging System
SOM	Service-Oriented Management
S&P	Seepage and Percolation
SPIP	Solar-powered Irrigation Project
SPIS	Solar-powered Irrigation System
SPISP	Southern Philippines Irrigation Sector Project
SQL	Standard Query Language
SRIP	Small Reservoir Irrigation System
SRTM	Shuttle Radar Topography Mission
SSIP	Small-scale Irrigation Project
STW	Shallow Tube Well
SUCs	State Universities and Colleges

SWAT	Soil and Water Assessment Tool
SWIP	Small Water Impounding Project
SWIS	Small Water Impounding System
SWISA	Small Water Irrigation System Association
SWOT	Strengths, Weaknesses, Opportunities and Threats
SWRFT	Senior Water Resource Facilities Technician
TB	Terabyte
TCP	Technical Cooperation Project
TCP3	Technical Cooperation Project No. 3
TDF	Technology Demonstration Farm
TGIS	Tarlac Ground Water Irrigation System
TIFF	Tagged Image File Format
TNA	Training Needs Assessment
TP	Technical Progress
TRIP	Three-Year Rolling Infrastructure Program
TSA	Turnout Service Area
TTWS	Technology Transfer for Water Savings
TWS	Transitory Water Storage
UAS	Unmanned Aerial Survey
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNGA	United Nations General Assembly
UNISDR	United Nations Office for Disaster Risk Reduction
UP DREAM	University of the Philippines Disaster Risk and Exposure Assessment for Mitigation
UPLBFI	University of the Philippines Los Baños Foundation, Inc.
UPRIIS	Upper Pampanga River Integrated Irrigation System
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
US-GD	Upstream Start-Going Downstream
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
VE/VA	Value Engineering/Value Analysis
WateRice	Water Efficient and Risk Mitigation Technologies for Enhancing Rice Production in Irrigated and Rainfed Environment
WB	World Bank
WDD	Water Distribution and Delivery
WR	Water Resources
WRR	Water Resources Region
WST	Water-Saving Technology
WUA	Water Users Association
WUE	Water Use Efficiency
ZOPP	Zielorientierte Projektplanung/Objectives-Oriented Project Planning

LIST OF FIGURES

LIST OF TABLES

MESSAGE

Through the years, the National Irrigation Administration (NIA) has served as the catalyst of change and the protagonist in serving the Filipino farmers with the best irrigation services that they deserve.

The 10-Year National Irrigation Master Plan (NIMP) serves as a blueprint for irrigation development in the Philippines for the period 2020-2030 with the hope of increasing irrigated agriculture, achieving food security, and alleviating poverty through farmers' improved productivity.

One of the major recommendations of the NIMP is on the NIA's Organizational Restructuring which primarily aims to strengthen the agency's organizational capacity. Positively acting on this recommendation is crucial in the realization of the strategic plan, goals and objectives of the NIA towards a more effective and efficient irrigation service delivery. "Strengthening NIA Organization" is the third pillar of my Four-Point Agenda.

May I extend my gratitude and appreciation to the National Economic and Development Authority (NEDA) for financing the NIMP and to the University of the Philippines Los Baños Foundation, Inc. (UPLBFI) for formulating the NIMP.

GEN RICARDO R VISAYA (Ret)
Administrator
National Irrigation Administration

EXECUTIVE SUMMARY

This document presents the National Irrigation Master Plan (NIMP) for the period 2020-2030, a national level master plan intended to provide national guidelines for irrigation development in the Philippines for the stated period. It is an updated and enhanced version of the old Master Plan (2017-2026). The general objective of the new NIMP (2020-2030) is to achieve food security and poverty reduction through enhanced farmers' competitiveness with accelerated and sustained irrigation development under diversified crop production systems. The new NIMP specifically intends to achieve the following objectives: 1) develop a new geodatabase system and generate updated geospatial data including updated estimates of potential irrigable areas, irrigation water supply and demand and other relevant irrigation system planning and design parameters; 2) formulate performance targets and indicators consistent with the Philippine Development Plan (PDP) Results Matrix; 3) formulate physical targets for irrigation development taking into account the Philippine Rice Industry Roadmap (PRIR) and Rice Tariffication Act (RTA); 4) develop an investment program of projects for the medium- and long-term including readily implementable new projects in the short term; 5) provide guidelines for the development of a maintenance enhancement and operation plan of irrigation systems including strategies on asset management and taking into consideration the Free Irrigation Service Act (FISA) of 2017 (RA 10969); 6) integrate emerging water-efficient technologies, and Climate Change Adaptation/Disaster Risk Reduction and Management (CCA/DRRM) in irrigation development; 7) realign irrigation development to support diversified agricultural production systems; and 8) formulate institutional reforms for an efficient and successful new master plan.

An assessment of the status of the irrigated agriculture sector is first presented for a better appreciation of baseline conditions. This includes status of land and water resources, socio-economic conditions, agricultural productivity and farmers' income, status of irrigation development, institutional development, emerging issues and constraints in irrigation development and Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis of the irrigated agriculture sector. Results of the critical review of the old Master Plan, focusing on its strengths and limitations, are also presented to serve as takeoff point for its updating and enhancement and as basis for formulating the new NIMP 2020-2030. Based on objective analysis, the old Master Plan lacks a clear statement of objectives, physical targets, mix of irrigation investment programs, a workable geodatabase, adequate irrigation support for crop diversification, mainstreaming of CCA and DRRM, institutional development concerns, social and environmental safeguards, monitoring and evaluation (M&E) among others. Moreover, some recommendations are no longer valid or relevant in view of recent legislative developments such as the FISA and the RTA among other contemporary issues.

The new NIMP 2020-2030 was formulated using a systematic and comprehensive approach based on a theoretical framework that takes into account overarching policies such as the PDP, Agriculture and Fisheries Modernization Act (AFMA), Agriculture and Fisheries Modernization Plan (AFMP), FISA, RTA, NIA's Rationalization Plan, DA's Rice Roadmap, and other environmental and social policies and contemporary issues such as climate change and climate variability, land use change, inefficient water management, crop diversification among others. The approach is holistic taking into account the various considerations such as technical (land and water resources), economic, financial, social, environmental, institutional, organizational and legal considerations.

Clustered regional Focus Group Discussions (FGDs) were conducted in the three island groups of Luzon, Visayas and Mindanao as part of consultation with stakeholders from all regions in the country to determine the various issues and constraints affecting irrigation development in each region; identify alternatives in irrigation development in each region; and perform validation of the proposed criteria for prioritization of irrigation projects among other issues. Field visitation and Unmanned Aerial Surveys (UAS) in selected existing irrigation systems and projects under construction were also conducted. Additional FGDs with other stakeholders including Irrigators Association (IA) were also conducted. Similarly, consultative meetings with the staff of the National Irrigation Administration (NIA) Office of the Deputy Administrator for Engineering and Operations and Office of the Corporate Planning Services (CorPlan) were conducted to level off on matters relevant to the refinement of the NIMP. Strategic planning workshops were also conducted as part of institutional development and for redefining NIA's mission, vision and core values and for determining NIA's strategic goals, objectives and programs as important inputs to the NIMP.

The new NIMP basically includes the following: 1) Statement of Mission, Vision and Core Values of NIA; 2) Strategic Goals and the Logical Framework of Irrigation Development; 3) Objectives of the New NIMP; 4) Results Framework; 5) NIMP Implementation Framework; 6) Physical Targets; 7) the New NIA Geodatabase and its Applications; 8) New Estimates of Potential Irrigable Areas at Various Slope Limits; 9) Estimates and Projections of Irrigation Water Supply and Demand; 10) Proposed Criteria for Prioritization of Irrigation Projects; 11) Proposed mix of irrigation projects and investment program (including readily implementable programs in the short term); 12) Maintenance Enhancement and Operation Plan of Irrigation Systems; 13) Water-use Efficient and Water Saving Technologies; 14) Climate Change and Disaster Resiliency in Irrigation Development Master Plan (IDMP); 15) Irrigation Support for High Value Crop Production Systems; 16) Environmental and Social Safeguards for Irrigation Development; 17) Strategic Shifts toward Organizational Effectiveness; 18) Projected Costs and Benefits for 2020-2030 Projects; 19) Budgetary Requirements and Financing Schemes; 20) Implementation Strategies; 21) Monitoring and Evaluation (Performance Indicators); and 22) Recommendations for Effective Implementation of the NIMP.

Based on strategic planning conducted, the new Vision-Mission for NIA was formulated and now stated in the new NIMP 2020-2030 along with such core values as integrity, continuous innovation, commitment and excellence. Strategic goals and programs along with a logical framework for irrigation development were also formulated. Strategic goals include accelerated irrigation development; increased farmers' productivity and income; enhanced irrigation efficiency; strengthened stability and climate resiliency of irrigation systems; and improved asset management and income generation. On the other hand, strategic programs include generation of new irrigated areas for diversified cropping; modernization of irrigation systems; sustainable watershed management; transformation of IAs into profitable agribusiness institutions; irrigation research and development (R&D) programs; and efficient and effective asset management. Most of these strategic goals and programs served as inputs to the NIMP 2020-2030. The objectives of NIMP, as previously stated, are consistent with the strategic plans and programs but also considered recent legislative developments such as the FISA and RTA among other contemporary issues previously stated.

Based on the specified objectives, a results framework/matrix was then developed and is presented in this NIMP. The results framework includes impacts, outcomes and outputs and their corresponding indicators and targets. Essentially, the framework was crafted to make it workable and achievable and at the same time consistent with the PDP Results Matrix. With food security rather than food self-sufficiency being the thrust of the PDP, this NIMP targets 98% rice sufficiency by year 2030. The NIMP also targets at least 10% of farm household areas moving up of income poverty threshold and at least 20% additional agricultural jobs created in irrigated areas by the end of 2030. With food security and poverty reduction, which indirectly address farmers' competitiveness through accelerated and sustained irrigation development under diversified cropping systems, as the impact, the desired outcomes include improved NIA irrigation system planning and management, enabled IAs, resilient systems and resilient farmers. The desired outputs include the new geodatabase system, new irrigated areas, investment program of projects of various terms, maintenance enhancement and operation plan and asset management guidelines, adoption of water use-efficient technologies and practices, irrigation support for crop diversification and institutional reforms. Various measurable indicators and targets are specified for each of these outputs, outcomes and impacts as presented in this NIMP.

To meet the desired results in the NIMP 2020-2030, physical area targets for irrigation development were developed for the whole period of implementation. Various scenarios for physical targets, aside from the status quo or baseline scenario based on the current trend of irrigation development, were formulated based on different physical, agronomic and policy options. The production-enhancing and cost-reducing Scenario 1, upon which the investment program is based, assumes a policy of national rice security, a constant annual growth in irrigated area of 2.8% and allows for improvements in agronomic conditions. National average crop yield under irrigated areas is assumed to be 4.43 tons/ha initially for 2020-2021, 5 tons/ha for 2022-2024 then improving to an average of 5.4 tons/ha (2025-2030), based on the assumption that yield enhancing interventions result in an average yield of 6 tons/ha in high yield provinces, 5 tons/ha in medium yield provinces, and 4 tons/ha for the rest of the rice producing provinces. National average cropping intensity in all irrigated systems is assumed at 170% from 2020-2030. It also assumes decreasing postharvest losses from 14% for 2020-2021, to 12% for 2022-2030. These assumptions are reflective of the general thrust of the PRIR and the Rice Tariffication Law of improving yields and reducing losses to boost competitiveness to ensure rice security. Eight (8) other scenarios, aside from S1 and the baseline scenario S0, are presented based on varying assumptions on factors that drive agricultural productivity. These scenarios are included to make the NIMP more flexible and adaptable to possible changes in food security policies at the national level since the PDP is valid only until 2022 and the NIMP will be implemented until 2030. At the same time provisions of additional scenarios or policy options will make the NIMP not only flexible but also more aggressive as recommended by most of the NIA regional managers during the stakeholders' consultative meetings.

This NIMP targets a total increase in new irrigated area of 681,709 ha for the period 2020 to 2030, under Scenario 1. Of this total, 620,357 ha will be contributed by NIA while the remaining 61,353 ha will be developed by Other Government Agencies (OGA). This total area will come from new irrigation projects (314,516 ha), restoration projects (190,052 ha) and multipurpose projects (MPs) (115,788 ha) by NIA while the rest will be contributed by OGA. The new irrigation projects by NIA will come from National Irrigation Projects (NIPs) (129,070 ha) and Communal Irrigation Projects (CIPs)/Small Irrigation Projects (SIPs) (185,446 ha). Irrigated areas to be restored under National Irrigation Systems (NISs) and Communal Irrigation Systems (CISs)/Small Irrigation Systems (SISs) will be 72,757 ha and 117,295 ha, respectively. All these irrigation developments will bring the total actual irrigated area in the country to about 2.60 M ha by year 2030. Consequently, rice production is projected to increase from 17.14 MT (palay) or 9.31 MT (milled rice) in 2020 to 23.6 MT and 13.5 MT in 2030 for unmilled and milled rice, respectively. The rice import requirement is then projected to decrease from 3.23 MT in 2020 to 0.79 MT in 2030 under Scenario 1.

Yearly projections of new irrigated areas and their breakdown into systems under NIA and OGA are also presented in this NIMP. Scenario 1 requires a total annual increase in irrigated area ranging from 53,776 ha (with 48,936 ha under NIA and 4,840 ha under OGA) in 2020 to 70,879 ha (with 64,500 ha under NIA and 6,379 ha under OGA) in 2030. The required new irrigated areas can still be catered by the remaining undeveloped Potential Irrigable Area (PIA) of 1,215,441 ha (as of 2018) based on 3% slope limit. The other more aggressive scenarios 2 and 3 would require a total increase in irrigated area of around 1,654,000 ha and 1,336,000 ha, respectively, for 2020-2030 obviously requiring more potential irrigable areas beyond the 3% slope limit. Nevertheless, both areal requirements can be satisfied based on the current geospatial estimates of PIA of up to 8% slope. Further breakdown of the annual requirements for new irrigated areas into NIPs, CIPs/SIPs, MPs, and OGA along with areas for restoration are also presented under each scenario.

A new NIA geodatabase system, containing both national and regional sets of geo-spatial data, was developed and is presented in this NIMP (2020-2030). The geodatabase has four major components and functionalities, namely 1) data content and nomenclature; 2) attribute design and structure; 3) use of attribute domains and the 4) incorporation of the Geographic Information System (GIS)-based Assessment, Monitoring and Evaluation (GAME) model. It is comprehensive and practical to use and at the same time flexible in that it can accommodate any new information in the future. Implementation strategies for the new geodatabase including hardware and software requirements, manpower requirements and capacity building at the national and regional levels are also presented in this NIMP.

Geospatial analysis of existing and potential irrigable areas based on satellite data and other reliable sources, taking into account areal restrictions particularly ancestral domains, protected areas, mangrove areas, active faults, forest areas, built-up areas and inland water has generated new estimates of potential irrigable areas per region at various slope limits and contiguous areas. For a new slope limit of 8%, the estimated net potential irrigable area in the whole country is 3,876,298 ha for contiguous areas of at least 5 ha and 3,717,898 ha for at least 10 ha of contiguous areas. The regional breakdown is also provided in this Master Plan. It should be stressed, however, that further refinement of these estimates is necessary and can only be done through local level verification which in turn can be carried out during the recommended formulation of lower level plans such as regional and provincial master plans. In addition, the potential irrigable areas in the 57 priority provinces identified in DA's Rice Roadmap were estimated and mapped for both high yield provinces (>4 tons/ha) and low yield provinces (<4 tons/ha).

Estimation and projections of irrigation water supply and demand per region were also performed as important irrigation system planning parameters. Regionalized estimates of unit dependable flow at 80% probability of exceedance were generated from flow duration (frequency) analysis of streamflow data from 291 rivers all over the country, the regional average and range of values of which are presented in this NIMP. Regionalized water duties at the farm and system levels were also estimated for years 2020, 2025 and 2030 based on historical data, climate change projections of the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) and typical biophysical characteristics and cropping patterns in various provinces and regions, the values of which are presented in this NIMP. The regionalized values of volumetric irrigation water demand for 2020, 2025 and 2030 were also estimated based on the regionalized water duties, estimated potential irrigable areas and typical cropping patterns and are presented in this NIMP. Analysis of water supply and demand showed that the total available surface water supply at 80% probability will be more than adequate to meet the total irrigation water demand for the required new irrigated areas in the physical targets for the period 2020-2030 at the national level. However, there are regional differences and estimates show that while many regions will have adequate surface water supply to meet the irrigation water demand until 2030, deficits are projected to be incurred in Regions I and III. Other potential irrigation water sources, most notably groundwater sources may also be tapped in various parts of the country, the areal extent of which is mapped and presented in this NIMP, to deal with the spatio-temporal variabilities of water supply. It is stressed that while the NIMP has provided national and regional estimates and projections of water supply and demand for irrigation, a more detailed and site-specific assessment should be done at the local level during the recommended formulation of regional and provincial master plans.

A new set of criteria for prioritization was also developed in this NIMP. The new set of criteria takes into account the four major considerations, namely: 1) technical (land and water resources) feasibility (35%); 2) institutional feasibility (20%); 3) economic and financial feasibility (25%); and 4) environmental and social feasibility (20%), each of which is further broken down into subcategories or sub-criteria with a proposed scoring system to be used as basis for ranking of irrigation projects under each of the five major types of irrigation projects, namely: 1) new NIPs; 2) rehabilitation or restoration of NIS; 3) new CIPs/SIPs; 4) rehabilitation or restoration of CISs/SISs; and 5) new MPs. The distribution of weights was based on the combination of stakeholders' opinion from the results from the Analytic Hierarchy Process (AHP) surveys performed during the clustered regional FGDs and expert's opinion. The subcategories under each major criterion and the scoring system were also subjected to stakeholders' consultation and are presented in this NIMP.

The NIMP 2020-2030 integrates NIA's Updated Public Investment Program (PIP) 2017-2022 into the proposed irrigation infrastructure investment plan. Under the PIP projects, a total of about 104,460 ha are programmed for NIPs, 1,048 ha are programmed for NIS restoration projects, 4,903 ha are programmed for CIPs and 88,918 ha are programmed for MPs for a total area of 199,329 ha. These PIP projects, with feasibility studies, were subjected to the criteria for prioritization, ranked and programmed for implementation based on gestation period, with 1-3 years for short, 4-6 years for medium and more than 6 years for long-term projects. The required additional areas for irrigation development will be covered by non-PIP projects. The total PIAs covered by the investment plan were distributed across the 57 priority provinces identified by the Philippine Rice Industry Roadmap 2030 using an allocation scheme based on the provincial share on PIA. The total potential area to be developed was distributed to short-term (about 166,000 ha) medium-term (about 180,000 ha) and long-term (336,000 ha) projects. This programming is intended to meet the required physical target of about 682,000 ha as previously stated. The programming of areas in this NIMP also considered incorporation of irrigation projects identified in the old provincial master plans. However, these projects still need to be subjected to feasibility studies and the criteria for prioritization. The disaggregated investment plan for each province for the short-, medium-and long-term is presented in this NIMP.

Projections of total costs for NIPs, CIPs/SIPs, MPs and OGA projects were made for Scenario1 based on estimated unit cost of irrigation development for various modes. For the period 2020-2030 under Scenario 1, the annual cost ranges from about PHP 3.7 B in 2020 to about PHP 17 B in 2030 for new NIPs; PHP 7.2 B in 2020 to PHP 2.1 B in 2030 for the restoration of NISs; PHP 7.4 B to PHP 13.8 B for new CIPs/SIPs; PHP 1.4 B to PHP 4.9 B for the restoration of CISs/SISs; PHP 13.4 B to PHP 31.5 B for new MPs and PHP 1.8 B to PHP 3.5 B for OGA irrigation projects. **Under Scenario 1, the total cost for all irrigation projects for 2020-2030 is estimated to be PHP 438.4 B (PHP 99.4 B for new NIPs, PHP 43.9 B for restoration of NISs, PHP 138.6 B for new CIPs/SIPs, PHP 25.7 B for restoration of CISs/SISs, PHP 101.9 B for MPs and PHP 28.9 B for OGA-projects),** just slightly higher than the cost projected for the baseline condition at PHP 386.1 B. Cost projections for other Scenarios are much higher than Scenario 1 and are also presented in this NIMP.

The costs for rehabilitation and modernization were also projected based on the assumptions of 10% and 20% additional costs, respectively and are presented in this NIMP. Under Scenario 1, the annual cost of rehabilitation ranges from about PHP 3 B to PHP 4 B per year while that for modernization ranges from about PHP 7 B to PHP 8 B per year. For the entire 2020-2030 period, the total projected rehabilitation cost is estimated to be about PHP 41 B while modernization cost is estimated to be PHP 82 B.

Overall, this NIMP will require a total budget of PHP 561.2 B for the period 2020 to 2030 for new irrigation projects (NIPs and CIPs/SIPs), restoration projects (NIS and CIS/SIS), MPs, rehabilitation projects and modernization projects, to achieve the physical targets under Scenario 1. Of this total, PHP 532.3 B shall be allocated to NIA and PHP 28.9 B to OGA. NIA's yearly budget will range from PHP 43 B in 2020 to PHP 49.1 B in 2030. The OGA will be allocated PHP 1.8 B in 2020 to PHP 3.5 B in 2030. These estimates do not differ much from the baseline scenario (status quo) which will require a total of PHP 494.3 B for both NIA and OGA unlike Scenarios 2 and 3 with PHP 508 B and PHP 460 B cost projections, respectively, for the same period.

Benefit-cost analysis for Scenario 1 indicated an Internal Rate of Return (IRR) of 40.6%, Benefit-Cost Ratio (BCR) of 5.25 and Net Present Value (NPV) of PHP 450 B at 10% discount rate. The return on investment for Scenario 1 is better than the baseline scenario, which has an IRR of only 37.44%, BCR of 4.69 and NPV of PHP 337 B at the same discount rate. Sensitivity analysis also proved that Scenario 1 is a more viable option than the baseline scenario from the economic standpoint.

The budgetary requirements and financing schemes for the various scenarios are consequently presented in this NIMP. Budgetary requirements are broken down into local or

National Government (NG)-funded at 83% and Foreign or Official Development Assistance (ODA) at 17%, based on historical record for the period 2015-2018. **Under Scenario 1, a total of PHP 339.9 B will be locally funded, and PHP 69.6 B will be foreign assisted for the period 2020-2030 for NIA projects alone. For OGA, PHP 24 B and PHP 4.9 B will be sourced through local and foreign funding, respectively for the same scenario and period.** Under this most conservative and most cost-effective scenario (Scenario 1), the annual local financing requirements for NIA alone will range from PHP 27.5 B in 2020 to PHP 31.4 B in 2030 while annual ODA will range from PHP 5.6 B in 2020 to PHP 6.4 B in 2030. For OGA under the same scenario and period, the annual local and foreign funding will range from PHP 1.5 B to PHP 2.9 B per year and from PHP 313.4 M to PHP 596.2 M per year, respectively.

As further enhancement to the NIMP, physical targets for selected high value crops (HVCs) are also presented in this NIMP. Projections of irrigated area requirements for the top three (3) HVCs (sugarcane, coconut and banana), based on production record and potential for export were made. The total required increase in areas to be supported by irrigation development for sugarcane, coconut and banana was estimated to be 79,022 ha, 423,857 ha and 52,325 ha, respectively for the period 2020-2030. Additional projections of total area requirements for the same period for other crops such as corn (142,343 ha), pineapple (21,174 ha), mango (30,090 ha) and tobacco (246 ha) were also made and presented in this NIMP. Cost projections under two (2) irrigation support options (drip irrigation with STW and drip with Solar-Powered Irrigation System [SPIS]) were also made and are presented in this NIMP. All additional areas will still fit in the estimated total potential irrigable area especially with the extension of the slope limit to 8%. Refinements of these projections at the regional and provincial levels and additional options for crop diversification and irrigation support can be done during the recommended formulation of the regional and provincial master plans.

Maintenance enhancement and operation plan of irrigation systems as well as recommendations on water-use efficient and water saving technologies (WSTs) are presented in the NIMP. Two approaches, namely 1) combined approach using Farmland Geographic Information System (FGIS), asset management and water distribution and delivery and 2) using design logic framework and Food and Agriculture Organization (FAO)-based Mapping System and Services for Canal Operation Techniques (MASSCOTE) approach are provided as options for maintenance enhancement and operation plan. Water-use efficient and water-saving technologies and practices are recommended in this NIMP including alternate wetting and drying (AWD), use of aerobic rice, crop diversification, use of short duration and drought resistant varieties, among others. Physical interventions such as the use of shallow tube wells (STW), SPIS, Transitory Water Storage (TWS) and drainage reuse along with procedural interventions such as laser land leveling, good bund management and proper tillage, construction of field channels or tertiary irrigation and drainage canals, community seedbed and adoption of direct seeded rice, use of short duration, high yielding, water-efficient and climate resilient varieties, adjustment of cropping calendar to periods of higher rainfall and/or low evaporative demand, rotational irrigation scheme, AWD, use of aerobic rice technology, use of crop manager, and PalayCheck system were also recommended. Specific guidelines on the various WST options are also provided. Furthermore, incentive mechanisms to enhance adoption of AWD and other water saving practices are presented in this NIMP.

In view of the vulnerability of irrigation systems to climate change, climate variability and natural disasters, recommendations for climate proofing of irrigation systems and infrastructures from planning and design to construction, operation and maintenance (O&M) and rehabilitation are presented. Climate change adaptation options and technologies are also recommended for irrigation development and management including watershed protection and management, modernization of irrigation systems, integration of climate change risk assessment into Environmental and Social Impact Assessment (ESIA), water supply augmentation, water conservation and storage and use of alternative water sources. Options for disaster risk reduction and management are likewise offered including flood and drought forecasting system and early warning systems (EWS) for floods, landslide and mudflow. Other recommendations in the form of policy and regulations, research, development and extension are also presented. Among the most important recommendations to address climate and disaster resiliency in irrigation development include the development of new engineering design standards and strict quality assurance and quality control during project construction.

Irrigation support for crop diversification is also presented in this NIMP to help augment farmers' income and enhance their competitiveness. Diversified cropping options including cropping patterns for various climatic types in the country are presented in this NIMP. Irrigation options for crop diversification such as sprinkler irrigation, drip irrigation, furrow irrigation among others are also presented. Irrigation support for crop diversification including the use of STW, small water impounding systems or small farm reservoirs, SPIS, pipe delivery systems or a hybrid of open channel and pipe distribution system and water management schemes are also offered. In view of the costly nature of farm level irrigation methods particularly the pressurized irrigation systems such as sprinkler and drip irrigation, public-private partnerships (PPP) should be explored in the provision of irrigation support for crop diversification. The details of the PPP for irrigation support for high value crop production systems can be fleshed out during the formulation of the regional and provincial master plans.

An additional enhancement to the NIMP includes recommendations for environmental and social safeguards to make irrigation development sustainable, environment-friendly and socially acceptable. Critical environmental and social issues in irrigated agriculture such as watershed degradation, land conversion, increasing occurrences of extreme weather events, indigenous people's resistance to irrigation projects, conflicting laws on water uses and presence of illegal settlers were identified based on surveys of irrigation stakeholders. Based on the combination of stakeholders' consultations and experts' knowhow, specific guidelines and recommendations on the implementation and strengthening of environmental and social safeguards are also presented in this NIMP. Moreover, capacity building for NIA on ESIA is recommended.

For the organizational and institutional aspects of the NIMP, strategic shifts toward organizational effectiveness are recommended. This includes shifting towards competitiveness, irrigation development programs, clearly defined functions and deliverables, decentralized/deconcentrated operations, broader objective for Irrigators Association on agribusiness development, strong and dynamic national R&D, strong private sector investment, dynamic research-based planning, a robust Results-Based Monitoring and Evaluation (RBME) and a strong and clearly defined accountability system. The creation of a Quality Assurance Office along with a Social and Environmental Safeguard Unit is also recommended as part of institutional development of NIA. Organizational restructuring directions and guiding principles are also provided for NIA.

An additional enhancement to the Master Plan is the inclusion of RBME system with specified performance indicators to ensure attainment of the physical targets and desired results. Essentially, the RBME system is based on the Results Framework developed for this NIMP. The RBME system is presented in this plan.

As a general guide in the proper implementation of the NIMP (2020-2030), an implementation framework is provided in this document. It covers the four stages in irrigation project development cycle, namely 1) planning 2) design and construction 3) O&M, and 4) monitoring and evaluation (M&E).

Numerous recommendations are also offered in this NIMP covering the technical (water resources management and Geodatabase), organizational, environmental, social and financial aspects. Furthermore, other important and urgent recommendations are emphasized including 1) Formulation of regional and provincial master plans, 2) Formulation of new engineering design standards to make irrigation infrastructure more climate and disaster resilient, 3) Creation of Quality Control/Quality Assurance to ensure high levels of standards during the construction of irrigation projects, 4) Implementation of Value Engineering/Value Analysis (VE/VA) in all stages of the irrigation development, 5) Strong coordination between the Department of Environment and Natural Resources (DENR) and NIA on watershed and aquifer protection and management, 6) Support and push for the enactment of the national land use policy act to protect agricultural lands, 7) Upgrading of the minimum requirements for conducting Feasibility Study (FS) to meet the data requirements of the new set of criteria for prioritization of irrigation projects and 8) Exploration of PPP for irrigation development particularly for MPs and for diversified cropping systems.

While this NIMP 2020-2030 provides the roadmap and sets direction for irrigation development for the whole country at the national level, it is emphasized herein that lower level plans such as regional and provincial master plans should be formulated to generate more detailed irrigation development plans based on the physical targets set in this NIMP for the various regions and provinces. These lower level plans should also generate more detailed irrigation-related information that could serve as basis for the continuous updating of the new geodatabase system and refinement of its entries. Overall, this NIMP 2020-2030 has laid down the groundwork and guidelines for national irrigation development to meet the goals of food security and poverty reduction in the Philippines through enhancement of farmers' competitiveness while addressing recent relevant legislative developments and contemporary issues and concerns.

CHAPTER 1
INTRODUCTION

1.1. Rationale for National Irrigation Master Plan

The need for a workable and comprehensive NIMP can never be overemphasized given the fact that the rate of irrigation development in the Philippines has been alarmingly slow over the last 30 years to address national food security, economic inclusivity and poverty reduction problems in the rural areas (Ella, 2019). Based on the most recent reported data, the level of irrigation development, i.e., the ratio of total actual to total potential irrigable area in the country, is estimated at 61.4% (NIA, 2018). In terms of actual areas, this means that out of the total potential irrigable area of 3,128,631 ha, only 1,920,563 ha are irrigated, implying that an appreciable amount of work still needs to be done to reach full irrigation development in the country.

In 2014, NIA embarked on the formulation of the 2014-2028 Irrigation Master Plan for the Department of Budget and Management (DBM) to release NIA's annual budget for the construction of new NIS and CIS. However, its initial implementation proved to be unsatisfactory since the observed incremental increases in irrigation service area were deemed to be insignificant considering government's efforts to open new service areas and restore or rehabilitate existing systems to achieve rice security. This, along with the government's effort to open up new service areas and restore/rehabilitate existing systems to achieve rice security, prompted NIA to revisit and update its current master plan (NEDA, 2018).

In December 2016, the 10-year Irrigation Master Plan (2017-2026) was formulated to set the directions to (i) guide NIA, as well as local government units (LGUs) and IAs, (ii) manage the current challenges in irrigation development, and (iii) meet the Government's rice security target by 2021 (NEDA, 2018).

However, despite the efforts of NIA, irrigation service to support agricultural production continues to increase but only very modestly. By the third quarter of 2017, NIA reported that the total firmed-up service area (FUSA) is 1.75 M ha or equivalent to 58% of the estimated total irrigable area of 3.020 M ha. In addition, majority of the NIS and CIS continue to deteriorate. Delayed fund releases, peace and order problems, and right-of-way issues continue to hamper the release of irrigation programs and projects. Hence, the NIA Board and NEDA called for the improvements to the draft master plan and inclusion of certain areas of concern, such as the adoption of free irrigation services and rice tariffication, and the improvement of the NIA organizational structure and beefing up of its human resources among others. Consequently, the draft master plan has not yet been approved (NEDA, 2018).

In view of all these developments, this project came about to deal with the updating and enhancement of the draft Ten-Year Irrigation Master Plan to make it more responsive to the needs of the irrigation sector in the country. The updated and enhanced NIMP is envisioned to be consequently adopted by the irrigation sector for acceleration and improvement in irrigation implementation and operation performance of NIA and other involved agencies. This is also found to be consistent with the strategy in the PDP 2017-2022 to formulate a master plan to set the direction for irrigation development and a framework for capital, and O&M financing of irrigation projects (NEDA, 2018).

1.2. Objectives of the New National Irrigation Master Plan

The general objective of the new NIMP 2020-2030 is to achieve food security and poverty reduction with accelerated and sustained irrigation development under diversified crop production systems.

The new NIMP specifically intends to achieve the following objectives:

- Develop a new geodatabase system and generate updated geospatial data including updated estimates of potential irrigable areas, irrigation water supply and demand and other relevant irrigation system planning and design parameters;
- Formulate performance targets and indicators consistent with the PDP Results Matrix;
- Formulate physical targets for irrigation development taking into account DA's Rice Roadmap and RTA;
- Develop an investment program of projects for the medium- and long-term including readily implementable new projects in the short term;
- Provide guidelines for the development of a maintenance enhancement and operation plan for irrigation systems including strategies on asset management and taking into consideration the FISA;
- Integrate emerging water use-efficient technologies and CCA/DRRM in irrigation development;
- Realign irrigation development to support diversified agricultural production systems; and
- Formulate institutional reforms for an efficient and successful new Master Plan.

CHAPTER 2
STATUS OF AND EMERGING ISSUES IN IRRIGATED AGRICULTURE SECTOR

An assessment of the status of the irrigated agriculture sector is needed to better appreciate the baseline conditions and scenarios presented in Chapter 4. This includes status of land and water resources, socio-economic conditions, agricultural productivity and farmers' income, status of irrigation development, institutional development, emerging issues and constraints in irrigation development and Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis of the irrigated agriculture sector.

2.1. Land Resources

Based on the National Mapping and Resource Information Authority (NAMRIA) Land Cover of 2015, Philippines has an estimated land area of around 29,359,301 ha. While the NIA draft master plan presents a different value of 29,817,000 ha, this report used the official government data from NAMRIA since the data is in map format.

Based on the 2015 land cover, Regions II, VI, and III have the largest areas with annual crops. In terms of perennial crops, Regions VIII, V, XI, and CALABARZON have the largest areas. In terms of comparison of land cover between 2010 and 2015, there were major increases for grassland, open-barren areas, and built-up areas. Fifty-six percent of the areas converted to built-up areas in 2015 were annual crop areas while 24% were perennial crops (Forest Management Bureau [FMB], 2019; Abino et al., 2015).

In terms of land classification, there is an existing 14,194,675 ha Certified Alienable and Disposable (A&D) land and 15,805,325 ha of Forest Land in which 755,000 ha are considered as Unclassified Forestland and 15,050,316 ha are declared as Classified Forestland based on the 2017 Philippine Forestry Statistics of DENR–FMB. The classified forestland is broken down into other classifications: 3,270,146 ha of established Forest Reserves, 10,056,020 ha of established Timberlands, 1,340,997 ha of National Parks and Game Refuge and Bird Sanctuaries/Wilderness Area, 126,130 ha of Military Reserves, 165,946 ha of Civil Reservation and 91,077 ha of Fishpond. It can be observed that there is a decrease of around 12,907 ha of certified A&D land between the reported land classification area in 2005 and 2017, in which it can be used or designated as irrigable area depending on the persisting ground cover.

The classification of soils is also used as basis in the formulation of irrigable areas for rice only, rice and diversified crops, diversified non-rice crops, and unsuitable areas. The areas which are highly suitable for diversified crops comprised the largest area (10,533,866 ha) followed by highly suitable areas for rice crops (5,887,863 ha) (Carating et al., 2014).

2.2. Water Resources

All estimates of water resources in the Philippines are based on the Master Plan Study on Water Resources Management conducted in 1998 by the National Water Resources Board (NWRB) in cooperation with the Japan International Cooperation Agency (JICA). This landmark study estimated the country's total available freshwater resources at 145,900 M cubic meters (mcm) per year. This includes 125,790 mcm per year of surface water and 20,200 mcm per year of groundwater resource contributing about 86% and 14% of the total available water supply, respectively (NWRB-JICA, 1998).

The study presented water demands from the agriculture, domestic and industry sectors, as well as the availability projections for different water resources regions (WRRs) under low and high growth scenarios in 2025. The total annual available water resource is far greater than the combined water demands but the regional distribution is highly variable primarily due to differences in land area, physical setting, and local climate. The water balance indicated that some WRRs will still have sufficient water available until 2025 while others, particularly those located within and/or near high growth centers (WRR II, III, IV, V, and VII), may experience water deficits. Water demands in 2018 for WRRs I, III, IV, VII, VIII, X, and XI have already exceeded the 2025 projections and that WRRs III, IV and VII are already experiencing deficits.

The NWRB divided the country into 12 WRRs, but with the implementation of integrated water resources management (IWRM) in the Philippines, the means of analysis is through the river basins. The country has 421 principal rivers with drainage areas ranging from 40 to 25,649 km2, comprising 70% of the country's terrestrial area. Among the principal river basins, 18 were identified as major river basins with drainage areas of at least 1,400 km2 (Kho and Agsaoay-Saño, 2006). The major river basins comprise 36% of the total land mass of the country. The archipelagic nature of the country allows for the presence of only small to medium-size watersheds, resulting in relatively small storage capacity of the streams, lakes, and aquifers.

The estimated groundwater resources of the Philippines include about 5.1 M ha of shallow well areas and 12.3 M ha of deep well areas. These areas are mostly located in rice and corn growing alluvial plains, which make groundwater ideal to be tapped to irrigate new areas or supplement the water supplies of existing NIS and CIS command areas.

As of March 2019, the total consumptive water allocation by sector shows that agriculture accounts for about 80% of all consumptive water uses with irrigation as the biggest user accounting for 67,056 MCM/yr (Abaño, 2019).

2.3. Socio-economic Conditions

The Philippines has a total population of 100,981,437 as of 01 August 2015 according to the latest official Census of Population published by the Philippine Statistics Authority (PSA). It had 8.64 M more population than that of the 92.34 M in 2010 and 24.47 M more as compared to the 76.51 M in 2000. During the period 2000 to 2015, the Philippines had an average annual increase of 1.84%. CALABARZON had the largest population of 14.41 M followed by the National Capital Region (NCR) with 12.88 M. On the other hand, CAR had the lowest population of 1.72 M.

In terms of population growth, CALABARZON had 2.9% and an increase of 55% since 2000, being the highest of all the regions, followed by Region XII with 2.28% and Region III with 2.07%. The lowest increase in population was observed in Region I, which recorded an increase of 19% in 15 years brought about by the relatively slow annual growth rate of 1.18%.

While large portion of the population in the Philippines is concentrated in the areas of CALABARZON, NCR, Region III and Region VII, agricultural workers are distributed all throughout the country with Regions VI, VII, ARMM, V, and II, which consistently have the highest number from 2011 to 2015. Distribution of the agricultural workers has been consistent over the years; however, most regions have experienced decline since 2011. Most notably, a huge decline in the number of agricultural workers occurred in Region VIII in 2014 driven largely by the disaster brought by Typhoon Yolanda in late 2013.

In terms of farm holdings, Region VI reported the highest number of farm holdings with 518,000 units covering a total area of 460,450 ha, followed by Region V with 486,000 farm holdings with a total area of 765,820 ha. Region II ranked third with 443,000 farm holdings covering 478,720 ha. As expected, NCR had the least number of farm holdings totaling 39,000 units with a total area of 20,270 ha.

The top four regions, in terms of farm area, are Region V with 765,820 ha, Region XII, 618,120 ha, Region XI, 571,240 ha and Northern Region X with 532,890 ha. Seventy percent of the total farm holdings consisted only of one parcel with a total area of 3.72 M ha. These farm holdings had an average area of 0.95 ha.

About one-third of total number of farm holding parcels were provided with water for crops planted using irrigation structure/facility. The coverage area of these parcels totaled 1.8 M ha. About 6.42 M farm households or individual persons are dependent on the production of this irrigated area.

In terms of employment in agriculture, sex disaggregated data shows that males dominate the sector from 2015-2017. Majority of the male agricultural workers were recorded in Region VI and Region XII in 2017. The bulk of the female agricultural workers, on the other hand, were in Regions VII and VI. Moreover, NCR had the least male and female agricultural workers reported.

The poverty incidence in the country has been declining since 1991 at 29.7% to 16.5% in 2015. However, poverty incidence in 11 of the 17 regions remain relatively high. NCR has the lowest incidence which declined nominally over time. While most regions exhibit declining incidence from 1991 to 2015, Regions III, CALABARZON, X and XII show sharp declines from 1991 to 2006 but hardly moved since then. ARMM is most alarming showing even rising incidence from 1991 to 2015. By 2015, Regions V, VII, X and XII are among those with the greatest number of poor families with over 300,000 each, with Region VII at the top. Regions VIII, ARMM and VI closely follow with just a little below 300,000 families.

The poverty incidence for irrigated rice farmers declined substantially from 41-24%. The incidence for rainfed farmers also declined but remained high at 45% in 2015. Comparing poverty status between irrigated and non-irrigated rice-based farmers, the former has been consistently lower (PhilRice, 2019).

In terms of farm size, the total farm sizes of rice-based farms appear to have stayed the same from 2006 to 2012. However, the total farm size for irrigated harvested farms declined from 1.56 ha in 2006 to 1.44 ha in 2012. The largest parcel has been about the same although for irrigated harvest area, this also declined from 1.14 ha to 1.11 ha. For the same period, the number of parcels remained the same (PhilRice, 2019).

2.4. Agricultural Productivity and Farmers' Income

In terms of palay productivity, the productivity of irrigated areas relative to rainfed areas are much higher for most regions. Regions I, III and X are the exception as they show much smaller advantage of irrigated areas over rainfed.

The yield advantage of irrigated palay over rainfed palay by region shows that the trends in all regions show declining advantage over time. The only exception is CAR where after the decline in early 1990s to mid-2000, the gaps have since been rising. Also, the yield advantages of irrigated areas for Regions I, III, MIMAROPA and VI have been historically low. By 2017, the regions with relatively larger yield advantages are CAR, Regions II, VIII and XI.

The top four regions in terms of yellow corn harvested areas are, in decreasing order in 2018, Regions II, XII, X, and III. The areas in Regions II and X were steadily increasing from 1987 to 2018 while the area in Region XII decreased sharply in 1998 and 2000 before slowly increasing from 2003. The area in Region III, on the other hand, was decreasing from 1987 before sharply increasing in 2015.

The top four regions in terms of banana harvested areas are, in decreasing order in 2018, Regions CALABARZON, X, XII and ARMM. The areas in all Regions were steadily increasing from 2002 to 2017 with Region X experiencing a sharp increase in 2006. The regions with the highest banana volume of production by 2017 are Regions XI, X, XII and ARMM. All regions have an increasing volume of production from 2001, with Region XI experiencing a sharp increase in 2002 and Region X in 2008.

The top two regions in terms of harvested area are Regions X and XII, with both being steadily increasing and alternating as the top area at several times. The rest of the regions remain at relatively the same level of harvested area from 1990 to 2017 at levels far below Regions X and XII. In terms of volume, while the top two regions are still Regions X and XII, Region X clearly has the larger volume by far after 1997 when the volume of Region X began to steadily increase while the volume of Region XII slightly increased. The rest of the regions also experienced a slight increase at levels far below Region XII.

For sugarcane, Region VI accounts for the largest total harvested area. Except for Region X, the rest of the regions fall below 50,000 ha. Also, Region VII shows some slight increases and, in fact, it had already close to 46,000 ha by 2017. Region VI also comprises the bulk of production. Regions X and VII are far second and third. With respect to the volume of production of sugarcane, the region with the largest is Region VI, by a significant amount from the second largest in 2017, which is Region X. There is a slow average increase in the overall volume of production, although it is more pronounced in Region VI.

In terms of farmers' annual incomes and their distribution by source by production environment, irrigated rice incomes were generally higher than rainfed farmers' incomes by 74% in 2006 and 67% in 2012. Over 50% of incomes of irrigated farms come from rice farming of own farms. This ratio has been rising over time. For non-irrigated farms, complementary sources to rice farming in own farms such as non-farming are relatively higher than those for irrigated farms.

In terms of conversion of irrigated areas, a part of the service area of an existing system originally used for agriculture was converted to non-agricultural use like commercial, industrial, subdivision, etc. Following the NIA regional classification, in 2010, the top region in terms of actual converted irrigated areas is Region III, followed by CALABARZON, Region XII, and MARIIS while in terms of percentage of converted irrigated areas, the top region is CALABARZON, followed by Region III and MIMAROPA. In the same year, Regions V, VIII, and ARMM had virtually no irrigated areas.

The provinces with the largest converted service areas in 2010, in descending order, were Bulacan, Isabela, Palawan, and Iloilo, with more than three fourths of the remaining provinces having less than 2000 ha in converted service areas. About half of the provinces have none. In 2017, Region III remained the top region in terms of actual converted areas followed by CALABARZON, Region VI, and MARIIS. In relative terms, CALABARZON is the top region with over 10% of its service areas converted. It is followed this time by

Region IX and Region III. The total converted areas increased from 2010 to 2017. As to the provinces with the largest converted service areas in 2017, in descending order, are still Bulacan and Isabela, with Iloilo replacing Palawan in the third place, and Zamboanga del Sur, with more than three fourths of the remaining provinces having less than 2000 ha. in converted service areas.

2.5. Irrigation Development

On a national scale, 1,920,563 ha or 61.4% of the total potential irrigable area of 3,128,631 ha, is irrigated as of December 2018. The remaining potential irrigable area in the country would even increase if the slope limit in the old definition of irrigable area is extended beyond the current 3% slope limit (NIA, 2019).

Over the past ten years, i.e., from 2009 to 2018, the level of irrigation development has increased from 49.3% to 61.4%, with corresponding total new irrigated areas generated amounting to 380,626 ha. On the average, this translates to a rate of irrigation development of 47,272 ha per year or about 2.5% annual rate of increase of irrigated area based on simple linear regression analysis.

A brief review of historical data would show that about 35 years ago, the level of irrigation development was already close to 50%. Based on the reports of NIA, the level of irrigation development in 1985 was already at 45.2% (Ella, 2016; David, 1990). This level even decreased to 41.8% in 1995 and just equaled the previous level in 2005 before slightly rising to a little more than 50% in 2011. It was only recently that irrigation development exceeded 60%.

It is apparent that over the span of almost four decades, the rate of irrigation development in the country has been considerably slow. Over a span of 33 years, the total increase in new irrigated areas generated only amounted to 507,435 ha or an annual average rate of only 15,377 ha/year. Hence, it is noteworthy that the current rate of irrigation development at 47,292 ha/year based on the last 10 years of record looks promising. However, the issue now is whether this can be sustained and even increased further to catch up with the increasing demand for food due to the exponentially growing population. From the analysis of Ella (2019), at the current rate of irrigation development, local rice production will never be able to meet the local rice demand with the increasing population. It is only through acceleration of irrigation development on a sustained basis can local rice production equal the local rice demand in the near future.

2.6. Institutional Development

NIA has a professionally run organization that has a very high degree of job satisfaction among its staff. The internet-based Job Satisfaction Survey (JSS), shows that over 90% of the total 1,955 respondents who held plantilla position are satisfied with working in NIA. It has a clearly defined structure that shows clear lines of command.

NIA has strong connection with its clients through its IAs. As of 31 December 2017, more than a million farmers are members of 8,732 IAs covering an area of 1.3 M ha. A total of 955,134 IA members (97%) are registered with the Securities and Exchange Commission (SEC). Over half of the members are from NIS, 43% from CIS, and remaining 4% from NIPs, SISs, and River Irrigation Systems (RISs).

Furthermore, NIA has a lean overburdened technical staff undertaking multifunction responsibilities. In the last decade, the budget of NIA has more than doubled compared to the budget level in the previous decade. The increase in budget entails additional work responsibilities for NIA. Unfortunately, the agency has not recovered from the reduction of its plantilla positions since it was rationalized in 2008. To cope with increased volume of work, NIA has employed non-plantilla positions (casuals, job-orders, COB, etc.), which as per management, affects the quality of work and stability of the workforce.

Likewise, NIA has ageing management staff and no succession plan based on the Key Informant Interviews (KIIs) and FGD in both central and regional offices. As of 2015, the average age of NIA personnel holding key positions is 59 years old. This is followed by technical personnel with an average age of 52 years old, and then by technical support with an average age of 51 years old. Administrative personnel have the lowest average age of 50 years old. Looking at the age distribution of all regular personnel, a large bulk of over 40% already belongs to the age bracket of 55 years and above.

NIA has also an unstable top management and unstable budget. Frequent changes in the administrator, however, create institutional instability, which has negative effects on institutional effectiveness. Instability in the NIA's budget as reflected in the wide variability of annual budgetary supports creates undue burden to bring about effective institutional response because of fixed in-house technical expertise. In the past five decades, public expenditures for irrigation seesawed from administration to administration.

2.7. Emerging Issues and Constraints in Irrigation Development

It is estimated that 57 provinces will likely remain "competitive", while 28 provinces will be "uncompetitive" because of low yield potential and high cost of production. The attendant Philippine Rice Industry Roadmap 2030 assumes that the uncompetitive provinces would want to divert away from rice as it will no longer be viable. If this will be the case, the said provinces may be expected to have less demand for irrigation for rice. These provinces are "expected" to diversify if not totally get out of rice. The 28 "uncompetitive" provinces are locations of "low potential" irrigation projects or provinces.

Meanwhile, the roadmap further states that irrigation development will focus on medium yield provinces with percent irrigated area harvested less than the national average.

The FISA, on the other hand, puts NIA, as a corporation, in a better financial position as receivables are written off, a cloud of doubt hovers over the long run financial sustainability of the free irrigation program since it adds to the financial burden of government. Even with irrigation service fees (ISF) collection, government subsidy has already been significant as the ISF is based only on the O&M costs for the NIS and did not cover the cost of construction of the irrigation infrastructure, nor reflect the scarcity of water. At the highest collection rate of 60%, ISF was only able to cover 69% of O&M costs in 2014 and the rest is subsidized by the government. The forgone revenue, estimated at PHP 1.5 B a year, will be recouped through appropriations. This implies that government must allot almost more than PHP 3 B annually to cover O&M costs with the budget increasing geometrically as NIS expand its areas of coverage with irrigation development. It is thus imperative that new sources of revenues be identified (Decena, 2016).

CHAPTER 3
METHODOLOGY FOR NIMP UPDATING AND FORMULATION

3.1. Summary of Review of the Old Master Plan

The various aspects of the old IDMP 2017-2026 were subjected to a rigorous, comprehensive and critical review with considerations not only of the prescribed conditions by the client such as free irrigation services, rice tariffication, DA's Rice Roadmap, recommendations under NEDA's Value Engineering/Value Analysis (VE/VA,) consistency of performance targets/indicators with the Results Matrix of the PDP and emerging water use efficient technologies but also of contemporary issues like CC and climate variability, land use change and land conversion issues, water resources policies, environmental policies, and overarching policies like the AFMA, and other agricultural plans and programs like the AFMP for 2018-2023, NIA's Rationalization Plan, among others.

The strengths and weaknesses of the old master plan were examined and the results were used as basis for its updating, refinement and enhancement to form the NIMP 2020-2030. The various assumptions and conditions used in the old master plan were also closely examined. Appropriate techniques for analysis and assessment, as detailed in the ensuing sections, were then employed to serve as basis for formulating an enhanced NIMP.

Based on objective analysis, the old master plan lacks a clear statement of objectives, physical targets, mix of irrigation investment programs, a workable geodatabase, adequate irrigation support for crop diversification, mainstreaming of CCA and DRRM, institutional development concerns, social and environmental safeguards, M&E, among others. Moreover, some recommendations are no longer valid or relevant in view of recent legislative developments such as the Free Irrigation Service Act and the RTA among other contemporary issues.

The performance targets and indicators used in the IDMP 2017-2026 were reviewed and evaluated for conformity with the results matrix of the PDP. Reviewing the performance against targets shows that NIA hardly met its annual physical targets for new area development. The trends in actual new vs. target had in fact been generally below 100%. This demonstrates that NIA never got to realize its new target area except in 1997. In fact, in 16 of the 29 years data, the accomplished new areas were just 50% or below of targets. These shortfalls in accomplishments from set targets are also true in the case of restoration. Unlike new areas, restored areas do not contribute to increasing the cumulative total irrigated areas, but they improve cropping intensity (Inocencio and Briones, 2019).

Moreover, the old Master Plan lacks guidance in terms of the strategic directions for the institutional development of NIA. Thus, the new strategic plan will catalyze a series of reforms that are expected to improve NIA's overall effectiveness and efficiency. The ultimate objective is a responsive national irrigation development i.e., one that effectively contributes to the modernization of irrigated agriculture and the attainment of its objectives of competitiveness, increase farmers' income, poverty reduction, and sustainable development.

The revision of physical targets would entail a recalculation of the projected costs and benefits in the previous IDMP 2017-2026. Also, projected costs and benefits need to be further revised to reflect the irrigation infrastructure targets set by the 2017-2022 PDP as operationalized by the NIA 2017-2022 PIP. Further projections need to be made given the additional investments needed to cover the years 2023-2030. Budgetary requirements presented in the previous Master Plan assumed that the ISFs are still being collected. However, with the implementation of the Free Irrigation Service Act, the budget subsidy for O&M have already increased significantly.

Also, the NIA 2017-2022 PIP Budget would also have to be incorporated as well as the additional investments needed to cover the years 2023-2030. With the slim prospect of PPP under the regime of Free Irrigation, budgetary requirements would significantly be different than the projected budget of the previous masterplan.

Lastly, NIA's current database was also reviewed with the objective of proposing a new spatial or map-based database (or geodatabase) for future use. The review included comments on the existing data acquired solely from NIA. The improvement of NIA's database is endeavored by creating a new geodatabase system which will prioritize mapping not just in operations and maintenance but also in planning.

3.2. Basic Guiding Principles

This project recognizes the fact that there are various levels by which water resources planning and master plan formulation can be accomplished. Depending on the scale, water resources planning can be done at the project level, regional or river basin or watershed level and at the national level. While the degree of detail would obviously decrease from project level to national level, these plans should nonetheless be consistent with one another, with the lower level plans being supportive of higher-level plans. While this project is supposed to generate an enhanced national level master plan, the lower level plans, both existing regional and provincial level plans, were likewise considered to generate sufficient basis for national level plan enhancement.

It should also be emphasized that water resources planning objectives such as irrigation development should be need-based or demand-driven. Hence, this project included consultative meetings with various stakeholders in irrigation and water resources development in the form of KIIs and FGDs. In the same way, the formulation of alternatives for the master plan should reflect stakeholders' concerns. Moreover, the alternatives to be formulated in the master plan should be consistent with national planning objectives. Hence, the NIMP should take into account the performance targets set under the PDP. However, other overarching relevant policies should not be ignored. Hence, consideration of the AFMA, which is still a valid law, among other national policies were taken into account.

Finally, the development of a national level master plan such the NIMP should take into account the various considerations such as technical, socio-economic, environmental, institutional, legal, etc. and all other contemporary issues such as CC and climate variability in order to come up with a comprehensive and more relevant and responsive national irrigation development roadmap.

3.3. General Framework and Methodology

3.3.1. General Conceptual Framework

The methodology for the updating of the irrigation master plan and/or formulation of a new irrigation master plan was generally based on the principles of advanced water resources planning for irrigation development. Water resources planning essentially involves the identification and development of alternative water resources plans and the evaluation of their technical feasibility, economic viability, social acceptability, environmental soundness among other considerations. There are three levels of water resources planning, namely (1) national or framework planning, (2) regional or river basin planning, and (3) project level planning. The formulation of NIMP is obviously a national level planning and would essentially involve development of guidelines by which lower level plans such as regional or river basin master plans and project level irrigation development plans should be carried out.

Water resources planning also essentially involves definition of objectives, data collection, data projection, project formulation, project analysis and evaluation, selection of final alternative and project authorization. The definition of planning objective depends on the level of planning and should be need-based. On the other hand, the formulation of alternatives for the master plan should reflect stakeholders' concerns and should be consistent with national planning objectives. At the same time, the formulation of alternatives should take into account various considerations (technical, socio-economic, environmental, institutional, legal, etc.). Furthermore, other existing plans such as river basin master plans should be taken into account in the development of national level master plans.

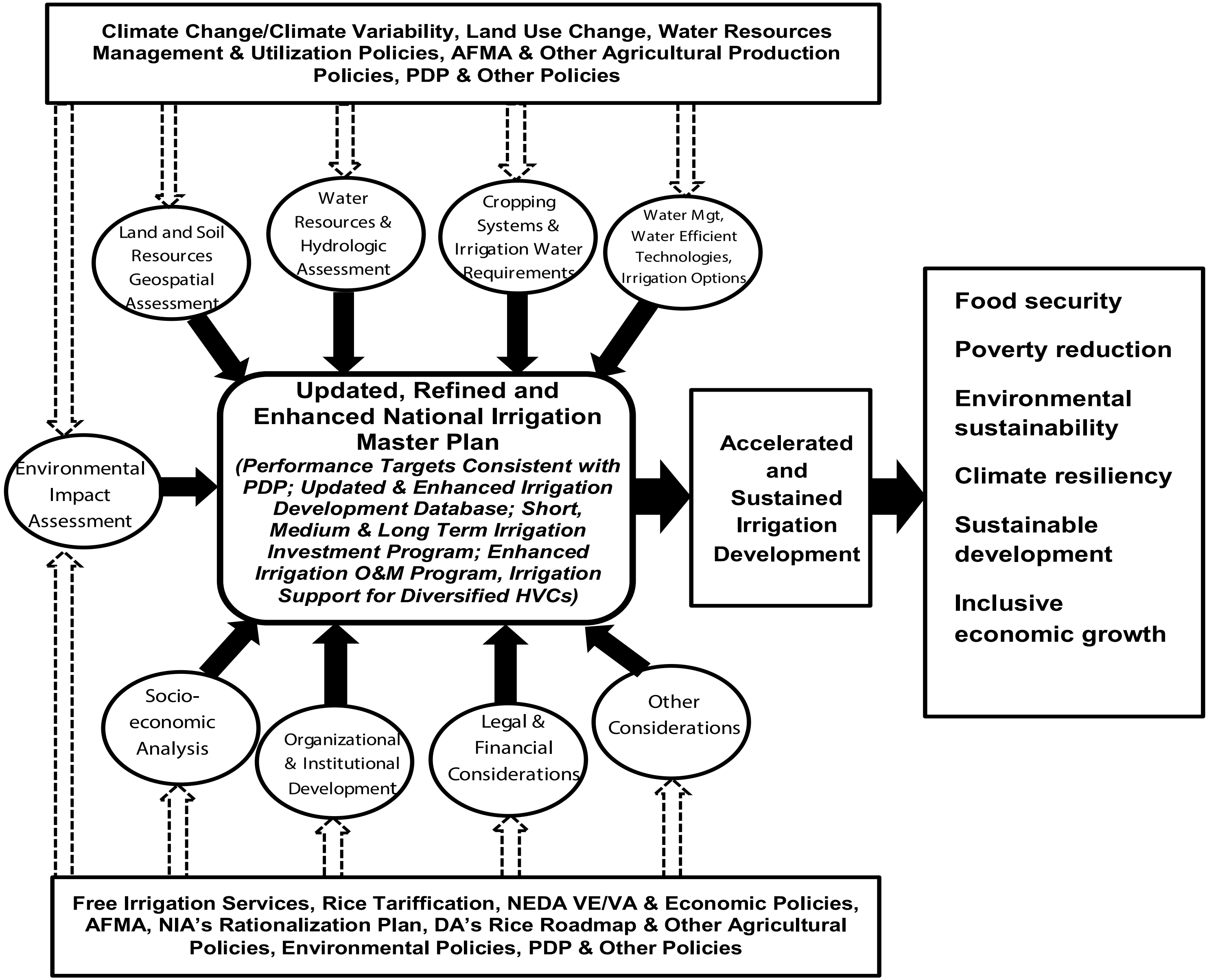
The methodology employed in the updating, enhancement and improvement of the NIMP is holistic and comprehensive in approach and took into account not only the engineering and technical aspects but also the economic, social, environmental, organizational, institutional, financial, legal and other considerations. The procedures employed were fundamentally based on relevant theories and concepts in water resources engineering and hydrology, agronomy, soil plant water relations, irrigation engineering and water management, hydraulics and hydraulic engineering, agricultural economics, environmental science, social science, institutional and organizational development, financial analysis and legal considerations. Contemporary issues and existing agricultural, socio-economic and environmental policies were also taken into account to ensure a more enhanced master plan that would lead to accelerated and sustained irrigation development in the Philippines and generate numerous beneficial outcomes. The general conceptual framework employed in this project, based on the aforementioned principles, is shown in Figure 3.1.

3.3.2. Description of Overall Methodology

In general, the methodology employed in this project involved document analysis, secondary data and information gathering, field validation, KII, FGD, surveys using AHP, data analysis using various techniques, and formulation of recommendations. In all data gathering and consultative activities, heavy coordination with the various government agencies and stakeholders was performed in coordination with NIA and with the endorsement of NEDA.

Clustered regional FGDs were conducted in the three island groups of Luzon, Visayas and Mindanao as part of consultation with stakeholders from all regions in the country. The FGDs were specifically aimed to determine the various issues and constraints affecting irrigation development in each region; identify alternatives in irrigation development in each region; and perform validation of the proposed criteria for prioritization of irrigation projects. Field visitation and drone surveys in selected existing irrigation systems and projects under construction were also conducted. Additional FGDs with other stakeholders including IAs were also conducted. Similarly, consultative meetings with the staff of NIA's office for engineering and operations and NIA's Corplan were conducted to level off on matters relevant to the refinement of the national irrigation master plan.

Figure 3.1. General Framework for the Updating, Refinement and Enhancement of the Irrigation Master Plan (Ella, 2018)



Geospatial analysis of existing and potential irrigable areas and quantitative hydrologic techniques such as flow duration analysis, dependable flow and groundwater assessment, estimation of irrigation water requirements and irrigable areas under various soil, agronomic and climatic conditions, and other appropriate techniques were also employed for the technical aspects of the master plan. Strategic planning workshops were also conducted as part of institutional development and for redefining NIA's mission, vision and core values and for determining NIA's strategic goals, objectives and programs as important inputs to the NIMP. Setting of results matrix, physical targets and food security options, application of criteria for prioritization of irrigation projects with FS, programming of irrigation area requirements, preparation of investment mix of new and rehabilitation/restoration projects, projection of costs and benefits and preparation of investment program, budgetary requirements and financing framework, maintenance enhancement and operation plan were performed for the economic, financial aspects and additional technical aspects of the master plan. Furthermore, recommendations on mainstreaming of water-use efficient and WSTs; CC and disaster resiliency in irrigation development master plan and irrigation support for HVC production systems; and environmental and social safeguards for irrigation development were formulated. Finally, a scheme for M&E of irrigation projects was formulated.

The general methodological framework is shown in Figure 3.2. The general framework highlighting the major components that are critical in the refinement and enhancement of the NIMP is shown in Figure 3.3. The specific methodologies employed in the various aspects of the master plan are presented in the ensuing sections.

Figure 3.2. The General Methodological Framework

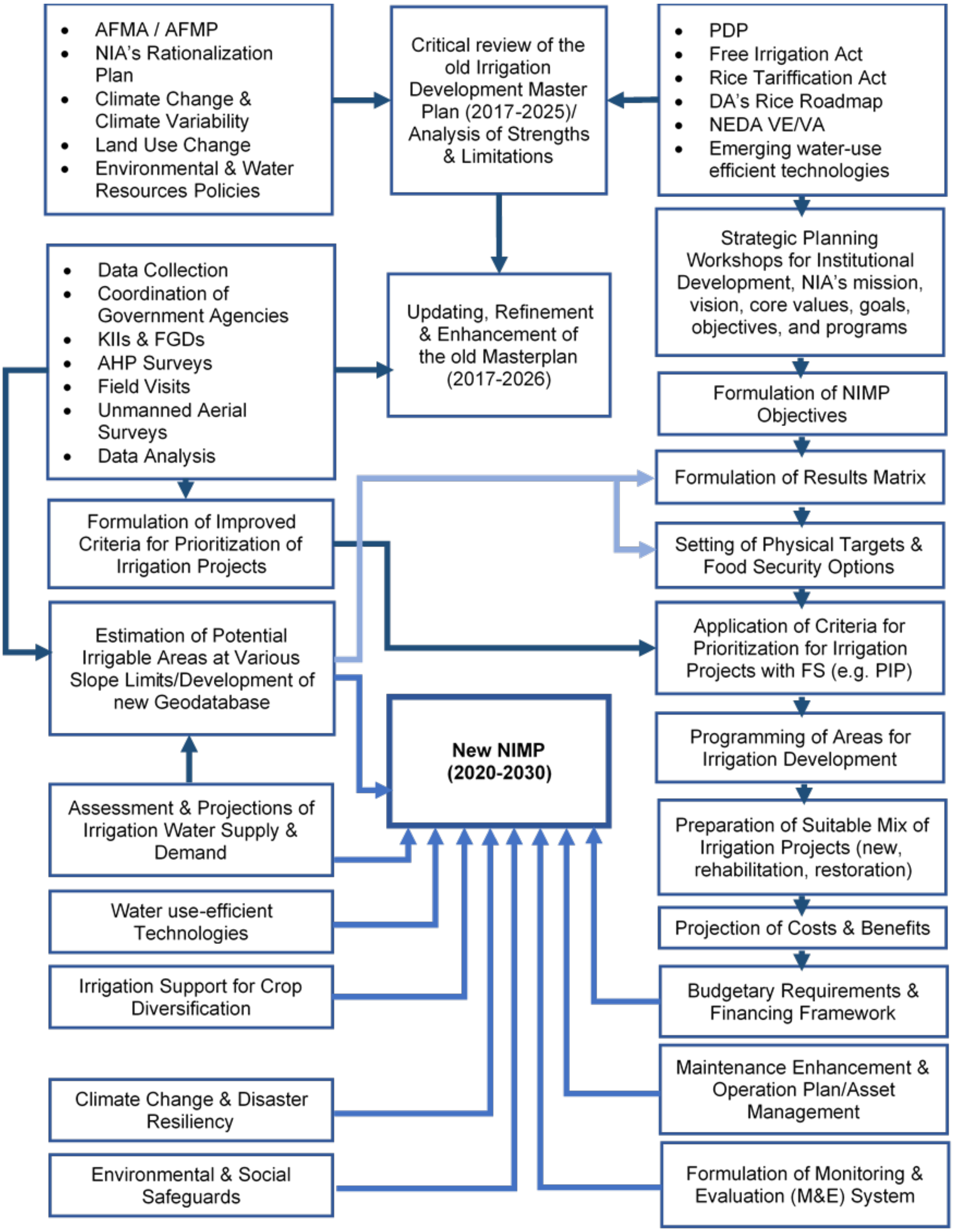
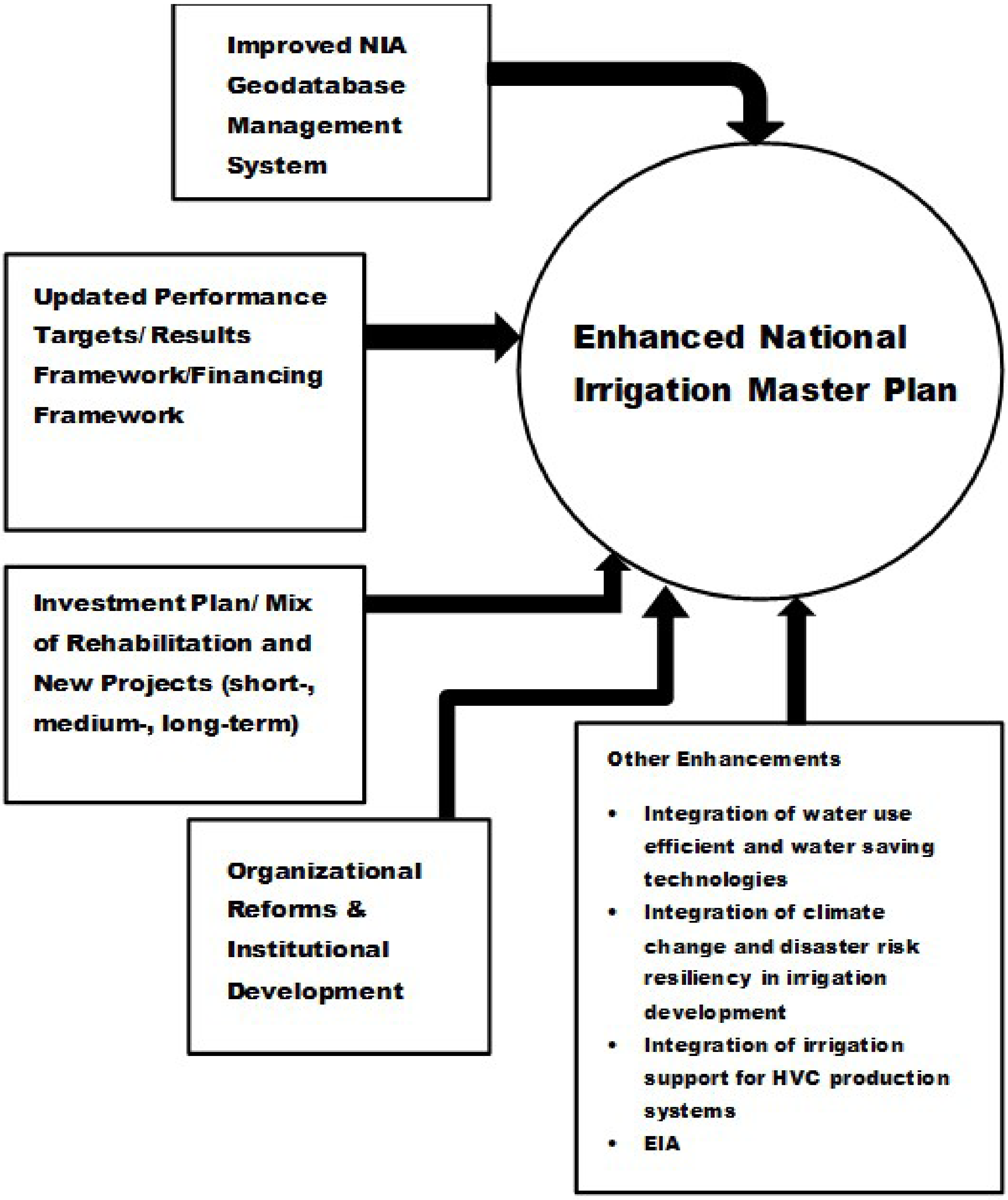


Figure 3.3. General Framework Highlighting the Major Components of the Enhanced NIMP



CHAPTER 4
THE NATIONAL IRRIGATION MASTER PLAN 2020-2030

4.1. Mission, Vision and Core Values of NIA

Vision and Mission

An agency's vision statement focuses and ennobles an idea about a future state of being in such a way as to excite and compel the agency toward its attainment (Department of Finance California, 1998). It crystallizes what the management wants the organization to be in the future. Similarly, the mission statement defines the basic purpose of the agency. It enables the employees of an agency to see how their work contributes to the broader mission. Furthermore, the vision-mission statement will help measure whether the strategic plan aligns with the overall goals of the agency and provide inspiration to both employees and clients (Hawthorne, 2019).

The "New" Mission

"A Dynamic Agency Developing and Managing Modern and Resilient Irrigation Systems"

The "New" Vision

" Highly Competitive and Sustainable Philippine Farming Communities"

Core Values

Core values create a moral compass for the organization and its employees. It guides decision-making and establishes a standard against which actions can be assessed.

The "New" NIA Core Values

Integrity: Ensuring that all NIA employees exhibit honesty and uprightness at all times inside and outside of the workplace.

Continuous Innovation: Making NIA as a catalyst for change through creative ingenuity and continuous improvement of irrigation services. NIA shall continuously strive to find new ways of doing things that are efficient and effective in achieving its vision.

Commitment: Making certain that all NIA employees shall dedicate themselves to the success of farming communities they serve.

Excellence: Providing farming communities the highest quality of irrigation services that meet the needs of farming households.

4.2. Strategic Goals and the Logical Framework of Irrigation Development

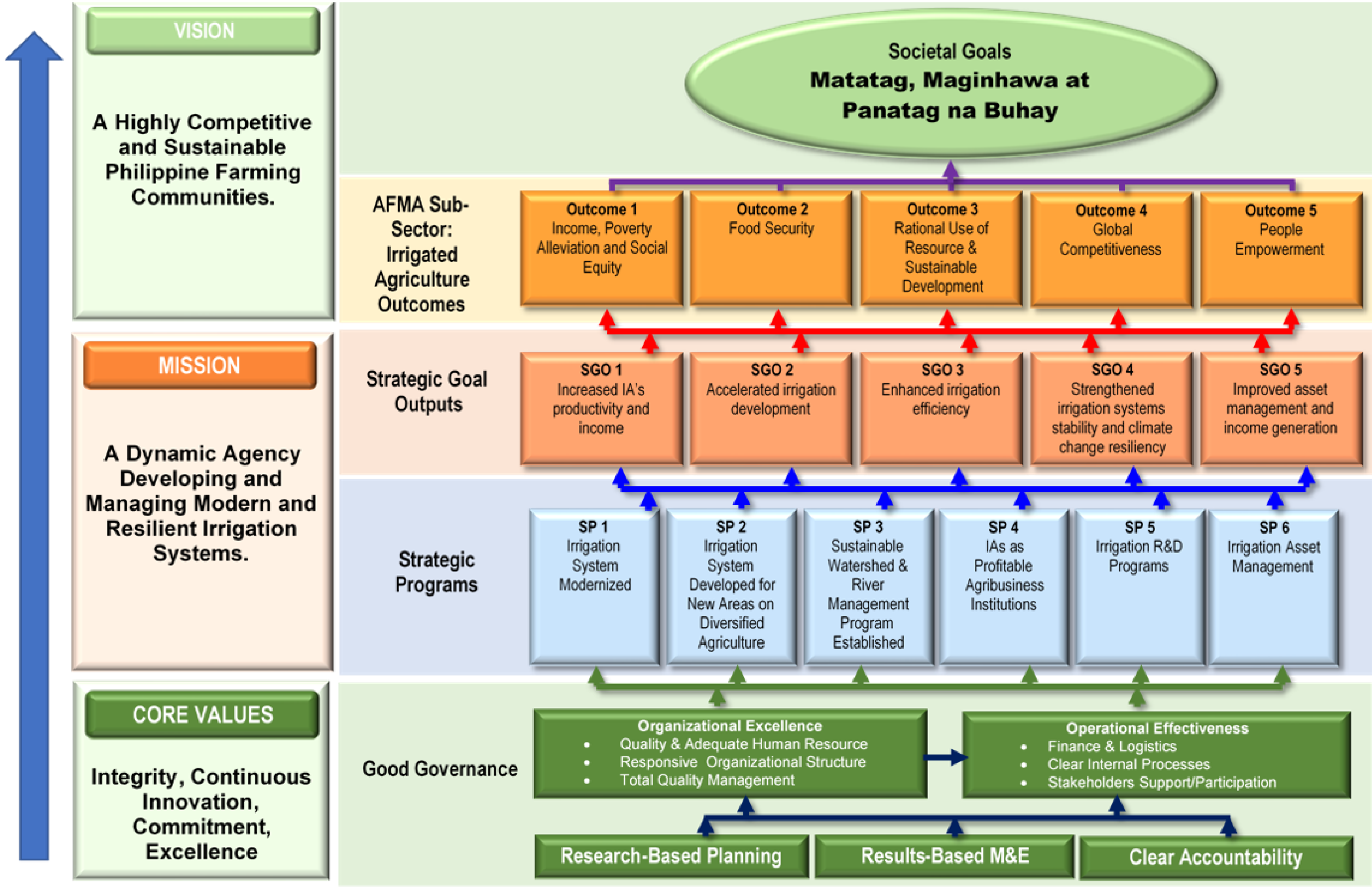
4.2.1 The NIA's Logical Framework

The NIA's logical framework for 2020-2030 is illustrated in Figure 4.1. The log frame is divided into three main parts: (1) The Vision, (2) The Mission and (3) The Core Values. The Vision is manifested in terms of the societal goals derived from AmBisyon 2040 and the corresponding outcomes expected of the sub-sector, Irrigated Agriculture, as mandated by AFMA (RA 8435). These outcomes define the vision of NIA i.e., "Highly competitive and sustainable Philippine farming communities."

The next part of the logical framework defines the Mission of NIA as "A dynamic agency developing and managing modern and resilient irrigation systems." The strategic programs and the corresponding strategic outputs are the means through which NIA fulfills its mission in relation to the strategic issues on irrigated agriculture. The strategic programs and the corresponding strategic outputs are results of a highly participatory process of consultations and workshops in all the regions of the country involving the NIA, the DA, and the IAs.

NIA's Core Values are the foundation of good governance that forms the base of the logical framework. Good governance is manifested in terms of organizational excellence and operational effectiveness. Organizational excellence is achieved through quality and adequate human resources, responsive organizational structure, and quality management. On the other hand, organizational effectiveness is dependent on adequate finance and logistics, well-defined, clear internal processes and strong stakeholders' support and participation. Research-based participatory planning, transparent RBME, and clear accountability are the key instrument through which good governance is attained.

Figure 4.1. NIA's Logical Framework for 2020-2030



4.2.2. Strategic Goals and Strategic Objectives

After the strategic goals were identified, the next step is to determine the metrics in terms of the strategic objectives through which NIA's performance is assessed. The metrics will be subject to further work and will subsequently be addressed as part of recommended work by the Program Formulation Team once the Agency-Wide programs are approved by the NIA Board of Directors.

STRATEGIC GOAL 1:

Assist Irrigated Farmers to Create Prosperity through Increased Productivity and Income

Strategic Objectives	1.1 To increase the level of productivity in irrigated agriculture, in % per year 1.2 To increase the level of crop diversification for non-rice areas, in % per year 1.3 To increase the level of crop production and water management technology application among IAs in % per year 1.4 To increase the level of farm mechanization in% per year 1.5 To lower the labor cost in % per year 1.6 To increase the level of credit & financial access in % per year 1.7 To increase the level of agriculture support services in % per year 1.8 To increase the level of market access in % per year

STRATEGIC GOAL 2:

Ensure Our Country's Irrigation Systems are Conserved, Restored, and Made More Resilient to Climate Change While Enhancing Our Water Resources

Strategic Objectives	2.1 To decrease the occurrence of water shortage in % per year 2.2 To eliminate the occurrence of illegal extraction of aggregates/ quarrying within 1 kilometer upstream and downstream of irrigation dams through proper coordination with LGUs 2.3 To decrease damage to agriculture infrastructure and production in % per year 2.4 To eliminate the occurrence of illegal logging and slash-and-burn farming 2.5 To re-vegetate denuded watersheds supporting irrigation system (within NIA's jurisdiction) by 3% per year 2.6 To regulate siltation rates of the reservoir within its designed rate 2.7 To improve the sustainability of agriculture production systems 2.8 To increase the level of water quality in % per year 2.9 To reduce the incidence of water use conflict in % per year

STRATEGIC GOAL 3:

Ensure the Effective and Efficient Functioning of Our Irrigation Systems to Meet the Irrigation Needs of Farmers

Strategic Objectives	3.1 To increase the number of improved systems in % per year 3.2 To increase funds for operation and maintenance in % per year 3.3 To increase the number of IAs adopting improved irrigation technology and water management technology in % per year 3.4 To increase the irrigation efficiency in % per year 3.5 To increase the number of systems undergoing irrigation management innovation in % per year 3.6 To increase the number of IAs satisfactorily maintaining irrigation facilities & infrastructure in % per year

STRATEGIC GOAL 4:

Ensure Accelerated Irrigation Development to Meet the Needs of Irrigated Agriculture

Strategic Objectives	4.1 To increase the pace of irrigation development in non-rice areas by 0.46% per year with an increase of farmer-beneficiaries in % per year 4.2 To increase the pace of irrigation development in rice areas by 1.42% per year with an increase of farmer-beneficiaries in % per year

STRATEGIC GOAL 5:

Create an Asset Management System that Effectively Increases the Sustainability and Efficiency of the Country's Irrigation System

Strategic Objectives	5.1 To improve the effectiveness of asset management system in % per year 5.2 To improve operation and maintenance of NIA facilities, infrastructure, and equipment in % per year 5.3 To increase the level of income generation in % per year 5.4 To increase the irrigation efficiency in % per year

4.3. NIMP Results Framework

The results framework in this NIMP has the following structure: (1) statements of the master plan objective and intermediate component outcomes; (2) indicators for the master plan objective outcome and intermediate component outcomes/results; and (3) an explicit statement of how the outcome information should be used

The indicators are quantitative and qualitative variables that provide a means to measure change over time. They can be used to assess the performance of a project compared to planned targets, and to provide evidence that the change observed was the result of the project interventions made. If a full logical framework analysis is completed, then indicators will also be defined for the higher-level development objectives and for outputs, activities and inputs. Table 4.1 presents the NIMP's Results Framework consistent with the PDP Results Matrix.

Table 4.1. NIMP (Irrigation Infrastructure Development) Results Framework

Impacts	Indicators	2019 Baseline	Targets	Means of Verification	Assumptions/Risks
Food security (availability, access, and poverty reduction with accelerated and sustained irrigation development under diversified crop production systems	•% of farm household areas move up of income poverty threshold by end of 2030 from baseline (2019) •Irrigated palay production relative to local demand/stable palay supply •% of agricultural jobs in irrigated areas created by end of 2030 from baseline (2019)	• Estimated poverty incidence for rice subsector projected to 2019 (using FIES data): 28.5% • 76% rice sufficiency (based on gross demand from PRIR projections including losses) (88% rice suffi-ciency based on actual demand) • 968,937 jobs	• 10% farm household areas • 98% rice sufficiency by 2030 (Scenario 1) • 20% additional agricultural jobs in irrigated areas	• PSA • PSA/PhilRice Statistics and Reports, Philippine Rice Industry Roadmap • Household surveys at Baseline, Mid-term and End of project	The targets are based on production-enhancing, cost-reducing scenario. The assumptions used are reflective of the general thrust of the Philippine Rice Industry Roadmap of improving yields and reducing losses to boost competitiveness to ensure rice security. This scenario assumes a constant annual growth in irrigated area of 2.8%. The NIMP assumes a rice demand projection of 13.91 million tons in 2019, 14.45 million tons in 2022, 15.18 million tons in 2026 and 15.88 million tons in 2030 as presented in the Philippine Rice Industry Roadmap 2030
Outcomes	**Indicators**	**2019 Baseline**	**Targets**	**Means of Verification**	**Assumptions/Risks**
1. Improved NIA irrigation systems planning and management	•Cropping intensity •Increased agricultural productivity	• 170% • Irrigated palay production: 14,378,679 MT/year • Irrigated palay yield: 3.13 tons/ha (rainfed), 4.43 tons/ha (irrigated)	• Cropping intensity 170% • Agricultural productivity o Irrigated palay production: 2.8% increase/year o Irrigated palay yield: 3.13 tons/ha (rainfed) 4.43 tons/ha (irrigated) (2020-2021); 5 tons/ha (2022-2024); 5.4 tons/ha (2025-2030	•NIA Reports •NIMP Baseline, Mid-term, End-of-Project surveys and Reports •PSA statistics on crops, Census of Agriculture and Fisheries	• Continuous government support in terms of budget and policy • The proposed maintenance and operation plan for irrigation systems presented in this NIMP will be fully implemented and sustained • Crop productivity enhancing programs will be fully implemented and sustained including proper and effective use of RCEF to enable crop yield improvement

Outcomes	Indicators	2019 Baseline	Targets	Means of Verification	Assumptions/Risks
		• Other agricultural commodities (OAC) production: MT/year	o Other Agricultural commodities (OAC):		
		Sugarcane: 25,101,782 tons/year	Sugarcane: 1.5% increase/ year		
		Coconut:14,873,427 tons/ year	Coconut: 1% increase per year		
		Banana: 9,452,372 tons/ year	Banana: 1% increase per year		
		Corn: 7,810,778 tons/ year	Corn: 0.5% increase per year		
		Pineapple: 2,799,259 tons/year	Pineapple: 2.5% increase per year		
		Mango: 581,151 tons/ year	Mango: 1.7% increase per year		
		Tobacco: 7,002 tons/ year	Tobacco: 0.5% increase per year		
		• OAC yield: tons/ha			
		Sugarcane: 57 tons/ha			
		Coconut: 4 tons/ha			
		Banana: 21 tons/ha			
		Corn: 3 tons/ha			
		Pineapple: 41 tons/ha			
		Mango: 4 tons/ha			
		Tobacco: 2 tons/ha			

Outcomes	Indicators	2019 Baseline	Targets	Means of Verification	Assumptions/Risks
2. Enabled IAs	• Increased number of IA's with income from Agri-business (including diversified agriculture)	• By 2020, **2,785 NIS** IAs with "modified" IMT contracts • By 2020, **2,080 CIS** IAs with "modified" IMT contracts	• 280 IAs per year (approx. 10% of 2,785 NIS IAs) • 210 IAs per year (approx. 10% of 2,080)	• NIA Reports • Survey of IAs every 3 years • 490 Business Plans per year	• Committed IAs • Continuous government support to IAs in terms of resources and budget • Increased IDD capacity • Strengthened partnerships with DA, DTI, Land Bank, and other financial institutions
	• Increased number of IA's undertaking group farming	• Number of IAs in group farming- zero	• 10% increase in IAs in group farming per year		
3. Resilient systems	• New projects implemented using new design standards starting 2026; these projects will decrease the value of damage to irrigation infrastructures currently at an average of PHP 1.3 B/ year	• Zero • Total of **2** existing systems retrofitted as of 2018 of 245 NIS	• new projects implemented using new design standards starting 2026 • 5% of existing number of NIS systems retrofitted per year	• NIA Reports	• Excluding extreme events (100-year return period) • Continuous government funding support • Continuous implementation of NIA Memo Circular to mainstream • Continuous training and capacity building of farmers • New design standards established • Strengthened NIA capacity to implement new standards
	• Increased number of farmers adopting water saving technologies	• **99,587** farmers adopted as of 2019 covering **119,549** ha	• 10% increase per year in farmers adopting water saving technologies		

Outputs	Indicators	2019 Baseline	Targets	Means of Verification	Assumptions/Risks
A. New geodatabase system	• GIS workstations and software acquired and installed	• None	• 1 per NIS system; 1 per IMO; 2 per region; 2 in CO	• NIA Reports	• Funds will be allocated • Plantilla items will be provided
	• Number of UAS equipment acquired for field validation and processing		• 1 per IMO; 1 per NIS system		
	• Training program instituted	• No-agency-wide program	• 1 per region per year		
	• Digitized parcellary maps of all NIS	• About 10 NIS	• 20 NIS per year		
	• Digitized parcellary maps of all CIS	• Existing NIS plus new to be developed (**245** NIS;10 developed under TCP) • Existing CIS plus new to be developed (**9,230** CIS as of 2018)	• 10% per year		
	• Number of GIS/ remote sensing personnel hired	• Currently no plantilla item	• 1 per NIS system; 1 per IMO; 2 per region; 2 in CO		
B. Irrigated area developed taking into account DA's Rice Roadmap and Rice Tariffication Act	New area generated	• **31,872 ha** 2018 anew area generated (actual)	• **129,069 ha** total additional new NIP by 2030 • **185,446 ha** additional new CIP by 2030	• NIA Annual and Yearend Reports • NIA GCG Performance Scorecard	• Resources and plantilla items will be allocated and provided • Continuous and rapid preparation of quality FS for all projects • Strengthened NIA project development unit in charge of FS preparation, implementation and monitoring

Outputs	Indicators	2019 Baseline	Targets	Means of Verification	Assumptions/Risks
B. Irrigated area developed taking into account DA's Rice Roadmap and Rice Tariffication Act	Restored irrigated Area	• **17,608 ha** 2018 restored (actual)	• **72,758 ha** total NIS restored areas by 2030 • **117,295 ha** total CIS restored areas by 2030	• NIA Annual and Yearend Reports • NIA GCG Performance Scorecard	• Resources will be allocated • Projected areas will depend on actual restorable areas
	Rehabilitated canals (earth & concrete), canal structures	• **274.07** earth canal (km) actual 2017 • **1,112.01** concrete lined canal (km) actual 2017 • **3,154.65** no. of canal structures (count) actual 2017	• Length of canal networks (km) (earth/lined; main and lateral) (rehab targets in pesos can be converted to physical using planning standard) • Number of dams • Number of intake structures • Number of on-farm level structures (turnouts, check gates, inverted siphon, etc.) (rehab targets in pesos can be converted to physical using planning standard)	• NIA Annual and Yearend Reports • NIA GCG Performance Scorecard	• Resources will be allocated
C. Investment program of projects for the **medium-** and l**ong-term** including readily implementable new projects in the **short term** taking into account NEDA's VE/VA recommendations	• Investments in short-, medium- and long-term projects	• 2019 PIP investment targets	Short-term:**165,887 ha** in the Rice Tariffication/ Roadmap 57 priority provinces Medium-term:**180,215 ha** in the Rice Tariffication/ Roadmap 57 priority provinces Long-term: **335,608 ha**	• Project Reports • NIA Annual and Yearend Reports	• All PIP projects with FS will pass selection and prioritization requirements • Additional projects identified will have FS to be included in selection and prioriti-zation

Outputs	Indicators	2019 Baseline	Targets	Means of Verification	Assumptions/Risks
D. Guidelines for the development of a maintenance enhancement and operation plan of irrigation systems including strategies on asset management and taking into consideration the FISA	• Operations and management plan per system	• Annual inventory of state of systems • O&M plans	• All systems to produce O&M plan every 3 years	• NIA System Performance (NISPER; CISPER) Reports on the following: o O&M plan per system o O&M Expenditures o O&M Expenditures/ha	• Asset management training conducted per region per year • Adoption of asset management system in all regions
E. Adoption of water-efficient technologies, and CCA/DRRM in irrigation development mainstreamed;	• Number of IAs trained	• **2,785** NIS IAs (as of 2018) • **9,230** CIS IAs (as of 2018)	• 10% per year increase in adoption	• NIA Reports	• Continuous implementation of NIA Memo Circular to mainstream • Continuous training and capacity building of farmers • Functional water control structures
F. Realigned irrigation development to support diversified agricultural production systems	• Increased irrigated area for diversified crops	Increase in irrigated area by 2030: • Sugarcane: 79,022 ha • Coconut: 423,857 ha • Banana: 52,325 ha • Corn: 142,343 ha • Pineapple: 21,174 ha • Mango: 30,090 ha • Tobacco: 246 ha	Annual increase in area: • 1.5% • 1.0% • 1.0% • 0.5% • 2.5% • 1.7% • 0.5%	• NIA Reports • NIA Inventory	• Continuous government support in terms of budget and policy • Available markets for diversified crops • Willingness of farmers to shift to diversified crops • NIA-IDO supports and promotes diversified cropping in irrigated areas • DA, DTI and financial institutions support diversified cropping (e.g. trainings, production inputs, credits, markets, etc.)

Outputs	Indicators	2019 Baseline	Targets	Means of Verification	Assumptions/Risks
G. Institutional reforms for an efficient and successful new Master Plan	• Establishment of research-based planning, monitoring and evaluation	• Formulation of an R&D agenda and establishment of an R&D unit	• R&D Agenda formulated by 2020 • R&D unit established by 2021	• NIA Reports to the Office of the President, GCG; NIA Board Approval; DBP approved plantilla; Memorandum Circulars	• Approval of the NIA Board and the GCG of the following structural shifts and the allocation by the DBM of the necessary financial resources
	• Strengthen the implementation capacity o Increased in **technical capacity** particularly in irrigation engineering, hydrology and water resources	• Increased in technical capacity particularly in irrigation engineering, hydrology and water resources • Increase authority specially for FS	• Number of approved FS approved and implemented in the regions • Number of technically competent IDOs hired • Number of IDOs trained **(Refer to Annex on NIMP Technical Staffing Requirement)**		
	o Social and Environmental Safeguards unit within IAS	• Establishment of Watershed Aquifer Management Unit	• Watershed Aquifer Management Unit by 2021		
	o Technical capacity upgraded to meet work standards	• Strengthening of Institutional Development (Details to be established)	• Strengthening of Institutional Development starting 2021		
	• Increased number of private sector investment		• Number of PPP contracts and area covered		
	• Accountability Manual		• Availability of manual • Degree of compliance		

Strategic Activities/Programs		Means Required to implement these activities (personnel, supplies, etc.) / Cost	Sources of information on Action Progress	Assumptions/ Pre-conditions required before the action
A. Establish a new geodatabase system	**1.** Establish GIS workstations, acquire and install software **2.** Acquire UAS equipment for field validation and processing **3.** Institute training program for geodatabase operation and management **4.** Digitized parcellary maps of all NIS **5.** Digitize parcellary maps of CIS **6.** Hire GIS/remote sensing personnel	• Refer to #A under OUTPUTS	• NIA Yearend and Annual Reports; Implementation/Project Completion Reports	• Budget be included in GAA for plantilla positions and software/ hardware requirements.
B. Develop irrigated areas taking into account Rice Roadmap and Rice Tariffication Act	1. Generate new areas 2. Restore irrigated areas 3. Rehabilitate canals and canal structures	• Total Investment (P'000) for Scenario 1 ▪ For 2020, 34,915,859 ▪ For 2021, 42,918,118 ▪ For 2022, 40,895,635 ▪ For 2023, 42,853,674 ▪ For 2024, 40,129,046 ▪ For 2025, 39,723,565 ▪ For 2026, 54,324,581 ▪ For 2027, 31,589,093 ▪ For 2028, 33,725,977 ▪ For 2029, 35,702,493 ▪ For 2030, 41,305,265 ▪ For 2020-2030, 438,353,307 • Investment for New Areas (P'000) for Scenario 1 ▪ For 2020, 11,098,813 ▪ For 2021, 16,814,189 ▪ For 2022, 19,426,012 ▪ For 2023, 39,356,196 ▪ For 2024, 15,070,021 ▪ For 2025, 17,059,723 ▪ For 2026, 19,267,150 ▪ For 2027, 21,710,288 ▪ For 2028, 22,983,868 ▪ For 2029, 24,332,279 ▪ For 2030, 30,798,611 ▪ For 2020-2030, 237,917,151	• NIA Yearend and Annual Reports; Implementation/Project Completion Reports	• Rice Roadmap will be finalized and fully operationalized

Strategic Activities/Programs		Means Required to implement these activities (personnel, supplies, etc.) / Cost	Sources of information on Action Progress	Assumptions/ Pre-conditions required before the action
		• Investment for Restore Areas (P'000) for Scenario 1 ▪ For 2020, 8,603,372 ▪ For 2021, 13,002,030 ▪ For 2022, 15,016,904 ▪ For 2023, 1,147,271 ▪ For 2024, 590,552 ▪ For 2025, 671,926 ▪ For 2026, 773,477 ▪ For 2027, 7,194,691 ▪ For 2028, 7,614,174 ▪ For 2029, 8,058,231 ▪ For 2030, 6,999,794 ▪ For 2020-2030, 69,672,422 • Investment for Rehab of canals (P'000) for Scenario 1 ▪ For 2020, 3,307,219 ▪ For 2021, 4,102,836 ▪ For 2022, 3,890,098 ▪ For 2023, 4,050,347 ▪ For 2024, 3,764,055 ▪ For 2025, 3,708,865 ▪ For 2026, 5,153,463 ▪ For 2027, 2,890,498 ▪ For 2028, 3,059,804 ▪ For 2029, 3,239,051 ▪ For 2030, 3,779,840 ▪ For 2020-2030, 40,946,076		
C. Identify and prioritize irrigation investment program taking into account VEVA Recommendations	**1.** Short-term investment **2.** Medium-term investment **3.** Long-term investment	• Short term investment (1-3 years) (P'000) for Scenario 1: 117,737,380 • Medium-term investment (4-5 years) (P'000) for Scenario 1: 124,679,176 • Long-term investment (6- 10 years) (P'000) for Scenario 1: 203,267,544	• NIA Yearend and Annual Reports; Implementation/Project Completion Reports	• Pre-feasibility or feasibility studies will be available

Strategic Activities/Programs		Means Required to implement these activities (personnel, supplies, etc.) / Cost	Sources of information on Action Progress	Assumptions/ Pre-conditions required before the action
D. Implement/ Follow guidelines for the development of maintenance enhancement and operation plan of irrig system including strategies on Asset Management taking into consideration FISA	**1.** Formulate Operations and Management Plan per system (should include annual inventory of state of systems) **2.** Carry out an inventory of irrigation facilities and their states	• Refer to #D under OUTPUTS	• NIA Yearend and Annual Reports; Implementation/Project Completion Reports	• Budget be included in GAA for plantilla positions and software/ hardware requirements.
E. Adopt water-efficient technologies and Mainstream CCA/DRRM in irrigation development	1. Train IAs in efficient technologies 2. Mainstream CCA/DRRM in irrigation development	• Refer to #E under OUTPUTS	• NIA Yearend and Annual Reports; Implementation/Project Completion Reports	• NIA will have the resources to fund these initiatives
F. Realign irrigation development to support diversified agricultural production systems	**1.** Increase irrigated area for diversified crops	• Option 1 (drip-STW) cost (P'000) • Sugarcane ▪ For 2020, 9,605,207 ▪ For 2021, 10,041,764 ▪ For 2022, 10,498,162 ▪ For 2023, 10,975,303 ▪ For 2024, 11,474,131 ▪ For 2025, 11,995,630 ▪ For 2026, 12,540,832 ▪ For 2027, 13,110,812 ▪ For 2028, 13,706,699 ▪ For 2029, 14,329,668 ▪ For 2030, 14,980,952 ▪ For 2020-2030, 133,259,160	• NIA Yearend and Annual Reports; Implementation/Project Completion Reports	• Farmers will choose non-rice crops.

Strategic Activities/Programs	Means Required to implement these activities (personnel, supplies, etc.) / Cost	Sources of information on Action Progress	Assumptions/ Pre-conditions required before the action
	• Coconut ▪ For 2020, 52,840,875 ▪ For 2021, 54,970,362 ▪ For 2022, 57,185,668 ▪ For 2023, 59,490,250 ▪ For 2024, 61,887,707 ▪ For 2025, 64,381,782 ▪ For 2026, 66,976,367 ▪ For 2027, 69,675,515 ▪ For 2028, 72,483,438 ▪ For 2029, 75,404,521 ▪ For 2030, 78,443,323 ▪ For 2020-2030, 713,739,808 • Banana ▪ For 2020, 6,523,151 ▪ For 2021, 6,786,034 ▪ For 2022, 7,059,511 ▪ For 2023, 7,344,009 ▪ For 2024, 7,639,973 ▪ For 2025, 7,947,864 ▪ For 2026, 8,268,162 ▪ For 2027, 8,601,369 ▪ For 2028, 8,948,005 ▪ For 2029, 9,308,609 ▪ For 2030, 9,683,746 ▪ For 2020-2030, 88,110,432 • Corn ▪ For 2020, 18,197,993 ▪ For 2021, 18,837,652 ▪ For 2022, 19,499,796 ▪ For 2023, 20,185,214 ▪ For 2024, 20,894,724 ▪ For 2025, 21,629,173 ▪ For 2026, 22,389,439 ▪ For 2027, 23,176,428 ▪ For 2028, 23,991,079 ▪ For 2029, 24,834,365 ▪ For 2030, 25,707,293 ▪ For 2020-2030, 239,343,155		

Strategic Activities/Programs	Means Required to implement these activities (personnel, supplies, etc.) / Cost	Sources of information on Action Progress	Assumptions/ Pre-conditions required before the action
	• Pineapple ▪ For 2020, 2,445,817 ▪ For 2021, 2,582,172 ▪ For 2022, 2,726,128 ▪ For 2023, 2,878,109 ▪ For 2024, 3,038,564 ▪ For 2025, 3,207,964 ▪ For 2026, 3,386,808 ▪ For 2027, 3,575,622 ▪ For 2028, 3,774,963 ▪ For 2029, 3,985,417 ▪ For 2030, 4,207,604 ▪ For 2020-2030, 35,809,169 • Mango ▪ For 2020, 3,620,563 ▪ For 2021, 3,792,576 ▪ For 2022, 3,972,762 ▪ For 2023, 4,161,508 ▪ For 2024, 4,359,221 ▪ For 2025, 4,566,327 ▪ For 2026, 4,783,274 ▪ For 2027, 5,010,527 ▪ For 2028, 5,248,577 ▪ For 2029, 5,497,937 ▪ For 2030, 5,759,144 ▪ For 2020-2030, 50,772,416 • Tobacco ▪ For 2020, 31,414 ▪ For 2021, 32,519 ▪ For 2022, 33,662 ▪ For 2023, 34,845 ▪ For 2024, 36,070 ▪ For 2025, 37,337 ▪ For 2026, 38,650 ▪ For 2027, 40,008 ▪ For 2028, 41,415 ▪ For 2029, 42,870 ▪ For 2030, 44,377 ▪ For 2020-2030, 413,166		

Strategic Activities/Programs	Means Required to implement these activities (personnel, supplies, etc.) / Cost	Sources of information on Action Progress	Assumptions/ Pre-conditions required before the action
	• Option 2 (drip-SPIS) cost (P'000) • Sugarcane ▪ For 2020, 4,939,821 ▪ For 2021, 5,164,336 ▪ For 2022, 5,399,055 ▪ For 2023, 5,644,442 ▪ For 2024, 5,900,982 ▪ For 2025, 6,169,181 ▪ For 2026, 6,449,571 ▪ For 2027, 6,742,704 ▪ For 2028, 7,049,159 ▪ For 2029, 7,369,544 ▪ For 2030, 7,704,489 ▪ For 2020-2030, 68,533,282 • Coconut ▪ For 2020, 27,175,307 ▪ For 2021, 28,270,472 ▪ For 2022, 29,409,772 ▪ For 2023, 30,594,986 ▪ For 2024, 31,827,964 ▪ For 2025, 33,110,631 ▪ For 2026, 34,444,989 ▪ For 2027, 35,833,122 ▪ For 2028, 37,277,197 ▪ For 2029, 38,779,468 ▪ For 2030, 40,342,280 ▪ For 2020-2030, 367,066,187 • Banana ▪ For 2020, 3,354,763 ▪ For 2021, 3,489,960 ▪ For 2022, 3,630,606 ▪ For 2023, 3,776,919 ▪ For 2024, 3,929,129 ▪ For 2025, 4,087,473 ▪ For 2026, 4,252,198 ▪ For 2027, 4,423,561 ▪ For 2028, 4,601,831 ▪ For 2029, 4,787,285 ▪ For 2030, 4,980,212 ▪ For 2020-2030, 45,313,936		

Strategic Activities/Programs	Means Required to implement these activities (personnel, supplies, etc.) / Cost	Sources of information on Action Progress	Assumptions/ Pre-conditions required before the action
	• Corn ▪ For 2020, 9,358,968 ▪ For 2021, 9,687,935 ▪ For 2022, 10,028,466 ▪ For 2023, 10,380,967 ▪ For 2024, 10,745,858 ▪ For 2025, 11,123,575 ▪ For 2026, 11,514,569 ▪ For 2027, 11,919,306 ▪ For 2028, 12,338,269 ▪ For 2029, 12,771,959 ▪ For 2030, 13,220,894 ▪ For 2020-2030, 123,090,766 • Pineapple ▪ For 2020, 1,257,849 ▪ For 2021, 1,327,974 ▪ For 2022, 1,402,009 ▪ For 2023, 1,480,170 ▪ For 2024, 1,562,690 ▪ For 2025, 1,649,810 ▪ For 2026, 1,741,787 ▪ For 2027, 1,838,891 ▪ For 2028, 1,941,410 ▪ For 2029, 2,049,643 ▪ For 2030, 2,163,911 ▪ For 2020-2030, 18,416,144 • Mango ▪ For 2020, 1,862,004 ▪ For 2021, 1,950,468 ▪ For 2022, 2,043,135 ▪ For 2023, 2,140,204 ▪ For 2024, 2,241,885 ▪ For 2025, 2,348,397 ▪ For 2026, 2,459,969 ▪ For 2027, 2,576,842 ▪ For 2028, 2,699,268 ▪ For 2029, 2,827,510 ▪ For 2030, 2,961,845 ▪ For 2020-2030, 26,111,528		

Strategic Activities/Programs		Means Required to implement these activities (personnel, supplies, etc.) / Cost	Sources of information on Action Progress	Assumptions/ Pre-conditions required before the action
		• Tobacco ▪ For 2020, 16,156 ▪ For 2021, 16,724 ▪ For 2022, 17,312 ▪ For 2023, 17,920 ▪ For 2024, 18,550 ▪ For 2025, 19,202 ▪ For 2026, 19,877 ▪ For 2027, 20,576 ▪ For 2028, 21,299 ▪ For 2029, 22,048 ▪ For 2030, 22,823 ▪ For 2020-2030, 212,486		
G. Carry out institutional reforms for an efficient and successful new Master Plan	1. Establish a research-based planning, monitoring, and evaluation 2. Strengthen implementation capacity (i) Increase technical capacity in engineering, hydrology & water resources (ii) Install social & environmental safeguards unit within IAs (iii) Upgrade technical capacity to meet work standards 3. Promote private sector investment 4. Establish accountability/ Develop Accountability Manual	• Refer to #G under OUTPUTS	• NIA Yearend and Annual Reports; Implementation/Project Completion Reports	• Budget be included in GAA for plantilla positions.

4.4. NIMP Implementation Framework

For a systematic implementation of the NIMP 2020-2030, a recommended framework for implementation is provided herein and is shown in Figure 4.2. It includes four stages in irrigation development, namely 1) planning 2) design and construction 3) O&M and 4) M&E

The physical targets and desired results at the national level formulated in the NIMP, which include food security options, food production targets, new irrigated areas, rehabilitation and restoration targets, crop diversification, enhanced farmers competitiveness, climate resiliency among others, were essentially guided by NIA's Mission/Vision, AFMA/AFMP, PDP and VE/VA principles. At the same time, the national physical targets were based on the new NIA Geodatabase developed in this NIMP.

Based on the national level physical targets and desired results, regional and provincial level irrigation development master plans will have to be formulated to fine-tune the national level irrigation development targets at the lower level. These lower level plans will initially be based on the new NIA geodatabase among other considerations. At the same time, the regional and provincial level master plans are expected to generate more detailed information at the lower levels which should be inputted back to the NIA geodatabase for its continued updating and enhancement.

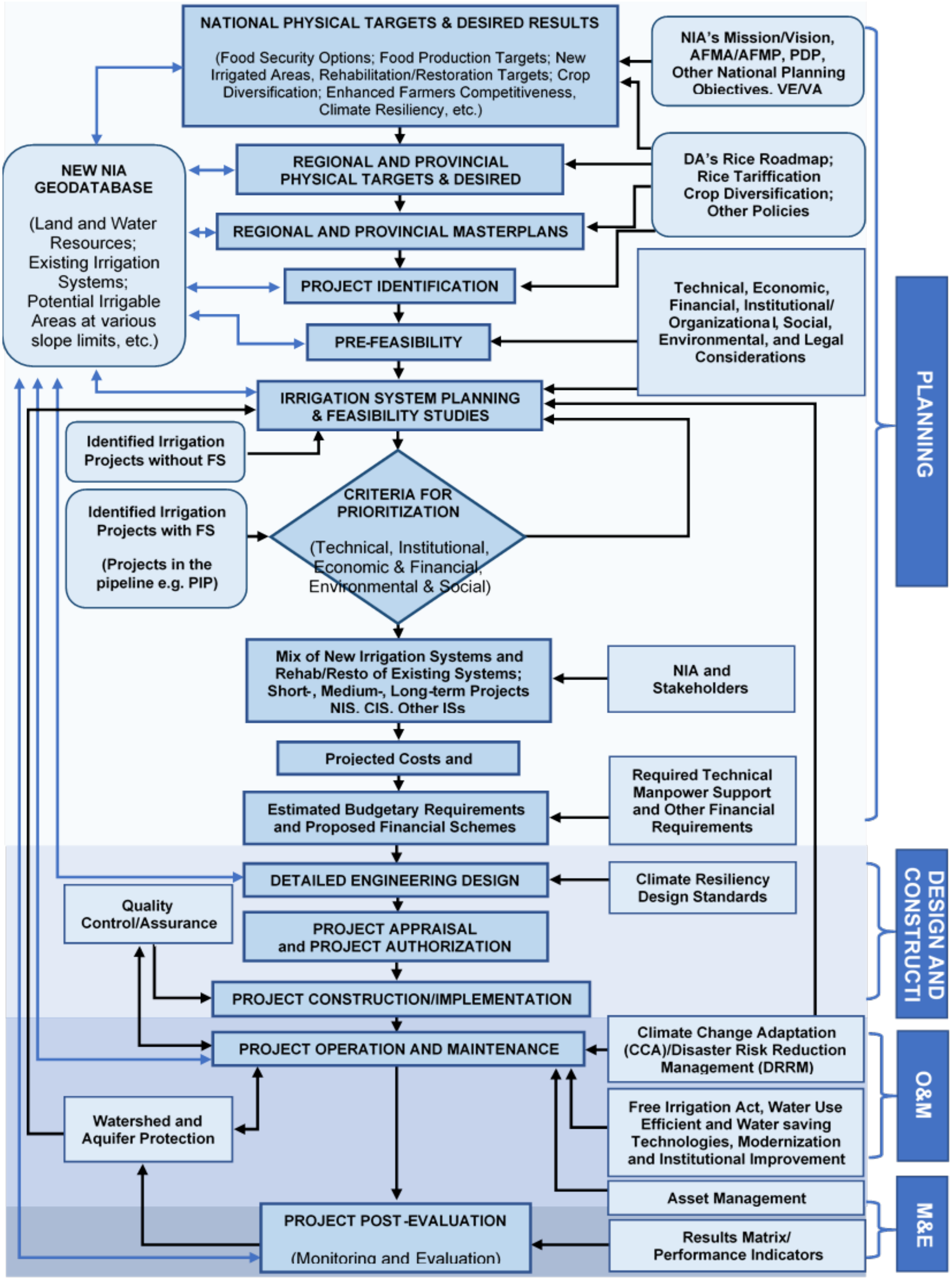
While irrigation projects currently in the pipeline such as those identified under the PIP and those reported in the previous provincial master plans have been initially considered for the initial years of implementation of the NIMP, the regional and provincial irrigation master plans should more rigorously identify irrigation development projects for the implementation period of the NIMP. Project identification should be guided by the DA's Rice Roadmap, the Rice Tariffication Law, the need for crop diversification and other relevant policies such as AFMA/AFMP among others. The new NIA Geodatabase will again serve as basis for project identification. All identified projects for irrigation development will have to be subjected to pre-feasibility and full-blown FS considering various technical, economic, financial, social, environmental, institutional, organization and legal aspects.

The prioritized list of irrigation projects will then serve as basis for filling up the projected mix of new irrigation projects and rehabilitation or restoration of existing irrigation systems for 2020 to 2030. The inputs of NIA and other stakeholders such as IAs among others may have to be considered in fine-tuning this mix through the years. Based on this mix, the projected costs and benefits, budgetary requirements and financing schemes can be prepared. For the design and construction stage, which involves detailed engineering design, project appraisal, project authorization and the eventual project construction or implementation, a new set of design standards will have to be developed by NIA. At the same time, a system for effective quality control and quality assurance will have to be developed and used during project construction or implementation to ensure that high level of quality of construction of irrigation projects.

During the O&M of newly constructed irrigation projects and existing irrigation systems, CCA and DRRM along with the use of water use efficient and water saving technologies and proper asset management will have to be implemented. At the same time, modernization of irrigation operation and institutional development will have to be considered. O&M will also have to be implemented in the current context of FISA, unless amendments to this law are promulgated during the implementation.

To ensure effective and efficient irrigation development and management targeted in the NIMP, a proper M&E system should be enforced. This system is essentially based on the Results Matrix and Performance Indicators developed.

Figure 4.2. Implementation framework for the New NIMP 2020-2030



4.5. Physical Targets

The NIMP 2020-2030 integrates the NIA's Updated PIP 2017-2022 into the proposed irrigation infrastructure investment plan. Seminal to this is the determination of total physical area targets for irrigation development for the period covered by the NIMP. The NIMP presents projected area targets under nine (9) different scenarios (apart from the status quo/baseline) based on different physical, agronomic and policy scenarios. However, the focus of irrigation development in this NIMP will be based on Scenario 1. The assumptions and physical targets under the scenarios considered are presented in the ensuing sections.

4.5.1. Key Assumptions

The physical area targets are determined relative to the projected total rice consumption of the country. The NIMP assumes a rice demand projection of 13.91 million tons in 2019 , 14.45 million tons in 2022, 15.18 million tons in 2026 and 15.88 million tons in 2030 as presented in the Philippine Rice Industry Roadmap 2030.

On the production side, the master plan assumes a baseline cropping intensity of 170% for the irrigated ecosystem, a rainfed ecosystem yield of 3.13 tons/ha, an irrigated ecosystem yield of 4.43 tons/ha, a milling recovery rate of 65%, and postharvest losses of 14%. Rainfed areas are assumed to be converted at weighted average rate of 0.53 ha per hectare of additional irrigated area based on the study by Perez, Rosegrant and Inocencio (2018). The NIMP uses farm level yield assumptions unadjusted for postharvest losses, hence, total projected paddy rice demand and total projected milled rice production reflect these losses. This allows demonstration of the contribution of reducing postharvest losses to total rice production. This is different from the PSA method of reporting where reported yield is assumed to be at 14% moisture content and is therefore already adjusted to account for postharvest loss.

Scenario 1 assumes a production-enhancing, cost-reducing scenario. Cropping Intensity is assumed to be 170%. Crop yield under irrigated areas is assumed to be 4.43 tons/ha (2020-2021), 5 tons/ha (2022-2024) and 5.4 tons/ha (2025-2030). It also assumes decreasing postharvest losses from 14% (2020-2021) to 12% (2022-2030). This is reflective of the general thrust of the Philippine Rice Industry Roadmap of improving yields and reducing losses to boost competitiveness to ensure rice security. This scenario assumes a constant annual growth in irrigated area of 2.8%.

4.5.2. Baseline Scenario

Table 4.2 shows the projections for the baseline scenario. NIA infrastructure projects account for 91% of the area while the remaining 9% is covered by projects of OGA projects. This share is based on the historical shares of NIA and OGA assets in the total infrastructure inventories (2014-2018).

By 2030, the total projected operational FUSA is about 2.52 M ha. Total increase in irrigated area is about 599,000 ha from 2020-2030, with NIA accounting for 545,000 ha and OGA responsible for a total 54,000 ha of irrigated area increase.

Figure 4.3. shows the projected palay production and projected palay demand for the baseline scenario.

Figure 4.3. Projected Palay Production vs Projected Palay Demand (Baseline) for 2020-2030

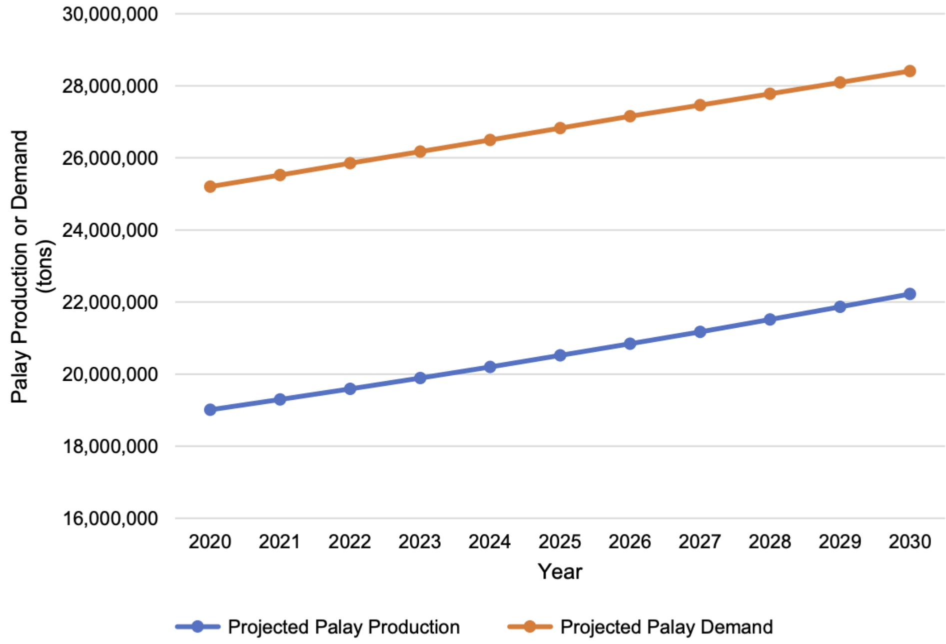


Table 4.2. Baseline Projection Scenario (Scenario 0)

Year	Projected Production Rainfed (t)	Projected FUSA (ha)*	Projected Production Irrigated (t)	Projected Total Production (t)	Projected Palay Demand	Projected Palay Demand (t) with allowance for losses	Required increase in irrigated areas per year (ha)	Required increase in irrigated area (ha) (NIA)	Required increase in irrigated area (ha) (OGA)
2019	4,350,700	1,920,563	14,463,760	18,814,460	21,400,000	24,883,721	-	-	-
2020	4,271,050	1,968,577	14,825,353	19,096,403	21,673,920	25,202,233	48,014	43,693	4,321
2021	4,189,408	2,017,792	15,195,992	19,385,400	21,951,346	25,524,821	49,214	44,785	4,429
2022	4,105,725	2,068,236	15,575,885	19,681,611	22,232,323	25,851,539	50,445	45,905	4,540
2023	4,019,950	2,119,942	15,965,283	19,985,233	22,507,944	26,172,028	51,706	47,052	4,654
2024	3,932,030	2,172,941	16,364,419	20,296,449	22,786,982	26,496,491	52,999	48,229	4,770
2025	3,841,912	2,227,264	16,773,525	20,615,437	23,069,479	26,824,976	54,324	49,434	4,889
2026	3,749,541	2,282,946	17,192,866	20,942,408	23,355,479	27,157,534	55,682	50,670	5,011
2027	3,654,861	2,340,020	17,622,691	21,277,552	23,620,194	27,465,342	57,074	51,937	5,137
2028	3,557,815	2,398,520	18,063,254	21,621,070	23,887,909	27,776,639	58,500	53,235	5,265
2029	3,458,343	2,458,483	18,514,835	21,973,178	24,158,659	28,091,464	59,963	54,566	5,397
2030	3,356,384	2,519,945	18,977,706	22,334,089	24,432,477	28,409,857	61,462	55,930	5,532

*Actual area may be smaller due to unrecoverable converted land.
Assumptions: Rate of decrease in rainfed area = 0.53 ha per ha irrigated; CI = 170%; Rainfed Yield = 3.13 tons/ha; Irrigated Yield = 4.43 tons/ha; Postharvest losses = 14%; Rice Demand Projection = 13.91 million tons (2019), 14.45 million tons (2022), 15.18 million tons (2026), 15.88 million tons (2030); Milling Recovery = 65%; Annual Rate of Irrigation Area Increase = 2.5%
Source: Author's calculation, PSA, Philippine Rice Industry Roadmap 2030

4.5.3. Scenario 1

Table 4.3 shows the projections for Scenario 1. Increase in irrigated area is based on a growth rate of 2.8% annually. Total irrigated area is projected to be about 2.60 M ha by 2030. Total increase in irrigated area of about 681,709 ha from 2020-2030, with NIA's share at 620,357 ha and OGA responsible for 61,353 ha.

Figure 4.4. shows the projected palay production and projected palay demand for Scenario 1.

Figure 4.4. Projected Palay Production vs Projected Palay Demand (Scenario 1) for 2020-2030

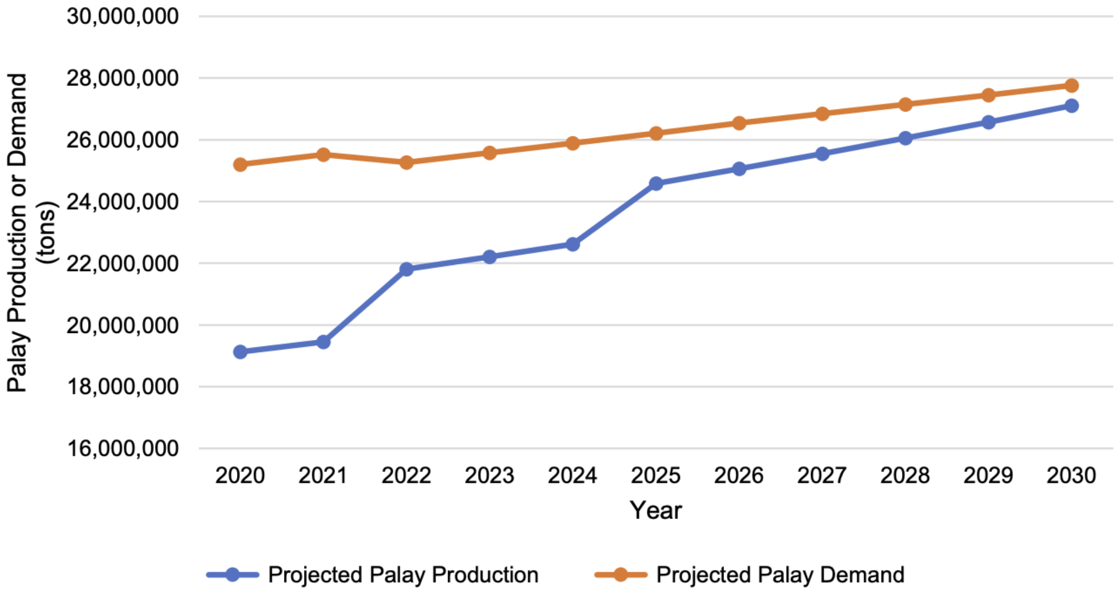


Table 4.3. Scenario 1 Projection

Year	Projected Production Rainfed (t)	Projected FUSA (ha)*	Projected Production Irrigated (t)	Projected Total Production (t)	Projected Palay Demand (t)	Projected Palay Demand (t) with allowance for losses	Required increase in irrigated areas per year (ha)	Required increase in irrigated area (ha) (NIA)	Required increase in irrigated area (ha) (OGA)
2019	4,350,700	1,920,563	14,463,760	18,814,460	21,400,000	24,883,721	-	-	-
2020	4,261,491	1,974,339	14,868,747	19,130,238	21,673,920	25,202,233	53,776	48,936	4,840
2021	4,169,785	2,029,620	15,285,068	19,454,854	21,951,346	25,524,821	55,281	50,306	4,975
2022	4,075,512	2,086,450	17,734,825	21,810,337	22,232,323	25,264,004	56,829	51,715	5,115
2023	3,978,597	2,144,870	18,231,395	22,209,992	22,507,944	25,577,209	58,421	53,163	5,258
2024	3,878,970	2,204,927	18,741,880	22,620,850	22,786,982	25,894,298	60,056	54,651	5,405
2025	3,776,553	2,266,665	20,807,985	24,584,538	23,069,479	26,215,318	61,738	56,182	5,556
2026	3,671,268	2,330,131	21,390,603	25,061,870	23,355,479	26,540,317	63,467	57,755	5,712
2027	3,563,034	2,395,375	21,989,543	25,552,577	23,620,194	26,841,129	65,244	59,372	5,872
2028	3,451,772	2,462,445	22,605,245	26,057,017	23,887,909	27,145,351	67,070	61,034	6,036
2029	3,337,394	2,531,394	23,238,197	26,575,591	24,158,659	27,453,021	68,948	62,743	6,205
2030	3,219,813	2,602,273	23,888,866	27,108,679	24,432,477	27,764,179	70,879	64,500	6,379

*Actual area may be smaller due to unrecoverable converted land.
Assumptions: Rate of decrease in rainfed area = 0.53 ha per ha irrigated; CI = 170%; Rainfed Yield = 3.13 tons/ha; Irrigated Yield = 4.43 tons/ha (2020-2021), 5 tons/ha (2022-2024), 5.4 tons/ha (2025-2030); Postharvest losses = 14% (2020-2024), 12% (2025-2030); Rice Demand Projection = 13.91 million tons (2019), 14.45 million tons (2022), 15.18 million tons (2026), 15.88 million tons (2030); Milling Recovery = 65%; Annual Rate of Irrigation Area Increase = 2.8%
Source: Author's calculation, PSA, Philippine Rice Industry Roadmap 2030

4.5.4. Projections of Area per Project/ System Type

The projections of total physical area per project/system are based on the required increase in irrigated area per year for each scenario. For NIA, total target areas of programmed projects from the updated PIP were incorporated. Additional areas (Non-PIP) were considered if the PIP was not able to cover the required increase per year. Non-PIP areas are divided between NIS (40%) and CIS (60%), allocated equally between new and restoration projects. These ratios were determined based on the results of the regional FGDs conducted.

For restoration areas, a limit of 72,758 ha for NIS and 131,193 ha for CIS were set. This is based on the total non-operational areas of the 2018 NIA inventory. Once the limit is reached, a constant 10% share of the areas is targeted for restoration for the succeeding years. No areas for MPs are allocated apart from those that were included in the PIP.

For areas allotted for OGAs, the share of each irrigation system on the area to be developed was based from the 2018 NIA inventory. Solar-Powered Irrigation Project (SPIP) areas were also considered in the programmed areas for OGA, which is based on the Small-Scale Irrigation Project (SSIP) Master Plan (2014-2022).

Baseline Scenario

Table 4.4 shows the projected areas for new, restoration, multipurpose, and OGA projects for 2020-2030 under the baseline scenario. Total projected area for new projects is estimated to be about 261,000 ha, while an estimated 168,000 ha are areas to be restored. An estimated 115,000 ha is attributable to MPs.

Figure 4.5. shows the graph of projected areas for new, restoration, multipurpose and OGA projects from 2020-2030 under the baseline scenario.

Figure 4.5. Annual Projected Target Area for New, Restoration, Multipurpose & OGA Projects (Baseline) in 2020-2030

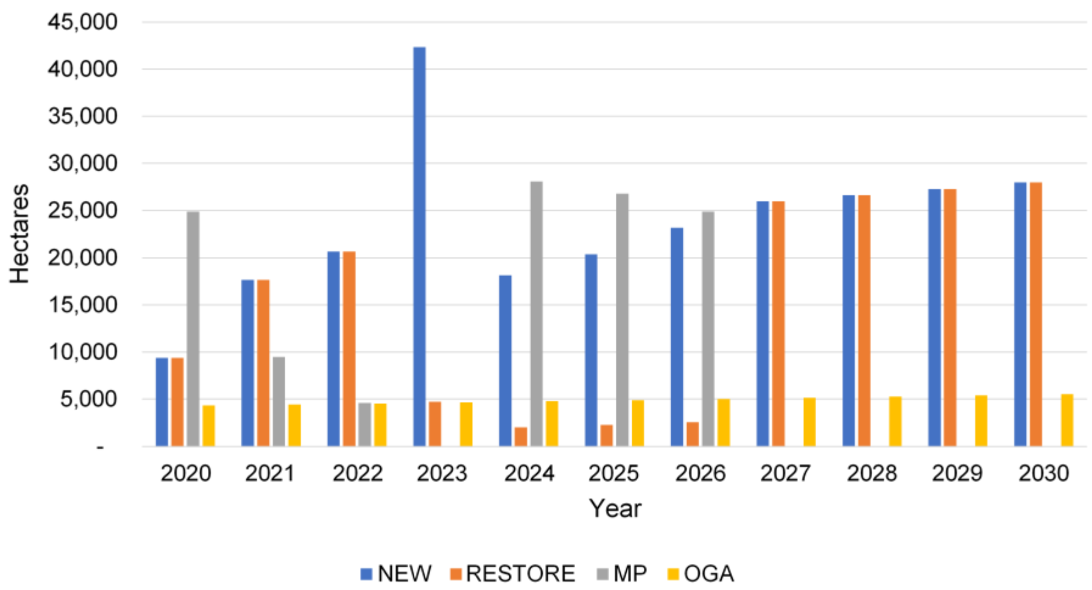


Table 4.4. Projected Total Areas of NIPs, CIPs, Multipurpose and Other Government Assisted Projects (2020-2030) under Baseline Scenario

YEAR	NIS/NIP (ha)		CIS/CIP/SIP (ha)		SUBTOTAL		MP (ha)	TOTAL (NIA)	OGA (ha)	GRAND TOTAL
	New	Restore	New	Restore	New	Restore				
2020	4,352	4,352	6,527	6,527	10,879	10,879	21,935	43,693	4,321	48,014
2021	7,057	7,057	10,586	10,586	17,643	17,643	9,500	44,785	4,429	49,214
2022	8,264	8,264	12,396	12,396	20,660	20,660	4,585	45,905	4,540	50,445
2023	16,939	1,882	25,408	2,823	42,347	4,705	-	47,052	4,654	51,706
2024	7,258	806	10,887	1,210	18,145	2,016	28,068	48,229	4,770	52,999
2025	8,148	905	12,223	1,358	20,371	2,263	26,800	49,434	4,889	54,324
2026	9,277	1,031	13,916	1,546	23,193	2,577	24,900	50,670	5,011	55,682
2027	10,387	10,387	15,581	15,581	25,969	25,969	-	51,937	5,137	57,074
2028	10,647	10,647	15,971	15,971	26,618	26,618	-	53,235	5,265	58,500
2029	10,913	10,913	16,370	16,370	27,283	27,283	-	54,566	5,397	59,963
2030	11,186	11,186	16,779	16,779	27,965	27,965	-	55,930	5,532	61,462
TOTAL	104,429	67,431	156,643	101,147	261,072	168,578	115,788	545,438	53,944	599,382

FUSA used is categorized as Service Area under existing NIA classifications.

Scenario 1

Table 4.5 shows the projected areas for new, restoration, multipurpose, and OGA projects from 2020-2030 under Scenario 1. Total areas generated by new projects were estimated to be about 314,500 ha, while 190,000 ha is programmed to be generated by restoration projects. Since no new MPs were programmed apart from what is in the PIP, areas generated from MPs are the same as those in the baseline.

Figure 4.6 shows the graph of projected areas for new, restoration, multipurpose and OGA projects from 2020-2030 for Scenario 1.

Figure 4.6. Annual Projected Target Area for New, Restoration, Multipurpose & OGA Projects (Scenario 1) for 2020-2030

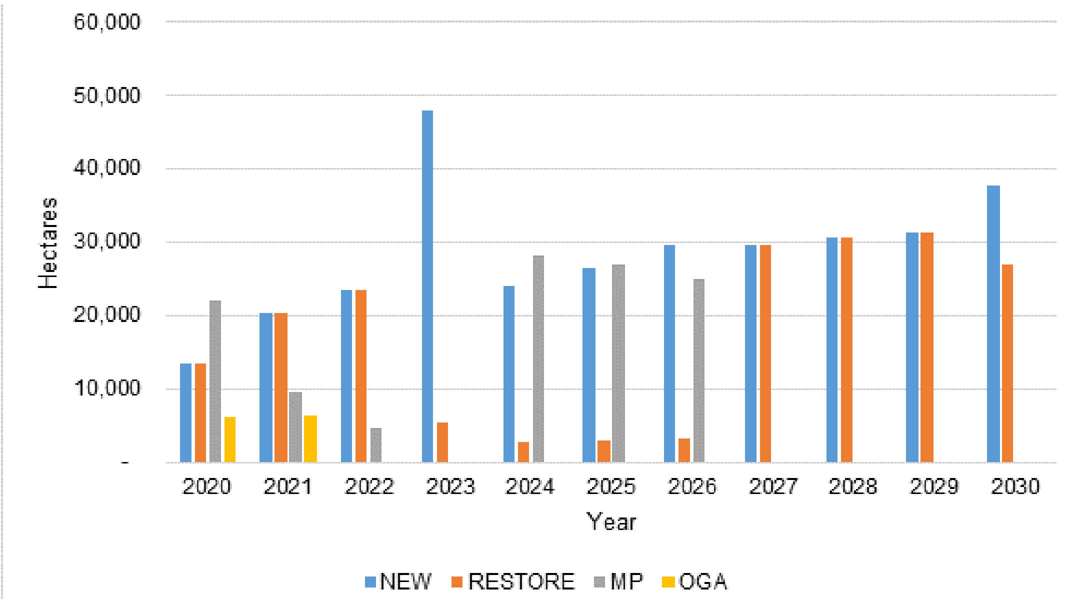


Table 4.5. Projected Total Areas of NIPs, CIPs, Multipurpose and Other Government Assisted Projects (2020-2030) under Scenario 1

YEAR	NIS/NIP (ha)		CIS/CIP/SIP (ha)		SUBTOTAL		MP (ha)	TOTAL (NIA)	OGA (ha)	GRAND TOTAL
	New	Restore	New	Restore	New	Restore				
2020	5,400	5,400	8,100	8,100	13,501	13,501	21,935	48,936	4,840	53,776
2021	8,161	8,161	12,242	12,242	20,403	20,403	9,500	50,306	4,975	55,281
2022	9,426	9,426	14,139	14,139	23,565	23,565	4,585	51,715	5,115	56,829
2023	19,139	2,127	28,708	3,190	47,846	5,316	-	53,163	5,258	58,421
2024	9,570	1,063	14,355	1,595	23,925	2,658	28,068	54,651	5,405	60,056
2025	10,577	1,175	15,866	1,763	26,443	2,938	26,800	56,182	5,556	61,738
2026	11,828	1,314	17,741	1,971	29,569	3,285	24,900	57,755	5,712	63,467
2027	11,874	11,874	17,812	17,812	29,686	29,686	-	59,372	5,872	65,244
2028	12,207	12,207	18,310	18,310	30,517	30,517	-	61,034	6,036	67,070
2029	12,549	12,549	18,823	18,823	31,372	31,372	-	62,743	6,205	68,948
2030	18,339	7,461	19,350	19,350	37,689	26,811	-	64,500	6,379	70,879
TOTAL	**129,070**	**72,757**	**185,446**	**117,295**	**314,516**	**190,052**	**115,788**	**620,357**	**61,353**	**681,709**

4.6. The New NIA Geodatabase and its Applications

For planning purposes, it is important to have a view of the proposed site prior to field visitation for the initial review of what should be expected on the ground. A look into maps is more efficient than directly going first to the area for reconnaissance. Different map files or shapefiles could be seen through overlaying one another. In irrigation system development, dam improvement and other irrigation-related projects or activities, risk of hazards should not be an option.

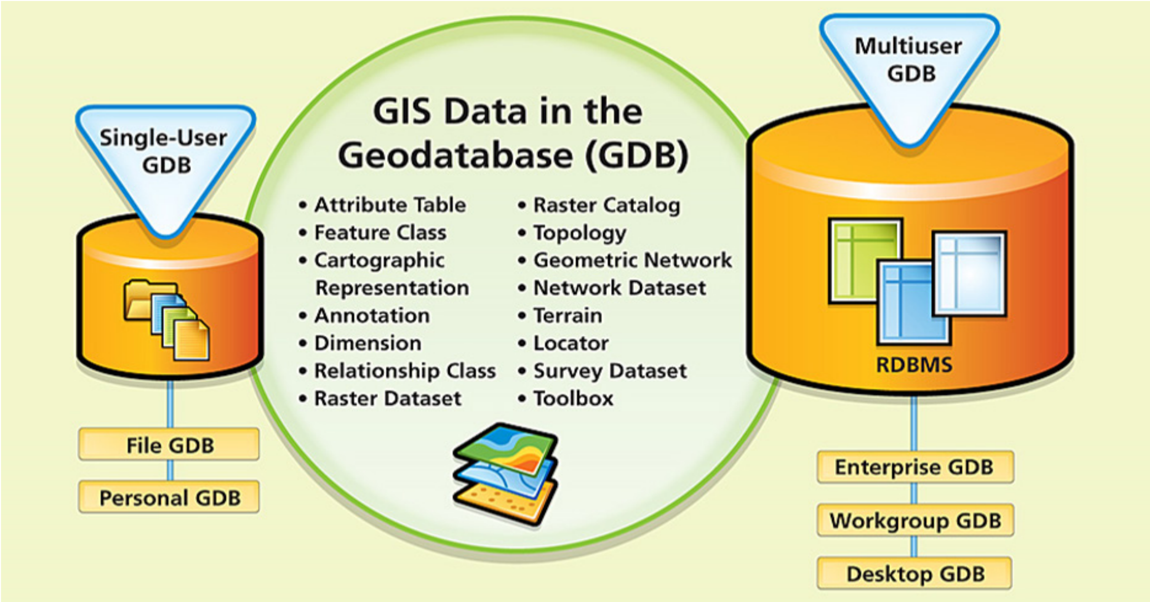
4.6.1. Description of the Geodatabase System

Geodatabases can be used as single-user or multiuser. Examples of single user are personal geodatabase and file geodatabase, while for multiusers, there are desktop geodatabase, workgroup geodatabase and enterprise geodatabase. The multiuser requires standard or advanced license of ArcGIS in order to view, create, edit and manage the database while all these activities are possible in single user as long as there are desktop licenses. In the case of the geodatabase created for NIA, it is in the format of a file geodatabase. Although it is intended for single use, a file geodatabase can still be edited through a shared network or a server.

The geodatabase made for the whole NIA system contains both national and regional set of data. Each region shall have its respective geodatabase (Table 4.6). All available maps of the whole country shall be kept and maintained by the CO for monitoring and other purposes. The rest of the data shall be used for planning and operations.

The geodatabase is used to provide storage for data access and retrieval using structured or standard query language (SQL) to create, modify, and query tables and data elements using different relational functions and operations just as what is illustrated in Figure 4.7. It also serves as a means for data integration across geodatabases.

Figure 4.7 Geodatabase Functionalities



Source: ESRI, 2016

The creation of this system implies benefits to NIA. It functions as an improvement of the existing NIA database management system and will accommodate and update all information gathered with the aim to: 1) greatly improve the efficiency and quality of decisions and developing policies for irrigation development and management; 2) accommodate updates and integrate new maps to monitor the progress and impacts of different projects; and 3) combine modelling techniques and optimization procedures into the system to enhance the capability of the agency to deliver more responsive and science-based decisions.

Table 4.6. Geodatabase File for Each Region

Region		Geodatabase
Number	Name	
CAR	Cordillera Administrative Region	CAR.gdb
I	Ilocos Region	REGION_I.gdb
II	Cagayan Valley	REGION_II.gbd
III	Central Luzon	REGION_III.gdb
IVA	CALABARZON	CALABARZON.gdb
IVB	MIMAROPA	MIMAROPA.gdb
V	Bicol Region	REGION_V.gdb
VI	Western Visayas	REGION_VI.gdb
VII	Central Visayas	REGION_VII.gdb
VIII	Eastern Visayas	REGION_VIII.gdb
IX	Zamboanga Peninsula	REGION_IX.gdb
X	Northern Mindanao	REGION_X.gdb
XI	Davao Region	REGION_XI.gdb
XII	SOCCSKSARGEN	REGION_XII.gdb
XIII	Caraga	REGION_XIII.gdb
ARMM	Autonomous Region of Muslim Mindanao	ARMM.gdb

The created geodatabase for NIA has four major components and functionalities which are: 1) data content and nomenclature, 2) attribute design and structure, 3) use of attribute domains, and the 4) incorporation of the GAME model.

Operationalization and Updating of Various Datasets from Government Agencies

This describes how the existing and future datasets will be utilized. The geodatabase functionalities can be maximized through the use of ArcGIS software especially the editing of features but it can also be used in QGIS.

From NIA datasets

Area declaration in their reports shall be based on the approximate computed area from boundary delineation through maps. Area in the inventory should always be validated in the field. For NIS, parcellary mapping shall pursue as what has been done in the ten pilot sites. The same approach is being suggested to CIS since it has a lower area coverage thus can be done in a shorter period of time. An approach of drone survey is proposed for systems inventory and for the delineation of the boundaries. The delineation will be done through editing the geodatabase file specifically among systems since there has been a created template for that purpose.

From other offices

Data from other agencies could be readily used depending on their needs. Acknowledgement of the data source should be a priority to avoid issues of illegal usage and copyright infringement.

4.6.2. Estimates of Potential Irrigable Areas

Gross Potential Irrigable Area

PIA for the NIMP is grouped in various categories: gross land based PIA, net land based PIA, and net land based PIA with areas ≥ 5 ha and areas ≥ 10 ha.

Based on the analysis, Region III has the highest gross PIA for 0-8% slope with a total of 904,561.15 ha followed by Region II with 634,886.46 ha then CALABARZON with 524,507.69 ha. However, there were differences when the slope category was broken down to 0-3% and 3-8%. For the first category, Region III has 718,272.32 ha followed by Region II with 449,266.29 ha then Region I with 382,491.38 ha. These regions are the flattest regions based on slope and have high level of suitability for crop production and irrigation based on soil textural class. CAR has the lowest area (69,078.95 ha) among the regions simply because it is mountainous as shown in Table 4.7.

On the other hand, for the latter category, Region V has the highest area with 232,421.35 ha followed by CALABARZON and Region VI with 221,805.87 ha and 215,431.95 ha, respectively. Same as the first category, CAR has the lowest among the regions in this category with 51,024.09 ha. Figure 4.8 illustrates the generated gross PIA of the country.

Total Validated Actual Irrigated Areas per Region

Shapefile data on NIS, CIS, OGA were acquired from NIA. These files were subjected to validation through GIS analysis using ArcGIS as the software.

The following were considered in this validation: 1) the NIS file from NIA were digitized in varying scales (e.g., 1:250,000, 1:100,000, etc.) which may have altered the results and have caused some NIS to fall outside the land area of the country; 2) some of the data, specifically CIS and OGAs cannot be validated since the shapefile, in vector format, are presented only by points rather than polygons; 3) various data that might be different from those of NIA were used in obtaining the NIS shapefiles (e.g., IFSAR data - a 5 m x 5 m resolution raster data that contains more comprehensive information on slope and elevation of the Philippines and Administrative Boundary which was extracted from NAMRIA's 2015 Land Cover; and 4) it is assumed that all the NIS shapefiles fall under 0-3% slope category.

The set of data were cleaned, re-projected using PRS92_UTM51N as mentioned in the Executive Order No. 45 and were subjected to various analysis. Based on the assessment, 193 out of 194 or 98% of the validated NIS have areas that belong to 3% and above slope category (Table 4.8). Moreover, based on the provided shapefile from NIA, a total of 876,564 ha were the recorded total area of NIS from the 2018 Status of Irrigation Development, but when the data were subjected to validation, the total area for all the NIS equates to 1,259,053 ha, which is 44% higher than that of the original value.

Also, Region II has the largest area that falls on 3% and above category: 38,140 for 3-8%, 15,113 for the 8-18% and 5,048.26 for the 18% and above totaling to 48,237 ha of discrepancy. Other regions have also discrepancies but relatively smaller than of Region II.

Table 4.7. Regional Gross Potential Irrigable Area

Region	Gross Potential Irrigable Area (ha)		
	0-3%	3-8%	0-8%
Region I	382,491.38	122,357.38	504,848.76
Region II	449,266.29	185,620.17	634,886.46
Region III	718,272.32	186,288.83	904,561.15
CALABARZON	302,701.82	221,805.87	524,507.69
MIMAROPA	269,047.77	149,325.15	418,372.93
Region V	276,203.51	232,421.35	508,624.86
Region VI	189,980.58	215,431.95	405,412.53
Region VII	81,686.48	152,948.90	234,635.39
Region VIII	299,954.73	146,198.56	446,153.29
Region IX	148,753.62	98,569.89	247,323.51
Region X	154,876.18	182,360.68	337,236.87
Region XI	263,114.25	117,576.18	380,690.44
Region XII	324,760.74	111,310.83	436,071.57
Caraga	268,411.44	107,888.24	376,299.67
CAR	69,078.95	51,024.09	120,103.04
ARMM*	267,019.30	146,474.69	413,493.99
Metro Manila	39,092.22	13,817.52	52,909.74
Total	**4,504,711.58**	**2,441,420.30**	**6,946,131.88**

Note: *Areas under the ARMM are managed by the Regional Office of Region X and XII

Figure 4.8. Generated Gross Potential Irrigable Area of the Philippines

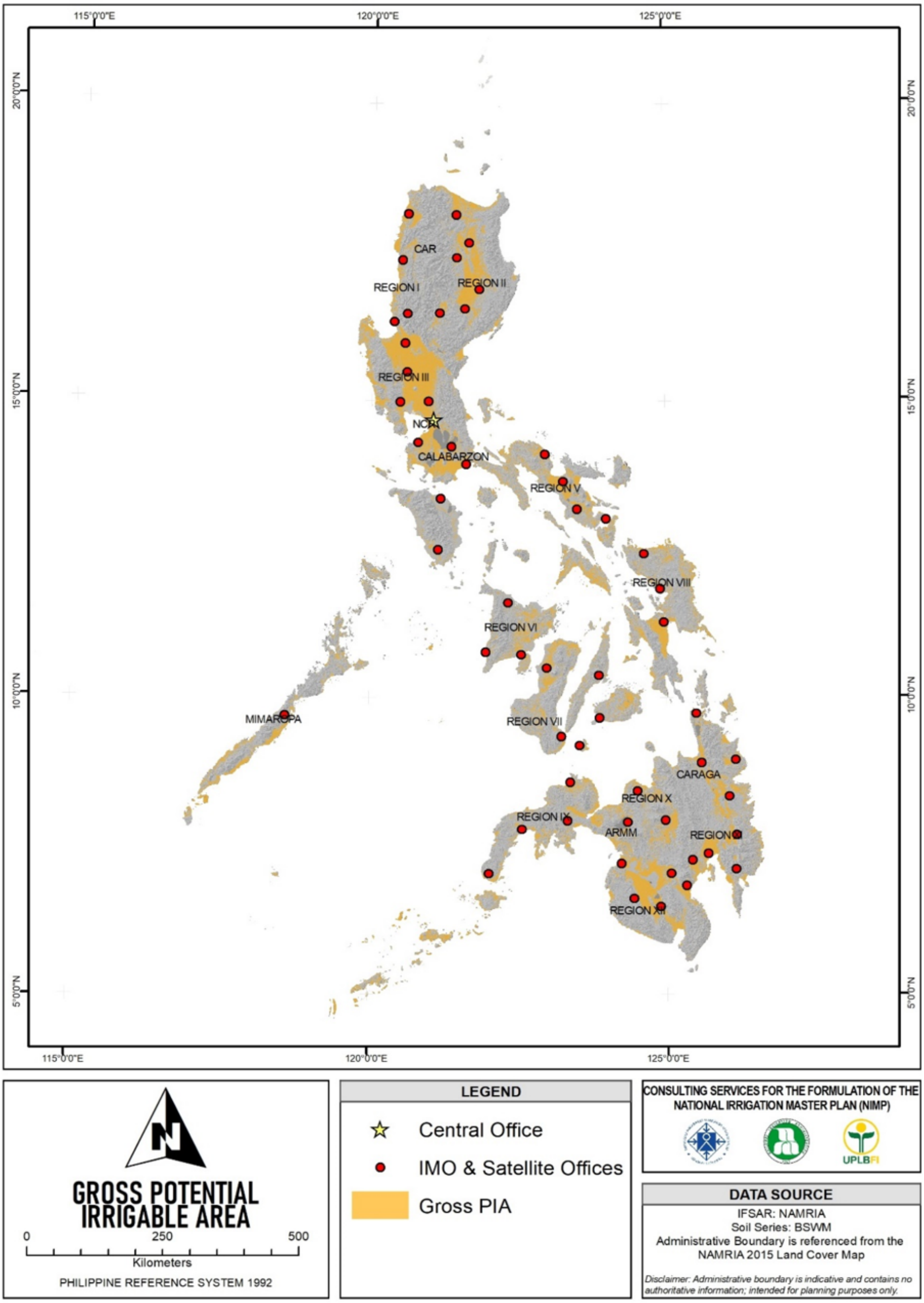


Table 4.8. Comparison between NIA and UPLBFI Estimates of Irrigated Areas under NIS

Region	National Irrigation System				
	NIA	UPLBFI			
		0-3%	3- 8%	8-18%	18% and Above
Region I	61,624.44	97,150.49	8,816.99	3,415.91	2,823.08
Region II	177,072.67	188,578.79	38,140.44	15,112.96	5,048.26
Region III	221,938.47	264,663.32	17,676.02	4,773.59	1,208.31
CALABARZON	29,034.00	38,117.22	7,536.77	1,788.83	1,076.36
MIMAROPA	30,372.46	38,217.00	3,743.66	1,038.45	738.74
Region V	24,016.05	40,493.50	3,552.41	1,162.86	399.69
Region VI	53,885.08	69,346.30	6,041.77	2,229.27	1,078.53
Region VII	12,211.80	2,967.62	3,441.33	549.29	73.06
Region VIII	26,678.50	49,074.13	2,121.05	954.56	708.45
Region IX	19,050.46	15,766.06	1,976.58	1,611.27	2,679.19
Region X	32,164.82	27,110.82	9,299.58	6,421.43	12,238.84
Region XI	38,762.77	46,304.63	3,886.94	1,617.73	506.34
Region XII	71,606.13	89,999.37	6,058.73	2,250.12	876.15
Caraga	33,301.70	34,757.53	2,486.92	1,269.63	769.62
CAR	16,297.00	13,835.75	3,285.55	2,211.13	1,341.56
ARMM*	28,160.37	37,333.38	3,074.11	2,720.56	3,504.09
Total	**876,563.73**	**1,053,715.89**	**121,138.85**	**49,127.60**	**35,070.26**

Note: *Areas under the ARMM are managed by the Regional Office of Region X and XII

Restrictions

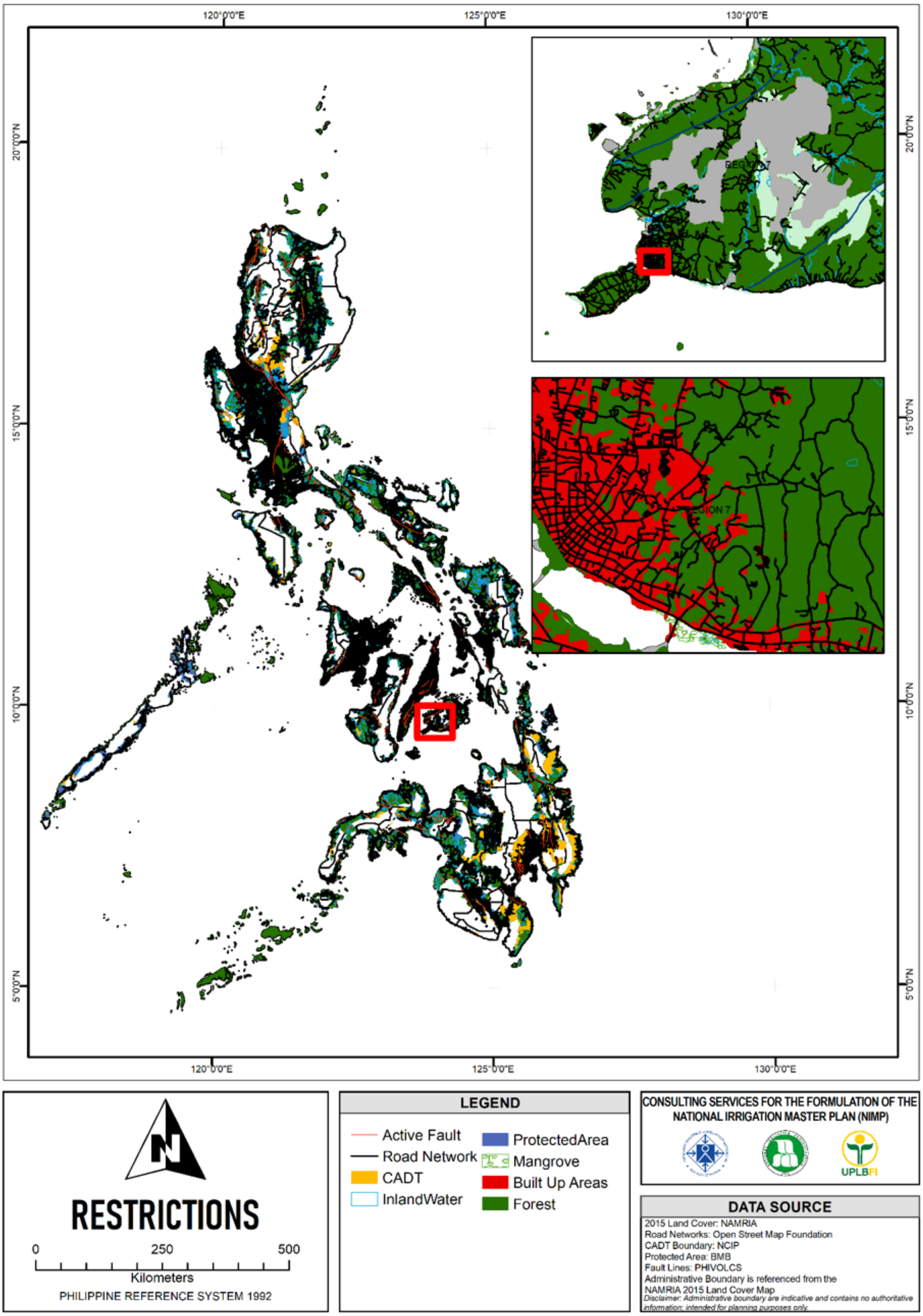
In deriving the net PIA, restrictions were removed from the gross PIA. Restrictions are defined as areas where irrigation development cannot proceed. Laws and ordinances were followed in deriving the restriction areas. Existing government laws and ordinances were also considered in deriving the restriction areas. In fact, all files were projected using the Philippine Reference System of 1992 (EO 45, s. 1993) to match with all the projections used. The net PIA also took out existing irrigated areas from the available mapped areas. The restrictions include:

a) Road Networks
b) Certificate of Ancestral Domain
c) Protected Area
d) Mangrove Area
e) Fault
f) Forest Area
g) Built-up Area
h) Inland Water

Net Potential Irrigable Area

Net PIA for the NIMP equates to the gross PIA minus the restrictions (forest area, road networks, etc.) and the existing NIS from NIA. This resulted to the total area of 0-8% slope which can be considered for irrigation expansion.

Figure 4.9. Compilation of Restrictions Used to Derive the Net Potential Irrigable Area



Based on the results, Region III has the highest net PIA on both ≥5 ha and ≥10 ha with 459,630.73 and 449,788.19 ha respectively. This is followed by Region V with 332,919.45 ha for ≥5 ha and 317,888.58 for ≥10 ha. Region I follows closely with 305,819.22 ha for ≥5 ha and 298,282.23 for ≥10 ha (Table 4.9).

Figures 4.10 to 4.12 illustrate the main generated net PIA, net PIA with minimum area of 10 ha, and net PIA with minimum area of 10 ha, respectively.

Table 4.9. Regional Net Potential Irrigable Area with ≥ 5 Ha and ≥ 10 Ha

Region	Net Potential Irrigable Area with Filter (0-8%)	
	Net PIA with ≥5 ha w/o NIS	Net PIA with ≥10 ha w/o NIS
Region I	305,819.22	298,282.23
Region II	301,444.01	292,880.69
Region III	459,630.73	449,788.19
CALABARZON	302,795.44	288,682.54
MIMAROPA	137,778.53	130,651.12
Region V	332,919.45	317,888.58
Region VI	274,527.18	254,152.83
Region VII	136,532.89	124,317.02
Region VIII	263,313.49	250,861.85
Region IX	154,372.65	144,544.58
Region X	197,555.37	185,375.56
Region XI	206,363.25	199,527.98
Region XII	254,282.70	250,457.87
Caraga	187,951.80	181,047.09
CAR	62,408.47	58,387.06
ARMM*	296,636.51	289,407.83
Total	**3,876,298.08**	**3,717,897.98**

Note: *Areas under the ARMM are managed by the Regional Office of Region 10 and 12

Figure 4.10. Generated Net Potential Irrigable Area of the Philippines

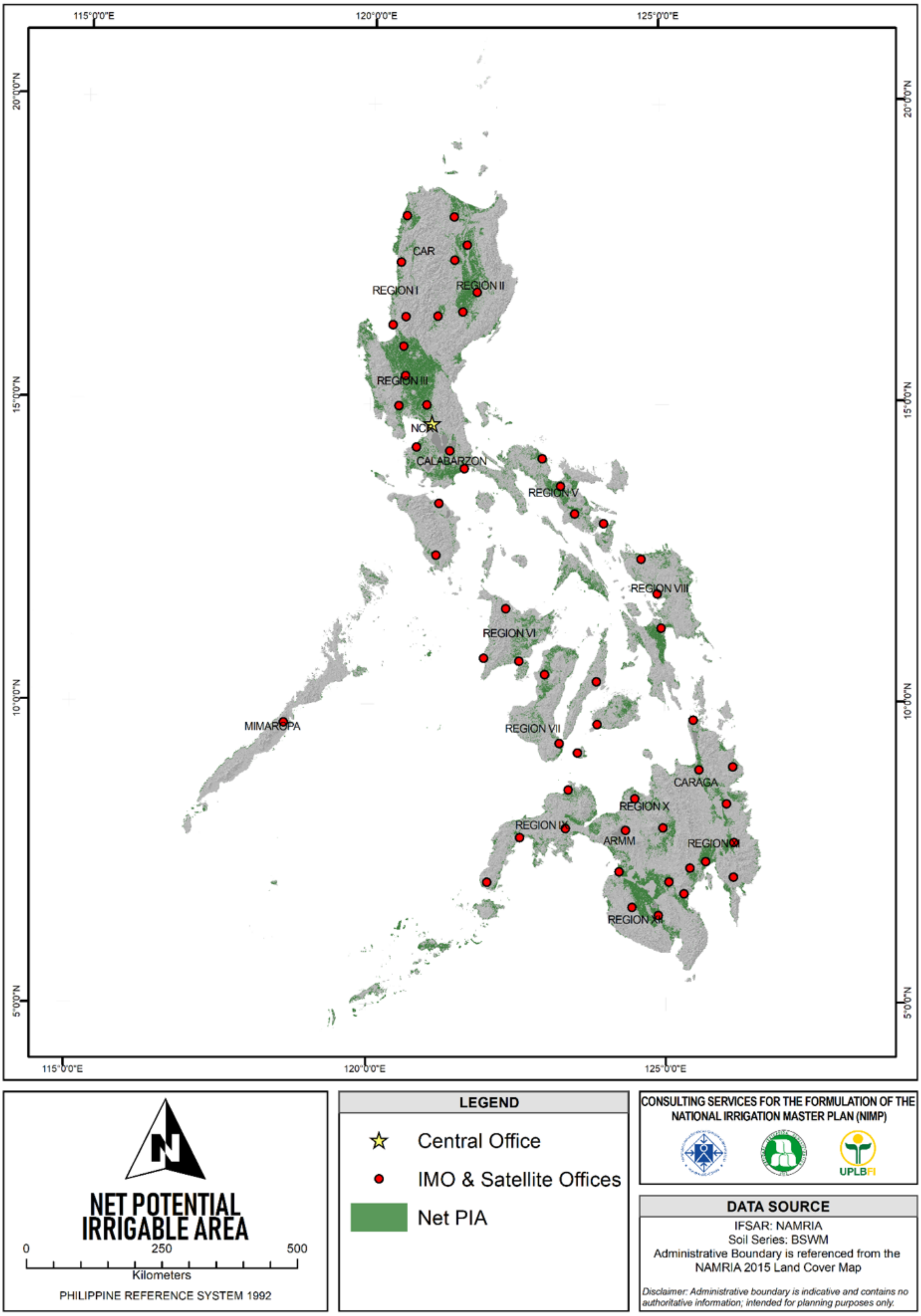


Figure 4.11. Net Potential Irrigable Area with Minimum Area of 5 ha

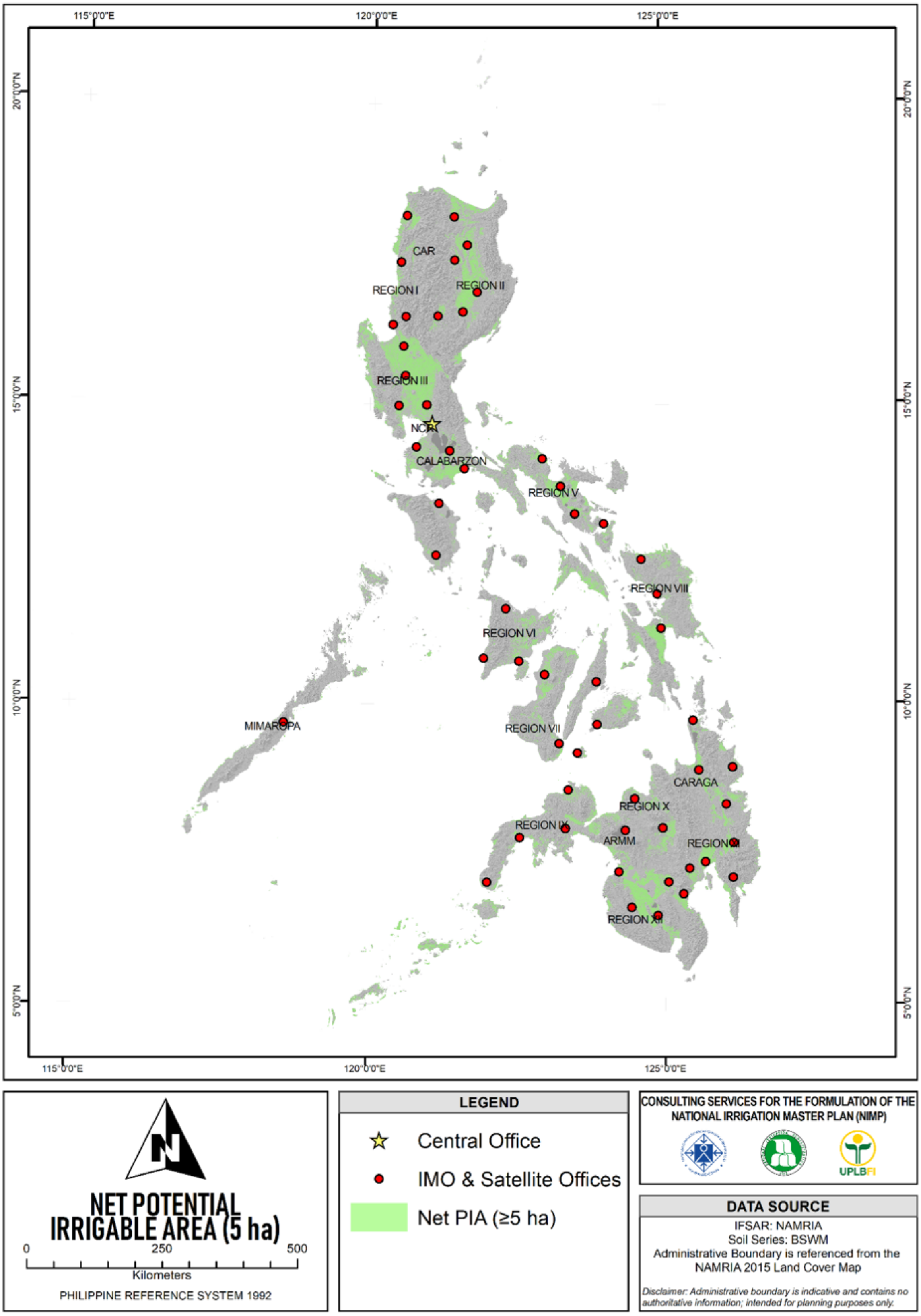
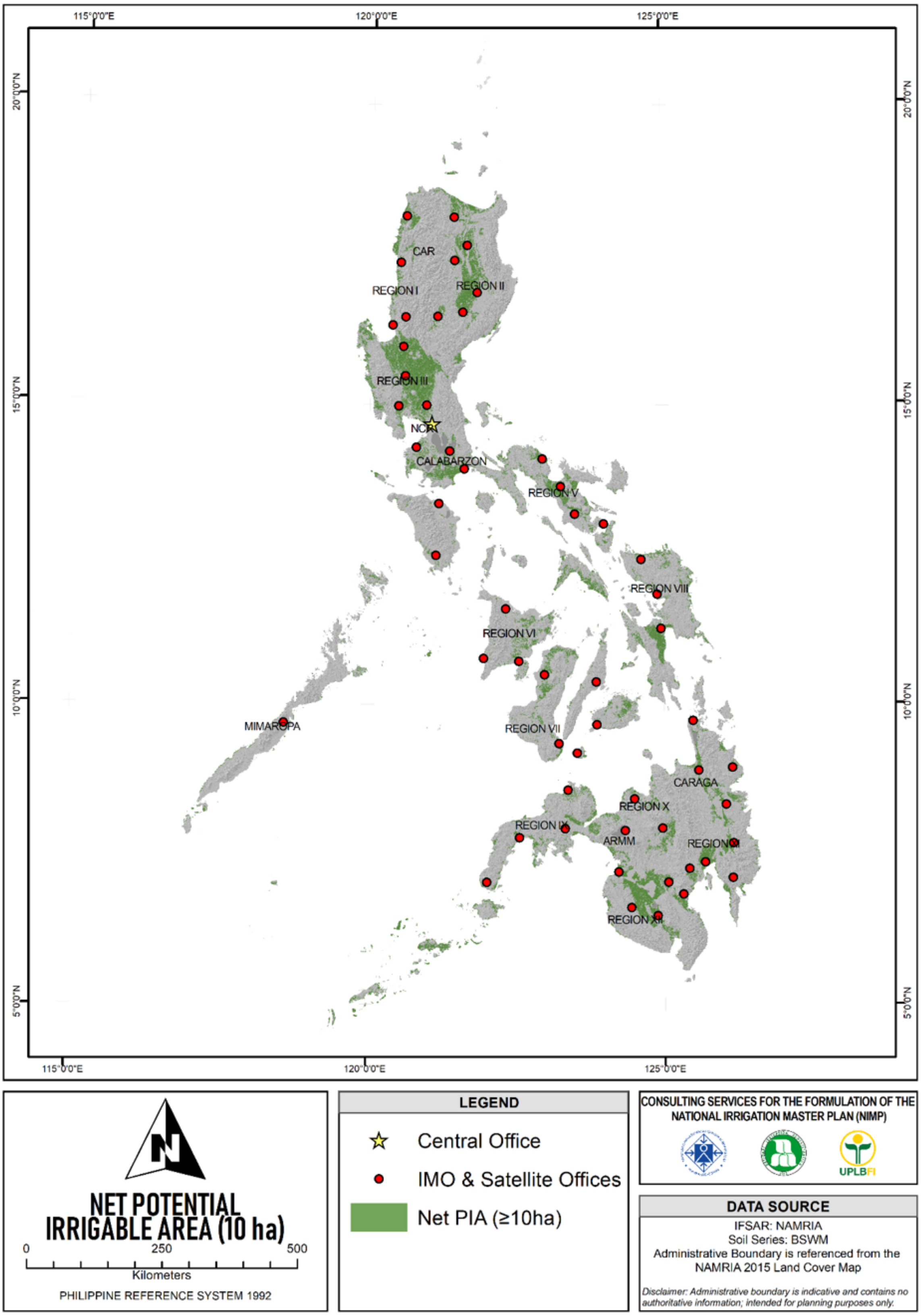


Figure 4.12. Net Potential Irrigable Area with Minimum Area of 10 ha



57 Priority Sites

The priority 57 provinces for the NIMP are divided into two groups: 1) High Yield Provinces (>4 tons/ha) and 2) Low Yield Provinces (<4 tons/ha), as shown in Tables 4.10 and 4.11, respectively. For the high yielding provinces, 11 are included in competitive low cost (<PHP 11.9/kg) and 18 are included in uncompetitive high cost (≥PHP 11.9/kg). Among the provinces included in the competitive low cost, Nueva Ecija has the largest area on net PIA with ≥5 ha and net PIA with ≥10 ha with 141,408.17 ha and 139,782.30 ha, respectively. This is followed by Isabela with 133,467.98 ha and 129,515.58 ha, respectively. Biliran has the lowest area with 3,983.40 ha and 3,563.95 ha, respectively

On the other hand, for the uncompetitive high cost, Pangasinan has the largest area with 194,797.40 ha and 190,881.22 ha, respectively, followed by Cagayan with 132,161.48 ha and 128,888.25 ha, respectively. La Union has the smallest area with 19,637.96 ha and 18,724.16 ha, respectively.

For the low yield provinces, 18 are included in competitive low cost while 10 are included in uncompetitive high cost. For the competitive low cost, Negros Occidental has the largest area among the provinces with 132,793.52 for ≥5 ha and 124,701.33 for ≥10 ha. This is followed by Masbate with 110,420.47 ha and 106,098.25 ha, respectively. Among the provinces, Aklan has the smallest area with only 5,801.11 ha and 4,673.11 ha, respectively. For the uncompetitive high cost, Quezon province has the largest area with 131,510.02 ha and 124,802.17 ha, respectively. Followed by Agusan Del Sur with 82,064.57 ha and 80,255.99 ha, respectively. In contrast, Sarangani has the smallest area with 2,832.26 ha and 2,653.36 ha, respectively.

Table 4.10. High Yield Provinces for the Potential Competitive Provinces under Rice Tariffed Regime

High Yield Provinces (> 4 tons/ha)											
Competitive: Low Cost (< PHP 11.9/kg)	NET PIA			Net PIA with ≥5 Ha w/o NIS	Net PIA with ≥10 Ha w/o NIS	Uncompetive: High Cost (≥ PHP 11.94/kg)	NET PIA			Net PIA with ≥5 Ha w/o NIS	Net PIA with ≥10 Ha w/o NIS
	0-3%	3-8%	0-8%				0-3%	3-8%	0-8%		
Nueva Ecija	226,050.63	39,281.94	265,332.58	141,408.17	139,782.30	North Cotabato	108,148.36	43,730.57	151,878.93	116,247.44	114,334.76
Isabela	199,026.11	88,791.81	287,817.92	133,467.98	129,515.58	Tarlac	119,569.66	29,998.84	149,568.50	96,494.47	95,068.74
Bukidnon	53,002.73	74,579.21	127,581.94	84,702.02	79,601.81	Cagayan	151,591.48	50,665.96	202,257.43	132,161.48	128,888.25
Zamboanga del Sur	37,756.63	24,483.38	62,240.00	39,766.57	36,749.74	Pangasinan	206,421.38	57,354.85	263,776.23	194,797.40	190,881.22
Pampanga	97,470.07	11,490.90	108,960.97	66,182.15	64,555.74	Bulacan	58,674.60	26,618.67	85,293.27	48,932.15	47,002.00
Misamis Occidental	17,662.43	25,781.09	43,443.52	36,969.38	34,849.77	Nueva Vizcaya	23,349.26	7,956.93	31,306.18	24,012.06	23,280.31
Lanao del Norte	30,630.42	29,370.26	60,000.68	45,623.79	43,559.33	Ilocos Norte	52,033.45	24,452.00	76,485.45	49,402.53	47,654.45
Biliran	2,479.34	3,078.43	5,557.77	3,983.40	3,563.95	Davao Oriental	31,239.92	13,301.29	44,541.20	34,454.78	33,035.15
Bataan	15,712.02	13,394.25	29,106.27	24,634.46	23,259.91	Davao del Sur	40,103.75	35,266.61	75,370.37	66,386.02	63,836.29
Aurora	27,989.02	7,383.74	35,372.76	32,289.30	31,607.30	Davao del Norte	80,025.64	14,430.24	94,455.88	56,620.23	55,217.94
Kalinga	20,407.89	12,009.54	32,417.43	22,286.63	21,413.72	Southern Leyte	6,458.96	5,525.06	11,984.02	7,706.93	7,020.70
TOTAL	**728,187.29**	**329,644.55**	**1,057,831.84**	**631,313.85**	**608,459.16**	Laguna	36,008.58	15,439.30	51,447.88	35,182.18	33,532.89
						Zambales	43,795.88	15,094.41	58,890.29	49,690.04	48,512.19
						Quirino	9,287.73	10,064.10	19,351.83	11,481.19	10,952.75
						Misamis Oriental	19,109.32	20,558.81	39,668.13	27,934.59	25,324.94
						Zamboanga Sibugay	34,026.85	23,203.18	57,230.03	45,367.41	43,194.13
						La Union	20,638.07	8,596.95	29,235.03	19,637.96	18,724.16
						Ilocos Sur	42,007.72	14,439.87	56,447.59	41,981.34	41,022.40
						TOTAL	**1,082,490.61**	**416,697.65**	**1,499,188.26**	**1,058,490.18**	**1,027,483.26**

Table 4.11. Low Yield Provinces for the Potential Competitive Provinces under Rice Tariffed Regime

Low Yield Provinces (<4 tons/ha)											
Competitive: Low Cost (< PHP 11.9/kg)	NET PIA			Net PIA with ≥5 Ha w/o NIS	Net PIA with ≥10 Ha w/o NIS	Uncompetitive: High Cost (≥ PHP 11.94/kg)	NET PIA			Net PIA with ≥5 Ha w/o NIS	Net PIA with ≥10 Ha w/o NIS
	0-3%	3-8%	0-8%				0-3%	3-8%	0-8%		
Camarines Sur	94,746.79	55,076.57	149,823.35	109,399.37	105,794.72	Sultan Kudarat	74,356.17	6,955.04	81,311.21	59,528.36	59,172.80
South Cotabato	68,923.16	29,829.54	98,752.70	67,825.02	66,494.23	Oriental Mindoro	5,893.68	15,583.17	21,476.85	13,044.15	11,470.59
Leyte	118,409.45	40,239.53	158,648.98	102,685.19	98,985.82	Agusan del Sur	80,507.58	24,777.61	105,285.19	82,064.57	80,255.99
Negros Occidental	67,973.58	98,301.88	166,275.46	132,793.52	124,701.33	Sarangani	2,475.95	1,023.00	3,498.95	2,832.26	2,653.36
Iloilo	61,262.89	48,595.92	109,858.81	80,470.97	74,533.33	Compostela Valley	42,022.23	9,982.95	52,005.18	42,611.95	41,779.25
Capiz	27,413.39	21,325.70	48,739.10	34,264.25	31,768.85	Negros Oriental	13,717.63	37,279.69	50,997.32	35,431.94	32,127.25
Albay	25,410.85	23,911.91	49,322.76	36,869.60	34,564.34	Bohol	30,792.40	55,499.00	86,291.40	63,869.48	59,574.54
Maguindanao	112,111.11	31,370.02	143,481.13	109,859.71	107,459.78	Occidental Mindoro	21,406.43	16,754.35	38,160.78	13,044.15	11,470.59
Agusan del Norte	36,892.10	11,116.57	48,008.67	36,845.44	35,709.77	Quezon	94,324.92	76,586.40	170,911.33	131,510.02	124,802.17
Antique	7,042.25	10,212.46	17,254.71	10,313.06	8,855.98	Ifugao	3,927.87	6,421.92	10,349.79	5,502.63	4,697.09
Sorsogon	23,015.91	21,844.65	44,860.55	33,203.83	31,031.59	TOTAL	369,424.87	250,863.11	620,287.98	449,439.50	428,003.62
Masbate	50,179.54	79,771.34	129,950.88	110,420.47	106,098.25						
Palawan	58,099.53	27,385.37	85,484.89	76,318.05	73,887.31						
Cavite	22,159.87	26,722.25	48,882.12	32,610.54	30,297.11						
Lanao del Sur	11,259.10	19,942.45	31,201.55	23,688.49	22,391.19						
Western	34,192.07	22,380.39	56,572.46	39,105.96	36,778.22						
Surigao del Sur	45,139.74	25,347.02	70,486.75	49,168.70	46,908.06						
Aklan	4,805.93	7,286.19	12,092.12	5,801.11	4,673.11						
TOTAL	869,037.25	600,659.74	1,469,696.99	1,091,643.30	1,040,932.99						

4.6.3. Estimates and Projections of Irrigation Water Demand and Supply

Estimation of Water Demand

For each region, the average computed Field Irrigation Requirement (FIR), Farm Water Requirement (FWR), and Diversion Water Requirement (DWR), for years 2020, 2025, 2030, and 2036 are shown in Tables 4.12 and 4.13. Table 4.12 gives the computed values where effective rainfall is considered while Table 4.13 gives the more conservative computed values where effective rainfall is neglected in the computations. No water requirement computations were made for NCR due to unavailability of data.

The average value per region is the average of the computed values from all the provinces within the region and considered the average for both wet and dry seasons. The estimation of irrigation water requirement was based on rice-rice cropping with 120-day growing period. The highest value either during land preparation stage or at peak vegetative stage was selected as the maximum irrigation water requirement. The year 2020 values were based on historical data while 2036 values were based from the effects of change in temperature and precipitation according to 2018 PAGASA climate projections for 2036-2065. Values for 2025 and 2030 were computed from linear interpolation between the 2020 and 2036 values. The water demands for the 57 priority provinces with and without considering effective rainfall are shown in Tables 4.14 and 4.15 respectively.

The irrigation water demands based on the computed diversion water requirement per region for 2020, 2025, 2030, and 2036 are shown in Tables 4.16 and 4.17 for estimates with and without effective rainfall under consideration, respectively. The irrigation water demand is computed for three sets of net PIA. The first set of net PIA was based on slopes of up to 8%. The other sets are net PIA of up to 8% slope but filtering all small potential farmlands, one removing areas less than 5 ha and another those less than 10 ha.

To estimate the water required to irrigate new development projects and restorations per region, the irrigation water demands of the remaining areas for irrigation development in 2020, 2025, 2030, and 2036 are computed as shown in Tables 4.18 and 4.19, for computations with effective rainfall and no effective rainfall, respectively. Two sets of values per region are computed. In the first set, the remaining areas for irrigation development set were derived by subtracting FUSA and newly generated areas (with non-operational areas) from the 0-8% slope net potential irrigable areas. The second set includes all the criteria of the first set but additionally subtracts the areas programmed under the DA SPIS.

Table 4.12. Average Irrigation Water Requirements per Region with Effective Rainfall

Region	With Effective Rainfall											
	Field Irrigation Requirement (FIR), lps/ha				Farm Water Requirement (FWR), lps/ha				Diversion Water Requirement (DWR), lps/ha			
	2020	2025	2030	2036	2020	2025	2030	2036	2020	2025	2030	2036
CAR	1.12	1.12	1.13	1.13	1.70	1.70	1.71	1.72	2.12	2.13	2.14	2.15
I	1.17	1.18	1.19	1.20	1.68	1.69	1.70	1.71	2.10	2.11	2.12	2.14
II	1.15	1.16	1.17	1.18	1.76	1.77	1.78	1.79	2.20	2.21	2.22	2.24
III	1.46	1.47	1.48	1.49	2.13	2.14	2.15	2.16	2.66	2.67	2.69	2.70
CALABARZON	1.03	1.04	1.05	1.07	1.51	1.53	1.55	1.57	1.89	1.91	1.93	1.96
MIMAROPA	1.06	1.07	1.07	1.08	1.61	1.62	1.63	1.63	2.02	2.02	2.03	2.04
V	0.88	0.88	0.88	0.88	1.44	1.44	1.44	1.45	1.80	1.80	1.81	1.81
VI	0.97	0.99	1.01	1.03	1.44	1.47	1.49	1.53	1.80	1.83	1.87	1.91
VII	0.92	0.92	0.92	0.92	1.51	1.47	1.42	1.36	1.89	1.83	1.78	1.71
VIII	0.92	0.92	0.92	0.92	1.55	1.55	1.55	1.55	1.85	1.85	1.84	1.84
IX	0.87	0.87	0.88	0.88	1.27	1.27	1.27	1.27	1.59	1.59	1.59	1.59
X	0.94	0.94	0.94	0.94	1.34	1.34	1.34	1.34	1.68	1.68	1.68	1.67
XI	1.14	1.16	1.17	1.19	1.67	1.69	1.70	1.72	2.09	2.11	2.13	2.16
XII	1.12	1.12	1.12	1.13	1.74	1.74	1.75	1.75	2.17	2.18	2.18	2.19
Caraga	0.95	0.94	0.94	0.93	1.39	1.42	1.45	1.49	1.73	1.77	1.81	1.86
AVERAGE	**1.05**	**1.05**	**1.06**	**1.06**	**1.58**	**1.59**	**1.60**	**1.60**	**1.97**	**1.98**	**1.99**	**2.00**

Notes:
1. 2020 values are based on historical data
2. 2036 values are based from PAGASA climate projections for 2036-2065

Table 4.13. Average Irrigation Water Requirements per Region without Effective Rainfall

Region	Without Effective Rainfall											
	Field Irrigation Requirement (FIR), lps/ha				Farm Water Requirement (FWR), lps/ha				Diversion Water Requirement (DWR), lps/ha			
	2020	2025	2030	2036	2020	2025	2030	2036	2020	2025	2030	2036
CAR	1.12	1.12	1.13	1.13	1.78	1.79	1.80	1.82	2.22	2.24	2.25	2.27
I	1.17	1.18	1.19	1.20	1.81	1.81	1.82	1.83	2.26	2.27	2.27	2.28
II	1.15	1.16	1.17	1.18	1.81	1.82	1.83	1.84	2.27	2.28	2.29	2.31
III	1.52	1.53	1.54	1.55	2.45	2.47	2.50	2.53	3.06	3.09	3.13	3.17
CALABARZON	1.10	1.10	1.11	1.11	1.78	1.79	1.80	1.80	2.22	2.23	2.24	2.26
MIMAROPA	1.15	1.15	1.15	1.16	1.86	1.87	1.88	1.89	2.33	2.34	2.35	2.36
V	1.10	1.11	1.11	1.12	1.83	1.84	1.85	1.86	2.29	2.31	2.32	2.33
VI	1.11	1.12	1.12	1.13	1.85	1.85	1.86	1.87	2.31	2.32	2.33	2.34
VII	1.06	1.07	1.07	1.08	1.77	1.78	1.79	1.79	2.21	2.22	2.23	2.24
VIII	1.18	1.18	1.18	1.19	1.79	1.80	1.81	1.82	2.23	2.25	2.26	2.27
IX	1.17	1.17	1.18	1.18	1.94	1.95	1.95	1.96	2.42	2.43	2.44	2.45
X	1.04	1.04	1.05	1.06	1.63	1.64	1.64	1.65	2.03	2.04	2.06	2.07
XI	1.27	1.28	1.29	1.29	2.06	2.07	2.07	2.08	2.58	2.58	2.59	2.60
XII	1.14	1.14	1.15	1.15	1.80	1.81	1.82	1.83	2.24	2.26	2.27	2.29
Caraga	1.19	1.20	1.20	1.21	1.76	1.82	1.87	1.94	2.22	2.29	2.36	2.45
AVERAGE	**1.16**	**1.17**	**1.18**	**1.18**	**1.86**	**1.87**	**1.89**	**1.90**	**2.33**	**2.34**	**2.36**	**2.38**

Notes:
1. 2020 values are based on historical data
2. 2036 values are based from PAGASA climate projections for 2036-2065

Table 4.14. Estimated Irrigation Water Requirements for the 57 Priority Provinces with Effective Rainfall

		WITH EFFECTIVE RAINFALL											
Region	Province	Field Irrigation Requirement (FIR), lps/ha				Farm Water Requirement (FWR), lps/ha				Diversion Water Requirement (DWR), lps/ha			
		2020	2025	2030	2036	2020	2025	2030	2036	2020	2025	2030	2036
CAR	Kalinga	1.29	1.30	1.30	1.30	2.16	2.16	2.16	2.17	2.69	2.70	2.71	2.71
CAR	Ifugao	1.00	1.00	1.01	1.02	1.43	1.44	1.44	1.45	1.79	1.79	1.80	1.81
I	Ilocos Norte	1.11	1.11	1.12	1.13	1.58	1.59	1.60	1.61	1.98	1.99	2.00	2.02
I	Ilocos Sur	1.13	1.13	1.14	1.15	1.61	1.62	1.63	1.64	2.01	2.03	2.04	2.05
I	La Union	1.10	1.11	1.11	1.12	1.57	1.58	1.59	1.60	1.97	1.98	1.98	2.00
I	Pangasinan	1.36	1.37	1.38	1.39	1.95	1.96	1.97	1.99	2.43	2.45	2.47	2.49
II	Cagayan	1.19	1.19	1.20	1.20	1.98	1.99	1.99	2.00	2.48	2.49	2.49	2.50
II	Isabela	1.27	1.28	1.28	1.29	1.82	1.82	1.83	1.84	2.27	2.28	2.29	2.30
II	Nueva Vizcaya	1.22	1.23	1.24	1.25	1.75	1.76	1.77	1.78	2.18	2.20	2.21	2.23
II	Quirino	0.96	0.97	0.98	0.99	1.38	1.39	1.40	1.42	1.72	1.74	1.75	1.77
III	Aurora	0.67	0.67	0.67	0.67	1.12	1.12	1.11	1.11	1.40	1.39	1.39	1.39
III	Bataan	1.23	1.24	1.24	1.25	1.76	1.77	1.78	1.79	2.20	2.21	2.22	2.23
III	Bulacan	1.16	1.16	1.16	1.17	1.65	1.66	1.66	1.67	2.06	2.07	2.08	2.09
III	Nueva Ecija	0.94	0.95	0.95	0.96	1.37	1.37	1.37	1.37	1.71	1.71	1.71	1.71
III	Pampanga	2.48	2.51	2.55	2.59	3.54	3.60	3.65	3.72	4.42	4.50	4.57	4.65
III	Tarlac	1.22	1.23	1.24	1.25	1.75	1.76	1.77	1.78	2.19	2.20	2.21	2.23
III	Zambales	2.53	2.54	2.55	2.56	3.72	3.71	3.70	3.69	4.65	4.64	4.62	4.61
CALABARZON	Cavite	1.21	1.22	1.23	1.23	1.73	1.74	1.75	1.76	2.17	2.18	2.19	2.20
CALABARZON	Laguna	1.02	1.03	1.03	1.04	1.46	1.47	1.47	1.48	1.82	1.83	1.84	1.85
CALABARZON	Quezon	0.84	0.87	0.90	0.94	1.40	1.45	1.51	1.57	1.75	1.82	1.88	1.97

		WITH EFFECTIVE RAINFALL											
Region	Province	Field Irrigation Requirement (FIR), lps/ha				Farm Water Requirement (FWR), lps/ha				Diversion Water Requirement (DWR), lps/ha			
		2020	2025	2030	2036	2020	2025	2030	2036	2020	2025	2030	2036
MIMAROPA	Occidental Mindoro	1.21	1.21	1.22	1.22	1.79	1.80	1.81	1.83	2.24	2.25	2.27	2.28
MIMAROPA	Oriental Mindoro	1.13	1.13	1.14	1.14	1.88	1.89	1.89	1.90	2.35	2.36	2.37	2.38
MIMAROPA	Palawan	1.15	1.16	1.17	1.18	1.92	1.93	1.94	1.95	2.40	2.41	2.42	2.43
V	Albay	0.81	0.81	0.80	0.80	1.36	1.35	1.34	1.33	1.69	1.68	1.67	1.66
V	Camarines Sur	0.81	0.81	0.81	0.80	1.36	1.35	1.34	1.33	1.70	1.69	1.68	1.67
V	Masbate	0.94	0.94	0.94	0.94	1.56	1.56	1.57	1.57	1.95	1.96	1.96	1.97
V	Sorsogon	0.80	0.80	0.80	0.80	1.22	1.22	1.23	1.23	1.52	1.53	1.53	1.54
VI	Aklan	0.92	0.92	0.93	0.94	1.36	1.36	1.37	1.38	1.70	1.70	1.71	1.72
VI	Antique	1.10	1.10	1.11	1.12	1.57	1.58	1.59	1.60	1.96	1.97	1.98	2.00
VI	Capiz	0.93	0.94	0.94	0.95	1.38	1.39	1.40	1.41	1.73	1.74	1.75	1.76
VI	Iloilo	1.06	1.07	1.07	1.08	1.51	1.52	1.53	1.54	1.89	1.90	1.91	1.93
VI	Negros Occidental	0.77	0.85	0.93	1.02	1.29	1.42	1.54	1.70	1.61	1.77	1.93	2.12
VII	Bohol	0.94	0.94	0.94	0.94	1.56	1.56	1.57	1.57	1.95	1.95	1.96	1.96
VII	Negros Oriental	0.92	0.92	0.92	0.91	1.48	1.43	1.37	1.30	1.86	1.78	1.71	1.63
VIII	Biliran	0.80	0.80	0.80	0.80	1.40	1.41	1.41	1.42	1.66	1.66	1.66	1.66
VIII	Leyte	0.81	0.81	0.81	0.81	1.41	1.42	1.43	1.43	1.68	1.68	1.68	1.68
VIII	Samar (Western Samar)	0.95	0.94	0.92	0.91	1.58	1.56	1.54	1.51	1.98	1.95	1.92	1.89
VIII	Southern Leyte	1.13	1.13	1.13	1.13	1.75	1.76	1.77	1.78	2.19	2.20	2.21	2.23
IX	Zamboanga del Sur	1.02	1.02	1.02	1.02	1.45	1.46	1.46	1.46	1.82	1.82	1.82	1.82
IX	Zamboanga Sibugay	0.88	0.89	0.89	0.90	1.29	1.29	1.29	1.28	1.61	1.61	1.61	1.61

		WITH EFFECTIVE RAINFALL											
Region	Province	Field Irrigation Requirement (FIR), lps/ha				Farm Water Requirement (FWR), lps/ha				Diversion Water Requirement (DWR), lps/ha			
		2020	2025	2030	2036	2020	2025	2030	2036	2020	2025	2030	2036
X	Bukidnon	0.91	0.91	0.91	0.91	1.31	1.30	1.30	1.30	1.63	1.63	1.63	1.63
X	Lanao del Norte	0.91	0.92	0.92	0.92	1.31	1.31	1.31	1.32	1.63	1.64	1.64	1.65
X	Misamis Occidental	1.01	1.01	1.01	1.00	1.45	1.44	1.44	1.43	1.81	1.81	1.80	1.79
X	Misamis Oriental	0.96	0.95	0.95	0.95	1.37	1.36	1.36	1.36	1.71	1.70	1.70	1.70
XI	Compostela Valley	1.31	1.27	1.23	1.18	2.15	2.07	1.99	1.89	2.69	2.59	2.48	2.36
XI	Davao del Norte	1.17	1.22	1.27	1.33	1.87	1.95	2.03	2.12	2.33	2.43	2.53	2.65
XI	Davao del Sur	1.29	1.29	1.30	1.30	2.11	2.09	2.07	2.04	2.63	2.61	2.59	2.56
XI	Davao Oriental	1.28	1.29	1.31	1.32	2.02	2.07	2.12	2.18	2.53	2.59	2.65	2.73
XII	North Cotabato	0.93	0.93	0.93	0.93	1.33	1.33	1.32	1.32	1.66	1.66	1.66	1.66
XII	Sarangani	1.11	1.11	1.12	1.13	1.59	1.59	1.60	1.61	1.98	1.99	2.00	2.01
XII	South Cotabato	1.22	1.22	1.23	1.23	2.03	2.04	2.05	2.06	2.54	2.55	2.56	2.57
XII	Sultan Kudarat	1.20	1.21	1.21	1.22	2.00	2.01	2.02	2.03	2.50	2.51	2.52	2.53
Caraga	Agusan del Norte	1.27	1.27	1.28	1.28	1.89	1.89	1.90	1.91	2.36	2.37	2.38	2.39
Caraga	Agusan del Sur	1.15	1.15	1.16	1.16	1.81	1.82	1.82	1.84	2.35	2.36	2.37	2.38
Caraga	Surigao del Sur	1.17	1.17	1.17	1.18	1.70	1.78	1.86	1.96	2.12	2.23	2.33	2.45
ARMM	Lanao del Sur	-	-	-	-	-	-	-	-	-	-	-	-
ARMM	Maguindanao	-	-	-	-	-	-	-	-	-	-	-	-

Table 4.15. Estimated Irrigation Water Requirements for the 57 Priority Provinces without Effective Rainfall

		WITHOUT EFFECTIVE RAINFALL											
Region	Province	Field Irrigation Requirement (FIR), lps/ha				Farm Water Requirement (FWR), lps/ha				Diversion Water Requirement (DWR), lps/ha			
		2020	2025	2030	2036	2020	2025	2030	2036	2020	2025	2030	2036
CAR	Kalinga	1.29	1.30	1.30	1.30	2.16	2.16	2.16	2.17	2.69	2.70	2.71	2.71
CAR	Ifugao	1.00	1.00	1.01	1.02	1.52	1.53	1.54	1.55	1.90	1.91	1.92	1.94
I	Ilocos Norte	1.11	1.11	1.12	1.13	1.71	1.72	1.73	1.74	2.14	2.15	2.16	2.17
I	Ilocos Sur	1.13	1.13	1.14	1.15	1.69	1.70	1.71	1.72	2.11	2.13	2.14	2.16
I	La Union	1.10	1.11	1.11	1.12	1.66	1.67	1.69	1.71	2.07	2.09	2.11	2.14
I	Pangasinan	1.36	1.37	1.38	1.39	2.17	2.16	2.15	2.13	2.72	2.70	2.68	2.66
II	Cagayan	1.19	1.19	1.20	1.20	1.98	1.99	1.99	2.00	2.48	2.49	2.49	2.50
II	Isabela	1.27	1.28	1.28	1.29	2.08	2.09	2.10	2.11	2.60	2.61	2.63	2.64
II	Nueva Vizcaya	1.22	1.23	1.24	1.25	1.75	1.76	1.77	1.78	2.18	2.20	2.21	2.23
II	Quirino	0.96	0.97	0.98	0.99	1.38	1.39	1.40	1.42	1.72	1.74	1.75	1.77
III	Aurora	0.95	0.96	0.97	0.99	1.58	1.60	1.62	1.65	1.98	2.00	2.03	2.06
III	Bataan	1.23	1.24	1.24	1.25	1.87	1.88	1.89	1.90	2.34	2.35	2.36	2.37
III	Bulacan	1.16	1.16	1.16	1.17	1.85	1.88	1.90	1.93	2.32	2.34	2.37	2.41
III	Nueva Ecija	1.03	1.03	1.04	1.04	1.72	1.72	1.73	1.73	2.15	2.15	2.16	2.17
III	Pampanga	2.48	2.51	2.55	2.60	3.96	4.07	4.19	4.33	4.95	5.09	5.24	5.41
III	Tarlac	1.22	1.23	1.24	1.25	1.87	1.88	1.89	1.90	2.33	2.34	2.36	2.37
III	Zambales	2.56	2.57	2.58	2.58	4.27	4.28	4.29	4.31	5.34	5.35	5.37	5.38
CALABARZON	Cavite	1.21	1.22	1.23	1.23	1.92	1.93	1.94	1.95	2.40	2.41	2.43	2.44
CALABARZON	Laguna	1.05	1.05	1.06	1.06	1.75	1.75	1.76	1.77	2.18	2.19	2.20	2.21
CALABARZON	Quezon	1.11	1.11	1.12	1.12	1.85	1.86	1.86	1.87	2.31	2.32	2.33	2.34
MIMAROPA	Occidental Mindoro	1.21	1.21	1.22	1.22	1.79	1.80	1.81	1.83	2.24	2.25	2.27	2.28
MIMAROPA	Oriental Mindoro	1.13	1.13	1.14	1.14	1.88	1.89	1.89	1.90	2.35	2.36	2.37	2.38
MIMAROPA	Palawan	1.15	1.16	1.17	1.18	1.92	1.93	1.94	1.95	2.40	2.41	2.42	2.43
V	Albay	1.12	1.13	1.13	1.14	1.87	1.88	1.89	1.90	2.33	2.35	2.36	2.38
V	Camarines Sur	1.12	1.13	1.13	1.14	1.85	1.86	1.87	1.88	2.34	2.35	2.36	2.38
V	Masbate	1.04	1.04	1.05	1.05	1.73	1.73	1.74	1.75	2.16	2.17	2.18	2.19
V	Sorsogon	1.11	1.11	1.12	1.12	1.84	1.85	1.86	1.87	2.30	2.31	2.33	2.34

		WITHOUT EFFECTIVE RAINFALL											
Region	Province	Field Irrigation Requirement (FIR), lps/ha				Farm Water Requirement (FWR), lps/ha				Diversion Water Requirement (DWR), lps/ha			
		2020	2025	2030	2036	2020	2025	2030	2036	2020	2025	2030	2036
VI	Antique	1.15	1.16	1.17	1.17	1.92	1.93	1.94	1.96	2.40	2.41	2.43	2.44
VI	Capiz	1.13	1.14	1.14	1.15	1.89	1.89	1.90	1.91	2.36	2.37	2.38	2.39
VI	Iloilo	1.13	1.13	1.14	1.14	1.88	1.88	1.89	1.90	2.35	2.35	2.36	2.37
VI	Negros Occidental	1.01	1.01	1.02	1.03	1.68	1.69	1.70	1.71	2.10	2.11	2.13	2.14
VII	Bohol	1.08	1.08	1.09	1.10	1.80	1.81	1.82	1.83	2.25	2.26	2.27	2.29
VII	Negros Oriental	1.05	1.05	1.06	1.06	1.75	1.76	1.76	1.77	2.19	2.20	2.21	2.22
VIII	Biliran	1.12	1.13	1.13	1.14	1.74	1.75	1.75	1.76	2.17	2.18	2.19	2.21
VIII	Leyte	1.13	1.14	1.14	1.15	1.75	1.76	1.77	1.78	2.19	2.20	2.21	2.22
VIII	Samar (Western Samar)	0.95	0.94	0.92	0.91	1.58	1.56	1.54	1.51	1.98	1.95	1.92	1.89
VIII	Southern Leyte	1.13	1.13	1.13	1.13	1.75	1.76	1.77	1.78	2.19	2.20	2.21	2.23
IX	Zamboanga del Sur	1.31	1.32	1.32	1.33	2.19	2.20	2.21	2.22	2.73	2.74	2.76	2.77
IX	Zamboanga Sibugay	1.22	1.23	1.24	1.24	2.03	2.03	2.04	2.05	2.53	2.54	2.55	2.57
X	Bukidnon	0.91	0.91	0.91	0.91	1.31	1.30	1.30	1.30	1.63	1.63	1.63	1.63
X	Lanao del Norte	0.91	0.92	0.92	0.92	1.31	1.31	1.31	1.32	1.63	1.64	1.64	1.65
X	Misamis Occidental	1.01	1.01	1.01	1.00	1.45	1.44	1.44	1.43	1.81	1.81	1.80	1.79
X	Misamis Oriental	0.96	0.95	0.95	0.95	1.37	1.36	1.36	1.36	1.71	1.70	1.70	1.70
XI	Compostela Valley	1.31	1.27	1.23	1.18	2.15	2.07	1.99	1.89	2.69	2.59	2.48	2.36
XI	Davao del Norte	1.17	1.22	1.27	1.33	1.87	1.95	2.03	2.12	2.33	2.43	2.53	2.65
XI	Davao Oriental	1.28	1.29	1.31	1.32	2.02	2.07	2.12	2.18	2.53	2.59	2.65	2.73
XII	North Cotabato	1.05	1.06	1.06	1.07	1.66	1.67	1.68	1.70	2.07	2.09	2.10	2.12
XII	Sarangani	1.05	1.06	1.06	1.07	1.66	1.67	1.68	1.70	2.07	2.09	2.10	2.12
XII	South Cotabato	1.18	1.19	1.20	1.20	1.83	1.85	1.86	1.87	2.29	2.31	2.32	2.34
XII	Sultan Kudarat	1.26	1.26	1.27	1.28	2.03	2.04	2.05	2.06	2.54	2.55	2.56	2.57
Caraga	Agusan del Norte	1.27	1.27	1.28	1.28	1.89	1.89	1.90	1.91	2.36	2.37	2.38	2.39
Caraga	Agusan del Sur	1.15	1.15	1.16	1.16	1.81	1.82	1.82	1.84	2.35	2.36	2.37	2.38
Caraga	Surigao del Sur	1.17	1.17	1.17	1.18	1.70	1.78	1.86	1.96	2.12	2.23	2.33	2.45
ARMM	Lanao del Sur	-	-	-	-	-	-	-	-	-	-	-	-
ARMM	Maguindanao	-	-	-	-	-	-	-	-	-	-	-	-

Table 4.16. Irrigation Water Demand per Region with Effective Rainfall

Region	WITH EFFECTIVE RAINFALL														
	Net PIA (0-8%), ha 1	Irrigation Water Demand, MCM				Net PIA >5ha (0-8), ha 2	Irrigation Water Demand, MCM				Net PIA >10ha (0-8%), ha 3	Irrigation Water Demand, MCM			
		2020	2025	2030	2036		2020	2025	2030	2036		2020	2025	2030	2036
CAR	97,245.33	2,138.43	2,146.98	2,155.53	2,165.80	76,394.60	1,679.92	1,686.64	1,693.36	1,701.42	72,243.01	1,588.62	1,594.98	1,601.33	1,608.96
I	425,944.30	9,261.40	9,317.25	9,373.11	9,440.13	394,536.32	8,578.49	8,630.22	8,681.96	8,744.04	386,169.27	8,396.56	8,447.20	8,497.84	8,558.60
II	541,657.79	12,351.83	12,420.12	12,488.41	12,570.35	498,690.23	11,372.01	11,434.88	11,497.75	11,573.19	489,370.20	11,159.48	11,221.17	11,282.87	11,356.90
III	732,524.64	20,207.89	20,304.67	20,401.45	20,517.59	699,249.49	19,289.94	19,382.33	19,474.71	19,585.57	687,639.35	18,969.66	19,060.51	19,151.36	19,260.38
CALABARZON	387,618.15	7,590.76	7,677.74	7,764.73	7,869.11	331,556.87	6,492.90	6,567.31	6,641.71	6,731.00	316,724.34	6,202.44	6,273.51	6,344.59	6,429.88
MIMAROPA	168,895.88	3,531.81	3,545.14	3,558.47	3,574.47	139,373.03	2,914.45	2,925.45	2,936.45	2,949.66	132,018.01	2,760.65	2,771.07	2,781.49	2,794.00
V	435,632.31	8,143.23	8,149.76	8,156.28	8,164.12	367,028.89	6,860.83	6,866.33	6,871.83	6,878.43	351,891.91	6,577.88	6,583.15	6,588.42	6,594.75
VI	371,317.71	6,917.26	7,051.59	7,185.91	7,347.09	286,098.07	5,329.71	5,433.20	5,536.70	5,660.89	265,291.06	4,942.10	5,038.06	5,134.03	5,249.19
VII	199,615.24	3,914.30	3,793.96	3,673.62	3,529.21	142,650.12	2,797.26	2,711.26	2,625.26	2,522.06	130,404.58	2,557.13	2,478.52	2,399.90	2,305.56
VIII	368,842.43	7,077.02	7,064.16	7,051.30	7,035.86	307,850.90	5,906.77	5,896.03	5,885.30	5,872.42	295,200.75	5,664.05	5,653.75	5,643.46	5,631.11
IX	209,419.80	3,457.41	3,457.22	3,457.04	3,456.81	166,053.99	2,741.46	2,741.31	2,741.17	2,740.99	156,186.13	2,578.55	2,578.41	2,578.27	2,578.10
X	273,786.06	4,771.49	4,766.04	4,760.60	4,754.06	226,151.39	3,941.32	3,936.82	3,932.32	3,926.93	213,695.27	3,724.24	3,719.99	3,715.74	3,710.64
XI	274,913.85	5,951.88	6,011.91	6,071.93	6,143.96	250,394.33	5,421.03	5,475.71	5,530.38	5,595.98	243,428.80	5,270.23	5,323.38	5,376.53	5,440.31
XII	343,350.90	7,730.95	7,753.82	7,776.68	7,804.12	328,516.36	7,396.93	7,418.81	7,440.69	7,466.94	324,220.84	7,300.21	7,321.81	7,343.40	7,369.31
Caraga	250,237.47	4,494.30	4,596.43	4,698.56	4,821.12	215,863.62	3,876.94	3,965.04	4,053.14	4,158.86	208,893.10	3,751.75	3,837.01	3,922.26	4,024.57
TOTAL	5,081,001.86	107,539.95	108,056.78	108,573.61	109,193.80	4,430,408.21	94,599.98	95,071.35	95,542.73	96,108.39	4,273,376.62	91,443.55	91,902.52	92,361.49	92,912.26

Notes: 1 Net Potential Irrigable Area (without Filter, 0-8% only)
2 Net Potential Irrigable Area (with >5ha Filter, 0-8%)
3 Net Potential Irrigable Area (with >10ha Filter, 0-8%)

Table 4.17. Irrigation Water Demand per Region without Effective Rainfall

	WITHOUT EFFECTIVE RAINFALL														
Region	Net PIA (0-8%), ha 1	Irrigation Water Demand, MCM				Net PIA >5ha (0-8%), ha 2	Irrigation Water Demand, MCM				Net PIA >10ha (0-8%), ha 3	Irrigation Water Demand, MCM			
		2020	2025	2030	2036		2020	2025	2030	2036		2020	2025	2030	2036
CAR	97,245.33	2,242.27	2,257.48	2,272.70	2,290.96	76,394.60	1,761.49	1,773.45	1,785.40	1,799.75	72,243.01	1,665.77	1,677.07	1,688.37	1,701.94
I	425,944.30	9,981.93	10,011.52	10,041.10	10,076.61	394,536.32	9,245.89	9,273.29	9,300.70	9,333.59	386,169.27	9,049.81	9,076.63	9,103.46	9,135.65
II	541,657.79	12,723.85	12,794.51	12,865.17	12,949.95	498,690.23	11,714.52	11,779.57	11,844.62	11,922.68	489,370.20	11,495.59	11,559.42	11,623.26	11,699.86
III	732,524.64	23,218.57	23,480.69	23,742.81	24,057.36	699,249.49	22,163.86	22,414.08	22,664.29	22,964.55	687,639.35	21,795.86	22,041.92	22,287.98	22,583.25
CALA-BARZON	387,618.15	8,938.90	8,978.88	9,018.87	9,066.85	331,556.87	7,646.06	7,680.27	7,714.47	7,755.51	316,724.34	7,304.01	7,336.68	7,369.35	7,408.56
MIMARO-PA	168,895.88	4,080.33	4,097.89	4,115.45	4,136.53	139,373.03	3,367.09	3,381.58	3,396.08	3,413.47	132,018.01	3,189.40	3,203.13	3,216.86	3,233.33
V	435,632.31	10,364.38	10,419.45	10,474.51	10,540.59	367,028.89	8,732.20	8,778.59	8,824.99	8,880.66	351,891.91	8,372.07	8,416.55	8,461.03	8,514.40
VI	371,317.71	8,883.28	8,923.30	8,963.32	9,011.35	286,098.07	6,844.51	6,875.35	6,906.19	6,943.19	265,291.06	6,346.73	6,375.33	6,403.92	6,438.23
VII	199,615.24	4,581.02	4,600.24	4,619.47	4,642.55	142,650.12	3,273.71	3,287.45	3,301.19	3,317.68	130,404.58	2,992.68	3,005.25	3,017.81	3,032.88
VIII	368,842.43	8,545.17	8,587.34	8,629.51	8,680.12	307,850.90	7,132.14	7,167.34	7,202.54	7,244.78	295,200.75	6,839.07	6,872.83	6,906.58	6,947.08
IX	209,419.80	5,258.45	5,280.78	5,303.11	5,329.91	166,053.99	4,169.55	4,187.26	4,204.96	4,226.21	156,186.13	3,921.77	3,938.43	3,955.08	3,975.07
X	273,786.06	5,773.87	5,803.74	5,833.60	5,869.43	226,151.39	4,769.31	4,793.97	4,818.64	4,848.24	213,695.27	4,506.62	4,529.93	4,553.23	4,581.20
XI	274,913.85	7,340.11	7,366.28	7,392.45	7,423.85	250,394.33	6,685.44	6,709.28	6,733.12	6,761.72	243,428.80	6,499.47	6,522.64	6,545.81	6,573.62
XII	343,350.90	7,988.21	8,037.06	8,085.90	8,144.51	328,516.36	7,643.08	7,689.81	7,736.55	7,792.63	324,220.84	7,543.14	7,589.27	7,635.39	7,690.73
Caraga	250,237.47	5,751.15	5,938.39	6,125.63	6,350.32	215,863.62	4,961.14	5,122.66	5,284.18	5,478.01	208,893.10	4,800.94	4,957.25	5,113.55	5,301.12
TOTAL	5,081,001.86	125,671.48	126,577.55	127,483.61	128,570.89	4,430,408.21	110,110.01	110,913.96	111,717.92	112,682.66	4,273,376.62	106,322.93	107,102.31	107,881.68	108,816.93

Notes: 1 Net Potential Irrigable Area (without Filter, 0-8% only)
2 Net Potential Irrigable Area (with >5ha Filter, 0-8%)
3 Net Potential Irrigable Area (with >10ha Filter, 0-8%)

Table 4.18. Irrigation Water Demand for Remaining Areas for Development with Effective Rainfall

Region	WITH EFFECTIVE RAINFALL									
	Remaining Area for Irrigation Development, ha1	Irrigation Water Demand, MCM				Remaining Area for Irrigation Development, (less SPIS area), ha2	Irrigation Water Demand, MCM			
		2020	2025	2030	2036		2020	2025	2030	2036
CAR	28,436.02	625.31	627.81	630.31	633.31	28,388.02	624.25	626.75	629.25	632.24
I	245,342.61	5,334.54	5,366.71	5,398.88	5,437.49	245,270.61	5,332.97	5,365.13	5,397.30	5,435.89
II	260,433.00	5,938.85	5,971.68	6,004.52	6,043.92	260,388.00	5,937.82	5,970.65	6,003.48	6,042.87
III	426,244.20	11,758.65	11,814.96	11,871.27	11,938.85	426,154.20	11,756.16	11,812.46	11,868.77	11,936.33
CALABARZON	336,929.15	6,598.11	6,673.72	6,749.33	6,840.06	336,878.15	6,597.11	6,672.71	6,748.31	6,839.03
MIMAROPA	85,335.52	1,784.46	1,791.20	1,797.94	1,806.02	85,296.52	1,783.65	1,790.38	1,797.11	1,805.20
V	315,673.41	5,900.85	5,905.58	5,910.31	5,915.99	315,598.41	5,899.45	5,904.18	5,908.91	5,914.58
VI	258,688.69	4,819.10	4,912.68	5,006.26	5,118.55	258,596.69	4,817.39	4,910.93	5,004.48	5,116.73
VII	153,731.49	3,014.56	2,921.88	2,829.20	2,717.98	153,677.49	3,013.50	2,920.85	2,828.20	2,717.03
VIII	294,865.07	5,657.61	5,647.32	5,637.04	5,624.70	294,829.07	5,656.92	5,646.64	5,636.35	5,624.02
IX	158,448.79	2,615.91	2,615.76	2,615.62	2,615.45	158,403.79	2,615.16	2,615.02	2,614.88	2,614.71
X	210,126.78	3,662.05	3,657.87	3,653.69	3,648.67	210,087.78	3,661.37	3,657.19	3,653.01	3,648.00
XI	205,221.25	4,443.04	4,487.85	4,532.65	4,586.42	205,152.25	4,441.54	4,486.34	4,531.13	4,584.88
XII	221,659.76	4,990.93	5,005.69	5,020.45	5,038.17	221,593.76	4,989.44	5,004.20	5,018.96	5,036.67
Caraga	185,591.05	3,333.24	3,408.99	3,484.73	3,575.63	185,546.05	3,332.43	3,408.16	3,483.89	3,574.76
TOTAL	3,386,726.77	70,477.19	70,809.70	71,142.21	71,541.22	3,385,860.77	70,459.17	70,791.60	71,124.02	71,522.93

Notes: 1 Remaining Area for Irrigation Development (0-8% Net PIA minus FUSA and newly generated area with non-operational3)
2 Remaining Area for Irrigation Development (0-8% Net PIA minus FUSA and newly generated area with non-operational3 minus SPIS Area4)
3 Based on NIA Inventory as of December 2018
4 Based on DA Inventory of SPIS CY 2019

Table 4.19. Irrigation Water Demand for Remaining Areas for Development with Effective Rainfall

Region	WITHOUT EFFECTIVE RAINFALL									
	Remaining Area for Irrigation Development ha1	Irrigation Water Demand, MCM				Remaining Area for Irri-gation Devel-opment, (less SPIS area), ha2	Irrigation Water Demand, MCM			
		2020	2025	2030	2036		2020	2025	2030	2036
CAR	28,436.02	655.67	660.12	664.57	669.91	28,388.02	654.57	659.01	663.45	668.78
I	245,342.61	5,749.56	5,766.60	5,783.64	5,804.10	245,270.61	5,747.87	5,764.91	5,781.95	5,802.39
II	260,433.00	6,117.72	6,151.69	6,185.67	6,226.43	260,388.00	6,116.66	6,150.63	6,184.60	6,225.36
III	426,244.20	13,510.51	13,663.03	13,815.56	13,998.59	426,154.20	13,507.66	13,660.15	13,812.64	13,995.63
CALABARZON	336,929.15	7,769.95	7,804.71	7,839.47	7,881.18	336,878.15	7,768.78	7,803.53	7,838.28	7,879.98
MIMAROPA	85,335.52	2,061.61	2,070.48	2,079.35	2,090.00	85,296.52	2,060.67	2,069.54	2,078.40	2,089.05
V	315,673.41	7,510.37	7,550.27	7,590.17	7,638.06	315,598.41	7,508.59	7,548.48	7,588.37	7,636.24
VI	258,688.69	6,188.78	6,216.66	6,244.54	6,278.00	258,596.69	6,186.58	6,214.45	6,242.32	6,275.77
VII	153,731.49	3,528.02	3,542.83	3,557.64	3,575.41	153,677.49	3,526.78	3,541.58	3,556.39	3,574.15
VIII	294,865.07	6,831.29	6,865.01	6,898.72	6,939.18	294,829.07	6,830.46	6,864.17	6,897.88	6,938.34
IX	158,448.79	3,978.58	3,995.48	4,012.38	4,032.65	158,403.79	3,977.45	3,994.35	4,011.24	4,031.51
X	210,126.78	4,431.36	4,454.28	4,477.20	4,504.70	210,087.78	4,430.54	4,453.46	4,476.37	4,503.87
XI	205,221.25	5,479.34	5,498.87	5,518.41	5,541.85	205,152.25	5,477.50	5,497.03	5,516.55	5,539.99
XII	221,659.76	5,157.01	5,188.55	5,220.08	5,257.92	221,593.76	5,155.48	5,187.00	5,218.52	5,256.35
Caraga	185,591.05	4,265.40	4,404.27	4,543.13	4,709.78	185,546.05	4,264.36	4,403.20	4,542.03	4,708.63
TOTAL	3,386,726.77	83,235.19	83,832.86	84,430.54	85,147.75	3,385,860.77	83,213.94	83,811.47	84,409.00	85,126.04

Notes:
1 Remaining Area for Irrigation Development (0-8% Net PIA1 minus FUSA and newly generated area with non- operational3)
2 Remaining Area for Irrigation Development (0-8% Net PIA1 minus FUSA and newly generated area with non- operational3 minus SPIS Area4)
3 Based on NIA Inventory as of December 2018
4 Based on DA Inventory of SPIS CY 2019

To determine the availability of needed irrigation water for the proposed developments and existing irrigated areas, an analysis was done to determine the water demand of the current irrigation sector as well as the target areas for the proposed physical targets.

Tables 4.20 and 4.21 show the computed irrigation water demand of all existing irrigation systems for 2020, 2025, 2030, and 2036 with and without considering the effect of rainfall, respectively. Since this covers all existing irrigation systems, the total irrigated area was determined from the sum of the FUSA and newly-generated area with non-operational from the inventory of all irrigation systems of NIA as of December 2018, and the proposed SPIS service areas from the inventory of DA as of 2019. The computed irrigation water demand is tabulated with the mean estimated available water supply based on the computed dependable flows, described in the ensuing subsection. All regions with the exception of Regions I and III showed adequate water supply. Since there are only 195 available and adequate data set of rivers for the basis of the dependable flow, this may not entirely project the actual available surface water resources, hence, the lower water supply estimates compared to the current irrigation water demand for Regions I and III. This is recommended to be done during the conduct of FS for proposed irrigation projects in these regions and during the formulation of regional and provincial master plans.

Tables 4.22 and 4.23 show the estimated required increase in target irrigated areas and the corresponding increase in the irrigation water demand per year for the period of 2020-2030.

The overall cumulative annual irrigation water demand from both existing areas and required increase in irrigated areas from the physical targets are tabulated with the total estimated water supply based on dependable flows as shown in Tables 4.24 and 4.25. **Based on these estimates, the available surface water supply will be more than adequate to meet the projected irrigation water demand for the specified physical targets of irrigation development on a national scale for years 2020 to 2030. However, there are regional differences and estimates show that while many regions will have adequate water supply to meet the irrigation water demand until 2030, deficits are projected to be incurred in Regions I and III**. While other water supply sources such as groundwater may be tapped in the said two regions and water use efficient and WSTs along with CCA measures can be employed, as discussed in the succeeding sections, these estimates of surface water supply should be further validated during the conduct of feasibility studies and in the formulation of regional or river basin plans and provincial master plans particularly for the said two regions.

Table 4.20. Irrigation Water Demand for All Existing Irrigation Systems and Estimated Available Water Supply per Region with Effective Rainfall

	With Effective Rainfall										
Region	Total Irrigated Area (Ha)		Irrigation Water Demand for Existing Systems (MCM)				Irrigation Water Demand for Existing Systems including SPIS (MCM)				Mean Estimated Available Water Supply Based on Dependable Flow (MCM)3
	Based on FUSA and Newly-generated Area with Non-Operational1	Based on FUSA, Newly-generated with Non-Operational1 and SPIS Area2	2020	2025	2030	2036	2020	2025	2030	2036	
CAR	95,258.40	95,321.40	2,094.73	2,103.11	2,111.49	2,121.55	2,096.12	2,104.50	2,112.89	2,122.95	37,400.13
I	180,601.70	180,673.70	3,926.86	3,950.54	3,974.23	4,002.64	3,928.43	3,952.12	3,975.81	4,004.24	1,828.90
II	281,517.54	281,568.54	6,419.66	6,455.15	6,490.64	6,533.23	6,420.82	6,456.32	6,491.82	6,534.41	7,959.86
III	306,280.44	306,370.44	8,449.25	8,489.71	8,530.18	8,578.74	8,451.73	8,492.21	8,532.68	8,581.26	3,967.90
CALABARZON	50,689.00	50,740.00	992.65	1,004.02	1,015.40	1,029.05	993.65	1,005.03	1,016.42	1,030.08	5,105.88
MIMAROPA	90,523.17	90,577.17	1,892.94	1,900.09	1,907.24	1,915.81	1,894.07	1,901.22	1,908.37	1,916.95	9,223.14
V	119,958.90	120,033.90	2,242.38	2,244.18	2,245.97	2,248.13	2,243.78	2,245.58	2,247.38	2,249.54	44,090.36
VI	112,629.02	112,721.02	2,098.16	2,138.90	2,179.65	2,228.54	2,099.88	2,140.65	2,181.43	2,230.36	10,339.41
VII	45,883.75	45,937.75	899.74	872.08	844.42	811.23	900.80	873.11	845.42	812.18	3,199.17
VIII	73,977.36	74,013.36	1,419.41	1,416.83	1,414.25	1,411.16	1,420.10	1,417.52	1,414.94	1,411.84	11,462.22
IX	45,750.51	45,795.51	755.32	755.28	755.23	755.19	756.06	756.02	755.98	755.93	8,490.83
X	63,659.28	63,698.28	1,109.44	1,108.18	1,106.91	1,105.39	1,110.12	1,108.85	1,107.59	1,106.07	8,933.87
XI	69,692.60	69,761.60	1,508.84	1,524.06	1,539.28	1,557.54	1,510.34	1,525.57	1,540.80	1,559.08	11,054.47
XII	116,885.36	116,954.36	2,631.81	2,639.60	2,647.38	2,656.72	2,633.37	2,641.15	2,648.94	2,658.29	12,122.29
Caraga	64,646.42	64,691.42	1,161.06	1,187.44	1,213.83	1,245.49	1,161.87	1,188.27	1,214.67	1,246.36	22,658.95
ARMM	48,222.81	48,222.81	-	-	-	-	-	-	-	-	4,748.96
TOTAL	1,766,176.26	1,767,081.26	37,602.26	37,789.18	37,976.09	38,200.39	37,621.13	37,808.13	37,995.13	38,219.54	202,586.33

1Based on NIA Inventory of NIS, CIS, PIS, OGA as of December 2018
2Based on DA Inventory of Proposed SPIS for CY 2019
3Based on computed dependable flows of rivers per region

Table 4.21. Irrigation Water Demand for All Existing Irrigation Systems and Estimated Available Water Supply per Region without Effective Rainfall

	Without Effective Rainfall										
Region	Total Irrigated Area (Ha)		Irrigation Water Demand for Existing Systems (MCM)				Irrigation Water Demand for Existing Systems including SPIS (MCM)				Mean Estimated Available Water Supply Based on Dependable Flow (MCM)3
	Based on FUSA and Newly-generated Area with Non-Operational1	Based on FUSA, Newly-generated with Non-Operational1 and SPIS Area	2020	2025	2030	2036	2020	2025	2030	2036	
CAR	95,258.40	95,321.40	2,196.45	2,211.36	2,226.26	2,244.15	2,197.90	2,212.82	2,227.73	2,245.63	37,400.13
I	180,601.70	180,673.70	4,232.37	4,244.91	4,257.46	4,272.51	4,234.06	4,246.61	4,259.16	4,274.22	1,828.90
II	281,517.54	281,568.54	6,613.01	6,649.73	6,686.45	6,730.52	6,614.21	6,650.94	6,687.67	6,731.74	7,959.86
III	306,280.44	306,370.44	9,708.06	9,817.66	9,927.26	10,058.77	9,710.91	9,820.54	9,930.17	10,061.73	3,967.90
CALABARZON	50,689.00	50,740.00	1,168.94	1,174.17	1,179.40	1,185.68	1,170.12	1,175.35	1,180.59	1,186.87	5,105.88
MIMAROPA	90,523.17	90,577.17	2,186.94	2,196.35	2,205.76	2,217.06	2,188.24	2,197.66	2,207.08	2,218.38	9,223.14
V	119,958.90	120,033.90	2,854.01	2,869.18	2,884.34	2,902.53	2,855.80	2,870.97	2,886.14	2,904.35	44,090.36
VI	112,629.02	112,721.02	2,694.50	2,706.64	2,718.78	2,733.35	2,696.70	2,708.85	2,721.00	2,735.58	10,339.41
VII	45,883.75	45,937.75	1,053.00	1,057.42	1,061.84	1,067.14	1,054.24	1,058.66	1,063.09	1,068.40	3,199.17
VIII	73,977.36	74,013.36	1,713.87	1,722.33	1,730.79	1,740.94	1,714.71	1,723.17	1,731.63	1,741.79	11,462.22
IX	45,750.51	45,795.51	1,148.78	1,153.66	1,158.53	1,164.39	1,149.91	1,154.79	1,159.67	1,165.53	8,490.83
X	63,659.28	63,698.28	1,342.51	1,349.45	1,356.40	1,364.73	1,343.33	1,350.28	1,357.23	1,365.57	8,933.87
XI	69,692.60	69,761.60	1,860.77	1,867.40	1,874.04	1,882.00	1,862.61	1,869.25	1,875.89	1,883.86	11,054.47
XII	116,885.36	116,954.36	2,719.39	2,736.02	2,752.65	2,772.60	2,721.00	2,737.63	2,754.27	2,774.24	12,122.29
Caraga	64,646.42	64,691.42	1,485.75	1,534.13	1,582.50	1,640.54	1,486.79	1,535.19	1,583.60	1,641.69	22,658.95
ARMM	48,222.81	48,222.81	-	-	-	-	-	-	-	-	4,748.96
TOTAL	**1,766,176.26**	**1,767,081.26**	**42,978.35**	**43,290.40**	**43,602.45**	**43,976.90**	**43,000.52**	**43,312.72**	**43,624.92**	**43,999.56**	**202,586.33**

1Based on NIA Inventory of NIS, CIS, PIS, OGA as of December 2018
2Based on DA Inventory of Proposed SPIS for CY 2019
3Based on computed dependable flows of rivers per region

Table 4.22. Irrigation Water Demand for Additional Irrigated Area Requirement Based on All Physical Target Scenarios with Effective Rainfall

With Effective Rainfall					
Year	Diversion Water Requirement (lps/ha)	Required increase in irrigated areas per year (ha)		Additional Irrigation Water Demand (MCM)	
		S1	Baseline	S1	Baseline
2020	1.97	53,776	48,014	1099.89704	982.045085
2021	1.98	55,281	49,214	1135.07195	1010.49965
2022	1.98	56,829	50,445	1166.85668	1035.77549
2023	1.98	58,421	51,706	1199.54484	1061.66731
2024	1.98	60,056	52,999	1233.11592	1088.21618
2025	1.98	61,738	54,324	1267.65204	1115.42209
2026	1.99	63,467	55,682	1308.19635	1147.73014
2027	1.99	65,244	57,074	1344.82428	1176.42237
2028	1.99	67,070	58,500	1382.46221	1205.81541
2029	1.99	68,948	59,963	1421.17198	1235.9711
2030	1.99	70,879	61,462	1460.97419	1266.86883

Table 4.23. Irrigation Water Demand for Additional Irrigated Area Requirement Based on All Physical Target Scenarios without Effective Rainfall

Without Effective Rainfall					
Year	Diversion Water Requirement (lps/ha)	Required increase in irrigated areas per year (ha)		Additional Irrigation Water Demand (MCM)	
		S1	Baseline	S1	Baseline
2020	2.33	53,776	48,014	1297.35778	1158.34826
2021	2.34	55,281	49,214	1343.1289	1195.72268
2022	2.34	56,829	50,445	1380.73972	1225.63154
2023	2.34	58,421	51,706	1419.41957	1256.2693
2024	2.34	60,056	52,999	1459.14418	1287.68453
2025	2.34	61,738	54,324	1500.01071	1319.87725
2026	2.36	63,467	55,682	1552.88307	1362.40306
2027	2.36	65,244	57,074	1596.36194	1396.46192
2028	2.36	67,070	58,500	1641.03972	1431.35267
2029	2.36	68,948	59,963	1686.98981	1467.14872
2030	2.36	70,879	61,462	1734.23668	1503.8256

Table 4.24. Overall Irrigation Water Demand and Available Water Supply Based on Physical Target Scenarios with Effective Rainfall

With Effective Rainfall						
Year	Irrigation Water Demand for Existing Systems including SPIS (MCM)	Additional Irrigation Water Demand (MCM)		Cumulative Total Irrigation Water Demand (MCM)		Mean Estimated Available Water Supply Based on Dependable Flow (MCM)
		S1	Baseline	S1	Baseline	
2020	37,621.13	1,363.78	1,217.65	38,984.91	38,838.78	202,586.33
2021	37,808.13	1,407.34	1,252.89	40,579.25	40,278.67	
2022		1,446.75	1,284.23	42,026.00	41,562.90	
2023		1,487.28	1,316.33	43,513.28	42,879.22	
2024		1,528.90	1,349.25	45,042.18	44,228.47	
2025		1,571.72	1,382.98	46,613.90	45,611.45	
2026	37,995.13	1,621.93	1,422.98	48,422.84	47,221.43	
2027		1,667.35	1,458.56	50,090.19	48,679.99	
2028		1,714.01	1,495.00	51,804.20	50,174.99	
2029		1,762.00	1,532.39	53,566.20	51,707.38	
2030		1,811.35	1,570.69	55,377.55	53,278.07	

Table 4.25. Overall Irrigation Water Demand and Available Water Supply Based on Physical Target Scenarios without Effective Rainfall

Without Effective Rainfall						
Year	Irrigation Water Demand for Existing Systems including SPIS (MCM)	Additional Irrigation Water Demand (MCM)		Cumulative Total Irrigation Water Demand (MCM)		Mean Estimated Available Water Supply Based on Dependable Flow (MCM)
		S1	Baseline	S1	Baseline	
2020	43,000.52	1,363.78	1,217.65	44,364.29	44,218.17	202,586.33
2021	43,312.72	1,407.34	1,252.89	46,083.83	45,783.26	
2022		1,446.75	1,284.23	47,530.58	47,067.48	
2023		1,487.28	1,316.33	49,017.86	48,383.81	
2024		1,528.90	1,349.25	50,546.77	49,733.06	
2025		1,571.72	1,382.98	52,118.49	51,116.03	
2026	43,624.92	1,621.93	1,422.98	54,052.62	52,851.22	
2027		1,667.35	1,458.56	55,719.97	54,309.77	
2028		1,714.01	1,495.00	57,433.98	55,804.77	
2029		1,762.00	1,532.39	59,195.98	57,337.16	
2030		1,811.35	1,570.69	61,007.33	58,907.85	

Estimation of Water Supply for the Projected Irrigation Water Demand

A total of 291 river streamflow data nationwide have been collected but only 195 data sets have at least seven years of complete records and were analyzed. Many of the streamflow data failed Mockus' test for the adequacy of the length of records but in the absence of other sources, they were still considered in the analysis. The streamflow data were subjected to hydrologic frequency analysis and the dependable flow values at 80% probability of exceedance were estimated from the flow duration curves of each of the rivers.

A summary of the estimated unit discharges including the minimum, maximum, and average values for the 16 regions (except NCR) are shown in Table 4.26 and plotted in Figure 4.13. The water supply per region (in MCM) was estimated from the computed dependable flows. Analysis was also done in view of the total granted water rights by NWRB as of April 2019.

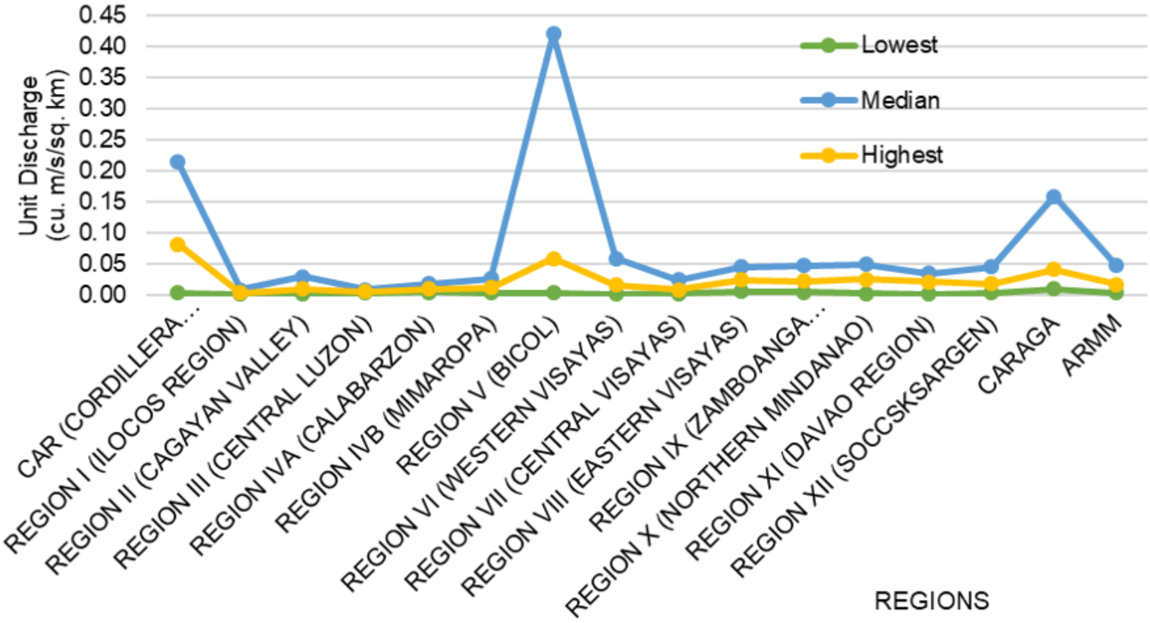
Table 4.26. Estimates of Unit Dependable Flow per Region

Region	Unit Discharge (m3/sec/km2)		
	Min	Max	Average
CAR	0.0027	0.2131	0.0807
Region I	0.0007	0.0078	0.0032
Region II	0.0006	0.0284	0.0095
Region III	0.0025	0.0077	0.0049
CALABARZON	0.0039	0.0175	0.0096
MIMAROPA	0.0026	0.0258	0.0110
Region V	0.0023	0.4200	0.0578
Region VI	0.0010	0.0583	0.0154
Region VII	0.0016	0.0239	0.0084
Region VIII	0.0047	0.0441	0.0235
Region IX	0.0034	0.0468	0.0214
Region X	0.0020	0.0491	0.0243
Region XI	0.0008	0.0343	0.0201
Region XII	0.0029	0.0450	0.0170
Caraga	0.0093	0.1581	0.0400
ARMM	0.0029	0.0464	0.0165
AVERAGE	**0.0027**	**0.0766**	**0.0227**

The estimated groundwater resources in the country include about 5.1 M ha of shallow well areas and 12.3 M ha of deep well areas. These are mostly located in rice and corn growing alluvial plains, which make groundwater ideal for irrigating new areas or supplementing the water supplies of existing NIS and CIS command areas.

Assuming an annual groundwater recharge equivalent to 5% of annual rainfall, and considering land cover and aquifer availability for recharge, the NWRB-JICA (1998) estimated the total groundwater potential at 20,200 mcm per year. The different River Basin Master Plans commissioned by the RBCO have estimates of the groundwater recharge of the respective river basins. Some adopted the JICA-NWRB (1998) method while others used hydrologic modeling such as SWAT in their analysis.

Figure 4.13. Plot of Maximum, Minimum and Average Unit Dependable Flow per Region

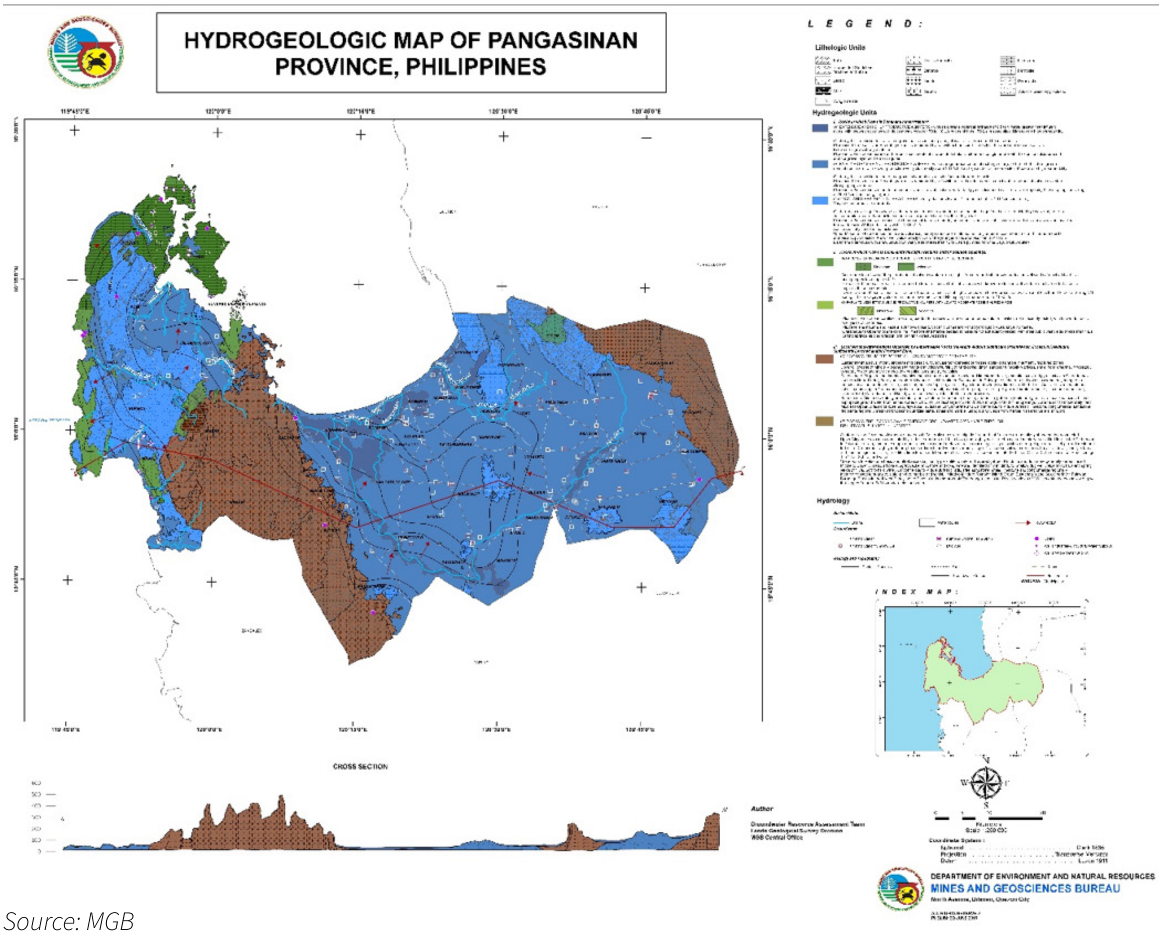


The groundwater potential map from NWRB was generated in the 1980s. With new wells and supported by geo-resistivity data, the MGB will soon publish improved hydrogeologic maps (sample in Figure 4.14) of different provinces in the Philippines. These maps contain lithologic, hydrogeologic data, and hydrologic data. Hydrogeologic data includes locations of aquifer formations (extensive and highly productive, fairly extensive and productive, and local and less productive aquifers), fractures and/or karst-controlled groundwater zone, and region without significant and/or limited pumpable groundwater. It also has estimates of well yield expected from these water bearing formations.

The LWUA maintains a groundwater data bank of deep wells used by the different water districts for domestic and industrial water supply. They include locations, depth, casing size, well logs, discharge, etc.

For groundwater resources, there is a need to delineate areas actually served by NIS and CIS, as well as those served by minor irrigation systems (e.g. Small Water Impounding Project [SWIP], SFR, STW, Pump Irrigation System from Open Sources [PISOS], diversion dam [DD], SPIS, Spring Development [SD]). In line with this, there is also a need to identify areas where groundwater sources are technically feasible, solely or in conjunction with existing gravity systems. This is because groundwater provides an extensive and reliable source of water and sustains streamflow during the dry season. Sustainable use of groundwater is also critical to drought and climate resilience, providing a sustainable water buffer during periods of low surface water availability. Among our water supply sources for irrigation, groundwater from aquifers is the last to be depleted during periods of prolonged drought.

Figure 4.14. Hydrogeologic Map of Pangasinan



Source: MGB

Availability of proximate water sources both surface water and groundwater to PIAs affirms irrigation development and the potential rehabilitation and restoration of existing service areas. Figures 4.15 and 4.16 present the water resources availability on net PIA for >5 ha and >10 ha filters, respectively. Gauging stations of rivers with computed dependable flows are plotted to the net PIA with buffer zones of 2 km and 5 km radial distances. Also, the groundwater maps and river network systems are overlaid to identify the nearest potential and alternative water source for large and small systems to render irrigation water supply to PIA.

Figure 4.15. Water Resources Availability for Net PIA (>5ha)

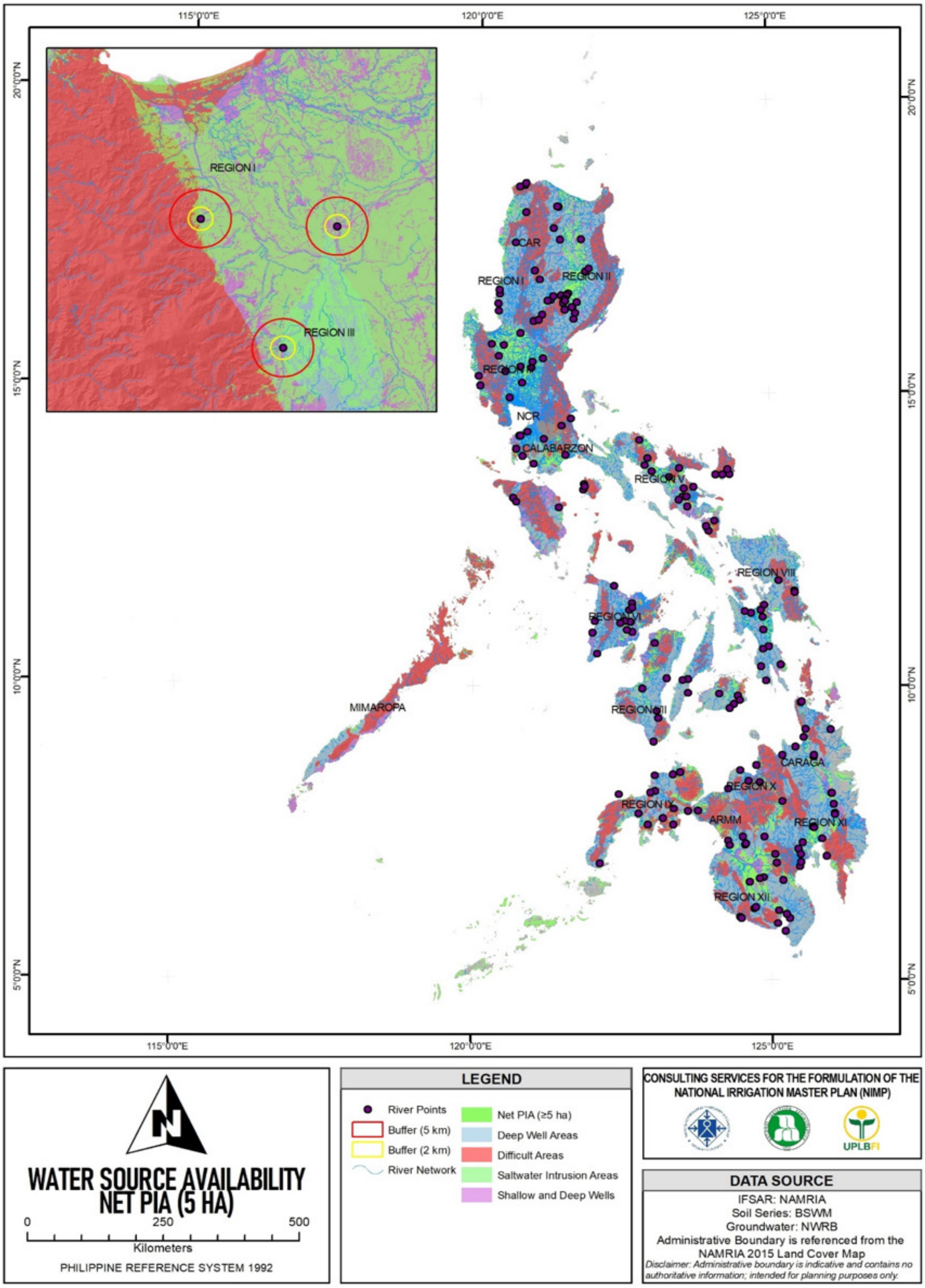
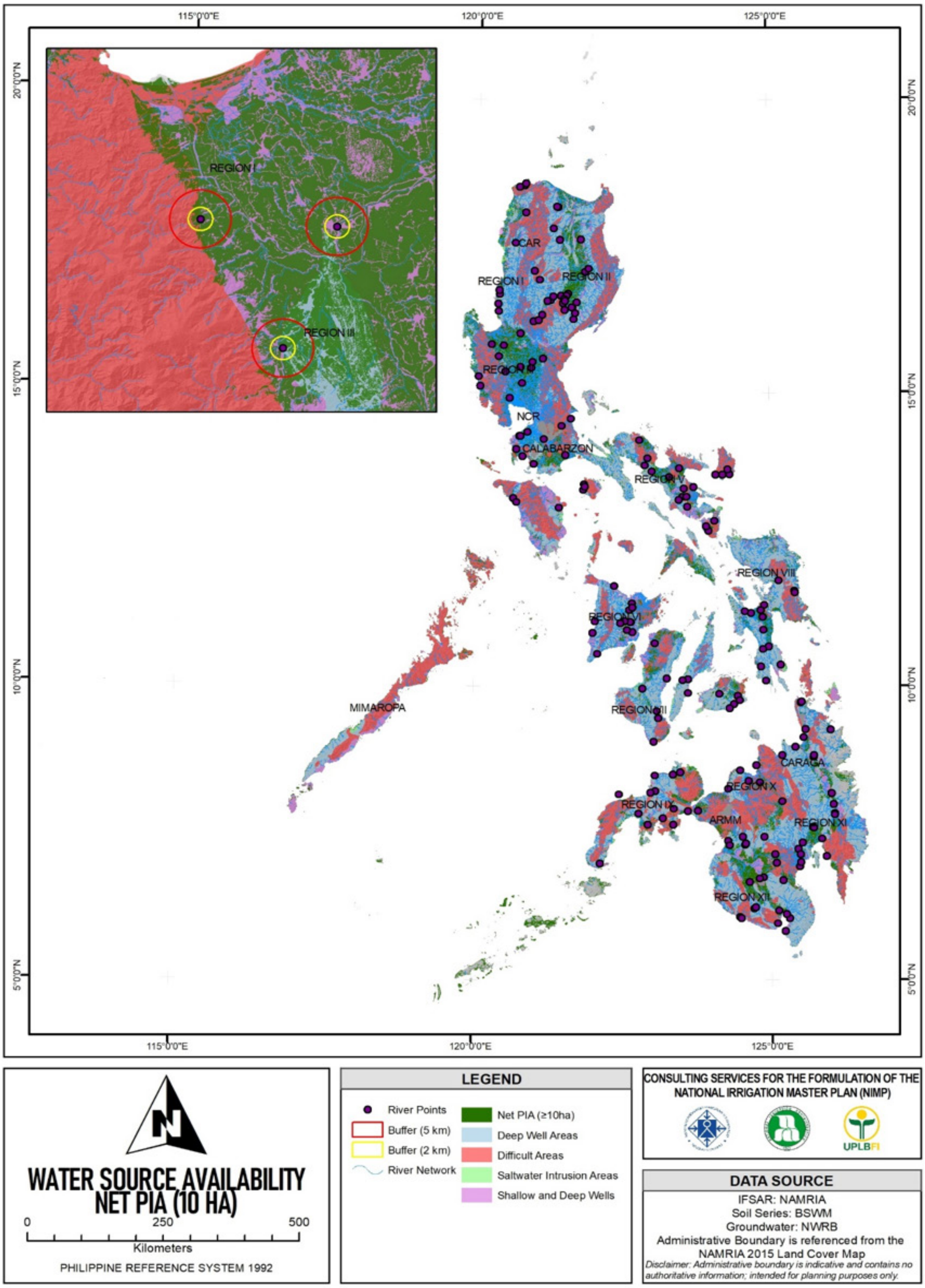


Figure 4.16. Water Resources Availability for Net PIA (>10ha)



4.7. Proposed Criteria for Prioritization of Irrigation Projects

The programmed areas for irrigation development under rice and diversified crops will require irrigation projects of various modes. In anticipation of the multitude of irrigation projects to be identified and subjected to FS after the formulation of the regional and provincial master plans, on top of those projects with FS and already in the pipeline such as irrigation projects identified under the PIP, it is all the more necessary to devise a system of prioritization for proper budgetary allocation in view of potential budgetary constraints for irrigation development. Hence, to provide a sound basis for prioritizing irrigation projects to be implemented in the NIMP 2020-2030, an improved set of objective criteria is proposed.

The new set of criteria for prioritization takes into account the four major considerations, namely, 1) technical (land and water resources) feasibility, 2) institutional feasibility, 3) economic and financial feasibility, and 4) environmental and social feasibility, each of which is further broken down into subcategories or sub-criteria with a proposed scoring system to be used as basis for ranking of irrigation projects under each of the five major types of irrigation projects, namely 1) NIPs, 2) rehabilitation or restoration of NIS, 3) new communal or SIPs, 4) rehabilitation or restoration of communal or SIPs, and 5) new MPs. For practical purposes, irrigation projects by OGA can be classified under SIPs as the service areas for OGAs are generally smaller than 1000 ha. The proposed distribution of weights for the four major criteria for prioritization of irrigation projects for each of the five types is given in Table 4.27.

Table 4.27. Proposed distribution of weights for the major criteria for prioritization of irrigation projects

	New NIP	NIS for Re-hab/Resto	New CIP/ SIP	CIS/SIS for Rehab/Resto	Multi-purpose
Technical	35.0	35.0	35.0	35.0	35.0
Institutional	20.0	20.0	20.0	20.0	20.0
Economic/Financial	25.0	25.0	25.0	25.0	25.0
Environmental/Social	20.0	20.0	20.0	20.0	20.0
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Technical Feasibility

The technical feasibility criterion essentially involves a rough assessment of land suitability and water resources availability and adequacy for irrigation in the project area. The assessment of adequacy of surface water resources relative to irrigation water demand is based on a new index called, the Irrigability Index (II), which is the ratio of the water resources-based potential irrigable area to the slope and soil-based potential irrigable area, given by the following equation:

$$\boldsymbol{Irrigability\ Index\ (II)} = \frac{WR\text{-}Based\ Potential\ Irrigable\ Area}{SS\text{-}Based\ Potential\ Irrigable\ Area} x100$$

The higher the value of II, the more recommendable is the project on the basis of surface water resources adequacy. The II is deemed to be a more acceptable measure of water resources adequacy and a better replacement for Irrigation Cropping Intensity which was proposed in the old master plan especially for new irrigation projects since actual cropping intensities are obviously still unknown for projects that are yet to be implemented. In the case of II, the WR-based PIA can be determined from estimated dependable flows and water duties, which may be extracted from the project feasibility reports or from the regional estimates of water supply and demand provided in this master plan. In the same way, the slope- and soil-based potential irrigable area may be extracted from either the FS reports or from the new geodatabase generated for the new master plan. Hence, unlike the Cropping Intensity Index, the II has a more realistic physical basis especially for new irrigation projects. The values of II may be greater than 1.0 for areas with surface water supply exceeding the irrigation demand or less than 1.0 for areas with inadequate surface water supply. It is further emphasized herein that the application of the II is based on the assumption of a rice-based cropping system. Hence, even if a third crop is added as a relay crop in the rice-rice cropping pattern to come up with a diversified cropping system, still the water duty will come from the rice cropping being obviously the more water consuming or demanding crop than non-rice crops.

Apart from the points given to the adequacy of surface water resources for irrigation, additional points are given for proposed projects in areas underlain by either shallow or deep aquifers. For the land resources, both land slope and land suitability are examined. Projects whose service areas have a larger areal extent of milder slopes of up to 8% get more points than otherwise.

On the other hand, projects with service areas that are suitable for both rice and diversified crops, i.e. dual class, get higher points than lands with a single class. The idea is to put more premium to irrigation development for diversified cropping systems.

For rehabilitation and restoration projects, the technical feasibility includes additional sub-criteria such as the extent of non-operational areas in the case of restoration and the nature of repair works in the case of rehabilitation. In addition, the irrigation cropping intensity prior to rehabilitation or restoration is now accounted for.

For MPs, additional technical sub-criteria include project components such as hydropower generation, flood control and other purposes.

Institutional

Institutional feasibility takes into account the willingness of farmers to abide by NIA and DA policy on participatory program along with ROW issues for new NIPs, new CIPs/SIPs and MPs. For the rehabilitation and restoration of NIS and CIS/SIS, institutional feasibility considers the level of commitment of IAs and Small Water Irrigation System Associations (SWISAs) to contribute to repairs and to assume full responsibility for O&M upon completion of the project along with the target number of IAs in the system.

Economic and Financial

The economic and financial feasibility essentially considers the economic internal rate of return (EIRR), level of irrigation development in the province and development cost per hectare of irrigation project. All three sub-criteria are used for all types of irrigation projects.

Environmental and Social

The environmental feasibility criterion takes into account the biophysical impacts of the irrigation project including consideration of presence of environmental management plan (EMP); occurrence of multi-hazards such as flooding, fault lines, landslides and drought; protection of biodiversity and status of land cover conditions. On the other hand, social feasibility takes into account socio-cultural impacts including poverty level in the area where the irrigation project will be implemented; presence of IP and vulnerable groups; the need for resettlement as a result of project implementation and potential effect of the project on cultural value and archaeological significance of the site. All the aforementioned environmental and social sub-criteria are used for all the five types of irrigation projects.

It is emphasized herein that only irrigation projects with FS can be subjected to the aforementioned criteria for prioritization regardless of the type or mode of irrigation.

4.8. Disaggregated Investment Plan

Public Investment Projects

Table 4.28 shows the list of PIP projects of NIA with their corresponding project area and cost.

Table 4.28. Public Investment Projects 2017-2022

Projects	Project Area (ha)	Project Cost (P'000)
Line Projects		
Marimay SRIP	1,000	650,000
Alfonso Lista Pump IP	2,300	1,100,000
Lower Apayao River Irrigation Project	1,211	1,220,000
Ziwanan River Irrigation Project	4,000	1,420,000
Agno River Irrigation System Extension Project	12,894	2,629,541
Lower Agno River Irrigation System Extension Project	9,305	3,500,000
Barbar SRIP	1,000	631,000
Sulvec SRIP	500	750,000
Dumoloc SRIP	200	800,000
Bayaoas SRIP	400	600,000
Ilocos Sur Integrated Irrigation Project	7,830	4,697,000
Ilocos Norte Irrigation Project, Stage 2	12,400	27,360,000
Gaco SRIP	600	500,000
Ilocos Sur Transbasin Project	3,570	7,688,000
Dibuluan Irrigation Project	2,080	705,316
Nassiping PIP, Ph. I	1,028	385,500
Chico River Pump IP	8,700	4,372,897
Tumauini River Multipurpose Project	4,585	4,458,066
Abuan SRIP	6,135	850,000
Balog-Balog MPIP, Phase II	21,935	13,370,000
Bulo SRIP	1,000	990,370
North Lawis Irrigation Project	1,270	400,000

Projects	Project Area (ha)	Project Cost (P'000)
Upper Gumain River Irrigation Project	16,750	9,885,710
Bancal (Nakhep) IP	1,064	212,800
Balbalungao SRIP	500	1,361,188
Marikit Irrigation Project	280	150,000
Maringalo Irrigation Project	7,000	3,320,000
Quipot Irrigation Project	2,800	1,449,500
Macalelon SRIP	630	775,000
Agos RIS Improvement Project	-	110,000
Bongabong River Irrig. Project	5,100	890,150
Daet-Talisay RIS	516	260,000
Rinconada Integ. IS	1,200	400,000
Cagaycay RIS	180	160,000
Ibingan SRIP	255	740,000
Jalaur River Multipurpose Project, Stage II	9,500	11,212,140
Barotac Viejo SRIP	724	993,300
Bayuyan SRIP	583	416,000
Panay River Basin Integrated Devt. Project	26,800	19,357,000
Cabano SRIP	340	533,000
Asue Irrigation Project	6,700	7,000,000
Hilabangan River IP	2,940	886,150
Malogo IP	8,625	893,524
Imbang IP	4,443	549,040
Binalbagan IP	7,000	1,400,000
Aklan RIS Imprvt. Project (Dam Const.)	308	655,200
Mabini-Cayacay SRIP	530	725,000
Malinao Dam Improvement Project	740	975,000
Bonot-Bonot SRIP	600	658,406
Calunasan SRIP	250	814,000
Benliw SRIP	500	590,000
Hibale SRIP	375	400,000
Bohol Northeast Basin Multipurpose Project	12,500	4,134,000
Sta. Agueda-Datagon IP,	1,000	259,500
Amlan Irrigation Project	500	228,600
Tanjay-Bais River IP	3,900	975,000
Jantianon IP	1,000	250,000
Dagangdang-Tampaga IP	1,800	540,000
Can-asujan SRIS Imprvt. Of Dam & Appurtenant Struct.	-	94,000
Sta. Rita SRIP	911	814,167
Hibulangan SRIP	1,738	992,046
Catarman Bobon Irrigation Project	1,060	934,460

Projects	Project Area (ha)	Project Cost (P’000)
Calbiga IP	913	695,400
Bugko Irrigation Project	1,010	717,093
Bantayan IP	438	414,782
Pinipisakan Irrigation Project	2,000	998,000
Bulao IP	742	304,377
Hagbay IP	708	354,937
Gandara IP-Pologon Area	250	244,000
Gandara IP (Concepcion-Nacube Area)	150	256,149
Upgrading/Rehab of NIS damaged by Typhoon Yolanda	-	-
Gandara IP-Bungliw Area	710	494,527
Pambujan Irrigation Project	500	462,080
Lower Sibuguey I RIS Ext’n. Project	1,400	850,000
Lower Sibuguey II RIS Ext’n. Project	1,550	750,000
Upper Sibuguey RIS Ext’n. Project	720	280,193
Calamba Irrigation Project	2,000	500,000
Managok SWIP	1,008	252,500
Kadingilan IP	6,000	2,280,000
Sultan Naga Dimaporo IP	980	340,028
Kapatagan Valley Irrigation Project	1,000	350,036
Claveria SRIP	1,230	2,856,693
Delapa SRIP	4,650	2,346,357
Lasang RIS Improvement Project	4,800	865,184
Asbang SRIP	469	1,355,000
Upper Saug RIP	980	450,000
Manat Irrigation Project	1,000	855,000
Malitubog-Maridagao Irrig. Project, Phase II	9,784	5,444,840
Kabulnan-2 Multipurpose Irrigation & Power Project	19,628	12,907,000
Tulunan SRIP	1,590	639,488
Lebak Integrated River IP	-	15,000
Malitubog-Libungan Transbasin IP	4,870	1,351,200
MAP IP	1,200	334,300
Umayam RIP	6,729	1,402,104
Libang River Irrigation Project	3,500	1,225,000
Logum IP	1,900	1,165,000
Mambalili Pump IP	2,000	700,000
Inahaoan IP	2,500	1,375,000
Bislig City Integ. Devt. Project-IC	1,340	484,920
Maasam IP	2,000	1,200,000
Culi IP	300	605,000
Solibao IP	2,000	1,200,000

Projects	Project Area (ha)	Project Cost (P'000)
Lapinigan IP	200	570,000
Bunawan IP	2,000	1,200,000
Malihog IP	500	517,500
Lumao-Butong SWIP	200	570,000
Danuman IP	520	682,000
Ditsaan-Ramain River IP	4,000	649,386
Sapalan River Irrigation Project	2,838	830,000
Tandubas IP (Mainland)	400	160,580
Upi River Irrigation Project	821	457,365
Buldon River Irrigation Project	10,493	4,823,750
Integrated Natural Resources and Management Project (INRE-MP) IFAD Financing Reallocation	1,577	608,000
Nationwide Projects		
National Irrig. Sector Rehab & Imprvt Project	50,076	3,392,702
Participatory Irrigation Development Project	43,375	5,141,433
National Irrig. Sector Rehab & Imprvt Project II	-	11,820,000
Resto/Rehab/Repair of Existing NIS	-	-
Restoration of NIS	-	-
Resto/Rehab/Repair of Existing CIS	-	-
Restoration of CIS	-	-
Repair and Maintenance of Irrigation Systems (NIS)	-	-
Repair and Maintenance of Irrigation Systems (CIS)	-	-
Coconet Slope Protection in NIS	-	-
Coconet Slope Protection in CIS	-	-
Improvement of Service Roads in NIS	-	-
Improvement of Service Roads in CIS	-	-
Extension/Expansion of Existing NISs	-	-
Extension/Expansion of Existing CISs	-	-
Repair of Groundwater Pump Irrig. Systems	-	-
Restoration of Groundwater Pump Irrig. Systems	-	-
Climate Change Adaptation Works NIS	-	-
Climate Change Adaptation Works CIS	-	-
For the Reqt. of the Program Beneficiaries Devt. Component of the CARP	-	-
Small Irrigation Project	-	-
Balikatan Sagip Patubig Program	-	-
Establishment of Groundwater Pump Irrig. Project	-	-

Source: NIA PIP 2017-2022

Table 5.29 shows the summary of PIP and non-PIP projects programmed in the short (2020-2022), medium (2023-2025) and long term (2026-2030). The area generated by the PIP projects are enough to cover the required area for 2020-2022. Investments in the medium and long term would thus be covered by Non-PIP projects.

Table 4.29. PIP Projects in the PIP Programmed into Short, Medium and Long Term

Period	Starting Year	PIP Projects
Short term (2020-2022)	2020	Ziwanan River Irrigation Project
		Ilocos Sur Transbasin Project
		Maringalo Irrigation Project
		Asue Irrigation Project
		Jantianon IP
		Dagangdang-Tampaga IP
		Pambujan Irrigation Project
		Calamba Irrigation Project
		Manat Irrigation Project
		Libang River Irrigation Project
		Logum IP
		Mambalili Pump IP
		Inahaoan IP
		Maasam IP
		Culi IP
		Solibao IP
		Lapinigan IP
		Bunawan IP
		Malihog IP
		Lumao-Butong SWIP
		Danuman IP
		Upi River Irrigation Project
		Buldon River Irrigation Project
	2021	Abuan SRIP
		Bancal (Nakhep) IP
		Tanjay-Bais River IP
		Gandara IP-Bungliw Area
		Kadingilan IP
		Sultan Naga Dimaporo IP
		Kapatagan Valley Irrigation Project
		Malitubog-Libungan Transbasin IP
	2022	Managok SWIP
		Claveria SRIP
		Delapa SRIP
		National Irrig. Sector Rehab & Imprvt Project II
Medium term (2023-2025)		Non-PIP Projects
Long term (2026-2030)		Non-PIP Projects

Note: Projects in bold are priority projects

The important details of the top priority projects (highlighted in yellow in Table 4.29), which are programmed in the short term are summarized in Table 4.30 While it is apparent that these projects will only generate 25,680 ha, the other identified PIP projects which have been subjected to the criteria for prioritization as listed in Tables 4.29 and in Tables 4.31 to 4.34 should be considered for irrigation development in order to meet the physical targets.

Table 4.30. Priority PIP Projects Programmed in the Short Term (2020-2022)

Priority PIP Project	Region	Province	Start Year	End Year	Project Area (ha)	Project Cost (P'000)
Ilocos Sur Transbasin Project	1	Ilocos Sur	2020	2024	3,570	7,688,000
Maringalo Irrigation Project	3	Nueva Ecija	2020	2026	7,000	3,320,000
Manat Irrigation Project	11	Compostella Valley	2020	2022	1,000	855,000
Libang River Irrigation Project	13	Agusan Del Sur	2020	2023	3,500	1,225,000
Tanjay-Bais River IP	7	Negros Oriental	2021	2023	3,900	975,000
Gandara IP-Bungliw Area	8	Western Samar	2021	2022	710	494,527
Kadingilan IP	10	Bukidnon	2021	2026	6,000	2,280,000

Priority PIP Projects

Table 4.31 to 4.34 show the list of priority PIP projects (with FSs as of June 2019) based on the set prioritization criteria and their corresponding service areas and costs. Based on the prioritized PIP projects, a total of 104,460 ha are programmed for NIPs, 1,048 ha are programmed for NIS restoration projects, about 4,903 ha are programmed for CIPs and 88,918 ha are programmed for MPs.

Table 4.31. Prioritized New NIPs and Their Costs

Project	Area (ha)	Cost (PHP '000)
Malogo Irrigation Project	8,625	893,524
Bongabong River Irrigation Project	5,100	890,150
Kadingilan Irrigation Project	6,000	2,280,000
Libang Irrigation Project	3,500	1,225,000
Dibuluan Irrigation Project	2,080	705,316
Manat Irrigation Project	1,000	855,000
Umayam River Irrigation Project	6,729	1,402,104
Nassiping Pump Irrigation Project (Phase I)	1,028	385,500
Hilabangan River Irrigation Project	2,940	886,150
Sta. Rita Small Reservoir Irrigation Project	911	814,167

Project	Area (ha)	Cost (PHP '000)
Lower Apayao River Irrigation Project	1,211	1,220,000
Bulo Small Reservoir Irrigation Project	1,000	990,370
Chico River Pump Irrigation Project	8,700	4,372,897
North Lawis Irrigation Project	1,270	400,000
Asbang Small Reservoir Irrigation Project	469	1,355,000
Imbang Irrigation Project, Negros Occidental	4,443	549,040
Tanjay-Bais Irrigation Project	3,900	975,000
Barotac Viejo Small Reservoir Irrigation Project	724	993,300
Alfonso Lista Pump Irrigation Project	2,300	1,100,000
Tulunan Small Reservoir Irrigation Project	1,590	639,488
Quipot River Irrigation Project	2,800	1,449,500
Mabini-Cayacay Small Reservoir Irrigation Project	530	725,000
Balbalungao SRIP	500	1,361,188
Upper Saug River Irrigation Project	980	450,000
Bislig City Integrated Development Project-IC	1,340	484,920
Cabano Small Reservoir Irrigation Project	340	533,000
Marimay Small Reservoir Irrigation Project	1,000	650,000
Bayaoas Small Reservoir Irrigation Project	400	600,000
Sulvec Small Reservoir Irrigation Project	500	750,000
Lower Sibuguey-II Irrigation Project	1,550	750,000
Ibingan Small Reservoir Irrigation Project	255	740,000
Binalbagan Irrigation Project	7,000	1,400,000
Benliw Small Reservoir Irrigation Project	500	590,000
Barbar Small Reservoir Irrigation Project	1,000	631,000
Macalelon Small Reservoir Irrigation Project	630	775,000
Bonot-Bonot Small Reservoir Irrigation Project	600	658,406
Gaco Small Reservoir Irrigation Project	600	500,000
Maringalo Irrigation Project	7,000	3,320,000
Hibulangan Small Reservoir Irrigation Project, Northern Leyte	1,738	992,046
Bayuyan Small Irrigation Project	583	416,000
Gandara Irrigation Project (Bungliw)	710	494,527
Gandara Irrigation Project (Pologon)	250	244,000
Gandara Irrigation Project (Concepcion-Nacube)	150	256,149
Dumoloc Small Reservoir Irrigation Project	200	800,000
Malitubog-Maridagao Irrigation Project (Phase-II)	9,784	5,444,840
TOTAL	**104,460**	**47,947,582**

Table 4.32. Programmed Areas and Costs based on PIP of National Irrigation System for Restoration

Project	Area (ha)	Project Cost (P'000)
Aklan RIS Imprvt. Project	308	655,200
Malinao Dam Improvement Project	740	975,000
TOTAL	**1,048**	**1,630,200**

Table 4.33. Programmed Areas and Costs based on PIP of Communal Irrigation Projects (CIPs)

Project	Area (ha)	Project Cost (P'000)
Calbiga IP	913	695,400
MAP IP	1,200	334,300
Amlan Irrigation Project	500	228,600
Sta. Agueda-Datagon IP	1,000	259,500
Bugko Irrigation Project	1,010	717,093
Marikit Irrigation Project	280	150,000
TOTAL	**4,903**	**2,384,893**

Table 4.34. Programmed Areas and Costs based on PIP of Multipurpose Projects (MPs)

Project	Area (ha)	Project Cost (P'000)
Kabulnan-2 Multipurpose Irrigation & Power Project	19,628	12,907,000
Ilocos Sur Transbasin Project	3,570	7,688,000
Tumauini River Multipurpose Project	4,585	4,458,066
Panay River Basin Integrated Devt. Project	26,800	19,357,000
Ilocos Norte Irrigation Project, Stage 2	12,400	27,360,000
Balog-Balog MPIP, Phase II	21,935	13,370,000
TOTAL	**88,918**	**85,140,066**

Priority Non-PIP Projects

The areas covered by the investment plan (non-PIP) were distributed across the 57 priority provinces identified by the Philippine Rice Industry Roadmap 2030. These potential projects classified into short-, medium- and long-term projects. Distribution of target areas to be developed in each province is based on the share of the latter to the total potential areas for development. Two versions are presented in this section based on the source of the data on PIA. One version uses data from NIA while the other uses data collected by the GIS component of the NIMP. Areas are lumped per province for the short- and medium-term projects distributed across the 57 provinces, while the long-term projects are concentrated on provinces with below 60% irrigation development.

Table 4.35 shows the areas per province for short and medium-term projects based on the irrigable area data from NIA. The required areas for the short-term are covered by PIP projects. On the other hand, total area for the medium-term is about 159,000 ha under baseline scenario and 180,000 ha under Scenario 1. It can also be observed that Ilocos Norte, Bataan, Pampanga, Palawan, Capiz, Negros Oriental, Biliran, Southern Leyte and Misamis Occidental have no remaining areas to be irrigated.

Table 4.35. Area per Province per Scenario for Short- and Medium-term projects based on NIA Data on Irrigable Area, 2020-2025

Provinces	Share	Baseline (ha)		Scenario 1 (ha)	
		Short	Medium	Short	Medium
Ifugao	0.3%	Covered by PIP	525	Covered by PIP	595
Kalinga	0.7%		1,123		1,273
Ilocos Norte	0.0%		-		-
Ilocos Sur	0.6%		898		1,018
La Union	0.0%		76		86
Pangasinan	5.4%		8,520		9,655
Cagayan	3.4%		5,357		6,071
Isabela	8.0%		12,792		14,497
Nueva Vizcaya	1.4%		2,236		2,534
Quirino	0.9%		1,497		1,696
Aurora	0.6%		907		1,027
Bataan	0.0%		-		-
Bulacan	0.7%		1,043		1,182
Nueva Ecija	5.1%		8,057		9,131
Pampanga	0.0%		-		-
Tarlac	5.5%		8,697		9,856
Zambales	1.6%		2,564		2,906
Cavite	0.3%		498		564
Laguna	0.7%		1,039		1,178
Quezon	0.5%		801		908
Occidental Mindoro	1.9%		3,095		3,507

Provinces	Share	Baseline (ha)		Scenario 1 (ha)	
		Short	Medium	Short	Medium
Oriental Mindoro	1.8%	Covered by PIP	2,906	Covered by PIP	3,293
Palawan	0.0%		-		-
Albay	2.0%		3,136		3,554
Camarines Sur	4.0%		6,358		7,205
Masbate	1.1%		1,792		2,031
Sorsogon	0.1%		137		155
Aklan	0.0%		52		59
Antique	0.6%		877		994
Capiz	0.0%		-		-
Iloilo	2.3%		3,624		4,107
Negros Occidental	2.9%		4,574		5,184
Bohol	0.3%		436		494
Negros Oriental	0.0%		-		-
Biliran	0.0%		-		-
Northern Leyte	1.2%		1,931		2,188
Southern Leyte	0.0%		-		-
Samar Western	0.1%		184		209
Zamboanga Del Sur	1.5%		2,381		2,698
Zamboanga Sibugay	0.1%		162		183
Bukidnon	3.7%		5,907		6,694
Lanao Del Norte	0.0%		13		15
Misamis Occidental	0.0%		-		-
Misamis Oriental	0.6%		920		1,043
Compostela Valley	7.1%		11,241		12,739
Davao Del Norte	0.0%		9		11
Davao Del Sur	1.3%		2,008		2,276
Davao Oriental	0.7%		1,168		1,324
North Cotabato	8.3%		13,126		14,875
Sarangani	0.0%		7		7
South Cotabato	5.3%		8,383		9,500
Sultan Kudarat	0.9%		1,452		1,646
Agusan Del Norte	2.9%		4,555		5,162
Agusan Del Sur	2.4%		3,774		4,276
Surigao Del Sur	1.9%		2,985		3,383
Lanao Del Sur	2.9%		4,555		5,162
Maguindanao	6.7%		10,645		12,063
Total	**100%**		**159,028**		**180,214**

Note: Provinces in bold indicate PIP project locations

Table 4.36 shows the areas per province for long-term projects based on the irrigable area data from NIA. It should be noted that these provinces have irrigation development below 60% (national average). Highest allocation is in North Cotabato (13%), followed by Compostela Valley (11.5%). Lowest allocation is in Aurora (0.9%), and Misamis Oriental (0.9%).

Table 4.36. Area per Province per Scenario for Long term projects based on NIA Irrigable Area, 2026-2030

Provinces	Share	Baseline (ha)	Scenario 1 (ha)
Quirino	1.5%	4,475	5,131
Aurora	0.9%	2,710	3,107
Tarlac	8.9%	25,997	29,810
Zambales	2.6%	7,665	8,790
Occidental Mindoro	3.2%	9,251	10,608
Albay	3.2%	9,376	10,751
Masbate	1.8%	5,358	6,144
Negros Occidental	4.7%	13,673	15,679
Zamboanga Del Sur	2.4%	7,117	8,161
Bukidnon	6.0%	17,656	20,246
Misamis Oriental	0.9%	2,750	3,153
Compostela Valley	11.5%	33,602	38,530
Davao Del Sur	2.1%	6,003	6,884
Davao Oriental	1.2%	3,492	4,004
North Cotabato	13.4%	39,237	44,992
South Cotabato	8.6%	25,060	28,735
Agusan Del Norte	4.7%	13,617	15,615
Agusan Del Sur	3.9%	11,281	12,935
Surigao Del Sur	3.0%	8,922	10,231
Lanao Del Sur	4.7%	13,617	15,615
Maguindanao	10.9%	31,821	36,488
Total	**100.0%**	**292,685**	**335,608**

Table 4.37 to Table 4.39 show the projected areas disaggregated into NIS and CIS, then into new and restore areas per province and region under NIA irrigable area.

Table 4.37. Area per System per Province per Scenario in the Short-term Based on NIA Irrigable Area

Region	Province	Baseline (ha)						Scenario 1 (ha)					
		NIS			CIS			NIS			CIS		
		New	Res	Tot	New	Res	Tot	New	Res	Tot	New	Res	Tot
CAR	Ifugao	97	97	195	146	146	292	109	109	219	164	164	328
	Kalinga	209	209	417	313	313	626	234	234	469	352	352	703
	Total	**306**	**306**	**612**	**459**	**459**	**918**	**344**	**344**	**688**	**516**	**516**	**1,032**
1	Ilocos Norte	-	-	-	-	-	-	-	-	-	-	-	-
	Ilocos Sur	167	167	334	250	250	501	187	187	375	281	281	562
	La Union	14	14	28	21	21	42	16	16	32	24	24	47
	Pangasinan	1,582	1,582	3,165	2,373	2,373	4,747	1,777	1,777	3,555	2,666	2,666	5,332
	Total	**1,763**	**1,763**	**3,526**	**2,645**	**2,645**	**5,290**	**1,981**	**1,981**	**3,961**	**2,971**	**2,971**	**5,942**
2	Cagayan	995	995	1,990	1,492	1,492	2,985	1,118	1,118	2,235	1,677	1,677	3,353
	Isabela	2,376	2,376	4,752	3,564	3,564	7,127	2,669	2,669	5,338	4,003	4,003	8,006
	Nueva Vizcaya	415	415	831	623	623	1,246	466	466	933	700	700	1,399
	Quirino	278	278	556	417	417	834	312	312	625	468	468	937
	Total	**4,064**	**4,064**	**8,128**	**6,096**	**6,096**	**12,192**	**4,565**	**4,565**	**9,131**	**6,848**	**6,848**	**13,696**
3	Aurora	168	168	337	253	253	505	189	189	378	284	284	567
	Bataan	-	-	-	-	-	-	-	-	-	-	-	-
	Bulacan	194	194	388	291	291	581	218	218	435	327	327	653
	Nueva Ecija	1,496	1,496	2,993	2,245	2,245	4,489	1,681	1,681	3,362	2,521	2,521	5,043
	Pampanga	-	-	-	-	-	-	-	-	-	-	-	-
	Tarlac	1,615	1,615	3,230	2,423	2,423	4,846	1,814	1,814	3,629	2,722	2,722	5,443
	Zambales	476	476	953	714	714	1,429	535	535	1,070	802	802	1,605
	Total	**3,950**	**3,950**	**7,900**	**5,925**	**5,925**	**11,850**	**4,437**	**4,437**	**8,874**	**6,656**	**6,656**	**13,312**

Region	Province	Baseline (ha)						Scenario 1 (ha)					
		NIS			CIS			NIS			CIS		
		New	Res	Tot	New	Res	Tot	New	Res	Tot	New	Res	Tot
CALABAR-ZON	Cavite	92	92	185	139	139	277	104	104	208	156	156	312
	Laguna	193	193	386	290	290	579	217	217	434	325	325	651
	Quezon	149	149	298	223	223	446	167	167	334	251	251	502
	Total	**434**	**434**	**869**	**652**	**652**	**1,303**	**488**	**488**	**976**	**732**	**732**	**1,464**
MIMAROPA	Occidental Mindoro	575	575	1,150	862	862	1,724	646	646	1,291	968	968	1,937
	Oriental Mindoro	540	540	1,079	810	810	1,619	606	606	1,213	909	909	1,819
	Palawan	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**1,114**	**1,114**	**2,229**	**1,672**	**1,672**	**3,343**	**1,252**	**1,252**	**2,504**	**1,878**	**1,878**	**3,756**
5	Albay	582	582	1,165	874	874	1,747	654	654	1,309	982	982	1,963
	Camarines Sur	1,181	1,181	2,362	1,771	1,771	3,542	1,326	1,326	2,653	1,990	1,990	3,979
	Masbate	333	333	666	499	499	999	374	374	748	561	561	1,122
	Sorsogon	25	25	51	38	38	76	29	29	57	43	43	86
	Total	**2,122**	**2,122**	**4,243**	**3,182**	**3,182**	**6,365**	**2,383**	**2,383**	**4,767**	**3,575**	**3,575**	**7,150**
6	Aklan	10	10	19	14	14	29	11	11	22	16	16	33
	Antique	163	163	326	244	244	489	183	183	366	275	275	549
	Capiz	-	-	-	-	-	-	-	-	-	-	-	-
	Iloilo	673	673	1,346	1,010	1,010	2,019	756	756	1,512	1,134	1,134	2,268
	Negros Occidental	850	850	1,699	1,274	1,274	2,549	954	954	1,909	1,431	1,431	2,863
	Total	**1,695**	**1,695**	**3,390**	**2,543**	**2,543**	**5,086**	**1,904**	**1,904**	**3,809**	**2,856**	**2,856**	**5,713**
7	Bohol	81	81	162	121	121	243	91	91	182	136	136	273
	Negros Oriental	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**81**	**81**	**162**	**121**	**121**	**243**	**91**	**91**	**182**	**136**	**136**	**273**

Region	Province	Baseline (ha)						Scenario 1 (ha)					
		NIS			CIS			NIS			CIS		
		New	Res	Tot	New	Res	Tot	New	Res	Tot	New	Res	Tot
8	Biliran	-	-	-	-	-	-	-	-	-	-	-	-
	Northern Leyte	359	359	717	538	538	1,076	403	403	806	604	604	1,208
	Southern Leyte	-	-	-	-	-	-	-	-	-	-	-	-
	Samar Western	34	34	68	51	51	103	38	38	77	58	58	115
	Total	**393**	**393**	**786**	**589**	**589**	**1,178**	**441**	**441**	**883**	**662**	**662**	**1,324**
9	Zamboanga Del Sur	442	442	884	663	663	1,327	497	497	993	745	745	1,490
	Zamboanga Sibugay	30	30	60	45	45	90	34	34	67	51	51	101
	Total	**472**	**472**	**944**	**708**	**708**	**1,417**	**530**	**530**	**1,061**	**796**	**796**	**1,591**
10	Bukidnon	1,097	1,097	2,194	1,645	1,645	3,291	1,232	1,232	2,465	1,848	1,848	3,697
	Lanao Del Norte	2	2	5	4	4	7	3	3	6	4	4	8
	Misamis Occidental	-	-	-	-	-	-	-	-	-	-	-	-
	Misamis Oriental	171	171	342	256	256	513	192	192	384	288	288	576
	Total	**1,270**	**1,270**	**2,541**	**1,906**	**1,906**	**3,811**	**1,427**	**1,427**	**2,854**	**2,141**	**2,141**	**4,281**
11	Compostela Valley	2,088	2,088	4,175	3,131	3,131	6,263	2,345	2,345	4,690	3,518	3,518	7,035
	Davao Del Norte	2	2	4	3	3	5	2	2	4	3	3	6
	Davao Del Sur	373	373	746	559	559	1,119	419	419	838	628	628	1,257
	Davao Oriental	217	217	434	325	325	651	244	244	487	366	366	731
	Total	**2,679**	**2,679**	**5,359**	**4,019**	**4,019**	**8,038**	**3,010**	**3,010**	**6,020**	**4,515**	**4,515**	**9,029**
12	North Cotabato	2,438	2,438	4,876	3,657	3,657	7,313	2,738	2,738	5,477	4,108	4,108	8,215
	Sarangani	1	1	2	2	2	4	1	1	3	2	2	4
	South Cotabato	1,557	1,557	3,114	2,335	2,335	4,671	1,749	1,749	3,498	2,623	2,623	5,247
	Sultan Kudarat	270	270	540	405	405	809	303	303	606	455	455	909
	Total	**4,266**	**4,266**	**8,531**	**6,399**	**6,399**	**12,797**	**4,792**	**4,792**	**9,584**	**7,188**	**7,188**	**14,376**

Region	Province	Baseline (ha)						Scenario 1 (ha)					
		NIS			CIS			NIS			CIS		
		New	Res	Tot	New	Res	Tot	New	Res	Tot	New	Res	Tot
13	Agusan Del Norte	846	846	1,692	1,269	1,269	2,538	950	950	1,901	1,426	1,426	2,851
	Agusan Del Sur	701	701	1,402	1,051	1,051	2,103	787	787	1,575	1,181	1,181	2,362
	Surigao Del Sur	554	554	1,109	832	832	1,663	623	623	1,245	934	934	1,868
	Total	**2,101**	**2,101**	**4,202**	**3,152**	**3,152**	**6,304**	**2,360**	**2,360**	**4,721**	**3,541**	**3,541**	**7,081**
ARMM	Lanao Del Sur	846	846	1,692	1,269	1,269	2,538	950	950	1,901	1,426	1,426	2,851
	Maguindanao	1,977	1,977	3,954	2,966	2,966	5,931	2,221	2,221	4,442	3,331	3,331	6,663
	Total	**2,823**	**2,823**	**5,646**	**4,235**	**4,235**	**8,469**	**3,171**	**3,171**	**6,343**	**4,757**	**4,757**	**9,514**

Table 4.38. Area per System per Province per Scenario in the Medium-term Based on NIA Irrigable Area

Region	Province	Baseline (ha)						Scenario 1 (ha)					
		NIS			CIS			NIS			CIS		
		New	Res	Tot	New	Res	Tot	New	Res	Tot	New	Res	Tot
CAR	Ifugao	105	105	210	157	157	315	119	119	238	178	178	357
	Kalinga	225	225	449	337	337	674	255	255	509	382	382	764
	Total	**330**	**330**	**659**	**494**	**494**	**989**	**374**	**374**	**747**	**560**	**560**	**1,121**
1	Ilocos Norte	-	-	-	-	-	-	-	-	-	-	-	-
	Ilocos Sur	180	180	359	270	270	539	204	204	407	305	305	611
	La Union	15	15	30	23	23	45	17	17	34	26	26	51
	Pangasinan	1,704	1,704	3,408	2,556	2,556	5,112	1,931	1,931	3,862	2,896	2,896	5,793
	Total	**1,899**	**1,899**	**3,798**	**2,848**	**2,848**	**5,696**	**2,152**	**2,152**	**4,304**	**3,228**	**3,228**	**6,455**
2	Cagayan	1,071	1,071	2,143	1,607	1,607	3,214	1,214	1,214	2,429	1,821	1,821	3,643
	Isabela	2,558	2,558	5,117	3,838	3,838	7,675	2,899	2,899	5,799	4,349	4,349	8,698
	Nueva Vizcaya	447	447	894	671	671	1,342	507	507	1,014	760	760	1,520
	Quirino	299	299	599	449	449	898	339	339	679	509	509	1,018
	Total	**4,377**	**4,377**	**8,753**	**6,565**	**6,565**	**13,130**	**4,960**	**4,960**	**9,919**	**7,439**	**7,439**	**14,879**
3	Aurora	181	181	363	272	272	544	205	205	411	308	308	616
	Bataan	-	-	-	-	-	-	-	-	-	-	-	-
	Bulacan	209	209	417	313	313	626	236	236	473	355	355	709
	Nueva Ecija	1,611	1,611	3,223	2,417	2,417	4,834	1,826	1,826	3,652	2,739	2,739	5,479
	Pampanga	-	-	-	-	-	-	-	-	-	-	-	-
	Tarlac	1,739	1,739	3,479	2,609	2,609	5,218	1,971	1,971	3,942	2,957	2,957	5,913
	Zambales	513	513	1,026	769	769	1,539	581	581	1,162	872	872	1,744
	Total	**4,254**	**4,254**	**8,507**	**6,381**	**6,381**	**12,761**	**4,820**	**4,820**	**9,641**	**7,231**	**7,231**	**14,461**

Region	Province	Baseline (ha)						Scenario 1 (ha)					
		NIS			CIS			NIS			CIS		
		New	Res	Tot	New	Res	Tot	New	Res	Tot	New	Res	Tot
CALABAR-ZON	Cavite	100	100	199	149	149	299	113	113	226	169	169	339
	Laguna	208	208	416	312	312	624	236	236	471	353	353	707
	Quezon	160	160	321	240	240	481	182	182	363	272	272	545
	Total	**468**	**468**	**936**	**702**	**702**	**1,403**	**530**	**530**	**1,060**	**795**	**795**	**1,590**
MIMAROPA	Occidental Mindoro	619	619	1,238	928	928	1,857	701	701	1,403	1,052	1,052	2,104
	Oriental Mindoro	581	581	1,162	872	872	1,744	659	659	1,317	988	988	1,976
	Palawan	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**1,200**	**1,200**	**2,400**	**1,800**	**1,800**	**3,601**	**1,360**	**1,360**	**2,720**	**2,040**	**2,040**	**4,080**
5	Albay	627	627	1,255	941	941	1,882	711	711	1,422	1,066	1,066	2,133
	Camarines Sur	1,272	1,272	2,543	1,907	1,907	3,815	1,441	1,441	2,882	2,162	2,162	4,323
	Masbate	358	358	717	538	538	1,075	406	406	812	609	609	1,219
	Sorsogon	27	27	55	41	41	82	31	31	62	46	46	93
	Total	**2,285**	**2,285**	**4,569**	**3,427**	**3,427**	**6,854**	**2,589**	**2,589**	**5,178**	**3,884**	**3,884**	**7,767**
6	Aklan	10	10	21	16	16	31	12	12	24	18	18	35
	Antique	175	175	351	263	263	526	199	199	398	298	298	597
	Capiz	-	-	-	-	-	-	-	-	-	-	-	-
	Iloilo	725	725	1,450	1,087	1,087	2,175	821	821	1,643	1,232	1,232	2,464
	Negros Occidental	915	915	1,830	1,372	1,372	2,745	1,037	1,037	2,073	1,555	1,555	3,110
	Total	**1,826**	**1,826**	**3,651**	**2,738**	**2,738**	**5,477**	**2,069**	**2,069**	**4,138**	**3,103**	**3,103**	**6,206**
7	Bohol	87	87	174	131	131	261	99	99	197	148	148	296
	Negros Oriental	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**87**	**87**	**174**	**131**	**131**	**261**	**99**	**99**	**197**	**148**	**148**	**296**

Region	Province	Baseline (ha)						Scenario 1 (ha)					
		NIS			CIS			NIS			CIS		
		New	Res	Tot	New	Res	Tot	New	Res	Tot	New	Res	Tot
8	Biliran	-	-	-	-	-	-	-	-	-	-	-	-
	Northern Leyte	386	386	772	579	579	1,158	438	438	875	656	656	1,313
	Southern Leyte	-	-	-	-	-	-	-	-	-	-	-	-
	Samar Western	37	37	74	55	55	111	42	42	84	63	63	125
	Total	**423**	**423**	**846**	**635**	**635**	**1,269**	**479**	**479**	**959**	**719**	**719**	**1,438**
9	Zamboanga Del Sur	476	476	952	714	714	1,428	540	540	1,079	809	809	1,619
	Zamboanga Sibugay	32	32	65	48	48	97	37	37	73	55	55	110
	Total	**508**	**508**	**1,017**	**763**	**763**	**1,525**	**576**	**576**	**1,152**	**864**	**864**	**1,729**
10	Bukidnon	1,181	1,181	2,363	1,772	1,772	3,544	1,339	1,339	2,677	2,008	2,008	4,016
	Lanao Del Norte	3	3	5	4	4	8	3	3	6	5	5	9
	Misamis Occidental	-	-	-	-	-	-	-	-	-	-	-	-
	Misamis Oriental	184	184	368	276	276	552	209	209	417	313	313	626
	Total	**1,368**	**1,368**	**2,736**	**2,052**	**2,052**	**4,104**	**1,550**	**1,550**	**3,101**	**2,325**	**2,325**	**4,651**
11	Compostela Valley	2,248	2,248	4,496	3,372	3,372	6,745	2,548	2,548	5,095	3,822	3,822	7,643
	Davao Del Norte	2	2	4	3	3	6	2	2	4	3	3	6
	Davao Del Sur	402	402	803	602	602	1,205	455	455	910	683	683	1,365
	Davao Oriental	234	234	467	350	350	701	265	265	530	397	397	794
	Total	**2,885**	**2,885**	**5,771**	**4,328**	**4,328**	**8,656**	**3,270**	**3,270**	**6,540**	**4,905**	**4,905**	**9,809**
12	North Cotabato	2,625	2,625	5,250	3,938	3,938	7,876	2,975	2,975	5,950	4,462	4,462	8,925
	Sarangani	1	1	3	2	2	4	1	1	3	2	2	4
	South Cotabato	1,677	1,677	3,353	2,515	2,515	5,030	1,900	1,900	3,800	2,850	2,850	5,700
	Sultan Kudarat	290	290	581	436	436	871	329	329	658	494	494	988
	Total	**4,594**	**4,594**	**9,187**	**6,891**	**6,891**	**13,781**	**5,206**	**5,206**	**10,411**	**7,809**	**7,809**	**15,617**

Region	Province	Baseline (ha)						Scenario 1 (ha)					
		NIS			CIS			NIS			CIS		
		New	**Res**	**Tot**	**New**	**Res**	**Tot**	**New**	**Res**	**Tot**	**New**	**Res**	**Tot**
13	Agusan Del Norte	911	911	1,822	1,367	1,367	2,733	1,032	1,032	2,065	1,549	1,549	3,097
	Agusan Del Sur	755	755	1,509	1,132	1,132	2,264	855	855	1,711	1,283	1,283	2,566
	Surigao Del Sur	597	597	1,194	895	895	1,791	677	677	1,353	1,015	1,015	2,030
	Total	**2,263**	**2,263**	**4,526**	**3,394**	**3,394**	**6,788**	**2,564**	**2,564**	**5,129**	**3,846**	**3,846**	**7,693**
ARMM	Lanao Del Sur	911	911	1,822	1,367	1,367	2,733	1,032	1,032	2,065	1,549	1,549	3,097
	Maguindanao	2,129	2,129	4,258	3,194	3,194	6,387	2,413	2,413	4,825	3,619	3,619	7,238
	Total	**3,040**	**3,040**	**6,080**	**4,560**	**4,560**	**9,120**	**3,445**	**3,445**	**6,890**	**5,168**	**5,168**	**10,335**

Table 4.39. Area per System per Province per Scenario in the Long-term Based on NIA Irrigable Area

Region	Province	Baseline (ha)						Scenario 1 (ha)					
		NIS			CIS			NIS			CIS		
		New	Res	Tot	New	Res	Tot	New	Res	Tot	New	Res	Tot
2	Quirino	2,161	452	2,612	3,241	677	3,919	2,720	276	2,996	4,080	414	4,493
	Aurora	215	45	259	322	67	389	270	27	297	405	41	446
	Total	**2,161**	**452**	**2,612**	**3,241**	**677**	**3,919**	**2,720**	**276**	**2,996**	**4,080**	**414**	**4,493**
3	Tarlac	15,147	3,166	18,314	22,721	4,749	27,470	19,066	1,933	21,000	28,599	2,900	31,500
	Zambales	8,243	1,723	9,966	12,364	2,584	14,949	10,375	1,052	11,428	15,563	1,578	17,141
	Total	**23,605**	**4,934**	**28,539**	**35,407**	**7,401**	**42,808**	**29,712**	**3,013**	**32,725**	**44,568**	**4,520**	**49,087**
MIMAROPA	Occidental Mindoro	4,085	854	4,939	6,128	1,281	7,409	5,142	521	5,664	7,714	782	8,496
	Total	**4,085**	**854**	**4,939**	**6,128**	**1,281**	**7,409**	**5,142**	**521**	**5,664**	**7,714**	**782**	**8,496**
5	Albay	4,776	998	5,775	7,165	1,498	8,662	6,012	610	6,622	9,018	915	9,933
	Masbate	2,989	625	3,614	4,484	937	5,421	3,763	382	4,144	5,644	572	6,216
	Total	**7,766**	**1,623**	**9,389**	**11,649**	**2,435**	**14,084**	**9,775**	**991**	**10,766**	**14,662**	**1,487**	**16,149**
6	Negros Occidental	3,346	699	4,045	5,019	1,049	6,068	4,212	427	4,639	6,317	641	6,958
	Total	**3,346**	**699**	**4,045**	**5,019**	**1,049**	**6,068**	**4,212**	**427**	**4,639**	**6,317**	**641**	**6,958**
9	Zamboanga Del Sur	3,984	833	4,817	5,976	1,249	7,225	5,014	509	5,523	7,522	763	8,284
	Total	**3,984**	**833**	**4,817**	**5,976**	**1,249**	**7,225**	**5,014**	**509**	**5,523**	**7,522**	**763**	**8,284**
10	Bukidnon	6,744	1,410	8,153	10,115	2,114	12,230	8,488	861	9,349	12,732	1,291	14,024
	Misamis Oriental	2,738	572	3,310	4,107	858	4,965	3,446	349	3,795	5,169	524	5,693
	Total	**9,481**	**1,982**	**11,463**	**14,222**	**2,973**	**17,195**	**11,934**	**1,210**	**13,145**	**17,901**	**1,815**	**19,717**

Region	Province	Baseline (ha)						Scenario 1 (ha)					
		NIS			CIS			NIS			CIS		
		New	Res	Tot	New	Res	Tot	New	Res	Tot	New	Res	Tot
11	Compostela Valley	2,318	485	2,803	3,477	727	4,204	2,918	296	3,214	4,377	444	4,820
	Davao Del Sur	1,919	401	2,320	2,878	602	3,480	2,415	245	2,660	3,623	367	3,990
	Davao Oriental	2,983	624	3,607	4,474	935	5,410	3,755	381	4,135	5,632	571	6,203
	Total	**7,220**	**1,509**	**8,729**	**10,830**	**2,264**	**13,093**	**9,087**	**922**	**10,009**	**13,631**	**1,382**	**15,014**
12	North Cotabato	2,598	543	3,141	3,896	814	4,711	3,270	332	3,601	4,904	497	5,402
	South Cotabato	1,528	319	1,847	2,292	479	2,771	1,923	195	2,118	2,885	293	3,178
	Total	**4,126**	**862**	**4,988**	**6,188**	**1,294**	**7,482**	**5,193**	**527**	**5,720**	**7,789**	**790**	**8,579**
13	Agusan Del Norte	3,051	638	3,689	4,577	957	5,534	3,841	389	4,230	5,761	584	6,345
	Agusan Del Sur	7,457	1,559	9,015	11,185	2,338	13,523	9,386	952	10,337	14,078	1,428	15,506
	Surigao Del Sur	6,289	1,314	7,603	9,433	1,972	11,404	7,915	803	8,718	11,873	1,204	13,077
	Total	**16,796**	**3,511**	**20,307**	**25,195**	**5,266**	**30,461**	**21,142**	**2,144**	**23,286**	**31,713**	**3,216**	**34,928**
ARMM	Lanao Del Sur	7,752	1,620	9,372	11,627	2,430	14,058	9,757	989	10,746	14,636	1,484	16,120
	Maguindanao	6,511	1,361	7,872	9,766	2,041	11,808	8,195	831	9,026	12,293	1,247	13,539
	Total	**14,262**	**2,981**	**17,244**	**21,394**	**4,472**	**25,865**	**17,952**	**1,821**	**19,773**	**26,928**	**2,731**	**29,659**

Table 4.40 shows the areas per province for short and medium-term projects based on the irrigable area computed by the GIS component of the project. Ifugao, Nueva Viscaya, Oriental Mindoro and Sarangani have no remaining areas to be irrigated under GIS data. Highest allocation (province with largest area not irrigated) is in Quezon (5.2%), and Pangasinan (5.2%).

Table 4.40. Area per Province per Scenario for Short- and Medium-term projects Based GIS Computed Irrigable Area

Province	Share	Baseline (ha)		Scenario 1 (ha)	
		Short	Medium	Short	Medium
Ifugao	0.0%	Covered by PIP	-	Covered by PIP	-
Kalinga	0.2%	Covered by PIP	306	Covered by PIP	347
Ilocos Norte	1.1%	Covered by PIP	1,786	Covered by PIP	2,024
Ilocos Sur	1.1%	Covered by PIP	1,827	Covered by PIP	2,071
La Union	0.5%	Covered by PIP	742	Covered by PIP	841
Pangasinan	5.2%	Covered by PIP	8,225	Covered by PIP	9,321
Cagayan	3.2%	Covered by PIP	5,162	Covered by PIP	5,849
Isabela	4.9%	Covered by PIP	7,789	Covered by PIP	8,827
Nueva Vizcaya	0.0%	Covered by PIP	-	Covered by PIP	-
Quirino	0.2%	Covered by PIP	372	Covered by PIP	421
Aurora	0.9%	Covered by PIP	1,395	Covered by PIP	1,581
Bataan	0.6%	Covered by PIP	896	Covered by PIP	1,015
Bulacan	1.6%	Covered by PIP	2,588	Covered by PIP	2,933
Nueva Ecija	4.1%	Covered by PIP	6,457	Covered by PIP	7,317
Pampanga	1.9%	Covered by PIP	3,015	Covered by PIP	3,417
Tarlac	3.4%	Covered by PIP	5,463	Covered by PIP	6,190
Zambales	1.4%	Covered by PIP	2,205	Covered by PIP	2,499
Cavite	1.2%	Covered by PIP	1,850	Covered by PIP	2,097
Laguna	1.2%	Covered by PIP	1,903	Covered by PIP	2,156
Quezon	5.2%	Covered by PIP	8,231	Covered by PIP	9,327
Occidental Mindoro	0.2%	Covered by PIP	365	Covered by PIP	413
Oriental Mindoro	0.0%	Covered by PIP	-	Covered by PIP	-
Palawan	1.8%	Covered by PIP	2,924	Covered by PIP	3,313
Albay	0.6%	Covered by PIP	969	Covered by PIP	1,098
Camarines Sur	2.5%	Covered by PIP	3,957	Covered by PIP	4,484
Masbate	4.2%	Covered by PIP	6,719	Covered by PIP	7,614
Sorsogon	1.1%	Covered by PIP	1,677	Covered by PIP	1,901
Aklan	0.1%	Covered by PIP	116	Covered by PIP	131
Antique	0.0%	Covered by PIP	25	Covered by PIP	28
Capiz	1.2%	1,743	1,877	1,958	2,127
Iloilo	2.3%	3,338	3,595	3,750	4,074

Province	Share	Baseline (ha)		Scenario 1 (ha)	
		Short	Medium	Short	Medium
Negros Occidental	4.4%	6,445	6,941	7,240	7,866
Bohol	2.1%	3,051	3,286	3,427	3,724
Negros Oriental	1.2%	1,786	1,924	2,007	2,180
Biliran	0.0%	72	78	81	88
Northern Leyte	4.0%	5,945	6,402	6,678	7,255
Southern Leyte	0.2%	254	273	285	309
Western Samar	1.7%	2,524	2,718	2,836	3,081
Zamboanga Del Sur	1.8%	2,612	2,813	2,934	3,188
Zamboanga Sibugay	1.5%	2,178	2,345	2,447	2,658
Bukidnon	3.0%	4,494	4,839	5,048	5,484
Lanao Del Norte	1.6%	2,325	2,504	2,612	2,837
Misamis Occidental	1.1%	1,684	1,813	1,891	2,055
Misamis Oriental	1.1%	1,635	1,761	1,837	1,995
Compostela Valley	1.3%	1,889	2,034	2,122	2,305
Davao Del Norte	2.3%	3,345	3,603	3,758	4,083
Davao Del Sur	1.9%	2,795	3,010	3,140	3,411
Davao Oriental	1.2%	1,788	1,926	2,009	2,182
North Cotabato	3.7%	5,418	5,835	6,087	6,612
Sarangani	0.0%	-	-	-	-
South Cotabato	2.2%	3,200	3,447	3,595	3,906
Sultan Kudarat	1.5%	2,185	2,353	2,454	2,666
Agusan Del Norte	1.1%	1,557	1,677	1,750	1,901
Agusan Del Sur	2.6%	3,903	4,203	4,384	4,763
Surigao Del Sur	1.8%	2,654	2,859	2,982	3,239
Lanao Del Sur	0.6%	875	942	983	1,068
Maguindanao	4.4%	6,506	7,006	7,308	7,940
Total	**100%**	**147,673**	**159,028**	**165,887**	**180,212**

Note: Provinces in bold indicate PIP project locations

Table 4.41 shows the areas per province for long term projects based on the irrigable area computed by the GIS component of the project. It should be noted that these provinces have irrigation development below 60% (national average). Across all scenarios, the highest allocation is in Quezon (5.2%), followed by Pangasinan (5.2%). Lowest allocation is in Southern Leyte (0.2%), followed by La Union (0.5%).

Table 4.41. Projected Area per Province per Scenario under Long Term Based on GIS Irrigable Area

Province	Share	Baseline (ha)	Scenario 1 (ha)
Ilocos Norte	1.1%	3,334	3,824
Ilocos Sur	1.2%	3,411	3,911
La Union	0.5%	1,386	1,589
Pangasinan	5.2%	15,354	17,606
Cagayan	3.3%	9,635	11,048
Isabela	5.0%	14,540	16,672
Aurora	0.9%	2,605	2,987
Bataan	0.6%	1,673	1,918
Bulacan	1.7%	4,831	5,540
Nueva Ecija	4.1%	12,052	13,820
Pampanga	1.9%	5,629	6,454
Tarlac	3.5%	10,197	11,692
Zambales	1.4%	4,117	4,721
Cavite	1.2%	3,454	3,960
Laguna	1.2%	3,552	4,073
Quezon	5.2%	15,364	17,617
Palawan	1.9%	5,457	6,258
Camarines Sur	2.5%	7,385	8,469
Masbate	4.3%	12,541	14,380
Sorsogon	1.1%	3,131	3,590
Capiz	1.2%	3,503	4,017
Iloilo	2.3%	6,711	7,695
Negros Occidental	4.4%	12,956	14,856
Bohol	2.1%	6,133	7,033
Negros Oriental	1.2%	3,591	4,117
Northern Leyte	4.1%	11,950	13,703
Southern Leyte	0.2%	510	585
Western Samar	1.7%	5,074	5,818
Zamboanga Del Sur	1.8%	5,251	6,021
Zamboanga Sibugay	1.5%	4,378	5,020

Province	Share	Baseline (ha)	Scenario 1 (ha)
Bukidnon	3.1%	9,033	10,358
Lanao Del Norte	1.6%	4,674	5,359
Misamis Occidental	1.2%	3,385	3,881
Misamis Oriental	1.1%	3,287	3,769
Compostela Valley	1.3%	3,797	4,354
Davao Del Norte	2.3%	6,725	7,711
Davao Del Sur	1.9%	5,619	6,443
Davao Oriental	1.2%	3,595	4,122
North Cotabato	3.7%	10,891	12,489
South Cotabato	2.2%	6,433	7,377
Sultan Kudarat	1.5%	4,392	5,036
Agusan Del Norte	1.1%	3,131	3,590
Agusan Del Sur	2.7%	7,845	8,995
Surigao Del Sur	1.8%	5,336	6,118
Lanao Del Sur	0.6%	1,759	2,016
Maguindanao	4.5%	13,078	14,996
Total	**100.0%**	**292,685**	**335,608**

Succeeding tables (Table 4.42 to Table 4.44) show the projected areas disaggregated into NIS and CIS, then into new and restore areas per province and region under GIS irrigable area.

Table 4.42. Area per System per Province per Scenario in the Short-term Based on GIS Irrigable Area

Region	Province	Baseline (ha)						Scenario 1 (ha)					
		NIS			CIS			NIS			CIS		
		New	Res	Tot	New	Res	Tot	New	Res	Tot	New	Res	Tot
CAR	Ifugao	-	-	-	-	-	-	-	-	-	-	-	-
	Kalinga	57	57	114	85	85	171	64	64	128	96	96	192
	Total	**57**	**57**	**114**	**85**	**85**	**171**	**64**	**64**	**128**	**96**	**96**	**192**
1	Ilocos Norte	332	332	664	498	498	995	373	373	745	559	559	1,118
	Ilocos Sur	339	339	679	509	509	1,018	381	381	762	572	572	1,144
	La Union	138	138	276	207	207	414	155	155	310	232	232	465
	Pangasinan	1,528	1,528	3,055	2,291	2,291	4,583	1,716	1,716	3,432	2,574	2,574	5,148
	Total	**2,337**	**2,337**	**4,673**	**3,505**	**3,505**	**7,010**	**2,625**	**2,625**	**5,250**	**3,937**	**3,937**	**7,875**
2	Cagayan	959	959	1,917	1,438	1,438	2,876	1,077	1,077	2,154	1,615	1,615	3,231
	Isabela	1,447	1,447	2,893	2,170	2,170	4,340	1,625	1,625	3,250	2,438	2,438	4,875
	Nueva Vizcaya	-	-	-	-	-	-	-	-	-	-	-	-
	Quirino	69	69	138	103	103	207	78	78	155	116	116	233
	Total	**2,474**	**2,474**	**4,948**	**3,711**	**3,711**	**7,423**	**2,779**	**2,779**	**5,559**	**4,169**	**4,169**	**8,338**
3	Aurora	259	259	518	389	389	777	291	291	582	437	437	873
	Bataan	166	166	333	250	250	499	187	187	374	280	280	561
	Bulacan	481	481	961	721	721	1,442	540	540	1,080	810	810	1,620
	Nueva Ecija	1,199	1,199	2,398	1,799	1,799	3,597	1,347	1,347	2,694	2,021	2,021	4,041
	Pampanga	560	560	1,120	840	840	1,680	629	629	1,258	944	944	1,887
	Tarlac	1,015	1,015	2,029	1,522	1,522	3,044	1,140	1,140	2,279	1,709	1,709	3,419
	Zambales	410	410	819	614	614	1,229	460	460	920	690	690	1,380
	Total	**4,090**	**4,090**	**8,179**	**6,134**	**6,134**	**12,269**	**4,594**	**4,594**	**9,188**	**6,891**	**6,891**	**13,782**

Region	Province	Baseline (ha)						Scenario 1 (ha)					
		NIS			CIS			NIS			CIS		
		New	Res	Tot	New	Res	Tot	New	Res	Tot	New	Res	Tot
CALABAR-ZON	Cavite	344	344	687	515	515	1,031	386	386	772	579	579	1,158
	Laguna	353	353	707	530	530	1,060	397	397	794	596	596	1,191
	Quezon	1,529	1,529	3,057	2,293	2,293	4,586	1,717	1,717	3,434	2,576	2,576	5,151
	Total	**2,226**	**2,226**	**4,451**	**3,338**	**3,338**	**6,677**	**2,500**	**2,500**	**5,000**	**3,750**	**3,750**	**7,501**
MIMAROPA	Occidental Mindoro	68	68	135	102	102	203	76	76	152	114	114	228
	Oriental Mindoro	-	-	-	-	-	-	-	-	-	-	-	-
	Palawan	543	543	1,086	814	814	1,629	610	610	1,220	915	915	1,830
	Total	**611**	**611**	**1,221**	**916**	**916**	**1,832**	**686**	**686**	**1,372**	**1,029**	**1,029**	**2,058**
5	Albay	180	180	360	270	270	540	202	202	404	303	303	607
	Camarines Sur	735	735	1,470	1,102	1,102	2,204	825	825	1,651	1,238	1,238	2,476
	Masbate	1,248	1,248	2,496	1,872	1,872	3,743	1,402	1,402	2,803	2,103	2,103	4,205
	Sorsogon	312	312	623	467	467	935	350	350	700	525	525	1,050
	Total	**2,474**	**2,474**	**4,948**	**3,711**	**3,711**	**7,422**	**2,779**	**2,779**	**5,559**	**4,169**	**4,169**	**8,338**
6	Aklan	21	21	43	32	32	64	24	24	48	36	36	72
	Antique	5	5	9	7	7	14	5	5	10	8	8	16
	Capiz	349	349	697	523	523	1,046	392	392	783	587	587	1,175
	Iloilo	668	668	1,335	1,002	1,002	2,003	750	750	1,500	1,125	1,125	2,250
	Negros Occidental	1,289	1,289	2,578	1,934	1,934	3,867	1,448	1,448	2,896	2,172	2,172	4,344
	Total	**2,331**	**2,331**	**4,663**	**3,497**	**3,497**	**6,994**	**2,619**	**2,619**	**5,238**	**3,928**	**3,928**	**7,857**
7	Bohol	610	610	1,220	915	915	1,831	685	685	1,371	1,028	1,028	2,056
	Negros Oriental	357	357	715	536	536	1,072	401	401	803	602	602	1,204
	Total	**967**	**967**	**1,935**	**1,451**	**1,451**	**2,902**	**1,087**	**1,087**	**2,174**	**1,630**	**1,630**	**3,260**

Region	Province	Baseline (ha)						Scenario 1 (ha)					
		NIS			CIS			NIS			CIS		
		New	Res	Tot	New	Res	Tot	New	Res	Tot	New	Res	Tot
8	Biliran	14	14	29	22	22	43	16	16	32	24	24	49
	Northern Leyte	1,189	1,189	2,378	1,783	1,783	3,567	1,336	1,336	2,671	2,003	2,003	4,007
	Southern Leyte	51	51	101	76	76	152	57	57	114	85	85	171
	Samar Western	505	505	1,010	757	757	1,515	567	567	1,134	851	851	1,701
	Total	**1,759**	**1,759**	**3,518**	**2,638**	**2,638**	**5,277**	**1,976**	**1,976**	**3,952**	**2,964**	**2,964**	**5,928**
9	Zamboanga Del Sur	522	522	1,045	784	784	1,567	587	587	1,174	880	880	1,761
	Zamboanga Sibugay	436	436	871	653	653	1,307	489	489	979	734	734	1,468
	Total	**958**	**958**	**1,916**	**1,437**	**1,437**	**2,874**	**1,076**	**1,076**	**2,152**	**1,614**	**1,614**	**3,229**
10	Bukidnon	899	899	1,797	1,348	1,348	2,696	1,010	1,010	2,019	1,514	1,514	3,029
	Lanao Del Norte	465	465	930	698	698	1,395	522	522	1,045	784	784	1,567
	Misamis Occidental	337	337	674	505	505	1,010	378	378	757	567	567	1,135
	Misamis Oriental	327	327	654	491	491	981	367	367	735	551	551	1,102
	Total	**2,028**	**2,028**	**4,055**	**3,041**	**3,041**	**6,083**	**2,278**	**2,278**	**4,555**	**3,416**	**3,416**	**6,833**
11	Compostela Valley	378	378	756	567	567	1,133	424	424	849	637	637	1,273
	Davao Del Norte	669	669	1,338	1,004	1,004	2,007	752	752	1,503	1,127	1,127	2,255
	Davao Del Sur	559	559	1,118	839	839	1,677	628	628	1,256	942	942	1,884
	Davao Oriental	358	358	715	537	537	1,073	402	402	804	603	603	1,205
	Total	**1,964**	**1,964**	**3,927**	**2,945**	**2,945**	**5,891**	**2,206**	**2,206**	**4,412**	**3,309**	**3,309**	**6,617**

Region	Province	Baseline (ha)						Scenario 1 (ha)					
		NIS			CIS			NIS			CIS		
		New	Res	Tot	New	Res	Tot	New	Res	Tot	New	Res	Tot
12	North Cotabato	1,084	1,084	2,167	1,625	1,625	3,251	1,217	1,217	2,435	1,826	1,826	3,652
	Sarangani	-	-	-	-	-	-	-	-	-	-	-	-
	South Cotabato	640	640	1,280	960	960	1,920	719	719	1,438	1,079	1,079	2,157
	Sultan Kudarat	437	437	874	655	655	1,311	491	491	982	736	736	1,472
	Total	**2,161**	**2,161**	**4,321**	**3,241**	**3,241**	**6,482**	**2,427**	**2,427**	**4,854**	**3,641**	**3,641**	**7,282**
13	Agusan Del Norte	311	311	623	467	467	934	350	350	700	525	525	1,050
	Agusan Del Sur	781	781	1,561	1,171	1,171	2,342	877	877	1,754	1,315	1,315	2,630
	Surigao Del Sur	531	531	1,062	796	796	1,593	596	596	1,193	895	895	1,789
	Total	**1,623**	**1,623**	**3,246**	**2,434**	**2,434**	**4,869**	**1,823**	**1,823**	**3,646**	**2,735**	**2,735**	**5,469**
ARMM	Lanao Del Sur	175	175	350	262	262	525	197	197	393	295	295	590
	Maguindanao	1,301	1,301	2,602	1,952	1,952	3,904	1,462	1,462	2,923	2,192	2,192	4,385
	Total	**1,476**	**1,476**	**2,952**	**2,214**	**2,214**	**4,428**	**1,658**	**1,658**	**3,316**	**2,487**	**2,487**	**4,975**

Table 4.43. Area per System per Province per Scenario in the Medium-term Based on GIS Irrigable Area

Region	Province	Baseline (ha)						Scenario 1 (ha)					
		NIS			CIS			NIS			CIS		
		New	Res	Tot	New	Res	Tot	New	Res	Tot	New	Res	Tot
CAR	Ifugao	-	-	-	-	-	-	-	-	-	-	-	-
	Kalinga	61	61	123	92	92	184	69	69	139	104	104	208
	Total	**61**	**61**	**123**	**92**	**92**	**184**	**69**	**69**	**139**	**104**	**104**	**208**
1	Ilocos Norte	357	357	715	536	536	1,072	405	405	810	607	607	1,215
	Ilocos Sur	365	365	731	548	548	1,096	414	414	828	621	621	1,243
	La Union	148	148	297	223	223	445	168	168	337	252	252	505
	Pangasinan	1,645	1,645	3,290	2,468	2,468	4,935	1,864	1,864	3,729	2,796	2,796	5,593
	Total	**2,516**	**2,516**	**5,033**	**3,774**	**3,774**	**7,549**	**2,852**	**2,852**	**5,703**	**4,277**	**4,277**	**8,555**
2	Cagayan	1,032	1,032	2,065	1,548	1,548	3,097	1,170	1,170	2,340	1,755	1,755	3,510
	Isabela	1,558	1,558	3,116	2,337	2,337	4,674	1,765	1,765	3,531	2,648	2,648	5,296
	Nueva Vizcaya	-	-	-	-	-	-	-	-	-	-	-	-
	Quirino	74	74	149	111	111	223	84	84	168	126	126	253
	Total	**2,664**	**2,664**	**5,329**	**3,997**	**3,997**	**7,993**	**3,019**	**3,019**	**6,039**	**4,529**	**4,529**	**9,058**
3	Aurora	279	279	558	419	419	837	316	316	633	474	474	949
	Bataan	179	179	358	269	269	538	203	203	406	305	305	609
	Bulacan	518	518	1,035	776	776	1,553	587	587	1,173	880	880	1,760
	Nueva Ecija	1,291	1,291	2,583	1,937	1,937	3,874	1,463	1,463	2,927	2,195	2,195	4,390
	Pampanga	603	603	1,206	905	905	1,809	683	683	1,367	1,025	1,025	2,050
	Tarlac	1,093	1,093	2,185	1,639	1,639	3,278	1,238	1,238	2,476	1,857	1,857	3,714
	Zambales	441	441	882	662	662	1,323	500	500	1,000	750	750	1,500
	Total	**4,404**	**4,404**	**8,808**	**6,606**	**6,606**	**13,212**	**4,991**	**4,991**	**9,982**	**7,486**	**7,486**	**14,972**

Region	Province	Baseline (ha)						Scenario 1 (ha)					
		NIS			CIS			NIS			CIS		
		New	Res	Tot	New	Res	Tot	New	Res	Tot	New	Res	Tot
CALABAR-ZON	Cavite	370	370	740	555	555	1,110	419	419	839	629	629	1,258
	Laguna	381	381	761	571	571	1,142	431	431	863	647	647	1,294
	Quezon	1,646	1,646	3,292	2,469	2,469	4,938	1,865	1,865	3,731	2,798	2,798	5,596
	Total	**2,397**	**2,397**	**4,794**	**3,595**	**3,595**	**7,190**	**2,716**	**2,716**	**5,432**	**4,074**	**4,074**	**8,148**
MIMAROPA	Occidental Mindoro	73	73	146	109	109	219	83	83	165	124	124	248
	Oriental Mindoro	-	-	-	-	-	-	-	-	-	-	-	-
	Palawan	585	585	1,169	877	877	1,754	663	663	1,325	994	994	1,988
	Total	**658**	**658**	**1,315**	**987**	**987**	**1,973**	**745**	**745**	**1,491**	**1,118**	**1,118**	**2,236**
5	Albay	194	194	388	291	291	581	220	220	439	329	329	659
	Camarines Sur	791	791	1,583	1,187	1,187	2,374	897	897	1,793	1,345	1,345	2,690
	Masbate	1,344	1,344	2,687	2,016	2,016	4,031	1,523	1,523	3,046	2,284	2,284	4,568
	Sorsogon	335	335	671	503	503	1,006	380	380	760	570	570	1,141
	Total	**2,664**	**2,664**	**5,329**	**3,997**	**3,997**	**7,993**	**3,019**	**3,019**	**6,039**	**4,529**	**4,529**	**9,058**
6	Aklan	23	23	46	35	35	69	26	26	52	39	39	79
	Antique	5	5	10	7	7	15	6	6	11	8	8	17
	Capiz	375	375	751	563	563	1,126	425	425	851	638	638	1,276
	Iloilo	719	719	1,438	1,079	1,079	2,157	815	815	1,630	1,222	1,222	2,444
	Negros Occidental	1,388	1,388	2,776	2,082	2,082	4,165	1,573	1,573	3,146	2,360	2,360	4,719
	Total	**2,511**	**2,511**	**5,021**	**3,766**	**3,766**	**7,532**	**2,845**	**2,845**	**5,690**	**4,268**	**4,268**	**8,536**
7	Bohol	657	657	1,314	986	986	1,971	745	745	1,489	1,117	1,117	2,234
	Negros Oriental	385	385	769	577	577	1,154	436	436	872	654	654	1,308
	Total	**1,042**	**1,042**	**2,084**	**1,563**	**1,563**	**3,126**	**1,181**	**1,181**	**2,361**	**1,771**	**1,771**	**3,542**

Region	Province	Baseline (ha)						Scenario 1 (ha)					
		NIS			CIS			NIS			CIS		
		New	Res	Tot	New	Res	Tot	New	Res	Tot	New	Res	Tot
8	Biliran	16	16	31	23	23	47	18	18	35	26	26	53
	Northern Leyte	1,280	1,280	2,561	1,921	1,921	3,841	1,451	1,451	2,902	2,176	2,176	4,353
	Southern Leyte	55	55	109	82	82	164	62	62	124	93	93	186
	Samar Western	544	544	1,087	816	816	1,631	616	616	1,232	924	924	1,848
	Total	**1,894**	**1,894**	**3,788**	**2,841**	**2,841**	**5,683**	**2,147**	**2,147**	**4,293**	**3,220**	**3,220**	**6,440**
9	Zamboanga Del Sur	563	563	1,125	844	844	1,688	638	638	1,275	956	956	1,913
	Zamboanga Sibugay	469	469	938	704	704	1,407	532	532	1,063	797	797	1,595
	Total	**1,032**	**1,032**	**2,063**	**1,548**	**1,548**	**3,095**	**1,169**	**1,169**	**2,338**	**1,754**	**1,754**	**3,507**
10	Bukidnon	968	968	1,936	1,452	1,452	2,904	1,097	1,097	2,194	1,645	1,645	3,290
	Lanao Del Norte	501	501	1,002	751	751	1,502	567	567	1,135	851	851	1,702
	Misamis Occidental	363	363	725	544	544	1,088	411	411	822	616	616	1,233
	Misamis Oriental	352	352	704	528	528	1,056	399	399	798	599	599	1,197
	Total	**2,183**	**2,183**	**4,367**	**3,275**	**3,275**	**6,550**	**2,474**	**2,474**	**4,949**	**3,711**	**3,711**	**7,423**
11	Compostela Valley	407	407	814	610	610	1,221	461	461	922	692	692	1,383
	Davao Del Norte	721	721	1,441	1,081	1,081	2,162	817	817	1,633	1,225	1,225	2,450
	Davao Del Sur	602	602	1,204	903	903	1,806	682	682	1,365	1,023	1,023	2,047
	Davao Oriental	385	385	770	578	578	1,156	436	436	873	655	655	1,309
	Total	**2,115**	**2,115**	**4,229**	**3,172**	**3,172**	**6,344**	**2,396**	**2,396**	**4,793**	**3,595**	**3,595**	**7,189**

Region	Province	Baseline (ha)						Scenario 1 (ha)					
		NIS			CIS			NIS			CIS		
		New	Res	Tot	New	Res	Tot	New	Res	Tot	New	Res	Tot
12	North Cotabato	1,167	1,167	2,334	1,750	1,750	3,501	1,322	1,322	2,645	1,984	1,984	3,967
	Sarangani	-	-	-	-	-	-	-	-	-	-	-	-
	South Cotabato	689	689	1,379	1,034	1,034	2,068	781	781	1,562	1,172	1,172	2,343
	Sultan Kudarat	471	471	941	706	706	1,412	533	533	1,066	800	800	1,600
	Total	**2,327**	**2,327**	**4,654**	**3,490**	**3,490**	**6,980**	**2,637**	**2,637**	**5,274**	**3,955**	**3,955**	**7,910**
13	Agusan Del Norte	335	335	671	503	503	1,006	380	380	760	570	570	1,140
	Agusan Del Sur	841	841	1,681	1,261	1,261	2,522	953	953	1,905	1,429	1,429	2,858
	Surigao Del Sur	572	572	1,143	858	858	1,715	648	648	1,296	972	972	1,944
	Total	**1,748**	**1,748**	**3,495**	**2,622**	**2,622**	**5,243**	**1,981**	**1,981**	**3,961**	**2,971**	**2,971**	**5,942**
ARMM	Lanao Del Sur	188	188	377	283	283	565	214	214	427	320	320	641
	Maguindanao	1,401	1,401	2,802	2,102	2,102	4,204	1,588	1,588	3,176	2,382	2,382	4,764
	Total	**1,590**	**1,590**	**3,179**	**2,384**	**2,384**	**4,769**	**1,801**	**1,801**	**3,603**	**2,702**	**2,702**	**5,404**

Table 4.44. Area per System per Province per Scenario in the Long-term Based on GIS Irrigable Area

Region	Province	Baseline (ha)						Scenario 1 (ha)					
		NIS			CIS			NIS			CIS		
		New	Res	Tot	New	Res	Tot	New	Res	Tot	New	Res	Tot
1	Ilocos Norte	3,040	635	3,675	4,559	953	5,512	3,826	388	4,214	5,739	582	6,321
	Ilocos Sur	1,433	300	1,732	2,149	449	2,599	1,804	183	1,987	2,706	274	2,980
	La Union	675	141	816	1,012	212	1,224	850	86	936	1,274	129	1,404
	Pangasinan	5,700	1,191	6,891	8,550	1,787	10,337	7,175	728	7,902	10,762	1,091	11,853
	Total	**10,848**	**2,267**	**13,115**	**16,271**	**3,401**	**19,672**	**13,654**	**1,385**	**15,038**	**20,481**	**2,077**	**22,558**
2	Cagayan	7,258	1,517	8,775	10,887	2,276	13,163	9,136	926	10,062	13,704	1,390	15,094
	Isabela	4,764	996	5,760	7,146	1,494	8,640	5,996	608	6,605	8,995	912	9,907
	Total	**12,022**	**2,513**	**14,535**	**18,033**	**3,769**	**21,803**	**15,132**	**1,535**	**16,667**	**22,699**	**2,302**	**25,000**
3	Aurora	87	18	105	131	27	158	110	11	121	165	17	181
	Bataan	722	151	873	1,084	226	1,310	909	92	1,001	1,364	138	1,502
	Bulacan	821	172	993	1,232	258	1,490	1,034	105	1,139	1,551	157	1,708
	Nueva Ecija	914	191	1,105	1,371	287	1,658	1,151	117	1,267	1,726	175	1,901
	Pampanga	4,794	1,002	5,796	7,191	1,503	8,694	6,034	612	6,646	9,051	918	9,969
	Tarlac	6,157	1,287	7,444	9,236	1,931	11,166	7,750	786	8,536	11,625	1,179	12,804
	Zambales	3,351	700	4,051	5,026	1,051	6,076	4,217	428	4,645	6,326	642	6,968
	Total	**16,847**	**3,521**	**20,368**	**25,270**	**5,282**	**30,552**	**21,205**	**2,150**	**23,355**	**31,808**	**3,226**	**35,033**
CALABAR-ZON	Cavite	1,723	360	2,083	2,585	540	3,125	2,169	220	2,389	3,253	330	3,583
	Laguna	694	145	839	1,040	217	1,258	873	89	962	1,310	133	1,442
	Quezon	1,233	258	1,491	1,850	387	2,237	1,552	157	1,710	2,329	236	2,565
	Total	**3,650**	**763**	**4,413**	**5,475**	**1,144**	**6,619**	**4,594**	**466**	**5,060**	**6,891**	**699**	**7,590**
MIMAROPA	Palawan	1,329	278	1,606	1,993	417	2,410	1,672	170	1,842	2,509	254	2,763
	Total	**1,329**	**278**	**1,606**	**1,993**	**417**	**2,410**	**1,672**	**170**	**1,842**	**2,509**	**254**	

Region	Province	Baseline (ha)						Scenario 1 (ha)					
		NIS			CIS			NIS			CIS		
		New	Res	Tot	New	Res	Tot	New	Res	Tot	New	Res	Tot
5	Camarines Sur	6,297	1,316	7,613	9,445	1,974	11,420	7,926	804	8,730	11,889	1,206	13,095
	Masbate	1,215	254	1,469	1,823	381	2,204	1,529	155	1,685	2,294	233	2,527
	Sorsogon	859	179	1,038	1,288	269	1,557	1,081	110	1,191	1,621	164	1,786
	Total	**8,371**	**1,750**	**10,120**	**12,556**	**2,625**	**15,181**	**10,536**	**1,068**	**11,605**	**15,804**	**1,603**	**17,407**
6	Capiz	1,918	401	2,319	2,877	601	3,478	2,414	245	2,659	3,621	367	3,988
	Iloilo	3,907	817	4,723	5,860	1,225	7,085	4,917	499	5,416	7,376	748	8,124
	Negros Occiden-tal	1,360	284	1,644	2,040	426	2,467	1,712	174	1,886	2,568	260	2,828
	Total	**7,184**	**1,502**	**8,686**	**10,777**	**2,253**	**13,029**	**9,043**	**917**	**9,960**	**13,564**	**1,376**	**14,940**
7	Bohol	1,461	305	1,767	2,192	458	2,650	1,839	187	2,026	2,759	280	3,038
	Negros Oriental	909	190	1,099	1,363	285	1,648	1,144	116	1,260	1,716	174	1,890
	Total	**2,370**	**495**	**2,865**	**3,555**	**743**	**4,298**	**2,983**	**302**	**3,285**	**4,474**	**454**	**4,928**
8	Northern Leyte	3,117	651	3,768	4,675	977	5,652	3,923	398	4,321	5,885	597	6,482
	Southern Leyte	642	134	777	963	201	1,165	808	82	890	1,213	123	1,336
	Samar Western	1,292	270	1,563	1,939	405	2,344	1,627	165	1,792	2,440	247	2,688
	Total	**5,052**	**1,056**	**6,107**	**7,577**	**1,584**	**9,161**	**6,358**	**645**	**7,003**	**9,538**	**967**	**10,505**
9	Zamboanga Del Sur	1,619	338	1,958	2,429	508	2,937	2,038	207	2,245	3,057	310	3,368
	Zamboanga Sibugay	577	121	698	866	181	1,047	727	74	800	1,090	111	1,200
	Total	**2,197**	**459**	**2,656**	**3,295**	**689**	**3,984**	**2,765**	**280**	**3,045**	**4,147**	**421**	**4,568**

Region	Province	Baseline (ha)						Scenario 1 (ha)					
		NIS			CIS			NIS			CIS		
		New	Res	Tot	New	Res	Tot	New	Res	Tot	New	Res	Tot
10	Bukidnon	2,741	573	3,314	4,112	859	4,971	3,450	350	3,800	5,176	525	5,700
	Lanao Del Norte	1,687	353	2,039	2,530	529	3,059	2,123	215	2,339	3,185	323	3,508
	Misamis Occi-dental	949	198	1,148	1,424	298	1,721	1,195	121	1,316	1,792	182	1,974
	Misamis Oriental	1,113	233	1,345	1,669	349	2,018	1,401	142	1,543	2,101	213	2,314
	Total	**6,490**	**1,357**	**7,847**	**9,735**	**2,035**	**11,770**	**8,169**	**828**	**8,998**	**12,254**	**1,243**	**13,496**
11	Compostela Valley	942	197	1,139	1,413	295	1,709	1,186	120	1,306	1,779	180	1,959
	Davao Del Norte	1,453	304	1,757	2,180	456	2,635	1,829	185	2,015	2,744	278	3,022
	Davao Del Sur	780	163	943	1,170	245	1,414	982	100	1,081	1,473	149	1,622
	Davao Oriental	1,213	253	1,466	1,819	380	2,199	1,526	155	1,681	2,289	232	2,522
	Total	**4,388**	**917**	**5,305**	**6,582**	**1,376**	**7,958**	**5,523**	**560**	**6,083**	**8,285**	**840**	**9,125**
12	North Cotabato	1,056	221	1,277	1,584	331	1,915	1,329	135	1,464	1,994	202	2,196
	South Cotabato	621	130	751	932	195	1,126	782	79	861	1,173	119	1,292
	Sultan Kudarat	1,784	373	2,157	2,676	559	3,235	2,245	228	2,473	3,368	342	3,710
	Total	**3,461**	**723**	**4,184**	**5,191**	**1,085**	**6,276**	**4,356**	**442**	**4,798**	**6,534**	**663**	**7,197**
13	Agusan Del Norte	1,240	259	1,500	1,860	389	2,249	1,561	158	1,720	2,342	237	2,579
	Agusan Del Sur	3,031	634	3,665	4,546	950	5,497	3,815	387	4,202	5,723	580	6,303
	Surigao Del Sur	2,556	534	3,091	3,834	801	4,636	3,218	326	3,544	4,826	489	5,316
	Total	**6,828**	**1,427**	**8,255**	**10,241**	**2,141**	**12,382**	**8,594**	**871**	**9,465**	**12,891**	**1,307**	**14,198**
ARMM	Lanao Del Sur	3,151	659	3,810	4,726	988	5,714	3,966	402	4,368	5,949	603	6,552
	Maguindanao	2,647	553	3,200	3,970	830	4,800	3,331	338	3,669	4,997	507	5,504
	Total	**5,797**	**1,212**	**7,009**	**8,696**	**1,818**	**10,514**	**7,297**	**740**	**8,037**	**10,946**	**1,110**	**12,056**

For visual appreciation of the geospatial concentration of the PIP projects in the country, heat maps of all PIP projects, priority provinces, and all priority projects are presented in Figures 4.17 to 4.19.

Figure 4.17. Heat Map of PIP Projects

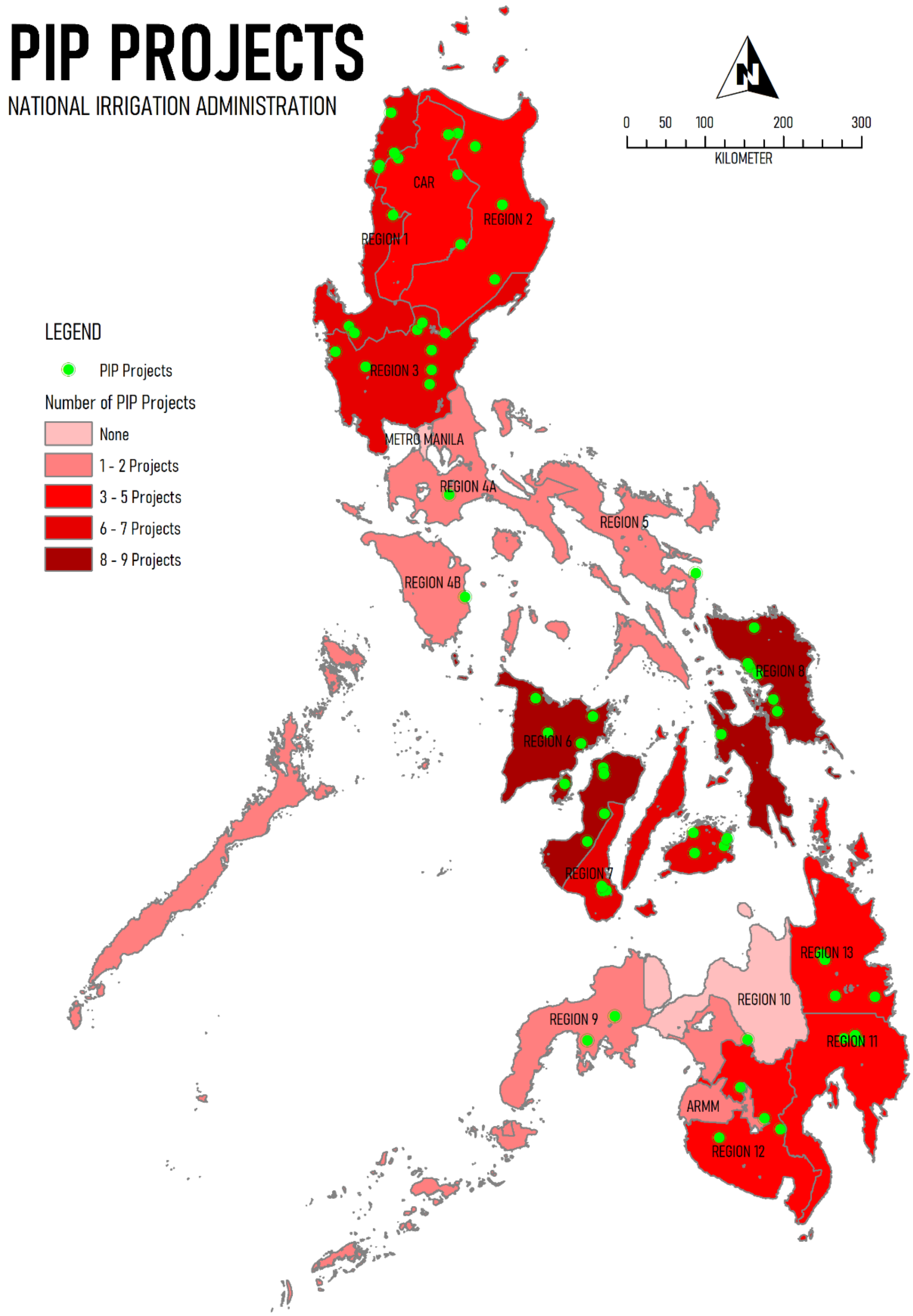


Figure 4.18. Map of 57 Priority Provinces

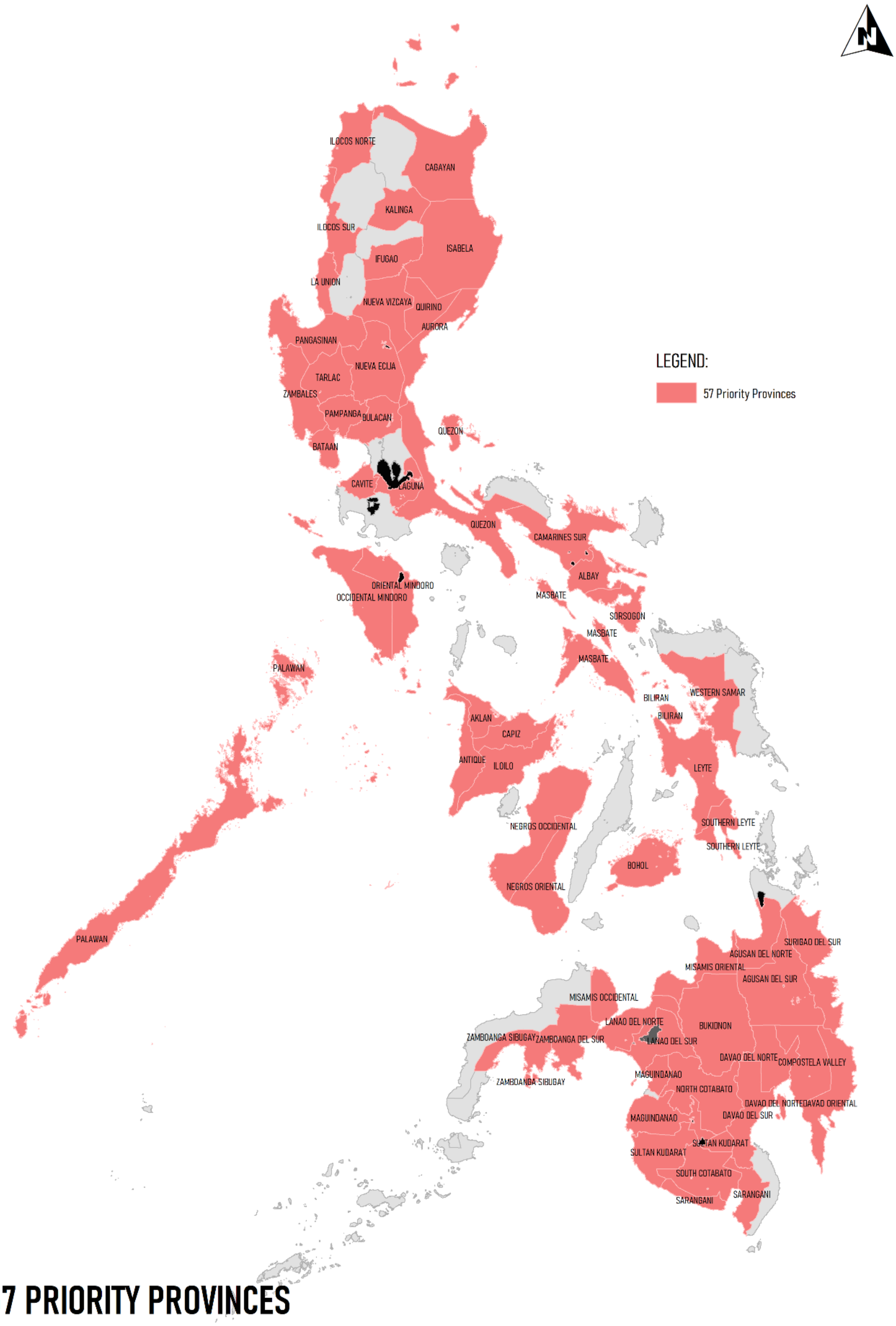
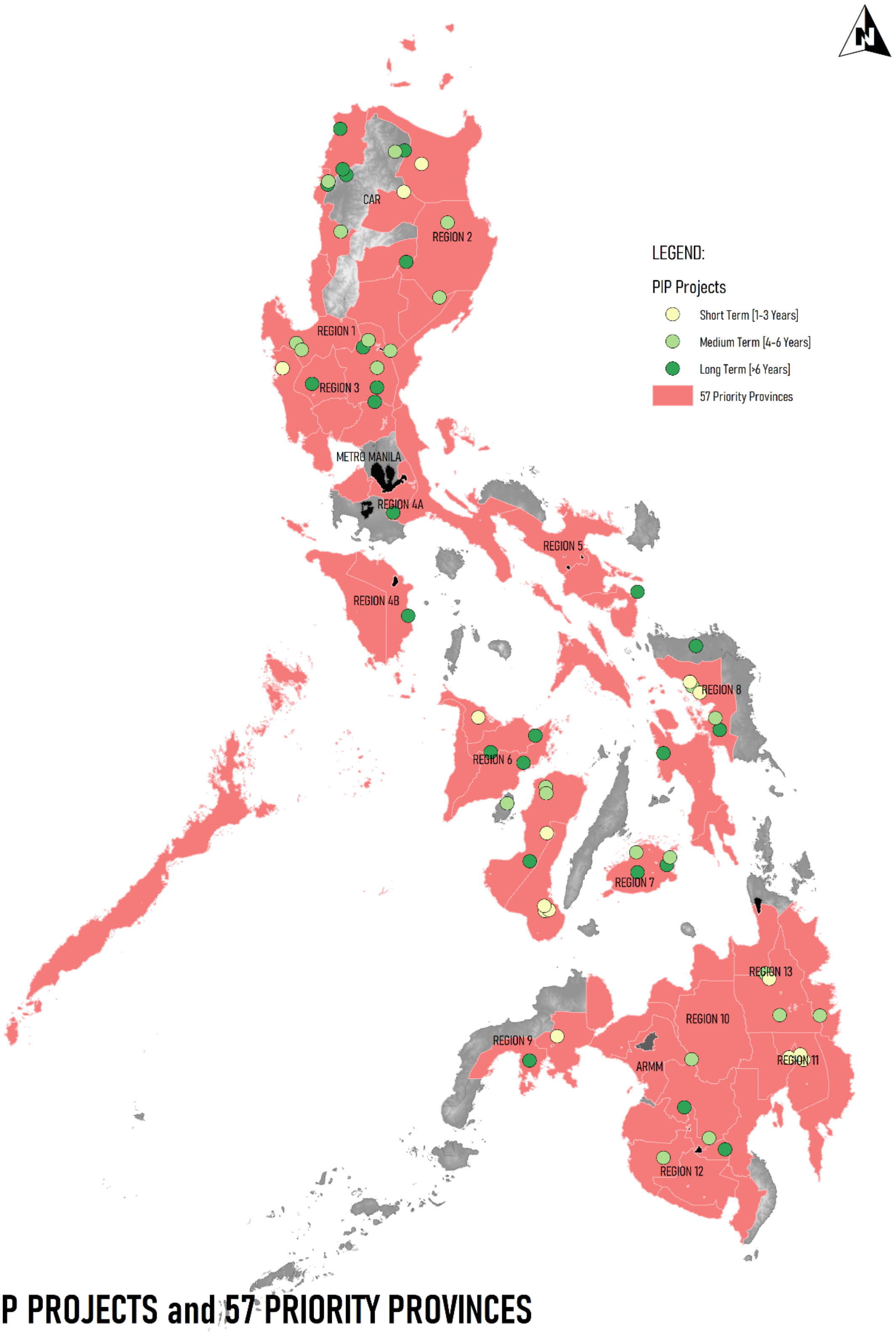


Figure 4.19. Map of All Priority Projects



The corresponding budgetary requirements for all irrigation projects are presented in Section 4.15. The timeline of irrigation investment program for both prioritized PIP and non-PIP projects is shown in Table 4.45.

Table 4.45. Gantt Chart for Irrigation Investment (2020 to 2030)

Period	Project	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Short term	Public Investment Projects (PIP)											
	Non-PIP Investment Activities											
Medium term	Public Investment Projects (PIP)											
	Non-PIP Investment Activities											
Long term	Public Investment Projects (PIP)											
	Non-PIP Investment Activities											

4.9. Maintenance Enhancement and Operation Plan of Irrigation Systems

In this master plan, two approaches are considered in maintenance enhancement and operation plan of irrigation systems. The first approach is the combined approach using farmland GIS, asset management and WDD, while the second approach is by using design logic framework and FAO-based MASSCOTTE approach.

4.9.1. Maintenance Enhancement and Operation Plan Using Farmland GIS, Asset Management, and Water Distribution and Delivery Approach

To address the O&M issues in national irrigation systems, a 4-year project was implemented from 2013-2017 through the NIA-JICA TCP3 to adopt improved O&M system in national irrigation systems (NIA 2017a). These involved reviewing existing O&M management methods, practices and monitoring systems, and proposing methods and strategic plans for improved O&M system. During the baseline survey in the project, some of the common issues found were: 1) outdated basic information of farmers and farmlands, 2) many discrepancies of data between NIA database and actual farm, 3) many lost data due to flood, fire and other reasons, 4) unrepaired damages of irrigation facilities, 5) existing of illegal turnouts, 6) inequitable water distribution and lower areas were not getting water, and 7) several canals were not constructed according to its design. From this baseline survey, three main activities were implemented by the TCP3 in selected pilot sites such as 1) farmland GIS, 2) asset management, and 3) WDD. These activities can be adopted in other national irrigation systems in the country.

Farmland GIS

The establishment of FGIS in each NIS is useful to minimize data accuracy issues and therefore improve the actual distribution of water, farming plan and others.

In developing the FGIS, parcellary map preparation, data validation and geotagging of irrigation facilities are critical steps. Accurate and precise parcellary maps can be prepared with the aid of modern technologies for accurate mapping such as use of satellite images or images captured by unmanned aerial vehicle (UAV) such as drones. Data validation is an integral part of parcellary mapping to ensure that the delineation and information attached to the parcel are correct and current. Data validation will be based on the following criteria (NIA 2017a):

- Data accuracy (how the data were created based on the satellite or drone images)
- Data precision (if the data created is based on the required specification)
- Data completeness (if farmland boundaries are completely created based on the satellite/drone images as well as the attributes that goes with it as required)
- Attribute verification (database structure, domain values and field population)
- Topological errors (dangles, switchbacks, knots, loops, overshoots, undershoots and silver)

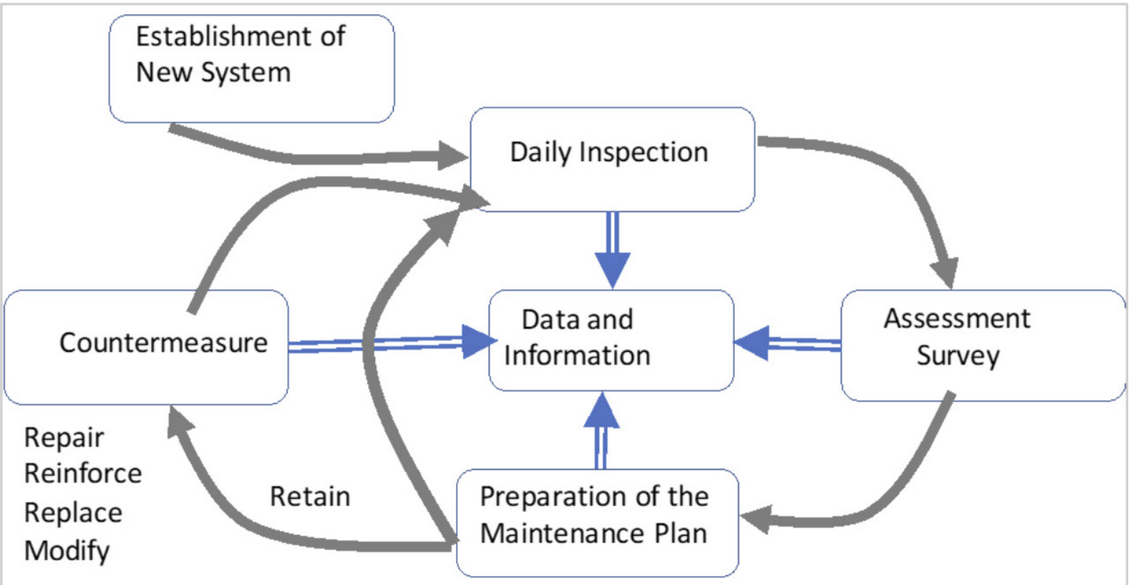
The current customized FGIS software was developed by Pasco Philippine Consultant through the TCP3, which comprised a database module to manage records and generates reports for each system, and a mapping management module that allows the users to interact with map like viewing of information and the creation of different thematic layers for analysis. In each module, farm administration system (FAS), AMS and WDD, and other essential data of NIS were incorporated. The FAS is the system responsible for managing information of farmland (i.e., parcel, landowner, farmer, etc.), while Asset Management System (AMS) is responsible for managing assets of irrigation facilities. The WDD is responsible for the water scheduling and monitoring. To ensure that data are available only to authorized uses, a user management faction was also created. The user management is responsible for adding users of the system, for controlling the access level and user's right to the data.

Asset Management

Asset management is a management method that considers financial, economic, social, and engineering condition to maintain the function of irrigation system in the most cost-effective manner. The concept of maintenance management is shown in Figure 4.20. It is important to develop a long-term maintenance plan and carry out countermeasure work after investigation and analysis of the problems and degradation situation of irrigation facilities by daily inspection and period survey. This preventive maintenance method can reduce the maintenance and life cycle cost of the facilities. Compared with breakdown maintenance method, the risks such as suspension of water supply or damage to a third property (secondary disaster) caused by sudden and unexpected accidents are low.

To prepare a maintenance plan of the system, the concept of asset management in the conduct of survey and assessment of the system is needed. The first process of asset management is the preparation process, where gathering of data, survey and assessment of irrigation facilities for a given system are undertaken. The next process is the maintenance plan, including the formulation of the countermeasures.

Figure 4.20. Concept of Maintenance Management



Source: NIA, 2017a

Assessment Survey

During the assessment survey of the irrigation facilities, the use of all technical data and information available are a necessity. These technical data include the latest layout map and irrigation network diagram indicating canal systems, canal structures, drainage systems and protection works, design drawings (built plans), and data on latest repair and rehabilitation work. The O&M data include the history of the diversion dam and the water source, and past repair and restoration works. Likewise, O&M data available on mechanical equipment are also needed.

The survey of irrigation facilities can be done using inspection tools (i.e., steel tape for taking dimensions of structures, caliper or ruler for measuring widths of gaps and cracks, ball peen hammer for determining cavities in concrete works particularly behind lining walls, rebound hammer for testing compressive strength of concrete, laser distance meter for taking distance measurement, and camera with GPS for taking pictures) and ocular or visual inspections on any defects and malfunctions of the structures.

The dam features including the dam main body, sluiceway, intake, upstream and downstream protection works, dikes and gates shall be checked against the as-built plan. In particular, more attention will be given to the following especially for diversion dams: sedimentation in the upstream of the dam, abrasion, cracks, separation and breakdown of concrete on the piers and retaining walls, compressive strength of concrete of pier and retaining walls, scouring and degradation of the river bed just after the downstream apron, guide banks erosion, conditions of various gates, conditions of gate's lifting mechanism and overall condition of the dam's mechanical system.

For the irrigation canals, the inventory survey should include the following: sedimentation along the canal, abrasion and cracks of concrete lining, erosion and scouring of canal and canal embankment, cracks and abrasions on canal structures such as head gate, conditions of steel gates and other mechanism, and complete inventory of canal structures to include illegal turnouts along the main and lateral canal.

For the pump system, motor or engines, an inventory checked on specifications of motors and pumps, rated versus actual performance on power and discharge, the condition of the pump and engine foundation, electrical wiring, and condition of the pump house should be taken. For the pump system, particular attention shall be given to the following: condition of the pump sets and the ancillary facilities, erosion/scouring and sedimentation at the intake channel and pump sump, condition of trash racks and other protection works, sedimentation of regulating pond, condition of the spillways, and floating debris at intake channel and other ancillary facilities.

For the survey and assessment, check lists for each facility should be used (example check lists can be found in NIA, 2017a), and should attain the objective assessment of the current degradation level of each facility. The assessment information obtained by survey is fundamental to preparation for a long-term maintenance plan.

Development of Maintenance Plan

The outputs of the field assessment survey shall be organized, tabulated, and categorized based on the importance of facilities, and soundness or stability of structure and its functional performance.

Table 4.46 presents the criterion of ranking according to the importance of facilities. The irrigation facility that is most crucial or important for the system or with a very high risk of secondary disasters due to facility damage should be prioritized for repair or replacement. For example, reservoir dam, diversion dam, head gate of main canal, and main canal traversing residential areas or highways should be recommended to be ranked "A". As the importance of influence of the irrigation facility in the system decreases, the ranking also decreases. However, the facility manager can also decide the rank considering the situation in the area.

Facility assessment survey is an important process to understand the current situation of irrigation facilities, and to obtain basic information for maintenance planning. Table 4.47 shows the classification of soundness of facility into five stages, and the appropriate technical countermeasure according to each stage. Based on the results of the facility survey and assessment, maintenance plan for each facility should indicate if countermeasure is necessary, and appropriate methods of the countermeasure and implementation schedule should be decided. The priority of countermeasure work will be decided based on Table 4.48. The facility with degradation level of stage 5 or stage 3-4, with importance rank of A, will be the top priority. These facilities should, therefore, be repaired or replaced immediately.

Table 4.46. Criterion of Ranking According to Importance of Facilities

Rank	Description
A	The irrigation facility that is one of the most important part for the system. If the facility is damaged, it affects the entire system. Or, the irrigation facility with a very high risk of secondary disasters due to facility damage. Preferential countermeasures are necessary.
B	The irrigation facility that is the important part of the system. If the facility is damaged, it affects the other part of the system. Or, the irrigation facility with a high risk of secondary disasters due to facility damage
C	The importance of facilities and the influence on the facilities are lower than those of Rank A and B. The risk of secondary disaster is low

Source: NIA, 2017a

Table 4.47. Classification of Soundness of Facility

Stage	Definition of Condition	Countermeasure
1	Almost no problem observed	Retain
2	Slight problem observed	Retain
3	Severe problems observed	Repair
4	Striking problems that may affect the structural safety of the facility observed	Repair (reinforce)
5	Striking problems that the structural safety if the facility observed. There is a high risk that the facility will lose its function or cause damage on a third party. Does not meet the desired dimensions and functionality to serve the command area as per design	Replace Modify

Source: NIA, 2017a

Table 4.48. Priority of Countermeasure Work

Priority	Degradation Level	Importance Rank
1 (Immediately)	Stage 5	All rank
	Stage 3-4	Rank A
2	Stage 3-4	Rank B
3	Stage 3-4	Rank C

Source: NIA, 2017a

Water Distribution and Delivery

In order to optimize the use of limited irrigation especially during dry seasons, an effective WDD plan is needed. The WDD plan provides guidance for proper and adequate diversion, delivery and distribution of irrigation water from the source (i.e., main canal head gate) to the lowest control points (i.e., turnout gates) to achieve timely and adequate irrigation applications at irrigation area (NIA, 2017a). The overall canal network make-up, cropping and farming schedules, and institutional arrangements, usually are the bases on how the irrigation shall be planned and managed in the system. With farmers' consent, the WDD plan regulates the schedule for each turnout based on accurate data. Proper monitoring of the implementation of WDD plan should be undertaken.

WDD Scheme in National Irrigation Systems

The most common scheme of irrigation delivery and distribution is by starting upstream then midstream, and downstream. This means that farmers near the source irrigates first, and areas at the downstream irrigate last.

Management of irrigation water delivery and distribution in an irrigation system is jointly undertaken by the field staff of the agency's Irrigation Systems Office (ISO) and the officers of the IA. The direct participation of IAs in the management of the irrigation systems is in accordance with the IMT program of NIA. Generally, ISO manages the main facilities and structures and control structures at secondary canals. In case of medium to large NIS, the Federation manages the secondary facilities and control structures at lower levels (sub-lateral, sub-sub-laterals and turnout gates) for medium to large NIS, while the IAs manages these facilities for medium to small NIS.

Farming Information

Cropping pattern, cropping calendar, and planting pattern provides key data and information in determining the way WDD will be initiated at the irrigation, how the service area will be planted, and how irrigation within the irrigated area are undertaken periodically until the completion of the irrigation period.

Cropping pattern refers to an orderly sequence and a logical combination of planting crops in a contiguous irrigated area during a 365-day calendar year of crop farming (wet season–dry season sequence). The cropping schemes can be the following: 1) one crop follows immediately after the preceding crop has been harvested, and so on; 2) two or more crops are simultaneously grown in the contiguous area during a particular season of the year. The first scheme is also referred as crop sequence, while the second scheme as crop combination. For instance, the cropping sequence and combination can be rice-rice, rice-diversified crops (non-rice crops such as vegetables, corn and/or mungbean), and rice-rice/diversified crops-diversified crops, etc.

Cropping calendar refers to the period of planting and irrigation (including land preparation, expected terminal irrigation and harvest of crop) in the whole irrigation service area in a crop year cycle. It provides the basis for the start and end of irrigation diversion from the source.

WDD Technical Guidelines

The WDD plan should be created and implemented based on the capability of the system, required water and beneficiary impartiality. Thus, the preparation of a detailed WDD plan that considers technical information (capability of the system and amount of water required) would result in effective delivery and distribution of the irrigation water in the service area. This WDD plan is based on the water balance analysis as described in the technical guidelines of WDD activity found in WDD manual (NIA, 2017b). The design of an irrigation system is based on the water requirement of the service area, and the system should be able to supply the required irrigation for different stages (e.g., land soaking, land preparation, transplanting and crop maintenance).

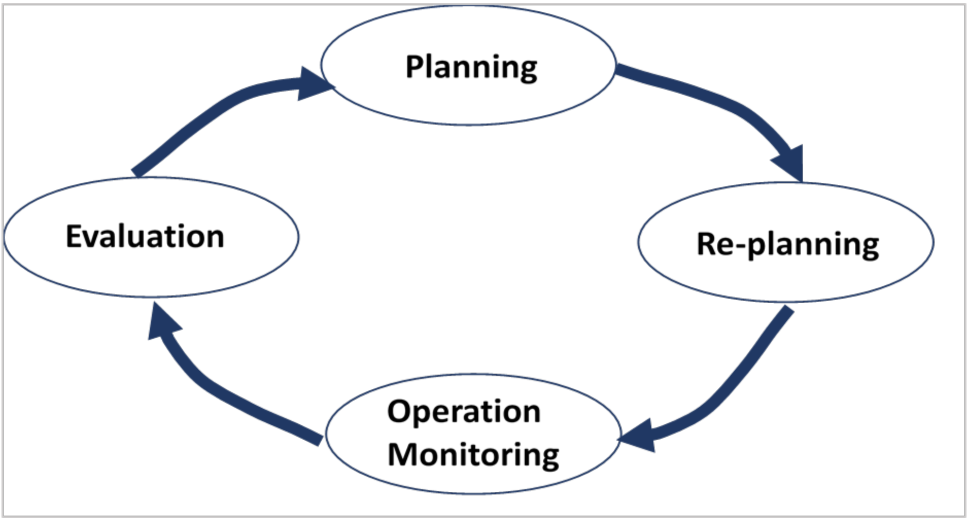
To calculate the water requirement needed to be supplied by the irrigation system by using water balance analysis, collecting key information such as climatological (i.e., rainfall, evaporation and evapotranspiration), hydrological (i.e., river flow discharge), water management parameters (i.e., seepage, percolation losses, farm waste and farm ditch losses in each irrigation units), and farming information (i.e., crop variety used, total area planted) is necessary. Actual discharge at diversion works should also be determined using acceptable flow measurement methods. Rating curves (head – discharge or H-Q curve) should also be established at the diversion points to facilitate discharge determination during operation.

Management Cycle of WDD

Figure 4.21 shows the management cycle of WDD adopted by NIA under TCP3. WDD plan should be compatible with the design capacity, and therefore it is important that the design of the irrigation system is well understood. In the planning stage, the required amount per hectare for each cropping stage must be determined using acceptable methodologies and considerations to attain equitable and fair allocation of water to beneficiaries. Before the implementation, WDD schedules must be cascaded properly to the people (i.e., gate keepers) who will be involved in the water diversion, delivery and distribution of irrigation to the end-users.

Once implemented, gate keepers should operate the system in accordance with the plan and monitor the actual situation of operation and farming activity. WDD plans need to be revised if problems happen or there are some deviations between the plan and actual condition during WDD implementation. At the end of the irrigation season, the WDD plan will be evaluated to determine the problems encountered with the plan vis-à-vis operation and farming. This will provide input in the improvement of the WDD plan of the next cropping season (NIA, 2017b).

Figure 4.21. Management Cycle of WDD



Source: NIA, 2017a

Capacity Building of NIA Staff

Regular training programs (i.e., FGIS, asset management, WDD) should be provided to NIA staff involved in the O&M activities of the irrigations systems. These will help them develop and strengthen their skills to carry out O&M activities specific for their respective systems.

4.9.2. Modernizing National Irrigation Systems Using Design Logic Framework and MASSCOTE Approach

The general methodology for the development of a modernization plan includes (a) diagnostic assessment of the irrigation system design and performance; (b) revalidation of design assumptions; (c) characterization of system management, services and demand to identify modernization potentials; and (d) formulation and identification of options and visions for the development of system modernization plan.

A preliminary analysis, which is deemed relevant before the conduct of the general methodology, involves the cross examination of all the previous rehabilitation and improvement efforts in the system, including the nature and impacts of such, carried out to attain specific performance targets. Such analysis would give light as to which measures had been non-effective and those that have potentials for improving the irrigation system. For the diagnostic assessment, it comprises of two parts:

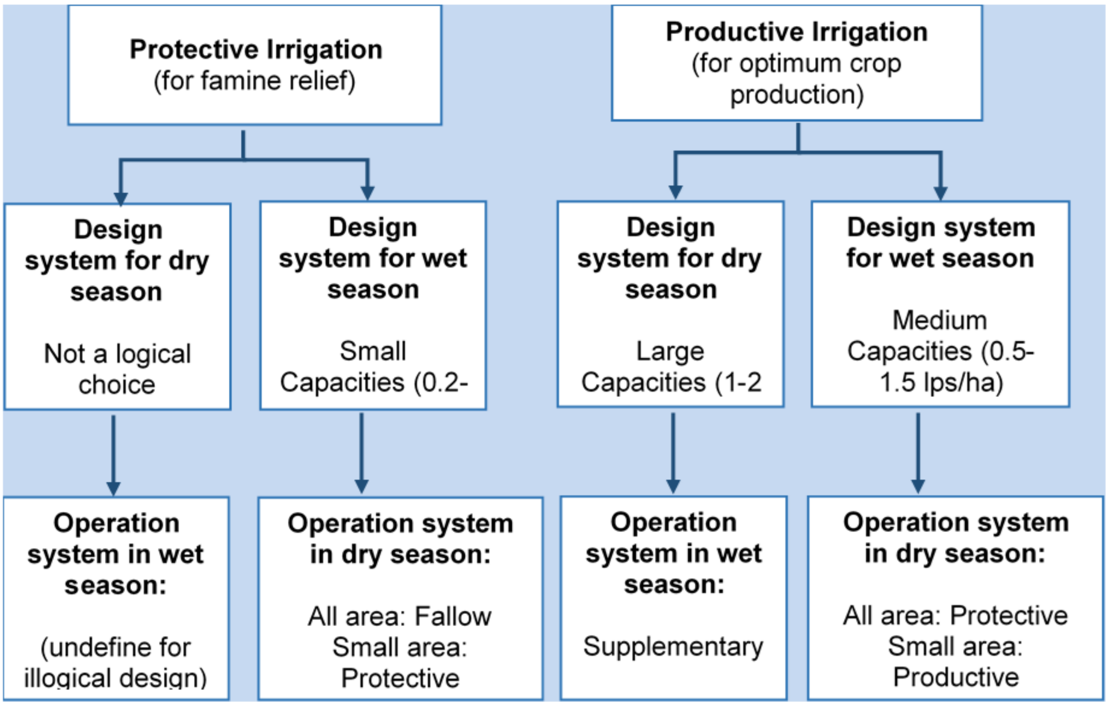
1. Critical analysis of the logical coherence of philosophy, system's overall and operational objectives and designs of physical structures using the design logic framework by Ankum (2001) cited by Delos Reyes (2017); and

2. Site investigation of current irrigation system condition using the initial three steps of MASSCOTE:

a. Rapid Appraisal Procedure (RAP)
b. Capacity and Sensitivity Assessment
c. Perturbation Analysis

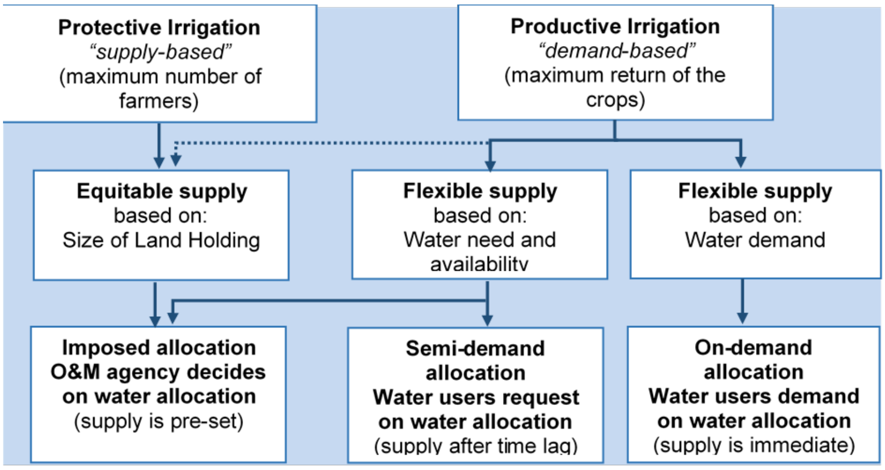
First is the identification, distinction, and consistency examination of the overall objectives as well as the operational objectives of the system. Overall system objectives include concepts of (1) protective or "supply-based" irrigation and productive or "demand-based" irrigation; (2) equitable supply and flexible supply; (3) design irrigation season (e.g., wet, dry); etc. Figures 4.22 and 4.23 present frameworks for determining the system's overall objectives while Figure 4.24 shows the framework for the three parameters that define the operational objectives.

Figure 4.22. Framework for Determining Season of An Irrigation System



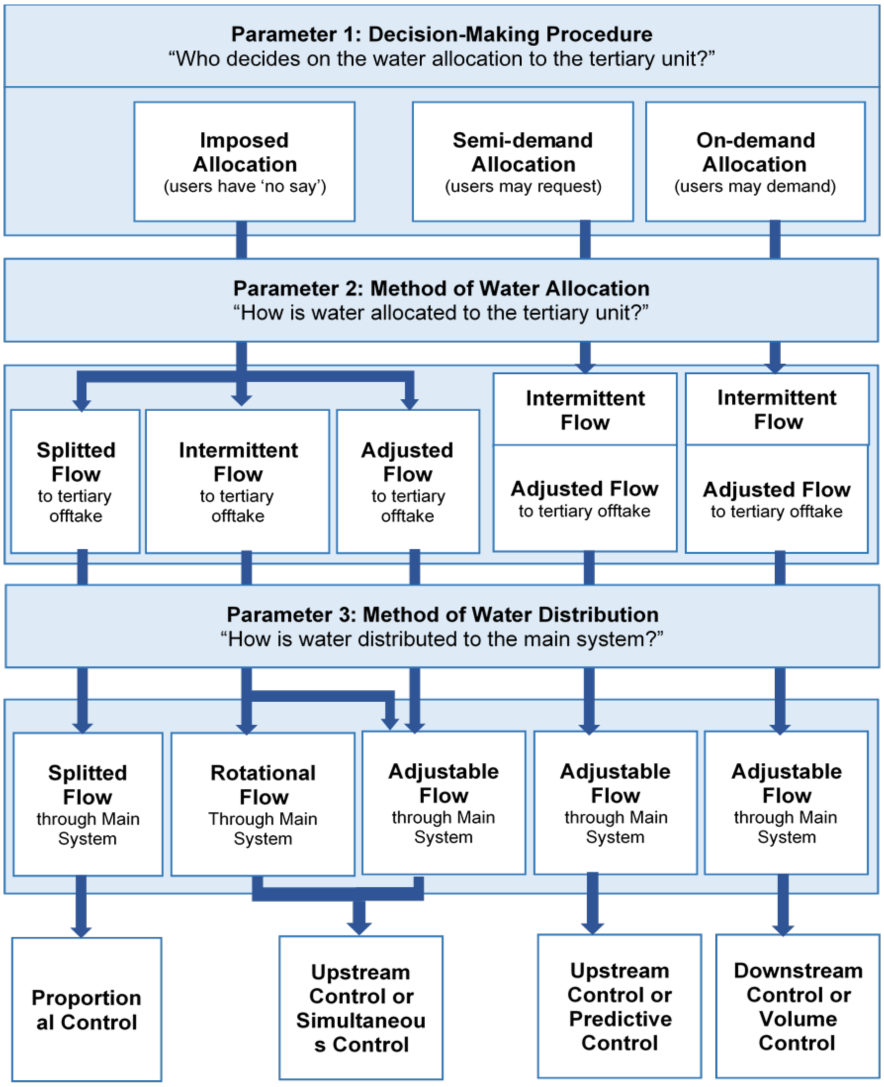
Source: Ankum, 2001 (adopted from Delos Reyes, 2017)

Figure 4.23. Framework for Equitable and Flexible Supply and Decision-making Procedure of an Irrigation System



Source: Ankum, 2001 (adopted from Delos Reyes, 2017)

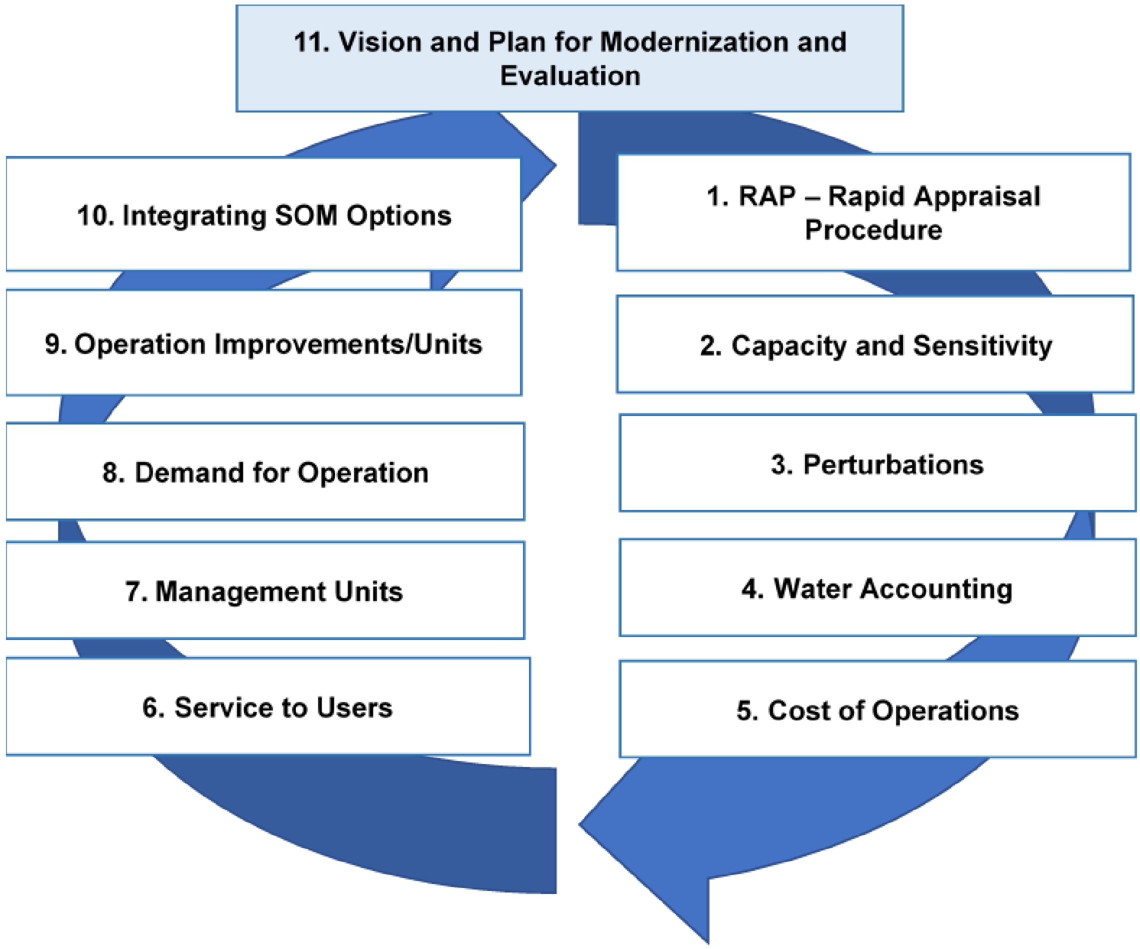
Figure 4.24. Relation Between Parameters of Operational Objectives and Logical Choices for Flow Control Methods



Source: Ankum, 2001 (adopted from Delos Reyes, 2017)

Second is the application of the MASSCOTE approach. which was developed by FAO for crafting modernization plans of irrigation systems whose underperformance mainly rooted from canal operation issues. MASCOTTE has been used in developing modernization plans for implementation as part of investment projects and programs in many countries (i.e. WB and ADB funded projects in China, India, Kyrgyzstan, Morocco, Pakistan, Sri Lanka, Viet Nam), capacity development and as research tool. The overall MASSCOTE framework is presented in Figure 4.25.

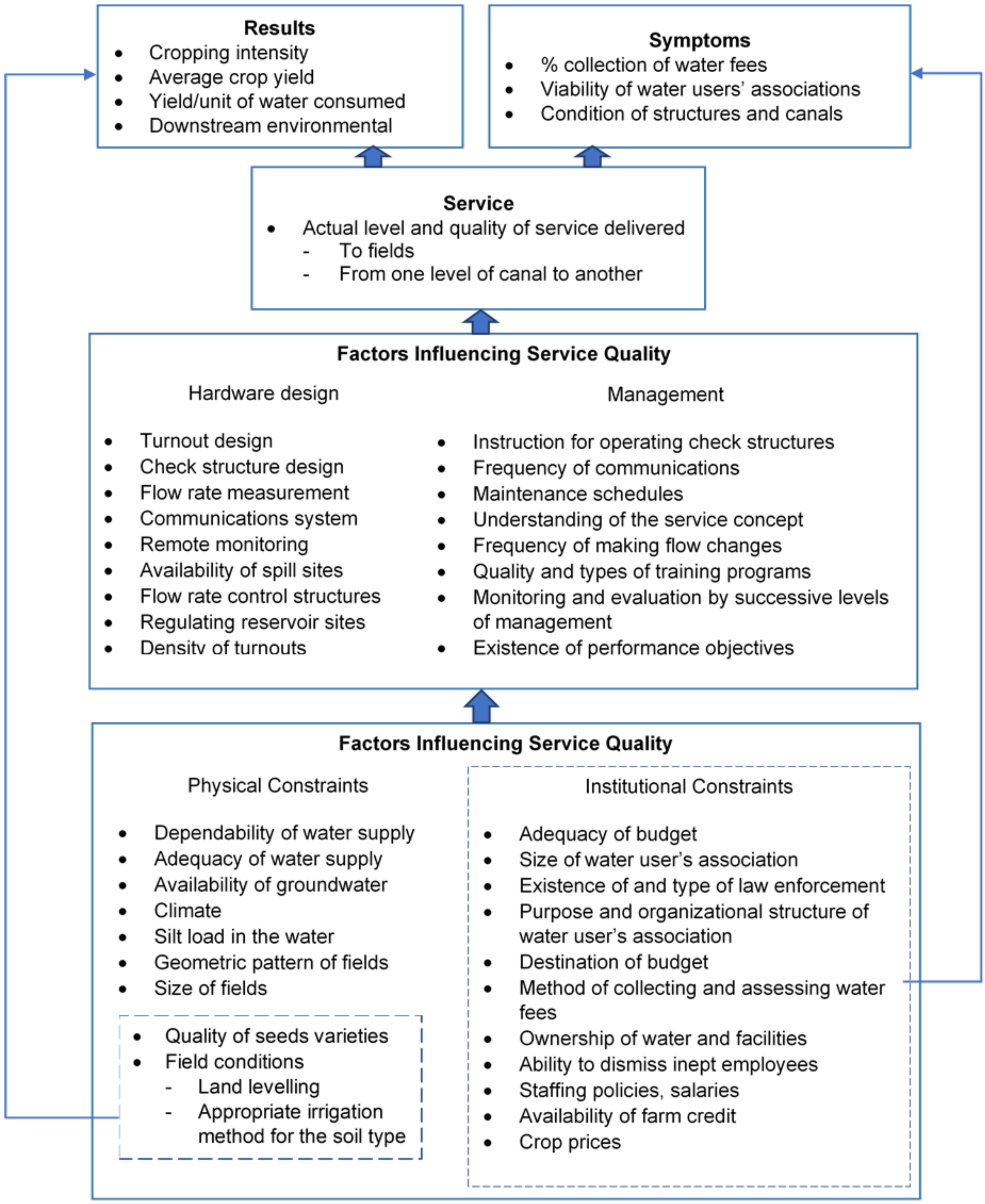
Figure 4.25. The MASSCOTE framework



Source: Renault et al., 2007

The RAP, which is the first step in MASSCOTE approach, is a system diagnosis and performance assessment tool that uses external and internal indicators to be assessed quantitatively for the initial evaluation of irrigation systems. External indicators examine concepts related to the water balance while internal indicators evaluate all the hardware and processes used within the system. The RAP would then be a set of questions in Excel format concerning all the indicators. Data input to the calculation of RAP indicators can be obtained through existing data such as system documents and weather agency datasets, KII of system personnel and through site investigation and ground truthing. The conceptual framework and indicators of RAP are presented in Figure 4.26 and Table 4.49, respectively.

Figure 4.26. Conceptual Framework of the RAP



Source: Renault et al., 2007 (adopted from Delos Reyes, 2017)

Table 4.49. External and Internal Indicators Computed by RAP

External Indicators:

- Total annual volume of irrigation water available at the user level
- Total annual volume of irrigation supply into the three-dimensional boundaries of the command area
- Total annual volume of irrigation water managed by authorities
- Total annual volume of water supply
- Total annual volume of irrigation water delivered to users by project authorities
- Total annual volume of groundwater pumped within/to the command area
- Total annual volume of evapotranspiration (ET_c) in irrigated fields
- Peak net irrigation water ET_c requirements
- Annual relative irrigation supply
- Annual relative water supply
- Command area irrigation efficiency
- Water delivery capacity

Sample Internal Indicator: Actual water delivery to individual units (e.g. farm)

Sub-indicator	Ranking criteria	Weight
1. Measurement of volumes to the individual units (0 – 4)	4 – Excellent measurement and control devices, properly operated and recorded	1
	3 – Reasonable measurement and control devices, average operation	
	2 – Useful but poor measurement of volumes and flow rates	
	1 – Reasonable measurement of flow rates, but not of volumes	
	0 – No measurement of volumes or flow	
2. Flexibility to the individual units (0 – 4)	4 – Unlimited frequency, rate and duration, but arranged by users within a few days	2
	3 – Fixed frequency, rate or duration, but arranged	
	2 – Dictated rotation, but it approximately matches the crop needs	
	1 – Rotation deliveries, but on somewhat uncertain schedule	
	0 – No established rules	
3. Reliability to the individual units (0 – 4)	4 – Water always arrives with the frequency, rate and duration promised. Volume is known	4
	3 – Very reliable in rate and duration, but occasionally there are a few days of delay. Volume is known	
	2 – Water arrives about when it is needed and in the correct amounts. Volume is known	
	1 – Volume is unknown, and deliveries are fairly unreliable, but less than 50% of the time	
	0 – Unreliable frequency, rate, duration, more than 50% of the time, and volume delivered is unknown	

Sub-indicator	Ranking criteria	Weight
4. Apparent equity to individual units (0 – 4)	4 – All fields throughout the project and within tertiary units receive the same type of water delivery service	4
	3 – Areas of the project receive the same amounts of water, but within an area the service is somewhat inequitable	
	2 – Areas of the project receive somewhat different amounts (unintentionally), but within an area it is equitable	
	1 – There are medium inequities both bet. areas and within areas	
	0 – There are differences of more than 50% throughout the project on a fairly widespread basis	

Source: Burt and Styles, 2004 (adopted from Delos Reyes, 2017)

For the assessment of system capacity and functionality, a comparative analysis of the design, actual, and required capacities of irrigation system structures is performed. Design capacity is based on the specifications and configurations in the system documents. Actual capacity can be obtained through direct estimation techniques at site level while required capacity is estimated based on present service area and actual demand at farm level obtained through consultation of system management and farmer beneficiaries.

A sensitivity analysis is conducted to assess the sensitivity of irrigation structures in response to the water distribution schemes being practiced in the system. The analysis is done at three levels: (a) on each main flow control structure (e.g. offtake, water level regulator) taken in isolation; (b) at key diversion and division points; and (c) along canal pathways, using discharge and water level records and on-site measurements.

In the perturbation analysis, main canal discharge and water levels are examined of occurring perturbations identified in aspects of origin, cause, magnitude and timing and frequency. This is done to assess the response action along main canals, if they are self-reacting or specific adjustments must be made to maintain the water level and discharge at the target range.

Next is the revalidation of design assumptions which involves comparison of measured percolation and farm ditch losses to the reference percolation values from design textbooks and manuals, estimation of crop water requirements and irrigation requirements based on measured percolation rates, and assessment of the reliability of the available water supply estimates. Percolation rates can be estimated using direct measurement methods such as the standard 3-cylinder method while conveyance losses can be estimated using seepage meters, inflow-outflow tests, ponding tests and through other indirect methods and empirical approaches. Methods of estimation of available water supply being practiced in the system must also be investigated as well as other accepted technical estimation techniques of dependable water supply in relation to the programmed area or projected area for irrigation and actual area served by the system in the identified irrigation seasons.

Phase 1 – Mapping the Baseline Information

- Performance. Initial rapid system diagnosis and performance assessment through RAP, with three objectives: determine key indicators of the system to identify and prioritize modernization improvements; mobilize the energy of system managers and water users for modernization; and generate baseline assessment, against which progress can be measured.

- Capacity of the Sensitivity of the system. Assessment of physical capacity of irrigation structures in performing the basic functions (conveyance, water level control, flow measurement, diversion, distribution, storage, safety, etc.) and their sensitivities at key locations.

- Perturbations. Analysis of the causes, magnitudes and frequency of perturbations to identify management or coping options.

- Water network and water balance. Assessment of the hierarchical structure and main features of the irrigation and drainage networks, natural surface streams, groundwater and drainage system to know where and where all the inflow points to and outflow points from the service area occurs in terms of flow rates, volume and timing.
- Cost of O&M. Disaggregation of cost associated with current operational techniques and cost analysis of options for various levels of services with current and with improved techniques.

Phase 2 – Mapping a Vision of Service-oriented Management (SOM) and Modernization of Canal Operation

- Service to the users. Assessment and cost analysis of the potential range of services to be provided to users as an initial step for crafting a preliminary vision of the irrigation scheme.

- Management units. A subunit approach; partitioning of service area into manageable units on the basis on participatory management, spatial variations and requirements for water services, conjunctive water management, drainage conditions, among others.

- Demand for operation. Assessment of the resources, opportunities and demand for canal operation; the higher the sensitivity, perturbations, and service demanded, the higher the demand for canal operation.
- Options for canal operation improvement. Identification of cost-effective options (service and economic feasibility) for improvements of each management unit for water management, water control and canal operation.

- Integration of SOM options. Improvement options for the subunits are finalized together with associated costs for every option, aggregated for the entire command area and checked for consistency within finalized improvement options at the main system level, A strategy for modernization is laid out with proposed achievements/ improvements.

- A consolidated vision and a plan for modernization and M&E. Consolidation of the vision for the irrigation scheme; finalizing a modernization strategy and progressive capacity development; selecting/choosing/deciding/phasing the options for improvements with the users; and developing M&E system.

Third, is the characterization of the system management, services and demand to identify modernization potentials which involves analysis of water networks, O&M, management unit and water distribution and irrigation service and demand using appropriate methods and techniques such as RAP and MASSCOTE. Water networks and flow paths composite maps can be generated using GIS. Management and O&M cost from financial statements of water users' associations and NIA can be investigated in relation to the country average and standard values adopted by NIA for planning. The quality of irrigation service can be assessed in aspects of adequacy, reliability, equity, flexibility, and measurements of water delivery. For ease of analysis, partitioning the service area into doable units, e.g. turnout service area (TSA) may be done. The adequacy, reliability, and flexibility can be assessed through system walkthroughs and KIIs of system personnel and TSA leaders. On the other hand, RAP can be applied to the assessment of equity in focus of the sufficiency of irrigation supply to the TSAs compared to the most upstream service areas. The result of the RAP method gives a sense of the spatial distribution of quality of irrigation service within the service area boundary. For the demand of canal operation, the MASSCOTE approach can be applied, constituting parameters for the three proposed factors – sensitivity, perturbations, and service demanded. Sample parameters are flow records and flow measurements, and level of crop risk or vulnerability due to water scarcity, absence of supplemental water and flood occurrence, respectively. In absence and infeasibility of parameters, indicators for the factors may be used.

In the formulation of modernization strategy, the visions and perceptions of system officials, farmers and all concerned stakeholders in view of the future of the irrigation system are critical in setting the targets and direction for the modernization. Consequently, these would serve as basis for possible options of modernization and enhancement. The options and visions for irrigation system modernization plan can be determined through consultative meeting with the system officials and farmers, in consideration of the constraints and potential improvements of the system as well as the willingness of farmers and contributions they may offer for a modernization program.

The outlines of a modernization plan are drafted based on the results and findings of preliminary studies, diagnostic assessment and characterization of the system as discussed. Furthermore, a modernization strategy is formulated using the mentioned analytical tools and procedures giving utmost importance to the coherent link of philosophy, system design, operation, maintenance, and available water supply to improve the current irrigation water service and delivery of the system.

4.10. Water-use Efficient and Water Saving Technologies

In this Master Plan, a range of options is available to help farmers cope with the different degrees and forms of water scarcity. These options can be physical or procedural interventions, as shown in Figure 4.27. Physical interventions include the use of STW (including SPIS), TWS, and drainage reuse system (DRS). Procedural interventions, which aim at increasing crop water productivity (amount of grain produced per amount of irrigation supplied), include water-saving practices such as AWD, aerobic rice, crop diversification, use of short duration and drought resistant varieties, among others.

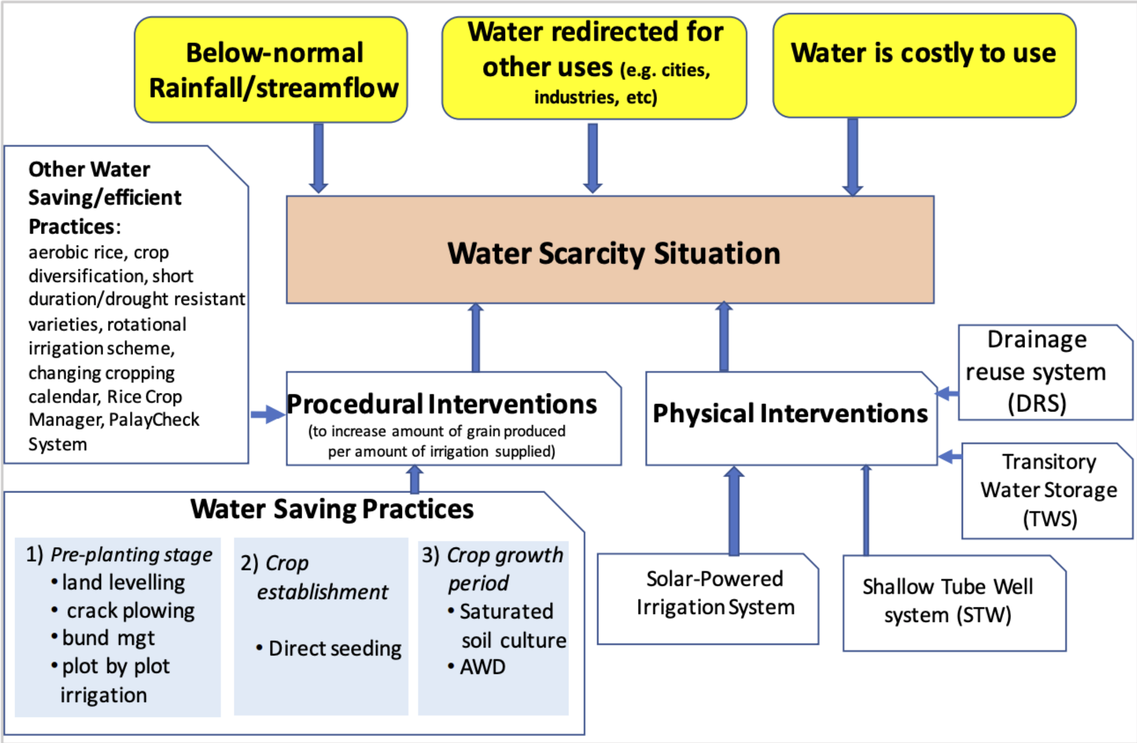
Usually, procedural interventions that respond to water scarcity are called "water savings," which imply a reduced use of water. There are three types/reasons as to why water savings exist: 1) reducing water used for irrigation so that it can be used for another purpose; 2) reducing the use of irrigation water because there is less of it, and thus needs to be conserved; and 3) reducing the use of irrigation water to lower the costs.

The first type of water saving is usually not a response to absolute shortage of water but a desire to use the available water not for irrigation, but for other purposes such as domestic or industrial. Increasing competition for water between sectors of society is the driving force behind such savings in agricultural water use. What is happening in Angat reservoir in Bulacan is a case in point: during water scarcity situation, the release of water in this reservoir for agriculture is reduced (if not suspended) and redirected to Metro Manila for domestic use.

The second type of water saving is induced by actual and physical water scarcity. An example of this situation for farmers is the "enforced water shortage" practice in some NIS in the Philippines such as Bohol Integrated Irrigation Systems (BIIS) (Lampayan et al., 2015). However, an absolute water shortage can also be induced by natural causes, such as seasonal rains that fail to fill up reservoirs or dams, making water insufficient to keep all rice fields flooded throughout the year.

The third type is applicable when farmers pay a high cost for water and reduce their water use to increase their profits. There might be plenty of water, but it is relatively expensive ("economic water scarcity"). An example of this is when farmers pump their own water, either individually or collectively. They pay a relatively high price for their water when the pumping is from deep aquifers and/or when the price for electricity and fuel is high. In this case, water savings by farmers are voluntary and deliberate choice of their own.

Figure 4.27. Framework for Water Scarcity Response Options



4.10.1. Physical Interventions

Shallow Tube Wells

Over the past years, STW systems have been widely used by farmers in irrigated and rainfed lowland rice areas as water augmentation intervention during water crises. STWs lift shallow groundwater or surface water and divert it to irrigation canals or distribute the water directly to rice fields.

The design of a tube well should involve the framing up of design philosophy, formulation of sound design criteria and specifications of the various components of the system. A good well design is aimed at efficient utilization of the aquifer resources and long economic life, low initial cost and low maintenance and operation costs of the STW irrigation system. Design criteria are parameters on which the specifications of the irrigation systems are based. They are determined usually from hydrologic, geologic, agronomic, climatological and socio-economic characteristics of the project area. Examples include well depth, diameter, length and nature of well perforations, crop water requirement, one-in-five-years low piezometric or water table level, aquifer transmissivity or hydraulic conductivity, sustained discharge of aquifer, and water use efficiencies.

The procedures in STW design, installation and development within the limits of the capability of a suction lift pump can be found in the published report on Philippine Agricultural Engineering Standards (PAES) on Groundwater Irrigation-Shallow Tube Well (PAES, 2016).

Solar Power Irrigation System

Instead of using diesel engines to operate the pumps for STWs or irrigation pump systems, SPIS can be another option, as it provides a clean alternative to fossil fuels and enables the development of low-carbon irrigated agriculture. In SPIS, the pumping facility is driven by solar energy, which consists of a solar panel, a controller and a pump. It is used to pump water for irrigation, a source of water for domestic and livestock use. With SPIS, farmers' access to water for irrigation can be improved. In areas with no or unreliable access to energy, it contributes to rural electrification and reduces energy costs for irrigation. This improves the access to water of many farmers and can have knock-on effects on agricultural productivity and incomes. The advantages of SPIS are the following: utilizes solar energy source, does not use fuel or electricity, easy to install, and spare parts are available locally. The disadvantages include high initial investment cost, however the cost of solar panels have significantly decreased recently. In using SPIS or any small-scale irrigation systems, it is important that water resources assessments and planning are properly considered to avoid increasing pressures on water resources.

SPIS has already been piloted by DA and NIA in some provinces in the Philippines to provide irrigation water for irrigated crops. In 2017, SPIS became the flagship program of the DA through the BSWM under the SSIP. DA released a Memorandum Order No. 13, series of 2017, dated March 6, 2017 for the general guidelines on the implementation of SPIS of DA. These guidelines cover the implementation of SPIS under the National Rice and Corn Program, High Value Development Program and National Organic Agriculture Program (NOAP) of the DA. Aside from the SPIS program under DA, NIA also piloted installations and operations of SPIS in selected provinces in the Philippines.

Furthermore, BSWM provides the overall direction on the planning and development of SPIS under its SSIP. The DA-Central Agriculture and Fishery Engineering Division (DA-CAFED) of the Field Operation Service provide technical and administrative assistance to BSWM in the planning and implementation of the SPIS. The DA-Regional Field Offices (RFOs) undertake the implementation of SPIS within their respective regions.

Transitory Water Storage

Transitory Water Storage, an emerging water-saving and augmenting intervention, stores diverted unallocated water from streams and canals for reuse during water shortage periods. When high rainfall occurs in irrigation systems during the cropping season, irrigation delivery is usually suspended so as not to aggravate possible flooding in irrigated areas. During irrigation suspensions and streamflow surges, excess water can be diverted into TWS sites. Natural swamps, plot-size depressions and flood-prone areas are preferred TWS sites, serving as water augmentation sources during water shortage.

Drainage Reuse System

Stretches of drainage channels (creeks and canals) traversing the middle and lower sections of irrigated areas teem with reusable water in fluctuating levels. This occurs due to water spillage and wastage emanating from excess of withdrawals and rainfall at the upper sections of irrigated areas. During wet season, excess rainfall combines with drainage water that makes creeks swell—causing localized flooding in the lower sections of irrigated areas.

During dry season, water supply dwindles—making the downstream sections of irrigation systems vulnerable to water deficit to deprivation. Though prone to wet season flooding and to dry season drought, lower sections of irrigation systems have shallow groundwater and primed streams. NIA adopts DRS as an intervention to reduce degree of water deficit to deprivation in the middle to lower sections of irrigation systems.

In the development process of irrigation systems, project management offices should consider the concept of integrated irrigation system configuration. This means that they develop all the surface streams within and around the target irrigated area—evolving a network of diversion dams and weirs. Once the irrigation operations start, the "dry" creeks will become "flowing" due to upstream water spillage and wastage—thus triggering the development of DRSs.

Re-use of Wastewater for Irrigation

In areas where surface water and groundwater sources are limiting, wastewater may be used for irrigation as stipulated in the Department of Agriculture Administrative Order (DA-AO) No. 26 Series of 2007 (Guidelines on the Procedures and Technical Requirements for the Issuance of a Certification Allowing the Safe Re-Use of Wastewater for Purposes of Irrigation and Other Agricultural Uses), as well as the PNS/BAFS/PAES 232:2017 (Wastewater Re-use for Irrigation). The AO No. 26 Series of 2007 covers the issuance of discharge permits for wastewater generation and certificates for safe wastewater re-use, which can be secured from DENR and DA, respectively.

Sources of wastewater include livestock (e.g., piggeries, beef, and dairy feedlots), agriculture and food industrial processes (e.g., food handling, processing and manufacturing plants, sugar mills, refineries and distilleries, slaughterhouses, and poultry dressing plants), aquaculture (e.g., in reservoirs, hatcheries, ponds, and tanks), domestic and municipal sewage, and other industrial and commercial establishments. The re-use of which for irrigation needs a certification from DA with the following prescribed general requirements:

- Description of the proposed irrigation site consisting of the location and access, topographic, soils and land use maps, and the distance to surface water and existing wells;
- Characteristic of wastewater based on the limits on wastewater quality for irrigation can be found at AO No. 26 S. 2007 or the PNS/BAFS/PAES 232:2017;
- Plan on the re-use of wastewater including the area to be irrigated, proposed crop/s, irrigation system, method of application and layout of distribution facilities, calculated irrigation water requirements, quantity of wastewater to be re-used, irrigation schedule, nutrient management plan, and the provisions for storage or impoundment at rainy periods and when irrigation is prohibited; and
- Baseline conditions of surface water, groundwater, and soils.

The wastewater shall be treated and tested for quality. Laboratory analysis shall be conducted by the DA and DENR recognized laboratories. With regard to the quantity of wastewater for re-use, the application rates are based on the hydraulic loading rate wherein the wastewater must only be applied to soil moisture conditions prohibiting runoff or ponding. Also, to satisfy the crop soil moisture deficit, the irrigation application must only be done under dry weather conditions.

4.10.2. Procedural Interventions

There are many technologies and/or practices which can be used to reduce irrigation input to rice fields. Some of these technologies/practices can be done at land preparation, crop establishment, and during the actual crop growth period (Bouman et al., 2017). A number of technologies are generic to all crops, others are specific to rice. These generic technologies/practices are soil surface manipulation technologies (laser land levelling, crack plowing), improved irrigation management (rotation irrigation system, application method–changing from flood to sprinkler and drip), use of short duration varieties and drought tolerant varieties, and changing of cropping calendar so that the crops grow during period of higher rainfall and/or lower evaporative demand. The rice-specific technologies include direct dry seeding crop establishment to reduce water input in land preparation and changing from prolonged or continuous flooding to AWD water management. Meanwhile, technologies such as RCM and Palay Check system aim at increasing yields and reducing input use in rice production system.

Laser Land Leveling

A pre-requisite for good water management is a well-leveled field. When fields are not level, water may stagnate in the depressions whereas higher parts may fall dry. This results in uneven crop emergence and uneven early growth, uneven fertilizer distribution, and even extra weed problems. Use of laser land leveler enables accurate soil surface levelling. This reduces irrigation water input in irrigated fields, especially when flood irrigation is practiced. The reduced water input with laser levelling is due to reduction of the time taken for water to flow across the field, and the depth of ponding required so that the higher parts of the field are covered with water. The reduced depth of ponding lowers the downward water pressure and thus the amount of deep drainage, and the reduced irrigation time lowers the percolation losses during irrigation. About 5-8% of water irrigation input reduction and about 6% yield increased for flooded rice in laser fields compared with traditional farmer leveling practice. Laser leveling does not need to be done every year, and desirable frequency depends on the degree of tillage. Current leveling practice involves leveling the land with zero slope in both directions. Practical guidelines on land leveling are available at http://www.knowledgebank.irri.org/images/docs/training-manual-laser-leveling.pdf.

Good Bund Management and Proper Tillage

Good bunds or paddy dikes limit water losses by seepage and underbund flows. To limit seepage losses, bunds should be compact, and any cracks or rat holes should be plastered with mud at the beginning of the crop season. Make bunds high enough (at least 20 cm) to avoid overbund flow during heavy rainfall. Small levees of 5-10 cm height in the bunds can be used to keep the ponded water depth at that height. If more water needs to be stored, it is relatively simple to close these levees. In very leaky parts of the bunds, the use of plastic sheets as lining can be adopted.

Most farmers puddle their fields to prepare the land for transplanting of seedlings. Puddling is the repeated harrowing of the soil under flooded conditions and it results in a muddy layer 15-20 cm thick. Before puddling takes place, farmers need to soak the land at the end of the previous fallow periods. Sometimes, large and deep cracks are present in the soil and a lot of water is lost with the water flowing down the cracks. A shallow tillage to fill the cracks before soaking can greatly reduce amount of water used in wet land preparation.

Thorough puddling results in a good compacted plow sole that reduces the permeability and the percolation rates. The efficacy of puddling in reducing percolation depends greatly on soil properties. Puddling is very efficient in clay soils that form cracks during the fallow period, which penetrate the semi-impermeable subsoil layer. Puddling may not be necessary in heavy clay soils with low vertical permeability or limited internal drainage. In such soils, direct dry seeding on land that is not puddled but tilled in a dry state is very well possible with minimal percolation losses.

Construction of Field Channel

Many irrigation systems in the Philippines lack field channels (or ‘tertiary’ irrigation or drainage channels), and water flows from one field into the other through outlets in the bunds. This is called “plot-to-plot” irrigation. The amount of water flowing in and out of a rice field cannot be controlled, and field-specific water management is not possible. This means that farmers may not be able to drain their fields before harvest because water keeps flowing in from other fields. In addition, they may not be able to have water flowing in if upstream farmers retain water in their fields, or let their fields dry out to prepare for harvest. Moreover, a number of technologies to cope with water scarcity require good water control for individual fields. Finally, the water that continuously flows through the paddies may remove valuable (fertilizer) nutrients. Constructing separate channels that convey water to and from each field (or to a small group of fields) greatly improves the individual water control and is the recommended practice in any type of irrigation system.

During land preparation, it is crucial for farmers to “get the basics right” because this lays the foundation of the whole cropping season. To facilitate good water management, it is important to properly build field channels, level the land, construct good bunds, and effectively implement tillage operations (puddling).

Community Seedbed and Adoption of Direct Seeded Rice

Minimizing the turnaround time between land soaking for wet land preparation and transplanting reduces the period that no crop is present, and that the outflows of water from the field do not contribute to production. In rice irrigated systems, farmers raise seedlings in part of their main field. Because of a lack of tertiary field channels, the whole main field is soaked when the seedbed is prepared and remains flooded upon the entire duration of the seedbed. In NIS and CIS, the turnaround time can be minimized by the installation of field channels, the adoption of common seedbeds, or the adoption of direct wet or dry seeding. With field channels, water can be delivered to the individual seedbeds separately and the main field does not need to be flooded. Common seedbeds, either communal or privately managed, can be located strategically close to irrigation canals and be irrigated as one block.

Direct dry seeding can also increase the effective use of rainfall and reduce irrigation needs. A major driving force for the adoption of direct seeding is scarcity of labor since direct seeding does not use labor for transplanting and can be a mechanized operation. Practical guidelines on dry seeding, including specific agronomy guides, are available at http://www.knowledgebank.irri.org/step-by-step-production/growth/planting/direct seeding.

Use of Short Duration, High Yielding, Water-efficient and Climate Resilient Varieties

Use of short duration varieties generally reduces the number of irrigations required to finish the crop. In the Philippines, about 263 rice varieties can be found in PhilRice website with seed information and variety characteristics (https://dbmp.philrice.gov.ph/dbmp_main/seed-information). Many of these varieties are bred for irrigated environments, but some are for rainfed, drought prone, flood prone, cool elevated, saline, and upland conditions.

Development of new varieties takes time, but recently, the fast-tracking of the development and acceleration of the adoption of high-yielding and climate-resilient varieties for different irrigated lowlands and adverse rice environments in the Philippines were undertaken by IRRI, PhilRice and UPLB since 2017, through their DA-BAR funded collaborative project "Accelerating the Development and Adoption of Next-Generation (Next Gen) Rice Varieties for Major Ecosystems in the Philippines" (Pamplona, et al., 2018). Multi-location testing of these high yielding varieties and production of high-quality seeds, participatory varietal trials (PVS) and trainings were conducted. In the 2018 dry season, 235 seed kits composed of 93 irrigated inbred, 61 hybrid, 16 special purpose, 50 rainfed/drought and 15 saline materials were assembled and dispatched to 16 regions in the country.

Adjustment of Cropping Calendar to Periods of Higher Rainfall and/or Low Evaporative Demand

Irrigation requirement is reduced when changing crop establishment dates to periods of high rainfall and lower evaporative demand. The total cropping system needs to be considered in optimizing crop calendar.

Rotational Irrigation Scheme

The Rotational Irrigation Scheme is a usual response to water scarcity where it involves alternate water delivery of water to the blocks in an irrigation system based on pre-agreed schedule by the IAs. RIS distributes available water at deficit to full levels among the blocks of an irrigation system, thus reducing the extent of damaged area and yield loss. This scheme is applicable in an irrigation system with adequate water control, which would enable the closing or opening of irrigation to any of the blocks.

Alternate Wetting and Drying

In implementing AWD, simple messages and tools were developed to help in deciding when to irrigate. Developed in the Philippines, the technology has been widely validated by various national institutes and organizations on farmer's field in many rice growing countries in the world with reported reduction in water use in the range of 15–30% without reducing rice crop yields. This translates to reduction in pumping cost, fuel consumption and higher income. AWD is very simple for farmers to adopt, provided that they have access to water on demand. It involves irrigating whenever the perched water table falls to about 15 cm below the soil surface. The water table can be observed using a cheap and simple 'field water tube' which is driven in a hole in the ground to a depth of 15 cm. Practical guidelines and other information on AWD are available at http://www.knowledgebank.irri.org/step-by-step-production/growth/water-management#for-safe-alternate-wetting-and-drying.

Aside from reduced irrigation water input, AWD has multiple benefits including reduced pumping cost and greenhouse gas emissions (GHG). With AWD, seasonal methane emissions can be reduced by 20-70% in comparison with continuously flooded rice.

Suitability of AWD in the Philippines

A suitability study conducted by Sander et al. (2017) showed that a maximum of 60% of the rice area of the Philippines is climatically suited to AWD, with more than 90% in the dry season and 34% in the wet season. Table 4.51 shows the summary of AWD suitability for major rice-growing areas in the Philippines. The potential maximum annual reduction would be around 265,000t of CH4 emissions from lowland rice in the Philippines, or around 15% of the country's annual emissions from the agriculture sector. Country-scale climatic suitability maps for AWD developed for the wet and the dry season are shown in Figure 4.28. These maps were included in the geodatabase developed for this masterplan.

Table 4.50. Estimated Number of Farmers Adopting AWD in the Philippines by Region as of May 2011

Region	AWD adoption	
	Area (ha)	Number of farmers
CAR	10,910	10,888
I - Ilocos Region	4,177	10,230
II - Cagayan Valley	3,549	5,205
III - Central Luzon	34,083	26,325
V - Bicol Region	150	292
VI - Western Visayas	18,555	13,075
VII - Central Visayas	8,312	7,677
VIII - Eastern Visayas	1,964	2813
X - Northern Mindanao	70	104
XI - Davao Region	27,853	17,294
XII - SOCCSKSARGEN	5,254	2,840
XIII - Caraga	4,530	2,986
Total	**119,407**	**99,729**

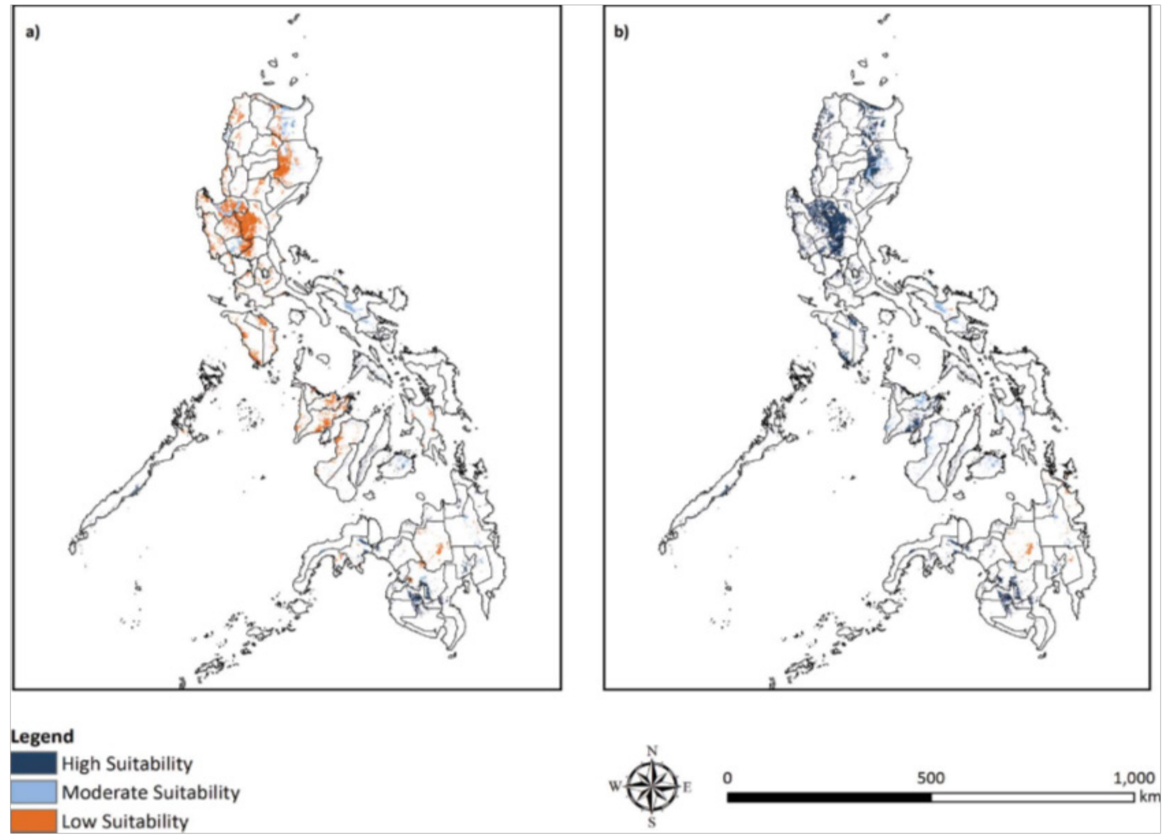
Note: Initial estimates were taken in 2011 from national irrigation systems with on-going widescale implementation of AWD, and with on-going demonstration trials and training activities. It was updated in 2019 through survey questionnaires distributed to NIA regional offices.
Source: Lampayan et al., 2016a

Table 4.51. Summary of AWD Suitability for Major Rice-growing Areas

Region (% rice production of the Philippines)	Suitability – wet season	Suitability – dry season
Ilocos (9%)	Mostly lowly suitable (LS) with some moderately suitable (MS) along central coastline (Ilocos Sur Province)	Almost completely highly suitable (HS)
Cagayan Valley (13%)	Predominantly LS but extensive areas of MS in eastern Cagayan Prov.	Almost completely HS in the northern part (Cagayan Prov.) but extensive MS areas in the southern part (Isabela Prov.)
Central Luzon (20%)	Predominantly LS with patches of MS	Predominantly HS with some scattered MS area along the western coastline
Bicol (7%)	Almost completely MS	Almost completely MS
Western Visayas (11%)	Predominantly LS with small patches of MS	Mostly JS with small patches of MS
SOCCSKSARGEN (7%)	Almost equal areas of HS, MS and LS	Predominantly HS with smaller areas of MS

Adopted from: Sander et al., 2017

Figure 4.28. Maps of AWD Suitability and Rice Extent in (a) Wet Harvest Season and (b) Dry Harvest Seasons in the Philippines



Adopted from: Sander et al., 2017

Aerobic Rice Technology

When water is very scarce, and there is not enough water to even intermittently flood the fields such as in AWD, the system of aerobic rice is useful. Aerobic rice is a production system in which specially developed "aerobic rice" varieties are grown in well-drained, non-puddled, and non-saturated soils. Because aerobic rice is grown like an upland crop such as wheat or maize, the potential water reductions at the field level are large, especially on soils with high S&P rates. Besides S&P losses declining, evaporation also decreases as there is no ponded water layer, and the large amount of water used for wet land preparation is eliminated altogether. While the yield potential of current aerobic rice varieties is only about two-thirds of paddy varieties when grown in flooded soil, as water input is reduced below what is required for continuous soil saturation, yields of traditional varieties fall below those of aerobic varieties grown with the same level of water deficit. Thus, aerobic rice is suited to areas where there is insufficient water to grow high yielding rice with safe AWD, but there is a need or desire to continue grow rice.

To achieve high yields under aerobic conditions, new varieties with combined drought-resistant characteristics of upland varieties and high yielding characteristics of lowland varieties are required. IRRI and PhilRice started the research and development of aerobic rice in the Philippines in 2001 (Lampayan et al., 2016b). From 2001 to 2009, the following strategic research and development activities were undertaken in order to: (a) identify and develop aerobic rice varieties with high yield potential, (b) understand crop management strategies including water, nutrient, and weed management, (c) identify key sustainability issues, and (d) develop practical technologies for crop establishment. As shown in Table 4.52, from 2006 to 2010, 271 demonstration farms were established, 240 technicians/researchers and 2,227 farmers were trained, and about 1250 farmers estimated to have adopted aerobic rice in the country were identified. At the farmers' fields, yields of aerobic rice ranged from 3.0-6.5 t/ha, with about 50% less water than the conventional flooded lowland rice cultivation.

Table 4.52. Estimated Number of Trained Agricultural Workers and Farmers, Established Demonstration Farms, and Farmer Adopters of Aerobic Rice in the Philippines as of September 2010

Province	Year started	No. of demo farms[a]	No. of trained technicians/ researchers	No. of trained farmers	No. of farmer adopters[b]	Yield range (ton ha^{-1})[c]
Bulacan	2006	80	35	550	350	3.5-6.0 (4.0)
Bataan	2008	55	20	155	55	3.0-4.5 (3.7)
Palawan	2007	25	20	632	460	3.8-5.0 (4.3)
La Union	2008	45	35	430	206	3.5-5.5 (4.2)
Aurora	2008	25	15	200	35	3.0-4.0 (3.4)
Pampanga	2008	15	5	45	15	4.0-6.0 (4.7)
Isabela	2008	20	35	125	65	3.5-6.5 (4.0)
Tarlac	2010	5	5	55	10	3.0-5.5 (3.9)
Occidental Mindoro	2010	1	10	35	-	4.5-5.0 (4.7)
Others	2010		60			na[d]
Total		**271**	**240**	**2227**	**1250**	

[a]Demonstration trials conducted on wet season only;
[b]Adoptors were farmers who planted aerobic rice in the wet season;
[c]Values in parentheses are average values.
[d]na = not applicable
Adopted from: Sander et al., 2017

4.10.3. Other Technologies that Enhance Productivity

Rice Crop Manager

Rice Crop Manager is a comprehensive decision-support tool developed by IRRI in collaboration with the DA, to help Philippine farmers increase farm yield and income. It uses a concept that when fertilizer is applied at the proper stage of the crop and in the right amount to match location-specific conditions, the fertilizer becomes more effective, resulting in higher yield. Additionally, farmer income increases. RCM recommendations are freely given to farmers as a one-page printout. For the last five years (from November 2013 to November 2018), more than 1.6 M printed RCM recommendations (Table 5.77.) were given out to individual rice farmers from various regions in the country. Following RCM recommendations, yields increased by an average of 370 kg (unmilled) and increased in income of PHP 4,337 per hectare per season in the pilot sites (http://books.irri.org/Rice_crop_manager_brochure.pdf). It is desired that all rice farmers in the Philippines gain access to RCM recommendations tailored for his own area, to optimize yield and income by reducing fertilizer cost.

To fast track the dissemination of the technology, IRRI established the RCM Advisory Service, which consolidates RCM and complementary decision-making tools and services into one integrated advisory and information service for rice-based farming in the Philippines. The development, maintenance, and deployment of the RCM Advisory Service are supported by the DA National Rice Program, through DA-BAR and DA-ATI.

The core of the RCM Advisory Service is the RCM, which provides farmers with a personalized crop and nutrient management recommendation for rice fields through a one-page printout and text messages to the phone of the farmer. This service can be accessed in IRRI website (https://phapps.irri.org/ph/ras/index.html#about). The RCM Advisory Service combines the RCM with additional tools and services aiming to reduce production costs, increase yields, increase net income, and facilitate better extension services to farmers through ICT.

The PalayCheck System

PalayCheck is a holistic and integrated crop management system developed by PhilRice for irrigated lowland rice that presents the best key technology and management practices as Key Checks (https://www.pinoyrice.com/palaycheck/). It compares farmers' practices with best practices and learns through farmers' discussion group to sustain improvement in productivity, profitability, and environment safety. The PalayCheck employs eight Key Checks to cover principal areas of crop management as shown in Table 4.53. These management areas include seed quality, land preparation, crop establishment, nutrient management, water management, pest management and harvest management. The Key Checks provide a standard guide for farmers on how to assess and achieve the Key Checks.

Table 4.53. Eight Key Checks of PalayCheck System

Crop Management Area	Key Checks
Seed and variety selection	1. Used high quality seeds of a recommended variety
Land preparation	2. No high and low spots after final levelling
Crop establishment	3. Practiced synchronous planting after a fallow period 4. Sufficient number of healthy seedlings
Nutrient management	5. Sufficient nutrients at tillering to early panicle initiation and flowering
Water management	6. Avoid excessive water or drought stress that could affect the growth and yield of the crop
Pest management	7. No significant yield loss due to pests
Harvest management	8. Cut and threshed the crop at the right time

4.10.4. Technology Options under Different Water Scarcity Situations

The appropriate technologies to be used by farmers to respond to water scarcity depend on several things: the type and level of water scarcity, the irrigation infrastructure (or the level of control that a farmer has over the irrigation water), and the socioeconomics of their production environment.

"Getting the basics right" is important even with abundant irrigation water. Good land leveling, bund management, construction of internal field channels, and thorough puddling (in the case of puddled systems) will contribute to better crop growth and yields, and increase water use efficiency. This is something that a farmer can do, whether they operate in large-scale or small-scale irrigation systems, or whether they use their own sources of irrigation (such as STWs or SPIS).

The first response option to decreasing water availability would be to check the said "basics." This is because the amount of water loss that can be reduced depends on the initial condition of the rice field. However, if the basics are right from the start, there is not much that can be done any more. With increasing water scarcity, establishment options that are alternative to transplanting can be considered. If community seedbeds or a commercial provider of seedlings could be organized, this would be the least water-consuming method of getting a crop established.

When water scarcity further increases, adjustment of water management practices during the whole growing season should be considered. Depth of ponded water of about 3 cm may be maintained during the growing season instead of keeping a 5–10cm depth of ponded water. Shallow ponding of water minimizes S&P losses due to reduced hydrostatic pressure. The adoption of safe AWD can reduce water losses to a considerable amount without reducing yield. The extent of reduction of water loss under AWD depends mainly on soil type and depth of the groundwater table, crop stage, and climatic condition. If water is getting so scarce that "safe AWD" is no longer possible, the periods between irrigation will have to become longer (letting the water in the field water tubes go deeper than 15 cm) and yield loss becomes inevitable. All forms of AWD require water control by the farmer. With one's own water sources, such as tube wells, this is not a problem. In communal or national irrigation systems, a collaborative approach to AWD is required in which delivery of water to groups of farmers through RIS is scheduled to realize a certain pattern of AWD. Irrigation system upgrading or modernization may be required to do this, or small storage facilities (i.e., on-farm reservoirs) may provide the required water control.

With still further increasing water scarcity, aerobic rice systems can become a viable alternative as yield of lowland rice under AWD will continue to go down. How much water is used under aerobic conditions than under flooded conditions depends mostly S&P losses under flooded conditions and on the deep percolation losses of irrigation water under aerobic conditions. When aerobic rice systems are direct (dry) seeded, as is the typical target technology, an additional amount of water input can be saved by forgoing the wetland preparation.

When water is physically available, but has a high cost, the choice of adopting any of the WSTs becomes more of an economic issue. Adopting certain WSTs may reduce water but at the expense of yield loss. If the financial savings incurred by using less irrigation water under a certain technology outweigh the financial loss of reduced yield, then the adoption of that technology becomes attractive.

A system can also be designed to maximize the reuse of S&P water as much as possible through check dams and pumping. If there is a salinization hazard, care should be taken to avoid using water that has become too saline by reuse, through judicious mixing of drainage and fresh water. Construction of field channels (irrigation, drainage) and land leveling should be considered to facilitate good water management. Farmers in a new irrigation system should be trained in sound water management practices such as those detailed above.

4.10.5. Incentive Mechanisms for Adopting AWD and Other Water-saving Practices

The success of farmers' adoption of AWD and other WSTs at the system level can only be realized when there is a strong support and cooperation of farmers and IA officials, and strong linkage between the NIA and farmers through the IA. Many farmers are willing to adopt the technology provided they are assured that there will be no detrimental effect on the crop and that enough water will be available when they need it. There are many benefits that can be derived from adopting AWD such as reduction in water input, reduced crop lodging problem, reduced methane emissions, and improved relationship among the water users in the lateral level. However, constraints related to farmer incentives for adopting AWD have also been recognized. If cost of using irrigation water for rice production is high, farmers would willingly adopt WSTs to reduce water input and hence cost. However, this is not the case in the Philippines. In the past, irrigation service fee was based on area, and with the passage of the FISA in 2018, there is no direct incentive for farmers to save water. This suggests that NIA needs to explore incentive mechanisms for the successful dissemination of AWD. Some suggestions include, among others, giving recognitions (or even monetary awards) and additional irrigation subsidy for O&M to IAs or systems adopting AWD. In 2012, under the Clean Development Mechanism (CDM) in rice production, the methodology on methane emission reduction by adjusted water management practice in rice cultivation has been approved by the United Nations Framework Convention on Climate Change (UNFCCC). In the approved methodology, default factors for reduced emissions (1.8 kg CO2 eq/ha/d) in the case of multiple aeration was decided. This means that Certified Emission Reduction (CERs) can be claimed for WSTs in rice production without the measurement of emission savings. AWD and aerobic rice cultivation methods are covered in the approved methodology, and therefore IAs can potentially tap CDM to claim payments by adopting AWD.

4.11. Climate Change Adaptation and Disaster Resiliency in Irrigation Development Master Plan

Irrigation systems are among the most vulnerable to CC, climate variability and natural disasters. The occurrence of extreme weather events such as excessive rainfall and flooding on the one hand and drought on the other hand tremendously affects not only the efficiency of the irrigation systems but also their resiliency and sustainability. This is more so in recent years as evidenced by the huge losses incurred due to damage to irrigation infrastructure as a result of the onslaught of super typhoons, flooding and other manifestations of CC and natural disasters. In fact, In fact, the average cost of damage to irrigation infrastructures has been estimated to be around PHP 1.3 B per year. It is therefore a must that CCA and disaster resilience be mainstreamed in the NIMP.

Adaptation measures enable agencies to reduce and manage climate risks and thus may cushion the environmental impacts of CC, such as drought and floods, on irrigation and drainage systems. The adaptive capacity of irrigation systems to climate risks, to a large extent, increases the resilience of irrigated agriculture to CC impacts. Nonetheless, adaptation measures alone can hardly remove all these impacts because CC and variability continue to intensify. Hence, mitigation measures, together with adaptation measures, can strengthen system resilience and capability to deal with impacts from climate variability and change. Mitigation measures can reduce long-term adaptation cost to a certain extent. Thus, to climate proof an irrigation system, it is necessary for irrigation systems to adopt both mitigation and adaptation measures at the same time.

4.11.1. Climate Proofing for Irrigation Development

Climate proofing, based on the United Nations Development Programme (UNDP) definition, refers to the "*explicit consideration and internalization of the risks and opportunities that alternative climate change scenarios are likely to imply for the design, operation and maintenance of infrastructure.*" From the practical standpoint, climate proofing essentially involves integrating CC risks and opportunities into the design, operation, and management of infrastructure (UNDP, 2010). The ADB, on the other hand, defined climate proofing as "*a shorthand term for identifying risks that a development project faces from climate variability and change, and ensuring that those risks are reduced to acceptable levels through long-lasting and environmentally sound, economically viable, and socially acceptable changes implemented at one or more of the following stages in the project cycle: planning, design, construction, operation, and decommissioning*" (ADB, 2012). While other definitions or descriptions of climate proofing of infrastructure exist in published literature, they all essentially point towards the same thing. Hence, recommendations for the integration of climate proofing in irrigation development in this section are based on the UNDP and ADB definitions.

Climate proofing of irrigation systems and facilities can be applied during any of the stages of the project development cycle, namely, planning, design, construction, operation, and decommissioning based on the ADB definition. In particular, this includes planning, design and construction of reservoirs, diversion works, irrigation canal network and water control structures and their eventual O&M. The recommendations for climate proofing of agricultural infrastructures made by Ella (2019) in the mainstreaming of CCA and disaster risk reduction management in the AFMP, particularly on irrigation systems and infrastructures from planning and design to construction, O&M and rehabilitation, are adopted in this NIMP.

Climate Proofing During Irrigation System Planning

Irrigation system planning generally starts with the assessment of water supply and irrigation water demand. In view of CC, both the water supply and irrigation demand at the local level will have to be assessed based on projected rainfall and temperature changes and their spatial variabilities. The assessment of dependable flow requires sufficiently long historical streamflow record whose consistency should be checked in view of CC. It is, therefore, recommended at the planning stage of the project development that engineers and planners perform the streamflow dependability assessment through flow duration analysis using projected streamflow series based on climate projections. This can be done through hydrologic modeling and simulation on a per watershed scale basis. Critical areas in the Philippines include those regions with projected rainfall reduction during the dry periods based on

CC projections. In terms of climate type, the critical areas are those belonging to Climate Type I with distinct wet and dry season.

Conversely, the assessment of irrigation water demand or irrigation water requirements at all levels should make use of new estimates of evapotranspiration and crop consumptive use based on CC projections in the locality in terms of temperature. Prior to the estimation of irrigation water demand, new cropping patterns are recommended to be developed for every region and province based on CC projections. Proposed cropping patterns should then serve as the basis for estimating irrigation water requirements for any given locality. The site-specific water duties can eventually be estimated for various regions in the country. Based on the new estimates of dependable flows and water duties, the PIAs can be properly estimated. At the planning stage alone, proper estimation of PIAs based on climate projections could essentially be treated as climate proofing in itself.

Climate Proofing During Irrigation System Design

Climate proofing during the design stage for irrigation projects would essentially involve adoption of new design criteria and standards that take into account the adverse effects of CC and occurrences of extreme weather conditions such as typhoons and high rainfall events due to severe low pressure areas and strong “habagat”. These conditions lead to increased magnitude of flood discharges and occurrences of flood discharges with relatively high return periods which should be taken into account in the proper design of dam spillway, riverbank protection, design of irrigation and drainage canals and design of water control structures. New design criteria and standards should include new design discharges and design flood values with specified return periods or recurrence intervals for designing dam spillways. It is recommended that these new design discharges be determined through hydrologic frequency analysis based on projected annual series of streamflow values through hydrologic modeling. This should be done on a per watershed basis throughout the country particularly those with potential for irrigation development. The dam reservoir capacity should also be increased particularly in areas with projected rainfall increases and in areas that are frequently hit by typhoons, low pressure areas and monsoons. This is not only to provide greater useful storage but also to avoid frequent releases of excess flood during the typhoon and monsoon season as in the case of dams in the Philippines which were constructed in the 70s based on relatively shorter return periods.

The provision of dead storage during the planning and design of reservoirs should likewise be based on climate projections taking into account the most likely water and sediment inflows and trap efficiencies. Otherwise, heavy sedimentation that results from excessive soil erosion and sediment transport due to CC and natural disasters will drastically reduce reservoir capacities.

Even for groundwater resources utilization for irrigation, the design of STWs should be based on projected piezometric levels which will potentially be affected by CC. These tube wells are usually used during the dry season when the water table declines significantly particularly in areas with limited groundwater recharge, a process that is also affected by CC. It is recommended that new design criteria be developed per aquifer region in the country in view of CC.

To address the potential flooding in irrigated areas due to CC and occurrences of extreme weather conditions such as occurrences of severe low-pressure area, strong habagat and super typhoon, adequate and well-designed drainage facilities should be provided. The choice of drainage coefficient to be used in the design should be based on climate projections particularly rainfall projections. In the same manner, new design standards should be adopted for drainage design. At the same time, more robust drainage tail escapes or end checks as well as cross drainage structures should be used.

The occurrence of the same extreme weather conditions such as super typhoon which lead to flooding, excessive soil erosion and sedimentation and floating debris in canals among other adverse impacts should also be considered in the selection and design of water control structures. The use of more sturdy discharge measurement structures such as Parshall flumes or broad crested weirs should be favored over sharp crested weirs which are more susceptible to damage by floating debris during typhoon occurrences.

The aforementioned recommendations reported in the mainstreaming of CCA and DRRM in the AFMP for 2018-2023 (Ella, 2019) are consistent with the results of study on the analysis of technical assumptions and processes for evaluating the feasibility of Philippine irrigation projects by Moya (2014) that concluded that the design of irrigation projects/systems calls for a new paradigm of interactive and integrated design to improve operational performance. However, there are other aspects of irrigation system design that need to be considered to enhance climate resilience. These include incorporation of design concepts such as maintainability, durability, functionality, operability, and safety in a design strategy that centers on consistency with available water supply, irrigation demand, physical design of the structures, and realistic operational plan. Moreover, good governance of irrigation systems must start with a design that ensures compatibility with operational realities and an acceptable level of financial viability to ensure sustainable performance. Part and parcel of irrigation operational realities that must be given close attention to in irrigation planning and design are impacts from climate variability and change.

Currently, there are four volumes of guideline/manuals titled "Supplemental Guidelines/Manual on Planning, Design, Construction, and Operations and Maintenance of Irrigation Projects/ Systems" that were developed under the Philippines Climate Change Adaptation Projects (PhilCCAP). The rationale behind the guidelines is to develop irrigation schemes that are sustainable and resilient to climate changes through systematic and stage wise project/system planning and design. Moreover, the preparation and implementation of irrigation projects are required now to bring forth environmentally friendly and socially acceptable irrigation project/system. It is recommended to review and institutionalize the irrigation guideline/ manual, then pilot test the applicability of the design manuals in upcoming new irrigation projects and in the modernization of existing ones by integrating CCA and mitigation measures in the project/system planning.

Climate Proofing During Irrigation Project Construction

Actual construction should undergo strict quality assurance and quality control. Even if CC and natural disasters are taken into account during the planning stage and new design standards are followed during the detailed engineering design if the actual construction is poorly done or managed, true climate proofing of irrigation and drainage infrastructures can never be achieved. This calls for greater accountability and transparency in project implementation and strict enforcement of applicable laws.

Climate Proofing During Operation and Maintenance of Irrigation Systems

Climate proofing should also be applied to O&M of irrigation systems and their irrigation infrastructures. A climate resilient O&M scheme should be able to handle both extreme conditions, i.e. extremely high rainfall conditions (flooding, erosion) and extremely low rainfall conditions (drought). To address extremely high rainfall conditions leading to occurrences of flood discharges, timely releases of excess flood flows from spillways should be facilitated, if possible, through the use of sensor-operated flood gates. This will avoid potential collapse of any dam spillway especially those that have been designed and constructed using old design standards or those that may have been designed with a less conservative level of risks in favor of economic viability. The idea is to be able to prevent potential damage to diversion works by flood discharges of high return periods through timely releases of surcharge flood discharges. Moreover, regular desilting or dredging operations in the dam reservoirs and irrigation and drainage canals should be performed as heavy soil erosion and sediment transport can be anticipated to occur under the extremely high rainfall condition.

For the other extreme (drought), climate resilient O&M would include cropping calendar adjustment, use of controlled irrigation such as AWD technology, rotational water distribution, use of division boxes and flow divisors, canal lining provision to prevent excessive conveyance losses, prevention of illegal offtakes and diversions, regular repair of water control facilities to prevent leakage, regular canal maintenance works to maintain and maximize canal discharge capacities among others. Wherever groundwater resources development is feasible, the use of STWs may also be recommended for supplementary irrigation particularly at the downstream portion of irrigation service areas during occurrences of drought conditions. For small scale irrigation systems, the use of small farm reservoirs, small water impounding systems and small diversion dams may be recommended wherever feasible.

Climate Proofing During Rehabilitation and Restoration of Irrigation Systems

For rehabilitation and restoration of irrigation infrastructures, the principle of "Building Back Better" should be applied. The United Nations General Assembly (UNGA) described the "Building Back Better" principle as "*the use of the recovery, rehabilitation and reconstruction phases after a disaster to increase the resilience of nations and communities through integrating disaster risk reduction measures into the restoration of physical infrastructure and societal systems, and into the revitalization of livelihoods, economies, and the environment*" (United Nations Office for Disaster Risk Reduction [UNISDR], 2017). Although this is an obviously general description, the basic idea can be extended to agricultural infrastructures particularly during rehabilitation and restoration after devastation by natural disasters and extreme weather conditions. This means that rather than simply restoring the agricultural infrastructure to its original state prior to the occurrence of the disaster, application of the building back better principle calls for reconstruction of the agricultural infrastructure that will make it more robust and resistant to similar adverse weather conditions and disasters that may happen in the future. This approach to rehabilitation will not only prolong the service life of the irrigation facilities and infrastructure but also avoid economic losses not only in the form of infrastructure damage and incapacitation but also in terms of loss in agricultural productivity and economic activities. This obviously call for new design standards for numerous structures which are site specific in view of the spatial and temporal variability of climate projections, paths and occurrences of extreme weather conditions such as occurrences of super typhoons, severe low-pressure areas and strong habagat.

4.11.2. Coping with Climate Change Impacts on Philippine Irrigation Systems on a Regional Level

Flooding, reduced water flows, and damages to irrigation facilities were commonly experienced by the NIA personnel in Luzon and Mindanao. Additional impacts observed by the NIA personnel in Luzon are canal siltation and service area reduction, while erosion is observed in Mindanao. Regional NIA managers in the Visayas region reported that a major impact of CC is damages to crops because of abnormal wet and dry seasons. CC impacts are not the same in all regions indicating plausible differences in contextual vulnerability among irrigation systems.

The coping schemes by irrigation managers and institutional officers from Mindanao tended towards climate-proofing of irrigation development. They devised strategies that have broader coverage and long-term effects on irrigation development, namely watershed protection, better environmental and social safeguards, planning and design considerations of irrigation structures and stakeholder engagement. They generally considered vulnerability reduction and mitigation and adaptation options to CC impacts.

Meanwhile, the adaptation measures/works developed by the regional NIA managers, engineers, and institutional officers in Luzon and Visayas are adjustments to year-to-year variability in climate, i.e., to be able to adapt to endure the impacts. The measures are a combination of structural and non-structural measures, which include provision and automation of steel gates to regulate irrigation water flows and adoption of crop WSTs. Synchronizing irrigation and cropping schedule according to seasonal climate forecasts and providing/lending pumps during period of scarce water supplies were also considered.

Table 4.54. Observed Climate Change and Variability Impacts and Adaptation Measures and Works in Philippine Irrigation Systems in Various Regions

Climate Variability and Change Impacts	Adaptation Measures/Works
Mindanao NIA Regions; N=4 • Reduced water flows in the dry season • Flooding and erosion in the wet season • Damages to irrigation facilities	Mindanao NIA Regions; N=4 • Give emphasis to environmental and social safeguards • Consider appropriate type of structure during project planning • Collect, analyze, and forecast impacts for use in project design • Watershed protection • Stakeholder consultation on environmental issues, culture and tradition
Visayas NIA Regions; N=4 • Crop damages because of abnormal dry and wet seasons	Visayas NIA Regions; N=4 • Provide farmers with pumps • Adopt water-saving technology
Luzon NIA Regions; N=12 • Flashfloods cause canal siltation • Damages to irrigation infrastructures and facilities • Reduced water storage in dams' reservoirs • Reduced irrigated areas	Luzon NIA Regions; N=12 • Provision of protection works • Fit intake and inlet structures with steel gates • Modify/adjust cropping calendar according to predicted seasonal climate forecast • Maintain close contact with all stakeholders in solving issues and problems as regards irrigation operations • Provision and automation of steel gates.

Note: N = number of respondents who completed and returned the survey questionnaires; Respondents consisted of Operations & Maintenance Engineers, Regional Irrigation Managers, Regional IMO, Division Managers

It is apparent that while certain CCA measures have already been employed in irrigation systems in the various regions in the country, there are still numerous ways by which irrigation systems can be made to be more climate and disaster resilient. Apart from the climate-proofing recommendations, additional CCA options and technologies are presented in support of irrigation development and management in the country.

4.11.3. Selected Climate Change Adaptation Options and Technologies for Irrigation Development and Management

At the broadest level of classification, technologies for CCA for irrigated systems may consist of "hard" technologies (e.g., use of ICT) and "soft" technologies (e.g., crop rotation patterns, improved varieties, modified planting dates). A review of adaptation portfolios of agricultural systems to climate risks of different countries, particularly the Asian countries, show that the portfolios often contain a mixture of "hard" and "soft" technologies. The same mix can be recommended in the Philippines in support of irrigation development. This section presents additional specific recommendations for CCA to enhance resilience of irrigation systems in the Philippines.

Protection and Proper Management of Watersheds

Proper watershed management and protection will maximize streamflow dependability for irrigation and minimize flood discharge occurrences, sediment transport and siltation problems. A well-managed and protected watershed sequesters carbon and therefore serves as a mitigation option for CC. Hence, safeguarding the source of irrigation water through the protection and management of watershed will strengthen resilience to and adaptive capacity of irrigation systems to CC impacts. Nonetheless, CC has been impacting watersheds and river basins that provide water to irrigation systems. These watersheds and river basins have already undergone long periods of development, land use change and degradation or depletion of environmental resources. Many of these watersheds are already at their critical state and their dependable water supply often proves to be inadequate to meet the irrigation water demand especially during dry season. NIA must therefore lead an interagency collaboration to protect and manage forests and other natural resources in the watershed.

Modernization of Irrigation Systems

Modernizing irrigation systems will enhance their adaptive capacity to impacts of climate variability and change. Irrigation system modernization is a process of technical and managerial upgrading, as opposed to mere rehabilitation of irrigation schemes with the objective to improve resource utilization (labor, water, economics, environmental) and water delivery service to farms (FAO, 2007). Central to the modernization strategy is the foremost importance of a coherent link of the system design, operation, maintenance, and water supply to improve irrigation water delivery (delos Reyes, 2014). Depending on the availability of new information or evidence, irrigation improvement or modernization should be established on adaptation options that make incremental improvement to irrigation hardware and software (Batchelor & Schnetzer, 2018).

An optimum combination of hardware and software comprises effective adaptation and mitigation alternatives. Irrigation modernization usually includes supplemental irrigation, rehabilitation of physical infrastructures, finding supplemental sources of irrigation such as STWs, re-use of drainage water, and modifying irrigation and cropping schedule. Modernization must also give attention to future allocation for multiple uses of water.

Irrigation planners and designers should connect CCA and mitigation options closely to overall irrigation modernization program. That way, modernization of irrigation systems should enhance and sustain CCA to year-to-year climate variations.

Other ways to modernize irrigation systems include the use of sensors to facilitate operation of irrigation facilities and water management practices such as the AWD technology. This type of modernization is currently the subject of intensive research under the Commission on Higher Education – Philippine-California Advanced Research Institutes (CHED-PCARI) project by Ella (2019).

Integrating Climate Change Risk Assessment into Environmental and Social Impact Assessment

The resilience of irrigation project/system can be increased through integration of CC impacts and adaptation options into EIA, as part of the project cycle. It is a complementary approach for increasing the effectiveness of EIA, at the same time, it would increase the adaptive capacity of irrigation project/system to climate variability and change. Risk assessment will consider not only the impacts of CC on the project but also the significance of the project on GHG emissions. The Netherlands, Canada, and Australia are the few countries that have started to integrate and legalize CC considerations into EIA process for development of major projects. The Philippines should follow suit since the country is highly vulnerable to CC impacts.

Water Supply Augmentation

Augmenting irrigation water supplies during times of water scarcity is a traditional practice by innovative farmers. Tapping base flows of small streams near their farms during the dry season is a practice commonly observed among water-deficient farms. In addition to the NIA water augmentation interventions, there are other practices and technologies that can be used to increase water supplies when needed. The following practices can increase water supplies and step-up irrigation systems' resiliency to cope with climate variability and change:

- **Maximizing effective rainfall** - Irrigation water originally emanates from rainfall. Not only rain-dependent agriculture does collect rain for growing crops but also irrigated farms, particularly farmers at the tail-end of irrigation systems. Apart from increasing effective rainfall, the practice can minimize runoff and flooding and at the same time recharge shallow groundwater. The NIA can extend assistance to farmers on how to manage paddy field water to increase effective rainfall use.

- **Conjunctive use of surface and groundwater** - Irrigation systems' vulnerability to the impacts of climate variability can be reduced by the joint use of surface water and groundwater for irrigation water supply. During rainy season, surface water recharges groundwater storage for use in rainless months or dry season. It will even out seasonal water variability in irrigation systems. Raise farmers' awareness through information education, and communication (IEC) campaigns to be led by the IAs on the significance of capturing rainfall in their paddy fields to recharge groundwater systems in the rainy for use in crop production in the dry season.

- **Aquifer recharge management** - Elsewhere in the world, groundwater is replenished through deliberate recharge of water to aquifers, in a way this is similar to, but on a bigger scale, the practice of conjunctive use of surface and groundwater. Excess water that will be otherwise lost during rainy season and periods of low demand is collected and percolated to aquifers or underground reservoirs. Proper aquifer recharge management can enhance the potential for using STWs and SPIS or solar powered pumps tapping groundwater resources to irrigate diversified and high value crops.

Luyun et al. (2018) in their Policy Study Towards Effective Groundwater Management for Sustainable Agriculture recommended the pilot study of groundwater recharge projects using STWs, Small Water Impounding Projects (SWIPs), and Small Farm Reservoirs (SFRs). SWIPs and SFRs store excess rainfall or runoff for irrigation, but at the same time they also recharge the aquifers. Upon improving the quality of water in the SWIPs and SFRs through various modes such as settling ponds or wetlands techniques, the water may be injected directly into the aquifer through the STWs. These are generally called Managed Aquifer Recharge (MAR) facilities and it is recommended that the use of these facilities be studied for the conservation of our groundwater resources.

- **Safeguarding water at the headworks** - It is necessary to protect the surroundings of the headwaters of most rivers to maintain optimal water recharge and infiltration process and consequently sustain irrigation water supplies even during the dry periods. Also, overuse and pollution of water sources at the headworks must be prevented or avoided to keep water resiliency. To minimize water pollution, intensive agricultural production using high fertilizer and pesticide inputs should be restricted. Land use zoning should restrict industrialization and urbanization of watersheds. Water allocation quotas for different sectors should be strictly followed by concerned agencies.

- **Improved irrigation efficiency** - Except for controlled irrigation, most of the NIA interventions are apparently focused on making do with little water to sustain crop production rather than on minimizing water use (water demand management). Managing water demands in such a way that only crops water requirements are supplied can be challenging in a surface, rice-based irrigation system that is a supply-based system. It will require retrofitting or even modernization of the whole system to reconfigure supply-based system to demand-based system. Water control and measurement facilities are indispensable to water demand management for increased efficiency. For diversified and HVCs, pressurized irrigation systems like drip and sprinkler irrigation systems can be used. Altering cropping pattern and adopting new farming systems, and adopting different crop growing practices such as direct seeding for rice cultivation and conservation tillage or conservation agriculture for diversified and HVCs will increase irrigation efficiency.

- **Reducing system water loss, illegal offtakes and leakages** - Water losses from irrigation systems occur anywhere from water diversion, to conveyance, to distribution, and finally to field application. Leakages along the canal systems and illegal offtakes at random places account for water losses. The degradation of irrigation facilities and poor repair and maintenance of canals, and upstream farmers' behavior are the causes for system losses. Concrete lining of canals to reduce leakages is highly undertaken, sometimes from main canal all the way to farm ditches. Nevertheless, care must be taken in implementing this intervention because it can potentially affect areas in the system that depends on conjunctive use of surface and groundwater for irrigation with STWs. As an adaptation measure to increase efficiency, lining irrigation canals to prevent leakage is at best a questionable suggestion and at worst could be a maladaptation to CC. The apparent water saved comes at the expense of groundwater depletion; and runs counter to the NIA's proposition to use STW irrigation to augment short water supplies. What is leakage to the irrigation operator may be recharge from the viewpoint of the well owner. These issues need to be addressed at the local level especially during the formulation of regional and provincial master plans recommended in this national level master plan.

Water Conservation and Storage

- **Rainwater harvesting** - This essentially involves collection and storage of rainfall and runoff in ponds and surface reservoirs during the rainy season. This is arguably a strong countermeasure against the negative impacts of droughts on irrigated agriculture due to CC and variability. It improves the reliability of irrigation supplies and evens out the impacts of climate variability on oftentimes temporally erratic water supplies. In parts of irrigation systems where diversified crops are to be grown, rainwater harvesting is a highly recommendable CCA scheme.

- **Small water impounding systems and farm reservoirs** - Similar to rainwater harvesting, the use of farm ponds and small water impounding systems is an important water conservation and storage scheme. They may be off-stream or on-stream type of ponds or reservoirs. These types of reservoirs have already been used in support of irrigation development in the country. In view of CC impacts, design standards just need to be upgraded.

- **Multipurpose dams and reservoirs** - Multipurpose reservoirs include functions other than irrigation such as power generation, flood control, navigation, runoff storage, water discharge regulation, fishery and recreation. While water conservation should be among the primary goals in using multi-purpose reservoirs, they can also help meet a number development goals in developing countries, such as those related to energy, water and food security, and economic development. Multi-purpose reservoirs reduce seasonal water stress and improve access to water during droughts. Through the production of renewable energy, they also serve as a mitigation option against CC.

- **On-farm soil moisture conservation techniques** - For irrigating diversified and HVCs, mulching and other soil conservation techniques not only preserve soil but also reduce irrigation water requirement during water scarcity period. The following agronomic practices had been developed and used for reducing excess soil moisture loss in farmers' fields; no tillage; spreading manure or compost over soils; crop rotation; green manuring; deep tillage; mixed cropping; contour plowing; and strip cropping. More recently, conservation agriculture has proven to be an effective soil water conservation measure and at the same time an effective long-term CCA and mitigation measure. It is a new paradigm in doing crop production, based on the principles of minimum soil disturbance, continuous mulch cover and diversified crop rotation (Ella, 2019).

- **Farmer controlled small-scale irrigation systems** - To raise the reliability of inadequate and uncertain water supplies, irrigation system planners and designers must innovate to incorporate farmer-controlled irrigation systems into large irrigation systems

(Moya, 2018). These include STWs, small inundation schemes, farm reservoirs and low-lift pumps, mini ponds, farm ponds or small water impounding reservoirs, or the melon-on-the-vine systems (FAO, 2007). Small surface reservoirs are local pond reservoirs used for collecting and storing rainfall as supplemental sources of water for irrigation. The small structures also store water from larger irrigation canals or catch drainage water and re-use it when canal water supplies and rainfall become unreliable.

- **Stakeholders' water conservation campaigns** - IEC campaigns on the environmental and economic benefits of water conservation can improve water use efficiency. The education and awareness campaigns are targeted at changing attitudes and behavior to use water more efficiently. IAs, with the help of NIA, can spearhead the campaigns on different irrigation water conservation methods through workshops, social media, or stakeholder dialogs.

Use of Alternative Water Sources

To deal further with scarce water supplies that are potentially caused by CC and variability, alternative sources of water must be exploited to enhance resiliency and adaptive capacity of irrigation systems. The following practices and technologies are applied for exploring alternative water sources.

- **Inter-basin or trans-basin water transfers** - Supply-side policy endeavors to provide water for growing demand for water at virtually any cost. Hence, inter-basin water transfer projects are undertaken to adapt to CC. Watersheds with surplus water (donor basin) can transport water over long pipeline and canal systems to alleviate water shortage in another watershed (recipient basin). Inter-basin transfers are likely very costly and only favored for big river basins and high-value demands. On account of economic and environmental impacts on the donor basin, it is strictly regulated or completely prohibited in some countries. A technology parallel to inter-basin transfers is the National River Linking Project (NRLP) of India (Amarasinghe & Sharma, 2008). The NRLP aims to transfer water from the water-excess Himalayan rivers to the water-short river basins of western and peninsular India. This is a complex water project with 30 river links and about 3,000 storages to connect 37 Himalayan and peninsular rivers to form an extensive South Asian water grid. Schemes such as this should be explored in the Philippines in support of irrigation development. Studies should be done to ascertain technical, economic, financial and environmental feasibility of the Inter-basin or trans-basin water transfer technology.

- **Groundwater exploration and extraction** - The increase in PIAs, expected from land suitability assessment with up 18% slope will call for exploration of groundwater. Exploring potential rich aquifers involves hydrogeological investigations, geophysical surveys, and remote sensing assessments. This is to identify aquifers of suitable quality and quantity groundwater. However, proper aquifer characterization in terms of lithologic and hydraulic properties is necessary to determine the suitability of groundwater resources for irrigation development.

4.11.4. Disaster Risk Reduction and Management in Irrigation Development and Management

Natural disasters, especially hydro-meteorological disasters, cause billions of pesos in economic damage annually and thousands of deaths. Globally, more people suffer from floods more than any other hazard (UNISDR, 2015). In irrigated agriculture, damages and losses due to floods are greater than those due to drought or to other disasters. CC is expected to exacerbate these losses, due to increased flood and drought frequency, coastal storm surges, and landslides and mudflows. Reducing disaster impact is possible only based on accurate information and a thorough understanding of the impact (FAO, 2018). In this way, the factors that cause disasters can be identified and analyzed for proper disaster risk management. Disaster awareness and understanding are essential considerations for disaster preparedness. Disaster preparedness is the most effective prevention and mitigation measures against disaster risks and consequences.

Disaster preparedness consists of EWS and application of disaster response technologies. EWS are essential components of disaster risk management because they provide essential advisories to responsible institutions, like the NIA, about an impending disaster. They alert institutions and communities at-risk to enable them to take precautionary actions to minimize disaster damages to irrigation facilities, assets and properties. For instance, the NIA practices preemptive spills of stored water in reservoirs during high rainfall events associated with typhoons. Also, EWS generally include monitoring of hydro-meteorological event, disaster risk evaluation, and communicating developments that may create risks (UNISDR, 2015). On the basis of early warnings, disaster response technologies are implemented to reduce the severe consequences of an impending flood, drought, or landslide and mudflow.

- **Flood forecasting systems** - These systems are used to facilitate forecasting of potential flood events and determine risks before they occur. When high risk is associated with a given flood event early warning is issued to via EWS to give sufficient lead time to affected institutions and communities to brace themselves to avoid exposure, and thus minimize consequent flood damage. Flood forecasting systems are established in flood-prone areas and important river watersheds. The forecasting systems estimate expected water level rise using inputs data to hydrologic simulation tools and models that predict precipitation levels and stream flow, as well as from hydrometric stations measuring water levels at selected points along a river or other water body. Data is often linked to the database through satellite telemetry. The PAGASA maintains flood forecasting and warning systems for 18 major river basins in the country. The system undertakes flood watch and issues early warning to relevant institutions and agencies to warn at-risk impact areas.

- **Early flood warning systems** - Usually, the flood warning advisories provide a forecast of the relative magnitude, timing, location and likely damages of the impending flood. The warning advisories are based on risk assessment by the flood forecasting systems. EWS for floods consist of four inter-related elements: 1) assessments and knowledge of flood risks in the area, 2) local hazard monitoring (forecasts) and warning service, 3) flood risk dissemination and communication service, and 4) community response capabilities. The execution of these four elements of flood EWS, are undertaken by different government agencies. The PAGASA Flood Forecasting and Warning systems give updates on status of water level (elevation) in monitored dams, daily hydrological forecast for basins, and general flood advisories. Additionally, it issues tropical cyclone warning for agriculture. Moreover, NIA coordinates with DPWH for flood control management. The grassroots factor cannot be discounted in DRRM. Barangays, being fundamental planning units, are mandated to implement RA

10121 otherwise known as DRRM Act, while Water Users Association (WUA) and other stakeholders can work together with the barangay DRRM Committee (BDRRMC) in reducing damages from flooding.

In view of the foregoing, effective NIA governance arrangements supported by strong political will are needed to maintain the operations of EWS. Roles and responsibilities for system management and maintenance should be agreed upon, and necessary staff training should be conducted prior to implementation of the early flood warning systems.

On different aspects of early flood warning, the speed to which a flood warning can be transmitted and communicated is important to mitigating flooding effects. To lessen the extent of flood damage, fast and reliable data and information transmission of flood watch advisories to affected communities will be needed. Advances in information technology and communication can be used to investigate how to develop a wireless climate and flood data acquisition network. A timely flood warning system, through mobile phones using short messaging system (SMS), will allow for adequate lead time so people can act appropriately to lessen flooding damages to properties, infrastructures and life.

Responses to disastrous flood could include anticipatory adaptation works such as constructing multi-purpose reservoir projects that include, aside from irrigation, other functions like, flood control, power generation fishery and recreation. Whenever appropriate, the building flow-through dams can be considered adaptation option for flood mitigation. Provision of adequate density of drainage channels is also necessary to carry away floodwaters generated by flood and rainfall with characteristic design return period. Retarding and retaining runoff in upstream watershed through agroforestry, afforestation/ reforestation and land use management in the watershed can decrease the magnitude of floods. Increase the carrying capacity of river by means of desilting, building dikes and floodwalls and/or constructing flood diversion and floodways. These adaptation technologies reduce disaster risks to irrigation systems/projects.

- **Drought forecasting systems** - Drought is essentially the absence of water at sufficient and sustainable quantities. Irrigation is supposed to be the perfect disaster solution to drought, but irrigation is adversely crippled too by the absence of water. Drought is a slowly developing disaster that creeps up and brings havoc to various sectors of the economy. Furthermore, drought runs on different time scales. Meteorologists and climatologists have defined four types of drought: 1) meteorological drought, 2) agricultural drought, 3) hydrological drought, and 4) socioeconomic drought. Meteorological drought takes place during prolonged rainless days while agricultural drought occurs when there is soil moisture to supply plants' and crops' needs for evapotranspiration. After many months of meteorological drought, when water level goes down in streams, reservoirs, and groundwater, hydrological drought happens. And socioeconomic drought relates the supply and demand of various commodities to drought. Drought is a complex phenomenon that is difficult to monitor and to predict. Drought forecasting systems use climate and atmospheric models to predict the probability of a drought occurring in a region or area of interest in the future (up to approximately three months).

Drought forecasting systems are an important part of EWS, as they provide lead-time to planners for threat responses, which helps minimize risk from drought. The PAGASA provides climate advisories on monthly climate assessment and outlook and occurrence of dry/drought to give early drought warning. This is to notify local communities of danger, potential harm, or risk of a drought, so they can plan and act to decrease the risks associated with crop damages and losses. When drought risks are so high that estimated losses from planting a crop are out of the question, a no-planting option is an adaptation solution. As in flood watch, the BDRRMC can be involved in disseminating information to the community about the impending drought and the necessary options/ actions they can take to minimize damages and losses.

The communities at risks to drought occurrences could mitigate impacts and consequences in a number of ways. More than any other CCA and mitigation measures, disastrous droughts demand high irrigation efficiency. Operations of irrigation systems can switch from continuous to rotational water distribution and implement strict water schedules. Where groundwater is available, STW or solar-driven pumps can be brought in the service area to augment scarce irrigation water supplies. Farmers can adopt drought resistant crop varieties to get by and harvest a crop during the dry spell. During prolonged drought episodes, the PAGASA carries out cloud seeding operations to induce rains.

- **Landslide and mudflow warning systems** - In view of unpredictable weather patterns resulting from CC, landslides and mudflows are increasingly likely to occur. Intense rainfall brought about by strong typhoons can trigger landslides and mudflows, particularly in sloping areas. Irrigation facilities and canals located nearby are threatened by landslides. Landslide warning systems that could predict danger of a landslide or mudflow event would improve disaster preparedness in an area, and reduce risks. Geo-indicators (local geological and meteorological conditions) should be identified and established. The PHILVOCS publishes data and information that the public can use to minimize risks from landslide and mudflows. Hazard maps, especially landslide susceptibility map, are accessible in its website. The map will help one to understand the vulnerability to landslide and mudflow events of his area, so he can prepare and plan how to avoid or mitigate landslide risks. It also launches public information campaign and put landslide warning signs on areas that are highly vulnerable to landslides. The institute also recommends a number of engineering measures or slope protection measures to adapt to impacts of landslide events. The engineering and protection measures include the building of retaining walls, riprap, gabion walls, and shotcrete. Moreover, improving drainage facilities and controlling erosion using coconut bioengineering and vetiver grass could minimize damages to irrigation facilities during landslide.

To forewarn communities that are vulnerable to landslide as indicated in the landslide susceptibility map, EWS are necessary. EWS, which are monitoring systems designed to predict events that precede landslides, are called for to issue a hazard warning. Information and education campaigns are indispensable to mitigate risk and reduce consequences of landslides. LGUs, particularly the BDRRCs should be involved in disaster preparedness planning for landslide and mudflows.

4.11.5. Other Recommendations

Apart from the climate proofing recommendations from irrigation system planning, design up to O&M previously presented, the other recommendations provided by Ella (2019) in the UNDP-FAO-funded project on the Integration of CCA and DRRM in the updating of AFMP, 2018-23 are adopted in this NIMP.

Policy and Regulations

To ensure climate proofing of irrigation infrastructures, the following policies may be considered:

- Formulation of new design standards for irrigation and drainage facilities
- Consideration of "Building Back Better" principle in the rehabilitation of irrigation infrastructures
- Strict quality assurance and quality control in the construction of irrigation infrastructures
- Development of more stringent environmental protection measures to protect damages to irrigation infrastructures by extreme weather conditions and disasters

Research, Development and Extension

To further strengthen the climate resiliency of irrigated agriculture, the following research and development activities may be considered:

- Promotion of appropriate irrigation water management techniques such as AWD, intermittent and rotational irrigation scheme and all other water saving practices
- Promotion of WSTs such as drip irrigation for HVC production systems
- Promotion of conservation agriculture as a water conservation measure in irrigated upland crop production areas to address drought conditions associated with CC and climate variability (Ella, 2018 and Ella et al., 2016)
- Development of site-specific design criteria for irrigation systems including reassessment of water duties and dependable flows as a result of CC using hydrologic models
- Design, development, and promotion of rainwater harvesting technologies
- Use of ICT such as wireless sensor networks for efficient irrigation water management of both upland and lowland crop production systems (Ella, 2019)

4.12. Irrigation Support for High Value Crop Production Systems

To augment farmers' income, enhance their competitiveness, and partly address the adverse effects of the recently enacted Rice Tariffication Law of 2019 on farmers' income due to the uncontrolled drop of farm gate prices of palay as a result of the influx of huge quantities of imported rice due to import liberalization induced by the said law, as already reported in the major dailies in 2019 (e.g., Philippine Star, Philippine Daily Inquirer, Manila Bulletin, Business Mirror, etc.), farmers should be given the option to go into crop diversification. While addressing this issue requires a holistic, integrated, multi-disciplinary and multi-agency approach and goes beyond irrigation development alone, irrigation support for crop diversification is nonetheless imperative in the NIMP.

Crop diversification may be employed in the form of relay cropping, intercropping and crop rotation. Relay cropping is essentially the growing of a third crop, preferably a high value after growing the traditional main crop which is usually rice. Hence, this is suitable for rice-based crop production systems and would obviously benefit the owners of the same piece of riceland. Intercropping, on the other hand, is the growing of one or more crops in between the main crop at the same time and in the same piece of agricultural land. Hence, this generally fits non-rice crop production areas like coconut and other upland crop production areas. Crop rotation, as the name implies, involves growing of a variety of crops in succession. This type of crop diversification also fits the new paradigm in crop production called conservation agriculture (Ella, 2018), which involves diverse crop species rotation along with minimum soil disturbance and continuous mulch cover, as part of CCA and even mitigation measure on CC and disaster resiliency in irrigation development.

4.12.1. Diversified Cropping Options for Various Climatic Types in the Philippines

The choice of diversified crops and the development of optimum cropping patterns involving relay cropping, intercropping and crop rotation is site-specific and should consider land, soil and climatic suitability along with market and other considerations. Based on regional FGDs conducted in the formulation of this NIMP, most of the IAs were amendable to diversified crop production systems to enhance their income. However, they raised the issue of market availability for their produce if they go into diversified cropping. Apart from irrigation support issues, other considerations include harvesting machineries to reduce labor for large areas, postproduction facilities and farm-to-market roads. The soil nutrient balance should also be considered in choosing diversified cropping patterns. All such should be considered formulation of the regional and provincial irrigation master plans, recommended in this NIMP.

As a general guideline, however, previous recommendations reported in the DCIEP of JICA (1991) on a number of diversified crops recommended for each climatic type may be used. These crops were found to be more profitable when planted during the dry season in conjunction to rice cropping during the wet season. Presented below are some of the most common diversified crops which can be grown under each of the four climatic types in the country:

- Type I Climate - Rice cropping during the wet season starts at transplanting in June and ends with the harvest season in September. Some of the non-rice crops that can be planted sequentially in the dry season after rice harvest are onion (October-December), garlic (January-March), eggplant (November-February), tomato (October-January), and mungbean (November-February).

- Type III Climate - The cropping calendar of rice is similar to that of the Type I climate. The diversified crops that can be planted after rice are corn (January-March), cabbage (October-December), eggplant (November-January), okra (October-December), and tomato (October-January).

- Type II and Type IV Climate - Since there is no pronounced dry season for these climactic types, the usual cropping is rice-rice. However, backyard farming of vegetable crops is done in some areas.

4.12.2. Irrigation Options for Crop Diversification

The provision of irrigation support for crop diversification essentially requires proper selection of irrigation methods at the farm level. Irrigation methods can be classified into surface methods, overhead or pressurized methods, and subsurface methods. Surface methods include such specific methods as basin irrigation, border, furrow, corrugation, and wild flooding. Overhead or pressurized methods include sprinkler and drip or trickle irrigation. Subsurface methods may be through water table maintenance or through the use of buried perforated pipes.

Proper selection of the most suitable method of irrigation requires consideration of the following criteria: 1) water supply, 2) soil, 3) topography, 4) crops to be grown, 5) climate, 6) economic and financial, 7) social, and 8) environmental considerations (Ella, 2013). Sprinkler and drip irrigation are generally adaptable to any soil, topography, upland crop and climate. Under limited water supply conditions, it is recommendable to use drip or trickle or micro-irrigation. However, it is important to provide adequate filtration systems especially for poor quality irrigation water supply to prevent emitter clogging. Under windy conditions, sprinkler irrigation may be used for tall crops by using low riser pipes. Pressurized irrigation systems are, however, generally more expensive than surface methods particularly in terms of investment cost. Its labor requirement and operating costs are however cheaper than surface methods. Surface methods such as basin, border, furrow, and corrugation are generally suitable for soils with high water holding capacity and low infiltration capacity to make irrigation less frequent and to avoid designing short field lengths which would be wasteful of lands. Basin requires land leveling while border, furrow and corrugation require land grading and would entail additional costs. Subsurface methods, which simply rely on capillary action to wet the rootzone depth, are seldom used for most practical application and should be avoided especially when the irrigation water supply has high levels of salinity. Surface methods generally result to surface water and groundwater contamination since runoff losses and percolation losses, which may carry excess agro-chemicals, are always incurred during irrigation application even for properly designed systems. On the other hand, properly designed pressurized irrigation systems do not lead to runoff losses. However, sprinkler irrigation may lead to groundwater contamination since percolation that may carry excess agro-chemicals will still be incurred. Each method of irrigation has its strengths and limitations and final choice for a given situation should consider all the aforementioned criteria collectively.

Among the most widely used irrigation methods that can be recommended for diversified cropping systems include sprinkler, drip and furrow irrigation. Hence, focus will be made on these specific irrigation methods as potential methods of irrigation for HVC production systems.

Sprinkler Irrigation System

Sprinkler irrigation is a method of providing rainfall-like irrigation (usually using pumps) to the plants, with water being distributed through a system of pipes. Spray heads at the outlets, which break up water into small water drops, distribute the water over the soil surface. To achieve uniform and adequate application of water, the pump supply system, sprinklers, and operating conditions must be designed properly. Sprinklers provide efficient coverage for small to large areas and are suited for most row, field, and tree crops and water can be sprayed over or under the crop canopy. However, large sprinklers are not recommended for delicate crops such as lettuce because the large water drops produced by the sprinklers may damage the crop (Brouwer et al., 1988). Furthermore, they can be adapted to either uniform or undulating terrain, and to nearly all irrigable soils (but best suited to sandy soils with high infiltration capacities) since irrigation sprinklers are available with a variety of discharge capacities.

The application rate from the sprinklers can also be controlled so that the infiltration capacity of the soil is not exceeded, and surface ponding, runoff, and redistribution are minimized. Application uniformity of the sprinkler system is affected by pressure variations in the system as well as wind speed and direction. However, the pressure variation can be corrected by improved design, while wind effects can be minimized by changing sprinkler spacing and operation when wind speeds are below a threshold value. The depth of water applied is usually greater near the sprinkler and decreases with the distance from the sprinkler. Uniformity of application is achieved by placement of sprinklers such that the wetting patterns overlap, usually about 60-80%. In irrigation design, the engineer considers the nozzle pressure, discharge rate, wetted diameter, and water distribution pattern to obtain acceptable uniformity.

The downside of sprinkler system, however, is that its sprinkler nozzles can easily be clogged with sediments or debris, and therefore requires good clean supply of water, free of suspended sediments. The foliar application of water can raise concerns on specific ion injury, health risk associated with human consumption following foliar contamination, and increased risk in fungal disease. Sprinklers are not suitable for soils which easily form a crust but if sprinkler irrigation is the only method available, then light fine sprays should be used. Moreover, large systems incur high capital investment and operating costs. However, the high returns on investment obtained by the producers, coupled with the low labor force associated with these systems increases its adoption in the agricultural sector.

The components of a typical sprinkler irrigation system include pump unit mainline (and sometimes sub-mainlines), laterals, and sprinklers. The pump unit (usually a centrifugal pump) takes water from the source and provides adequate pressure for delivery into the pipe system. The mainline (and sub-mainlines) are pipes which deliver water from the pump to the laterals, while the laterals deliver water from the mainline or sub-mainlines to the sprinklers. Sprinkler systems for field crops include fixed (solid set), hand move (single lines of sprinklers that are moved across the field) and travelling irrigators, and center pivot systems.

A solid set system is a system with main line and laterals that remain in place throughout the cropping season and suitable for crops that require light frequent irrigations. These systems have high capital cost but require very little labor for irrigation. The fixed pipes and risers may obstruct farming operations. The hand move system generally consists of a portable main line that is in place for the growing season and one or two laterals. The laterals are moved right across the field for each irrigation cycle. This system reduces the capital cost but dramatically increases labor costs. These systems should be designed so the average application rate is less than the soil infiltration capacity to avoid runoff.

The travelling irrigation systems are a portable irrigation option for crop irrigation. An example of this is a Traveller Spray Boom, a complete mechanized automated spraying irrigation system. The spray boom-irrigating lateral, placed on a wheel trolley 1.3-2.5 m above the ground, is towed at the far end of the field up to 400 m apart from the machine main body, which stays near the hydrant. They are connected to each other with a long polyethylene (PE) pipe laid on ground. When operated, the pipe is re-winded on a reel (dram) attached to the machine main body and the spray boom on the trolley is dragged backwards irrigating a strip until the full length of the field is covered. The traveller spray booms are compact irrigation systems of low–medium operating pressure (3.0–4.5 bars). The area irrigated per shift (setting) ranges from 0.4-2.0 ha depending on the size of the unit. The Spray booms are used for the irrigation of forage, grain, potatoes, groundnuts, and most agro-industrial field crops.

A center pivot irrigation system is a movable pipe structure that rotates around a central pivot point connected to a water supply. Center pivot irrigation systems are the most popular sprinkler irrigation systems in the world because of their high efficiency, adaptability to a wide variety of field sizes and crop types, high uniformity, ability to irrigate uneven topography, and low maintenance, and management costs (Waller et al., 2016). The systems move through the field by electrically powered tractor wheels. Sprinkler flow rates increase toward the outer end of the pivot because the end of the pivot travels faster. The primary design constraint is the prevention of runoff at the end of the pivot, where application rates are highest. Though center pivot systems involve a high initial investment, the returns obtained is comparatively more in terms of long-term usage, efficient water management, higher crops yields, and low labor cost.

Drip Irrigation System

Drip irrigation (sometimes called trickle irrigation) is a micro-irrigation system that has to save water and nutrients by allowing water to drip slowly (2-20 liters/hour) to the roots of plants, either from above the soil surface or buried below the surface. Since water is applied close or onto the plant roots, it minimizes evaporation and unnecessary losses of water as only the portion of the soil in which the roots grow is wetted, unlike surface and sprinkler irrigation which involve wetting the entire topsoil layer. With drip irrigation water, applications are more frequent (usually every 1-3 days), thus providing very favorable high moisture level in the soil for crop water use on a daily basis.

Drip irrigation systems distribute water through a network of valves, pipes, tubing, and emitters or drippers, and can apply accurately metered quantities of water evenly to plants. A drip irrigation system can be more efficient than other types of irrigation systems, such as surface irrigation or sprinkler irrigation. However, the system entails high cost of investment and high level of management skills. For drip irrigation scheme to be successful, it must be well-designed, properly installed, and well-managed. Increased skills of irrigation managers and well-developed farm business plan may ensure return of investments. Generally, only HVCs are considered because of the high capital costs of using a drip irrigation system.

Drip irrigation is most suitable for row crops (vegetables, soft fruit), tree and vine crops where one or more emitters can be provided for each plant. It is adaptable to any farmable slope and suitable for most soils. Water must be applied slowly on clay soils to avoid surface water ponding and runoff, while sandy soils need higher emitter discharge rates to ensure adequate lateral wetting of the soil (Brouwer et al., 1988). A typical drip irrigation system consists of the following components: pump unit control head, main and submain lines, laterals, and emitters or drippers. A drip system is usually permanent (remain in place during more than one season) and can be easily automated to reduce labor cost.

Drip irrigation allows for improved irrigation efficiency and water savings due to the reduction in evaporation, surface runoff, and deep percolation. Evaporation loss from the soils is reduced evaporation since only a small area of the surface is wetted (or negligible if the drip is buried). Rainfall runoff is much reduced as it can be stored in the dry soil between the drip lines, and amount of water passing below the root zone is minimal and thus deep percolation losses are unlikely.

One possible problem with drip irrigation is that the emitters or drip holes can become plugged with tiny particles or salts in the water supply. For this reason, water should be filtered. Cartridge-type filters are available and relatively inexpensive. The drip system can be used to provide nutrients to plants (fertigation), but some planning is required. Soluble nitrogen and organic fertilizers can be applied through drippers, but phosphate fertilizers and many organic fertilizers cannot.

While conventional drip systems are generally costly, low-cost drip irrigation kits have evolved in the market in recent years and may be used in the Philippines. An example of low-cost drip systems is the gravity type drip kit developed by the International Development Enterprises (IDE). It was tested and promoted in the Philippines under the USAID-funded Sustainable Agriculture Natural Resource Management (SANREM) project (Ella et al., 2008). A drum reservoir served as water supply for the IDE drip system, and water is directly delivered to plants through small plastic tubes. The drip kit consists of microtube emitters inserted through plastic tape roll laterals connected to polyethylene submain pipes which in turn can be connected to a drum water reservoir. The system is operated without the need of pumping unit as it uses an elevated drum reservoir at appreciable head to supply the water to laterals by gravity. Typical operating heads of the IDE drip kits range from 1-3m (Keller, 2002). This drip irrigation technology is suitable for developing countries because of its low cost and simplicity of design and installation. It has started gaining popularity in some upland watersheds in Southeast Asian countries for vegetable production under agroforestry systems (Reyes, 2007). In the Philippines, this type of drip irrigation system has been successfully used in the production of onions in Nueva Ecija (The Technical Committee, 2012). Field trials of the IDE low-cost drip irrigation system in upland HVCs namely cabbage, Chinese cabbage, tomato, and pepper in Lantapan, Bukidnon showed 20-50% higher crop yield than non-drip irrigated crops (Ella, 2012). The water productivity is also higher in the drip irrigated crops. Financial analysis also revealed the BCR to be >1, and achieved a short 1-2.5-year payback period (Ella, 2012). Hence, with proper drip irrigation system design, the use of low-cost drip system has the potential to increase farmer's income under diversified cropping systems.

Other advantages in using drip irrigation systems include reduction in runoff and percolation losses and generation of water savings of 50-80% compared to most traditional surface irrigation methods. Crop productivity (production per unit of water consumed by plant evapotranspiration) is also increased by 10-50% (The Technical Committee, 2012).

Nevertheless, one limitation of the low-cost drip kit is the non-uniformity of water distribution particularly in sloping areas. This issue of non-uniformity of water distribution can, however, be addressed using pressure regulators at the head of each lateral. In fact, results of field tests performed by Ella (2013) showed a significant increase in both the coefficient of uniformity (CU) and distribution uniformity (DU) to a range of 76-94% and 64-91%, respectively, with the use of pressure regulators. For all pressure heads and submain slope of 30%, CU and DU were increased by an average of 25% and 82%, respectively, with the pressure regulator. Technologies such as this may be employed as part of the possible options of irrigation support for crop diversification in the Philippines.

Drip irrigation can also be automated using wireless sensor network. This is the subject of intensive research in the CHED-PCARI project by Ella (2019). Once pilot-tested, this technology may be promoted in the future application of drip irrigation for HVC production systems in the Philippines.

Summarized in Table 4.55 are the basic design considerations for pressurized irrigation systems such as sprinkler and drip.

Table 4.55. Design Criteria and Considerations for Pressurized Irrigation Methods

Type of pressurized irrigation	Design criteria and consideration	Irrigation scheduling programme
Hose-move sprinkler irrigation (for full coverage crops: maize, cotton, potatoes, carrots, groundnuts)	Sprinkler Spacing (Sm): ▪ Not to exceed 65% of sprinkler diameter coverage under light to moderate wind for square and rectangular patterns ▪ Up to 70% diameter coverage for triangular pattern. ▪ 50% under strong wind with lateral direction perpendicular to wind direction Not recommended for over 3.5 m/s wind strength. Common sprinkler spacing for low discharge and precipitation rates of 8-14 mm/h: ▪ 6,9, or 12 m along laterals ▪ 12 or 18 m between lateral Sprinklers can be extended to both lateral line sides, 6 lateral positions at 12-m Sm spacing, covering up to 60 m distance. Precipitation rates should not exceed the soil infiltration of: ▪ 25 mm/h (light soils) ▪ 8-16 mm/h (loam) ▪ 2-8 mm/h (clay) Height of sprinkler above ground ▪ 60 cm minimum for low-growing crops Loss of pressure due to friction in lateral line: ▪ Not exceed 20% of the pressure at entrance Minimum operating pressure: ▪ At least 2.0 bars	Standard procedure for preparation of irrigation programme (consider soil moisture holding capacity, plant physiology, climate). Irrigation dosage application depth: ▪ 40-100 mm (for deep rooted field crops) Precipitation rate: ▪ About 14 mm/h Operating time at each position: ▪ 3-7 hours Irrigation intervals: ▪ 2 weeks (common) Irrigation efficiency: ▪ 75%
Microsprinklers	Sprinkler spacing: ▪ Not exceed 50% of diameter coverage ▪ Sm along and between laterals should range from 5 -7 m.	Fixed depletion irrigation for shallow rooted crops (e.g. vegetables)

Type of pressurized irrigation	Design criteria and consideration	Irrigation scheduling programme
Microsprinklers (potatoes, carrots, leafy vegetables, groundnuts, and other densely planted field crops)	Common spacings: ▪ 5 m x 5 m ▪ 5 m x 6 m ▪ 5 m x 7 m ▪ 6 m x 7 m Pipe sizes: ▪ 32 mm (optimum for LDPE) More sprinklers per unit area should be operated simultaneously to mitigate adverse wind effects.	Gross application depth: ▪ 20-30 mm (potatoes and vegetables) Total no. of irrigation required: ▪ 12-15 mm (for 300-400 mm gross water requirement of potato and vegetable)
Minisprinklers (for fruit tree crops)	One emitter per tree Emitter spacings = tree spacings Emitter flow rate should match available water, area, number, age and tree size, and number of irrigation shifts Distance between minisprinklers and tree trunks: ▪ 30-50 cm Maximum permissible pressure variation: ▪ 20% pressure difference for a 10% discharge difference	Irrigate at fixed interval on a weekly basis (twice a week for young trees)
Bubbler irrigation (for fruit tree crops)	Two bubbler emitters, one on each side, for mature trees One lateral per two rows of trees Flow rate: ▪ 500 lph	80% wetted root soil volume Either fixed depletion or fixed interval irrigation programme
Drip irrigation	Indicative average radius of water lateral spread: ▪ 0.3 m (light texture) ▪ 0.65 m (medium texture) ▪ 1.2 m (fine texture) Wetted soil volume per tree: ▪ Not less than 35% ▪ 50-60 cm (to avoid deep percolation)	Soil moisture depletion: ▪ Not exceed 40% of soil available moisture (late growing stages of vegetables and fruit trees) ▪ 20-30% (early stage of vegetables)

Type of pressurized irrigation	Design criteria and consideration	Irrigation scheduling programme
Drip irrigation (for intensive row cultivated crops, vegetables, fruit trees, melons, bananas, papayas, flowers, grapes, watermelon, etc.) *Not recommended for potatoes, leafy vegetables, groundnuts and other dense planted crops	Dripper lateral design arrangements: ▪ Single line per row of trees, with 4-8 drippers at pprox.. 0.8-1.2m interval along the line ▪ Circular layout or loop around tree, either smaller extension line 5-8 drippers around the trees for single line per row, or multi-exit dripper with 4-6 small emission tubes radial to the tree. Circle diameter ranges from 1.2 to 2.2m. Two drippers at both sides at 35-40 cm away for newly planted trees. ▪ Double lines per row of plants (banana), two dripper lines per row, one on each side, 1.2-1.6 m apart. Dripper spacing is 0.7-1.2 m.	Irrigate every day in the later parts of growth stage
Low-cost hose irrigation (for fruit tree crops, field crops, and veg-etables)	Conventional hose basin for trees: ▪ One 24-m-long hose irrigate 36 tree basins spaced at 6 x 6 m ▪ 36 m (every 6 rows) lateral spacing along rows ▪ 36 m (every six trees) hose spacing along laterals Drag hose basin for trees: ▪ Each 20-32 mm soft black LDPE pipes, 2.5 or 4.0 bars, irrigate 2 or 4 rows of trees on both sides of lateral line Hose basin for field crops: ▪ Size of small basins: 12 x 12 m, 6 x 12 m, or 6 x 18 m ▪ Laterals are more close-spaced than trees ▪ Hoses can be soft PVC or LDPE, 18-24 m long, 25 mm - 1_in	Conventional hose basin for trees: ▪ Hoses are moved by hand from one basin to another Drag hose basin for trees: ▪ The hoses are extended to the distant end basins at the beginning of each irrigation and moved to the other basing by dragging them backwards. Hose basin for field crops: ▪ Hoses can be moved from one basin to another by dragging them backwards or by carrying them

Type of pressurized irrigation	Design criteria and consideration	Irrigation scheduling programme
	Hose furrow for vegetables: ▪ Hoses are 25-32-mm soft black LDPE or 1_-in soft PVC garden hoses ▪ Hose spacing along lateral is same with furrow length ▪ Furrows are usually short, 18-30 m long, 15 vm deep, 1m apart	Hose furrow for vegetables: ▪ Minimum flow for small basins while maximum possible flow for large basins. ▪ Small discharge hoses can be moved from one place to another in the basin itself for sandy soils with high infiltration rates.

Sources: FAO (1999) and Phociades (1999)

Furrow Irrigation

Furrow irrigation uses small open channels or miniature trench called furrows to deliver and apply irrigation water in between row crops. The bottom and sides of the furrow allows the vertical and lateral infiltration of water, which is then absorbed by the roots of the crop. This type of irrigation system must be carefully installed, as any change to the plans can affect its smooth operation. Proper and regular maintenance, especially on the supply system, would ensure good irrigation.

Furrow irrigation is suitable for most soil types except for very coarse sand due to high percolation losses and crusty soils, and for many crops especially row crops that are sensitive to water logging. Crops suitable for furrow irrigation include row crops such as maize, sunflower, sugarcane, soybean; crops that would be damaged by inundation, such as tomatoes, vegetables, potatoes, beans; fruit trees such as citrus, grape; broadcast crops (corrugation method) such as wheat (Brouwer, 1988). Uniform flat or gentle slopes are preferred for furrow irrigation.

Techniques to improve distribution uniformity with furrow irrigation include increased furrow flow rate, reduced run length, and cut-back flow. Increasing the flow rates in the furrow decreases the advance time of the furrow stream and thus reduces the difference in opportunity time between the ends of the field. The furrow advance time should not exceed 25% of the total set time. Reducing the furrow length has the same effect on opportunity time as increasing the furrow flow rate. Surface runoff is lessened by reducing the furrow flow rate after the advance is completed by a cut-back flow.

When water moves from the head furrow to the tail end furrow, it produces significant amount of water loss due to deep percolation. To reduce the loss, innovations have been adopted farmers by using segmented pipes (2.5 m in length and 3.2 cm in diameter per segment) to convey water in each furrow (The Technical Committee, 2012). Each PE pipe segment is manually laid out and connected at the beginning of irrigation of one furrow, then the pipe segments are removed one by one starting at the tail end of the furrow as soon as the irrigation of a section of furrow covered by a pipe segment has been completed. The pipe segment that has been removed will be transferred to the adjacent furrow. After the irrigation of the full length of the furrow has been completed, the segmented pipes at the adjacent furrow will all be reconnected again, and the process continues until the entire field has been irrigated.

4.12.3. Other Low-cost Irrigation Technologies for Diversified Crops

Flexible Hose

The use of long flexible hoses to irrigate diversified crops such as tomatoes, corn, tobacco, eggplant is popular among farmers in the Ilocos Region (The Technical Committee, 2012). The flexible hose (usually 1.25-1.50" diameter PE pipe) is attached to pump from STWs or dug wells. During irrigation, the flexible hose is being held by two or three persons to distribute the water in the field. Since water is being applied directly on the field (and sometimes on the individual plants), it eliminates conveyance losses, and reduces runoff and deep percolation losses. It also shortens the duration of the irrigation activity thus reducing fuel costs during pump operation. However, this method is labor intensive.

Use of Clay Pots for Subsurface Irrigation

This traditional technology is suitable for crops that require special attention on water availability for irrigation during their early crop growth stage. Clay pots are simple and efficient device that provide controlled irrigation to plants, and thereby maximizes yield and water productivity. The clay pots are unglazed indigenous earthen pots with micro-porous wall. The water seeps out from micro-porous wall of the buried clay at a rate in the direction where suction develops at a rate that is influenced by the plant's water use. Using this technology water is made available as crops need it, which results to very high efficiency, even better than drip irrigation, and as much as 10 times better than conventional surface irrigation (Bainbridge, 2001).

The system has been used successfully for irrigating vegetables and orchards. Some advantages of using clay pots for sub-surface irrigation include the following: salt accumulation in soils is limited as no waterlogging occurs; weed growth around the plant is suppressed, reducing transpiration losses of irrigation water through weeds; water molecules are attracted to the plant roots as the suction force is created by soil moisture tension and/or plant roots themselves.

During irrigation, a clay pot is filled with water and then covered with a ceramic lid to prevent evaporation losses, disturbance from small animals, and to prevent soil from being washed into them during rains or being deposited in them by wind. Water savings between 50% and 70% are achievable with the clay pot irrigation system as compared to the conventional watering can system where water is applied onto the soil surface, causing soil crusting and inducing excessive evaporation (The Technical Committee, 2012).

4.12.4. Other Irrigation Support for Crop Diversification

In addition to proper selection of farm level irrigation methods, irrigation support for crop diversification may also the following:

- Use of shallow tube wells
- Use of small water impounding systems or small farm reservoirs
- Use of solar-powered irrigation systems
- Use of pipe delivery systems or a hybrid of open channels and pipe distribution system
- Use of rotational irrigation schemes during water-scarce conditions

4.12.5. Potential of PPP in the Provision of Irrigation Support for Crop Diversification

In view of the costly nature of farm level irrigation methods particularly the pressurized irrigation system such as sprinkler and drip irrigation, PPPs should be explored in the provision of irrigation support for crop diversification. The details of the PPP for irrigation support for HVC production systems can be fleshed out during the formulation of the regional and provincial master plans.

4.13. Environmental and Social Safeguards for Irrigation Development

4.13.1. Impacts of Irrigation Development to the Environment and Society and Vice Versa

The Need for Sustainable Irrigation Development

Irrigated agriculture plays a major role in achieving national food security and in raising the quality of human life in many countries. Hence, the Philippine government has been massively investing in irrigation, drainage and flood control projects to boost crop yield and enlarge irrigated areas for decades now. It is hoped that the irrigation infrastructure development projects will raise the socio-economic well-being of farmers and other people dependent on agriculture. Thus, in the past two centuries, socio-economic development has focused on boosting agricultural production without adequate regard to associated environmental impacts and changes. However, the consequences of neglected environmental and social impacts cause many irrigation systems to underperform; some of them even fail. Irrigation development becomes unsustainable without giving close attention, especially at the project feasibility stage, to the prevention, reduction, or compensation of the likely adverse effects to environment and people. Equally important, irrigation field personnel must be capable to manage risks and consequences of unanticipated environment and social impacts during the O&M of irrigation systems. A well-planned, designed and constructed irrigation system that incorporates environmental and social considerations is poised to perform in the long term and be sustainable.

Planning for sustainable irrigation development must be based not only on technical and economic/financial feasibility but also on sound environmental and social feasibility. Numerous unanticipated effects of irrigation projects/systems on the environment and people have been reported to cause unsustainable irrigation development from a wide range of geographic, climatic and social conditions around the globe (Dougherty and Hall, 1995; Holy, 1993; WB, n.d.). The adverse impacts affect the performance of the irrigation/drainage projects/systems themselves and the wider environment. Given that the biophysical and social impacts are interlinked and interrelated, remedial actions intended to solve problems caused by one type of impact can lead to evolution of other impacts and problems. The environmental and social impact evolution trajectory to sustainable irrigation development forms feedback loops. Irrigation planners and managers must design safeguards to weaken or break the loops to protect the environment and people from adverse impacts of unsustainable irrigation development.

The Philippine government and other multi-lateral lending agencies enforce environmental and social safeguard policies to protect the environment and society from the risks and damages from socio-economic development projects, like irrigation infrastructure development. Environmental and social assessment is common to all these safeguard policies. The process is meant to maintain the environmental and social sustainability of irrigation projects. Hence, the integration of the assessment results and outcomes into detailed engineering design during the project FS could lead to sustainable irrigation performance. Environmental and social problems caused by irrigation can be avoided or considerably mitigated by proper planning, design, and operation of irrigation projects (Ochs and Plusquellec, 2003).

This section characterizes environmental and social circumstances relevant to planning, design, construction, and operation of sustainable irrigation projects/systems through post audit of EISs, FS, performance evaluation reports. Based on the distilled information and knowledge, guidelines for the improvement of safeguards against impacts of irrigation projects on the environment and people were developed.

Environmental and Social Impacts of Irrigation

Irrigation brings about both beneficial and adverse impacts to the environment and people. Improving the people's well-being and the society in general, a major benefit from irrigation development, is its keystone role in dealing with the constraints to achieving national food security. Furthermore, Morales and Mongcopa (2008) reported that successful irrigation and drainage projects in Asia contribute to improvement in (a) agricultural productivity, (b) employment opportunities, particularly for marginal and landless workers, (c) transport systems, through better farm and access roads, (d) women's participation, and (e) strengthening institutional capabilities.

Changes in quantity and quality of land and water resources and the consequent effects on natural and social conditions constitute the environmental impacts of irrigation especially on the tail-end and downstream parts of the irrigation system (International Commission on Irrigation and Drainage [ICID], 1993). Irrigation system directly alters the environmental hydrology in the catchment area where it draws water from the river or groundwater, then distributes it to the command area (Rosenburg et al., 2000). As a result, (a) river discharge downstream diminishes, (b) groundwater recharge rate in the system increases, (c) water table level rises/falls, (d) drainage flow increases, and (e) evaporation in the scheme increases. Delayed impacts of irrigation include soil salinization in arid and semiarid regions and waterlogging in humid regions. This is followed by water pollution with pollutants including salts, nutrients, pesticides, trace elements, sediments, pathogens, acids and elevated temperatures. Obviously, the interlinkage and interaction among hydrological impacts cause new environmental effects. The subsequent impacts of irrigation on the people are intricate in view that the environment x social impacts will interact with the technical, economic, financial, and institutional aspects and could produce even more complex impacts and cause irrigation project/system to fail (ICID 2008, Holy 1993).

For assessment of probable impacts of irrigation on the environment and society, the ICID developed a framework of a procedure for identifying environmental effects of new or existing projects (ICID, 2008). The framework is intended for engineers and planners who are not specialists in the environmental sciences. Effects are grouped under eight topic areas, namely (1) hydrology, (2) pollution, (3) soils, (4) sediments, (5) ecology, (6) socio-economic, (7) human health, and (8) ecological imbalances. Environmental and social impacts of irrigation development, according to FAO (2008), included those on (a) hydrology, (b) water and air quality, (c) soil properties and safety erects, (d) erosion and sedimentation, (e) biological and ecological change, (f) socio-economic impacts, (g) ecological imbalances, and on (h) human health.

Impacts of Environmental and Social Changes on Irrigation Systems

If left neglected and allowed to evolve, the foregoing impacts of irrigation development on the environment and humans will eventually feed back into the irrigation development pathway and reduce the efficiency performance of irrigation systems/projects. The environmental and social impacts will constrain the operations of irrigation systems such that they become operationally inflexible. Furthermore, the impacts will also take a heavy toll on farmers' productivity thus reducing their economic well-being.

Meanwhile, on account of natural and anthropogenic causes, environmental and social changes occur in irrigation schemes and in catchment areas where they are located. Deforestation, urbanization, CC, land use and land cover changes and their cascading effects on the environment complicate the aforementioned environmental and social impacts of irrigation to a large extent. The complication will arise from the interrelationship and interactions between the environmental changes. For instance, deforestation and illegal logging upstream engender water supply problems, river sedimentation, and canal siltation in the irrigation scheme. Flooding usually occurs due to surface runoff and river overflows during heavy rains contributed by climate variability and change. Clogging of irrigation canals with solid wastes due to indiscriminate waste disposal is explained by urbanization process within the watershed and service areas of irrigation systems. Environmental changes will influence sustainable irrigation performance and the concerns can be addressed by combined institutional mechanisms and engineering. Moreover, the combined effects of environmental impacts and environmental changes would ramify planning, design, construction, and O&M of many irrigation systems. Thus, Irrigation planners and designers should study and incorporate such in irrigation project FS.

A review and examination of FS and EISs of existing irrigation systems indicated that local environmental issues confronting the Philippine irrigation systems are reportedly similar with those described in the regional and global literature. The following environmental and social concerns were observed during rehabilitation of 12 NISs:

a. Systemic siltation of irrigation canals
b. Flooding
c. Soil erosion
d. Indiscriminate solid waste disposal
e. Forest/watershed denudation
f. Land use conversion
g. Excessive use of pesticides
h. Incidence of infestation
i. Water pollution with chemicals
j. Saline intrusion
k. Mining issues
l. Minimal use of IPM/organic fertilizers and
m. Weak environmental capacity

In other FS, environmental concerns include IP concerns and involuntary resettlement. The unique subset of environmental and social concerns for a given irrigation project differs according to the biophysical and social contexts (spatial and temporal variability) in which a given project/system will be built and operated.

Environmental and Social Safeguards and Policies

"*Safeguards policies are essential tools to prevent and mitigate undue harm to people and their environment in the development process*" (FAO, 2019). Most international financing corporations and multi-lateral development banks apply environmental and social safeguards to projects that they finance. The WB, ADB, International Finance Corporation (IFC), and other lending institutions apply its suite of environmental and social safeguard policies to projects they would extend loan to.

a.Safeguard policies of Philippines and International Agencies

The environmental and social safeguards adhere to the provisions of the Philippine EIS Law (PD 1586), the Philippine Indigenous Peoples Rights Act (RA 8371), the Right of Way Acquisition Law (RA 8974) and their implementing rules and regulations. WB-assisted irrigation projects considered the Philippine safeguards in addition to the operational policies of WB on Environmental Assessment (Operational Policy/Bank Policy 4.01), Natural Habitats (Operational Policy/Bank Policy 4.04), Pest Management (Operational Policy 4.09), Indigenous Peoples (Operational Policy/Bank Policy 4.10) and Involuntary Resettlement (Operational Policy/Bank Policy 4.12). ADB aims to ensure the environmental soundness and sustainability of projects, and to support the integration of environmental considerations into the project decision-making process. It has three key safeguard areas, namely environmental safeguards, involuntary resettlement safeguards and IP safeguards. Common to all these environmental and social safeguard policies is ESIA, which many countries implement to shield the environment and people from probable harm and damage from development projects.

b.National Institutions/Agencies Managing the Environment

To ensure proper implementation of national laws and policies, government agencies are mandated with specific roles and functions necessary for environmental management. These institutions/agencies include:

Table 4.56. Key Institutions in Managing the Environment

Institution/Agency	Environmental Management Aspect	Key Environmental Evaluation Parameters
Environmental Management Bureau (EMB) - DENR	Environmental Quality parameters and corresponding stressors	Air and water quality stressors: environmental impacts, solid wastes, toxic chemicals and hazardous wastes
BMB - DENR	Biodiversity management/ conservation	Wildlife conservation and protected area management
Mines and Geosciences Bureau (MGB) - DENR	Management of the use of mineral resources	Mineral resources quantity/ sustainability
Forest Management Bureau (FMB) - DENR	Management of the use of forestry resources	Primary and secondary growth forests and watershed management

Institution/Agency	Environmental Management Aspect	Key Environmental Evaluation Parameters
Land Management Bureau (LMB) - DENR	Survey, classification, lease, sale or any other forms of concessions or disposition of public lands	Compatibility of classification of adjacent lands
Ecosystems Research and Development Bureau (ERDB) - DENR	Ecosystems research (forests, upland farms, grasslands, degraded areas, coastal zones, freshwater and urban areas)	Ecosystems Services
National Water Resources Board (NWRB) - DENR	Management of the use of water	Water quantity
Department of Agriculture (DA)	Management of the use of agricultural resources	Soil quality for agriculture purposes including the effect of the use of fertilizers and pesticides; regulation of use of agricultural resources
Bureau of Fisheries and Aquatic Resources (BFAR) - DA	Management of the use of fishery and other aquatic resources	Marine and freshwater resources
Philippine Coast Guard (PCG)	Management of marine environment	Marine pollution, sea dumping of wastes and other matters
Department of Energy (DOE)	Management of the use of energy resources	Use of fossil fuel, gas, hydro, wind, solar resources
Climate Change Commission (CCC)	Climate change adaptation/ mitigation	Climate change projections adaptation strategies
National Disaster Risk Reduction and Management Council (NDRRMC)	Management of disaster risks/disaster risk reduction	Natural hazards vulnerabilities/ exposure to disaster risks
Local Government Unit (LGU)	Overall management at the local level	All environmental parameters
Department of Social Welfare and Development (DSWD) and Department of Health (DOH)	Peoples' health and welfare management	Socio-economic and health impacts resulting to environmental quality impacts: displacement, livelihood impacts, health impact, etc.

Institution/Agency	Environmental Management Aspect	Key Environmental Evaluation Parameters
National Commission on Indigenous People (NCIP)	Indigenous People/ Indigenous communities (ICCs) welfare management	Displacement, livelihood, indigenous cultural integrity, rights and practices
National Commission for Culture and the Arts (NCCA), National Historical Commission of the Philippines (NHCP), National Museum	Protection, prevention and conservation of cultural heritage	Physical cultural resources, ethnicity of local communities, intangible cultural resources

Adapted from: Environmental Management in the Philippines, Guia-Pedrosa, 2016

c. National Environmental Management Laws and Policies

There are several laws in the Philippines that guide planners in managing environmental resources. Among these key laws and policies are listed in Table 4.57.

Table 4.57. Key Laws and Policies in Managing the Environment

Aspect	Legislation	Title/Description
Environmental Quality Management		
Environmental Quality Management and Standards and Status Monitoring		
Air Quality	RA 8749 (1999)	Philippine Clean Air Act
Water Quality	RA 9275 (2004)	Philippine Clean Water Act
	PD 979 (1976)	Marine Pollution Decree
	RA 9993 (2009)	Philippines Coast Guard Law
Land Quality	PD 933 (1976)	Recognized the need to regulate land use vis-à-vis management of the quality of life
Management of Environmental Quality Stressors		
Impacts of Undertakings	PD 1586 (1978)	Establishing the Philippine EIS System
Solid Waste	RA 9003 (2000)	Ecological Solid Waste Management Act
Toxic Chemicals and Hazardous Wastes	RA 6969 (1990)	Toxic Chemicals and Hazardous Waste Management Act
	PD 856 (1976)	Code of Sanitation: requirement to install sewage treatment facilities

Aspect	Legislation	Title/Description
Adjunction of Pollution Cases	RA 3931, PD 984, Executive Order (EO) 192	The Pollution Adjudication Board (PAB) created under EO 192 assumes the power of the National Pollution Control Commission with respect to the adjudication of pollution cases under RA 3931 and PD 984
Management of the Use of Natural Resources		
Land-based Natural Resources Management		
Forestry	PD 705 (1975)	Revised Forestry Code of the Philippines
Mineral Resources	RA 7942 (1995)	Philippine Mining Act
Agriculture	RA 8435 (1997)	Agriculture and Fisheries Modernization Act
	RA 6657 (1988)	Comprehensive Agrarian Reform Law
Water Resources Management		
Water	PD 1067 (1976)	The Water Code of the Philippines
Fisheries	RA 8550 (1998)	The Philippine Fisheries Code
Energy Resources and Management	RA 7638 (1992)	Department of Energy Act of 1992
Biodiversity and Ecosystems Management		
Protected Areas	RA 7586 (1992)	National Integrated Protected Areas System (NIPAS) Act
Wildlife Protection	RA 9147 (2001)	Wildlife Resources Conservation and Protection Act
Caves and Cave Resources	RA 9072 (2001)	National Caves and Cave Resources Management and Protection Act
Climate Change and Disaster Risk Management		
Climate Change	RA 9729 (2009)	Climate Change Act
Disaster	RA 10121 (2010)	Philippine Disaster Risk Reduction and Management Act
Socio-Cultural Resources Management		
Indigenous People	RA 8371 (1997)	Indigenous Peoples' Right Act (IPRA)
Cultural Resources	RA 10066 (2009)	National Cultural Heritage Act

Adapted from: Environmental Management in the Philippines, Guia-Pedrosa, 2016

4.13.2. The Environmental and Social Impact Assessment Process

Generically, ESIA entails the following safeguards activities:

Screening

This activity involves environmental and social screening of proposed projects. Adequate screening of alternatives often results in a categorization of the project and from this a decision is made on whether a full ESIA is to be carried out. The NIA prescribes ESIA of proposed projects with service areas ≥ 1,000 ha, including line projects and foreign-assisted projects. Rehabilitation projects must be assessed carefully. The fact that an irrigation scheme needs to be rehabilitated indicates underperformance. Irrigation modernization, which is more than rehabilitation, requires a more careful environmental and social assessment. Furthermore, when required, an IEC campaign is carried out in the affected IP community. The output from the screening process is often a document called an Initial Environmental Examination or Evaluation (IEE).

Scoping

Scoping involves pinpointing, characterizing, and categorizing the key environmental and social issues and concerns. Conducted at the early stage of project planning, it is the EIA safeguard activity that can most strongly influence a proposal. The views and opinions of various project stakeholders are solicited during this process. The main EIA techniques used in scoping are baseline studies, checklists, matrices and network diagrams.

Impact Prediction and Mitigation

Following scoping activity, likely impacts are predicted using prediction methods that are commensurate to the required level of prediction accuracy. An important result of this safeguard activity includes recommendations for mitigating measures, which should be included in the EIS.

Environmental Impact Statement

The main output in ESIA is EIS that contains a detailed plan for managing and monitoring environmental impacts both during project implementation and after decommissioning. Monitoring will indicate the deviation of predicted impacts from actual impacts/problems so that corrective actions could be taken.

Audit of the EIA process

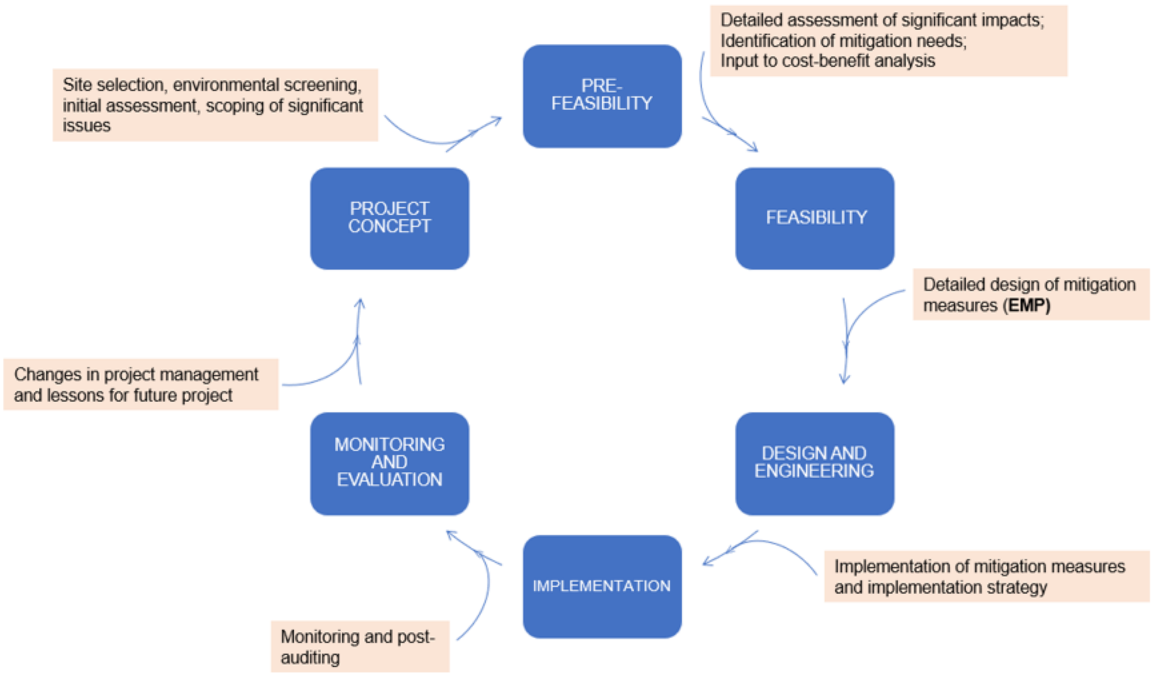
An examination of the outcomes of EIA is carried out some time after project operations. The audit serves a useful feedback and learning function for improving safeguards to shield the environment and people from risks and damages due to irrigation development. A systematic EIA follow-up may also be implemented, which is a generic term that refers to many different activities that aim to pursue the consequences of individual projects or plans. These activities may relate to several overlapping and loosely used terms, such as environmental monitoring, auditing, evaluation, post-decision analysis, and post-decision management. Follow-up is often considered to be a weak or even a missing element in EIA (Jalavaa et al., 2015). It provides opportunities to enhance the possibilities to improve safeguards for environmental and social protection.

The evaluation of environmental and social safeguards to impacts of irrigation development strongly adhered to the Philippine EIA system. Depending on the type of project, safeguards and procedures developed by international funding agencies are also implemented.

ESIA within the Project Life Cycle

Many countries require EIA/EIS for major projects, like irrigation development. The relationship between project cycle and environmental and social assessments and how the EIA safeguard activity relates to the whole project life cycle are shown in Figure 4.29. EIA must be an integral part of the FS. Where these laws are enforced, they can be a powerful means of directing development towards sustainability.

Figure 4.29. The EIA Process in the Project Cycle



Adapted from: Mekong EIA Briefing: Environmental Impact Assessment (EIA) Comparative Analysis in Lower Mekong Countries

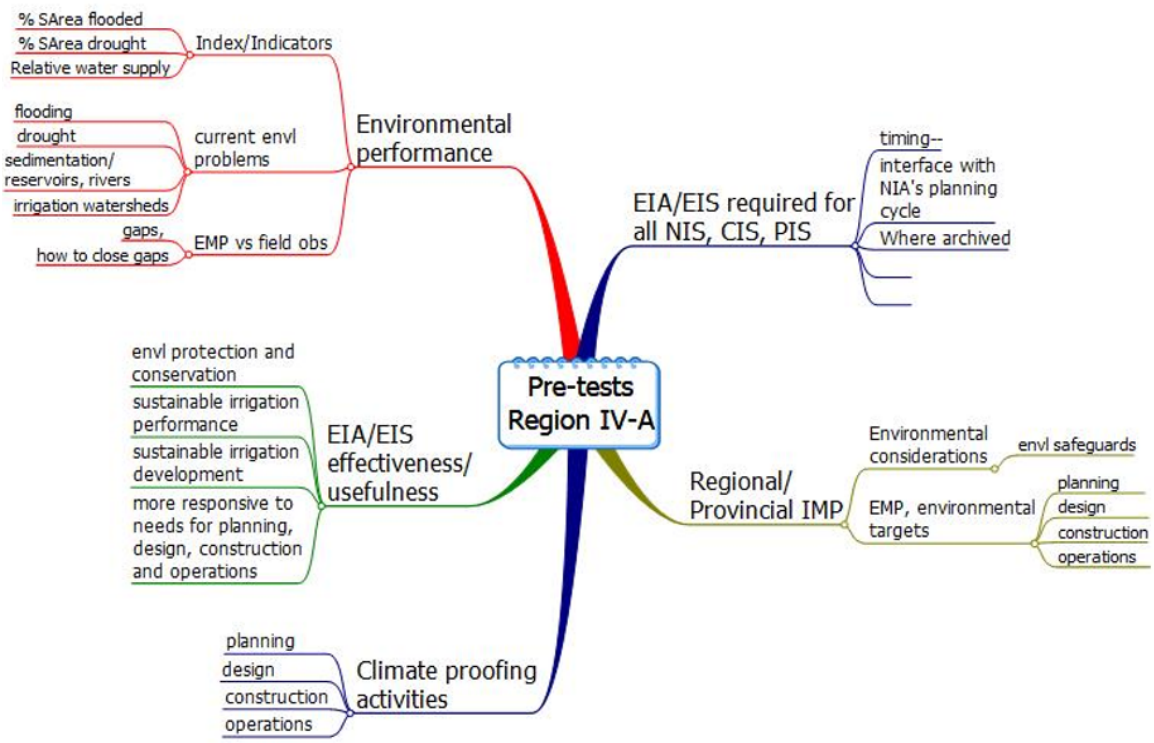
A project cycle can be generically described in terms of six stages: (1) project concept, (2) pre-feasibility, (3) feasibility, (4) design and engineering, (5) implementation, and (6) monitoring and evaluation. Most ESIA activities take place during project pre-feasibility and feasibility stages, with less effort devoted to implementation, and M&E stages. When done adequately, ESIA could enhance the project and augment the planning process. Finally, the integration of ESIA can strengthen the environmental and social safeguards to potential risks and damages from development projects.

4.13.3. Environmental and Social Considerations for the NIMP

The results obtained from the regional and global examination of environmental and social concerns and safeguards from the desk research were validated with those collected in the fields through structured survey questionnaires, KII, FGDs, and interpersonal interviews. The comparative analysis affirmed the environmental and social considerations critical to sustainable irrigation development. Moreover, the critical concerns facilitated crafting of guidelines for improvement of environmental and social safeguards for irrigation development.

To obtain preliminary data, the team conducted FGD with staff of NIA CALABARZON. Information gathered were used in crafting the survey questionnaires with which effectiveness or usefulness of EIA, considerations on environmental performance, and climate proofing activities were assessed to improve environmental and social safeguards (Figure 4.30).

Figure 4.30. Mind Map for Pre-test of Questionnaires and Other Participatory Techniques



Most of the NIA planners and designers in Luzon strongly agree that a well-designed and constructed irrigation system or project protects the environment and contributes to environmental sustainability (Table 4.58). Most of them also agree that the environmental data and information in the EIA/EIS reports are adequate, of high quality, and accurate enough to develop sustainable irrigation system/project. Further, they attested that the environmental data and information helped them in designing environmental management and mitigation plans (EMMPs) for detailed engineering design. The EIA/EIS data and information helped irrigation planners and designers in Luzon make important decisions during the project feasibility stage.

Table 4.58. Environmental Sustainability and Irrigation Planning, Design and Construction; various NIA stakeholders; formulation of NIMP; 2018-2019

Environmental Sustainability and Irrigation Planning	Luzon	Visayas	Mindanao
1. A well-planned, designed and constructed irrigation system/project protects the environment and contributes to environmental sustainability.	Strongly agree	Agree	Strongly Agree
2. The environmental data and information in the EIA/EIS reports are adequate, of high quality, and accurate enough to develop sustainable irrigation development projects/systems.	Agree	Neutral	Disagree
3. The environmental data and information reported in the EIA/EIS system greatly helped irrigation planners and designers in making important decisions during Project site selection in pre-FS (IEE, Screening).	Agree	Neutral	Agree
4. The environmental data and information reported in the EIA/EIS system greatly helped irrigation planners and designers in making important decisions during FS (Significant impacts, mitigation measures).	Agree	Neutral	Strongly Agree
5. The environmental data and information reported in the EIA/EIS system greatly helped irrigation planners and designers in making important decisions during Detailed Engineering Design (Integration of measures in the Environmental Management/Mitigation Plan).	Agree	Neutral	Strongly Agree
6. The environmental data and information reported in the EIA/EIS system greatly helped irrigation planners and designers in making important decisions during Construction (EMP).	Agree	Neutral	Agree
7. The environmental data and information reported in the EIA/EIS system greatly helped irrigation planners and designers in making important decisions during Post-construction/post-project analysis (M&E).	Agree	Neutral	Agree
8. An EIA/EIS follow-up is needed to identify actual impacts and to learn from these impacts (prediction correctness and accuracy, surprises and uncertainties; to assess effectiveness of mitigation measures; and to manage risks and uncertainties.	Strongly agree	Neutral	Strongly Agree

Surprisingly, the respondents asserted that the EIA/EIS data and information also facilitated decision-making during post-construction/post-project M&E. Nonetheless, they strongly agreed that an EIA follow-up would be needed to assess accuracy of impact prediction, effectiveness of mitigation measures and to learn about environmental surprises from unanticipated and residual impacts. For the Visayas region, respondents agree that a well-planned, designed and constructed irrigation system/ project could protect the environment and contribute to environmental sustainability. However, they neither agree nor disagree that the environmental data included in the EIS are of high quality and are useful in all phases of irrigation system development. This result is coherent with the findings during the FGD wherein it was revealed that EIA/EIS is only being prepared for mere compliance to obtain an Environmental Compliance Certificate (ECC) and is not efficiently being utilized during planning of irrigation development. Lastly, while they disagree that the information indicated in the EIS are adequate, of high quality, and accurate enough to develop a sustainable irrigation development projects/system, Mindanao respondents believe that this report is essential in the decision making during all phases of irrigation development.

Contrary to the previous findings, interview with most field personnel from operations and engineering division revealed lack of awareness and knowledge on EIA/EIS. These personnel are supposedly responsible for managing the environment and form an important node to sustain irrigation performance. This is a clear circumstance that bolstered the fact that EIA is a planning tool used by stakeholders at the top of the irrigation development chain.

Probable Impacts of Irrigation Project/ System on the Environment

The various effects of irrigation development project stem from direct and indirect changes it brought in the elements and processes of the biophysical and social environment. To gain insights from the perspectives and experiences of various irrigation stakeholders in the country, changes in more than 30 parameters relating to these elements and processes were grouped into three major categories, namely Watershed, Water Quality, and Flooding Risks . Under each major class are detailed probable environmental and social impact characteristics. The significance to irrigation planning, design, construction, and operations of these changes was evaluated and rated by various stakeholders. The differential importance of potential impacts under each class to a respondent reflects the biophysical and social contexts in which an irrigation system is embedded.

Environmental and social impacts of irrigation project/system due to alteration in the watershed or catchment areas are a direct or indirect result of changes in land cover and land use, in water inflows to reservoirs and dams, in sedimentation and siltation level, and in people and ecosystems to be submerged on account of irrigation project/system development. All the effects projected from changes in the watershed area were considered important/very important environmental and social considerations by respondents from Luzon. For the irrigation stakeholders in the Visayas, grassland and reduction in inflows into reservoir are least important environmental consideration; however, all other probable impacts are deemed very important to irrigation project/system.

The stability of water inflows into reservoirs was not so important environmental consideration to Mindanao stakeholders, thus the uncertainty of water supply due to CC was least important to them. Sedimentation and siltation are projected impacts from change in land cover and land use in association with increased reservoir inflow due to intense rainfall. Sedimentation and siltation are very important probable impacts on the environment of irrigation project/system in Luzon and the Visayas. For Mindanao regions, the parameters for sedimentation and siltation are differentially important. It ranges from very important (sediment inflow and erosion) to important (sediment trapping efficiency and presence of natural waterways) to not so important (potential for flushing sediment). The multiple uses of reservoirs are important parameters for environmental and social impacts consideration according to the stakeholders interviewed. The complete details are shown in Table 4.59.

In terms of water pollution, all the water quality parameters are deemed very important by the stakeholders from the Visayas and Mindanao (Table 4.60), and important by stakeholders from Luzon for sustainable irrigation development. Changes in the irrigation system, such as urbanization, industrialization and increased human settlements cause water pollution from solid wastes and effluent discharges .

Table 4.59. Degree of Importance of Watershed Condition as Environmental Parameter to Sustainable Irrigation Performance during O&M

Parameters	Luzon	Visayas	Mindanao
Watershed area			
1 Land cover/use change (forest)	Very important	Very important	Very important
2 Land cover/use change (grassland)	Important	Least important	Very important
3 Land use change (service areas)	Very important	Very important	Important
Inflow to the Reservoirs or at Diversion Point			
4 Volume of reservoir (estimate)	Very important	Very important	Important
5 Significantly increased	Very important	Very important	Not so import-ant
6 Stable since start of operations	Very important	Very important	Not so import-ant
7 Significantly reduced	Very important	Least important	Important
8 Uncertainties of water supply due to climate change	Very important	Very important	Least important
Sedimentation/Siltation			
9 Sediment inflow	Very important	Very important	Very important

Parameters	Luzon	Visayas	Mindanao
10 Sediment trapping efficiency	Very important	Very important	Important
11 Potential for sediment flushing	Very important	Very important	Not so important
12 Erosion rate in the watershed	Very important	Very important	Very important
13 Presence of natural streams, drains or gullies around the reservoir	Very important	Very important	Important
Reservoirs Uses			
14 Hydro power (installed)	Very important	Important	Very important
15 Flood control	Very important	Very important	Very important
16 Municipal Water Supply	Important	Not so important	Important
17 Reservoir fisheries	Important	Not so important	Very important
18 Recreation	Important	Not so important	Very important
Submerged Areas			
19 Displaced people	Very important	Important	Very important
20 Loss of cultivable land	Important	Very important	Not so important
21 Clearing of forest	Important	Important	Important
22 Potential agriculture in drawdown zone	Important	Not so important	Not so important

Table 4.60. Degree of Importance of Water Quality as Environmental Parameter to Sustainable Irrigation Performance during O&M

Parameters	Luzon	Visayas	Mindanao
Water Quality			
1 Increase of industries and settlement in the watershed area	Important	Very important	Very important
2 Effluent discharges from point and non-point sources	Important	Very important	Not so important
3 Solid wastes	Important	Very important	Not so important
4 Floating debris	Important	Very important	Very important
5 Urbanization	Important	Very important	Very important

Riverine floods and flashfloods may result from high rainfall events and changes in the watershed. Irrigation project/system may bring about overabundant or scarce water depending on rainfall events. Too much or too little water is an important environmental consideration for irrigation development for all irrigation stakeholders interviewed. Moreover, the flooding frequency and the extent of damages it wrought are very important environmental and social consideration for irrigation development. Hence, respondents consider the provision of adequate drainage networks to mitigate flooding in the irrigation service area very important/important.

Table 4.61. Degree of Importance of Flooding as Environmental Parameter to Sustainable Irrigation Performance during O&M

Parameters	Luzon	Visayas	Mindanao
Flooding risks			
1 Flooding of nearby areas	Very important	Very important	Important
2 Reduction of water supplies to nearby areas	Very important	Important	Important
Frequency and Intensity of Flooding			
3 How many times a year	Very important	Very important	Important
4 Extent of Damage	Very important	Very important	Important
Presence of Drainage Systems			
5 Drainage network density adequate	Very important	Very important	Important
6 Drainage network density inadequate	Important	Very important	Very important
7 Absence of Drainage network	Very important	Very important	Important

All in all, the biophysical and social elements and processes that affect the changes in quantity and quality of water for irrigation are deemed important considerations by stakeholders in irrigation planning, design, construction and operations. These results indicate that even the basic parameters for irrigation development, such as water quantity and quality, are influenced to a large degree by complex feedback relationship of natural and anthropogenic changes in the environment and the changes irrigation development brought into the biophysical and social environment.

The results mentioned above were used as background knowledge and information or precursors for more in-depth and comprehensive discussion on critical environmental and social issues particularly on irrigation project/system development and on irrigated agriculture in general. The discussions were carried out through FGDs, KIIs, and interpersonal interviews with various stakeholders.

Prioritization of Irrigation Projects

Following the results of the surveys and interviews, environmental and social considerations were developed (Table 4.62) for the prioritization of irrigation projects. These criteria, along with other considerations (technical, financial and institutional), will be used in assessing irrigation projects and in deciding which of these projects should be prioritized for funding.

Table 4.62. Environmental and Social Considerations in the Prioritization of Irrigation Projects

Criteria	Description
Environmental/Biophysical Criteria	
1. Protection and management of watershed	As a critical factor in achieving a sustainable irrigation system, watersheds need to be protected. EIS or FS of the proposed irrigation projects should have EMP/Watershed Management Plan which would identify the likely impacts of the projects to the environment, particularly to the watersheds, and propose mitigation measures and alternatives to ensure that there would be minimal adverse effects.
2. Protection of biodiversity	Presence of flora and fauna, particularly those that are endemic and threatened, must be properly documented. As much as possible, construction of irrigation projects must not be in protected areas. Otherwise, mitigation plans must be crafted following also the NIPAS law and other biodiversity related laws.
3. Occurrence of multi-hazards	Natural hazards such as flood, drought, landslide, earthquakes and other natural phenomena can greatly affect irrigation systems. Ensuring that the area where the irrigation projects will be constructed is not vulnerable to such events is important in site selection.
4. Land cover in the catchment area	Healthy catchment areas (forest/more trees) provide better protection to the rivers, dams and groundwater environment which could help ensure more water for irrigation.
Socio-Cultural Criteria	
1. Impoverished communities	Poverty is still rampant in the Philippines. Targeting the poorest of the poor is important to know where investments should be placed first.
2. Indigenous people and other vulnerable groups	IP follow certain beliefs about the environment which should also be considered. Guided by the IPRA Law, an Indigenous People Development Plan (IPDP) should be crafted to safeguard the welfare of IPs and their community.

Criteria	Description
3. Resettlement	Implementation of appropriate compensation and relocation program for families to be affected by the construction of the project is important. A Resettlement Action Plan should be included in the EIS/FS.
4. Cultural value	Cultural aspects should also be given importance in any social impact assessment. These include presence of archeological structures or anything that may represent cultural heritage and ethnicity.

4.13.4. Guidelines for Improving Environmental and Social Safeguards

The synthesis of findings from survey, FGD, interpersonal discussion, and KII with personnel from different NIA departments and offices, such as central and regional field offices, and LGU officials and IAa members, brought out the recommendations to improve environmental safeguards for sustainable irrigation development.

The impacts of environmental changes, such as watershed degradation, land cover and land use changes, CC, and their ripple effects, on the performance of existing irrigation systems and on the planning, design, and construction of new irrigation systems, indicate environmental safeguards that will be critical in maintaining sustainability of irrigation development.

Specific guidelines and recommendations on the implementation and strengthening of such environmental and social safeguards are elaborated in the recommendations chapter of this report.

4.14. Strategic Shifts toward Organizational Effectiveness

Strategic shifts mean restructuring of an organization's business plans to achieve its strategic goals and objectives. Listed below are the ten (10) strategic shifts NIA must undertake to enable the organization to achieve its strategic goals and objectives in the strategic plan:

1. From the RTA: irrigation towards rice self-sufficiency to irrigation towards competitiveness i.e., from rice monocrop to diversified irrigated agriculture. Therefore, the NIA must pursue a two-track irrigation systems development that should take into consideration the unique irrigation water needs of the commodities central to each system.

2. From a narrow focus on irrigation infrastructure to more encompassing irrigation development programs. Therefore, from a passive/ reactive policy player to a catalytic policy leader in pursuit of a more encompassing objective of irrigated agriculture development.

3. Form follows function principle: From loosely defined to clearly defined functions and deliverables to underpin NIA’s organizational restructuring.

4. From a partially to a fully decentralized/deconcentrated operations over time as a key strategy to achieve organizational efficiency and effectiveness.

5. IAs: From a narrow objective on irrigation canal maintenance to a broader objective on agribusiness development.

6. From weak irrigation R&D towards a strong, dynamic national R&D to underpin NIA'S irrigation modernization programs.

7. From weak to strong private sector investment in irrigation development to speed up the irrigation development of the country.

8. From a traditional to a dynamic research-based planning. The objective is to transform NIA into a knowledge organization with a high degree organizational effectiveness through up to date shared database to improve management decisions at all levels of operations in all offices.

9. From simple operational monitoring to a robust RBME, which includes the use of modern technologies like GIS.

10. From weak to strong, clearly defined accountability system at all levels of operations.

- **Create a competently staffed Quality Assurance Office** for NIA infrastructure function to ensure compliance to standards (design, construction, and maintenance) and avoid conflict of interest. This office should be directly under the NIA Administrator.

- **Establish a Social and Environmental Safeguard Unit** to ensure compliance to safeguard requirements. This unit can be integrated to the Quality Assurance Office.

4.15. Projected Costs and Benefits for 2020-2030 Projects

Projected costs for 2020-2030 were calculated based on the development cost per hectare, O&M cost per hectare, and cost of Feasibility Study and Detailed Engineering (FSDE), and the targeted increase in irrigated area. For development costs, unit costs used for PIP areas were based on the developmental costs from the PIP plan. For Non-PIP projects, NIA's planning standard costs per type of system were used as baseline. These include costs for NIS new (PHP 650,000/ha), NIS restore (PHP 200,000/ha), CIS new (PHP 500,000/ha) and CIS restore (PHP 180,000/ha). The values are adjusted by 3% annually based on the ten-year average increase of the Wholesale Cost of Construction Material Index (2009-2018). For O&M costs, an adjusted current price value of PHP 4,208/ha was used based on the optimal O&M cost/ha determined by the 2000 ADB study on Cost Recovery Mechanisms for NISs. The value was used for both NIS and CIS in computing for the O&M cost of projects. For FSDE, costs were estimated as a percentage of total cost. Based on the 2018 NIA Year-End Report, FSDE cost is around 2.5% of total cost. For OGA systems, development cost of the various types of systems under OGA projects in the 2018 NIA inventory was used.

Projected benefits were computed based on projected area (cumulative), crop yield (based on the assumption per scenario), cropping intensity (based on the assumption per scenario) and farmgate price. Third cropping production was also considered. Based on 2018 NIA inventory, 1.41% of the total area was allocated for the third crop with an average crop yield of 2.04 tons/ha.

4.15.1. Baseline Scenario

Table 4.63 shows the projected costs for new, restoration, multipurpose, and OGA projects for 2020-2030 under the baseline scenario. For 2020-2030, total projected cost for new projects is estimated to be about PHP 197.6 B, while for restoration projects, it is estimated to be PHP 61.3 B. MPs have a total cost of about PHP 101.9 B. For NIA, a total of PHP 360.7 B needs to be programmed for the period 2020 to 2030. OGA on the other hand needs to program an estimated PHP 25.3 B. In total, the projected cost from 2020-2030 is about PHP 386.1 B.

Figure 4.31 shows the graph of projected cost for new, restore, multipurpose, and OGA projects for 2020-

Figure 4.31. Annual Projected Total Cost (P'000) for New, Restoration, Multipurpose & OGA Projects (Baseline) for 2020-2030

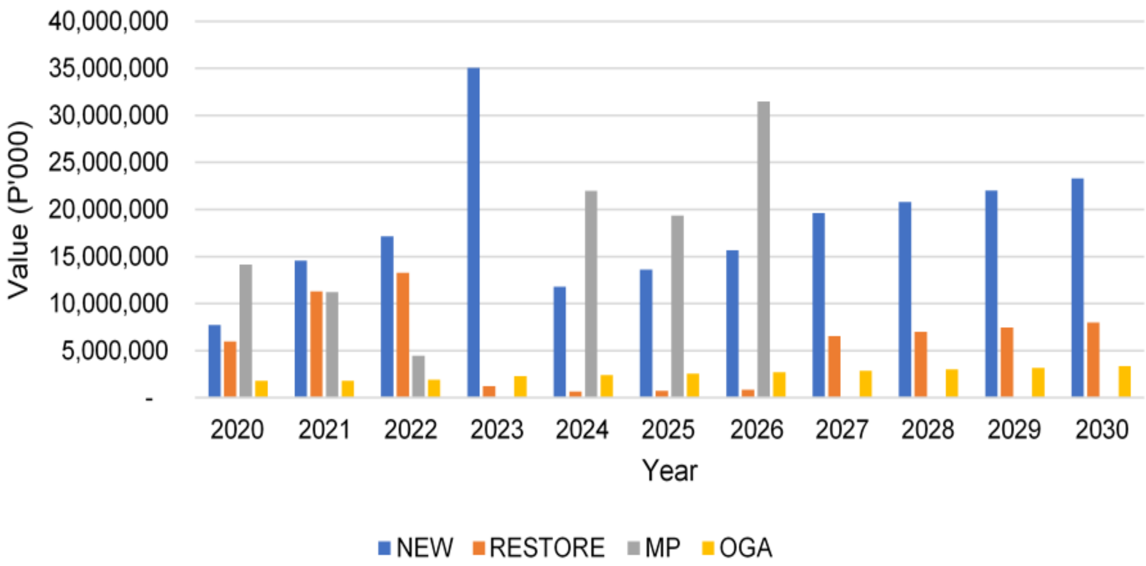


Table 4.63. Projected Total Cost of NIPs, CIPs, Multipurpose and Other Government Assisted Projects (2020-2030) under Baseline Scenario

YEAR	NIS/NIP (P'000)		CIS/CIP (P'000)		SUBTOTAL		MP (P'000)	TOTAL (NIA)	OGA (P'000)	GRAND TOTAL
	New	Restore	New	Restore	New	Restore				
2020	2,946,971	5,825,228	5,996,730	1,107,528	8,943,701	6,932,756	13,370,000	29,246,457	1,631,555	30,878,012
2021	4,779,111	9,446,790	9,765,745	1,796,081	14,544,856	11,242,871	11,212,140	36,999,867	1,659,698	38,659,565
2022	5,626,457	11,062,424	11,411,456	2,103,255	17,037,913	13,165,679	4,458,066	34,661,658	1,745,288	36,406,946
2023	11,476,537	431,583	23,358,830	583,825	34,835,368	1,015,407	-	35,850,775	2,080,081	37,930,856
2024	4,915,110	190,368	6,513,946	257,505	11,429,056	447,873	21,979,980	33,856,909	2,196,046	36,052,954
2025	5,638,788	220,023	7,531,061	297,603	13,169,849	517,626	19,357,000	33,044,475	2,318,475	35,362,950
2026	6,282,707	257,891	8,829,921	348,804	15,112,627	606,695	31,494,000	47,213,322	2,447,730	49,661,052
2027	8,810,529	2,675,401	10,181,126	3,618,347	18,991,655	6,293,748	-	25,285,403	2,584,191	27,869,594
2028	9,300,372	2,823,210	10,746,707	3,818,054	20,047,079	6,641,264	-	26,688,344	2,728,260	29,416,603
2029	9,817,490	2,979,226	11,343,770	4,028,844	21,161,260	7,008,071	-	28,169,330	2,880,360	31,049,691
2030	10,363,403	3,143,906	11,974,067	4,251,334	22,337,470	7,395,240	-	29,732,710	3,040,940	32,773,650
TOTAL	79,957,476	39,056,049	117,653,358	22,211,181	197,610,834	1,267,230	101,871,186	360,749,250	25,312,624	386,061,874

4.15.2. Scenario 1

Table 4.64 shows the projected costs for new, restoration, multipurpose, and OGA projects for 2020-2030 under Scenario 1. For 2020-2030, total projected cost for new projects is estimated to be about PHP 237.9 B, while for restoration projects, it is estimated to be PHP 69.7 B. Multipurpose projects have a total cost of about 101.9 billion pesos. For NIA, a total of PHP 409.5 B needs to be programmed for the period 2020 to 2030. OGA on the other hand needs to program an estimated PHP 28.9 B. In total, projected cost from 2020-2030 is about PHP 438.4 B.

Figure 4.32 shows the graph of projected cost for new, restore, multipurpose and OGA projects for 2020-2030 under Scenario 1.

Figure 4.32. Annual Projected Total Cost (P'000) for New, Restoration, Multipurpose & OGA Projects (Scenario 1) for 2020-2030

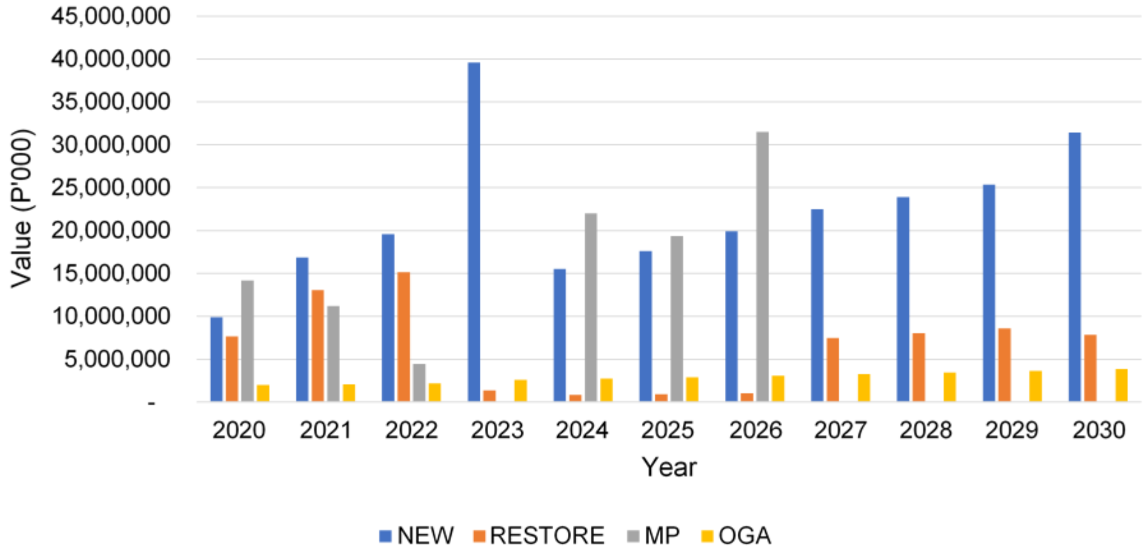


Table 4.64. Projected Total Cost of NIPs, CIPs, Multipurpose and Other Government Assisted Projects (2020-2030) under Scenario

Year	NIS/NIP (P'000)		CIS/CIP (P'000)		SUBTOTAL		MP (P'000)	TOTAL (NIA)	OGA (P'000)	GRAND TOTAL
	New	Restore	New	Restore	New	Restore				
2020	3,657,115	7,228,958	7,441,698	1,374,414	11,098,813	8,603,372	13,370,000	33,072,185	1,843,674	34,915,859
2021	5,526,893	10,924,918	11,287,296	2,077,112	16,814,189	13,002,030	11,212,140	41,028,359	1,889,759	42,918,118
2022	6,413,375	12,617,910	13,012,637	2,398,994	19,426,012	15,016,904	4,458,066	38,900,982	1,994,653	40,895,635
2023	12,966,224	487,629	26,389,973	659,642	39,356,196	1,147,271	-	40,503,467	2,350,206	42,853,674
2024	6,480,921	251,013	8,589,100	339,539	15,070,021	590,552	21,979,980	37,640,553	2,488,493	40,129,046
2025	7,283,716	285,610	9,776,008	386,316	17,059,723	671,926	19,357,000	37,088,649	2,634,916	39,723,565
2026	8,009,848	328,786	11,257,302	444,691	19,267,150	773,477	31,494,000	51,534,627	2,789,954	54,324,581
2027	10,071,746	3,058,381	11,638,542	4,136,310	21,710,288	7,194,691	-	28,904,978	2,954,115	31,859,093
2028	10,662,826	3,236,795	12,321,042	4,377,379	22,983,868	7,614,174	-	30,598,042	3,127,935	33,725,977
2029	11,288,643	3,425,664	13,043,636	4,632,567	24,332,279	8,058,231	-	32,390,510	3,311,983	35,702,493
2030	16,989,930	2,097,089	13,808,681	4,902,705	30,798,611	6,999,794	-	37,798,405	3,506,860	41,305,265
TOTAL	99,351,238	43,942,755	138,565,913	25,729,667	237,917,151	69,672,422	101,871,186	409,460,759	28,892,547	438,353,307

4.15.3. Rehabilitation and Modernization

Irrigation systems deteriorate over time, and this entails cost. However, through modernization, cost can be lessened in the long term. Modernization is assumed to cost an additional 20% while rehabilitation is assumed to add 10% to the total cost. Succeeding tables show the projected cost inclusive of modernization and rehabilitation costs.

Table 4.65 shows the projected cost inclusive of modernization and rehabilitation for the baseline scenario. From 2020-2030, total projected rehabilitation cost is estimated to be about PHP 36.1 B pesos while modernization costs are estimated to be about PHP 72.1 B. NIA total cost increased to about PHP 469 B, with total projected cost at PHP 494.3 B.

Table 4.66, on the other hand, shows the projected cost inclusive of modernization and rehabilitation for Scenario 1. From 2020-2030, total projected rehabilitation cost is estimated to be about PHP 40.9 B while modernization costs are estimated to be about PHP 81.9 B. NIA total cost increased to PHP 532.3 B, with total projected cost at PHP 561.2 B.

Table 4.65. Projected Total Cost with Rehabilitation and Modernization Cost (2020-2030) under Baseline Scenario

YEAR	New (P'000)	Restore (P'000)	MP (P'000)	Rehab (P'000)	Moderniza-tion cost (P'000)	Total (NIA)	OGA (P'000)	GRAND TOTAL
2020	8,943,701	6,932,756	13,370,000	2,924,646	5,849,291	38,020,394	1,631,555	39,651,949
2021	14,544,856	11,242,871	11,212,140	3,699,987	7,399,973	48,099,827	1,659,698	49,759,525
2022	17,037,913	13,165,679	4,458,066	3,466,166	6,932,332	45,060,156	1,745,288	46,805,444
2023	34,835,368	1,015,407	-	3,585,078	7,170,155	46,606,008	2,080,081	48,686,089
2024	11,429,056	447,873	21,979,980	3,385,691	6,771,382	44,013,982	2,196,046	46,210,027
2025	13,169,849	517,626	19,357,000	3,304,447	6,608,895	42,957,817	2,318,475	45,276,292
2026	15,112,627	606,695	31,494,000	4,721,332	9,442,664	61,377,319	2,447,730	63,825,049
2027	18,991,655	6,293,748	-	2,528,540	5,057,081	32,871,024	2,584,191	35,455,215
2028	20,047,079	6,641,264	-	2,668,834	5,337,669	34,694,847	2,728,260	37,423,107
2029	21,161,260	7,008,071	-	2,816,933	5,633,866	36,620,130	2,880,360	39,500,490
2030	22,337,470	7,395,240	-	2,973,271	5,946,542	38,652,523	3,040,940	41,693,463
TOTAL	197,610,834	61,267,230	101,871,186	36,074,925	72,149,850	468,974,025	25,312,624	494,286,649

Table 4.66. Projected Total Cost with Rehabilitation and Modernization Cost (2020-2030) under Scenario 1

YEAR	New (P'000)	Restore (P'000)	MP (P'000)	Rehab (P'000)	Modernization cost (P'000)	Total (NIA)	OGA (P'000)	GRAND TOTAL
2020	11,098,813	8,603,372	13,370,000	3,307,219	6,614,437	42,993,841	1,843,674	44,837,515
2021	16,814,189	13,002,030	11,212,140	4,102,836	8,205,672	53,336,866	1,889,759	55,226,626
2022	19,426,012	15,016,904	4,458,066	3,890,098	7,780,196	50,571,277	1,994,653	52,565,930
2023	39,356,196	1,147,271	-	4,050,347	8,100,693	52,654,508	2,350,206	55,004,714
2024	15,070,021	590,552	21,979,980	3,764,055	7,528,111	48,932,719	2,488,493	51,421,212
2025	17,059,723	671,926	19,357,000	3,708,865	7,417,730	48,215,244	2,634,916	50,850,159
2026	19,267,150	773,477	31,494,000	5,153,463	10,306,925	66,995,016	2,789,954	69,784,970
2027	21,710,288	7,194,691	-	2,890,498	5,780,996	37,576,472	2,954,115	40,530,587
2028	22,983,868	7,614,174	-	3,059,804	6,119,608	39,777,455	3,127,935	42,905,390
2029	24,332,279	8,058,231	-	3,239,051	6,478,102	42,107,663	3,311,983	45,419,646
2030	30,798,611	6,999,794	-	3,779,840	7,559,681	49,137,926	3,506,860	52,644,786
TOTAL	**237,917,151**	**69,672,422**	**101,871,186**	**40,946,076**	**81,892,152**	**532,298,987**	**28,892,547**	**561,191,534**

4.15.4. Benefit-Cost Analysis

Using a 10% discount rate, a Benefit-Cost Analysis (BCA) was performed. The NPV, IRR, and BCR were computed. The analysis used the development cost per system as basis for the costs. The stream of benefits is assumed to cover the period 2020-2040.

Baseline Scenario

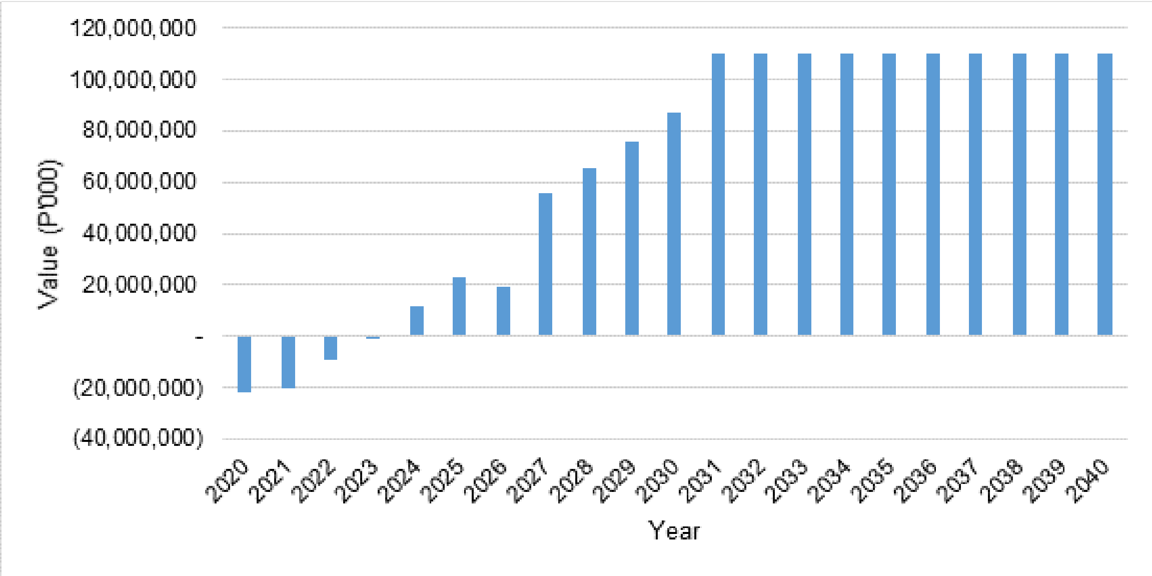
Table 4.67. shows the BCA for the baseline scenario. NPV at 10% discount rate is about PHP 337 B. IRR is 37.44%. and BCR is 4.69. Figure 4.33. shows the graph of annual net benefits under baseline scenario.

Table 4.67. Benefit-Cost Analysis (BCA) for Baseline Scenario

Year	Benefits (P'000)	Costs (P'000)	Net Present Benefit
2020	8,980,053	30,834,284	(21,854,231)
2021	18,184,556	38,666,561	(20,482,005)
2022	27,619,172	36,517,466	(8,898,294)
2023	37,289,654	38,001,788	(712,135)
2024	47,201,898	35,414,112	11,787,786
2025	57,361,947	34,384,773	22,977,174
2026	67,775,998	48,244,728	19,531,270
2027	78,450,401	22,946,970	55,503,430
2028	89,391,663	23,716,685	65,674,978
2029	100,606,457	24,505,642	76,100,815
2030	112,101,620	25,314,323	86,787,297
2031	112,101,620	1,807,967	110,293,653
2032	112,101,620	1,807,967	110,293,653
2033	112,101,620	1,807,967	110,293,653
2034	112,101,620	1,807,967	110,293,653
2035	112,101,620	1,807,967	110,293,653
2036	112,101,620	1,807,967	110,293,653
2037	112,101,620	1,807,967	110,293,653
2038	112,101,620	1,807,967	110,293,653
2039	112,101,620	1,807,967	110,293,653
2040	112,101,620	1,807,967	110,293,653
	NPV @ 10		337,381,378
	IRR		37.44%
	BCR		4.69

Note: At current prices

Figure 4.33. Annual Net Present Benefit of Baseline Scenario



Scenario 1

Table 4.68 shows the BCA for Scenario 1. NPV at 10% discount rate is about PHP 450 B. IRR is 40.63% and BCR is 5.25.

Figure 4.34 shows the graph of annual net benefits under Scenario 1.

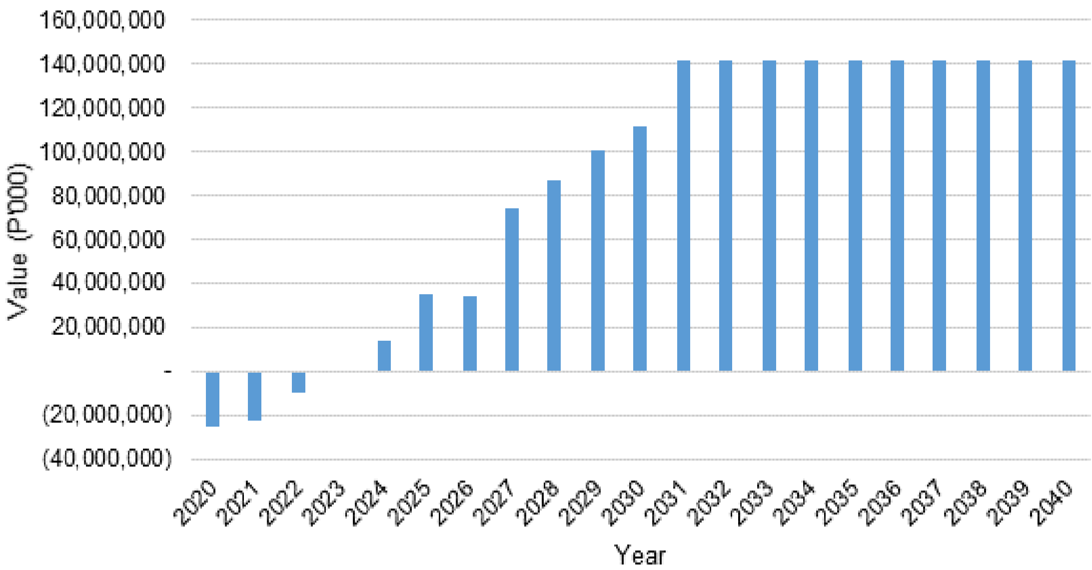
Table 4.68. Benefit-Cost Analysis (BCA) for Scenario 1

Year	Benefits (P'000)	Costs (P'000)	Net Present Benefit
2020	10,057,604	34,865,952	(24,808,348)
2021	20,396,821	42,933,971	(22,537,150)
2022	31,025,536	41,030,290	(10,004,754)
2023	41,951,855	42,949,810	(997,955)
2024	53,184,110	39,243,145	13,940,965
2025	73,027,982	38,429,482	34,598,500
2026	86,419,539	52,513,863	33,905,677
2027	100,186,060	26,283,592	73,902,468
2028	114,338,043	27,239,097	87,098,946
2029	128,886,282	28,221,357	100,664,925
2030	143,841,871	31,881,451	111,960,420
2031	143,841,871	2,123,223	141,718,648
2032	143,841,871	2,123,223	141,718,648
2033	143,841,871	2,123,223	141,718,648
2034	143,841,871	2,123,223	141,718,648
2035	143,841,871	2,123,223	141,718,648
2036	143,841,871	2,123,223	141,718,648

Year	Benefits (P'000)	Costs (P'000)	Net Present Benefit
2037	143,841,871	2,123,223	141,718,648
2038	143,841,871	2,123,223	141,718,648
2039	143,841,871	2,123,223	141,718,648
2040	143,841,871	2,123,223	141,718,648
	NPV @ 10		450,884,674
	IRR		40.63%
	BCR		5.25

Note: At current prices

Annual Net Present Benefit of Scenario 1



4.15.5. Sensitivity Analysis

This section presents how different values of the benefits and costs will affect the values of the BCA evaluation criteria (IRR, BCR, and NPV) per scenario. Case 1 assumes an increase in cost of 20%. Case 2 presents a scenario wherein benefits decrease by 20%, while Case 3 is the combination of both. Table 4.69 shows the summary of the results of the sensitivity analysis.

As can be seen from the table, both baseline and scenario 1 were able to meet the threshold IRR of 10% for all cases.

Table 4.69. Summary Table per Scenario under Each Case

SCENARIO	CASE											
	NORMAL			CASE 1			CASE 2			CASE 3		
	NPV (billion)	IRR (%)	BCR	NPV (billion)	IRR (%)	BCR	NPV (billion)	IRR (%)	BCR	NPV (billion)	IRR (%)	BCR
Baseline	337	37.44	4.69	292	29.50	3.91	225	27.99	3.75	178	21.91	3.11
Scenario 1	450	40.63	5.25	400	32.43	4.38	310	30.85	4.20	260	24.67	3.50

4.15.6. Projections for High-Value Crops and Cost Projections

This section presents the projected of area for development and the corresponding cost for HVCs. The top 3 crops identified based on production are Sugarcane, Coconut and Banana. There are also projections for other crops, which include Corn, Pineapple, Mango and Tobacco. The projections used the growth rate of area harvested per crop as basis. Two options are presented for the cost projections: unit cost for drip or sprinkler irrigation (PHP 1.2 M/ha)-STW (PHP 200,000/ha) for option 1 and drip or sprinkler irrigation (PHP 1.2 M/ha)-SPIS (PHP 6 M/10 ha) for option 2.

Projections for Sugarcane, Coconut and Banana

Table 4.70 shows the annual projected area, required increase in area and the projected costs for the two options for sugarcane. Growth rate used for the projection is 1.5%. A total of 79,000 ha are projected to be added in the area for sugarcane for the period 2020-2030. This translates to a projected cost of about PHP 133 B for option 1 (drip-STW unit cost) and about PHP 69 B for option 2 (drip-SPIS unit cost).

Table 4.70. Projected Area and Cost for Sugarcane, 2020-2030

Year	Projected Area (ha)	Increase in Area (ha)	Projected Cost (P'000)	
			Option 1	Option 2
2019	444,069	-	-	-
2020	450,730	6,661	9,605,207	4,939,821
2021	457,491	6,761	10,041,764	5,164,336
2022	464,353	6,862	10,498,162	5,399,055
2023	471,318	6,965	10,975,303	5,644,442
2024	478,388	7,070	11,474,131	5,900,982
2025	485,564	7,176	11,995,630	6,169,181
2026	492,847	7,283	12,540,832	6,449,571
2027	500,240	7,393	13,110,812	6,742,704
2028	507,744	7,504	13,706,699	7,049,159
2029	515,360	7,616	14,329,668	7,369,544
2030	523,090	7,730	14,980,952	7,704,489
Total	**5,791,194**	**79,022**	**133,259,160**	**68,533,282**

Table 4.71 shows the annual projected area, required increase in area and the projected costs for the two options for coconut. Growth rate used for area is 1%. A total of 424,000 ha are projected to be added in the area for coconut for the period 2020-2030. This translates to a projected cost of about PHP 714 B for option 1 (drip-STW unit cost) and about PHP 367 B for option 2 (drip-SPIS unit cost).

Table 4.71. Projected Area and Cost for Coconut, 2020-2030

Year	Projected Area (ha)	Increase in Area (ha)	Projected Cost (P'000)	
			Option 1	Option 2
2019	3,664,416	-	-	-
2020	3,701,060	36,644	52,840,875	27,175,307
2021	3,738,070	37,011	54,970,362	28,270,472
2022	3,775,451	37,381	57,185,668	29,409,772
2023	3,813,206	37,755	59,490,250	30,594,986
2024	3,851,338	38,132	61,887,707	31,827,964
2025	3,889,851	38,513	64,381,782	33,110,631
2026	3,928,750	38,899	66,976,367	34,444,989
2027	3,968,037	39,287	69,675,515	35,833,122
2028	4,007,718	39,680	72,483,438	37,277,197
2029	4,047,795	40,077	75,404,521	38,779,468
2030	4,088,273	40,478	78,443,323	40,342,280
Total	**46,473,963**	**423,857**	**713,739,808**	**367,066,187**

Table 4.72 shows the annual projected area, required increase in area and the projected costs for the two options for banana. Growth rate used for area is 1%. A total of 52,000 ha are projected to be added in the area for banana for the period 2020-2030. This translates to a projected cost of about PHP 88 B for option 1 (drip-STW unit cost) and about PHP 45 B for option 2 (drip-SPIS unit cost).

Table 4.72. Projected Area and Cost for Banana, 2020-2030

Year	Projected Area (ha)	Increase in Area (ha)	Projected Cost (P'000)	
			Option 1	Option 2
2019	452,368	-	-	-
2020	456,892	4,524	6,523,151	3,354,763
2021	461,461	4,569	6,786,034	3,489,960
2022	466,075	4,615	7,059,511	3,630,606
2023	470,736	4,661	7,344,009	3,776,919
2024	475,444	4,707	7,639,973	3,929,129
2025	480,198	4,754	7,947,864	4,087,473
2026	485,000	4,802	8,268,162	4,252,198
2027	489,850	4,850	8,601,369	4,423,561
2028	494,749	4,899	8,948,005	4,601,831

Year	Projected Area (ha)	Increase in Area (ha)	Projected Cost (P'000)	
			Option 1	Option 2
2030	504,693	4,997	9,683,746	4,980,212
Total	**5,737,162**	**52,325**	**88,110,432**	**45,313,936**

Projections for Other Crops

Table 4.73 shows the annual projected area, required increase in area and the projected costs for the two options for corn. Growth rate used for area is 0.5%. A total of 142,000 ha are projected to be added in the area for corn for the period 2020-2030. This translates to a projected cost of about PHP 239 B for option 1 (drip-STW unit cost) and about PHP 123 B for option 2 (drip-SPIS unit cost).

Table 4.73. Projected Area and Cost for Corn, 2020-2030

Year	Projected Area (ha)	Increase in Area (ha)	Projected Cost (P'000)	
			Option 1	Option 2
2019	2,523,993	-	-	-
2020	2,536,613	12,620	18,197,993	9,358,968
2021	2,549,296	12,683	18,837,652	9,687,935
2022	2,562,043	12,746	19,499,796	10,028,466
2023	2,574,853	12,810	20,185,214	10,380,967
2024	2,587,727	12,874	20,894,724	10,745,858
2025	2,600,666	12,939	21,629,173	11,123,575
2026	2,613,669	13,003	22,389,439	11,514,569
2027	2,626,738	13,068	23,176,428	11,919,306
2028	2,639,871	13,134	23,991,079	12,338,269
2029	2,653,071	13,199	24,834,365	12,771,959
2030	2,666,336	13,265	25,707,293	13,220,894
Total	**31,134,879**	**142,343**	**239,343,155**	**123,090,766**

Table 4.74. shows the annual projected area, required increase in area and the projected costs for the two options for pineapple. Growth rate used for area is 2.5%. A total of 21,000 ha are projected to be added in the area for pineapple for the period 2020-2030. This translates to a projected cost of about PHP 36 B for option 1 (drip-STW unit cost) and about PHP 18 B for option 2 (drip-SPIS unit cost).

Table 4.74. Projected Area and Cost for Pineapple, 2020-2030

Year	Projected Area (ha)	Increase in Area (ha)	Projected Cost (P'000)	
			Option 1	Option 2
2019	67,845	-	-	-
2020	69,541	1,696	2,445,817	1,257,849
2021	71,280	1,739	2,582,172	1,327,974

Year	Projected Area (ha)	Increase in Area (ha)	Projected Cost (P'000)	
			Option 1	Option 2
2023	74,888	1,827	2,878,109	1,480,170
2024	76,761	1,872	3,038,564	1,562,690
2025	78,680	1,919	3,207,964	1,649,810
2026	80,647	1,967	3,386,808	1,741,787
2027	82,663	2,016	3,575,622	1,838,891
2028	84,729	2,067	3,774,963	1,941,410
2029	86,848	2,118	3,985,417	2,049,643
2030	89,019	2,171	4,207,604	2,163,911
Total	**935,961**	**21,174**	**35,809,169**	**18,416,144**

Table 4.75 shows the annual projected area, required increase in area and the projected costs for the two options for mango. Growth rate used for area is 1.7%. A total of 30,000 ha are projected to be added in the area for mango for the period 2020-2030. This translates to a projected cost of about PHP 51 B for option 1 (drip-STW unit cost) and about PHP 26 B for option 2 (drip-SPIS unit cost).

Table 4.75. Projected Area and Cost for Mango, 2020-2030

Year	Projected Area (ha)	Increase in Area (ha)	Projected Cost (P'000)	
			Option 1	Option 2
2019	147,694	-	-	-
2020	150,204	2,511	3,620,563	1,862,004
2021	152,758	2,553	3,792,576	1,950,468
2022	155,355	2,597	3,972,762	2,043,135
2023	157,996	2,641	4,161,508	2,140,204
2024	160,682	2,686	4,359,221	2,241,885
2025	163,413	2,732	4,566,327	2,348,397
2026	166,191	2,778	4,783,274	2,459,969
2027	169,017	2,825	5,010,527	2,576,842
2028	171,890	2,873	5,248,577	2,699,268
2029	174,812	2,922	5,497,937	2,827,510
2030	177,784	2,972	5,759,144	2,961,845
Total	**1,947,796**	**30,090**	**50,772,416**	**26,111,528**

Table 4.76 shows the annual projected area, required increase in area and the projected costs for the two options for tobacco. Growth rate used for area is 0.5%. A total of 246 ha are projected to be added in the area for tobacco for the period 2020-2030. This translates to a projected cost of about PHP 413 M for option 1 (drip-STW unit cost) and about PHP 212 M for option 2 (drip-SPIS unit cost).

Table 4.76. Projected Area and Cost for Tobacco, 2020-2030

Year	Projected Area (ha)	Increase in Area (ha)	Projected Cost (P'000)	
			Option 1	Option 2
2019	4,357	-	-	-
2020	4,379	22	31,414	16,156
2021	4,401	22	32,519	16,724
2022	4,423	22	33,662	17,312
2023	4,445	22	34,845	17,920
2024	4,467	22	36,070	18,550
2025	4,489	22	37,337	19,202
2026	4,512	22	38,650	19,877
2027	4,534	23	40,008	20,576
2028	4,557	23	41,415	21,299
2029	4,580	23	42,870	22,048
2030	4,603	23	44,377	22,823
Total	**53,747**	**246**	**413,166**	**212,486**

4.16. Budgetary Requirements and Financing Schemes

Fund for irrigation is sourced mainly from the local government or NG and foreign sources or ODA. Succeeding tables show how projected costs are divided between local and foreign sources. Percentage allocation for local is 83%, while foreign is 17%. This distribution is based on the average share of each fund source for the period 2015-2018.

Table 4.77 shows the annual projected cost of NIA and OGA for the baseline scenario divided between the fund sources. For the period covered by the NIMP, NIA's total projected cost sourced from local funds is estimated to be about PHP 299.4 B, while those sourced from the ODA will be about PHP 61.3 B. For OGA, local funding is about PHP 21 B, while foreign funding is about PHP 4.3 B.

Table 4.77. Projected Costs for NIA and OGA based on Fund Source under Baseline Scenario, 2020-2030

YEAR	NIA (P'000)			OGA (P'000)		
	NG	ODA Loan	Total	NG	ODA Loan	Total
2020	24,274,559	4,971,898	29,246,457	1,354,191	277,364	1,631,555
2021	30,709,889	6,289,977	36,999,867	1,377,549	282,149	1,659,698
2022	28,769,176	5,892,482	34,661,658	1,448,589	296,699	1,745,288
2023	29,756,143	6,094,632	35,850,775	1,726,467	353,614	2,080,081
2024	28,101,234	5,755,675	33,856,909	1,822,718	373,328	2,196,046
2025	27,426,914	5,617,561	33,044,475	1,924,334	394,141	2,318,475
2026	39,187,057	8,026,265	47,213,322	2,031,616	416,114	2,447,730
2027	20,986,884	4,298,519	25,285,403	2,144,879	439,312	2,584,191
2028	22,151,325	4,537,018	26,688,344	2,264,456	463,804	2,728,260

YEAR	NIA (P'000)			OGA (P'000)		
	NG	ODA Loan	Total	NG	ODA Loan	Total
2029	23,380,544	4,788,786	28,169,330	2,390,699	489,661	2,880,360
2030	24,678,149	5,054,561	29,732,710	2,523,980	516,960	3,040,940
TOTAL	**299,421,878**	**61,327,373**	**360,749,250**	**21,009,478**	**4,303,146**	**25,312,624**

Table 4.78 shows the annual projected cost of NIA and OGA for Scenario 1 divided between the fund sources. For the period covered by the NIMP, NIA's total projected cost sourced from local funds is estimated to be about PHP 339.9 B, while those sourced from the ODA will be about PHP 69.6 B. For OGA, local funding is about PHP 24 B, while foreign funding is about PHP 5 B.

Table 4.78. Projected Costs for NIA and OGA based on Fund Source under Scenario 1, 2020-2030

YEAR	NIA (P'000)			OGA (P'000)		
	NG	ODA Loan	Total	NG	ODA Loan	Total
2020	27,449,914	5,622,272	33,072,185	1,530,249	313,425	1,843,674
2021	34,053,538	6,974,821	41,028,359	1,568,500	321,259	1,889,759
2022	32,287,815	6,613,167	38,900,982	1,655,562	339,091	1,994,653
2023	33,617,878	6,885,589	40,503,467	1,950,671	399,535	2,350,206
2024	31,241,659	6,398,894	37,640,553	2,065,449	423,044	2,488,493
2025	30,783,579	6,305,070	37,088,649	2,186,980	447,936	2,634,916
2026	42,773,741	8,760,887	51,534,627	2,315,662	474,292	2,789,954
2027	23,991,132	4,913,846	28,904,978	2,451,915	502,200	2,954,115
2028	25,396,375	5,201,667	30,598,042	2,596,186	531,749	3,127,935
2029	26,884,124	5,506,387	32,390,510	2,748,946	563,037	3,311,983
2030	31,372,676	6,425,729	37,798,405	2,910,694	596,166	3,506,860
TOTAL	**339,852,430**	**69,608,329**	**409,460,759**	**23,980,814**	**4,911,733**	**28,892,547**

4.17. Monitoring and Evaluation

Planning, implementation, and M&E are three interconnected processes in irrigation development that significantly enhance the effectiveness, efficiency and sustainability of investment programs and projects. The development and use of Results Framework for every irrigation program and project of NIA under this NIMP will ensure the interconnectedness of these three processes throughout the different stages of the program/project cycle, and establish the correlation between well-defined objectives, indicators and interventions, and the achievement of the expected development results (i.e., outcomes and outputs) of individual programs and projects and their links with the NIMP's overall Results Framework. If properly designed, the use of Results Framework will make it easy to track progress and take proactive measures during implementation and explain both successes and weaknesses at the time of completion of program and project.

M&E systems are designed to inform project management whether implementation is going as planned and whether corrective action is needed to adjust implementation plans. In addition, M&E systems should provide evidence of project outcomes and justify project funding allocations. M&E is essential for a results-based approach to program/project implementation management, which is carried out in all phases of the program/project cycle. An M&E plan is designed during the planning stage to incorporate the relevant indicators and targets and identify the means of verification (or sources of information) for those indicators and targets.

Tables 4.79 and 4.80 show the RBME to be used in this NIMP for the monitoring and evaluation of impacts and outcomes, respectively. Unlike in the past where M&E has focused on physical achievements and financial disbursements, the RBME proposed in the NIMP focuses on outputs, outcomes, and impact described in the Results Framework. RBME also includes economic, social, environmental, institutional and other indicators that allow measurement of the relevance, effectiveness, efficiency, impact, and sustainability of irrigation programs and projects included in the NIMP.

Table 4.79. Results-based M&E: Evaluation of the NIMP Impacts

Impact	Impact Indicators	Baseline	Annual Targets											Data Collection and Reporting		
			2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Frequency and Reports	Data Collection Instruments	Responsibility for Data Collection
1. Food security (availability, access) and poverty reduction with accelerated and sustained irrigation development under diversified crop production systems	% of farm household areas move up of income poverty threshold by end of 2030 from baseline (2019)	28.5% poverty incidence for rice subsector (2019)	1% farm household areas	1% farm household areas	1% farm household areas	1% farm household areas	1% farm household areas	1% farm household areas	1% farm household areas	1% farm household areas	1% farm household areas	1% farm household areas	1% farm household areas	• Mid-term • End of Project • Every 5 years thereafter	-Household surveys -PhilRice RBHS adjusted to also capture impacts of NIMP	NEDA commissioning surveys
	Increased availability and accessibility of palay (production relative to local demand)	76% rice sufficiency (2019) (88% rice sufficiency based on actual demand)	19,130,238 mt palay production	19,454,854 mt palay production	21,810,337 mt palay production	22,209,992 mt palay production	22,620,850 mt palay production	24,584,538 mt palay production	25,061,870 mt palay production	25,552,577 mt palay production	26,057,017 mt palay production	26,575,591 mt palay production	27,108,679 mt palay production (98% rice sufficiency by 2030)	• Mid-term • End of Project • Every 3 years thereafter	Household surveys	NFA/DA
	Increased agricultural jobs in irrigated areas created by end of 2030 from baseline (2019)	968,937 jobs (2019)	2% agricultural jobs in irrigated areas	2% agricultural jobs in irrigated areas	2% agricultural jobs in irrigated areas	2% agricultural jobs in irrigated areas	2% agricultural jobs in irrigated areas	2% agricultural jobs in irrigated areas	2% agricultural jobs in irrigated areas	2% agricultural jobs in irrigated areas	2% agricultural jobs in irrigated areas	2% agricultural jobs in irrigated areas	2% agricultural jobs in irrigated areas	• Mid-term • End of Project • Every 3 years thereafter	Household surveys	DA

Table 4.80. Results-based M&E: Monitoring and Evaluation of the NIMP Outcomes

Outcome	Outcome Indicators	Baseline	Annual Targets											Data Collection and Reporting		
			2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Frequency and Reports	Data Collection Instruments	Responsibility for Data Collection
1. Improved NIA irrigation systems planning and management	Cropping intensity	170%	170%	170%	170%	170%	170%	170%	170%	170%	170%	170%	170%	-Seasonal data -Annual reports	NIA Reports	NIA
	Increased agricultural productivity	IIrrigated palay production: 14,463,760 mt/year Irrigated palay yield: 4.43 tons/ha	14,868,747 mt palay production (4.43 tons /ha/season X1.70 cropping int.)	15,285,068 mt palay production (4.43 tons /ha/season X1.70 cropping int.)	17,734,825 mt palay production (5 tons / ha/season X1.70 cropping int.)	18,231,395 mt palay production (5 tons / ha/season X1.70cropping int.)	18,741,880 mt palay production (5 tons / ha/season X1.70cropping int.)	20,807,985 mt palay production (5.4 tons / ha/season X1.70cropping int.)	21,390,603 mt palay production (5.4 tons / ha/season X1.70cropping int.)	21,989,543 mt palay production (5.4 tons / ha/season X1.70 cropping int.)	22,605,245 mt palay production (5.4 tons / ha/season X1.70 cropping int.)	23,238,197 mt palay production (5.4 tons / ha/season X1.70 cropping int.)	23,888,866 mt palay production (5.4 tons / ha/season X1.70 cropping int.)	-Seasonal data - Annual reports	NIA Reports PSA Data	NIA/DA

Out-come	Out-come Indica-tors	Baseline	**Annual Targets**											Data Collection and Re-porting		
			2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Frequen-cy and Reports	Data Col-lection Instru-ments	Re-spon-sibility for Data Collec-tion
		OAC pro-duction & yield: Sugarcane produc-tion: (1.5% increase/ year): 25,101,782 tons/year Sugarcane yield: 57 tons/ha	25,478,309 tons/year	25,860,484 tons/year	26,248,391 tons/year	26,642,117 tons/year	27,041,748 tons/year	27,447,375 tons/year	27,859,085 tons/year	28,276,972 tons/year	28,701,126 tons/year	29,131,643 tons/year	29,568,618 tons/year			
		Coconut produc-tion (1% increase/ year): 14,873,427 tons/year Coconut yield: 4 tons/ha	15,022,161 tons/year	15,172,383 tons/year	15,324,107 tons/year	15,477,348 tons/year	15,632,121 tons/year	15,788,443 tons/year	15,946,327 tons/year	16,105,790 tons/year	16,266,848 tons/year	16,429,517 tons/year	16,593,812 tons/year			

Outcome	Outcome Indicators	Baseline	Annual Targets											Data Collection and Reporting		
			2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Frequency and Reports	Data Collection Instruments	Responsibility for Data Collection
		Banana production (1% increase/ year): 9,452,372 tons/year Banana yield: 21 tons/ha	9,546,896 tons/year	9,642,365 tons/year	9,738,789 tons/year	9,836,177 tons/year	9,934,538 tons/year	10,033,884 tons/year	10,134,223 tons/year	10,235,565 tons/year	10,337,920 tons/year	10,441,300 tons/year	10,545,713 tons/year			
		Corn production (0.5% increase/ year): 7,810,778 tons/year Corn yield: 3 tons/ha	7,849,832 tons/year	7,889,081 tons/year	7,928,527 tons/year	7,968,169 tons/year	8,008,010 tons/year	8,048,050 tons/year	8,088,290 tons/year	8,128,732 tons/year	8,169,376 tons/year	8,210,222 tons/year	8,251,274 tons/year			
		Pineapple production (2.5% increase/ year): 2,799,259 tons/year Pineapple yield: 41 tons/ha	2,869,241 tons/year	2,940,972 tons/year	3,014,496 tons/year	3,089,858 tons/year	3,167,105 tons/year	3,246,283 tons/year	3,327,440 tons/year	3,410,626 tons/year	3,495,891 tons/year	3,583,289 tons/year	3,672,871 tons/year			

Outcome	Outcome Indicators	Baseline	Annual Targets											Data Collection and Reporting		
			2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Frequency and Reports	Data Collection Instruments	Responsibility for Data Collection
		Mango production (1.7% increase/ year): 581,151 tons/year Mango yield: 4 tons/ha	591,031 tons/year	601,078 tons/year	611,297 tons/year	621,689 tons/year	632,257 tons/year	643,006 tons/year	653,937 tons/year	665,054 tons/year	676,360 tons/year	687,858 tons/year	699,551 tons/year			
		Tobacco production (0.5% increase/ year): 7,002 tons/year Tobacco yield: 2 tons/ha	7,037 tons/year	7,072 tons/year	7,107 tons/year	7,143 tons/ year	7,178 tons/year	7,214 tons/ year	7,250 tons/year	7,287 tons/ year	7,323 tons/year	7,360 tons/year	7,397 tons/year			

Outcome	Outcome Indicators	Baseline	Annual Targets											Data Collection and Reporting		
			2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Frequency and Reports	Data Collection Instruments	Responsibility for Data Collection
2. Enabled IAs	Increased number of IA's with income from Agri-business (including diversified agri-culture)	By 2020, 2,785 NIS IAs with "modified" IMT contracts By 2020, 2,080 CIS IAs with "modified" IMT contracts	280 IAs per year (approx. 10% of 2,785 NIS IAs) 210 IAs per year (approx. 10% of 2,080)	280 IAs per year 210 IAS per year	280 IAs per year 210 IAS per year	280 IAs per year 210 IAS per year	280 IAs per year 210 IAS per year	280 IAs per year 210 IAS per year	280 IAs per year 210 IAS per year	280 IAs per year 210 IAS per year	280 IAs per year 210 IAS per year	280 IAs per year 210 IAS per year	280 IAs per year 210 IAS per year	-Seasonal data -Annual reports	NIA report Survey of IAs every 3 years 490 Business plans	NIA
	Increased number of IA's undertaking group farming	Number of IAs in group farming - zero	10% increase in IAs in group farming	10% increase in IAs in group farming	10% increase in IAs in group farming	10% increase in IAs in group farming	10% increase in IAs in group farming	10% increase in IAs in group farming	10% increase in IAs in group farming	10% increase in IAs in group farming	10% increase in IAs in group farming	10% increase in IAs in group farming	10% increase in IAs in group farming	-Seasonal data - Annual reports	NIA report Survey of IAs every 3 years 490 Business plans	NIA/DA

Outcome	Outcome Indicators	Baseline	Annual Targets											Data Collection and Reporting		
			2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Frequency and Reports	Data Collection Instruments	Responsibility for Data Collection
3. Resilient systems	New projects implemented using new design standards starting 2026; these projects will decrease the value of damage to irrigation infrastructures currently at an average of PHP 1.3 B/ year	Zero Total of 2 systems out of 245 NIS	5% of existing number of NIS systems retrofitted	5% of existing number of NIS systems retrofitted	5% of existing number of NIS systems retrofitted	5% of existing number of NIS systems retrofitted	5% of existing number of NIS systems retrofitted	5% of existing number of NIS systems retrofitted	5% of existing number of NIS systems retrofitted	5% of existing number of NIS systems retrofitted	5% of existing number of NIS systems retrofitted	5% of existing number of NIS systems retrofitted	5% of existing number of NIS systems retrofitted	Annual inventory	NIA Annual Reports	NIA
	Increased number of farmers adopting water saving technologies	99,587 farmers adopted as of 2019 covering 119,549 ha	10% increase per year in farmers adopting water saving technologies	10% increase per year	10% increase per year	10% increase per year	10% increase per year	10% increase per year	10% increase per year	10% increase per year	10% increase per year	10% increase per year	10% increase per year	NIA Accomplishment Report	Survey of farmers/ IAs	NIA

CHAPTER 5
RECOMMENDATIONS FOR EFFECTIVE IMPLEMENTATION OF NIMP


KUBOTA

5.1. Recommendations for Water Resources Management

One of the main reasons for the low performance of irrigation systems is the lack of water during dry season. The estimation of dependable (low) water supply and flood (high) discharges for rivers, potentially viable for reservoir and/or diversion dams, is very important. Cognizant of this, the NIMP computed the 80% dependable flow of 195 rivers nationwide. They can be used to estimate the irrigability index for existing PIPs or new irrigation development areas. Regional unit discharges have also been estimated and can be used for new irrigation development projects for rivers in ungauged watershed. Spatial proximity technique can also be used to estimate the dependable flows of adjacent ungauged rivers. It is advisable however, that in the conduct of FS especially for ungauged rivers, estimated dependable flow values given here should be verified using actual flow measurements during dry season months or through deterministic modeling (e.g. SWAT or HEC HMS). Continuous hydrologic data acquisition and monitoring should also be pursued to improve the data set and consider the effect of changing land use and climate change.

There is a need to delineate areas served by NIS and CIS, as well as those served by minor irrigation systems (e.g., SWIP, SFR, STW, PISOS, DD, SPIS, SD). The NIA through the different RIOs and IMOs have already started delineating the areas served by NIS and CIS. The BSWM has also been delineating the areas served by SWIPs and DDs including the parcellary mapping of individual farms since 2014. It has also collaborated with different state universities and colleges (SUCs), in several DA-BAR funded projects aimed at identifying and delineating potential sites for small scale irrigation systems using GIS-based assessment. The Phil-LiDAR 2 Project 1 (Agricultural Resources Assessment using LiDAR and other RS Data) of UP Diliman has also embarked on a nationwide endeavor to establish baseline inventory of resources. This entails high resolution mapping of agricultural, aquaculture and forest resources, as well as, establishing hydrologic datasets for flood modeling to generate risk maps and EWS. With all these efforts and together with the geospatial maps generated through this NIMP, NIA should finally be able to establish the total irrigable areas in the country and help identify and zone areas where various modes of irrigation are feasible. NIA should identify areas where surface water and groundwater sources are technically feasible.

Climate change is expected to increase water stress in more regions, increasing the reliance on groundwater use for agriculture. Surface water variability and weather extremes will greatly expand the role of groundwater in current and future irrigated areas. As a result, several regions that do not significantly use groundwater for agriculture will likely do so in the future and risk facing the same challenges currently experienced in the regions which already use groundwater intensively. The implementation of sustainable resource management policies would allow groundwater to act as a powerful CCA option. The vast groundwater resources in the country are underutilized especially for agricultural use and could be tapped to provide irrigation all year round. The practice of supplementing irrigation from surface sources with groundwater from STWs should be encouraged especially for areas where the surface water sources (i.e., creeks) have very low dependable discharges during the dry season and for areas underlain by good shallow aquifers.

Cognizant of the country's vast groundwater potential, the DA through the DA Regional Field Units (RFUs) and in collaboration with the University of the Philippines Los Baños, launched an STW

Irrigation Program in 1992 to promote cost-effective and sustainable STW irrigation technologies. Parallel STW irrigation projects were then implemented at the same time by BSWM and NIA. All these projects helped popularized STW irrigation and increased the STW population through private sector initiatives. These STWs provided farmers with reliable irrigation source during intense drought periods and especially in all the El Niño episodes that have occurred since then. It is high time that the NIA revive this project. NIA still distributes STWs although on a much lower number and based only on necessities. They also maintain drilling rigs and planned to procure more. The NIA CO also plans to procure more geo-resistivity equipment and distribute them to the ROs to help identify locations for STW installations. Some NIA IMOs (e.g., Region 11) have already installed standby STWs which they only use during prolonged dry spells. The practice of using STWs to supplement gravity irrigation should be encouraged even at the farmer's own initiatives. This is not only as a short-term solution to improve the cropping or irrigation intensity but also to encourage crop diversification.

Sedimentation is one of the main problems that cause canal deterioration and decrease in water yield during dry season. To reduce future rehabilitation works due to desilting, provision of silt control devices, either on the head works or on main or lateral canals, should be included in the design, especially for sediment laden rivers or creeks. Estimation of sediment discharge should also be included in the FS, considering the escalating erosion of our watersheds.

More comprehensive and specific studies on modernized structural/infrastructure facilities and auxiliaries (e.g., precision agriculture systems), alternative power sources (e.g., renewable resources and biomass) for irrigation systems and farm operations and/or business diversification, and use of wastewater for irrigation and supporting production systems can be done and incorporated in the development of lower level plans to optimize productivity and efficiency of irrigation systems.

Other possible evaluation tools such as those established by other institutions such as the Technology Assessment Protocol espoused by DOST-PCAARRD, the UN's Clean Development mechanisms, and Sustainable Consumption and Production approaches among others can be considered and employed after comprehensive discussion and validation. Incorporation of the validated approaches can be done in the formulation of lower level plans such as the regional and provincial master plans and in the next updating of the NIMP.

5.2. Implementation Strategies for the New NIA Geodatabase

The NIA geodatabase will play a significant role in the organization both as a data repository and as a tool to monitor performance of various projects and activities being implemented on the local and regional levels. It is also a vital component of the entire information system that can highly impact decisions at the CO or at the national level. However, it is also important to investigate the management issues related to introducing and implementing GIS technology at NIA because this is often deemed more crucial than their technological issues. This is because GIS, compared to other technologies, requires specialized organizational and management approaches. Some of these issues include the nature of geographic datasets and their roles in the organization's operations, the current state of GIS technology and its future direction, the relationship of GIS with other existing technologies in the organization, and the multiuse nature of GIS data, among others. GIS implementation may also vary from one organization to another. In NIA, GIS will serve as data and operational framework that affects and ties together different activities in the organization. Thus, it is significant to determine the appropriate role of GIS in NIA, understand its implications, and identify appropriate implementation strategies.

GIS as a tool and technology provides new perspective and serves as basis for operations and decision making. Laying out the role and scope of this technology in the organization leads to identifying appropriate models for implementation and management. In GIS, there are different kinds of models that can be followed depending on the scope, the degree of integration of GIS into its operation and planning, degree of centralization of GIS operation and use, the degree of centralization of management control, and the like. For NIA, an enterprise GIS setup is more appropriate than other alternative models. In this environment, GIS provides an information and operations framework for different major activities and applications within NIA. This means that various GIS applications will be central in the organization which in turn would result to the widespread use of the technology. In addition, this will also aid NIA's corporate decision making and operations. Although GIS is expected to be utilized by different divisions and offices (e.g., IMOs, ROs, system offices) in NIA, coordination and control should be centralized. This means that wherever GIS management is to be placed in the organization or a new GIS unit is to be established in NIA, it should be able to coordinate all the users, and the design, implementation, expansion, and standards in the system should be centrally managed by this unit.

In order to build and fully operationalize the system, implementation is key and would require some planning and management. GIS implementation simply involves designing, acquiring, installing, and operationalizing the necessary components of the system (e.g., data, software, hardware, and people) to attain the organization's GIS needs. There are several steps in the implementation process. The first is the requirements analysis phase. This particular stagenot only involves determining the functional and data requirements for the GIS applications and users, but also entails assessment of resources, opportunities, and constraints in the organizational and institutional environment. In NIA, the main objective in the implementation of GIS is to generate reliable data from various irrigation developments in the country and use such information to build better and improved decisions. The next step is the design phase, which employs developing a conceptual design for the system, database, applications, and organizational components. This part also centers on the hardware and software requirements including data needs. In terms of hardware requirement, the following specifications are recommended for the GIS server and GIS workstations:

GIS Server (NIA CO)

- Intel Xeon Gold or Intel Xeon Platinum Processors
- 64GB DDR4 Memory
- SSD 4 x240GB
- 2 x 10TB Sata HDD
- Nvidia Graphics Card

GIS Workstation (NIA CO, ROs, IMOs, Systems)

- 27" UHD Dual Monitor
- Intel Core i7-8700 Processor
- 16GB DDR4 Memory
- 2TB HDD + 512GB SSD Storage
- Nvidia GTX1050 4GB VRAM

In terms of software requirement, an ArcGIS Enterprise is recommended for NIA CO while ArcGIS Desktop Advanced licenses for the regional and local offices (e.g., IMOs, system offices). ArcGIS Enterprise is regarded by ESRI as the foundational software system for GIS, powering mapping and visualization, analytics, and data management. It is also closely integrated with ArcGIS Desktop and ArcGIS Pro, and is complementary with ArcGIS Online in the implementation of web GIS. The main difference between ArcGIS Online and ArcGIS Enterprise is that the former runs in an ESRI-managed cloud infrastructure where computation and data storage are all done in a highly scalable environment, while the latter runs on the organization's own infrastructure. With regard to ArcGIS Desktop license, a standard or advanced level is proposed so that users can optimize the potential of the software and capitalize on its various functionalities and uses. An ArcGIS Desktop Advanced license includes map creation, interactive visualization, spatial analysis, multi-user editing, advanced data management, advanced analysis, high-end cartography, and extensive database management, among others. In summary, here are the software requirements recommended for NIA and its regional/local offices:

NIA CO

- ArcGIS Server Enterprise
- ArcGIS Desktop Advanced
- Windows Server
- SQL Server
- Firewall and Antivirus

Regional and Local Offices

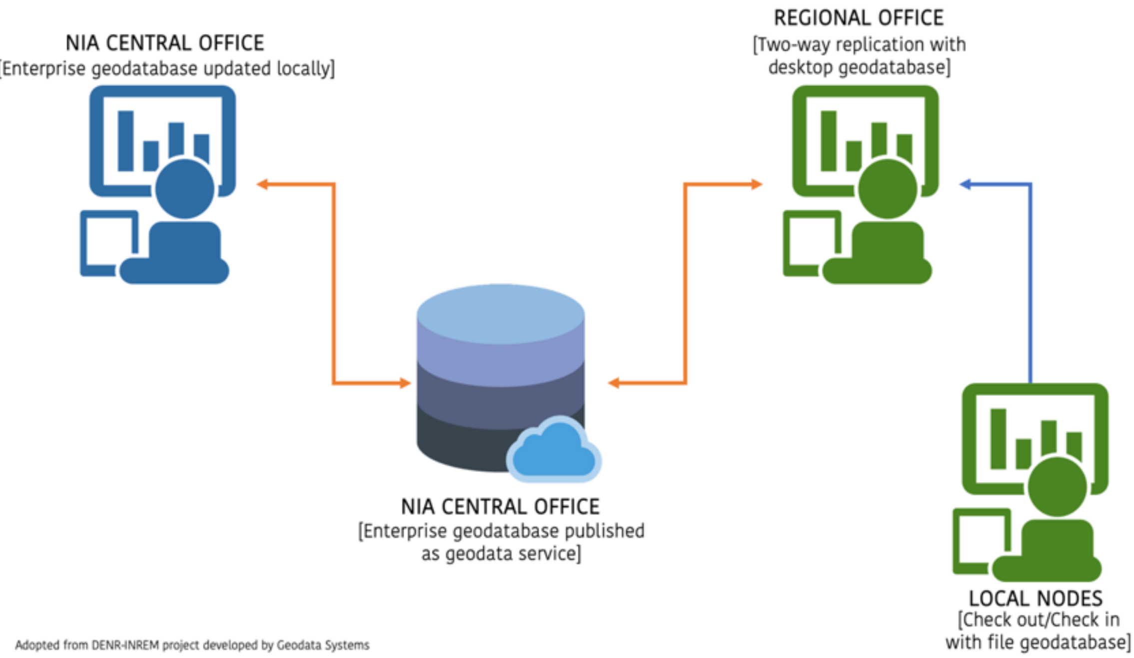
- ArcGIS Desktop Standard or Advanced
- Windows 10
- Antivirus

The next phase is the construction phase which essentially involves developing the specifications for system selection and acquisition. This is where the efforts on data acquisition and database design efforts also begin. For NIA, the detailed design structure of the geodatabase has been prepared already and can be updated periodically to cater any additional information or changes in the data attributes. Prototype testing is also under this stage to validate the performance of the system.

Finally, the last part is the implementation phase which already includes the O&M of the system. This consists of integrating GIS into the organization's operating environment, supporting various users, and managing the ongoing process of data and system maintenance. Apart from the deployment and operational testing, user training is also a critical aspect of this phase as it intends to build capacities and competencies of NIA personnel in implementing GIS workflows, populating the different feature classes in the geodatabase, and updating existing thematic layers of the organization. In the general, this can be divided into three processes, namely data loading, data updating, and data maintenance.

Data loading relates to how data can be loaded directly in the NIA geodatabase from source data such as shapefiles or from other file geodatabases. This could be done by connecting through an SQL Server or SQL Database, or it can be loaded directly to the central geodatabase by using a wizard assistance such as the Simple Data Loader or Object Loader. Data updating, on the other hand, is conducted primarily to modify the data that are already stored in the geodatabase. The data updating process for NIA from the local offices to the regional and to the CO follows the illustration (Figure 5.1.).

Figure 5.1. Data Updating Workflow for the NIA Geodatabase



The local nodes include the IMOs and system offices where data will be mostly generated and populated. This will then be transmitted or fed to the RO for evaluation and verification before forwarding them to the NIA CO. It is also important that a geodata service for each region will be created in the NIA CO. A geodata service allows a user to access a geodatabase through a local area network (LAN) or the Internet using ArcGIS Server. It can also be used to perform geodatabase replication operations, make copies using data extraction and perform various queries in the geodatabase. When this service becomes accessible to the RO, a two-way replica of the data in the desktop geodatabase should be created. This will allow data changes to be sent from the parent replica to the child replica or vise versa. Under this set-up, the parent replica is the NIA CO geodata service and the child replica is the RO's desktop geodatabase. Updated data from the local nodes will be synchronized to the desktop geodatabase of the region. Once these data have been reviewed and verified, the RO will then synchronize its geodatabase to the geodata service so that NIA CO will have access to the updated feature classes. Otherwise, the data will again be reverted to the local nodes for further editing, correction, and updating.

The last step is data maintenance. This activity helps organizations like NIA to keep track of the changes required in the data to keep it updated and relevant. It is also referred to as a process of continual improvement and regular checks. Like any other type of data, geographic data in NIA is no different. Some examples of these include updating of address of farmers, subdividing parcels of irrigation systems, adding pumps and wells in the area, updating the FUSAs, etc. In GIS, there are two strategies in data maintenance—without versions and with versions. The former is appropriate for simpler features wherein a user does not need to manage history or multiple versions of the data. On the other hand, the latter strategy allows multiple concurrent states of databases known as versions to exist at the same time. This means that each version signifies an ongoing work and there is no limit to the number of versions a geodatabase can have. This type also allows one to manage past, present, and proposed changes to the data.

5.3. Organizational Reform to Implement the New NIA Geodatabase

It is recommended that NIA coordinate with the irrigation units of other agencies for the purpose of linking them with the NIA geodatabase, to improve the management of the geospatial data such as the boundary of CIS, OGA and PIS. In order to assure the proper implementation of the new NIA geodatabase, establishment of a Geodatabase Unit is deemed necessary. This Geodatabase Unit shall be set up at the CO and at each of the ROs, as indicated below:

Table 5.1. Proposed Composition of the Geodatabase Unit

NIA Office		No of Position Items
CO	Corporate Planning Department: Management Information Division	6
RO/UPRIIS/MARIIS	Regional Manager	2 X 17
IMO/Interim/Division		2 X 56
Total		**152**

5.4. Capacity Building on the New NIA Geodatabase and Related Topics on Irrigation Development

Rationale for Capacity Building

Data management is necessary for a more organized, efficient and productive flow of work and it tremendously improves planning and operations. All these data, which are geographic in nature necessitates their management in a geodatabase—a collection of geographic datasets with a comprehensive information model that can represent and manage geographic information. For NIA, the new geodatabase serves the compilation, storage, management and data integrity maintenance of all necessary spatial information.

For planning and operations, it is important to have a view of the proposed site prior to field visit for the initial review of what should be expected on the ground. A look into maps is more efficient than directly going first to the area for reconnaissance. Different map files could be seen through overlaying one another. In irrigation system development, dam improvement and other irrigation-related projects or activities. Thus, a capacity building is critical to train concerned NIA personnel on the use of the new NIA geodatabase. Moreover, national datasets have been gathered for NIMP necessitating a practical and operational awareness of NIA personnel to ensure the success of irrigation development in the country.

This capacity building program is designed to be undertaken twice a year for the next 3 years, until such time that a Geodatabase Unit is installed at the NIA CO and at the NIA ROs with the corresponding plantilla positions equivalent to the participants identified for this program.

Objectives

The main objective of the capacity building program is to enhance the current skills and understanding of the NIA staff in the use of GIS and UAS as applied in irrigation development and management.

Specifically, the training aims to:

- Introduce the participants on the basics of GIS and map making;
- Demonstrate fundamental workflows for the NIA geodatabase; and
- Perform UAS survey and image processing.

Participants

All NIA personnel involved in irrigation development are highly encouraged to participate in the capacity building. Table 5.2 shows the breakdown of participants across all NIA offices in the country.

Table 5.2. Number of Participants for Geodatabase Capacity Building

Office	Number of Participants
NIA CO	6
RO/UPRIIS/MARIIS	3
IMO/Interim/Division	56

Number of Trainings and Proposed Activities

A total of two batches of training will be held, representing each of the island group in the country, to cater to all NIA offices.

Table 5.3 summarizes the preparatory activities to be done with the corresponding office assigned, while Table 5.4 shows the initial topics and schedule to follow for the conduct of trainings.

Table 5.3. Preparatory Activities and Office in Charge

Activity	Office in Charge
• Identification and invitation of participants • Identification and preparation of training venue • Provision of accommodation for participants • Provision of accommodation for UPLBFI Resource Persons • Production of training manual (UPLBFI will provide the pdf file) • Drone package (1 per region; drone unit with peripherals; image processing software eg. Agisoft)	NIA
• Preparation of the training manual • Preparation of the data for the training: o Map ATLAS (per Region) in e-format o Other map data • Installation software (Open Source) • Drone	UPLBFI

Table 5.4. Topics and Schedule

Day	Topic	Office in Charge	Materials Needed
Day 0	Arrival at the venue Preparation of the venue	NIA	LCD Projector and Screen Power outlets; extension cables Whiteboard and markers
Day 1			
AM	Opening Program	NIA	
AM	Introduction to the Training (objectives and schedule) Distribution of Training Manual Installation/downloading of e-files of training manual and map data Installation/downloading of e-files of GIS, image processing and other related software	NCB/CLT	Training Manual Laptop per participant ArcGIS software Quantum GIS software NIA GIS data NEW NIA Geodatabase
PM	Introduction to ArcGIS Working with Map Data	CLT/NCB	GIS data Map ATLAS
Day 2	Working with ArcGIS Introduction to the NEW NIA Geodatabase	CLT/NCB	
Day 3 AM	Working with the NEW NIA Geodatabase Working with QGIS	CLT/NCB	
PM	Unmanned Aerial System for irrigation development	NCB/CLT	UAS (drone) plus peripherals

Day	Topic	Office in Charge	Materials Needed
Day 4	Unmanned Aerial System for irrigation development - Flight planning - Actual flight - Image Process-ing	NCB/CLT	UAS (drone) Image processing software
Day 5	Working with UAS products ie. photomo-saics Updating the NEW NIA Geodatabase eg. In-tegrating spatial data, UAS data products Closing Program	NCB/CLT CLT/NCB	

Materials Needed

1. 1 laptop per participant
2. ArcGIS software (NIA-acquired)
3. Quantum GIS (please download latest version)
4. UAS (drone; at least 1 unit per region) plus software for image processing
5. Map ATLAS by Region (prepared by UPLBFI as part of NIMP)

5.5. NIA's Organizational Restructuring Directions

There are many reasons why organizations restructure. However, most organizations are compelled to restructure to be more efficient and effective. In the case of NIA, the primary reasons include the following:

- To better address the critical needs of Filipino farmers in irrigated agriculture
- To better respond to NIA's legal obligations in the irrigation development of the country
- To better meet the critical issues of resilience and climate change in irrigation development
- To comply with the Rice Tariffication Act
- To strengthen NIA's organizational capacity to implement the Strategic Plan and NIMP

The Four Principles in Organizational Effectiveness and Efficiency

Each of principles below is central to creating more effective yet affordable government (Farrell and Goodman, 2013):

1. The use of better evidence for decision making
2. Greater engagement and empowerment of citizens
3. Thoughtful investments in expertise and skill building
4. Closer collaboration with the private and social sectors

Key Principles that Should Guide NIA in Achieving Organizational Effectiveness and Efficiency

Listed below are key principles that should guide NIA in crafting its "new" organizational structure. These principles must be fully understood and appreciated by the whole organization. The rank and file employees must be involved in how best to implement these principles in the "new" NIA. The role of the Change Management Office that is suggested in the "Way Forward" recommendations is central to this objective.

- *Function specialization to achieve efficiency.* The NIA must organize itself according to the core or key functions of the agency. These are defined by various laws. These functions are articulated in the "new" NIA strategic goals and Agency Wide Programs (AWPs). Function specialization, involving the separation of tasks within a system to achieve organizational efficiency, must be supported by a highly competent staff.

- *Flatter organizational structure towards greater efficiency.* A flatter organization can be achieved through de-concentration and decentralization. These involve the delegation of power, authority, and responsibility from the CO to the ROs and from the ROs to the IMOs. NIA's major operational strength must be manifested in highly competent IMOs whose major task is to manage the irrigation infrastructure.

- *Removal of conflict of interest and to institute a system of check and balance.* The NIA must carefully review its development and approval system to avoid conflict of interest in offices, units, or persons. As a rule of thumb, there should be no competing interest in relation to the official tasks or responsibilities assigned to an office, unit, or person. In addition, NIA must institute a transparent and highly objective system of check and balance.

- *Strengthen governance as key strategy to increase NIA's organizational effectiveness.* NIA must exert efforts to improve its transparency, predictability and accountability. NIA must strengthen the offices/units that are central to the improvement of governance. Of central importance to this strategy is the technical skills and morale of its employees, which can be achieved through a highly competent and responsive Office on Human Resource Management (HRM).

5.6. Recommendations and Guidelines for Environmental and Social Safeguards

Protection and Management of Irrigation Watersheds

Many irrigation systems exist in degraded watersheds, resulting to the alteration of their structure and function. Their capability had been reduced to provide essential ecosystem services including regulation of hydrologic regimes, regulation of stream sediment loads, and regulation of nutrient inputs into storage reservoirs and to farmers' fields. Consequently, these irrigation systems experience either too little or too much water in their operations. The hydrologic regulation function of these watersheds had been altered. Irrigation field personnel and farmers, during FGDs, attest to the fact that previously the stream or river base flows of these watersheds were enough to sustain their irrigation supplies for about nine consecutive rainless months. Presently, after two consecutive rainless months the base flows of rivers and streams in the watersheds are inadequate to sustain a crop irrigation demands.

An interagency convergence of critical stakeholders, such as the NIA, DENR, BSWM, NWRB, LGUs, WUAs and IPs should be organized to protect and manage irrigation watersheds. Encourage interagency planning and management of water resources in each watershed based on the principles of IWRM. Wherever a Watershed Management Council exists, close collaboration with it is imperative.

Management of Land Cover and Land Use Change in the Watersheds and Irrigation System Service Area

Changes in land cover and land use within the catchment areas are a major factor in watershed degradation. Deforestation and the subsequent use of deforested land for agriculture is a major cause of soil erosion. Corollary to erosion, the sediments in the eroded soil from the uplands silt up rivers, dams, and reservoirs according to irrigation field personnel and farmers who joined FGDs. Sedimentation and siltation severely reduce reservoir capacity, thus shortening the lifespan of irrigation infrastructures and appurtenant facilities. Reportedly, a few NIA-operated dams and reservoirs have been silted up long before reaching their lifespan because of upland erosion. Moreover, runoff from upland fields can potentially pollute water with pesticides and fertilizers and degrade water quality.

To curb erosion and sedimentation in rivers and reservoirs, initiatives by local stakeholders included reforestation and joint development with IPs and other upland farmers of cropping systems that minimize soil erosion. Upland farmers should be encouraged to apply land management practices, such as contour plowing, terracing, and agroforestry around the catchment area of the dam and reservoir. More importantly, an IWRM plan by all stakeholders should be developed. For sustainable management of land cover and use in the catchment area, local stakeholders must monitor the vegetation conditions and correct adverse changes through community efforts.

Resilience to Climate Change and Disaster Risks

The Philippines has been heavily investing in irrigation development to boost crop yield and enlarge currently irrigated areas for many years now. However, the Philippine climate has been changing and the climatic variations pose potential threats to the resilience and sustainability of the Philippine irrigation systems and ultimately to the national food production and distribution system. CC is predicted to alter the Philippine hydrologic cycle, changing the temporal and geographical patterns of rainfall, evapotranspiration, runoff, and ground water recharge, and particularly in their extremes. Spatially and temporally, irrigated agriculture will suffer from either too much or too little water, or both. The planning, design and construction of new irrigation systems and the O&M of existing ones will be badly affected by these projected temporal and geographical changes in water availability or scarcity or both.

Fundamentally, the existing irrigation systems had not been planned, designed, and constructed to consider the risks posed by CC and climate variability, especially the parameters relating to design flood event. Typically, infrastructure codes and standards use historical climate data and analyses to calculate climatic design values, assuming that the average and extreme conditions of the past will represent conditions over the future lifespan of the structure. While this assumption has worked in the past, it will become less valid as the climate changes. The PhilCCAP included CC considerations into the guidelines/ manual it has developed for the planning, design, construction, and O&M of irrigation systems. The NIA must institutionalize the guidelines/manual, which could be a sound basis for irrigation modernization.

LGUs consider irrigation systems, flood control and drainage systems as economic support infrastructure to boost household income. Intrinsically, these infrastructures are shields from the impacts of CC and vulnerability. Moreover, with decent household income, farmers will be less vulnerable to disasters, such as climate variability and change and its ripple effects, thus making them more adaptive and resilient.

On another front, irrigation planners and designers should pay attention to the development and improvement of tertiary systems to facilitate introduction of climate smart-agriculture (CSA) incorporating climate-resilient (eg., enhanced reservoir, slope protection, etc.) and water-efficient features. With improved on-farm water control and application facilities, farmers can adopt CSA to increase the adaptive capacity of agricultural production in the project/service areas. Farmers adopting improved agricultural technology strengthen the technical capacity on both social and environmental safeguards management.

Rehabilitation and Restoration of Existing Irrigation Systems

Apart from conducting studies on technical, economic/financial and institutional feasibility, the restoration/rehabilitation and improvement of existing NIS and CIS also calls for study, through Environmental Performance Report and Management Plan (EPRMP), on environmental feasibility. EPRMP can be conducted for restoration/rehabilitation of existing irrigation systems, especially if large areas will be involved, and 5 years or longer had already passed. Possibly, so much changes had already occurred within the service areas and in the watershed where it is located and have caused varied environmental and social problems. Environmental assessment is needed to upgrade and modernize river infrastructure, where relevant, including irrigation and drainage canals, and storage facilities, flow control structures, measurement devices, and supporting infrastructure such as service roads.

Environmental and Social Impact Assessment

ESIA is a sustainability tool to safeguard and manage the environment in which a proposed/new irrigation project will be constructed and will operate later. It is used to characterize the nature, magnitude, intensity and ultimately the significance of the likely impacts. The Philippine EIA systems require proposed irrigation projects with a potential service area greater than or equal to 1000 ha; line irrigation projects and foreign-assisted projects need to undergo environmental assessment as a safeguard policy.

ESIA is a well-established method used to identify, predict, interpret and communicate information about the impact of major projects on human health and well-being, including that of ecosystems on which human survival depends upon. Although ESIA process has been used to assess likely environmental impacts of projects for decades, its effectiveness as a planning and management tool is reportedly not clearly evident. For ESIA application to sustainable irrigation development, the process can be further improved to produce striking effects.

Importantly, the contextual dimension of impacts should be identified because they must have a meaning to the decision makers and stakeholders. Rather than delve into ex-ante impact evaluation, ESIA must focus on enhancement of beneficial environmental impacts and mitigation of adverse effects. EIS must also strive to design and manage project activities to prevent impact from occurring rather than focus on mitigating or "curing'"the impacts. The purpose of EIA process is not just to assess impacts and complete an EIS, but rather it is to improve the quality of decisions. Consequently, the EIA process will provide environmental information that will help irrigation agency to take actions that protect, restore, and enhance the environment in the long term. The following are guidelines in improving EIS:

1. An EIS should synthesize complex environmental data and information on air, water, land, and people, that are digestible to irrigation planners, designers, and to field operations staff and farmers.

The environmental problems that irrigation planners, designers, constructors, and field operations staff must deal with are complex and are generally multi- and cross-disciplinary in nature. So, environmental problems are difficult to pin down and solve because they are in feedback loops. Expectedly, the environmental impacts of irrigation projects on air, water, land and people are, to a large degree, interlinked and interrelated. On account of the foregoing, accurate data and information must be collected and used in environmental and social assessments because these form part of project FS. Given these, it will allow the proponent to prepare the Environmental and Social Management or Mitigation Plans (ESMPs).

The design of an ESMP will also be effective if the root causes of the impacts are ascertained. Impact can be better reduced or avoided or mitigated when the root causes are known. Long term, rather than temporary solutions, are easier to study and develop, thus irrigation planning and designing lead to sustainable environmental performance of irrigation systems with ESMPs based on accurate and digestible data and information.

Still, the data and information on problems and impacts and corresponding root causes, which must be synthesized in substance and format, are needed by irrigation planners and designers. Oftentimes, the data and information presented in EISs are mostly prescriptive. The irrigation planners and designers found such data and information indigestible and therefore ineffective to planning and design. EIA preparers should sit down with irrigation planners and designers to consult with them the kind of data and information that would be useful to planning and design for integration with project development phases.

2. An EIS should strengthen interaction and inter linkage between ESIA at project planning and design stage and environmental management system (EMS) at project operations after decommissioning.

During the interviews with key informants and interpersonal discussions with operations staff, and dialogues with officers and members of IA, it was found that most of them in the field do not know about ESIA. The lack of knowledge about ESIA by the operations staff and farmers stemmed from the fact that ESIA at the planning or project feasibility stage is mainly used to secure ECC. Most of the decisions about the project design and implementation are made by a project planning team. Field operations staff and farmers had not participated in the public consultation aimed at identifying the consequences of the project that led to the adoption of a particular management measure.

In practice there is often poor linkage between the EIS produced to gain approval for a project and the environmental management strategies that are implemented once the project is operational. Environmental performance can be sustained in the irrigation project area if the ESIA at the planning and design stage is strongly linked to environmental management during operations stage after project decommissioning. There exists a potential to marry ESIA at the planning stage to International Standard Organization EMS of the organization to check environmental compliance during post-project operations period.

3. An EIS should establish ESIA follow-up programs for post audits of EISs

Corollary to the foregoing, the NIA could implement EIA follow-up to keep an eye on the real effects of projects. ESIA predicts likely environmental impacts of irrigation projects, but the real problems, issues and impacts take place and are experienced by farmers and field personnel during O&M of the system. Thus, it is important to place equal or even larger significance to environmental management and protection after project construction. During the operations phase, field operations personnel usually deal with environmental and social issues due to impact prediction uncertainties and non-environmental compliance from planning to construction phase. NIA can carry out for post audits of ESIAs to see to it that environmental management systems are being implemented or enforced, which will require in-house capacity. Foremost, the NIA should establish an environmental and social safeguard unit at the CO and ROs.

Engaging Stakeholders in Environmental and Social Impact Assessment

Public participation is essential to ensure that assessment of a proposed project's environmental and social impacts is in the context of the stakeholders' bio-physical and socio-cultural environment. It is a process in concurrence with DENR-EMB Memorandum Circular No.: 2010-4 dated June 29, 2010, "*The Standardization of Requirements and Enhancement of Public Participation in the Streamlined Implementation of the Philippine EIS*" that aims to ensure that the EIA process is based on a timely and well-informed public participation of potentially affected communities. Through such process, the stakeholders are not just being informed and capacitated but more importantly, they are given a sense of ownership of the project.

Engaging stakeholders through a participatory ESIA could generate creative and locally appropriate solutions to the identified likely impacts. This could also help incorporate indigenous knowledge systems in the assessment that shall consider the socio-cultural conditions of the communities to be affected. Furthermore, it shall improve public awareness and understanding of the project and issues involved in decision making, which is a precondition for functioning democratic system and public satisfaction and trust in the project. This process hopes to build a future of good relations and trust with community leaders, the proponents, and the funders (Roquia, 2014).

To facilitate engagement of stakeholders and to ensure that all their issues and concerns will be properly documented, below are guidelines of plans that need to be developed during the Socio-Cultural Assessment:

Indicative Indigenous People Development Plan

The IPDP is done through a series of consultation with the decision makers of the project affected, barangay and municipal interagency, the tribal leaders of the ancestral domain, barangay chairperson of LGUs and the government agencies such as the Municipal Social Welfare Development Office (MSWD), Municipal Health Office (MHO), DA, Department of Education (DepEd), NCIP, Peoples Organizations (POs) as well as the Non-government Organizations (NGOs).

The objectives are to:

- Identify the basic needs and welfare of the community as basis for the framework of social development program/IP development plan of the project affected Municipality/ Barangay within the project operation area;

- Prepare an indicative sustainable plan based on the government requirement DENR DAO 2003-30 revised and the mandated corporate responsibility of Ancestral Domain Sustainable Development and Protection Plan (ADSDPP); and

- Establish a working relation with ADSDPP and the various community stakeholders with the goal of improving the quality of life of the project affected communities by enabling them to become self-reliant.

The ISDP also provides an opportunity for:

- Addressing key socio-economic issues and concerns by the various stakeholders, including those that were raised during the public scoping;

- Identifying and designing the recommended measures in response to the issues and concerns that were raised;

- Identifying the lead agency or organization responsible in implementing the measures; and

- Setting of timelines to implement these measures consistent with the plans and programs of the lead agencies.

It is expected that in the long term, the economic benefits from tax revenues, funds from the mandated services of the inter-agencies, and socio-economic benefits to the host communities, will be partly the sources of funds to sustain the implementation of the Social/IP Development and Management Plan. The ADSDPP will support such plan in concurrence with the Internal Revenue Allotment (IRA) of concerned LGUs and surrounding communities.

The information collected from the perception survey will also form part of the SDP that mainly address the following issues:

- Perceived fears of environmental “destruction” or degradation due to pollution of land, air, water and resources, and health risks;

- Possibility of the IPs losing their Ancestral domain;

- Possibility of the non-IPs (migrant farmers) of losing their homes and farmlands; and

- Possibility of losing their source of livelihood.

On the other hand, IPRA (RA 8371) concretizes the constitutional mandate to recognize, protect and promote the rights of IP within the context of national unity and development, especially their rights to their ancestral lands and domain, to the preservation and development of their cultures, traditions and institutions, and to their human rights and freedoms as mandated in the 1987 Constitution.

It is a plan drafted to address the issues of IPs, in cooperation with NCIP as the institution that facilitates the planning and implementation of programs in coordination with the local government. The NG recognizes the importance of the IPs/ ICCs protection and development such that it enshrined its commitment in the Medium-Term Philippine Development Plan for 2001–2004, Chapter 13–Protecting Vulnerable

Groups-Assistance to specific vulnerable groups-of which the IPs of the area is one. The government, in coordination with the local government and ADSDPP, will have to provide economic opportunities to uplift majority of those from poverty. Thus, the IPDP shall guide ADSDPP and concern LGUs in the preparation and implementation according to the LGU guidelines for the five-year SDP/ADSDPP.

The overall focus of the indicative IPDP is to assure DENR EMB/NIA that the ADSDPP can mitigate the major impacts, which include health and safety programs, environmental preservation, and alternatives to livelihood programs of the affected communities. ADSDPP will take the local needs in making strategic partnerships with all concerned stakeholders that include the LGUs, NGOs, and people organizations.

Gender Action Plan

The Project's Gender Action Plan (GAP) will be implemented by the Project's Management Unit (PMU) which will hire a community development/gender specialist in the project team. The specialist will be responsible for incorporating the GAP into project planning and program, including sensitivity workshops, gender analysis, and establishment of sex and gender -disaggregated indicators, and culturally sensitive indicators for project performance and monitoring. The PMU will include reporting on progress of GAP activities in quarterly progress reports on overall project activities to NIA. Table 5.5 shows how planners could integrate gender in the ESIA.

Table 5.5. Considerations in the Integration of Gender in Environmental and Social Impact Assessment

ESIA Process	Integrating Gender-related Considerations
Scoping	Identify key gender issues
Terms of Reference	Indicate the need to collect gender-specific and sex-disaggregated data; ensure gender expertise and gender balance of the team. The latter improves consideration of multiple perspectives. In some culture, only female data collectors can interview women. Use networks of female professionals if no suitable team members are available.
Impact Identification	Conduct a gender analysis; identify positive/negative effects on women and men.
Public consultation	Ensure meaningful participation of men and women from different groups. Consider cultural gender perceptions: Who speaks? Would separate meetings for men and women improve participation? If women normally do not speak out, women's groups may help them to speak with a united voice. Identify appropriate meeting times and locations based on data on gendered tasks and time use.

ESIA Process	Integrating Gender-related Considerations
Mitigation measures	Include measures to address the identified adverse impacts on both women and men
Environmental Management Plan	Include a GAP or gender strategy.
Post-monitoring	Use gender sensitive indicators for identified impacts, measuring outcomes for women and men. Use participatory monitoring mechanisms for women and men.

Adapted from: NCEA, 2015

Resettlement Action Plan

The Resettlement Action Plan for the Project is formulated to ensure that the Project Management Office (PMO) of the project will provide a just compensation and peaceful relocation procedure prior to the commencement of the project in accordance with the appropriate and applicable laws, policies and/or guidelines of the country as well as taking into consideration the policies/guidelines of the international financing institution particularly the WB and JICA's Resettlement Guidelines/Policies for Social Considerations, and other related institutions.

The objectives of this Resettlement Action Plan are as follows:

- Provide project impact assessment to the Project Affected Families (PAFs),
- Quantify the private and public properties which shall not be taken for public use without just compensation,
- Present a strategic scheme/plan to ensure proper resettlement of the PAFs in a timely manner,
- Recognize and consider the involvement of the PAFs in the implementation of the RAP,
- Provide necessary resources that may be needed, particularly the funds needed for the social component of the project which include among other cost for the resettlement of the PAFs, and
- Provide livelihood/income restoration.

Capacity Building

To sustain irrigation development, NIA must build technical capacity and adequate competence in ESIA practice and training. Lack of this capacity has slowed down irrigation development in the regions, which is an issue raised by a number of stakeholders in the series of regional FGDs conducted. Building ESIA capacity in NIA is supported by the legal framework elucidated by the Philippine EIS Law (PD 1586), the Philippine Indigenous Peoples Rights Act (RA 8371), the Right of Way Acquisition Law (RA 8974) and their implementing rules and regulations. Additionally, a number environmental and natural resource use laws complement and fortify PD 1586, RA 8371, and RA 8974. Similarly, there are a number of local and national institutions that can backstop capacity building efforts at NIA CO and ROs. In view of this, NIA must build productive relationships with these agencies and institutions.

NIA staff have skills and competence to undertake ESIA. At the NIA CO, an interim Environmental Unit (EU) can be strengthened to assume ESIA functions through academic or professional and practical training and workshop. Training is not the only component, but it is the core component of capacity building. Short training courses on important aspects of ESIA, particularly its effectiveness to capacitate the NIA, can be held. Reference manuals and procedures for the conduct of ESIA are widespread in textbooks and published reports locally, nationally, and internationally, in a wide range of sectors such as infrastructure, agriculture, etc. As previously stated in this report, an ESIA methodology generically consists of screening, scoping, impact prediction and mitigation, EIS, and audit of ESIA. Thus, depending on project objective and relevant biophysical and social contexts, ESIA procedures could be custom fitted to the needs of the trainees. For instance, under the supervision of mentors, trainees will conduct an ESIA of a new irrigation system as part of their practical capacity building.

In these trainings, the focus of discussion and skill building should be on the benefits of ESIA to sustainable irrigation development rather than on technical aspects of conducting acceptable ESIA. Trainers must conduct follow-on trainings until such time the NIA gains enough technical skills and competence in the ESIA. That way, environmental compliance and safeguards can be enforced, and irrigation development becomes sustainable. Ultimately, this can pave the way for mainstreaming ESIA in irrigation planning, design, construction, and O&M in the near future.

Establishment of Environmental and Social Safeguards Unit

The interim environmental unit at the NIA CO can be formally organized as a section specifically tasked to oversee enforcement of environmental and social safeguards of new and existing irrigation projects/systems. Its fundamental function is to ensure that environmental compliance in all stages of irrigation development is fully abided by. As much as possible, the section should be ran by NIA staff with multidisciplinary training and skills.

5.7. Recommendations for Financing

On Public-Private Partnership

As farmers become competitive in rice production through the confluence of irrigation development and other productivity enhancing interventions provided by the government, it is but prudent to consider weaning them from free irrigation (but still provide subsidies as needed) as this would allow for more private sector participation (through PPP) in the irrigation sector in terms of construction, O&M, and rehabilitation. PPPs have the potential to facilitate an expanded role for the private sector in irrigation, mobilize expertise in the sector, and ensure medium- to long- term sustainability. This would greatly ease the financial burden on the government while farmers in turn, would be assured of efficient irrigation services. After all, farmers will only be willing or able to pay the service fees if the irrigation services (together with other improved inputs where needed) help them to increase yields and thereby incomes to a level that enables them to afford the fees and make a suitable profit.

Given this context, PPP in irrigation can be a viable option if the main stakeholders are satisfied by the arrangement. The WB[1] provides an analysis of the main considerations of each of the three main stakeholder groups, the tables of which are reproduced in the following page:

[1] Mandri-Perrot, C. and J. Bsitbey. 2016. How to develop sustainable irrigation projects with private sector participation. Washington DC: International Bank for Reconstruction and Development / The World Bank

Figure 5.2. Stakeholders' Requirements for Entering into PPP

PRIVATE SECTOR

Key concerns	Dependencies	Scope to mitigate?
Is it feasible to provide the services specified in the PPP service contract?	Depends on the specification of services that government wants to be provided on a given scheme.	• The specification of service requirements needs to reflect the technical realities (e.g., the enabling engineering infrastructure) as well as the physical and social environment of the existing/ proposed scheme location. • The requirements have to develop following negotiation between the government, private sector firms, and the users/farmers. • Private firms will only take on risks that they have some control over, the design of the contract/specification of services will need to take this into account.
Is it possible to obtain a reasonable rate of return from providing the services specified in the contract?	Depends on the willingness and ability of farmers to pay for the services and the capital and O&M costs that it expects to incur to provide the services. Also the extent to which farmers already pay for services.	• Government may need to provide subsidies to cover the shortfall between what farmers are willing to pay and what is required to cover costs. • Depending on the capacity and willingness of the farmers there may be need for technical and financial support from government/development partners to improve the quality of their farming practices and access to other inputs so that they can increase yields and then access markets to increase their incomes. • There may also be need for government to provide additional investment in roads/supporting infrastructure to enable farmers to access local, national and international markets.
Are the risks of relying on farmers to pay service fees too high?	Depends on the type of farmers being provided irrigation services by the scheme and the nature of the crops that they are producing.	• Government can agree to pay subsidies to provide some cover for the risks that the private firms would ordinarily face. • Potential to formalize a contractual agreement with an agribusiness that will agree to offtake a proportion of the farmer's agricultural produce for pre-defined prices. • Potential to provide technical support to the farmers to improve their farming practices.
Can government be relied upon to pay any subsidies on a consistent and timely basis?	Willingness and ability of government to pay of government	• Does the government have a track record of adhering to the terms of PPP arrangements, if not government could consider providing guarantees and/or establishing a dedicated fund that could be used to provide the necessary payments. • In addition government may need to implement reforms to improve the existing enabling environment for the implementation of sustainable PPPs (the minimum requirements are discussed in Part B of this guide).
Can I rely on government to enforce the terms of the agreed PPP service contract?	The ability of government to design, implement and enforce a sustainable arrangement.	

GOVERNMENT

Key concerns	Dependencies	Scope to mitigate?
Are there enough potential private sector firms with track record to deliver required services to the necessary standard?	Availability of private firms with a track-record/ capacity to deliver services.	• Ensure that the service requirements for the PPP are realistic and specified clearly to attract relevant private sector participants. • Develop an effective procurement process that ensures that potential private firms are aware of the opportunity and can understand what is being requested.
Will the private sector provide the services at the agreed level of quality on a sustainable basis?	Provisions specified in the service contract and the ability of government to monitor and enforce those provisions.	• Develop an appropriate enabling environment in which it is possible to define and enforce a suitable service contract. • Identify a relevant government institution that can play the role of monitoring and enforcing the terms of the contract.

FARMERS		
Key concerns	**Dependencies**	**Scope to mitigate?**
Are the farmers willing and able to pay service fees at the level specified in the service contract?	Ability to generate enough income from farming activity to make it worthwhile to pay the required tariffs for accessing irrigation services.	• This is dependent on the market price that the farmers can get for their produce and the quantity of the produce that they are able to generate. The farmers might therefore need assistance to consider appropriate cropping plans and intensity (depending on whether it is feasible to do so given the agronomic conditions and whether markets and other supporting services are available) and more general support to improve the productivity of their agricultural practices.
	Ability of the private firms working with government to deliver the services specified in the contract.	• Government may need to provide investment to support the improvement of the supportive infrastructure, e.g. roads, access to power necessary to enable the farmers served by a potential scheme to access markets, research and innovation, market information systems etc..

Adapted from: World Bank

On Official Development Assistance

The utilization of ODA Funds can be further increased in the long term from the NIMP recommended 17% of total financing to around 20%. The basic merits in financing infrastructure projects through ODA include, among others, (1) longer-term maturity and favorable concessional financing terms, with grant element of at least 25 %, (2) a wider access to knowledge, experience, and technology, and 3) improved overall project implementation due to the absence of contractual disputes. This is very much suited for large infrastructure projects that will require long-term financing, especially if these have long gestation period. ODA accessed by Government has favorable financing terms that match the needs of such infrastructure projects much better than commercial sources of finance. However, for NIA and OGA involved in irrigation to take full advantage of this, weak agency-level capacity must be addressed. Line agencies must make efforts towards increasing and diversifying its manpower, in order to enhance its absorptive capacity to handle infrastructure projects, especially big-ticket ones.

Also, ODA financing is not without risks and disadvantages. In considering ODA as an infrastructure financing option, appraisals must be constantly conducted to determine whether such an option is the best fit for a particular the project, while taking into full consideration both the advantages and disadvantages of this financing option.

On Projections and Target Setting and Interventions

The static, linear model used in the consumption, production, and subsequently physical area projections in the NIMP abstracts from a lot of factors that affect supply and demand of rice and demand for irrigation services and can be further improved. Developing a dynamic equilibrium/multi-market model for the agriculture sector or at the very least an agricultural crops forecasting model and utilizing its results to project and simulate the need for irrigation services for various crops will be the next step forward in enhancing the masterplan. Thus, it is recommended that another project be commissioned specifically for that purpose.

In the meantime, policymakers can augment their information by making full use of the PRISM which can generate start-of-season maps and yield estimates as well as damage assessments from typhoons, flood, and drought which can be used for rapid decision-making on emergency response, planning and implementation of rehabilitation programs.

On the Disaggregation of Project Budgeting

What the NIMP presents in its Non-PIP investment plan is the estimated yearly cost based on the area needed to be generated per province based on the national projected targets. This merely serves as a guide in crafting provincial level masterplans. Hence, the NIMP needs to be cascaded to the regional and provincial levels. It is left to the provincial level personnel to identify the specific projects that can meet the given targets keeping in mind the recommendation of the NIMP that the cost of O&M as well as the cost of the FSDE be already included in the budget.

5.8. Other Important and Urgent Recommendations

Formulation of regional and provincial master plans with the NIMP as a national guideline

While this NIMP provides guidelines, directions, priorities and schemes for irrigation development at the national level, lower level plans such as regional and provincial master plans should be formulated in order to develop more detailed irrigation development plans based on the physical targets set in this NIMP for the various regions and provinces. The need for these lower level plans is indicated in the implementation framework presented in this master plan.

Regional level plans are essentially river basin plans transcending political boundaries and using the river basin as the basic planning unit. Hence, regional irrigation master plans should be formulated based on the river basin approach. This is to ensure integrated and sustainable water resources management and to address competing water use issues within the region. Project level plans will constitute the provincial master plans, which in turn will form part of the regional master plans. The provincial master plans to be formulated should be supportive of and in harmony with the regional master plans, which in turn should be supportive of and in harmony with this NIMP to ensure consistency of irrigation development plans at all levels.

The other principles and guidelines presented in this NIMP should likewise be used in the formulation of regional and provincial master plans. It is stressed that lower level planning objectives should be need-based or demand-driven and the formulation of alternatives should reflect stakeholders' concerns and should be consistent with national planning objectives such as those set by the PDP and other national policies and legislations. It is again stressed here that this NIMP was formulated in accordance with the provisions of PDP, which calls for food security rather than food self-sufficiency. Furthermore, the formulation of regional and provincial master plans should take into account the various considerations such as technical, economic, financial, environmental, social, institutional, and legal and all other contemporary issues such as CC and climate variability in order to ensure the development of more comprehensive, relevant and responsive plans. Furthermore, the principles of VE/VA should be applied during the formulation of regional and provincial master plans, as described separately in this list of other recommendations.

The formulation of regional and provincial master plans should commence immediately upon the approval of this NIMP, either internally or by commissioning an independent team of qualified professionals.

Formulation of new engineering design standards to make irrigation infrastructure more climate and disaster resilient

While details on how to make irrigation infrastructure more climate and disaster resilient are already presented under the section on CCA and Disaster Resiliency in this document, the need to formulate new engineering design standards for irrigation infrastructure is included in this list of recommendations for greater emphasis. As a concrete way to deal with extreme weather conditions due to CC, the design of irrigation infrastructure like dams and spillways, reservoirs, and other water control and erosion control structures should be based on new and more stringent engineering standards.

To facilitate the formulation of new design standards for irrigation infrastructure, the DGCS of DPWH may be considered, modified and improved if necessary or adapted. The DGCS is basically intended to standardize the design for all classes of infrastructure projects undertaken by the DPWH in accordance with some overriding requirements. The DGCS for Water Engineering Projects has complete provisions for all water engineering projects including data requirements, hydrology, hydraulics, modeling, flood control, drainage, and CC. Hence, its use is highly recommendable for the design of irrigation infrastructure. A technical working group or engineering task force should be created to review and modify the guidelines to suit site specific peculiarities or adapt the applicable guidelines and design criteria in the DGCS in order to formulate the new design standards specifically intended for irrigation infrastructure. This new set of design standards should then be used to update the NIA Design Manual.

Creation of Quality Control/Quality Assurance to ensure high levels of standards during the construction of irrigation projects

To ensure high level of standards and quality of work during the construction of irrigation projects, an independent body may have to be created for Quality Control/ Quality Assurance (QC/QA). This body should conduct a thorough assessment and evaluation of the quality of supplies and materials and workmanship and in ensuring that construction is based on approved engineering design during the construction of irrigation projects. This body should prepare substantive reports to the CO as part of M&E during project construction. The same body should also take charge of QA/QC during rehabilitation and restoration of irrigation systems to ensure high quality of civil works. Depending on the nature of the project (size, cost and other practical considerations), the QC/QA may be put up at the national, regional or IMO level.

The need for this QC/QA is included in the recommended implementation framework of this NIMP. It is included in this list for greater emphasis of its importance.

Implementation of Value Engineering/ Value Analysis (VE/VA) in all stages of the irrigation development

The NEDA report on VE/VA Study on Irrigation for Food Water Security (NEDA, 2018) provides various options in irrigation development based on VE/VA. While the VE/VA principles and the recommended options in the said NEDA study were employed in the formulation of this NIMP, it is emphasized that these principles and options should be considered at all stages of the irrigation development and even in the formulation of regional and provincial master plans. The NEDA recommendation in that report on the "change orientation" from a rice self-sufficiency and rice-based cropping systems mindset to a food security and diversified cropping systems mindset, as reflected in the physical targets set in this NIMP and in the provision of support for crop diversification, should be observed at all levels for consistency. The cost-effectiveness principle of VE/VA, which is reflected in the proposed criteria for prioritization of irrigation projects in this NIMP and in the investment program, should likewise be observed and continuously applied to maximize the use of capital for irrigation development. Other recommendations in the NEDA VE/VA report such as the strengthening of institutions, augmentation of NIA organization, strengthening of program/project implementation and the principle of "building participation/interest" and "improvement of services" along with consolidation of RDE, as reflected in the institutional and organizational components of this NIMP, should be considered during the course of implementation of this NIMP.

In the formulation of regional master plans, as recommended above, river basin planning or the "river basin approach" should be used and this is consistent with the recommendations of NEDA in that VE/VA study. The "bundle water" approach, which is essentially intended to optimize the use of water resources should also be observed in regional level or basin level planning. The other NEDA recommendations such as improvement of efficiency and effectiveness should also be adopted during the formulation of lower level plans. Furthermore, for the other NEDA recommendations such as diversification, intensification and resiliency adoption, while already reflected in this NIMP in the sections on Irrigation Support for High Value Crop Production Systems (Section 5.13), Water Use Efficient and Water Saving Technologies (Section 5.11), and Climate Change Adaptation and Disaster Resiliency in Irrigation Development (Section 5.12), respectively, it is emphasized that these should all be observed and sustained during the course of implementation of this NIMP at all levels.

All other details of VE/VA including processes and recommended options that can be employed during the formulation of regional and provincial master plans and in the implementation of this NIMP can be found in the VE/VA report by NEDA.

Strong coordination between DENR and NIA on watershed and aquifer protection and management

With the DENR being responsible for the development of projects and programs of all watersheds in the country regardless of their classification, size, use, and administrative jurisdiction and with water resources supplying irrigation systems emanating from these watersheds, it is imperative that a strong coordination between DENR and NIA be operationalized.

Coordination between DENR and DA, which at certain periods in the past had NIA under its administrative jurisdiction, is already stipulated in Section 27 of AFMA (RA 8435 of 1997) to wit,

> *"The Department shall coordinate with the Department of Environment and Natural Resources concerning the preservation and rehabilitation of watersheds to support the irrigation systems."*

To further strengthen the coordination between DENR and NIA and between DENR and DA through BSWM, a Memorandum of Agreement (MOA) should be formulated based on the principles of IWRM among other considerations to ensure sustainable irrigation water supply from watersheds and aquifers. While a MOA of this sort already exists and was signed between NIA and DENR on August 5, 2019, additional provisions may have to be included to make the coordination even stronger and more comprehensive.

In the current MOA between NIA and DENR, the objective is geared towards effective management and development of the 143 watersheds supporting the NISs in the Philippines. Since the current MOA obviously caters only to these large watersheds supplying water for existing NIS, expansion of coordination efforts should be considered to include other watersheds catering to other existing irrigation systems and all other watersheds that have the potential for supplying irrigation water for future NIPs, CIPs, SIPs, MPs and other irrigation projects that would evolve based on the physical targets set in this NIMP. Furthermore, since the current MOA is only focused on watersheds, additional provisions should be considered to include protection and management of aquifers particularly their recharge areas. These additional provisions can easily be subsumed in the current MOA since watersheds and aquifer systems are hydraulically connected and continuously interact with each other.

To make the operationalization effective, it is important to establish a clear delineation of the respective roles and responsibilities of the DENR and NIA for this joint undertaking. A special task force composed of members from each of the two agencies, may have to be formed. This dedicated task force should ensure the proper implementation of protection and management measures for all applicable watersheds and aquifers, including but not limited to maintenance of adequate land cover within the catchment areas and recharge areas, to ensure sustainability of surface and groundwater resources for irrigation development.

For watersheds and aquifer systems supplying irrigation water for small irrigation projects of DA-BAFE and BSWM, a separate MOA will have to be formulated with DENR. The same principles previously mentioned can be applied in the crafting of this MOA.

While this NIMP has identified Watershed Protection & Development as one of the NIA Core Functions, and at the same time strongly recommended an interagency convergence of critical stakeholders, such as the NIA, DENR, BSWM, NWRB, LGUs, WUAs and IPs to protect and manage irrigation watersheds, this strong coordination between DENR and NIA and other agencies and stakeholders involved is included in this list of other recommendations to highlight its paramount importance.

Support and push for the enactment of the national land use policy act to protect agricultural lands

Irrigation development largely depends not only on available water resources but also on available land resources. In view of the pervasive land conversion of agricultural lands in the country into other uses such as residential, commercial and industrial, there is an urgent need to fast track the enactment of the National Land Use Policy Act to prevent the unwanted areal decrease of prime agricultural lands. Land conversion of existing highly productive agricultural lands and other productive agricultural lands that have the potential for irrigation development such as those identified in this NIMP under the new NIA Geodatabase should be strictly prohibited in order to safeguard food security through irrigation development as espoused in this NIMP. This recommendation is consistent with the pronouncement of the President of the Republic of the Philippines in his State of the Nation Address for two consecutive years to include the National Land Use Policy Act in the legislative agenda.

Upgrading of the minimum requirements for conducting FS to meet the data requirements of the new set of criteria for prioritization of irrigation projects

To ensure the technical feasibility, economic viability, environmental sustainability and social acceptability of any proposed irrigation project and at the same time enable the application of the proposed criteria for prioritization presented in this NIMP, certain minimum requirements should be imposed in the conduct of feasibility studies for irrigation projects. This includes a clear specification of the various technical, economic/financial, institutional and environmental/social data used in the feasibility studies. Technical data include water resources (e.g., dependable flows, water duties, groundwater, etc.) and land resources (e.g., slope, land suitability, etc.). Economic/financial data include development cost, EIRR, etc. Institutional data include ROW issues, willingness of farmers, etc. Environmental data include watershed land cover, watershed management and protection issues, biodiversity and multi-hazard occurrence. Social data include presence of impoverished communities, IP and vulnerable groups, resettlement issues and cultural values. All detailed information and data requirements are presented in the section on criteria for prioritization of irrigation projects and in the Annexes. Feasibility reports should not be considered acceptable in the absence of a summary sheet showing a complete listing of the aforementioned data requirements to facilitate the application of the criteria for prioritization of irrigation projects by the national agencies such as NIA, BSWM and DA-BAFE.

Exploration of PPP for irrigation development particularly for MPs and for diversified cropping systems

While the potential of PPP for irrigation development is already presented under the financial recommendations and also in the section on irrigation support for crop diversification, it is included in this list for greater emphasis, particularly for MPs and for pressurized irrigation under diversified cropping systems.

Exploration of PPP for MPs is consistent with the principles of VE/VA. In the NEDA report on VE/VA Study on Irrigation for Food Water Security, they stated that *"the bundling of water resources projects would not limit development not only to irrigation but also in the development of water supply and hydropower projects be it in the main river or on tributary rivers. This would entice or attract private developers to invest under a PPP scheme or any other modality under a shorter timeline than what is being done at present."*

Past records have already proven the attractiveness of PPP to the private sector. In fact, as evidenced by the earlier BOT experiences for a number of irrigation projects in the country (e.g., Casecnan and San Roque), there is interest from the private sector in entering into PPP in MPs with hydropower. The advantage of PPP is that it can provide the financing for construction of dams and reservoirs for irrigation and hydropower generation. The PPP should, however, be mutually beneficial to both parties.

Moreover, if PPP is to be pursued, NIA needs to clearly define its objectives and what it wants from the partnership. NIA needs to develop and establish the guidelines for PPPs in MPs, learn to assess the likely success of proposed options, and identify logistical and operational problems and uncover potential ones, determine what resources (e.g., funds, materials, and staff) will be required. NIA can set up a committee of experts with members coming from the academe, engineering firms, private sector, and the ranks of prominent civil servants to help carry out the above.

To get the most from PPP projects, NIA should consider hiring transaction advisors to prepare getting into PPPs. The advisor can prepare project documentation, analyze more deeply the proposed PPP projects, provide better advice and guidance to NIA, and assist in engaging the potential private sector partner.

In the case of HVC production systems to be irrigated by pressurized irrigation such as drip and sprinkler irrigation systems with pumps and pumping units, partnership between the private sector with either NIA or DA should be explored to ease up the financial burden on the part of the farmers and the government. A MOA will have to be fleshed out to come up with a mutually acceptable andbeneficial working arrangement. The details of the PPP for irrigation support for HVC production systems can also be fleshed out during the formulation of the regional and provincial irrigation master plans.

Acknowledgement

The support and contribution of the following institutions, agencies, and organizations in the formulation of this NIMP is gratefully acknowledged:

- Biodiversity Management Bureau
- Bureau of Soils and Water Management
- Department of Agriculture
- Department of Budget and Management
- Department of Environment and Natural Resources
- Department of Public Works and Highways
- Department of Science and Technology Advanced Science and Technology Institute
- Department of Science and Technology LiDAR Portal for Archiving and Distribution
- Forest Management Bureau
- International Rice Research Institute and Philippine Rice Information System
- Mines and Geosciences Bureau
- National Commission on Indigenous People
- National Economic and Development Authority
- National Irrigation Administration
- National Irrigation Administration Irrigation Management Offices
- National Irrigation Administration Regional Offices
- National Mapping and Resource Information Authority
- National Water Resource Board
- Philippine Atmospheric Geophysical and Astronomical Services Administration
- Philippine Institute of Volcanology and Seismology
- Philippine Rice Research Institute
- Philippine Statistics Authority
- River Basin Control Office
- University of the Philippines Disaster Risk and Exposure Assessment for Mitigation
- Local Government Agencies of Davao
- Local Government Agencies of Nueva Ecija
- Local Government Agencies of Ilocos Sur
- Local Government Agencies of Bohol

References

Abaño, S. P. (2019). State of Water Resources Planning and Management in the Philippines. Philippine Country Report presented at the Program Development Workshop on Sustainable Water Resource Management for Food Security in Southeast Asia, SEARCA, UP Los Banos. June 26-28, 2019.

Abino, A., Kim. S. Y., Jang, M. N., Lee, Y. J.,and Chung, J. S. (2014). Assessing land use and land cover of the Marikina sub-watershed, Philippines. Forest Science and Technology. 11. 1-11. 10.1080/21580103.2014.957353.

Agisoft LLC. (2018). Agisoft Photoscan User Manual: Professional Edition, Version 1.4 2018, Agisoft LLC.

Allen, R. G., Pereira, L. S., Raes, D. and Smith, M. (1990). Crop evapotranspiration: Guidelines for computing crop water requirements, Irrigation and Drainage Paper. 56, Food and Agriculture Organization, Rome, Italy.

Amarasinghe, U. A. and Sharma, B. R., eds. (2008). Strategic analyses of the National River Linking Project (NRLP) of India, series 2. Proceedings of the Workshop on Analyses of Hydrological, Social and Ecological Issues of the NRLP. Colombo, Sri Lanka: International Water Management Institute. 500 p.

American Public Human Service Association. (2009). APHSA Organizational Effectiveness Handbook. Washington, DC.

Ankum, P. (2001). Flow control in irrigation systems. Lecture notes. UNESCO-IHE, Delft, the Netherlands.

Asian Development Bank. (2005). Climate proofing: A risk-based Approach to adaptation. https://www.adb.org/sites/default/files/publication/28796/climate-proofing.pdf.

Asian Development Bank. (2011). Guidelines for Climate Proofing Investment in the Transport Sector Road Infrastructure Projects.

Asian Development Bank. (2012). Guidelines for climate proofing investment in agriculture, rural development, and food security.

Asian Development Bank. (2015). Guidance Note: Irrigation subsector risk assessment. Retrieved from: https://www.adb.org/sites/default/files/institutional-document/154591 /guidance-note-irrigation-subsector-risk.pdf.

Asian Development Bank. Various years. Various Project Completion Reports. ADB: Mandaluyong City.

Ankum, P. (2001). Flow control in irrigation systems. Lecture notes. UNESCO-IHE, Delft, the Netherlands. 344 pages.

Awofeso, N. (2013). Organizational Capacity Building in Health Systems. Oxon, London.

Bainbridge, D. A. (2001). Buried clay pot irrigation: a little known but very efficient traditional method of irrigation. Agricultural Water Management 48, 79-88.

Baietti, A. (2005). Conceptual Framework and Transaction Model for a Public-Private Partnership In Irrigation in the West Delta, Egypt. Retrieved August 8, 2019, from Public-Private Infrastructure Advisory Facility: https://ppiaf.org/documents/1406/ download.

Baietti, A., and Abdel-Dayem, S. (2008). A demand-driven design for irrigation in Egypt: Minimizing risks for both farmers and private investors. Retrieved August 8, 2019, from Public-Private Infrastructure Advisory Facility: https://ppiaf.org/ documents/3029/download.

Baird, M. and Frankel, R. (2015). Mekong EIA Briefing: Environmental Impact Assessment Comparative Analysis in Lower Mekong Countries. Retrieved from http://www.pactworld.org/sites/default/files/local-updates files/MPE_Mekong_EIA_Briefing_Final.pdf.

Balana, B., Appoh, R., Adimassu, Z., and Lefore, N. (2017). "Profitability and Economic Feasibility Analysis of Small Scale Irrigation Technologies in Zanlerigu and Bihinaayili, Northern Ghana". Technical Report May 2017. Innovation Lab for Small-Scale Irrigation: Ghana. Retrieved from https://www.researchgate.net/publication/ 319043853_Profitability_and_Economic_Feasibility_Analysis_of_Small_Scale_Irrigation_Technologies_in_Zanlerigu_and_Bihinaayili_northern_Ghana_Innovation_Lab_for_Small-Scale_Irrigation_Ghana.

Bantayan, N. C., Combalicer, E. A., Tiburan, C. L., Jr., Barua, L. D., and Dida, J. J. V. (2015). GIS in the Philippines: Principles and applications in forestry and natural resources. Second edition. ISBN 978-971-547-318-7 UPLB.

Barghouti, S., Kane, S., Sorby, K. and Ali, M. (2004). Agricultural Diversification for the Poor: Guidelines for Practitioners. Washington, D.C., USA: The International Bank for Reconstruction and Development.

Batchelor, C. and Schnetzer, J. (2018). Compendium on Climate-Smart Irrigation: Concepts, evidence and options for a climate smart approach to improving the performance of irrigated cropping systems. Global Alliance for Climate-Smart Agriculture, Rome, 2018.

Belloumi, M., and Matoussi, M.S. (2009). "Measuring agricultural productivity growth in MENA countries" Journal of Development and Agricultural Economics,1(4):103-113.

Benabderazik, H. and Inocencio, A. (2013). Public Private Partnership (PPP) Options for Irrigation Investment in the Philippines final Report to World Bank (June), Manila, Philippines.

Berkman International, Inc. (2015). Formulation of Integrated River Basin Management and Development Master Plan for Abra River Basin. River Basin Control Office, Department of Environment and Natural Resources (RBCO-DENR).

Bouman, B. A. M., Tuong, T.P. and Lampayan, R.M. (2007). Water Management in Irrigated Rice: Coping with Water Scarcity. Los Banos (Philippines): International Rice Research Institute. 54 p.

Brouwer, C., Prins, K., Kau, M. and Heibloem, M. (1988). Irrigation Water Management: Irrigation Methods, Training Manual No. 5. Food and Agricultural Organization of the United Nations (FAO), Rome.

Browder, G., Ozment, S., Rehberger, Bescos, I., Gartner, T. and Lange, G. M. (2019). Integrating Green and Gray: Creating Next Generation Infrastructure. Washington, DC: World Bank and World Resources Institute. World Bank and World Resources Institute. Retrieved from: https://openknowledge.worldbank.org/handle/10986/31430 License: CC BY 4.0.

Brown, A.L. and McDonald, G.T. (1995). 'From Environmental Impact Assessment to Environmental Design and Planning', Australian Journal of Environmental Management, 2: 65–77.

Burt, C. M., Styles, S. W. (2004). Conceptualizing irrigation project modernization through benchmarking and Rapid Appraisal Process. Irrigation and Drainage, 53, 145-154.

Cai, X., McKinney, D. C. and Rosegrant, M. W. (2001). Sustainability analysis for irrigation water management: Concepts, methodology, and application to the Aral Sea Region. Discussion Paper No. 86, Environment and Production Technology Division, International Food Policy Research Institute (IFPRI), Washington, D. C., U.S.A.

Carating, R. B., Galanta, R. G., and Bacatio, C. D. (2014). The Soils of the Philippines. World Soils Book Series. doi:10.1007/978-94-017-8682-9.

Center for Environmental Studies and Management. (2014). Integrated River Basin Management and Development Master Plan for Cagayan de Oro River Basin. River Basin Control Office, Department of Environment and Natural Resources (RBCO-DENR).

Challinor A. J., Watson J., Lobell D. B., Howden S.M., Smith D.R., and Chhetri N. (2014). A meta-analysis of crop yield under climate change and adaptation. Nature Climate Change 4:287–291.

Chandegara, V. (1997). Efficacy of Sprinkler irrigation in Chickpea. Gujarat Agricultural University Research Journal. GAU Res J.1998.24(1):1:3. 1-3. Retrieved from https://www.researchgate.net/publication/269629244_Efficacy_of_Sprinkler_irrigation_in_Chickpea.

Clemente, R. S., A. L. Fajardo, VG Ballaran Jr., and JCP Ureta, Julie Carl P. 2019. Evaluation of National Irrigation Systems in the Philippines. Philippine Institute for Development Studies.

Coelli, T.J., Rao, D.S.P., O'Donnell, C.J., Battese, G.E. (2005). An Introduction to Efficiency and Productivity Analysis. Springer Science and Business Media, Inc. New York. USA.

Cogley, J. G. (1979). The Albedo of Water as Function of Latitude. American Meteorological Society. 779 pp.

Concepcion, R. N. (2004). Water Resources (AQUASTAT). Retrieved fromhttp://www.apipnm.org/swlwpnr/reports/y_ta/z_ph/ph.htm#waterr

College of Forestry and Natural Resources, University of the Philippines Los Banos. (2016). Climate-Responsive Integrated Master Plan for Agno River Basin. River Basin Control Office, Department of Environment and Natural Resources (RBCO-DENR).

College of Forestry and Natural Resources, University of the Philippines Los Banos (CFNR-UPLB). (2016). Climate-Responsive Integrated Master Plan for Buayan-Malungon River Basin. River Basin Control Office, Department of Environment and Natural Resources (RBCO-DENR).

College of Forestry and Natural Resources, University of the Philippines Los Banos (CFNR-UPLB). (2016). Climate-Responsive Integrated Master Plan for Cagayan River Basin. River Basin Control Office, Department of Environment and Natural Resources (RBCO-DENR).

College of Forestry and Natural Resources, University of the Philippines Los Banos (CFNR-UPLB). (2016). Climate-Responsive Integrated Master Plan for Mindanao River Basin. River Basin Control Office, Department of Environment and Natural Resources (RBCO-DENR).

Corales, R. G., Juliano, L. M., Capistrano, A. O., Tobias, H. S., Dasalla, N. V., Canete, S. D. and Sebastian, L. S. (2004). Palayamanan: A Rice-Based Farming Systems Model for Small-Scale Farmers. Philippine Journal of Crop Science 29(1): 21-27.

College of Forestry and Natural Resources, University of the Philippines Los Banos (CFNR-UPLB). (2014). Integrated River Basin Management and Development Master Plan for Ranao (Agus) River Basin. River Basin Control Office, Department of Environment and Natural Resources (RBCO-DENR).

College of Forestry and Natural Resources, University of the Philippines Los Banos (CFNR-UPLB). (2014). Integrated River Basin Management and Development Master Plan for Tagoloan River Basin. River Basin Control Office, Department of Environment and Natural Resources (RBCO-DENR).

Concepcion, R. N. (2004, November 24). AQUASTAT. Country Profile of the Philippines. Retrieved August 7, 2019, from http://www.apipnm.org/swlwpnr/reports/y_ta/z_ ph/ph.htm.

Court, J., Wright, C. and Guthrie, A. (1994). Assessment of Cumulative Impacts and Strategic Assessment in Environmental Impact Assessment, Canberra: Commonwealth Environmental Protection Agency.

Cruz, R. V. O., Aliño, P. M., Cabrera O. C., David, C. P. C., David, L. T., Lansigan, F. P., Lasco, R. D., Licuanan, W. R. Y., Lorenzo, F. M., Mamauag, S. S., Peñaflor, E. L., Perez, R. T., Pulhin, J. M., Rollon, R. N., Samson, M. S., Siringan, F. P., Tibig, L. V., Uy, N. M., Villanoy, C. L. (2017). 2017 Philippine Climate Change Assessment: Impacts, Vulnerabilities and Adaptation. The Oscar M. Lopez Center for Climate Change Adaptation and Disaster Risk Management Foundation, Inc. and Climate Change Commission.

CTI Engineering International Co. Ltd., Halcrow, and Woodfields Consultants, Inc. (2008). Master Plan for the Agusan River Basin. Department of Environment and Natural Resources. National Water Resources Board. Asian Development Bank.

Dalumpines, J. S. (2019). Fault markers indicate where quake may hit. Philippine Information Agency. Retrieved from https://pia.gov.ph/news/articles/1023678.

Daugovish, O., Faber, B., J. Mochizuki, M. & Styles, S. (2010). Strawberry Establishment with Drip or Sprinkler Irrigation. https://www.researchgate.net/publication/267278101 _Strawberry_Establishment_wit h_Drip_or_Sprinkler_Irrigation.

David, C. and Inocencio, A. (2012). Irrigation policy and performance indicators in the Philippines. Final report under the Monitoring and Evaluation of Agricultural Policy Indicators Project. Makati City, Philippines: Philippine Institute for Development Studies.

David, C. and Inocencio, A. (2014). Measuring irrigation performance: Lessons from national systems. PIDS Policy Notes 2014-20. Makati City: Philippine Institute for Development Studies.

David, C., Inocencio, A., Briones, R together with G. Tabios, T. Moya, M. delos Reyes, M. Duka, A. dela Cruz. (2013). A Rapid Appraisal of the Irrigation Program of the Philippine Government. Final report to the Philippine Institute for Development Studies (November), Makati, Philippines.

David, W. P. (1990). Irrigation development in the Philippines-Present status, issues, problems and policy recommendations. Philippine Journal of Crop Science. 15(1):17-26

David, W. P. (2003). Averting the Water Crisis in Agriculture: Policy and Program Framework for Irrigation Development in the Philippines. University of the Philippines Press, Diliman, Quezon City, Philippines.

David, W. P. (2004). Water resources and irrigation policy issues in Asia. Asian Journal of Agriculture and Development 1(1): 83-106.

David, W. P. (2006). Agriculture and Fisheries Modernization Act (AFMA) Review: Irrigation and SAFDZ Components. Report to the Congressional Oversight Committee on Agriculture and Fisheries Modernization (COCAFM). Congress of the Philippines. Manila.

David, W. P. (2008). Irrigation (Chapter 6): In Modernizing Philippine Agriculture and Fisheries: The AFMA Implementation Experience. Dy, R.T., Gonzales, L.A., Bonifacio, M.F., David, W.P., De Vera III, J.P.E., Lantican, F.A., Llanto, G.M., Martinez, L.O., Tan, E.E. University of Asia and the Pacific. Manila, Philippines

David, W. P. (2009). Impact of AFMA on Irrigation and Irrigated Agriculture. The Philippine Agricultural Scientist, 91 (3) 315–328.

Dawe, D.C., Moya, P.F. & Casiwan, C.B. (Eds.). (2006). Why Does the Philippines Import Rice? Philippines: International Rice Research Institute.

Dayrit, H. (2001). The Philippines: Formulation of a National Water Vision. The FAO-ESCAP Pilot Project on National Water Visions - From Vision to Action - A Synthesis of Experiences in Southeast Asia. Final Project Report for submission to the Environment and Natural Resources Development Division of ESCAP and to the FAO Regional Office for Asia and the Pacific. FAO, Bangkok, Thailand. Retrieved from: http://www.fao.org/3/AB776E/ab776e03.htm.

Decena, F.L. (2016). Analysis of the Effects of Various Irrigation Service Fees for National Irrigation Systems in the Philippines. FFTC Agricultural Policy Article. Taipei: Food and Fertilizer Technology Center for the Asian and Pacific Region (FFTC-AP). Retreved from: http://ap.fftc.agnet.org/ap_db.PHP?id=585.

Delos Reyes, M. L. F. (2014). Process, nature, and impacts of irrigation system rehabilitation. (Policy Notes 2014-14). 106 Amorsolo Street, Legaspi Village, 1229 Makati City: Philippine Institute for Development Studies.

Delos Reyes, M. L. F. (2017). Modernisation Strategy for National Irrigation Systems in The Philippines: Balanac and Sta. Maria River Irrigation Systems. PhD dissertation. CRC Press/Balkema. PO Box 11320, 2301 EH Leiden, The Netherlands. www.crcpress.com – Retrieved from: www.taylorandfrancis.com.

Department of Agriculture. (2016). High Value Crops Development Program. Retrieved from http://bpi.da.gov.ph/bpi/index.php/hvcdp.

Department of Budget and Management. (2018). Project Dime: DBM & DOST launch monitoring of gov't projects using digital data, imaging tech. Retrieved from https://www.dbm.gov.ph/index.php/secretary-s-corner/press-releases/list-of-press-releases/709-project-dime-dbm-dost-launch-monitoring-of-gov-t-projects-using-digital-data-imaging-tech.

Department of Environment and Natural Resources. (1999). The Philippines' Initial National Communication on Climate Change. Philippines. p. 8.

Doorenboos, J., Pruitt, W.O., Aboukhaled A., Damagnez, J., Dastane, N.G., Van Den Berg, C., Rijtema, P.E., Ashford, O.M., and Frère, M. (1977). FAO Irrigation and Drainage Paper 24 - Crop Water Requirements. 80 pp.

Dougherty, T. C. and A. W. Hall. (1995). Environmental impact assessment of irrigation and drainage projects. FAO Irrigation and Drainage Paper 53. Food and Agriculture Organization (FAO) of the United Nations, Rome.

Ella, V. B. (2012). Potential applicability of a low-cost drip irrigation system as a water-saving, water use-efficient and cost-effective technology for sustainable upland crop production in the Philippines. Retrieved from http://www.geyseco.es/geystiona/ adjs/comunicaciones/304/P04530001.pdf.

Ella, V. B. (2013). Lecture notes in irrigation and drainage engineering, CEAT, UPLB, College, Laguna.

Ella, V.B. (2014). Lecture notes in advanced water resources planning, CEAT, UPLB, College, Laguna

Ella, V. B. (2016a). Irrigation development in the Philippines, In: Banta, S.J. (Ed). (2016). Water in Agriculture: Status, Challenges and Opportunities. The Asia Rice Foundation, College, Laguna, Philippines. 298 pp. ISBN 978-621-95588-0-8.

Ella, V.B. (2016b). Irrigation and Water Resources, In Barrios,E.B., R.M. Briones, V.B. Ella, A.R. Elepano, E.T. Gonzalez, Y.R. Munsayac, N. C. Oliveros, M.D. Saliendres, C.C. Tabunda, Jr. and S.J. V. Villejo. 2016. A Rapid Assessment of the Agriculture and Fisheries Modernization Act (AFMA), (Phase I Evaluation). Philippine Council for Agriculture and Fisheries (PCAF)-Department of Agriculture & Center for Quality and Competitiveness, Development Academy of the Philippines, pp. 140-170

Ella, V. B. (2018). Conservation Agriculture: A Biological Engineering Approach to Sustainable Agriculture in Support of Rural Development in Southeast Asia. SEARCA Professorial Chair Lecture Monograph. SEARCA, College, Los Baños, Laguna, Philippines, 46pp.

Ella, V. B. (2019). Accelerating and sustaining irrigation development in the Philippines: A key to food security and inclusive economic growth. UPLB Centennial Professorial Chair Lecture, University of the Philippines Los Baños, College, Laguna, 51 pp.

Ella, V. B. (2019). Annual Report for the CHED-PCARI project "Development of wireless sensor network-based water information system for efficient irrigation water management in the Philippines" CHED-PCARI.

Ella, V. B. (2019). Recommendations for climate proofing of agricultural infrastructures. Integration of Climate Change Adaptation (CCA) and Disaster Risk Reduction Management (DRRM) in the Updating of Philippine Agriculture and Fisheries Modernization Plan (AFMP), 2018-23. UNDP-FAO Project "Support to Integrate Agricultural Sector into National Adaptation Plans (NAP-Ag).

Ella, V.B., M.R. Reyes, A. Mercado Jr., A. Ares and R. Padre. (2016). Conservation agriculture increases soil organic carbon and residual water content in upland crop production systems. Eurasian Journal of Soil Science, 5(1):24-29

Ella, V. B., J. Keller, M. R. Reyes and R. Yoder. (2013). A low-cost pressure regulator for improving the water distribution uniformity of a microtube-type drip irrigation system. Applied Engineering in Agriculture, 29(3): 343-349.

Ella, V. B., Reyes, M. R., Yoder, R. (2008). Effect of Hydraulic Head and Slope on Water Distribution Uniformity of a Low-cost Drip Irrigation System. Applied Engineering in Agriculture 25 (3), 349-356.

Ella, V.B. and W.P. David. (2001). Resource allocation model for irrigation development in the Philippines. Paper presented under the Sustained Growth, Poverty and Household Food Security in the Philippines Project funded by UNDP through the FAO, Quezon City

Engineering and Development Corporation of the Philippines. (2014). Integrated River Basin Management and Development Master Plan for Jalaur River Basin. River Basin Control Office, Department of Environment and Natural Resources (RBCO-DENR).

Environmental Management Bureau. (2001-2005). National Water Quality Status Report. Philippines. p. 5.

Environmental Systems Research Institute. (2016). Building Geodatabases. Student Manual.

Environmental Systems Research Institute. (2019). ArcGIS field data types. Retrieved from https://desktop.arcgis.com/en/arcmap/latest/manage-data/geodatabases/arcgis-field-data-types.htm#GUID-70728949-2016-4DB5-A723-5493B4330AE0.

Environmental Systems Research Institute. (n.d.). The Geodatabase: Modeling and Managing Spatial Data. Retrieved from https://www.esri.com/news/arcnews/winter0809articles / the-geodatabase.html.

Espino, R.C., & Atienza, C.S. (2001). Crop Diversification in the Philippines. In Crop Diversification in the Asia-Pacific Region. Paper presented at the Regional Expert Consultation on Crop Diversification in the Asia-Pacific Region, Bangkok, Thailand (pp. 95-111). Rome, Italy: FAO.

Executive Order No. 45. (1993). Adopting the Philippine Reference System of 1992 as the Standard Reference System for Surveys in the Philippines. Congress of the Philippines. Malacaňang, Manila, Philippines.

Facon, T., Renault, D., Rao, P.S. and Wahaj, R. (2008). High-yielding capacity building in irrigation system management: targeting managers and operators. Irrigation and Drainage, 57, 288–299.

Fandika, I. R., Kadyampakeni, D. and Zingore, S. (2011). "Performance of bucket drip irrigation powered by treadle pump on tomato and maize/bean production in Malawi". Irrigation Science. Retrieved from https://www.researchgate.net/publication/ 251201175_Performance_of_bucket_drip_irrigation_by_treadle_pump_on_tomato_and_maize-bean_production_in_Malawi.

Farrel, D. and Goodman, A. (2013). Government by design: Four principles for a better public sector. Retrieved from: https://www.mckinsey.com/industries/public-sector/our-insights/government-by-design-four-principles-for-a-better-public-sector#.

Faustino, A. Z. and Madela, H. L. (2018). Local government units' initiatives on coastal resource management in adjacent municipalities in Camarines Sur, Philippines IOP Conf. Ser.: Earth Environ. Sci. 139 012029. Retrieved from: https://iopscience .iop.org/article/10.1088/1755-1315/139/1/012029/pdf.

Fleischhauer, M. (2009). Road Map to climate proofing for cities. Presented at Conference "Road Map Towards a Flood Resilient UrbanEnvironment". Paris, France, 27 November 2009.

Food and Agriculture Organization of the United Nations. (2000). Land Resources Information Systems in Asia. World Soil Resources Report.

Food and Agriculture Organization of the United Nations. (2007). Modernizing Irrigation Management - the Masscote Approach: Mapping System and Services for Canal Operation Techniques. FAO Irrigation and Drainage Paper #63. Rome.

Food and Agriculture Organization of the United Nations. (2008). Climate change and food security: a framework document. Food and Agriculture Organization of the United Nations, Rome.

Food and Agriculture Organization of the United Nations. (2011). "Philippines". Irrigation in Southern and Eastern Asia in figures – AQUASTAT Survey. Retrieved from http://www.fao.org/docrep/ 016/i2809e/i2809e.pdf.

Food and Agriculture Organization of the United Nations. (2012). Climate change adaptation and mitigation: Challenges and opportunities in the food sector. Natural Resources

Management and Environment Department, Rome, September 2012.

Food and Agriculture Organization of the United Nations. (2015). The impact of natural hazards and disasters on agriculture, food security and nutrition. Retrieved from: http://www.fao.org/3/a-i5128e.pdf.

Food and Agriculture Organization of the United Nations. (2016). AQUASTAT Main Database-FAO. Retrieved from http://www.fao.org/nr/water/aquastat/data/query/ results.html.

Food and Agriculture Organization of the United Nations. (2018). 2017 The impact of disasters and crises on agriculture and food security. Rome. Retrieved from: http://www.fao.org /3/I8656EN/i8656en.pdf.

Food and Agricultural Organization of the United Nations. (2018). Statistical Yearbook of the Food and Agricultural Organization (FAO). Retrieved from http://www.fao.org/faostat / en/#country/171/.

Food and Agriculture Organization of the United Nations. (2019). Environmental and social safeguards. Retrieved from: http://www.fao.org/investment-learning-platform/themes-and-tasks/environmental-social-safeguards/en/.

Food and Nutrition Research Institute-Department of Science and Technology. (2010). Philippine Nutrition Facts and Figures 2008.DOST Complex, FNRI Bldg., Bicutan, Taguig City, Metro Manila, Philippines.

Forest Management Bureau. (2006). Philippine Official Reference of Forest related Terms and Definitions.

Forest Management Bureau. (2017). 2017 Philippine Forestry Statistics.

Forest Management Bureau. (2017). Writeshop on 2015 Philippine forest cover change analysis using the 2015 and 2010 Philippine land cover data. Retrieved from: http://forestry.denr.gov.ph/index.php/writeshop-on-2015-philippine-forest-cover-change-analysis-using-the-2015-and-2010-philippine-land-cover-data.

Frenken, K. (Ed.). (2012). Irrigation in Southern and Eastern Asia in figures - AQUASTAT Survey 2011. Rome, Italy: FAO.

Gadde, B., Menke, C., Siemers, W. and Pipatmanomai, S. (2007). Technologies for energy use of rice straw: a review. International Rice Research Notes, 32.2/2007. International Rice Research Institute. 5-10.

Gilpin, A. (1995). Environmental Impact Assessment: Cutting Edge for the Twenty-First Century, Cambridge: Cambridge University Press.

Glasson, J., Therivel, R. and Andrew, C. (1994). Introduction to Environmental Impact Assessment, London: UCL Press.

Gleick, P.H. (2000). Water: The potential consequences of climate variability and change for the water resources of the United States. National Water Assessment Group. USGS and Pacific Institute for Studies in Development, Environment and Security, Oakland, CA.

Gleick, P. H. (2001). Making every drop count. Scientific American, Feb 2001.

Gutierrez, N. (2013). Disappointed Aquino scolds NIA for poor performance. Rappler. Retrieved from https://www.rappler.com/nation/32200-disappointed-aquino-scolds-nia-for-poor-performance.

Habito, C. F. and Briones, R. M. (2005). Philippine Agriculture Over the Years: Performance, Policies and Pitfalls. Paper presented at the conference, Policies to Strengthen Productivity in the Philippines. Asia-Europe Meeting (ASEM) Trust Fund, Asian Institute of Management Policy Center, Foreign Investment Advisory Service, Philippines Institute of Development Studies and the World Bank on June 27, 2005.

Hawtorne, M. (2019). The Purpose of Mission and Vision Statements in Strategic Planning. Retrieved from https://smallbusiness.chron.com/purpose-mission-vision-statements-strategic-planning-13161.html.

Holmes, O. (2012). A brief history of aerial photogrammetry. Aerometrex. Retrieved from http://aerometrex.com.au/photogrammetry/a-brief-history-of-aerial-photogrammetry/.

Holy, M. (1993). Is Irrigation Sustainable? Canadian Water Resources Journal, 18:4, 443-449, DOI: 10.4296/cwrj1804443.

Horst, L. (1998). The Dilemmas of Water Division: Considerations and Criteria for Irrigation Systems Design. International Water Management Institute. Colombo, Sri Lanka. Retrieved from: publications.iwmi. org/pdf/H023588.pdf.

Houdret, A. (2012). The Water Connection: Irrigation, Water Grabbing and Politics in Southern Morocco. Water Alternatives, 5(2), 284-303.

Houdret, A., and Bonnet, S. (2013). Public Private Partnerships in Irrigation Management: Socioeconomic, Political and Environmental Concerns. ECPR General Conference. Bordeaux.

Inocencio, A. (2016). Water in Agriculture: Key Challenges and Opportunities for the Philippines. In Water in Agriculture: Status, Challenges and Opportunities Proceedings. College, Laguna: Asia Rice Foundation. (November).

Inocencio, A. Chapter 3. (2019). Trends in Agricultural Water Resources." In M. Rosegrant, M. Sombilla, A. Balisacan (eds). The Future of Philippine Agriculture: Scenarios, Policies, and Investments under Climate Change. Institute of Southeast Asian Studies Publishing, Singapore.

Inocencio, A. and Barker, R. (2018). Current Challenges in Water Resource Development and Management. DLSU Business & Economics Review, (Special Issue on Agriculture Water in the Philippines). Vol. 28., No. 1. pp.1-17.

Inocencio, A. and Briones, R. (2019). Irrigation and Agriculture Development, Philippine Institute for Development Studies, Quezon City.

Inocencio, A., David, C. and Briones, R. (2013). A rapid appraisal of the irrigation program of the Philippine Government: Final report submitted to the Philippine Institute for Development Studies. 106 Amorsolo Street, Legaspi Village, 1229 Makati City: Philippine Institute for Development Studies.

Inocencio, A., Ureta, C., Baulita, A. Baulita, A., Clemente, R., Luyun, R., Jr., and Elazegui, D. (2016). Technical and Institutional Evaluation of Selected National and Communal Irrigation Systems and Characterization of Irrigation Sector Governance Structure. Philippine Institute for Development Studies Discussion Paper no. 2016-12. Makati City, PIDS.

Inocencio, A., Yoshinaga, K., Tiongco, M. and Manalang, A. (2018). Exploring the Potential of PPP in Philippine Irrigation. DLSU Business & Economics Review, (Special Issue on Agriculture Water in the Philippines). Vol. 28., No. 1. pp. 18-30.

International Commission on Irrigation and Drainage. (1993). HR Wallingford Ltd. Wallingford, Oxfordshire, UK.

International Commission on Irrigation and Drainage. (2012). Sprinkler and Micro Irrigated Area. Retrieved from https://www.icid.org/icid_data.html

International Finance Corporation. (2010). Public-Private Partnership Impact Stories Morocco: Guerdane Irrigation. Retrieved from https://library.pppknowledgelab.org /documents/2005/download.

Israel, D. C. and Briones, R. M. (2013). Impacts of Natural Disasters on Agriculture, Food Security, and Natural Resources and Environment in the Philippines. ERIA Discussion Paper Series, ERIA-DP-2013-15. 54 pp. Retrieved from: http://www.eria.org/ERIA-DP-2013-15.pdf.

Jalavaa, K., Haakanab, A. and Kuitunen, M. (2015). The rationale for and practice of EIA follow-up: an analysis of Finnish road projects. Impact Assessment and Project Appraisal, 2015, Vol. 33, No. 4, 255–264. Retrieved from http://dx.doi.org/10.1080/14615517.2015.1069997.

Japan International Cooperation Agency (JICA). (2011). Integrated Water Resources Management for Poverty Alleviation and Economic Development in the Pampanga River Basin in the Republic of the Philippines. National Water Resources Board (NWRB).

Keller, J. (2002). Evolution of drip/microirrigation: traditional and non-traditional uses. Paper presented as keynote address at the International Meeting on Advances in Drip/Micro Irrigation, December 2 to 5, 2002, Puerto de la Cruz, Tenerife, Spain.

Keoduangsine, S. and Goodwin, R. (2012). A GPRS-Based Data Collection and Transmission for Flood Warning System: The Case of the Lower Mekong River Basin. International Journal of Innovation, Management and Technology, Vol. 3, No. 3, June 2012.

Kho, J. and Agsaoay-Saño E. (2006). Country study on customary water laws and practices. Food and Agriculture Organization (FAO) of the United States.

Kumar, A., Kumar, P. & Sharma, A.N. (2012). Crop diversification in Eastern India: Status and determinants. Indian Journal of Agricultural Economics, 67, 600 – 616.

Kumar, M. D. (2018). Impacts of microirrigation systems: Perception versus reality. Water Policy Science and Politics. Retrieve from https://www.sciencedirect.com /topics/earth-and-planetary-sciences/drip-irrigation/pdf.

Kumar, M. D., Turral, H., Sharma, B., Amarasinghe, U., and Singh, O.P. (2008). "Water Saving and yield enhancing micro-irrigation technologies in India: When and where can they become best bet technologies?". Retrieved from https://www.researchgate.net/publication/228894953_Water_Saving_and_Yield_Enhancing_Micro_Irrigation_Technologies_in_India_When_and_where_can_they_become_best_bet_technologies.

Laguna Lake Development Authority. (1995). Laguna de Bay Master Plan.

Lampayan, R. M., Bouman, B. A. M., Palis, F. G. and Flor, R. J. (2016a). Developing and disseminating alternate wetting and drying water savingwater-saving technology in the Philippines. In: Regional: Development and Dissemination of Climate Resilient Rice Varieties for Water-short Areas of South Asia and Southeast Asia. Technical Assistance Consultant Report prepared by the International Rice Research Institute and partner organizations in Bangladesh, India, Nepal, Pakistan and the Philippines for Asian Development Bank, pp 329-351.

Lampayan, R. M., Palis F. G. and Bouman, B. A. M. (2016b). Farmer's participatory research and adoption of aerobic rice in the Philippines. In: Regional: Development and Dissemination of Climate Resilient Rice Varieties for Water-short Areas of South Asia and Southeast Asia. Technical Assistance Consultant Report prepared by the International Rice Research Institute and partner organizations in Bangladesh, India, Nepal, Pakistan and the Philippines for Asian Development Bank. pp 308-328.

Lapong, E. & M. Fujihara. (2008). Water Resources in the Philippines: An Overview of its Uses, Management, Problems and Prospects. Journal of Rainwater Catchment Systems. 14. 57-67. 10.7132/jrcsa.KJ00004978343.

Laycock, A. (2007). Irrigation Systems: Design, Planning and Construction. Wallingford, UK: CABI, pp. 320.

Lebdi, F. (2016). Irrigation for agricultural transformation. Join research between African Center for Economic Transformation (ACET) and Japan International Cooperation Agency Research Institute (JICA-RI).

Lee, D., Oh, B., Kim, H., Lee, S., and Chung, G. (2013). Comparison of the hydro-climatological characteristics for the extra-ordinary flood induced by tropical cyclone in the selected river basins. Tropical Cyclone Research and Review, Volume 2, No. 1. Retrieved from: https://reader.elsevier.com/reader/sd/pii/S2225603218300663? token=BF333FD3F3C-1167186448850CD3759B4491F0838CDDB1A076E41C2892DA44CD206CD6720D74B6C-DE262190851CDFEC45.

Library of Congress - Federal Research Division. (2003) Country Profile: Philippines. Retrieved from: https://www.loc.gov/rr/frd/cs/profiles/Philippines-new.pdf.

Lichel Technologies, Incorporated. (2014). Integrated River Basin Management and Development Master Plan. For Ilog-Hilabangan River Basin. River Basin Control Office, Department of Environment.

Linsley, R.K., J.B. Franzini and D.L. Freyberg and G. Tchobanoglous. 1992. Water Resources Engineering. McGraw-Hill, Inc., New York, New York.

Lobell, D. and M. Burke (eds). (2010). Climate Change and Food Security: Adapting Agriculture to a Warmer World. Vol 37, Advances in Global Change Research.

Luyun, R.A., Fajardo, A.L. and Elazegui, D.D. 2018. Managing Groundwater Resources for Sustainable Agriculture. CPAf Policy Brief. ISSN 2362-8499. Issue No. 2018-01.

Malawi Government. (2016). National Irrigation Policy. Retrieved from https://cepa.rmportal.net/Library/government-publications/national-irrigation-policy-2016.

Marotrao, K. M. (2017). Effect of drip irrigation on sugarcane production: A case study. International Journal of Tropical Agriculture. Vol. 35. No. 2. ISSN 0254-8755.

Marouelli, W. A., Lage, D. A., Gravina, S. G., Filho, M. M. and de Souza, R.B. (2013). "Sprinkler and drip irrigation in the organic tomato for single crops and when intercropped with coriander". Artigo Cientifico. Revisita Cienca Agronomica, v. 44, n. 4. p. 825-823.

Masicat, P., de Vera, M. V. and Pingali, P. (1990). National irrigation systems: degradation trends for Luzon from 1966 1989. Paper presented at the 6th Annual Scientific conference of the Federation of Crop Science Societies of the Philippines, Naga City, 16-18 May 1990.

Mccauley, G. N. (1990). "Sprinkler vs. flood irrigation in traditional rice production regions of Southeast Texas. Agronomy Journal - AGRON J. 82. 10.2134/agronj1990.00021962008200040006x. Retrieved from https://www.researchgate.net/publication/250102363_Sprinkler_vs_Flood_Irrigation_in_Traditional_Rice_Production_Regions_of_Southeast_Texas/citation/download

Merz, R. and Bloschl, G. (2005). Flood frfequency regionalization - spatial proximity vs. catchment attributes. J. of Hydrology 302 (2005) pp. 283-306.

Mitchell, J. P. Anil, S., Klonsky, K., Turini., T. A. and Hembree, K. J. (2014). "Overhead and Drip Irrigation System Effects on Tomato Growth and Yield in California's Central Valley. HortTechnology. December 2014. 24(6). Retrieved from https://www.researchgate.net/

publication/270285002_Overhead_and_Drip_Irrigation_System_Effects_on_Tomato_Growth_and_Yield_in_California's_Central_Valley.

Mockus, V. (1960). Selecting a flood frequency method. Trans. ASAE. 3(1):48-54.

Morales, A. C. and Mongcopa, C. J. (2008). Best Practices in Irrigation and Drainage: Learning from Successful Projects. Operations Evaluation Department. Asian Development Bank (ADB).

Moya, T. B. (2014). Analysis of technical assumptions and processes of evaluating feasibility of irrigation projects (Policy Notes No. 2014-11). 106 Amorsolo Street, Legaspi Village, 1229 Makati City: Philippine Institute for Development Studies.

Moya, T. B. (2018). Resilience of Irrigation Systems to Climate Variability and Change: A Review of the Adaptive Capacity of Philippine Irrigation Systems. DLSU Business & Economics Review (2018) 26(1): 1-17.

National Economic and Development Authority. (2018). Terms of Reference for the Consulting Services for the Formulation of the National Irrigation Master Plan.

National Economic and Development Authority. (2018). Value Engineering/Value Analysis (VE/VA) Study on Irrigation for Food Water Security

National Irrigation Administration. (2006). Design Manual for Canals & Canal Structures.

National Irrigation Administration. (2009). Feasibility study and detailed design on the improvement of Malinao Dam.

National Irrigation Administration. (2009). Feasibility study report for Barbar Small Reservoir Irrigation Project.

National Irrigation Administration. (2013). Asbang Small Reservoir Irrigation Project. Feasibility Study Report.

National Irrigation Administration. (2017a). Completion Report of the Project for Improving Operations and Maintenance of National Irrigation Systems in the Philippines. Technical Cooperation Project 3 (TCP3) of National Irrigation Administration (NIA) and Japan International Cooperation Agency (JICA). April 2017.

National Irrigation Administration. (2017b). Irrigation Water Delivery and Distribution Manual. National Irrigation Administration, Quezon City, Philippines.

National Irrigation Administration. (2017). The Project for Improving Operations and Maintenance of National Irrigation Systems.

National Irrigation Administration. (2018). NIA Annual Report.

National Irrigation Administration. (n.d.) Banaoang Project Completion Report. NIA: Quezon City.

National Irrigation Administration. (n.d.). Construction of Irrigation Systems. Retrieved from https://www.nia.gov.ph/?q=content/construction-irrigation-systems.

National Irrigation Administration. (n.d.). Feasibility study report of Upper Tabuating Small Reservoir Irrigation Project.

National Irrigation Administration (NIA) and Japan International Cooperation Agency (JICA). (1992). Irrigation Engineering Manual for Diversified Cropping, Diversified Crops Irrigation Engineering Project

National Mapping and Resource Information Authority. (2010) Land cover data 2015.

National Mapping and Resource Information Authority. (2015) Land cover data 2010.

National Oceanic and Atmospheric Administration National Centers for Environmental Information. (2019). Definition of Drought. Retrieved from: https://www.ncdc.noaa.gov / monitoring-references/dyk/drought-definition.

National Research Council. (2012). Disaster Resilience: A National Imperative. Washington, DC: The National Academies Press. doi: 10.17226/13457.

National Water Resources Board (NWRB) and Japan International Cooperation Agency (JICA). (1998). Master Plan Study on Water Resources Management in the Republic of the Philippines.

Ochs, W. and Plusquellec, H. (2003). Irrigation and Drainage: Development. In: Davis,R. and R. Hirji (eds.). Water Resources and Environment Technical Note E.1.The International Bank for Reconstruction and Development/THE WORLD BANK. 1818 H Street, N.W., Washington, D.C. 20433, U.S.A.

Ochs, W. and Plusquellec, H. (2003a). Water Conservation: Irrigation. In: Davis, R. and R. Hirji (eds.). Water Resources and Environment Technical Note F.2.The International Bank for Reconstruction and Development/The World Bank. 1818 H Street, N.W., Washington, D.C. 20433, U.S.A.

Ochs, W. and Plusquellec, H. (2003b). Water Resources and the Environment: Technical Note E.1. The International Bank for Reconstruction and Development/THE WORLD BANK, Washington, D.C., U.S.A.

Official Gazette. (2019). About the Philippines. National Government Portal. Retrieved from: https://www.gov.ph/about-the-philippines.

Orient Integrated Development Consultants, Incorporated. (2014). Integrated River Basin Management and Development Master Plan for Panay River Basin. River Basin Control Office, Department of Environment and Natural Resources (RBCO-DENR).

Orient Integrated Development Consultants, Incorporated. (2015). Integrated Bicol River Basin Management and Development Master Plan. River Basin Control Office, Department of Environment and Natural Resources (RBCO-DENR).

Orient Integrated Development Consultants, Incorporated. (2015). Davao River Basin Management and Development Plan. River Basin Control Office, Department of Environment and Natural Resources (RBCO-DENR).

Oosterbaan, R. J. (1988). Effectiveness and Social/Environmental Impacts of Irrigation Projects: A Criticial Review. In: ILRI Annual Report 1988, p.18-34, International Institute for Land Reclamation and Improvement, Wageningen, The Netherlands. Retrieved from https://www.waterlog.info/pdf/irreff.pdf.

Ouda, S., Farag, H., Taha, A., and Noreldin, T. (2016). "Assessment of drip irrigation system for maize to reduce food water and energy insecurity in Egypt". Retrieved from https://www.researchgate.net/publication/301765638_ASSESSMENT_OF_DRIP_IRRIGATION_SYSTEM_FOR_MAIZE_TO_REDUCE_FOOD_WATER_AND_ENERGY_INSECURITY_IN_EGYPT.

Pamplona, A., Padolina, T., Caguiat, J. D., Managkil, O. E. and Hernandez, J. E. (2018). Accelerating the development and adoption of next-generation (Next Gen) varieties for major ecosystems in the Philippines (Phase 2). A progress report submitted to the DA-BAR. 2018 (unpublished).

Panwar, M. S. (2015). An economic analysis of drip irrigation system in cotton crop in Khargone district of Madhya Pradesh. Retrieved from https://pdfs.semanticscholar.

org/2446/083d6e4b44555f507420b246358665b77836.pdf.

Parthasarathi, T., Vanitha, K., Mohandass, S., Vered, E., Meenakshi, V. et al. (2016). "Effect of drip irrigation on growth, physiology, yield, and water use of rice. Journal of Agricultural Science. Vol. 9. No. 1. 2017. Canadian Center of Science and Education. Retrieved from http://www.ccsenet.org/journal/index.php/jas/article/download/51142/ 35071.

Pasiona, S. (2016). PhilRice adopts Sorjan cropping system. Retrieved August 6, 2019 from https://www.philrice.gov.ph/philrice-adopts-sorjan-cropping-system/.

Pestleanalysis Contributor. (2015). What is Environmental Analysis. Retrieved from https://pestleanalysis.com/what-is-environmental-analysis/.

Petts, J. (1999). Handbook of Environmental Impact Assessment: Environmental Impact Assessment in Practices: Impacts and Limitations, Oxford: Blackwell Scientific.

Philippine Agricultural Engineering Standards. (2016). Philippine Agricultural Engineering Standards on Groundwater Irrigation – Shallow Tube well (PAES 615:2016). Prepared by Agricultural Machinery Testing and Evaluation Center (AMTEC) under the project entitled "Enhancement of Nutrient and Water Use Efficiency Through Standardization of Engineering Support Systems for Precision Farming" funded by the Philippine Council for Agriculture, Aquaculture and Forestry and Natural Resources Research and Development - Department of Science and Technology (PCAARRD - DOST).

Philippine Atmospheric, Geophysical and Astronomical Services Administration. (2011). Climate Change in the Philippines. Quezon City, Philippines: PAGASA.

Philippine Institute of Volcanology and Seismology. (2019). Landslide preparedness. Retrieved from: https://www.phivolcs.dost.gov.ph/index.php.

Philippine National Standard, Bureau of Agriculture and Fisheries Standards, and Philippine Agricultural Engineering Standard. (2017). Irrigation - Determination of Irrigation Water Requirements.

Philippine Rice Research Institute. (2018). Exploring digital farming to enhance agricultural precision and efficiency. PhilRice Magazine. Jul-Sep 2018. Vol. 31. No. 3.

Philippine Statistics Authority. (2003-2012). Family Income & Expenditure Survey. Retrieved from https://psa.gov.ph/content/2012-fies-statistical-tables.

Philippine Statistics Authority. (2018). Crops Statistics of the Philippines 2013-2017. Quezon City, Philippines: Philippine Statistics Authority.

Philippine Statistics Authority. (2018). Gender-Based Indicators of Labor and Employment in Agriculture.

Philippine Statistics Authority. (2018). Labor Force Surveys (2008-2018). Quezon City, Philippines: Philippine Statistics Authority.

Philippine Statistics Authority. (2018). Selected Statistics in Agriculture. Quezon City, Philippines: Philippine Statistics Authority.

Phocaides, A. (1999). Pressurized irrigation techniques. Food and Agriculture Organization of the United Nations. Retrieved from http://www.fao.org/tempref/agl/AGLW/ ESPIM/CD-ROM/documents/7D_e.pdf.

Pingali, P. (2004). Agricultural diversification in Asia: opportunities and constraints. In Toriyama K., Heong K.L. & Hardy B. (Eds), Rice is life: scientific perspectives for the

21st century. Proceedings of the World Rice Research Conference, Tokyo and Tsukuba, Japan (pp. 420-421). Philippines: International Rice Research Institute and Japan:Japan.

Plusquellec, H. (2002). How Design, Management and Policy Affect the Performance of Irrigation Projects. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand.

Plusquellec, H. (2005). Module 8: Investments in irrigation and drainage. Pages 345-384, In World Bank. (2005). Agriculture Investment Sourcebook. Agriculture and Rural Development. Washington, DC: World Bank. Retrieved from: https://openknowledge.worldbank.org/handle/10986/7308 License: CC BY 3.0 IGO.

Plusquellec, H., Burt, C. and Wolter, H. W. (1994). Modern Water Control in Irrigation: Concepts, Issues, and Applications. World Bank Technical Paper 246. Irrigation and Drainage Series. The World Bank. Washington D.C., USA.

Plusqullec, H. (2002). How design, management and policy affect the performance of irrigation projects: Emerging modernization procedures and design standards. Bangkok: FAO.

Ponce, E. R. & Inocencio, A. B. (2017). Toward a More Resilient and Competitive Philippine Rice Industry: Lesson from the Past Three Decades. International Rice Research Institute (IRRI). Los Banos, Laguna.

Presidential Decree No. 552. (1974). Amending Certain Sections of Republic Act Numbered Thirty-Six Hundred and One, Entitled, “An Act Creating The National Irrigation Administration.” Malacaňang, Manila, Philippines.

Presidential Decree No. 705. (1975). Revised Forestry Code of the Philippines. Malacaňang, Manila, Philippines.

Presidential Decree No. 1067. (1976). A Decree Instituting a Water Code, Thereby Revising and Consolidating the Laws Governing the Ownership, Appropriation, Utilization, Exploitation, Development, Conservation and Protection of Water Resources. Malacaňang, Manila, Philippines.

Presidential Decree No. 1702. (1980). Amending Section 3 of Republic Act No. 3601, as Amended by Presidential Decree No. 552. Malacaňang, Manila, Philippines.

Public-Private Insfrastructure Facility. (2010). PPIAF Supports Private Sector Participation in Egypt’s West Delta Irrigation Project. Retrieved from https://ppiaf.org/documents /3057/download.

Regalado, M. J., Sibayan, E. B., Juliano, L. M., Ramos, P. S., Martin, E., Pascual, K. S., Yadav, S., Cabangon, R. and Lampayan, R. M. (2017). Accelerating the development and dissemination of associated technologies on rice production that are resource-efficient. Project completion report submit to DA-BAR. Jan 2017 (unpublished).

Renault, D. (2001). Re-engineering irrigation management and system operations. Agricultural Water Management, 47, 211–226.

Renault, D., Facon, T. and Wahij, R. (2007). Modernizing irrigation management – the MASCOTTE approach. FAO, Rome, Italy.

Republic Act No. 3601. (1963). An Act Granting the National Irrigation Administration. Article I. Section 2. Malacaňang, Manila, Philippines.

Republic Act No. 7607. (1992). Empowering Smallhold Farmers in their Economic Endeavors. Chapter 6. Section 19. Malacaňang, Manila, Philippines.

Republic Act No. 8435. (1997). An Act Prescribing Urgent Related Measures to Modernize the

Agriculture And Fisheries Sectors of the Country in Order to Enhance Their Profitability, and Prepare Said Sectors for the of the Globalization Through An Adequate, Focused And Rational Delivery Of Necessary Support Services, Appropriating Funds Therefor and for Other Purposes. Chapter 4, Sec. 26-27, 36. 10th Congress. Republic of the Philippines. Malacaňang, Manila, Philippines.

Republic Act No. 10969. (2018). An Act Providing Free Irrigation Service, Amending for the Purpose Republic Act No.3601, As Amended, Appropriating Funds Therefor and for Other Purposes. Republic of the Philippines. Congress of the Philippines. Metro Manila. Philippines.

Republic Act No. 11038. (2017). An Act Declaring Protected Areas and Providing for Their Management, Amending for This Purpose Republic Act No. 7586, Otherwise Known as the "National Integrated Protected Areas System (NIPAS) Act of 1992" and for Other Purposes. 17th Congress. Republic of the Philippines. Congress of the Philippines. Malacaňang, Manila, Philippines.

Republic Act No. 11203. (2018). An Act Liberalizing the Importation, Exportation and Trading of Rice, Lifting for the Purpose the Quantitative Import Restriction on Rice, and for Other Purposes. Section 15. 17th Congress. Republic of the Philippines. Congress of the Philippines. Malacaňang, Manila, Philippines.

Reyes, M. R. (2007). Agroforestry and sustainable vegetable production in southeast asian watersheds, Annual Report, SANREM-CRSP. North Carolina A&T State University.

Roquia, F. H. (2011). Engaging stakesholders in Environmental Impact Assessment. Paper presented at the DENR-EMB Regional EIA Chief Workshop.

Rosenburg, D., McCully, P. and Pringle, C. (2000). Global-Scale Environmental Effects of Hydrological Alterations: Introduction. BioScience. Sep 2000 (9): 746–751. doi:10.1641/0006-3568(2000)050[0746:GSEEOH]2.0.CO;2.

Saaty, T. L. (1980). "The Analytic Hierarchy Process." McGraw-Hill, New York.

Sangakkara, U. R., Pietsch, G., Gollner, R. M., Freyer, B. (2005). Effect of incorporating rice straw or leaves of gliricidia (G. sepium) on the productivity of mungbean (Vigna radiata) and on soil properties. In: Proceedings of ISOFAR Conference, Adelaide, Australia.

Sawaneh, M., I.A. Latif and A.M. Abdullah. (2013). Total factor productivity of rice farming in selected Southeast Asian countries. Proceeding of the International Conference on Social Science Research, ICSSR 2013 (e-ISBN 978-967-11768-1-8). 4-5 June 2013, Penang, Malaysia, organized by WorldConferences.net. Retrieved from http://worldconferences.net/proceedings/icssr2013/toc/165%20%20mamma%20sawaneh%20%20total%20factor%20productivity%20of%20rice%20farming%20in%20selected%20southeast%20asian%20countries.pdf.

Sander, B. O., Wassmann, R., Palao, L. and Nelson, A. (2017). Climate-based suitability assessment for alternate wetting and drying water management in the Philippines: a novel approach for mapping methane mitigation potential in rice production, Carbon Management, 8:4, 331-342, DOI: 10.1080/17583004.2017.1362945.

Schema Konsult, Inc., Eptisa. (2016). Irrigation Development Master Plan 2017-2026. National Irrigation Administration (NIA).

Schwab, G. O., Fangmeier, D. D., Elliot, W. J. and Frevert, R. K. (1993). Soil and Water ConservationEngineering. John Wiley & Sons, Inc., New York.

Stockle, C. O. (n.d.). Environmental impact of irrigation: A review. State of Washington Water

Research Center, Washington State University. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.488.4861&rep=rep1&type=pdf.

The California State Department of Finance. (1998). Strategic Planning Guidelines. California, USA.

The Philippine Star. (2019). NDRRMC releases P18.3 million for cloud seeding ops. Retrieved from:https://www.philstar.com/headlines/2019/03/14/1901446/ndrrmc-releases-p183-million-cloud-seeding-ops#5R9rjPDCUOjM5kio.99.

The Technical Committee. (2012). The Philippines recommends for water-saving technologies for rice and other crops. Los Banos, Laguna: PCAARRD-DOST, 2012. 139p. (Philippines Recommends Series No. 1/2012).

Tolentino, L. L., & Landicho, L. D. (2013). Climate change adaptation strategies of selected smallholder upland farmers in Southeast Asia: Philippines and Indonesia. APN Science Bulletin, (3), 61–64.

Tolentino, P. L. M., Poortinga A., Kanamaru H., Keesstra S., Maroulis J., David C. P. C., et al. (2016). Projected Impact of Climate Change on Hydrological Regimes in the Philippines. PLoS ONE 11(10): e0163941. Retrieved from: https://doi.org/10.1371 /journal.pone.0163941.

Trébuil, G., Ekasingh, B. and Ekasingh, M. (2006). Agricultural Commercialisation, Diversification, and Conservation of Renewable Resources in Northern Thailand Highlands. Moussons, 9-10 | 2006, 131-155. doi: 10.4000/moussons.2005.

Tubiello, F. (2012). Climate change adaptation and mitigation: challenges and opportunities in the food sector. Natural Resources Management and Environment Department, FAO, Rome. Prepared for the High-level conference on world food security: the challenges of climate change and bioenergy, Rome, 3-5 June 2008.

Uitamo, E. (1996). Land Use History of the Philippines. Environmental Science and Technology Library, 141–156. doi:10.1007/978-94-009-1588-6_8.

United Nations Development Programme. (2010). Paving the Way for Climate-Resilient Infrastructure: Guidance for Practitioners and Planners.

United Nations Framework Convention on Climate Change. (2012). Least Developed Countries National Adaptation Plans: Technical guidelines for the national adaptation plan process. Retrieved from: https://unfccc.int/files/adaptation/cancun_adaptation_ framework/national_adaptation_plans/application/pdf/naptechguidelines_eng_low_res.pdf.

United Nations International Strategy for Disaster Reduction. (2009). UNISDR Terminology on Disaster Risk Reduction. Retrieved from: https://www.unisdr.org/files/7817_UNISDR TerminologyEnglish.pdf/.

United Nations International Strategy for Disaster Reduction. (2015a). Global Assessment Report on Disaster Risk Reduction: Making Development Sustainable.

United Nations International Strategy for Disaster Reduction. (2015b). HFA Decade: the Economic and Human Impact of Disasters in the Last 10 Years.

United Nations Office for Disaster Risk Reduction. (2017). Build Back Better in recovery, rehabilitation, and reconstruction. Geneva: UNISDR. https://www.unisdr.org/files/ 53213_bbb.pdf.

Villano, M. G., and Fajardo, A. L. (2010). "Evaluation of the performance and sustainability of a drip irrigation system in a small-scale corn-based diversified farm in Kay-Anlog, Calamba City [Philippines]". Philippine Agricultural Mechanization Journal. ISSN 0118-8275. Retrieved from http://agris.fao.org/agris-search/search.do?recordID= PH2014000173.

Waller, P., Yitayew, M. (2016). Center Pivot Irrigation Systems. In: Irrigation and Drainage Engineering. Springer, Cham.

Warner, M., Kahan, D., and Lehel, S. (2008). Market-oriented agricultural infrastructure: appraisal of public-private partnerships. Rome: Food and Agriculture Organization.

Water Environment Partnership in Asia. (2018). Outlook on Water Environmental Management in Asia 2018. Institute for Global Environmental Strategies (IGES). Ministry of the Environment, Japan. Retrieved from: http://wepadb.net/3rd/en/ publication/2018_outlook/wepa_outlook_report_2018_en.pdf.

Wood, C. (2003). Environmental Impact Assessment: A Comparative Review, Upper Saddle River, NJ: Prentice Hall.

Woodfields Consultants Incorporated. (2012). Integrated River Basin Management and Development Master Plan for Cagayan River Basin. River Basin Control Office, Department of Environment and Natural Resources (RBCO-DENR).

Woodfields Consultants Incorporated. (2012). Integrated River Basin Management and Development Master Plan for Mindanao River Basin. River Basin Control Office, Department of Environment and Natural Resources (RBCO-DENR).

Woodfields Consultants Incorporated. (2014). Integrated River Basin Management and Development Master Plan for Apayao-Abulug River Basin. River Basin Control Office, Department of Environment and Natural Resources (RBCO-DENR).

Woodfields Consultants Incorporated. (2016). Integrated River Basin Management and Development Master Plan for Tagum-Libuganon River Basin. River Basin Control Office, Department of Environment and Natural Resources (RBCO-DENR).

World Bank. (1987). The Philippines: Irrigation Program Review. No. 3545-PH., World Bank: Washington, D. C.

World Bank. (1996). Irrigation O&M and System Performance in Southeast Asia: An OED Impact Study. Report NO. 15824. Washington, D. C. Retrieved from http://documents.worldbank.org/curated/en/271511468768578259/pdf/multi-page.pdf.

World Bank. (2000). "Measuring growth in total factor productivity", PREM notes Economic Policy No. 42 (September). Washington, D.C.: The World Bank.

World Bank. (2000). "Rural Development and Natural Resource Management: Trends, Strategy Implementation, and Framework Performance Indicator System 20918 Vol. 2", A Joint Report of the Government of the Philippines (May). Washington, D.C.: The World Bank.

World Bank. (2003). Philippine Environment Monitor 2003 - Water Quality. Philippines.

World Bank. (2007). Emerging Public-Private Partnerships in Irrigation Development and Management. Washington: The International Bank for Reconstruction and Development/ The World Bank.

World Bank. (2009). The Philippines: Country Environmental Analysis. Sustainable Development Department, East Asia and Pacific Region, World Bank. Manila, Philippines.

World Bank. (2011). Philippines - Typhoons Ondoy and Pepeng: Post-Disaster Needs Assessment - Main Report.

World Bank. (2012). Note on Cancelled Operation Report (IBRD-74680) on a Loan in the Amount of US$ 145 Million to the Arab Republic of Egypt for a West Delta Water Conservation and Irrigation Rehabiliation Project. Retrieved from http:// documents.worldbank.org/curated/en/659211468237315041/pdf/NCO22210P0879700disclosed0100240140.pdf.

World Bank. (2017). Options for increased private sector participation in resilience investment: Focus on agriculture. Retrieved from: http://documents.worldbank.org/curated/en/969921521805628254/pdf/INVESTING-IN-RESILIENCE-FOCUS-ON-AGRICULTURE.pdf.

World Bank. (2017). PPPs in Irrigation. Retrieved from https://ppp.worldbank.org/public-private-partnership/ppp-sector/water-sanitation/ppps-irrigation#examples.

World Bank. Various years. Various Irrigation Project Completion Reports. World Bank: Manila, Philippines.

World Bank Group and International Finance Corporation. (2012). First in Irrigation PPPs. Retrieved from https://library.pppknowledgelab.org/documents/4728/download.

World Bank East Asia and Pacific Region. (2003). Philippines: Country Water Resources Assistance Strategy. Retrieved from: http://siteresources.worldbank.org /INTRANETENVIRONMENT/1705736112775805 4592/20680779/PhilippinesWaterResourcesAssistanceStrategy.pdf.

World Bank-Operations and Evaluation Department (OED), World Bank. (1996). "Irrigation O&M and System Performance in Southeast Asia: An OED Impact Study." Report No. 1584. World Bank. Washington, D. C.

Wrachien, D. D. and Goli, M B. (2015). Global warming effects on irrigation development and crop production: A World-wide view. Agricultural Sciences, 6, 734-747. Retrieved from: http://www.scirp.org/journal/PaperInformation. aspx?paperID=58496.

Yadav, S. and Regalado, M. J. C. (2017). Water efficient and risk mitigation technologies for enhancing rice production in irrigated and rainfed environment (WateRice). Paper presented at the WateRice Inception Meeting held at IRRI on June 1, 2017. (unpublished).

For more information about the NIMP 2020–2030,
please get in touch with us:

National Irrigation Administration
Email: pais@nia.gov.ph
Phone: (632) 921-3741
Fax: (632) 921-3741
Website: www.nia.gov.ph