DEPARTMENT OF AGRICULTURE
BUREAU OF AGRICULTURAL RESEARCH

Research and Development, and Extension Agenda and Programs

RDEAP 2016-2022

Message

I wish to extend my sincerest appreciation and commendation to the Bureau of Agricultural Research for formulating the Research and Development, and Extension Agenda and Program (RDEAP) for 2016-2022.

The era of globalization and competition in the world market is not an easy task to reckon with. Trading agricultural and fishery products, both locally and internationally, requires a strong determination of producing high-end quality products and services. Philippine agriculture is technically-sound already, what we need is a time-bound and feasible research and development master plan, which the bureau has produced through the RDEAP.

The steps you have undertaken in forging this R&D Medium Term will provide significant accomplishment and create a supply and demand scenario, should one stick and adhere to the principles by which the agenda program was conceptualized and crafted. The researchable areas identified, matched with the corresponding appropriation and implemented by the reputable government and R&D institutions, including the local government and state universities and colleges, are the surest way of accomplishing things at hand.

This office, the DA Policy, Planning, Research and Project Development, has been the staunch partner of BAR in the delivery of R&D related policies and direction. I salute your agency for another worthy endeavor. The RDEAP is an indication of professionalism and commitment to make a difference in the lives of the Filipino farmers and fisherfolk.

On behalf of the Department, I wish BAR all the success as you traverse another avenue of strengthening and improving the sector through R&D.

Mabuhay!

DR. SEGFREDO R. SERRANO
Undersecretary, Policy, Planning,
Research and Project Development

Message

It is with pride and honor to present to you the Research and Development, and Extension Agenda Program (RDEAP) for 2016-2022 – the final output of a series of consultations and collaborations with the various key players in the agriculture and fishery R&D sector.

As the national R&D coordinating agency of the Department of Agriculture (DA), the Bureau of Agricultural Research (BAR) has witnessed how investing in research has significantly contributed in making sure that the sector stays competitive and responsive to the needs and challenges of our time. With our farmers and fisherfolk as the main beneficiaries of technologies generated from our supported initiatives, BAR sees to it that their critical needs are being met, following the Department's major thrusts on food security, poverty alleviation, and agriculture sustainability.

With the updated RDEAP, the bureau, through the support of the members of the National Research and Development System for Agriculture and Fisheries (NaRDSAF) community, crafted agenda which are more holistic and inclusive. We looked into the status of developed and existing R&D technologies of various agri-fishery commodities and assessed the next logical step by strategizing researchable areas with respect to sustainable growth and development perspective. With this, we believe that not only are we setting the path to further utilize these technologies toward optimizing their benefit to our farmers and fisherfolk, but we are able to avoid duplication and stagnation of technologies.

Further, we categorized the researchable areas into the essential stages of value chain for the various commodities and sector to ensure that all aspects are systematically given priority in partnership with the concerned stakeholders.

We now have a material that is improved and more responsive to the sector for the next medium term. We are proud of this output and we know that this would not have been possible if not for the support of everyone who took part during the series of consultations, workshops, and rigorous discussions we have had for the past months. We are honored for your support and your continued dedication in making sure that R&D stays resilient and competitive.

This material is a product of the shared-informed decision-making process of the most brilliant minds in the agri-fishery sector. It is my hope that what is inside in this publication will be utilized by our researchers and scientists toward continually serving our farmers and fishers and the community as a whole.

DR. NICOMEDES P. ELEAZAR, CESO IV
Director

table of contents

list of tables

list of figures

list of acronyms

AO	Administrative Order
AgRIDOC	Agricultural Development Officers of the Community
AMAS	Agribusiness and Marketing Assistance Services
AMTEC	Agricultural Machinery Testing and Evaluation Center
APEC	Asia-Pacific Economic Cooperation
ASEAN	Association of Southeast Asian Nations
ATI	Agricultural Training Institute
AWD	Alternate Wetting and Drying
AWS	Automatic Weather Station
BAAs	Bureau and Attached Agencies
BAI	Bureau of Animal Industry
BAFS	Bureau of Agriculture and Fisheries Standards
BAR	Bureau of Agricultural Research
BAS	Bureau of Agricultural Statistics
BFAR	Bureau of Fisheries and Aquatic Resources
BIOTECH	National Institute of Molecular Biology and Biotechnology
BPI	Bureau of Plant Industry
BSWM	Bureau of Soils and Water Management
CAEV	Caprine Arthritis Encephalitis Virus
CARPer	Comprehensive Agrarian Reform Program Extension with Reforms
CBSUA	Central Bicol State University of Agriculture
CLSU	Central Luzon State University
CLT/CLOA	Certificate of Land Transfer/Certificate of Land Ownership Award
CLUP	Comprehensive Land Use Plan
CMU	Central Mindanao University
CNFIDP	Comprehensive National Fisheries Industry Development Plan
COCAFM	Congressional Oversight Committee on Agricultural and Fisheries Modernization
CPD	Cassava Phytoplasma Disease
CPUE	Catch Per Unit Effort
CSA	Climate Smart Agriculture
CVRC	Cagayan Valley Research Center
CVS	Computer Vision System
CY	Calendar Year/Crop Year
DA	Department of Agriculture
DAR	Department of Agrarian Reform
DENR	Department of Environment and Natural Resources
DILG	Department of Interior and Local Government

DNA	Deoxyribonucleic Acid
DOE	Department of Energy
DOST	Department of Science and Technology
DTI	Department of Trade and Industry
EFB	European Foul Brood
FAO	Food and Agriculture Organization
FBD	Flatbed Dryer
FDA	Food and Drug Administration
FDC	Food Development Center
FFTC	Food and Fertilizer Technology Center
FMA	Farmers Market Authority
FMAs	Fisheries Management Areas
FNRI	Food and Nutrition Research Institute
FOB	Free On Board
FPA	Fertilizer and Pesticide Authority
GAP	Good Agricultural Practices
GCB	Green Coffee Beans
GDP	Gross Domestic Product
GIS	Geographic Information System
GM	Genetically Modified
GMP	Good Manufacturing Practices
GPS	Global Positioning System
GVA	Gross Value Added
HVCDP	High Value Crops Development Program
HYV	High Yielding Variety
IA	Irrigation Association
ICM	Integrated Crop Management
IEC	Information, Education and Communication
IFAD	International Fund for Agriculture Development
IK	Indigenous Knowledge
IMTA	Integrated Multi-Trophic Aquaculture
IP	Indigenous People
IPB	Institute of Plant Breeding
IPM	Integrated Pest Management
IPR	Intellectual Property Rights
IRRI	International Rice Research Institute
ITA	International Trade Administration
ITCAF	Information Technology Center for Agriculture and Fisheries
IUU	Illegal, Unreported and Unregulated
LAD	Land Acquisition and Distribution
LCA	Life Cycle Analysis
LGU	Local Government Unit
LSTD	Location-Specific Technology Development

MAP	Modified Atmosphere Packaging
MDDC	Mill District Development Committees
MMSU	Mariano Marcos State University
MRL	Maximum Residue Limit
MSME	Micro, Small and Medium Enterprises
MSY	Maximum Sustainable Yield
NAMRIA	National Mapping and Resource Information Authority
NAPC	National Anti-Poverty Commission
NaRDSAF	National Research and Development System in Agriculture and Fisheries
NCIP	National Commission on Indigenous People
NCPC	National Crop Protection Center
NCRC	National Coconut Research Center
NDA	National Dairy Authority
NEDA	National Economic and Development Authority
NFA	National Food Authority
NFRDI	National Fisheries Research and Development Institute
NGA	National Government Agencies
NGO	Non-Government Organization
NHA	National Housing Authority
NIA	National Irrigation Administration
NIR	Near-Infrared
NLP	National Livestock Program
NMIS	National Meat Inspection Service
NMRDC	National Mango Research and Development Center
NSCB	National Statistics Coordination Board
NSIC	National Seed Industry Council
NSO	National Statistics Office
NSQCS	National Seed Quality Control Services
OP	Open Pollination
OPV	Open-Pollinated Varieties
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services
PCA	Philippine Coconut Authority
PCAF	Philippine Council for Agriculture and Fisheries
PCC	Philippine Carabao Center
PCIC	Philippine Crop Insurance Corporation
PhilFIDA	Philippine Fiber Industry Development Authority
PhilMaize	Philippine Maize Federation
PhilMech	Philippine Center for Postharvest Development of Mechanization
PhilRice	Philippine Rice Research Institute
PMD	Philippine Mallard Duck
PNAD	Philippine Native Animal Development
PNS	Philippine National Standards
POT	Package of Technology
PPA	Program, Projects and Activities

PRISM	Philippine Rice Information System
PRRI	Philippine Rubber Research Institute
PSA	Philippine Statistics Authority
PSAU	Pampanga State Agricultural University
PRRI	Philippine Rubber Research Institute
QR	Quantitative Restriction
RA	Republic Act
RCM	Rice Crop Manager
RCPC	Regional Crop Protection Center
RDE	Research and Development, and Extension
RDEAP	Research and Development, and Extension Agenda Program
RFO	Regional Field Office
ROC	Republic of China
RPC	Rice Processing Complexes
SARAI	Smarter Approaches for Reinvigorate Agriculture as an Industry
SALT	Sloping Agricultural Land Technology
SCoPSA	Sustainable Corn Production in Sloping Areas
SEAFDEC	Southeast Asian Fisheries Development Center
SEARCA	Southeast Asian Regional Center for Graduate Study and Research in Agriculture
SHB	Small Hive Beetle
SPS	Sanitary/ Phyto-Sanitary
SRA	Sugar Regulatory Administration
SSIP	Small Scale Irrigation Projects
SSIS	Small Scale Irrigation Systems
SSNM	Site Specific Nutrient Management
SUC	State Universities and Colleges
TCA	Tarlac College of Agriculture
TPD	Tapping Panel Dryness
UN	United Nations
UNDP	United Nations Development Program
UPD	University of the Philippines Diliman
UPLB	University of the Philippines Los Baños
USDA-FAS	United States Department of Agriculture Foreign Agricultural Services
USM	University of Southern Mindanao
VAMRI	Vesicular Arbuscular Mycorrhiza Root Inoculant
VCA	Value Chain Analysis
VMS	Vessel Monitoring System
VSU	Visayas State University
WHO	World Health Organization
WTO	World Trade Organization

INTRODUCTION

Global Agriculture Scenarios

The world's population is rapidly growing with 7.2 billion people in 2014 and is projected to reach 9 billion in 2050 (UN, 2015). The increasing population correspondingly leads to an increase in food demand which were provided by the world's agriculture sector with a total food production amounting to US$2,246,912 (in millions) from 2,781 million hectares of harvested land areas. The population growth has increased the global agriculture's total production by almost 40% from 2000 to 2014 (FAO, 2015). Aside from food demand, agriculture also contributes significantly to the global trade and labor force. The food exports for 2014 reached US$945,572 million while food imports accumulated US$966,964 million. On the other hand, in terms of employment, agriculture comprised 30.70% of the world's labor force (FAO, 2015).

Agriculture helps address population growth by improving technologies and production systems but due to continued population growth, it has to produce more in the future. According to the Food and Agriculture Organization (FAO,2013), the agriculture sector needs to generate 60% more food and 100% more in developing regions to meet the demands of the current level of consumption by 2050. Despite the current technologies, FAO reported that the past agriculture performance is no longer a guarantee for the future. Sustainability issues must be addressed as these greatly affect the ecosystem and the people particularly those living in rural areas which are mostly the resource-poor and vulnerable. They consider agriculture as their main source of livelihood and unsustainable agriculture can lead to further poverty and undernourishment (FAO, 2013).

Philippine Agriculture

As an archipelagic country with one-third of its total land area consisting of arable and crop lands, agriculture is considered as one of the important sectors in the Philippines. With a Gross Value Added (GVA) in agriculture of PhP 712 billion in 2014, it contributed 10% to the country's Gross Domestic Product (GDP) (Table 1) (PSA, 2015).

Table 1. Philippine macroeconomic growth indicators, Philippines, 2010-2014 (Value at constant 2000 prices)

ITEM	2010	2011	2012	2013	2014
GNI (million pesos)	6,851,138	7,058,037	7,559,511	8,168,768	8,640,645
Growth Rate (%)	-1.97	3.02	7.11	8.06	5.78
GDP (million pesos)	5,701,539	5,910,201	6,305,229	6,750,079	7,164,017
Growth Rate (%)	7.63	3.66	6.68	7.06	6.13
GVA IN AGRICULTURE EXCLUDING FORESTRY					
(million pesos)	659,989	679,075	695,130	701,325	712,559
Growth Rate (%)					
Agriculture Sector	0.02	2.44	2.82	0.89	1.60
Crops	-1.89	4.97	4.27	0.03	2.38
Livestock	0.64	1.96	1.09	1.77	1.02
Poultry	7.67	4.40	4.60	4.22	0.32
Fishing	-0.50	-4.33	-0.38	0.75	-0.39
Agricultural Activities and Services	3.31	3.02	2.14	0.65	4.51

Source: PSA, 2015

The total gross output in agriculture and for each sub-sector is shown in Table 2. For 2010-2014, the crops sub-sector had the highest contribution to the total gross output followed by livestock and poultry sector, then the fisheries sector. Similarly, for 2014 alone, crops contributed around 51% of the gross output (PhP 788 billion) while livestock and poultry combined, 31% and fisheries, 18% (PSA, 2015).

Table 2. Performance of agriculture by subsector, 2010-2014 (Value at constant 2000 prices)

ITEM (in million pesos)	2010	2011	2012	2013	2014
GROSS OUTPUT IN AGRICULTURE	731,489	747,353	768,836	777,457	788,319
Crops	363,718	380,096	396,342	396,351	406,258
Livestock	120,268	122,679	124,041	126,216	127,495
Poultry	100,965	105,379	110,136	114,859	115,169
Fisheries	146,538	138,389	138,318	140,030	139,397

Source: PSA, 2015

It is observed that there is a decreasing trend in the agriculture employment from 31% in 2010 down to 28% in 2014 (Table 3). Nonetheless, the agriculture labor force of 11.21 million people in 2014 still accounts for 28% of the country's total labor force and 10% of its population (PSA, 2015).

Table 3. Population, labor force and employment, 2010-2014.

ITEM	2010	2011	2012	2013	2014
Population (million persons)	92.34	94.82	96.51	98.20	99.88
Labor Force (millions persons)	38.89	40.00	40.43	41.02	40.05
Employment	36.04	37.19	37.60	38.12	37.31
Agriculture	11.96	12.27	12.09	11.84	11.21
Unemployment	2.86	2.81	2.83	2.90	2.74

Source: PSA, 2015

The value of the total agricultural exports has increased from 2010 to 2014. With a growth rate of 14%, the country's value of agricultural exports amount to US$ 6,769.65 (FOB in million) in 2014 from US$ 4,101.09 (FOB in million) in 2010. The Philippine's top agricultural exports are: coconut oil, banana, tuna, pineapple, tobacco, desiccated coconut, seaweeds and carrageenan, and copra oil cake and the country's major trading partners are: Australia, Japan, and USA (PSA, 2015).

The DA National Research and Development and Extension Agenda and Program 2016-2022

The Department of Agriculture (DA), the government's lead agency for promoting agricultural and fisheries development in the country provides the necessary policy framework, investment, and support services including implementation of national programs that would actively respond to the specific needs of the sector. Research and Development (R&D) is one of these support services. Agricultural research and technological improvements remain as major drivers for a productive, profitable, and sustainable agri-fishery sector, thereby contributing greatly in addressing incidences of poverty, hunger, and malnutrition in the countryside. DA continuously invests in R&D as it catalyzes innovation and greater productivity towards a progressive rural development.

The Bureau of Agricultural Research (BAR), the central coordinating agency for the DA R&D programs, projects and activities, is committed to enhance, support, consolidate, and orchestrate the National Research and Development System in Agriculture and Fisheries (NaRDSAF). The bureau, in supporting and strengthening the full implementation of a unified agenda setting and program planning, implementation and monitoring of agriculture and fisheries R&D, has updated and formulated the National Research and Development, Extension Agenda and Programs (RDEAP) 2016-2022. A product of highly participative and consultative process with national government agencies, DA-regional research offices, state universities and colleges, private sector, civil society organizations, DA-partner implementing agencies, international agricultural research organizations, and other relevant stakeholders of the sector, this document serves as a valuable reference for prioritizing and allocating resources for agricultural R&D activities for 2016-2022.

The RDEAP 2016-2022 focuses on the following: i) food staples, feed resources, and other alternatives; ii) commercial crops; iii) poultry and livestock; and iv) fisheries and aquaculture. As the main concern among farmers and fishers is not only productivity and household food consumption, but more on better market access and opportunities, the updated RDEAP 2016-2022 has adopted the value chain structure and identified problems, researchable areas, and expected outputs for each level of the chain. This aims to promote market-oriented research designed to help improve the competitiveness of Philippine crops, livestock and poultry, and fisheries by providing solutions to specific problems on competitiveness for each stage in the value chain.

A reference material, not only for BAR, but primarily for its partner implementing agencies, the RDEAP 2016-2022 contains a more comprehensive and inclusive agenda and directives that provide guidance and information on where we are, what we have been doing, where we want to go and what R&D activities must be pursued to guide the path towards a competitive, sustainable, and resilient agriculture and fishery sector.

References

Briones, N.D. (2005). Environmental Sustainability Issues in Philippine Agriculture. Asian Journal of Agriculture and Development, Vol. 2, Nos. 1,2. Retrieved March 30, 2016, from:http://searca.org/ajad/files/070314092228_AJAD_2005_2_1&2_6Briones.pdf.

Department of Agriculture. The Agriculture and Fisheries Modernization Plan 2011-2017. April 2014. DA-OSEC Bldg., Elliptical Road, Diliman, Quezon City, Philippines. pp 236.

Food and Agriculture Organization. Building a common vision for sustainable food and agriculture: Principles and Approaches. Retrieved March 29, 2016, from: http://www.fao.org/3/a-i3940e.pdf.

Food and Agriculture Organization. FAO Statistical Pocketbook 2015: World Food and Agriculture. Retrieved March 30, 2016, from: http://www.fao.org/3/a-i4691e.pdf.

Food and Agriculture Organization. FAO Food and Numbers 2014. Retrieved March 31, 2016, from: www.fao.org/3/a-i4175e.pdf.

Philippine Statistics Authority. Selected Statistics on Agriculture 2015. PSA-CVEA Building, East Avenue, Diliman, Quezon City, Philippines. pp 1-8.

United Nations-Sustainable Development Solutions Network. (2013). Solutions for Sustainable Agriculture and Food Systems: Technical Report for The Post-2015 Development Agenda. Retrieved March 30, 2016, from: http://unsdsn.org/wp-content/uploads/2014/02/130919-TG07-Agriculture-Report-WEB.pdf.

United Nations. World Population Prospects: 2015 Revision. Retrieved March 31, 2016, from: esa.un.org/unpd/wpp/publications/files/key_findings_wpp_2015.pdf. .

World Bank Organization. Philippine Agriculture Modernization. Retrieved April 1, 2016, from: http://siteresources.worldbank.org/INTPHILIPPINES/Resources/DB20-grmodernization-June23.pdf.

Food Staples, Feed Sources, and other Alternatives


RICE

Domestic performance

Over the past 10 years, rice production has increased by 27% from 14.5 million metric tons in 2004 to 18.44 million metric tons in 2013. During this period, production has been increasing at an annual average of 2.78% with the highest growth of 8.08% recorded in 2012 brought by an increase in yield (Fig. 1) and increase in area harvested which were attributed to recovery from damages by a series of typhoons in the previous year leading to 2011. The most significant decrease in production was experienced in 2009 largely due to damages brought by two destructive typhoons in the last quarter of the year that caused heavy rains and flooding in Northern and Central Luzon where some 30% of the country's area planted to rice are located. Production further decreased in 2010 because of the prolonged dry spell that resulted to lower area harvested resulting to lower farm yields (PSA, 2015).

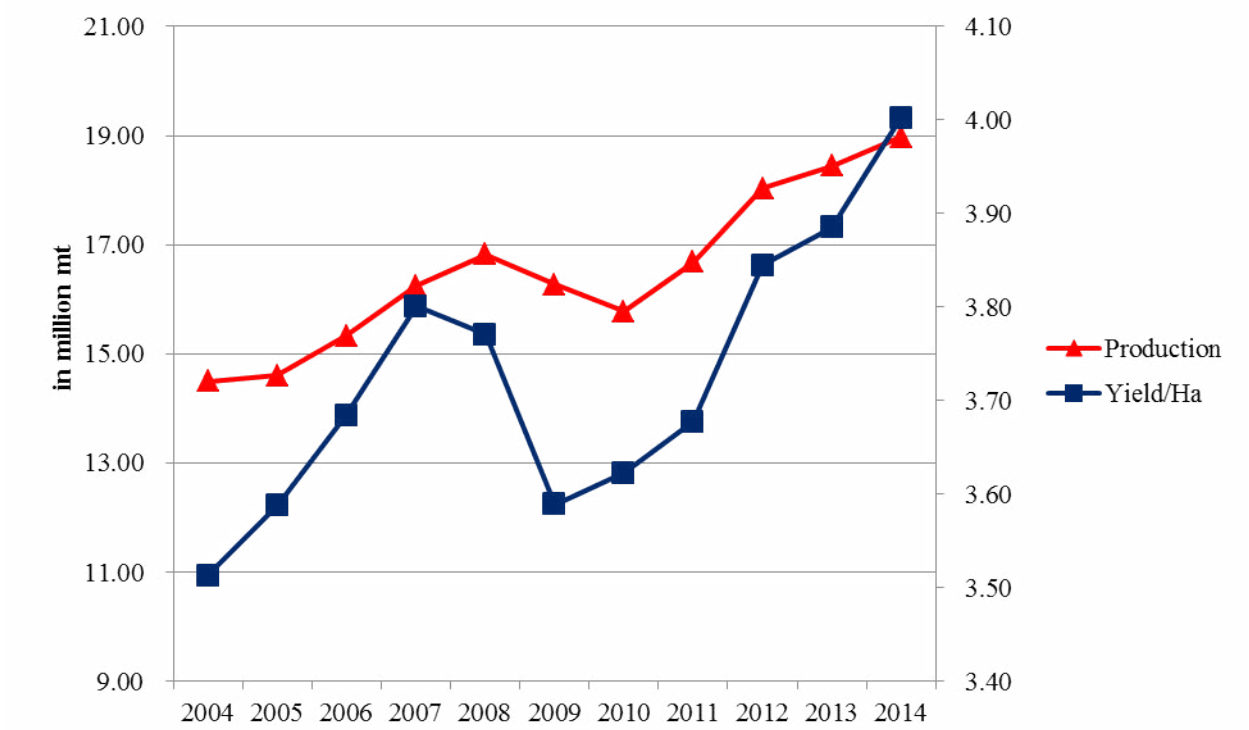


Figure 1. Rice production and yield per hectare, 2005-2014 (Source: PSA, 2015).

Production in rainfed areas has been fluctuating with notable decreases of 5.22% and 9.54% during the drought years of 2005 and 2010, respectively (Fig. 2). On a per season basis, wet season production has been higher than dry season harvest by an average of 33% over the past 10-year period. In the said period, dry season production averaged 43% of the annual harvest while wet season production averaged 57%. Though decline in production was also observed in 2009, over-all production in irrigated and rainfed areas has increased over the last 10 years by 2.88 million metric tons and 1.06 million metric tons or 26% and 30%, respectively.

Economic Importance

Rice is a very important crop in the country with 2,467,164 hectares cultivated and distributed across 2,149,971 rice farmers (NSO, 2003). Among these rice areas, 61.93% were irrigated and 38.07% were rainfed. Average size of farm holdings was 1.32 hectares while the average size of farm devoted to rice was 0.97 hectare. In terms of tenure, 45.94% of rice farms were fully owned, 30.23% were tenanted, and the remaining 23.83% were either leased/rented, under rent-free arrangement, under Certificate of Land Transfer/Certificate of Land Ownership Award (CLT/CLOA), or in other tenurial systems like mortgaged/pawned, co-owned/ owner-like possessions, among others.

Rice farmers in the country are predominantly male (88.64%) with an average of 24 years rice farming experience. Majority of rice farming population is already aging with an average age of 54 years, 29.47% belonging to 51-60 years bracket and only 2.57% aged less than 31 years. About 43.65% of rice farmers owned carabaos while some 2.96% and 0.60%, respectively, have cattle and horse, which they used as work animals. Half of the total rice farmers own a plow, while 22.56% own two-wheel tractors and 1.13%, four-wheel tractors. Less than 10% of rice famers own threshers.

The country's rice areas are classified by type of growing environment, namely irrigated (lowland) and rainfed (lowland and upland). Irrigated (lowland) is defined by the Philippine Statistics Authority (PSA) as the total area within the service area of an irrigation system served in a particular season – wet (first crop) and dry (second crop) seasons including any third crop. On the other hand, rainfed refers to the system that depends solely upon rainfall for its water supply, usually planted through transplanting or direct seeding in fields with dikes that retain water. There may be dikes in the field to hold the water in the case of lowland rainfed, or none in the case of upland rice. By number of cropping, 84.98% of rice farmers plant two times a year, 9.87% plant once, and 5.15% thrice.

In terms of labor, majority still utilize man-animal labor for plowing, rotavating, and field leveling. However, in the case of harrowing, 49.15% used two-wheel tractors, which is higher than the 34.23% who used man-animal labor. For crop establishment, 65.97% of rice farmers adopted transplanting method while 40.27% sow rice seeds by broadcasting method and 0.34% used drum seeders. Overall, the human, animal, and mechanical power input in the farm is estimated by the Philippine Center for Postharvest Development and Mechanization (PhilMech) to be at 2.31hp/ha.

In terms of seed utilization, about 98.05% of the rice farmers used inbred seeds, of which 28% used certified and good seeds while 43% used farmer seeds. Less than 2% of the total number of respondent planted hybrid seeds.

Key stakeholders in the rice industry include farmers, production loan providers (formal lending institutions and informal lenders), fertilizer handlers, farm labor and machine operators, seed growers, harvest and post-harvest equipment operators, millers, and traders (wholesalers and retailers), and support institutions.

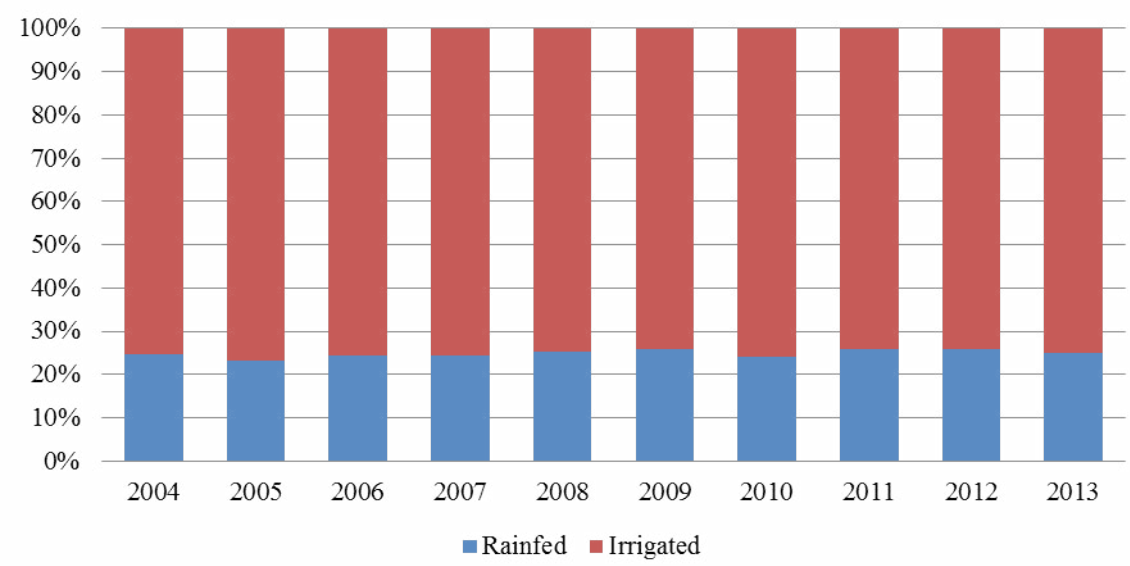


Figure 2. Annual rice production, percentage share by ecosystem, 2004-2013 (Source: PSA-BAS).

In 2013, the total area harvested for rice was 4.65 million hectares, 70 % (3.2 million ha) of which were irrigated and 30% (1.4 million ha) were rainfed. In the last 10 years, the total area harvested increased by 15% and was attributed to expansion of both in irrigated (16%) and rainfed ecosystems (13%) (Fig. 3). Average annual growth is at 1.6%, with harvested irrigated and rainfed rice areas increasing at 1.67% and 1.5%, respectively. Decrease in area harvested was observed during years with prolonged dry spells showing greater decline in rainfed areas by 4.18% in 2005 and 8.85% in 2010.

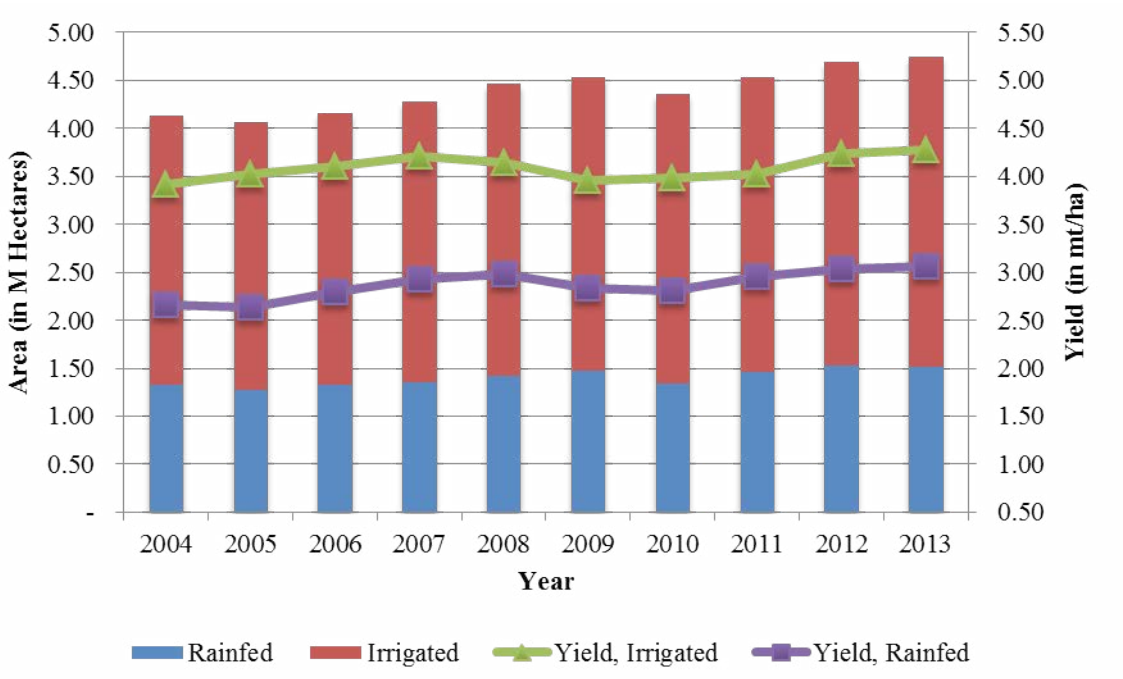


Figure 3. Annual rice area harvested and yield, by ecosystem, 2004-2013 (Source: PSA-BAS).

The average yield per hectare of rice across all ecosystems increased from 3.51 mt/ha in 2004 to 3.89 mt/ha in 2013 (Fig. 3). Irrigated areas contributed to this yield growth by 0.35 mt/ha (9%) and rainfed areas by 0.39 mt/ha (15%) over the last ten years. A drop in average yield was observed in 2008 and 2009, which were attributed by BAS to incidence of pests and diseases, and adverse effects of a series of typhoons. Over the same period, there is no significant different between yields on per season basis.

Despite the reported growth in yield, annual production was still unable to cope with the country's increasing demand brought about by an already large population base compounded by a high annual growth rate. Based on the 2012 BAS food consumption survey, rice per capita consumption is at 114.265 kg/year. In terms of utilization, 87.55% of rice is used as food, while the remaining 12.45% are used for seeds (1.95%), processing (4%), and feeds and wastes (6.5%).

Climate change and weather disturbances, leading to heavy rains, flooding, and drought had adverse effects to the country's rice production. From 2009 to 2011, more than 2.3 million hectares of rice land were affected resulting in 3.4 million metric tons of production loss/damages in these three years (Table 4). These areas damaged and production losses were also the highest recorded in Philippine history.

Table 4. Summary of annual damages to rice, 2001 -2013.

YEAR	TOTAL AREA AFFECTED (HA)	PRODUCTION LOSS	
		VOLUME (MT)	VALUE (PhP) MILLION
2004	365,031.00	650,083.00	1,697.73
2005	131,972.00	226,937.00	645.58
2006	411,578.00	710,251.00	3,398.89
2007	215,198.53	105,623.98	1,881,876.37
2008	379,222.60	258,627.05	5,015,258.88
2009	713,037.33	1,345,658.19	23,574,631.11
2010	661,097.00	936,901.71	15,559,066.74
2011	930,536.05	1,162,572.08	17,842,484.47
2012	227,559.65	170,297.15	3,878,438.12
2013	452,176.40	459,256.71	7,138,924.99

Source: DA-MID

Current and Available Technologies

Research and development activities for rice have generated, developed, and improved the following information and technologies:

Crop management

- Pinoy Rice KnowledgeBank
- Online rice information system (PRISM) that collects, processes, generates, consolidates, archives, and presents accurate, timely and location-specific information on the status of the rice crop
- Decision support tool (Rice Crop Manager) for modern precision farming by providing farmers with personalized crop and nutrient management recommendations matching their location-specific rice-growing conditions
- Minus One Element Technique that determines soil nutrient deficiencies in actual field conditions
- Leaf Color Chart that measures green color intensity of leaf, which is related to the plant's nitrogen content.
- Palaycheck system and integrated crop management options for irrigated, rainfed, upland and abiotic stress-prone environments
- Mechanized dry direct seeding technology for the drought-prone environments
- Reduced tillage technology, alternate wetting and drying (AWD) technique or controlled irrigation, aerobic rice technology, water harvesting systems for small farms
- Palayamanan models, integrated rice based production/farming system
- Information on yield, production and marketing costs, crop management practices, and competitiveness of Philippine rice as compared to selected Asian countries

Pest and disease management

- rice disease and insect pest diagnostic kits for farmers, decision guides for pest management, field guide for weed management
- records on the intensity of injuries caused by emerging pests
- ecological engineering approaches for pest management (bund agriculture)

Varietal improvement

- higher-yielding rice varieties and hybrids with resistance to/tolerance of biotic and abiotic stresses - drought, flood , saline, pest and disease
- genetic identity, grain quality profile and nutritional value of selected traditional rice varieties

Postharvest practices and processing

- combine harvesters for mechanized harvesting
- fully-fluidized bed drying system for high moisture paddy
- Computer Vision System (CVS) designed to analyze the quality of rice
- rice hull gasifier engine-pump system for optimum application in rainfed areas
- rice products and by products (rice wine, rice bran oil, rice based snacks)

Industry and RDE Sector Goals

The Philippine rice industry should create an environment that would foster competitiveness and sustainable growth by:

- Developing resiliency of local rice production to climate adversity and trade liberalization
- Providing decent income for the farming household
- Sustaining industry growth for food security

By the next medium-term, it is assumed that the rice sufficiency targets have been achieved. The immediate next step, therefore, is to ensure that rice supply is sustained to meet the demand of a growing population in the succeeding years.

However, the most pressing challenge that needs to be swiftly and judiciously addressed is the further liberalization of the rice trade market in the country. As part of the commitment to the World Trade Organization (WTO), the quantitative restriction (QR) in rice is scheduled to be lifted by 2017.

Coupled with the ASEAN Economic Integration, which has started in 2015, the lifting of QR will pose as a threat to producers, as it will leave the industry exposed to shocks associated with increased market competition. For one, majority (most particularly the small farmers) will not be able to compete with the importers who can sell to the market at a lower price. Also, the influx of rice imports in the country will drive the market price down, which will in turn discourage farmers to plant for the succeeding seasons. On the other hand, consumers will benefit from lower prices of rice in the market due to further trade liberalization.

Considering the trade environment in the next medium-term, the policy on self-sufficiency cannot be retained. In the event that the quantitative restriction of rice lapses and legal instruments are enforced supporting this, the volume of imported rice that will enter the domestic market cannot be controlled. Thus, a shift to a food security policy is in order to manage the supply of domestically produced and imported rice in the country.

With a changing global environment geared towards a more liberalized trade, coupled with the foreseen risks associated with the changing climate, the industry is geared towards ensuring sustainability and competitiveness: that is, production is set at a level that will generate a profitable income to farmers, particularly the marginalized ones. It shall also be ensured that farmers adopt sustainable farm practices that will enable them to adapt to the changing climate. Hence, strategies will be aimed towards reducing cost of production and increasing farmers' competitiveness, as follows:

Strategy 1: Increase farm productivity

Invest in resilient irrigation, postharvest facilities, and equipment

- Promote high quality and tolerant seed varieties, fertilizers and other integrated crop management practices
- Conduct research and development in new varieties and crop management
- Strengthen local extension services
- Provide enabling mechanisms to farmers

Strategy 2: Diversify farmer income streams

- Promote integrated and diversified farming
- Shift disadvantaged farmers to more productive and competitive commodities

- Exploit the potential of the niche market of specialty rice, domestically and internationally

Strategy 3: Pursue market promotion and enterprise development

- Support the transformation of farmer groups and cooperatives into formal and viable Micro, Small and Medium Enterprises (MSMEs)
- Intensify market-matching efforts
- Strengthen market intelligence capabilities
- Fast-track Good Agriculture Practice (GAP) certification of rice farms
- Strengthen capacities of farmers by providing training
- Increase RD&E on agri-processing and product development

Strategy 4: Increase resiliency to climate change risks

- Ensure seed availability through buffer stocking
- Intensify development and promotion of climate resilient rice varieties
- Promote design and establishment of climate-responsive facilities

References

NSO (National Statistics Office). 2003. Census of Agriculture 2002.

PSA (Philippine Statistics Authority). June 2015. Selected Statistics on Agriculture 2015. www.psa.org.

The Philippine Rice Industry Road Map. 2016

DA National Rice Program. www.da.gov.ph

System	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
Input (seed, soil, water, fertilizer, pesticide)	Changing weather patterns and climatic conditions. Biotic and abiotic stresses (e.g. pests, tungro, black bug, heat, drought, submergence, salinity)	Development of high yielding varieties (hybrids and inbreds) that are short maturing, with good eating quality, resilient to climate change and has potential tolerance to biotic and abiotic stresses	High yielding varieties (hybrids and inbreds) with good eating quality, climate change resilience and potential tolerance to biotic and abiotic stresses (8 tons/ha for inbred and 10 tons/ha for hybrid and beyond yield potential under irrigated condition, 5 tons/ha for rainfed; 90 days maturity)	PhilRice, IRRI, SUCs, and other breeding institutions	2016-2022
		Adaptability of varieties to different agro-ecological systems	Locally adapted varieties identified	DA RFOs, PhilRice, SUCs, LGUs	2016-2022
		Adjustment of location specific cropping calendar	Dynamic cropping calendar for seed production in close coordination with LGUs	DA-RFOs, LGUs, NIA and IAs, PAGASA, BSWM; AWS c/o LGUs	2016-2017

System	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
	Scarcity of labor during peak operations in seed production areas	Development of a mechanization protocol for seed production and post-harvest (both for lowland and upland)	A protocol for mechanized rice seed production and post-harvest that ensures high purity and germination	PhilRice, BPI, PhilMech and Seed Network	2016-2022
	Insufficient seed supply and uneven distribution of seeds in the strategic areas in some provinces and regions No available seeds appropriate for rainfed rice production under adverse conditions (e.g. saline, submerged, drought, zinc deficient etc.)	Enhancement/assessment of policy directions on formal and informal seed systems	Policy recommendations on rice seed systems	BPI, PhilRice, SUCs	2016-2017
		Improvement of (access to) seed delivery system	Policy recommendations on seed system. (regions can address to Philrice the development of the varieties)	BPI-NSQCS, DA RFOs, PhilRice	2016-2022
		Development of information system on availability of seeds (real time)	Responsive system on real time data and information on seed availability	BPI-NSQCS, DA RFOs, PhilRice	2017-2018
	Water scarcity as aggravated by climate change; declining stream flow & increasing siltation rate due to watershed degradation resulting to low cropping intensity	Improvement on the Irrigation Design Systems to withstand and cope with impacts of adverse weather condition	Developed and pilot tested water management protocols and guidelines/designs	NIA, BSWM, DENR, LGUs	2016-2022
		Identification and development of water harvesting technologies to improve water use efficiency	Location-specific recommendations of water saving and harvesting technologies	NIA, BSWM, DA RFOs, DENR, LGUs, PhilRice	2016-2022

System	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
		Adoption and impact evaluation of Alternate Wetting and Drying (AWD) strategy	Recommendations for increasing adoption of AWD technology	NIA, BSWM, LGUs, PhilMech	2016-2022
		Inventory of water resources including watershed assessment	Information and recommendation on water resource management	NIA, BSWM, DENR, LGUs	2016-2022
		Performance and impact evaluation of Small Scale Irrigation Systems (SSIS/SSIPs) for all ecosystems	Performance rating of SSIS and recommendations on improving it relative to investment, location and management systems. Impact valuation of SSIS	BSWM, NIA, DENR, LGUs	2016-2022
	Deterioration of water quality for rice irrigation and other agricultural uses	Assessment of water quality in SSIS for rice irrigation and other agricultural uses	Database on water quality and recommendations/guide lines on water management of SSIS	BSWM, SUCs	2017-2019
	Soil Degradation	Determination of soil health conditions (can cut across commodities)	Philippine soil health atlas (physico-chemical, biological, land use and vegetation, etc.) -Thematic and derived maps (e.g. Fertility, suitability, etc.)	BSWM, PhilRice, SUCs, DA RFOs, LGUs, DENR	2017-2022

System	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
		Improvement of soil conservation and rejuvenation practices	Location specific recommendations on soil health management	BSWM, PhilRice, SUCs, DA RFOs, LGUs	2016-2022
	Low utilization and inadequate supply of biological control agents and biofertilizers	Assessment of utilization of biocontrol agents and biofertilizers	Recommendations on the utilization of biocontrol agents and biofertlizers	PhilRice, SUCs, DA RFOs-RCPCs, LGUs	2016-2017
		Development of high quality biocon, biopesticides and biofertilizers	Available quality biocontrol agents and biofertilizers	PhilRice, SUCs, DA RFOs-RCPCs, LGUs	2016-2017
Production	Changing weather patterns and climatic conditions Decreased productivity due to different biotic and abiotic stresses	Improvement of decision support and diagnostic tools / guides / markers (RCM, PRISM/SARAI) for precision farming	Improved decision support tools	PhilRice, IRRI, SUCs, DA RFOs, LGUs	2016-2017
		Improvement of weather and climate forecasting as part of crop forecasting of DA (modelling and weather data generation)	Cropping calendar given downscale seasonal climate outlook	PhilRice, IRRI, SUCs, DA RFOs, LGUs	2017-2022
		Dynamic location-specific planting calendar based on seasonal climate outlook	Information on optimal planting period for rice in different agro-climatic conditions	PhilRice, IRRI, SUCs, DA RFOs, LGUs	2017-2022

System	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
		Development of localized surveillance, early warning and forecasting systems for pest outbreaks and epidemics	Database, forecasting models, early warning systems, surveillance and protocols for pest and disease forecasting	PhilRice, IRRI, SUCs, DA RFOs, LGUs	2017-2022
		Development of crop management options	Pest and disease management options	DA RFOs, LGUs, PhilRice, BPI, SUCs	2016-2022
	Low income on rice farming and rice farming households	Intensification, diversification and integration of rice-based farming systems and enterprises including agro-ecotourism	Rice-based Farming System Models (e.g. Localized Palayamanan Models, Community based Participatory Action Research) under Irrigated, Rainfed and Upland Ecosystems	ATI, DA-RFOs, PhilRice, PhilMech, SUCs, LGUs	2016-2022
	Low productivity, high cost of production and low resiliency to climate change risks in irrigated lowlands	Development of yield enhancing and cost reducing management practices	Package of technologies that will produce at competitive level (e.g. 10tons per P5/kilos production cost - 10/5 Challenge)	PhilRice, SUCs, DA RFOs, NGOs, Farmers' Associations	2016-2022

System	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
	Low productivity and low resiliency to climate change in the rainfed lowlands	Adaptability trial of high yielding rainfed varieties	Locally adapted varieties identified	PhilRice, DA RFOs, ATI, LGUs,	2016-2022
	Low productivity and low resiliency to climate change risks in the uplands	Optimization of crop management system for water scarce areas (rainfed lowlands and rainfed uplands)	Integrated crop management system for rainfed lowlands and rainfed uplands	LGUs, PhilRice, ATI, DA RFOs	2016-2022
		Development of innovative strategies in seed production and distribution for the upland environment	Design of seed system appropriate for upland areas developed	LGUs, PhilRice, ATI, NCIPs and DA RFOs	2016-2022
	Low productivity and low resiliency to climate change risks in the irrigated highland areas	Improvement of the cultivation techniques/management/production system for irrigated highlands	Integrated crop management system for irrigated highland areas	DA-RFO, SUCs, Private Institutions, NGOs, LGUs, IRRI, PhilRice, PhilMech, NIA	2016-2017
		Evaluation of available machineries for irrigated highlands	Recommendations on the use of machinery in highlands	DA-RFO, SUCs, Private Institutions, NGOs, LGUs, IRRI, PhilRice, PhilMech, NIA	2016-2017
	Sustainability of the system in the irrigated highland areas	Effect of Climate Change to rice cropping and hydrological system in irrigated highlands	Recommendations on irrigation and drainage for sustainable rice farming in irrigated highlands	DA RFOs, SUCs, Private Institutions, NGOs, LGUs, IRRI, PhilRice, NCIP	2016-2022

System	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
		Development of appropriate, technically feasible and socially acceptable production machineries *(across ecosystems)*	Farm production machinery, equipment and gadgets developed	PhilMech, PhilRice, SUCs, IRRI, Private Sector	2017-2022
		Determine optimal level of mechanization relative to rice productivity and competitiveness *(across ecosystems)*	Information on current level of mechanization, inventory of available farm machines Energy audit (Energy requirements), life cycle analysis of farm machinery, carbon footprint	PhilMech, PhilRice, SUCs, IRRI, Private Sector	2017-2022
	Need for future sources of growth	Precision Agriculture (e.g. robotics for precision farming and increased efficiency, GIS-based/enabled machines)	Remote controlled machines for farm operations (e.g. Drones for field surveying and farm operations.)	PhilMech, PhilRice, DOST	2016-2022
		Utilization of biotechnology tools for increasing yield and qualities	Shorter development period of varieties that address various challenges	PhilRice, SUCs, DA RFOs, DOST	2016-2022

System	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
Postharvest/ Processing	High postharvest losses and inefficient postharvest technologies and facilities	Needs assessment for postharvest technologies among stakeholders	Information system on available custom service providers Information on investment requirements and technology needs Inventory of available drying technologies to determine which is suited for a specific area	PhilMech, PhilRice, DA RFOs, Private Sectors, SUCs	2017-2018
		Development of appropriate, technically feasible and socially acceptable postharvest machinery and equipment	New postharvest machinery and equipment (i.e. milling equipment for brown rice)	PhilMech, PhilRice, DA RFOs, Private Sectors, SUCs	2017-2022
		Improvement of the adaptability of postharvest machinery for resiliency to climate change	Innovations on existing postharvest machinery and equipment	PhilMech, PhilRice, DA RFOs, Private Sectors, SUCs	2017-2022
	High drying costs	Development, improvement and promotion of drying technologies and facilities to lower the drying cost	Improved Flatbed Dryer (FBD) design (automated smart-system technology, optimized drying parameters, tested and evaluated reversible FBDs)	PhilMech, PhilRice, SUCs	2016-2022

System	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
	Inconsistent product standards relative to competitiveness of rice quality (physical)	Development of appropriate product standards for locally produced rice	Updated product standard protocol	NFA, PhilMech, PhilRice, BAFS, AMAS	2017-2018
	Limited option for value-adding	Development of value-added products from rice (i.e. traditional/ specialty rice varieties); product and strategies/systems development for specialty rice	Ready to eat products, rice-based products from traditional/specialty rice (i.e. wine, nutraceutical, cosmeceutical products, etc); market-matching efforts, market intelligence capabilities	PhilRice, SUCs, Private Sector, DA RFOs, DOST	2016-2022
		Development of machines for value-adding	Design of huller for Brown Rice/ equipment for the brown rice flavor and nutrient fortification	PhilMech, PhilRice	2016-2022
		Development of appropriate packaging materials that will prolong shelf-life of commodities	Quality packaging materials for storage, i.e. laminated sacks with plastic lining, hermetic cocoon Standard sacks/packaging materials for feeds, palay, and rice	PhilMech, DOST	2016-2022

System	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
Marketing	Low income on rice farming and rice farming households	Analysis of market status and potential of Philippine traditional rice varieties, specialty rice, organic rice and brown rice	Market information on Philippine traditional rice varieties, specialty rice, organic rice and brown rice. Recommendations on linking market players Geomapping of producers/suppliers/production areas Profiling/database of buyers, producers and processors	PhilRice, DA RFOs, DA AMAS, NFA, SUCs	2016-2018
	High Marketing Cost	Feasibility studies of new and assessment of existing alternative marketing systems	Policy recommendation on implementing alternative rice marketing systems including institutional support (i.e. Quedan system, RPCs, buy back system)	SUCs, NFA, PhilRice, PhilMech	2016-2022
	Low utilization and high price of brown rice	Development of promotional strategies for brown rice (including packaging and pricing)	Strategies for brown rice nationwide promotion	PhilMech, PhilRice, DA RFOs	2017-2022

System	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
By-Product Utilization and Waste Management	Utilization of rice by-products in farm based enterprises	Development of enterprises on commercial utilization of rice by-products (i.e. carbonized rice hull, charcoal briquette, as substrate for mushroom production)	Recommended enterprises, business modules	BPI, DA RFOs, SUCs, PhilRice, PhilMech	2017-2019
		Development of machinery for commercial utilization of rice by-products	Machinery for commercial utilization of rice by-products	PhilRice, PhilMech, SUCs	2017-2022
Socio-economic and Policy	Lack of firm basis for priority setting for program interventions for competitiveness	Development of appropriate criteria for prioritizing rice areas relative to enhancing competitiveness Development of criteria for prioritizing interventions to enhance competitiveness of specific rice area	Policy recommendations on priority setting	PhilRice, DA RFOs	2017-2018
	Inadequate/outdated rice statistics	Updating of rice statistics (recurrent or periodic)	Rice database as basis for policy making	PhilRice, IRRI, PSA, SUCs, DA RFOs, LGUs	2017-2022

System	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
	Need for incorporating gender sensitivity in rice industry	Gender sensitivity of developed technologies, farming systems and enterprises	Recommendations on the design of gender sensitive technologies, farming systems and enterprises	SUCs	2017-2022
	High cost of credit/ financing, and low accessibility	Assessment of available credit facilities for farmers	Policy recommendations on improved credit accessibility/ guidelines	ACPC, SUCs, DA RFOs	2017-2018
	Low accessibility to crop insurance	Assessment of available crop insurance for farmers	Policy recommendations on improved crop insurance accessibility/ guidelines	PCIC, SUCs, DA RFOs	2017-2018
	Low adoption and utilization of technologies	Assessment of constraints, social and economic factors affecting technology adoption	Policy recommendations on improving technology adoption	ATI, PhilRice, SUCs, DA RFOs, PhilMech	2017-2022
		Assessment of technology promotion models (e.g. LSTD) and improvement of technology delivery system (e.g. AgRIDOC)	Improved and evaluated technology delivery system, innovative approaches for technology adoption	LGUs, ATI, DA-RFOs, SUCs, PhilRice, IRRI	2016-2022
	Changes in labor market as affected by farm mechanization	Socio-economic evaluation of a mechanized farming system	Policy recommendations on farm mechanization	PhilRice, SUCs, PhilMech	2017-2022

System	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
	Prolonged implementation of land reform	Impact assessment of land reform program relative to rice competitiveness	Policy recommendations on implementation of land reform	SUCs, NEDA	2019-2020
	Land use conversion (from irrigated rice lands to industrial, commercial, residential uses) a. prime agriculture lands b. irrigated lands (law: no conversion)	Assessment of existing land use policy, cost benefit analysis of land conversion	Policy recommendations concerning land conversion; Information on rice areas converted to non-agricultural purposes	DENR, DAR, LGUs and DA BSWM	2016-2017
		Policy study on the integration of Comprehensive Land Use Plan (CLUP) and protected areas	Recommendations for improving national land use plan	DENR, DAR, DILG, NHA and DA	2016-2017
		Development of simulation models for forecasting available irrigated rice lands	Forecast of available irrigated rice lands	DENR, DAR, DILG, NHA and DA	2017-2022


CORN
CASSAVA
ADLAY

Economic Importance

Corn

Corn is the second most important crop in the Philippines. About 14 million Filipinos prefer white corn as their main staple while yellow corn accounts for about 50% of livestock mixed feeds. Some 600,000 farm households depend on corn as a major source of livelihood, in addition to transport services, traders, processors, and agricultural input suppliers who directly benefit from corn production, processing, marketing and distribution. Corn is also processed into high value products, such as cornstarch, corn syrups, corn oil, gluten, and snack foods (DA, 2013).

In 2014, corn production reached 7.77 million metric tons, 5.33% higher than the output in 2013 of 7.38 million metric tons (Fig. 4). Harvest area increased to 2.61 million hectares, 1.86% higher than last year's 2.56 million hectares while yield improved from 2.88 MT per hectare to 2.98 MT per hectare, or by 3.41% (PSA, 2015a). In 2014, corn production was valued at 100.6 billion pesos, an 11.6% increase from the previous year.

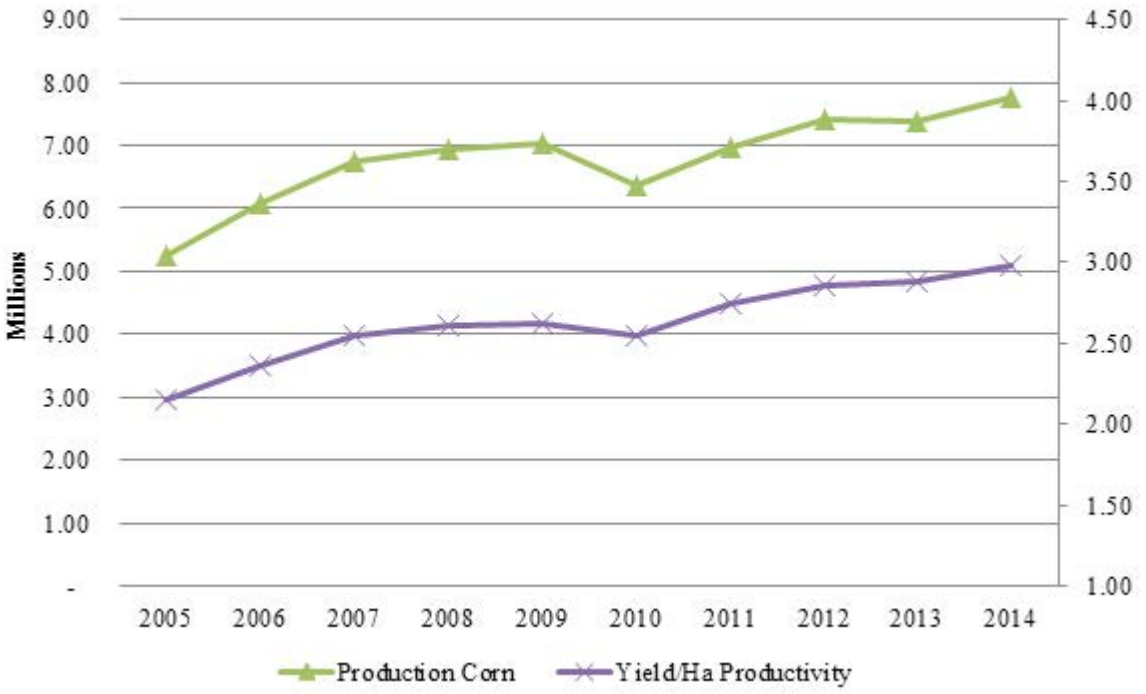


Figure 4. Corn production and yield per hectare, 2005-2014 (Source: PSA, 2015).

Cassava

Cassava is the third most important source of calories in the tropics (after rice and corn) and generally grown by poor farmers often on marginal land (FAO, 2015). In the Philippines, cassava is also regarded as one of the important agricultural crops which can be used as food, ingredients for feeds, and for numerous industrial uses including starch, flour and bioethanol (DA, n.d.). In

the country, at least 218,000 farmers are partially/fully dependent on cassava production and about 15 million Filipinos are consuming cassava as staple and supplemental to rice.
Cassava production in 2014 was recorded at 2.54 million metric tons, 7.57% higher than the 2013 output of 2.36 million metric tons (Fig. 5). Harvest area was lower by 371 hectares or by 0.17% and thus, the yield improved from 10.88 to 11.72 metric ton per hectare from 2013 to 2014. In terms of value, the cassava industry contributed 14.80 billion pesos (1.21%) to the country's gross domestic product in 2014.

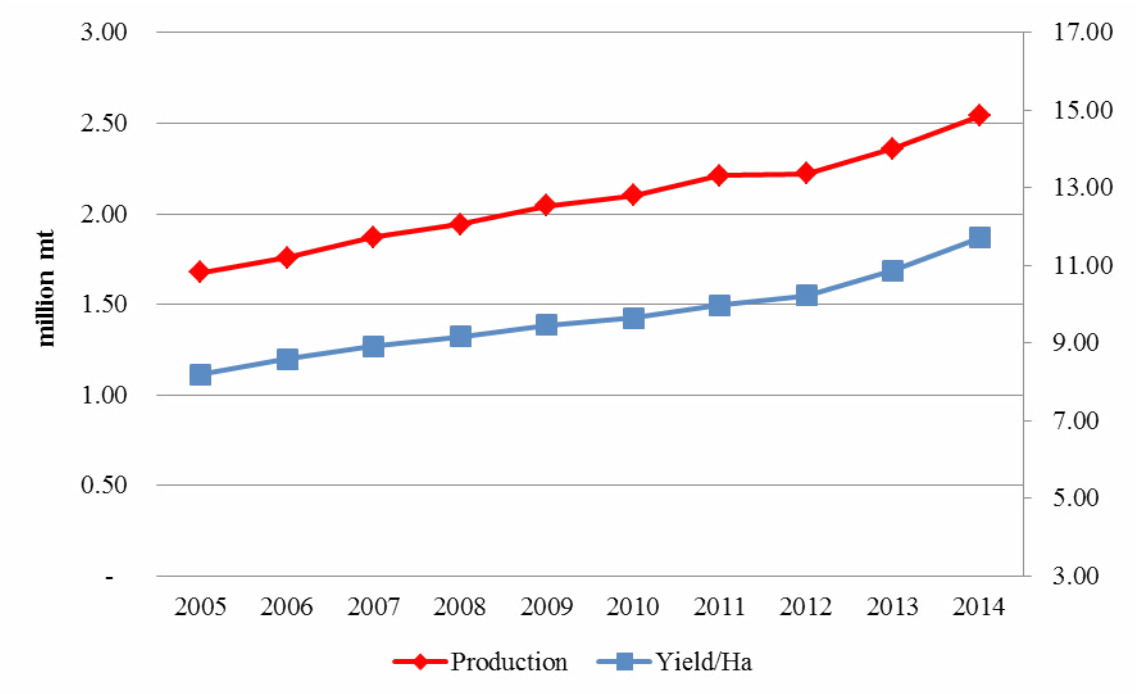


Figure 5. Cassava production and yield per hectare, 2005-2014 (Source: PSA, 2015).

Adlay

The Department of Agriculture (DA) extensively promotes Adlay (Coix lacryma-jobi L.) in line with its goal of attaining food staples sufficiency in the Philippines. This tall grain-bearing tropical plant adapts well in some regions of the country, particularly in high elevation areas such as the hillsides of Nueva Vizcaya and Zamboanga del Sur, and in other parts of Regions II, IVA, V, IX, and X. Among the Subanens in Zamboanga Del Sur and Misamis Occidental, it is considered as one of the staple food crops and is pounded, threshed, winnowed and cooked just like rice.

Adlay is a minor cereal crop throughout the tropics and subtropics, including the Philippines. It can be planted as hedgerows and intercropped with fruit trees/plantation crops (coconut, banana, citrus, mango, coffee, etc.). Initial studies showed that adlay performs best in high elevations but can also thrive in low elevation especially during wet season. It thrives even in adverse conditions, thus farmers, especially in the highlands where rice and corn productions are generally low, have opted to grow adlay. Farmers report that it can tolerate low pH levels, poor soil quality, and waterlogging.

In the country, there is sustained expansion of adlay seed production in all regions, especially Region IX. From June 2014 to May 2015, DA-RFO research stations and farmers' fields in

regions II, IVA, V, IX, X and XI have utilized 31 hectares for adlay seed production. As of May 2015, Region IX alone was able to expand seed production to a total of 183 hectares across ten municipalities in Zamboanga del Sur (39 hectares), four municipalities in Zamboanga del Norte (76 hectares), and four municipalities in Zamboanga Sibugay province (69 hectares). In Region X, expansion areas are located in Bukidnon, Camiguin, Misamis Oriental, Misamis Occidental and Lanao del Norte while those in Region II are located in selected municipalities in Nueva Vizcaya and Cagayan. The rest of the regions are also planning to expand their adlay production areas in 2016.

The adlay industry has a great potential to contribute to the country's growing food demand as an alternative staple food to rice and corn. It has a yield potential of 3.5-5 tons/ha in high elevation and is generally resistant to pests and diseases. Unlike rice and corn, it is not that dependent on the use of inputs such as fertilizer/pesticide and does not require large amount of irrigation water. On the other hand, the industry currently faces issues such as lack of basic information on adlay production and management, low productivity in low elevation areas, limited awareness and promotion on adlay as other staple food crop, shortage of seeds (in both quantity and quality) as planting material, and lack of postharvest, processing and milling facilities.

Current and Available Technologies

Corn

- Use of corn mill for white corn
- Development of Site Specific Nutrient Management (SSNM) Quick Guide on fertilizing dry/wet season hybrid maize
- Development of Nutrient Expert Software for yellow, OPV, hybrid and traditional corn varieties
- National Seed Industry Council (NSIC) registration of drought tolerant varieties
- Developed two new improved white flint corn varieties: CVRC 15-10, CVRC15-12
- Use of Vesicular Arbuscular Mycorrhiza Root Inoculant(VAMRI) as biofertilizer and biopesticide to many soil borne plant diseases of corn with a rate of 70-140g/ha and can be applied by seed coating
- Use of corn cobs as source of K fertilizer

Cassava

- Development of cassava harvester (Phase II – lifter/puller)
- Development of commercial belt dryer for granulated cassava
- Use of streptomycin sulfate (antibiotic) to control witches' broom or Phytoplasma disease

Adlay

The Adlay R&D program, a collaborative partnership between DA-BAR, DA-HVCDP, and other adlay proponents/partners, has been instrumental in initiating the sustained growth of the industry. In the last six years, the following products, technologies, practices and knowledge products were developed/in the process of development:

- Adlay production techno guides such as biocontrol for adlay borer
- Modified rice-thresher for threshing adlay to reduce labor cost in threshing
- Adlay products such as wine, breakfast cereal, energy bar, coffee, gourmix, etc.
- Production protocols and techniques such staggered planting, fertilizer management and proper spacing
- Market information to determine market acceptability and distribution areas

Industry and RDE Sector Goals

The Department of Agriculture's Corn Program is aimed at increasing production of quality staple foods for human consumption, feeds and industrial uses, as well as empowering the farmers and supporting various stakeholders to be cost-efficient, profitable, sustainable and resilient. The over-all strategy is to fast track the expansion of hybrid corn, cassava and other feed crops production to achieve food and feed self-sufficiency, enhance the competitiveness of the domestic livestock and poultry sectors through cheaper feed inputs as well as generate jobs in rural communities. Specifically, this involves:

- Provision of farm mechanization in order to encourage continuous land cultivation for corn and cassava production
- Sustain the seed buffer stock in order to ensure the availability of high quality corn seeds that can be accessed by farmers in times of calamities and unfore seen events affecting corn production
- Establish and distribute more postharvest facilities and equipment in corn and cassava producing areas in order to reduce losses and maintain premium quality produce in accordance with approved standards
- Intensify interventions on empowering corn and cassava farmers and LGU partners through the conduct of various trainings to assure comprehensive extension support relative to Good Agricultural Practices (GAP), utilization of latest technologies that increase productivity and promote cost efficiency, and appropriate mechanization and postharvest technologies
- Strengthen climate change resiliency through the provision of irrigation equipment (open source pumps), conduct of cloud seeding operations, and implementation of the Sustainable Corn Production in Sloping Areas (SCoPSA)
- Organize and strengthen more clusters that will increase bargaining power for farmers and assure market for their produce, thereby creating a sustainable source of income and encourage continuous growth in corn and cassava production
- Ensure that research and development results shall be mainstreamed in order to realize goals on increased productivity and cost efficiency, such as the SSNM, etc.
- Coordinate with lending institutions to provide guarantee to conduits, credit to farmers especially in new areas and insurance in highly vulnerable areas

Aligned with these goals are the subsector targets of the corn, cassava, and adlay industries and specific strategic directions to be able to contribute to this sectoral goal.

Corn

The goal of the corn industry is to increase production of quality yellow corn for animal feeds

and industrial uses, and empower corn farmers to be competitive, cost-efficient, profitable, sustainable and resilient. Specifically, the industry aimed to:

- Increase yellow corn production to 8.62 million metric tons by 2022
- Reduce post-harvest losses to 5% of total produce by 2022
- Sustain sufficiency and produce 35% surplus for export
- Increase farmers' income
- Create jobs across the supply/value chain
- Strengthen climate change resiliency

To achieve this, the industry needs to focus on two major aspects and key strategies:

- Increasing productivity and expanding area for corn production
    - o Encourage diversified farming and sustainable production in sloping area
    - o Ensure adoption of HYV, balance plant nutrition and integrated crop management practices
    - o Sustain farm mechanization support
- Producing high quality grains with minimal post-harvest losses
    - o Accelerate construction of post-harvest facilities
    - o Sustain post-harvest training and quality awards
    - o Unify RD&E and revive the assignment of corn specialist per region
    - o Proactive pest and disease control & management

Cassava

The goal of the industry is to increase cassava production, enhance farmers' income and generate more employment opportunities in the rural areas. Specifically, the industry s aimed to:

- Increase cassava production (fresh roots) from 2.54M mt to 6.338 million metric tons by 2022
- Increase average yield from 11.72mt/ha to 19.26 mt/ha by 2022
- Increase yearly income of farmers per hectare
- Improve quality of cassava primary and other by-products
- Increase cassava per capita consumption to from 2.59 kg to 7.0 kg per year by 2022

Adlay

The goal of the industry is to make adlay as other important staple food crop for Filipinos. In support of this goal, the RDE sector aims to initiate and push forward adlay R&D initiatives contributing to the following outcomes:

- Adlay crop accepted by Filipinos as other important staple food
- Adlay seeds available and accessible in all regions
- Adlay postharvest and processing facilities promoted and commercialized
- Package of technologies developed through sustained investment on adlay R&D activities

References

DA (Department of Agriculture). 2013. Updates on DA Corn Program. Agri-Pinoy Corn Program: Diliman, Quezon City.

DA. n.d. Cassava. Agri-Pinoy Corn Program: Diliman, Quezon City

FAO (Food and Agriculture Organization of the United Nations). 2015. Cassava. Food and Agriculture Organization of the United Nations. Retrieved from http://www.fao.org/ag/agp/agpc/gcds/index_en.html

PSA (Philippine Statistics Authority). 2015a. Retrieved from https://psa.gov.ph/sites/default/files/ricorsit_jan2015.pdf

Sub-system	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
Input	High cost of fertilizers	Development and screening of new and existing varieties efficient to nutrient absorption*	Developed/Identified corn varieties with high efficiency on nutrient utilization	BIOTECH, DA-RFOs, SUCs	2017-2022
		Improvement on nutrient use efficiency (using tracer technique) to different soil fertility levels*	Technologies that would improve nutrient use efficiency (frequency of application, timing of application, level/amount and kind of fertilizer)	BSWM and DA-RFOs	2017-2022
Production	Low productivity	**Precision farming**			
		Performance of different corn hybrids to different planting patterns *	Optimum plant density recommendation	DA-RFOs, PhilMech	2017-2020
		Field validation/promotion of macronutrients (i.e. Ca, Mg, S) and micronutrients (i.e. Bo, Zn) fertilization *	Location specific recommended rate of micronutrient and macronutrient fertilizer application	DA-RFOs, BSWM	2017-2022
		Development of GPS guided/enabled machines/equipment with tracking system microchips **	GPS-guided/ enabled machines/equipment with tracking system microchips	PhilMech, SUCs	2017-2022

Sub-system	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
		Development of site-specific small scale irrigation systems in corn-based areas *	Site-specific small scale irrigation system protocol in corn-based areas Optimum water requirement of different varieties in different soil types	DA-RFOs, BSWM, SUCs	2018-2022
		Soil health (Soil physico-chemical, biological) assessment under varying levels of fertilizer inputs and different varieties*	Soil health map for corn areas	BSWM, SUCs, DA-RFOs,	2017-2022
		Characterization of soil health using the population of macro-organism(ants, termites and earthworms)**	Brochure on characterizing the soil health based on soil macro-organism population(ants, termites, earthworms)	BSWM, SUCs	2017-2019

Sub-system	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
		Adaptation of corn farming to climate change Improvement of farming system/pattern to optimize moisture availability and reduce soil degradation in sloping areas (SALT/SCoPSA)*	Package of technologies on site-specific farming systems and soil and water conservation in different corn-based sloping areas	BSWM, DA-RFOs,	2017-2022
		Development of crop production model (Water availability, temperature, variety, soil type)*	Crop production models (water availability, temperature, variety, soil type)	BSWM, DA-RFOs, SUCs	2017-2022
		Assessment of water and carbon footprint of corn varieties under different management and agroecosystem*	Data on water and Carbon footprint Recommendation on the improvement of water use efficiency	BSWM, DA-RFOs, SUCs	2017-2022
		Development of management strategies for emerging and resurging pest and diseases *	Information on present and emerging pests and diseases Pest management systems/strategies for emerging and resurging pests and	DA-RFOs, SUCs, NCPC	2017-2022

Sub-system	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
			diseases Rapid detection kit for diseases		
		- Assessment on the adoption and utilization of biological control agents (e.g. earwigs, trichogramma)	Information on the status on the adoption/non-adoption of biological control agents	PhilMaize, SUCs	2018-2020
		- Assessment of secondary pest emergence (Hybrid Corn)	Information on potential development of secondary pest	SUCs	2017-2022
		- Identification of bio-indicator species in disturbed corn agroecosystem (Hybrid Corn)	Bio-indicator species for corn agroecosystem	SUCs	2017-2022
		Development of tolerant/resistant varieties against pests and disease(emerging and resurging)*	Tolerant/resistant varieties	BPI, SUCs, DA-RFOs	2017-2022
Postharvest/ Processing	High postharvest losses	Performance evaluation of current postharvest facilities vis-a-vis postharvest losses in the Philippines **	Information and recommendations for better post-harvest facilities, options and policies	SUCs, PhilMech, DA-RFOs,	2017-2020

Sub-system	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
			Updated data on postharvest losses in corn		
	Scarcity of labor during peak harvest	Improvement/development of small scale picker/harvester **	Improved prototype small scale picker/harvester	PhilMech, SUCs, DA-RFOs	2017-2019
	Lack of rapid detection for mycotoxin	Development of rapid detection kit *	Rapid detection kit	PhilMech, SUCs	2017-2019
	Short shelf life of white corn stored for human consumption	Development of different storage and packaging technologies (OPV Corn) **	Protocol for developed appropriate storage and packaging technologies for OPV	DA-RFOs, SUCs, PhilMech	2017-2019
	High drying cost and inefficient drying technologies	Development and improvement of efficient and low cost drying technologies**	Improved low cost drying technologies	DA-RFO's, SUCs, PhilMech	2016-2018
Marketing	Low value of corn grains	Product and market development of corn*	Innovative usage and product lines	SUCs, DA-RFOs	2017-2022
	Lack of data on consumption of corn grits as food staple	Study on consumption of corn grits as food staple*	Updated information on consumption of corn grits as food staple	SUCs, DA-RFOs	2017-2022
	Increased competition pressure with other APEC member countries	Identification of competitive advantage to be developed in order to improve competitiveness *	Identified capabilities/skills to be developed and policy recommendation	(Third party) SUCs, NGOs	2017-2019

Sub-system	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
	Lack of updated regional value chain information on hybrid (GM and conventional) and OPV	Regional value chain analysis of corn *	Updated information on regional value chain of corn	(Third party) SUCs, NGOs	2017-2019
By-product utilization and Waste Management	Poor waste management	Continuous development on the utilization of corn waste **	New technologies on the utilization of corn waste Compendium on the utilization of different corn waste	DA-RFOS, SUCs, PhilMech	2017-2022
Support system	Limited access to credit services	Study on existing credit policies vis-à-vis ASEAN countries*	Recommendation for improvement of credit systems and policies	(Third party) SUCs, NGOs	2017-2022

Legend: * - 1st Priority **- 2nd Priority

Sub-system	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
Input	Insufficient supply of quality planting materials (due to emerging diseases)	Adoptability of rapid propagation techniques of quality planting materials *	Protocol on rapid propagation techniques	DA-RFOs , ATI,	2017-2022
		Development of rapid detection technique for emerging diseases(CPD) on planting materials*	Rapid detection technique for diseases (CPD) on planting materials	SUCs, BPI	2017-2019
		Screening of different pre-planting treatments against diseases *	Improved and effective technologies on pre-planting treatments	SUCs, BPI	2017-2019
Production	Low productivity	Establishment of Cassava Genetic Resources Pool (Collection, Characterization, Rejuvenation, Hybridization) Development of varieties high in yield, starch content and tolerant to environmental stresses	Cassava varieties high in yield , starch content and stress tolerant	SUCS, BPI,	2017-2022

Sub-system	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
	Poor soil and variable growing conditions	Development of package of technology(POT)in different agro-ecosystem *	POT of cassava in specific agro-ecosystem	DA-RFOs, BSWM	2017-2022
		Improvement on the nutrient use efficiency (using tracer technique) to different soil fertility levels *	Technologies that would improve nutrient use efficiency (level/amount and kind of fertilizer, frequency of application, timing of application)	BSWM	2017-2022
		Development of farming systems technology in sloping areas *	Production guide/manual/ protocol on farming systems, and soil and water conservation in sloping areas	SUCs, DA-RFOs, BSWM	2019-2022
	-Emerging insect pest and diseases	Long term monitoring on the population of emerging insect pests and diseases *	Developed database and prediction model for emerging insect pests and diseases	SUCs, BPI, DA-RFOs	2017-2022
		Establishment of IPM in cassava *	Developed IPM in cassava	SUCs, BPI, DA-RFOs	2017-2022
		Development of resistant/tolerant cassava varieties to insect pest and diseases	Developed tolerant/resistant cassava varieties	SUCs	2017-2022

Sub-system	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
	Scarcity of water and extreme weather conditions	Assessment of water and carbon footprint of cassava varieties under different management and agroecosystem*	Data on water and carbon footprint Recommendation on the improvement of water use efficiency	BSWM,DA-RFOs, SUCs	2017-2022
Postharvest/ Processing	High wastage/losses during harvest and postharvest handling and processing	Improvement of the existing cassava dryers(feed grade) ** Improvement and development of equipment and postharvest facilities (food grade) **	Prototype of efficient cassava dryer Developed prototype postharvest equipment and facilities	PhilMech,SUCs PhilMech, SUCs	2018-2020 2018-2020
	Lack of information on the level of cyanide and mycotoxin	Evaluation on the cyanide content residue and mycotoxin of cassava primary products and by-products *	Data on cyanide residue and mycotoxin Recommended protocol on the processing of cassava Established the mycotoxin present in cassava	SUCs, FNRI	2017-2019
	Lack of regional value chain information	Value chain analysis of cassava in all regions (food and other industrial uses) *	Established regional value chain for food and industrial uses	DA-RFOs	2017-2019

Sub-system	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
	Lack of updated data on per capita consumption	Assessment on the per capita consumption of cassava *	Updated information on per capita consumption of cassava	SUCs, BAS	2017-2019
	Lack of information on the shelf life of fresh cassava roots	Study on the shelf life of fresh cassava roots *	Technology on the storage of fresh cassava roots	SUCS, NFRI	2019-2021
	Increase competition pressure with other APEC member countries	Identification of competitive advantage to be developed in order to improve competitiveness *	Identified capabilities/skills to be developed and policy recommendation	SUCs, NGOs	2017-2019
By-product utilization and Waste Management	Limited technologies on the utilization of cassava by-products and wastes	Development of technologies on the utilization of cassava by-products and wastes **	New technologies on the utilization of cassava by-products and wastes	SUCs, DA-RFOs, BSWM	2017-2022
Support Systems	Low adoption of appropriate technology(ies)	Socio-economic study on the adoption of new technologies**	Policies/action plan/recommendations for increase adoption of technologies	SUCs	2020-2022
	Limited access to credit services	Study on existing credit policies vis-à-vis ASEAN countries**	Recommendation for improvement of credit systems and policies	SUCs, NGOs	2017-2022

Legend: * - 1st Priority **- 2nd Priority

Sub-system	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
Input	Inadequate supply of planting materials	Improvement on mass propagation of good seeds*	Ready supply of good seeds of existing varieties in major producing areas Protocol on informal seed system	DA-RFOs, SUCs	2017-2022
	No standard protocol for varietal registration and certification	Development of proper protocol/standard for variety registration and seed certification *	Protocol for variety registration and seed certification	BPI, DA-RFOs	2017-2022
Production	Low productivity	**Improvement of Adlay POT**			
		-Evaluation of cultural practices to reduce unfilled grains (Integrated Crop Management- ICM)*	ICM for adlay production	DA-RFOs	2017-2022
		-Verification trial to improve nitrogen use efficiency using tracer technique*	Fertilizer recommendation	BSWM	2017-2019
		-Varietal improvement for reduced unfilled grains, early maturity and short stature *	Improved varieties	DA-RFOs , SUCs	2017-2022
		-Evaluation on adlay ratooning *	Recommended ratooning technology	DA-RFOs	2017-2019

The Research and Development, and Extension Agenda and Programs for the Adlay Industry

Sub-system	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
		Evaluation of adlay under adverse environmental conditions (drought and saline prone as potential production areas) *	POT for adverse environment	DA-RFOs	2017-2020
		-Development of Integrated Pest Management *	POT on IPM	DA-RFOs	2017-2022
		Development of GAP for organic certification *	Protocol on GAP	DA-RFOs	2017-2022
Postharvest/ Processing	Low milling recovery	Improvement of milling performance of existing machine **	Improved adlay milling machine	PhilMech, DA-RFOs	2016-2017
	No available information on the shelf life of milled adlay and seeds	Evaluation of the shelf-life of different varieties on milled adlay and seeds **	Established benchmark information on milled adlay (POT on storage of seeds and milled adlay)	PhilMech, DA-RFOs	2017-2018
		Secondary product processing **	Value-added products	SUCs, DA-RFOs, FNRI	2017-2019
Marketing	High price gap of grains and milled adlay in different regions Lack of awareness on adlay products	Supply and value chain of adlay (include pricing) *	Value Chain Analysis (VCA) for adlay	SUCs	2017-2018

The Research and Development, and Extension Agenda and Programs for the Adlay Industry

Sub-system	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
By-product utilization and Waste Management	No protocol for proper handling of adlay bran and other waste materials intended for health research purposes	Development of protocol for proper handling of adlay bran and other waste materials intended for health related research **	Protocol for proper handling and storage of adlay bran and other waste materials	DA-RFOs	2017-2018
Others	Lack of documentation on adlay utilization and benefits by IPs/tribe in regions IX and X	Socio-cultural and bio-physical studies of adlay production and consumption in regions IX and X that uses adlay as staple food *	Documentation on the utilization and benefits of adlay as staple, food medicine and other uses Biophysical characterization of adlay and its suitability in regions IX and X	DA-RFOs, SUCs BSWM	2016-2017

Legend: * - 1st Priority ** - 2nd Priority

Commercial Crops


PLANTATION
BIOFUELS

Economic Importance

The production volume of plantation crops derives from coconut and sugarcane (Fig. 6) and from cacao, coffee, and rubber (Fig. 7), the former two with production in million metric tons.

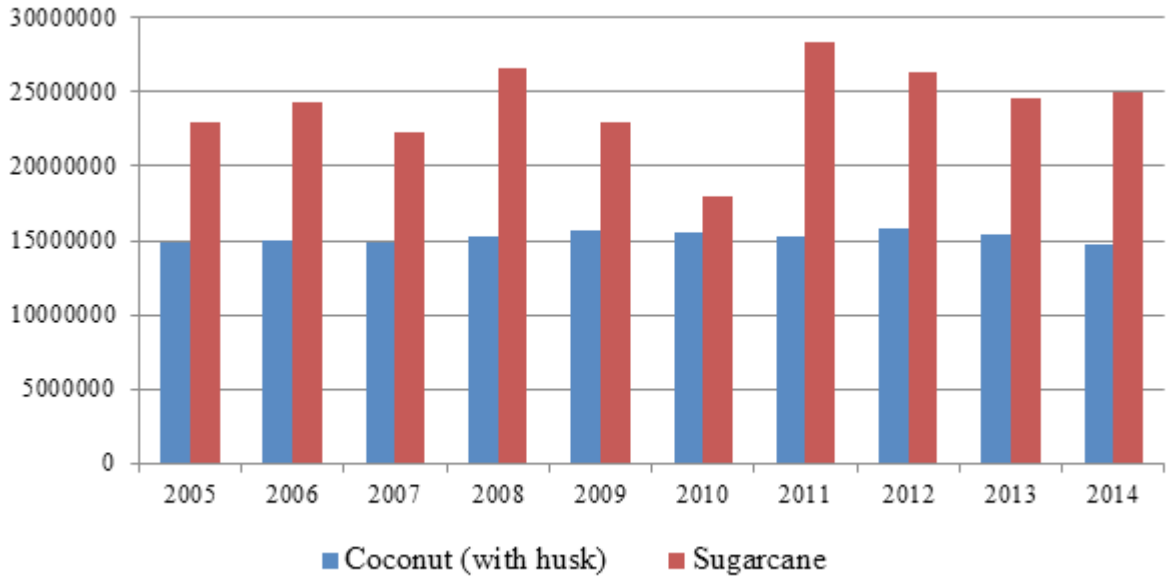


Figure 6. Volume of production of coconut and sugarcane, 2005-2014 (metric tons) (Source: PSA, 2016).

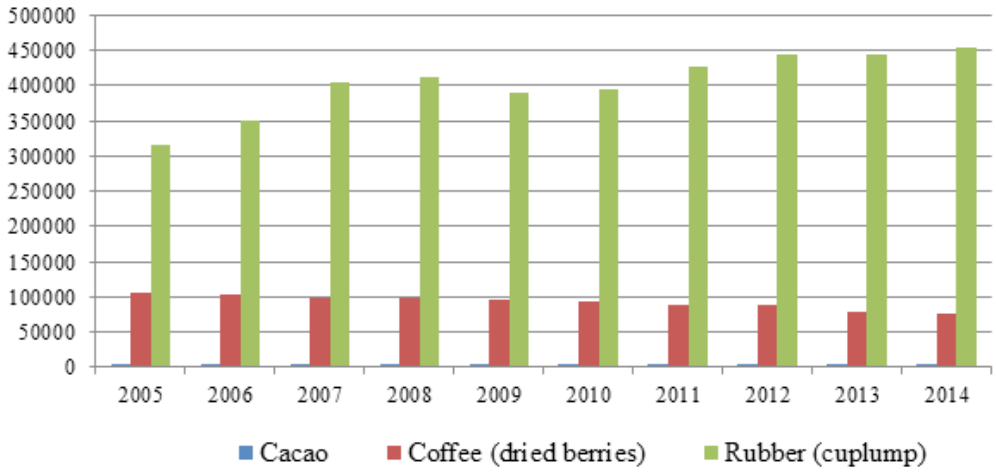


Figure 7. Volume of production of cacao, coffee and rubber, 2005-2014 (metric tons) (Source: PSA, 2016).

The Philippines is among the world's largest producers and exporters of coconut products, accounting for 23% of world production and 59% of world exports. It is the third largest exporter of coconut products, with coconut oil being the top agricultural commodity export generating average annual export earnings of US$ 935 million from 2005 to 2009 (NAPC, 2013).

Among all agricultural commodities, coconut consistently contributes the highest export earnings (PSA, 2016) with 70% of total production being absorbed by international markets (Forbes, 2013). Cultivated in 69 provinces out of the 79 provinces in the country, it consistently posted modest gains in 2015 while the crops sector in general contracted by 1.95% (PSA, 2015b).

The sugar industry contributes about PhP70 billion to the Philippine economy from the production of raw and refined sugar, molasses, and bioethanol. In addition, it supports foreign currency earnings through exports of sugar under the US Sugar Quota Program, exports of sugar to other Asian countries, and exports of molasses (SRA, 2012a).

In fact, the industry contributed about PhP87 billion to the Philippine economy in Crop Year 2013-14 from the sales of raw sugar, molasses and bioethanol, from tolling fees on sugar refining and VAT on refined sugar. In addition, it brought in US$ 111.76 million in CY 2013-14 through exports of sugar to the US and world markets (SRA, 2015).

The production of sugarcane, on the other hand, has contributed an average of PhP31,014.74 million (current prices) to the economy from 2005 to 2010 (PSA, 2016). Although production dropped slightly from the 2012 levels, the industry increased its contribution to an average of PhP45,005.88 million from 2011 to 2014 (PSA, 2015a) .

In crop year 2011-12, the sugarcane industry comprised around 64,765 farmers wherein 89.5% were small farmers (landholders with 10 hectares and below). The figure is expected to rise with continuing implementation of CARPer (SRA, 2015). In CY 2013-2014, the number of small farmers with less than 5 hectares of farmlands rose to 81.46% which corresponds to a total plantation area of 120,364 hectares equivalent to 26.61% of the total sugarcane farmlands in the country.

Coffee grows well in the Philippines, with mostly small farmers growing the four varieties: Robusta, Arabica, Liberica and Excelsa. Though most Filipinos are coffee drinkers, coffee production is quite low (0.2-0.3 tons/ha) compared to Indonesia (0.6 tons/ha) and Vietnam (2.4 tons/ha) (Bacbac, 2015) and thus, accounts for only 2% of the world's production (COCAFM, 2011). Of the total export value in 2011, extracts, essences and concentrates of coffee accounted for 70%, while ground roasted coffee accounted for 29% (DA HVCDP, 2013).

Production since 2005 was relatively constant and started a slow decline in 2010, which continued to 2014. However, PSA (2015a) reports that production increased in 2015 despite the general downtrend in the crops sector. This increased the contribution of coffee by PhP189.5 million in 2015 for a total of PhP 5,785.50 million.

The Philippines is a net importer of cocoa products with annual consumption equivalent to 50,000 MT of dried cocoa beans, 90% of which comes from growing areas in Mindanao. By 2020, the Philippines chocolate industry's projected demand is expected to reach an estimated 100,000 metric tons of dried cocoa beans (Boquiren and Idrovo, 2014). In the world market,

demand for cocoa beans is projected to reach 4.7M to 5 M in 2020 with average annual deficit of 100,000 MT (Cocoa Barometer, 2010).

Thus, while the country's production is quite low, local and international demand drives potential expansion in the industry through increase in local production. In addition, expansion will provide more opportunities for livelihood and employment because cocoa production is labor intensive and returns are higher than copra, coffee or other cash crops.

In the past five years, rubber production in the country has been relatively higher than the average production from 2005 to 2010 (Figure 2). However, value has decreased from PhP30,667.4 million in 2011 to PhP11,412.6 in 2014 (PSA, 2015a).

Eighty-five percent of land devoted to rubber is smallholder farms, most located specifically the provinces of Zamboanga Sibugay, North Cotabato, and Basilan which together account for 79% of the total hectarage planted to rubber in the country (DA-CARAGA, 2016). While the share of the Philippines is only 0.2% of the regional trade in natural rubber (DA-CARAGA, 2016), the industry envisions the country as one of the major natural rubber producing countries in Asia supplying 50% of domestic natural rubber requirements by 2016 (Cruz, 2012).

The Philippines Biofuels Act of 2006 (RA 9367) mandated the blending of biodiesel and ethanol in all locally distributed diesel and gasoline (currently at 2 % and 10 %, respectively) by February 2009. Sugarcane and coconut oil are the preferred Philippine ethanol and biodiesel feedstocks, respectively (USDA-FAS, 2014).

The Department of Energy (DOE) estimates that local ethanol demand reached 455 million liters (MLi) in 2014, and is expected to grow by an average of 5% annually in the near future. Overall fuel consumption is expected to continue increasing (USDA-FAS, 2015) through 2025 mainly due to the expanding population and continued growth of the Philippine economy.

Meeting the current 10% ethanol blend in gasoline has been problematic using local ethanol (USDA-FAS, 2015). Thus, imported ethanol (mostly from the US) is expected to satisfy at least half of the domestic demand in the Philippines for the next several years while domestic production capacity catches up (ITA, 2015).

Aside from sugarcane (molasses) and coconut, the country is exploring the production of biofuel from agricultural residue (rice straw and corn stover), seaweeds (Phaeophyceae, Rhodophyceae and Chlorophyceae), and oil palm (Elaeis guineensis). Other options being explored include bitaog (Calophyllum inophyllum), hanga or petroleum nut (Pittosporum resiniferum), and nipa (Nypa fruticans).

Current and Available Technologies

Research for these plantation crops has produced the following technologies:

Disease and pest management

- Location-specific control measures for major diseases using botanical extracts, organic-based formulations, fungicides, and cultural practices
- Low-cost pest management technologies

Varietal improvement

- Recommended varieties for specific locations
- Molecular markers techniques for identification of clones/genotypes
- Collection, characterization, and identification of clones in major growing areas
- Virus resistant cultivars using modern biotechnology

Crop management

- Nutrition management, Integrated Pest Management, Good Agricultural Practices
- Effective and efficient farming systems

Postharvest practices, processing, and marketing

- Fermentation and distillation protocols
- Harvesting and postharvest techniques to reduce losses
- Traceability for sustainability production system
- Drying system for export quality products
- Standardization of high value products
- Marketing strategies of new and emerging products
- Market research, value chain analysis, and feasibility studies
- Improvement of packaging materials
- Development of new products with high market potential

Industry and RDE Sector Goals

In general, the subsector aims for the "achievement of high productivity and profitability level set by industry through varietal improvements and sustainable farming systems."

Coffee

The goal of the coffee industry is a cost-competitive, aligned with global quality standards, reliable and environment-friendly industry that provides sustainable benefits to farmers, processors, traders and exporters (DA-HVCDP, 2013a). Specifically, the industry aims to:

- Increase productivity and production;
- Improve farmer's standard of living through diversified high value agriculture;
- Increase rural employment;
- Promote environment-friendly technologies;
- Lessen coffee bean and coffee products importation; and
- Improve incomes of farmers, processors and other stakeholders (Bacbac, 2015)

Cocoa

The main challenge in the cocoa industry in the short term is to evolve to intensive yet sustainable production that will: i) increase exports and improve the balance of trade; ii) supply the domestic processing industry especially the large companies to create a strong internal market; and iii) reduce vulnerability to economic liberalization and globalization (Boquiren and Idrovo, 2013).

With the above competitiveness vision in mind, the overarching intervention framework is shaped by the following broad and mutually reinforcing needs (Boquiren and& Idrovo, 2013):

- Development of inclusive value chains which would entail strengthening of capacities and capabilities of farmers and smallholders in particular to move up the commercial and market integration ladder and the establishment of enabling mechanisms that will enable exporters and integrators to source from small scale farmers;
- Upgrading of infrastructure and establishment of systems to lower cost of transactions, facilitate chain-wide compliance to quality and food safety standards, and ensure that incentives are available for increased quality, yield and scale; and
- Promotion of rational and sustainable use of natural resources while ensuring compatibility between social, economic, technical, and environmental objectives.

To address the above needs as platform for the achievement of industry's competitiveness, vision will require the following systemic changes (Boquiren and Idrovo, 2013):

- Increased access, availability, and use of good quality clean planting materials of the high yielding varieties;
- Improved access to, availability, and use of fertilizer and other inputs appropriate for cacao smallholders while reducing environmental costs;
- Enhanced flow and quality of extension services for cacao farming to facilitate adoption of GAP and Sustainable Farming Practices;
- Improved access to GMP compliant postharvest facilities and extension services necessary for the consistent production of high quality fermented beans;
- Judicious utilization of existing coconut and banana farms through cacao intercropping to increase areas planted to cacao with priority given to contiguous areas to facilitate establishment of cocoa hubs;
- Improved physical/infrastructure linkages to input, support, and product markets;
- Enhanced organizational capacity of farmer groups to become effective economic players;
- Improved flow and transparency of information at all nodes of the chain including basic traceability system; and
- Improved access to facilities and resources to catalyze value addition and lay the groundwork for commercial scale processing of cocoa by-products.

Coconut

The Coconut Industry Road Map, published by the National Anti-Poverty Commission, focused on addressing critical constraints through Nucleus Estates, a group of coconut farmers organized for economic inclusion, as one form of poverty reduction in first 12 pilot coconut provinces. Specifically, the road map was emphasized on the following concerns (NAPC, 2013):

- Agro-enterprise Development
- Transform subsistence farmers into significant participants of the market value chain.
- Social Protection
- Address the multidimensional risks and vulnerabilities (i.e. resulting from economic and social shocks as well as natural and man-made disasters) faced by poor farming households towards being able to manage risks, improve their well-being and get out of poverty traps.
- Fast Tracking Agrarian Reform in Coconut Lands
- Distribute the CARPer balance on Land Acquisition and Distribution (LAD) in coconut ands to address problem of tenure security for majority of coconut farmers.
- Institutional Reforms

To develop and initiate policy reforms aimed at strengthening state and market governance in the industry and establish local mechanisms for the participation and empowerment of coconut farmers.

Rubber

The goal of the rubber industry is to have a sustainable industry that is technologically advanced and globally competitive. Specifically, the industry is aimed at (DA-CARAGA, 2016):

- Increasing rubber production by 10% per year;
- Integrating and strengthening existing markets, and expanding to new ones for natural rubber, rubber wood and manufactured products;
- Meeting world market standards with respect to quality and consistency of processed rubber;
- Increasing the income of rubber growers and those in the peripheral industries by 5-10% per year within 6 years.

Sugarcane

The sugarcane industry is envisioned as a strategically diversified, sustainably viable industry that is beneficial to all its stakeholders. In order to realize this vision, the industry seeks to have the following in place (SRA, 2015):

- An organized and synergistic partnership among all industry stakeholders working in unison for the good of all;

- Well-managed sugar milling districts - led by MDDCs – that are conducive to efficient production and processing of cane into sugar and other products;
- Efficient sugar mills and refineries with capacity utilization increasing by 2-3% a year;

- Productive and economically-viable cane growers producing a sustainable supply of cane to meet present and future demand;
- National self-sufficiency in competitively-priced sugar;
- A robust bioethanol and power cogeneration sector utilizing molasses, cane juice, bagasse and cane trash as feedstocks to produce the mandated requirements for bioethanol and to supply at least 200 MW of renewable power to the grid;
- An active community of service providers to meet the needs of farmers, millers and workers;
- A more efficient, skilled and fairly-compensated labor sector with access to meaningful socio-economic support services and opportunities, and last but not least; and
- Favorable government and public support for the Philippine sugarcane industry.

References

Bacbac, Joan D. 2015. Towards a Roadmap/Masterplan for the Philippine Coffee Industry. Presented during the Industry Roadmaps and AEC Gameplan: Roadmap Localization for Competitiveness on May 28-29, 2015, Baguio Country Club, Baguio City.

Boquiren, Marian and Ivan Idrovo. 2014. Value Chain Analysis and Competitive Strategy: Cocoa Bean Mindanao. Philippine Rural Development Project, I-Plan Component. 124 pp.

Congressional Oversight Committee on Agricultural and Fisheries Modernization (COCAFM) 2011. The Coffee Industry: Performance, Policies and Strategic Directions. Retrieved from http://cocafm.gov.ph/wp-content/uploads/downloads/2011/02/Coffee.pdf. Accessed on 8 March 2016.

Cruz, Merlyn M. 2012. Overview of the Rubber Industry. Presented during the first Philippine Rubber Investment and Market Encounter (PRIME 2012) on 18-19 September 2012 at the Holiday Inn, Clark, Pampanga, Philippines.

DA-CARAGA. 2016. The Philippine Rubber Industry Roadmap. Retrieved from http://caraga.da.gov.ph/htdocs/images/opportunities/rubberroadmap.pdf. Accessed on 10 March 2016.

DA-HVCDP. 2013a. Coffee. Department of Agriculture High Value Crops Development Program. Retrieved from . Accessed on 22 April 2016.

DA-HVCDP. 2013b. Rubber. Department of Agriculture High Value Crops Development Program. Retrieved from . Accessed on 22 April 2016.

Forbes, Euclides G. 2013. 2013 Outlook for the Coconut Industry. Philippine Coconut Authority, Diliman, Quezon City. Retrieved from http://www.philexport.ph/c/document_library/get_file?uuid=fb6d1043-340d-4050-b81e-3f08215b39bb&groupId=127524. Accessed on 22 April 2016.

Infante, Ricardo S. 2007. Roadmap towards security of biofuels supply in the Philippines. Presentation during the 5th Asian Petroleum Technology Symposium, Japan Petroleum Energy Center, on 23-25 January 2007 at Jakarta, Indonesia.

International Trade Administration. 2015. Philippines - ITA Renewable Fuels Top Markets Report. USDA FAS/Office of Agricultural Affairs, Manila, Philippines. 3pp.

National Anti-Poverty Commission (NAPC). 2013. Integrated Coconut Industry and Poverty Reduction Road Map: Moving towards poverty alleviation and inclusive growth. Open Door Review, Issue No. 2. NAPC, Water System Training Center, MWSS-LWUA Compound, Katipunan Avenue, Quezon City. 56pp.

Philippine Statistics Authority (PSA). 2015a. Selected Statistics on Agriculture 2015. PSA-CVEA Building, East Avenue, Diliman, Quezon City, Philippines. Pp 21-24. ISSN 2012-0362

PSA. 2015b.CountrySTAT Philippines (Performance of Philippine Agriculture, various years). Retrieved from http://www.countrystat.psa.gov.ph. Accessed 09 April 2016. ISSN 2012-0451.

PSA. 2016. CountrySTAT Philippines (Other Crops: Volume and Value of Production) Retrieved from http://www.countrystat.psa.gov.ph. Accessed 18 March 2016.

Sugar Regulatory Administration (SRAa). 2012a. The Philippine sugarcane industry: Challenges and opportunities. Presented to the officers and staff of Banco de Oro. Accessed on 18 March 2016.

SRAb. 2012b. The Sugarcane Industry Roadmap 2011-2016. Sugar Regulatory Administration. Diliman, Quezon City.

SRA. 2015. Sugarcane Roadmap 2020: A Medium-Term Plan for the Philippine Sugarcane Industry. CY 2014-2015 to 2019-2020 Version. Sugar Regulatory Administration. Diliman, Quezon City. Retrieved from http://www.sra.gov.ph/wp-content/uploads/downloads/2016/04/SUGARCANE-ROADMAP-2020_final_03282016.pdf. Accessed on 20 April 2016.

United States Development Authority – Foreign Agricultural Service (USDA-FAS). 2014. Biofuels Annual – Philippines. Global Agricultural Information Network (GAIN) Report. 11pp. Retrieved from http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_Manila_Philippines_10-22-2014.pdf. Accessed on 8 March 2016.

United States Development Authority – Foreign Agricultural Service (USDA-FAS). 2015. Biofuels Annual – Philippines. Global Agricultural Information Network (GAIN) Report. 11pp. Retrieved from http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_Manila_Philippines_9-4-2015.pdf. Accessed on 22 April 2016.

Yang, Fredrick. 2011. The Philippine Rubber Industry to be Top 5 in Asia. Presentation. Mabuhay Integrated Farms. Retrieved from http://www.map-abcdf.com.ph/documents/presentations/Agribusiness/Agricultural%20Activities%20and%20Services/The%20Philippine%20Rubber%20Industry%20to%20Be%20Top%205.pdf . Accessed on 22 April 2016.

The Research and Development, and Extension Agenda and Programs for the Plantation Crop Industry

Sub-system	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
Input	Limited farmer access to low-cost commercial fertilizer	Formulation of low-priced appropriate fertilizer for coconut	Coconut	Low-priced appropriate fertilizer	PCA	2016-2017
	Need to validate/assess fertilizer recommendation	Soil analysis and nutrient management	Sugarcane	Validated fertilizer recommendation	SRA, BSWM, SUCs	2016-2019
	Lack of quality planting materials (i.e. disease-free, location appropriate)	Enhancement of micropropagation techniques	Abaca, Rubber	Protocol on micropropagation technique (*e.g.* micrografting for rubber) including disease elimination	PhilFIDA, SUCs	2016-2022
		Virus detection	Abaca	Developed/ enhanced protocols on virus detection (protein-based, nucleic acid-based & diagnostic kits)	PhilFIDA, SUCs	2016-2022
		Molecular characterization of viruses and insect vectors	Abaca	Compendium/ database on abaca diseases	PhilFIDA, SUCs	2016-2022

Sub-system	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
		Upscaling of production of polyclonal antibodies/ antiserum	Abaca	Antisera for virus detection	PhilFIDA, SUCs	2016-2022
		Development of biocontrol vectors and fusarium species	Abaca	Biocontrol measures for abaca production	PhilFIDA	2018-2020
		Varietal improvement under different ecological conditions	Cacao	Identified location specific clones	DA-RFOs, SUCs	2016-2022
		Multi-location adaptability trials of NSIC recommended coffee varieties	Coffee	Location-specific clones/ variety of coffee to be recommended for coffee growers in specific location	DA-RFOs, NCRC, SUCs	2016-2022
		Assessment/evaluation on propagation methods and primary sources of scions by commercial nurseries	Cacao	Certified quality planting materials	BPI, DA-RFOs, SUCs	2016-2022

Sub-system	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
		Development of protocol for tissue culture production of planting materials	Rubber	Package of technology (POT) for tissue culture and micropropagation of rubber	DA-RFOs, PRRI, SUCs	2016-2022
		Rapid multiplication of sufficient quality planting materials through traditional method	Rubber	Improved propagation techniques	DA-RFOs, PRRI, SUCs	2016-2022
	Lack of high-yielding and disease resistant varieties	Development of high-yielding and disease resistant abaca varieties thru DNA marker assisted selection breeding and genetic engineering	Abaca	High-yielding and disease resistant abaca varieties developed	PhilFIDA, SUCs	2016-2022
		Enrichment, collection, characterization and evaluation of abaca germplasm	Abaca	Identified profiles of abaca germplasm Abaca genebanks	PhilFIDA, SUCs	2016-2022
		Molecular characterization of abaca germplasm	Abaca	Information on the molecular characterization of abaca germplasm	PhilFIDA, SUCs	2016-2022

Sub-system	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
		Abaca genomic studies and bioinformatics	Abaca	Technology information on Abaca gene maps and databases	PhilFIDA, Crop Biotech Center, Philippine Genome Center, SUCs	2016-2022
		Abaca transformation	Abaca	Protocol on Abaca transformation	PhilFIDA, SUCs	2016-2022
		Abaca regeneration system	Abaca	Protocol on Abaca regeneration system	PhilFIDA, SUCs	2016-2022
		Flower induction of potential varieties	Sugarcane	Selected good parent material	SRA, BSWM	2016-2020
	Lack of information on site compatibility	Biophysical characterization of rubber	Rubber	Suitability maps for rubber	DA-RFOs, PRRI, SUCs	2016-2022
	Declining soil fertility	Fertilization and soil enhancement	Rubber	Guide on soil fertility maintenance	DA-RFOs, PRRI, SUCs	2016-2022
	Lack of manpower	Development of appropriate farm machineries/ equipment	Sugarcane	Cultivator, planter	SRA, PhilMech	2016-2020
Production	Low yield/ productivity	Formulation of low-priced appropriate fertilizer for coconut	Coconut	Low-priced appropriate fertilizer	PCA	2016-2017

Sub-system	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
		Development of appropriate farming system: - *Water and nutrient management* - *Integrated pest management* - *Good agricultural Practices* - *Integrated crop management* - *Cropping and forming systems (e.g agroforestry, intercropping)* - *Tapping Panel Dryness (TPD) management*	Abaca, Cacao, Coconut, Coffee, Rubber	Guide for sustainable production, cultural management, and food safety practice for adaptation/verification, and dissemination Recommended irrigation system to increase production	ATI, PhilFIDA, DA-RFOs, NCRC, BAFS, PCA, PRRI, SUCs	2016-2022
		Development of appropriate and cost-effective, and climate resilient production technologies (*e.g.* SALT, IK, CSA, harvesting techniques)	Abaca, Cacao, Coffee, Rubber	New/existing technologies and strategies for verification/ adaptation and dissemination	ATI, PhilFIDA, DA-RFOs, NCRC, PRRI, SUCs	2016-2022

Sub-system	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
		Nutrient Diagnostic for cacao trees: tree or clone -specific nutrient requirement and needs	Cacao	Guide on fertilization and nutrient management	DA-RFOs, SUCs	2016-2022
		Identification and development of high-yielding and disease-resistant varieties through molecular marker technology and genetic breeding	Abaca, Coconut, Sugarcane	High-yielding and disease-resistant varieties Model farms/Sustainable farming modules Hybridization of varieties (i.e. sugarcane) from bi-parental crosses)	ATI, PhilFIDA, DA-RFOs, PCA, SRA, SUCs	2016-2022
		Adaptability trials of new and improved varieties under different ecological conditions and locations	Sugarcane	Evaluated lines adaptable under specific ecological conditions Production guide of stress tolerant and resilient crops Location-specific varieties	SRA, SUCs	2016-2022

Sub-system	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
		Clonal improvement	Rubber	Recommended clones for specific locations	SUCs, DA-RFOs, PRRI	2016-2022
	No specific POT for organic coffee production	Appropriate practices for organic coffee production	Coffee	Package of technology for organic coffee production	DA-RFOs, NCRC, SUCs	2016-2022
	Low performance of parental varieties	Use of markers for diseases in sugarcane	Sugarcane	High-yielding and disease resistant varieties	SRA, SUCs	2016-2022
	Occurrence of pests and diseases	Survey of emerging and re-emerging diseases	Sugarcane	Database and control measures of emerging and re-emerging diseases	SRA, SUCs	2016-2022
		Development of environment-friendly pesticides	Abaca	Environment-friendly pesticides	ATI, PhilFIDA, DA-RFOs, SUCs	2016-2022
	Lack of growth and yield prediction model for different pili varieties	Development of growth and yield forecast for different pili varieties	Pili	Supply model of different pili varieties	DA-RFOs, SUCs	2016-2022
	Long gestation period	Development of early bearing pili varieties	Pili	Early bearing pili varieties	DA-RFOs, SUCs	2016-2022

Sub-system	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
	Lack of established technologies commercial production	Development of commercial production	Medicinal and indigenous plants	Recommended production technologies	DA-RFOs, SUCs	2016-2022
Post-harvest/ Processing	Lack of appropriate post-harvest technologies and practices	Development and packaging of new designs of machines, tools and equipment for safe and efficient extraction of standard grades of fiber	Abaca	Machines/tools/equipment for safe and efficient extraction (*i.e.* Tandem Decorticating machine with additional safety mechanism, Three - series spindle stripping machine, Mobile autofed decorticating machine, Portable spindle stripping machine with increased output capacity, and Knotting machine)	PhilFIDA, PhilMech, SUCs	2016-2017
		Development of drying and storage methods adaptable to abaca growing areas	Abaca	Multi-fiber mechanical dryer	PhilFIDA, SUCs	2017-2019

Sub-system	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
		Generation of efficient tools and technologies for rubber tapping	Rubber	Generated efficient tools and technologies for rubber tapping	DA-RFOs, PRRI, SUCs	2016-2022
				IEC on rubber tapping techniques	DA-RFOs, PRRI, SUCs	2016-2022
		Development of commercial processing of medicinal plants	Medicinal and indigenous plants	Recommended processing technologies	DA-RFOs, SUCs	2016-2022
		Development of appropriate tools and machinery for postharvest (*e.g.* roaster, nut cracker, grinder, extractor)	Pili	Efficient/affordable postharvest and processing machineries/equipment	DA-RFOs, SUCs	2016-2022
	Poor quality beans	Drying and other post-harvest technologies	Cacao, Coffee	Manual on best postharvest practices	DA-RFOs, NCRC, SUCs	2016-2018
		Influence of materials used in cacao beans fermentation (*i.e.* specific type of wood, rattan/wicker baskets, banana leaves, etc.)	Cacao	Manual on best postharvest practices	DA-RFOs, NCRC, SUCs	2016-2018

Sub-system	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
		Effects of roasting techniques to chocolate flavor and nutritional value of cacao beans	Cacao	Developed guide for cacao beans roasting (for small tablea producers)	BAFS, FDA, DA-RFOs, SUCs	2016-2018
		Quality improvement of green coffee beans (GCB)	Coffee	Manual on best practices on coffee postharvest	DA-RFOs, NCRC,SUCs	2016-2018
		Good manufacturing practices	Coffee		DA-RFOs, NCRC, SUCs	2016-2018
	Need for commercial uses of abaca fiber	Development other uses of abaca fibers.	Abaca	Electrospun abaca nanofiber; abaca-reinforced biocomposites with improved properties; biodegradable packaging materials; abaca-blended nonwoven materials; pulp and pulping characteristics of abaca varieties	PhilFIDA, SUCs	2016-2022
	Limited development of new products	Development of new products and processing technologies	Coconut	New products and technologies	PCA	2016-2022

Sub-system	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
		Derivation of other products from rubber	Rubber	Developed other rubber products	DA-RFOs, PRRI, SUCs	2016-2022
	Insufficient supply of labor services during harvesting	Development of appropriate farm machineries/equipment	Sugarcane	Mechanical harvester	PhilMech, SUCs	2016-2022
	Need to eliminate the incidence of *tayangawon*	Reduction/ elimination of tayangawon in pili nuts which causes unpleasant or bland taste during processing	Pili	Processing techniques	DA-RFOs, SUCs	2016-2022
	Lack of studies on the storage Life of raw and packaged pili products	Evaluation of different processes of storing pili products	Pili	Developed appropriate storage practices for pili products	DA-RFOs, SUCs	2016-2022
Marketing	Lack of market information/ need for market information dissemination	Supply and demand analysis	Abaca, Rubber	Adequate and comprehensive market information	PhilFIDA, DA-AMAS, PCAF, DA-RFOs, PRRI, SUCs	2016-2022
		Dissemination of market information to farmers	Abaca		PhilFIDA, DA-AMAS	

Sub-system	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
	Lack of promotion and established technologies for organic cacao production	Development and promotion of appropriate technologies for organic cacao farming	Cacao	Promotional/ IEC materials Developed appropriate technologies	DA-RFOs, AMAS, SUCs	2016-2022
	Proliferation of traders (*e.g.* farmers remain mere producers of raw materials)	Assessment of marketing channels	Coconut	Value Chain Map for coconut	PCA	2016-2022
	Low market acceptability	Competitive packaging and promotional strategies for coffee products	Coffee	Improved product packaging and promotion	DA-RFOs, NCRC, SUCs	2016-2022
	Lack of acceptability assessment	Socioeconomic and cultural acceptability in non-rubber producing regions	Rubber	Comprehensive resource assessment on rubber production	DA-RFOs, PRRI, SUCs	2016-2022
By-product utilization & Waste Management	Limited/ low utilization of by-products	Production of biofuels and power from abaca residues	Abaca	Bioethanol from abaca residues Alternative energy source	PhilFIDA, SUCs	2016-2020
		Extraction of oil from abaca seeds	Abaca	Fatty acids for Abaca as drying and antifoaming agent	PhilFIDA,	2016-2020

Sub-system	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
		Antimicrobial application of Abaca Extracts	Abaca	Extracts from abaca with antimicrobial activity	PhilFIDA	2016-2022
		Utilization of coffee pulp and other by-products	Coffee	Other marketable products out of coffee	DA-RFOs, NCRC, SUCs	2016-2022
	Need for improved waste management	Utilization of wastes to develop marketable products (*e.g.* cacao beans skins into special paper or packaging materials; pili nut shells, seedcoat, and pulp in fuel and craft industry)	Cacao, Coconut	Developed other marketable products from wastes (*e.g.* bean skins, saw dust, shells, pulp)	DA-RFOs,PCA, SUCs	2016-2022
			Pili	IEC materials and POT for various product utilization	DA-RFOs, SUCs	2016-2022
	Contamination of water system due to improper waste disposal from rubber processing centers	Development of appropriate waste management	Rubber	Appropriate waste management techniques	DA-RFOs, PRRI, SUCs	2016-2022

Sub-system	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
Others	Need for sustainability assessment	Carbon footprint, water footprint and energetics of pulp, latex, raw and refined sugar, biogasoline, biodiesel and bioaviation gasoline production	Abaca, Cacao, Coconut, Coffee, Rubber, Sugarcane	Life Cycle Assessment, carbon footprint, water footprint and energetics	PhilFIDA, PCA, SRA, SUCs	2016-2022
	Inefficient supply chain	Supply chain analysis on cacao	Cacao	Information materials on reduced losses, efficient utilization of inputs, reduced transaction cost, improved output and chain efficiency	DA-RFOs, SUCs	2016-2018
	Lack of baseline information on cacao genetic diversity	Morphological and genetic characterization of different cacao varieties	Cacao	Database on cacao clones and genetic collections	DA-RFOs, SUCs	2016-2018
	Lack of standards for specialty coffee	Establishment of quality standards and certification process for *Civet* coffee and organic coffee	Coffee	Established standards and certification process	DA-RFOs, NCRC, BAFS, SUCs	2016-2018

Sub-system	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
	Use of premium and high priced oil like coconut oil in biofuel blending	Possible amendments in the biofuel act covering technical, financial and economic considerations	Coconut	Amended biofuels act	PCA, DOE, UPLB	2016-2019
		Use of cheaper oils for biofuel blending	Coconut	Lower priced biofuel blend	PCA, SUCs	2016-2022
	Food safety and quality	Identification of chemical and toxin contamination of coffee beans	Coffee	Identified level of chemical and toxin contaminants in coffee beans produced by fungal species	DA-RFOs, NCRC, SUCs	2016-2022
	Low technology adoption on production techs for rubber	Assessment of factors affecting the adoption of rubber technologies	Rubber	Determined factors affecting the adoption of technologies	DA-RFOs, PRRI, SUCs	2016-2022
	Lack of basis on therapeutic properties/ effects	Pharmacological identification and testing	Medicinal and indigenous plants	Identified products and therapeutic properties	DA-RFOs, SUCs	2016-2022
		Germplasm collection and screening of new plants for medicinal uses	Medicinal and indigenous plants	Identified plants and pharmacological properties	DA-RFOs, SUCs	2016-2022

Sub-system	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
	Lack of baseline information on traditional and medicinal plants	Identification and characterization of traditional and medicinal plants and corresponding ethno medical utilization	Medicinal and indigenous plants	Identified medicinal plant varieties for nutraceutical purposes	DA-RFOs, SUCs	2016-2022

The Research and Development, and Extension Agenda and Programs for the Biofuel Industry

Sub-system	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
	Lack of cultural management practices for high yield and quality juice and grain	Irrigation schedule, nitrogen and potassium levels	Sweet sorghum	Matrix of the interaction of nitrogen, potassium level and irrigation management on juice and grain yield	SUCs	2016-2022
		Amount and time of nitrogen/ potassium application and irrigation schedule on the performance of ratoon	Sweet sorghum	System of applying and managing fertilizer and water to attain maximum yield of ratoon on juice and grain yield	SUCs	2016-2022
	Lack of manpower	Development of appropriate farm machineries/equipment	Sweet sorghum	Cultivator, planter	PhilMech, SUCs	2016-2022
Production	No physiological/ maturity indices for optimum nipa sap collection and sugar concentration	Establishment of physiological/ maturity inclusive for optimum sap volume and sap concentrated across Nipa varieties	Nipa	Database on the maturity indices for optimum sap volume and sugar concentration	SUCs	2016-2018

Sub-system	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
	Lack of data on sugar/ chemical profile across varieties	Chemotaxonomy of Nipa across varieties	Nipa	Sugar/chemical profile of Nipa	SUCs	2016-2018
	Lack of information on the nationwide distribution/ densities of nipa varieties	National inventory and database for Nipa varieties and population densities	Nipa	Inventory of nipa varieties and population densities	SUCs	2016-2018
	Lack of cultural management practices for high yield and quality produce	Varietal response to population density and row spacing	Sweet sorghum	Planting management that indicate optimum population density is established to attain maximum yield of sweet sorghum juice and grain	SUCs	2016-2022
		Varietal response to time of planting, fertilizer application and irrigation	Sweet sorghum	Technology matrix indicating the effect of time of planting, fertilizer input and irrigation frequency level/ to attain maximum yield	SUCs	2016-2022

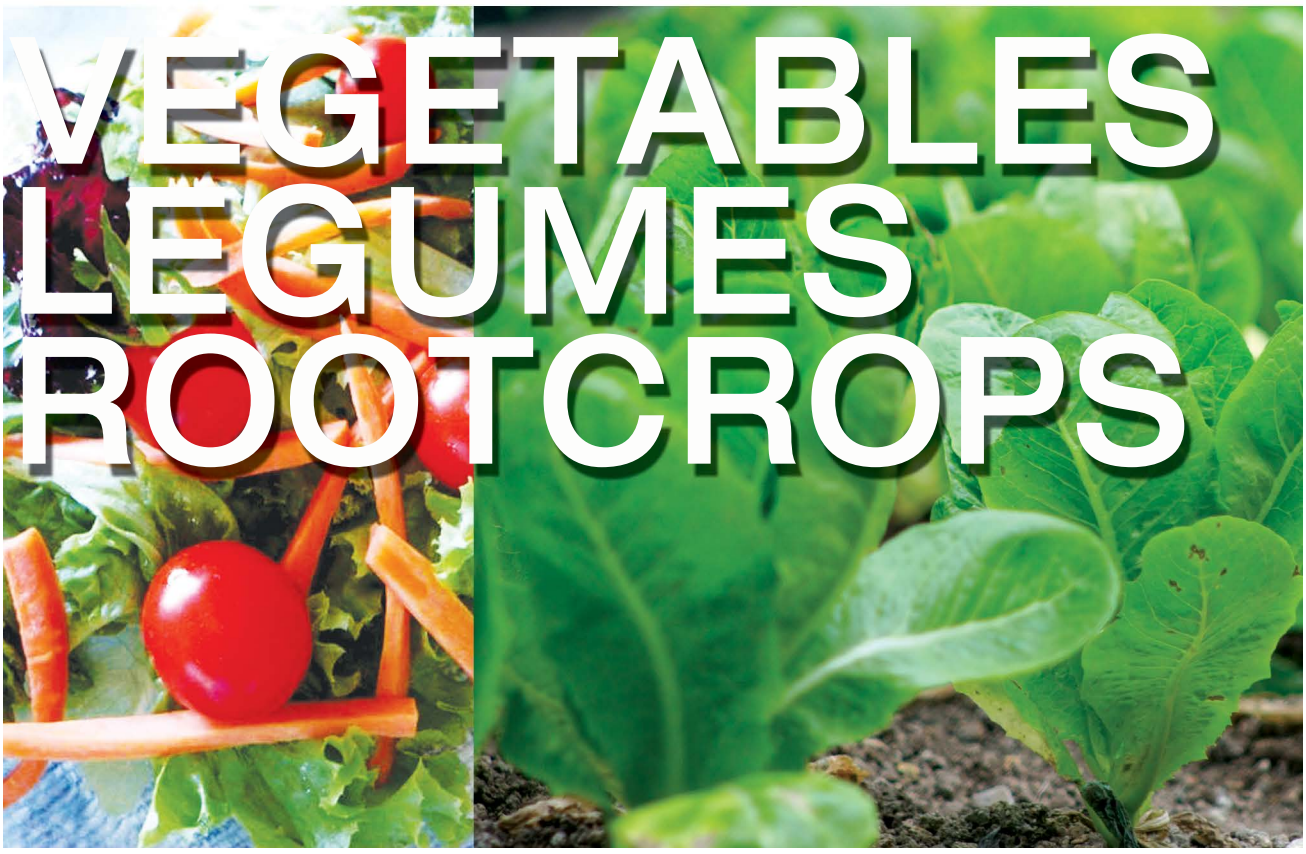
Sub-system	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
		Response to varying duration of water stress at different growth stages	Sweet sorghum	Yield levels on different moisture levels (flooding and drought) at different growth stages determined	SUCs	2016-2022
		Light intensity and planting schedule	Sweet sorghum	Planting calendar	SUCs	2016-2022
		Effect of thinning, and other cultural management on the flowering and sap production	Nipa	Guide for proper cultural management for optimum flowering and high sap yield	SUCs	2016-2022
		Development of biological control method	Sweet sorghum	Biological control system of insect pest of sweet sorghum to substitute chemical pesticides	SUCs	2016-2022
		Determination of ecological factors that influence the presence of insect pests	Sweet sorghum	The climatic and environmental conditions that affect occurrence of insect pests are identified	SUCs	2016-2022

Sub-system	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
		Response to varying duration of water stress at different growth stages	Sweet sorghum	Yield levels on different moisture levels (flooding and drought) at different growth stages determined	SUCs	2016-2022
		Light intensity and planting schedule	Sweet sorghum	Planting calendar	SUCs	2016-2022
		Effect of thinning, and other cultural management on the flowering and sap production	Nipa	Guide for proper cultural management for optimum flowering and high sap yield	SUCs	2016-2022
		Development of biological control method	Sweet sorghum	Biological control system of insect pest of sweet sorghum to substitute chemical pesticides	SUCs	2016-2022
		Determination of ecological factors that influence the presence of insect pests	Sweet sorghum	The climatic and environmental conditions that affect occurrence of insect pests are identified	SUCs	2016-2022

Sub-system	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
		Medicinal and nutritional properties of Nipa sugar	Nipa	High-value sugar for medicinal and nutritional use	SUCs	2016-2018
		Bioprocessing of Nipa lignocellulose for cellulose ethanol	Nipa	Cost-effective bioprocessing protocol for cellulose ethanol and other value adding product; cellulose ethanol and other products	SUCs	2016-2022
	Lack of appropriate mechanization equipment	Design on mechanical stalk harvester	Sweet sorghum	Appropriate stalk harvester	PhilMech, SUCs	2016-2022
By-product utilization and Waste Management	Inefficient/ poor by-product utilization	Utilization of sweet sorghum waste to develop new and marketable value-added products	Sweet sorghum	Value-added products from sweet sorghum waste and by-product	SUCs	2016-2022
	Lack of technology for the utilization of waste nipa distillate effluent	Recovery metabolites from nipa waste effluent	Nipa	New emerging product from nipa waste effluent	SUCs	2016-2022
		Utilization of Nipa waste/ distillate	Nipa	Nipa distillate as liquid organic fertilizer and soil ameliorant	SUCs	2016-2022

Sub-system	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
			Nipa	Growth medium for macro and micro algae; for fish culture	SUCs	2016-2019
	Lack of information on the LCA and bionergetics as biofuel feedstock	Life Cycle Analysis (LCA) for nipa bioethanol and energetics	Nipa	LCA and bioenergetics of Nipa as biofuel feedstock	SUCs	2016-2018
	Limited information on microbial strains which is indigenously present in Nipa sap and biomass	Others	Lack of updated data on economic study	Updating of feasibility study on production of sweet sorghum	Sweet sorghum	Feasibility study
	Need for sustainability assessment for the second and third generation biofuel production	Carbon footprint, water footprint and energetics of biogasoline, biodiesel and bio-aviation gasoline production	Second and third generation feedstock	Life cycle assessment and energetics for advanced biofuels production	SUCs	2016-2019

Sub-system	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
		National assessment of biomass resources for biofuels and energy production	Second and third generation feedstock	Biomass potential for biofuels and energy production	SUCs	2016-2019
		Feasibility study on the production of biogasoline, biodiesel and bio-aviation gasoline	Second and third generation feedstock	Economic viability of advanced biofuel production	SUCs	2016-2019
		Assessment of indigenous Phil oil-bearing seeds for biodiesel production	Second and third generation feedstock	Database of oil-bearing seeds for biomass production	SUCs	2016-2022
	No available data on the utilization of hydrous ethanol	Conduct of studies on the performance of engines using hydrous ethanol	Sweet sorghum	Data on performance using hydrous ethanol on transport engines and agricultural machinery	SUCs	2016-2022


VEGETABLES
LEGUMES
ROOTCROPS

Economic Importance

The importance of vegetables and other crops to the country's economy and well-being is such that government enacted the High-Value Crops Development Act of 1995 (RA 7900) to enhance productivity and incomes of farmers and the rural population, improve investment climate, competencies and efficiency of agribusiness and develop high-value crops as export crops that will significantly augment the foreign exchange earnings of the country.

Under the High Value Crops Development Program (HVCDP) of the Department of Agriculture, there are four main categories of vegetables – highland, lowland, spices and indigenous. Under these categories, 20 vegetables are considered priorities: 1) ampalaya, 2) asparagus, 3) broccoli, 4) cabbage, 5) carrots, 6) cauliflower, 7) eggplant, 8) garlic, 9) ginger, 10) gourd, 11) habitchuelas, 12) lettuce, 13) okra, 14) onion, 15) Chinese pechay, 16) native pechay, 17) squash, 18) stringbeans, 19) tomato, and 20) white potato (DA HVCDP, 2013).

These vegetables have been cultivated on an average of 147,497 hectares in the country from 2005 to 2014, producing about 1,570, 856 metric tons annually (Fig. 8 and Fig. 9) (PSA, 2016). Figure 8 shows the first 10 vegetables with annual production volumes beyond 50,000 metric tons, while Figure 9 shows the production volumes of the next ten vegetables with annual production volumes at or below this same level.

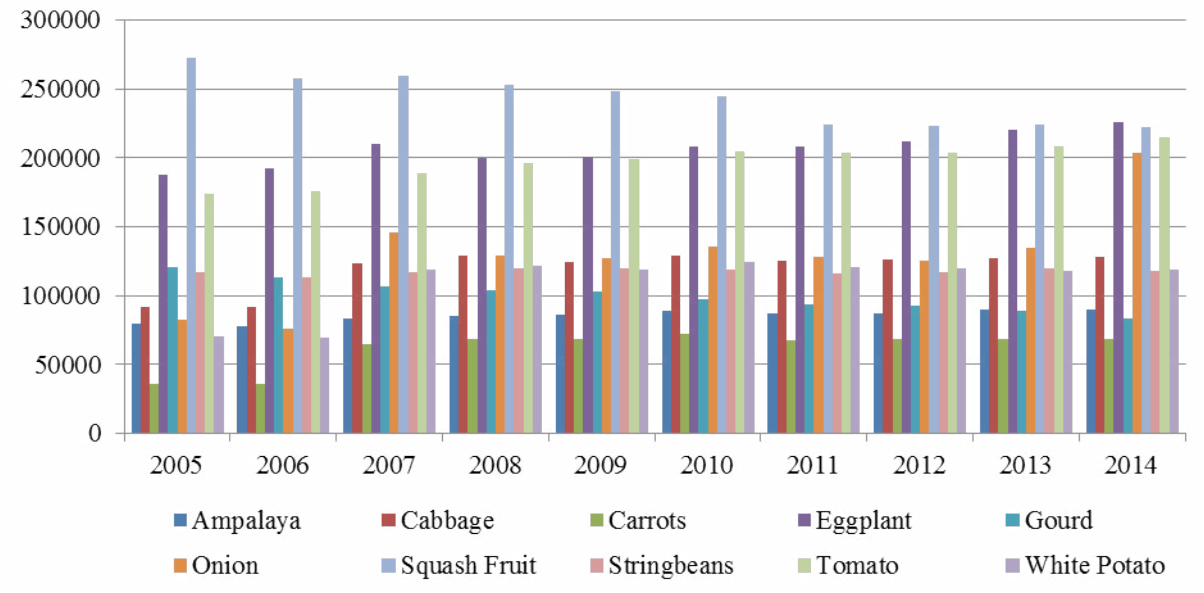


Figure 8. Volume of production of top 10 priority vegetables, 2005-2014 (Source: PSA, 2016)

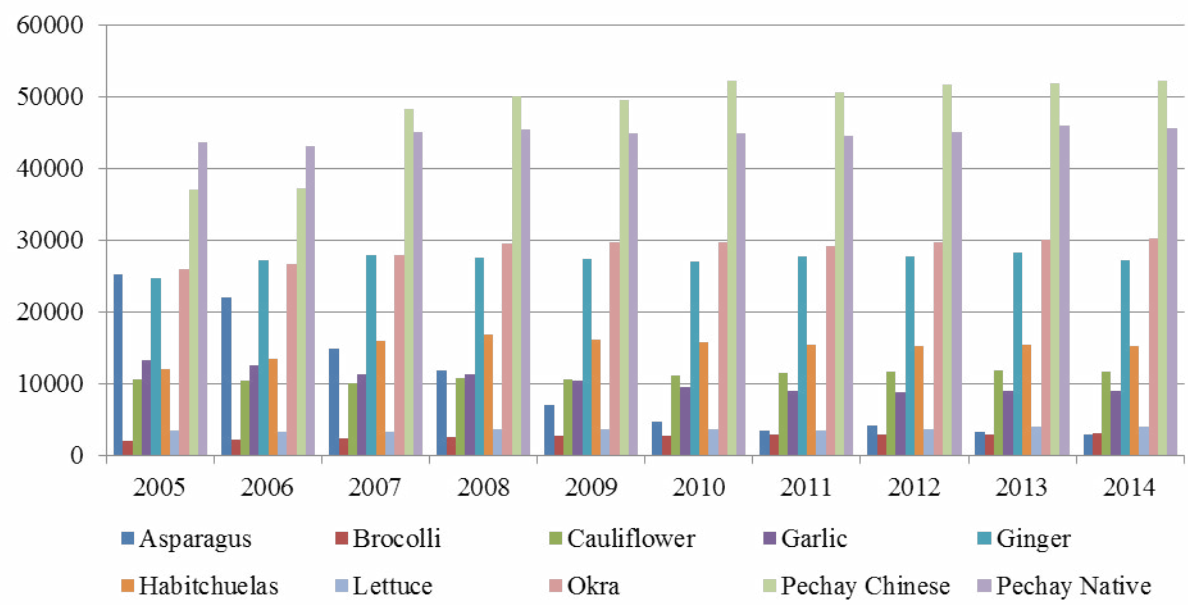


Figure 9. Volume of production of next ten vegetables, 2005-2014 (Source: PSA, 2016)

In 2006, the United Nations Development Programme (UNDP) reported that the vegetable industry in the Philippines contributes >30% to total agricultural production and is a major component of Gross Domestic Product (GDP). That situation hasn't changed in recent times (Albert, 2013; Bersales, 2015).

Vegetables are highly perishable but their production exhibits the highest returns, requires the most inputs, and is exposed to high production risk (Briones,2013). Studies however consistently show that the ratio of benefits to costs for fruit and vegetable crops is two times higher than the corresponding ratio for predominant cereals and pulses (IFAD, 2008).

The World Health Organization (WHO, 2003) recommends 400 grams per day or 146 kg per year of vegetables and fruits to help prevent various diseases. However, local per capita consumption has been quite low at 22 kg of vegetables, 19 kg of roots and tubers and 10 kg of beans, nuts and seeds or a total of 51 kg per year (Batt et al., 2007).

However, vegetable consumption may still increase based on projections made by Briones (2013). Under the reference scenario where agricultural output grows to meet the requirements of domestic and foreign markets (business as usual), per capita consumption of vegetables is estimated to increase by 39% to 34 kg/year by 2020 (up from 25kg/year in 2009).

Of the first 10 vegetables, the highest producers are gourd, eggplant, tomato, and onion in that order, while carrots have the lowest production in this group. In the next group of ten vegetables, the highest producers are Chinese pechay, native pechay, ginger and okra with broccoli producing the least.

Among the legumes and rootcrops grown in the country, the priorities for the former are mongo (mung bean) and peanut/ground nut while the priorities for the latter are camote (sweet potato), cassava, gabi (taro) and ubi (purple yam). Except for cassava which has posted slight gains from

2005, production for these crops has remained almost constant or has decreased slightly from 2005 to 2014 (Fig. 10) (PSA, 2016).

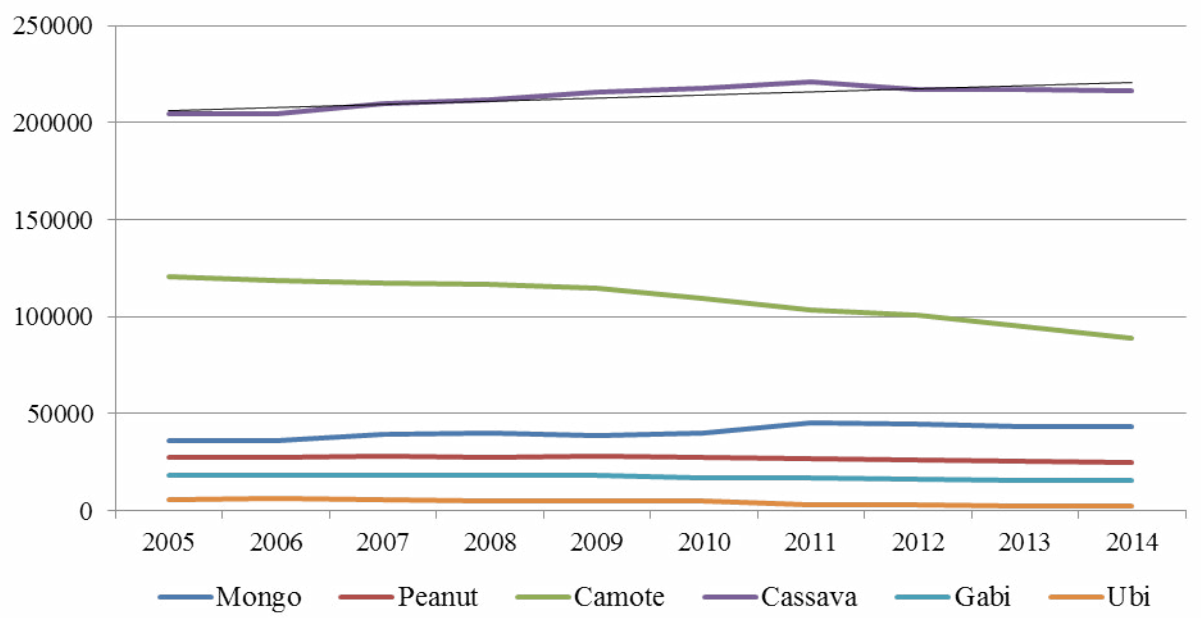


Figure 10. Production volume of priority legumes and root crops, 2005-2015 (Source: PSA, 2016)

Current and Available Technologies

For the past six years, research on vegetables, legumes, and rootcrops has produced the following technologies and information:

Input

- New and improved organic fertilizer system for selected vegetables and legumes
- Recommended nutrient management
- Innovations in fertilization techniques
- Organic planting media for rootcrops and vegetables.
- Plant-based pesticides production
- Multiplication and mass production of planting materials (e.g. in-vitro culture techniques and vine cuttings for yams and leaf cutting for white scallion)
- Seed support system for peanut production

Production

- Organic production systems/ technology of legumes and vegetable (and documentation of these)
- Hydroponics Technology for tomato and sweet pepper
- Improved production protocol for arrowroot

- Tolerance of mungbean mutant to acid soil condition
- Disease and pest control for pigeon pea, spices, bulbs, vegetables, and rootcrops
- Tomato breeding lines resistant to tomato leaf curl
- New and improved varieties for vegetables, legumes, and rootcrops
- Package of technology for pigeon pea as alternative feedstuff
- Pigeonpea for erosion control
- Plants that are accumulators of heavy metals (lettuce and upland kangkong) (Phytoremediation)

Post-harvest and processing

- Development of test protocols for pesticide residue
- Compendium of pigeon pea-based food and non-food products
- Package of technology for Nutraceuticals.
- Alternative process/treatment to maintain quality and extend the shelf–life of selected vegetables during transit and storage
- Technical and financial viability of the horizontal conveyor for onion sorting
- Processing systems and technologies to produce vegetable and rootcrop based products
- Supply chain benchmarking study for selected agricultural commodities using data gathered from Thailand, Vietnam, India, Taiwan (ROC), and, Mexico
- Profitability of organic vegetables production

Other information

- Database of thermo-physical properties of selected Philippine foods and agricultural materials
- Benchmark information on the extent of chemical and biological contamination on food crops
- Identification of contaminants (chemical and microbiological in origin) present in organically and conventionally grown crops and their possible sources
- Information on the technical and socio-economic value of non-refrigerated systems for onion
- Information on pests and diseases of spices, garlic, and vegetables
- Protocol on garlic DNA extraction

Industry and RDE Sector Goals

The DA's HVCDP aims to 1) increase production, income and livelihood opportunities among small producers through the production of high value crops, and to 2) provide access to affordable, safe and healthy food. Through these goals, the program will ensure the following outcomes:

- Increased consumption of diverse vegetables, beans, and roots

- Enhanced quality and food safety
- fficient production resulting to sustainable livelihoods/ enterprises and stable supply and prices for consumers

References

Albert, Jose Ramon G. 2013. Performance of the Philippine Economy 3rd Quarter 2013. National Statistical Coordination Board (NSCB). Retrieved from http://www.nscb.gov.ph/sna/2013/3rd2013/tables/JRGA%203Q%202013_FINAL.pdfAccessed on 27 April 2016.

Batt, Peter, Sylvia Concepcion, Ma. KlondyDagupen, Ma. Connie Lizada, and Roy Murray-Prior. 2007. The Vegetable Industry in the Philippines. Final Report of a small research and development activity (Project No. ASEM/2005/062). Australian Centre for International Agricultural Research (ACIAR), Canberra, Australia. 63pp.

Bersales, Lisa Grace S. 2015. Performance of the Philippine Economy 1st Quarter 2015. National Statistical Coordination Board (NSCB). Retrieved from http://www.nscb.gov.ph/sna/2015/tables/Q1_2015_NAP_long%20version.pdf. Accessed on 27 April 2016.

Briones, Roehlano M. 2013. Philippine Agriculture 2020: Threats and Opportunities from Global Trade. Philippine Institute for Development Studies (PIDS) Discussion Paper Series No. 2013-14. PIDS, Makati City, Philippines. 24pp.

DA HVCDP. 2013. Vegetables Commodity Profile. Retrieved from http://hvcc.da.gov.ph/vegetables.htm. Accessed on 08 March 2016.

International Fund for Agriculture Development (IFAD). 2008. The role of high value crops in rural poverty reduction in the Near East and North Africa. IFAD, Rome, Italy. 26pp.

Philippine Statistics Authority (PSA). 2016. CountryStat – Other Crops. Retrieved from http://countrystat.psa.gov.ph/?cont=10&pageid=1&ma=A50PNVOP. Accessed on 20 April 2016.

UNDP. 2006. A logistical evaluation of the vegetables sub-sector. Globalization and Corporate Citizenship (Project ID00014496) From Seed to Shelf, a Logistic Evaluation of the Vegetables Sub-Sector (Unpublished Report). United Nations Development Programme.

World Health Organization (WHO). 2003. Diet, nutrition and the prevention of chronic diseases. Report of a joint FAO/WHO Expert Consultation. WHO Technical Report Series, No. 916. World Health Organization, Geneva, Switzerland.

The Research and Development, and Extension Agenda and Programs for the Vegetables, Legumes, and Rootcrops Industries

Sub-system	Problems	Researchable Areas	Specific Commodities	Expected Outputs	Possible Implementing Agencies	Timelines
Input	Poor soil fertility due to degradation and acidity	Development/Improvement of soil amendment technologies (organic fertilizers, soil enhancers/ conditioners)	Vegetables, Legumes and Rootcrops	IEC materials (technoguides, manuals, etc.) , capability building on soil amendment technologies	BSWM, ATI, FPA, DA-RFOs, SUCs, LGUs	2016-2018
	Low utilization of green manure	Development/Improvement of green manuring technology	Vegetables, Legumes and Rootcrops	Recommended crops and seeds for cover/ green manure		2016-2018
	Lack of awareness on available technologies on biological control agents	Development/Improvement and promotion of biocontrol agents	Vegetables, Legumes and Rootcrops	IEC materials (technoguides, manuals, etc.), capability building on available technologies on biological control agents	DA-RFOs, SUCs, ATI, BPI, LGUs	2016-2018
				Upscaling of potential biological control agents		2016-2020
	High cost of labor	Mechanization of labor-intensive activities	Vegetables, Legumes and Rootcrops	Demo centers for available small machineries (planter, harvester, postharvest processing machineries, etc.)	DA-RFOs, SUCs, ATI, PhilMech, LGUs	2016-2018

Sub-system	Problems	Researchable Areas	Specific Commodities	Expected Outputs	Possible Implementing Agencies	Timelines
				IEC materials (brochures, leaflets, manuals, etc.)		2016-2018
	Limited supply of quality planting materials	Development of sustainable seed system	Vegetables, Legumes and Rootcrops	IEC materials (technoguides, manuals, etc.), capability building on seed production and storage	DA-RFOs, SUCs, ATI, BPI	2016-2022
				Quality seeds,disease-free		2016-
				(for Rootcrops) planting materials by formal seed sectors		2022
		Development of open-pollinated varieties as alternative for F1 hybrids; conservation and sustainable utilization of traditional varieties	Vegetables, Legumes and Rootcrops	IEC materials (technoguides, manuals, etc.) of recommended varieties		2016-2018
				At least one recommended variety (OP) for stressed environments (drought, frost, wet season) for priority crops		2016-2022

Sub-system	Problems	Researchable Areas	Specific Commodities	Expected Outputs	Possible Implementing Agencies	Timelines
				Enhanced collection of traditional varieties/strains/population		2016-2022
Production	Low volume of production due to seasonality of crops	Development/Improvement of low-cost protective structures and water and fertilizer application recommendation	Vegetables, Legumes and Rootcrops	IECs (technoguides, manuals, etc.), capability building on low-cost protective structures	DA-RFOs, SUCs, ATI, BPI, LGUs	2016-2018
				Recommended precision water and fertilizer application		2016-2018
		Development/Improvement of recommended varieties for off season crops and protected cultivation	Vegetables, Legumes and Rootcrops	IECs materials (technoguides, manuals, etc.) of recommended varieties	DA-RFOs, SUCs, ATI, BPI	2016-2018
				Varieties of priority crops for protected cultivation		2016-2022
				Varieties of priority crops for off-season		2016-2022
		Development/Improvement of recommended practices for off-season crops and protected cultivation including grafting technology	Vegetables, Legumes and Rootcrops	IEC materials (technoguides, manuals, etc.), capability building on recommended practices (including grafting technology)	DA-RFOs, SUCs, ATI, BPI	2016-2018

Sub-system	Problems	Researchable Areas	Specific Commodities	Expected Outputs	Possible Implementing Agencies	Timelines
	High production cost (i.e. fertilizer, pesticide, planting materials, etc.)	Integrated Crop Management	Vegetables, Legumes and Rootcrops	IEC materials (technoguides, manuals, etc.), capability building on Integrated Crop Management	DA-RFOs, SUCs, ATI, BPI, FPA	2016-2018
	High incidence of pests and diseases and inappropriate use of pesticides	Monitoring of emerging pests and diseases	Vegetables, Legumes and Rootcrops	Forecasting models and knowledge products on emerging pest and diseases	DA-RFOs, SUCs, ATI, BPI, FPA	2016-2022
		Development/Improvement of varieties with enhanced resistance to priority pest and diseases		Disease indexing protocols		2016-2018
				Recommended varieties with enhanced resistance to priority pest and diseases		2016-2022
				IEC materials (technoguides, manuals, etc.), capability building on GAP including the use of biocontrol agents		2016-2018

Sub-system	Problems	Researchable Areas	Specific Commodities	Expected Outputs	Possible Implementing Agencies	Timelines
Postharvest / Processing	Postharvest Losses and Quality -Poor postharvest handling system and facilities (fresh produce)	**Postharvest system** Development/Improvement of appropriate postharvest and storage technologies and systems	Vegetables, Legumes and Rootcrops	IEC materials (techno guides, manuals, etc.), Capability Building	SUCs, DA-RFOs, LGUs, ATI, BAFS, PhilMech	2016-2018
				Cleaning/sanitizing agents (for Vegetables)		2016-2018
	-High microbial contamination -High postharvest losses (fresh produce)			Protocol for fresh and minimally-processed produce, sprouts (for Vegetables)		2016-2018
				Packaging and storage systems including Modified Atmosphere Packaging (MAP) materials		2016-2018
				Agents for extending shelf-life and controlling diseases for vegetables and legumes		2016-2018

Sub-system	Problems	Researchable Areas	Specific Commodities	Expected Outputs	Possible Implementing Agencies	Timelines
				Protocols and design of recommended technologies and systems		2016-2022
		Integrated crop management Development/Improvement varieties and cultural practices for enhanced postharvest quality	Vegetables, Legumes and Rootcrops	Recommended crop production practices to enhance postharvest quality	SUCs, DA-RFOs, LGUs, BPI	2016-2018
				Recommended varieties with enhanced postharvest quality		2016-2022
	Few nutritious food products available	**Food science and technology** Development/Improvement of processing technologies and	Vegetables, Legumes and Rootcrops	Vegetable-based (rootcrop-based and bean-based) cookies, chips, snacks, beverages, bakery products (technologies)	SUCs, DA-RFOs, BAFS, ATI, NFA-FDC	2016-2020
		processed products		Dried vegetables as ingredients for other food (technologies)		2016-2020
				Ready-to-eat, nutrient-dense products (Primary targets: feeding programs and emergency food)		2016-2020

Sub-system	Problems	Researchable Areas	Specific Commodities	Expected Outputs	Possible Implementing Agencies	Timelines
				Improved processing technologies IEC materials (recipe book, technoguides, manuals, etc.)		2016-2022 2016-2018
	High processing and packaging costs	Development/Improvement of varieties and cultural practices for specific food products	Vegetables, Legumes and Rootcrops	Recommended varieties and crop production practices for specific food products	SUCs, DA-RFOs, LGUs, BPI	2016-2022
Marketing	Inefficient value chain (i.e. high transport costs, marginal participation of farmers, quality standards, etc.)	Sustainable value chain development	Vegetables, Legumes and Rootcrops	Policy recommendations	SUCs, DA-RFOs, AMAS	2016-2019


FRUITS

Economic Importance

The Philippines is a major producer of tropical fruits (DTI, 2015) and derives considerable export revenues from fresh fruit. Among the food exports, the single biggest source of earnings from agriculture is edible fruits (Briones, 2013) in terms of volume and value (PSA, 2016), the major export commodities being banana, pineapple, mango and papaya (Espino and Espino, 2013).

In 2014 (PSA), banana contributed 5% to the gross value added by agriculture, while mango and pineapple contributed 2% each. Production trends of these four crops range in the million metric tons (Fig. 11), while production of other fruits falls below 250,000 metric tons (Fig. 12).

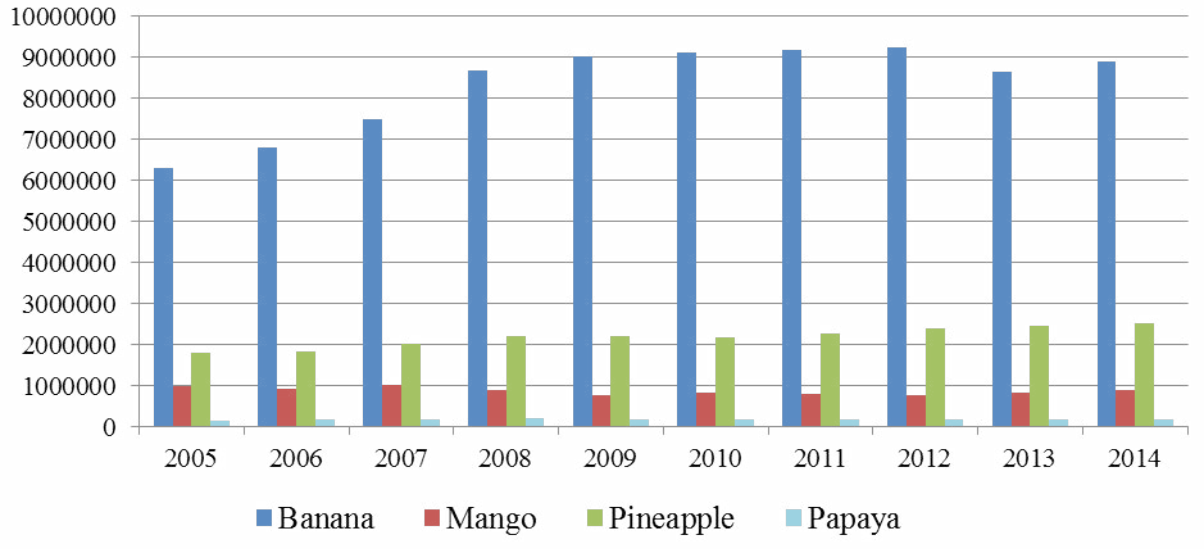


Figure 11. Volume of production of banana, mango, pineapple and papaya, 2005-2014 (metric tons) (Source: PSA, 2016).

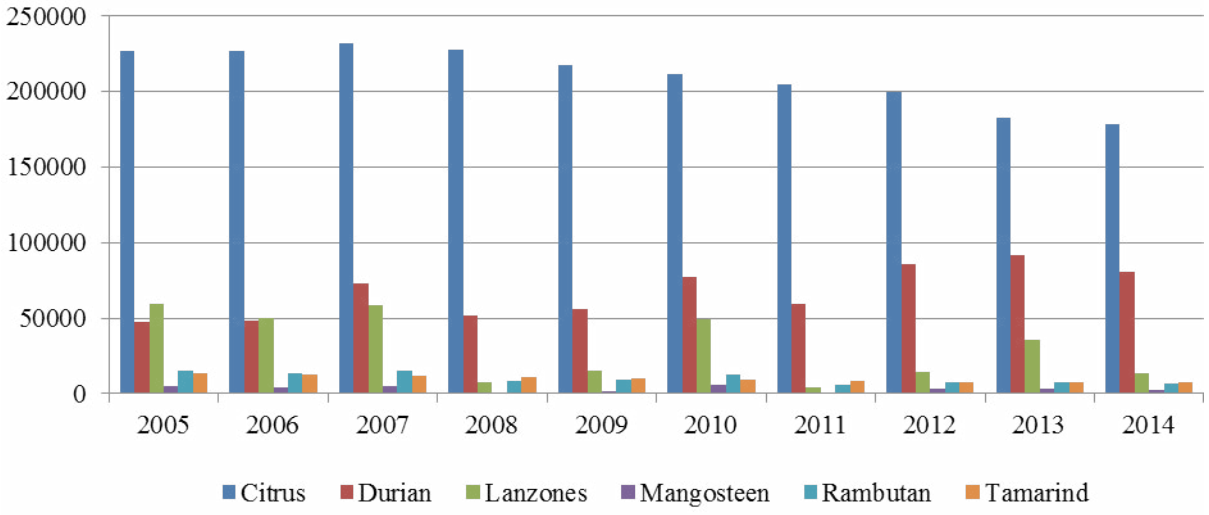


Figure 12. Volume of production of other fruits, 2005-2014 (metric tons)
(Note: Citrus represents the total of calamansi, mandarin and orange)
(Source: PSA, 2016)

Aside from these popular and often commonly available fruits, the Philippines has a rich collection of fruits that few other tropical countries can surpass or even equal in number (Coronel, 2011). More than 300 species have been reported and a good number of them are economically important but are not yet fully utilized.

Some of the economically-important fruits that are locally-grown but are underutilized are: bayabas (Psidium guajava), atis (Annona squamosa), kaimito (Chrysophyllum cainito), chico (Manilkara zapota), guyabano (Annona muricata), duhat (Syzygium cumini), rambutan (Nephelium lappaceum), santol (Sandoricum koetjape), sinigwelas (Spondias purpurea), dalanghita (Citrus sinensis), avocado (Persea americana), mabolo (Diospyros blancoi), tiesa (Pouteria campechiana), balimbing (Averrhoa carambola), marang (Artocarpus doratissimus), aratilis (Muntingia calabura), mangosteen (Garcinia mangostana), lanzones (Lansium domesticum), and dragonfruit (Hylocereus polyrhizus), among others (Dela Cruz, 2012).

Dela Cruz (2012) further cited that those fruits that are less-known or never-heard-of: granada (Punica granatum), lipote (Syzygium curranii), kalumpit (Terminalia microcarpa), sapinit (Rubus rosifolius), yambo (Syzygium samarangense), paratungon (Salacca ramosiana), batuan (Garcinia binucao), bignay (Antidesma bunius), yayasi (Ficus ulmifolia), and paho (Mangifera altissima) among many more.

Processed fruits also contribute to export revenue. Food and beverage processing remains as the Philippines' dominant industry in food exports, accounting for 48% share or US$988.31 million of total food exports in 2009 (DTI, 2016). Prepared/preserved fruits account for 53% of total exports; juices/concentrates and purees account for 24%; and dried fruits account for 18%. In fact, the country is a market leader in canned pineapple and pineapple juice.

Banana

Banana is the most-widely consumed fruit in the world and as the leading fruit grown in the Philippines, it is a consistent top dollar earner. The major markets for fresh banana are Japan (35%) and China (23%) (PSA, 2014).

Most of the bananas produced in the country come from the Davao Region, which represents 37.7% of the national total. The country produces many varieties of banana, but there are four commercial varieties, namely Saba, Lacatan, Latundan, and Cavendish.

The market is divided between the multinationals and large local producers that produce for export, and numerous small farms growing banana mainly for local market. In general, the exporters produce Cavendish in large plantations in Mindanao.

Although banana production is highly profitable, several issues still confront the industry. As with other crops, adverse climatic conditions and/or climate change increase risks of damage and/or crop loss. Extreme climatic events also can increase the occurrence of banana pests and diseases like bunchy top, Fusarium, Sigatoka. These pests and diseases cause preharvest losses but are more damaging after harvest. Postharvest losses are generally high for this perishable product, which lacks quality standards (fresh and processed).

Pineapple

In 2014, pineapple proved to be the most profitable among the non-staple major crops of the Philippines with net profit-cost ratio of 3.02, followed by red onion at 1.00. Its production has steadily increased from 2010 and has reached 2,507,100 metric tons in 2014 (PSA, 2015). Most of the country's pineapples are produced in Northern Mindanao, SOCCSKSARGEN, Bicol Region, and CALABARZON. Major pineapple varieties produced in the Philippines are Smooth Cayenne or Hawaiian, Queen or African Queen or Formosa, Native Philippine Red or Red Spanish, and Cabezona (DA-HVCDP, 2013).

Pineapple has been among the country's top export products, being the fourth most important exported commodity in terms of value (USD 436,140,000) and third in terms of volume (698,680 metric tons) in 2014 mostly going to United States of America, Japan, South Korea, Singapore, and China, and other countries, respectively (PSA, 2015). In fact, the country is the second leading exporter of fresh and processed pineapple product in the world next to Thailand (Balito, 2010), although the Philippines prides itself to be the leading exporter of pineapple juice and juice concentrates, specifically (DA-HVCDP, 2013). Dole, Del Monte Philippines, and a farmers' cooperative in Basud, Camarines Norte were among the biggest exporters in the country (Balito, 2010).

According to the Department of Agriculture Agribusiness and Marketing Assistance Service (AMAS) study, prospects for the Philippine pineapple industry is bright with domestic demand estimated over the next 10 years to be growing by an average of 4-7% every year (Balito, 2010). However, the industry is threatened by insufficient supply of quality fruits, concerns on the management of Phytophtora sp., and environmental impact of the conventional management in pineapple (DA-HVCDP, 2013).

Mango

Mango is the third most important fruit crop based on export volume and value, serving as one of the backbone industries of the country's agriculture sector (DA AFMIS, 2009). As a result, the Philippines is the sixth largest exporter of fresh mangoes after Mexico, India, Brazil, Netherlands, and Peru.

The 'Carabao' variety is the most popular among the varieties, followed by 'Piko' and 'Indian' varieties. Almost three-fourths (73%) of the total area planted is owned by small farmers, whose farms are less than 10 hectares. About 91% of production in consumed locally.

Aside from the adverse effects of climate change, the industry is constrained by the lack of quality planting materials, due mainly to lack of accredited nurseries and trained propagators. As with the other fruits, pests and diseases are a major concern, as is the poor implementation of quality standards.

Papaya

Papaya is grown in small farms (1-5 ha) with productivity period of 3-4 years (Espino and Espino, 2013). It is harvested all year round, but production has remained almost constant (PSA, 2016).

Most of the production is consumed fresh locally, but 3.0% finds its way into the export market, specifically to Japan and Singapore. While papaya has a big export demand, only a few exporting companies have access to these markets because of the stringent requirements and big capital outlay (Rivera, 2005).

Most of the top papaya producing regions are in Mindanao. Very little has changed in the industry since the study by Briones and Galang (2012). Then, only 2% of total production was exported fresh and dried, 92% was consumed domestically, and 6% was used as feeds. Papaya accounted for 0.6% of the total edible fruit exports of the Philippines, averaged from 2008 to 2010.

In the Philippines, there are currently seven commercial varieties of papaya sold for human consumption (PNS/BAFS, 2015). These are Cavite Special, Morado, Solo, Sinta, Cariñosa, Red Lady, and Red Royale. Papayas from these varieties are: sold fresh either in its whole or fresh-cut form for direct consumption; or sold to food industries for further processing. The fresh-cut form of papayas, however, are gaining popularity with consumers and can often be found in supermarkets and in food carts.

Current and Available Technologies

Input

- Vermicomposting technology
- production of disease-free planting materials

Production systems

- Package of Technology (POT) for Sapinit Production
- Adoption of ICM and GAP for hi
- gh value commodity products (banana, mango)
- Fruit-based Integrated farming systems (Banana + Rice + Corn, Pomelo + Vegetables + Native chicken)

Pest management

- Integrated Pest management
- Non-chemical based management strategies
- Automated Hot Water Treatment
- Light Trapping Technology
- Information on the Prevalence and Distribution of Lanzones scale insects
- Disease Indexing
- Test protocols on detection of pesticide residue from Mango

Storage

- Compendium of thermophysical properties of mango
- Ethanol vapor releasing system
- Postharvest Quality Maintenance of Pummelo Using Chitosan and 1-Methylcyclopropene

Value-addition

- Production of high value food and non-food products from the by-products of mango and sapinit
- Food and non-food products form wastes and by-products (e.g. seeds, peel, peduncle) of mango and banana

Documentation

- Identification, characterization, evaluation of these underutilized and neglected indigenous tropical fruit species
- Mango production and marketing practices in Major areas in Ilocos Region
- Identified areas where sapinit are naturally growing

Industry and RDE Sector Goals

The Department of Agriculture High Value Crops development Program (DA-HVCDP) was created with a mission of increasing income, creating livelihood opportunity, and contributing to national agricultural development of the Philippines through promotion of production, processing, marketing, and distribution of high value crops, including fruits. The vision for the three major fruit commodities of the country are:

Banana

The Philippines as a leading banana product exporter contributing towards food security and improvement of the socio-status of all stakeholders.

Pineapple

To remain the top exporter of juice concentrates and pineapple juice in the South East Asian Region.

Mango

A sustainable, productive and profitable mango industry that will benefit all stakeholders

References

Balito LP. 2011. The Philippine Pineapple Industry. ActaHortic. 902. Retrieved from http://dx.doi.org/10.17660/ActaHortic.2011.902.2.

Briones RM. 2013. Market structure and distribution of benefits from agricultural exports: The case of the Philippine mango industry. Discussion Paper Series no. 2013-16. Philippine Institute for Development Studies. 22pp.

Briones RM and IMR Galang. 2012. Assessment of Prospective Impact of Fruits and Vegetables Research at the Industry Level in the Philippines: the Case of the ACIAR-PCAARRD Horticulture Project. Discussion Paper Series no. 2014-40. Philippine Institute for Development Studies. 27pp.

Coronel RE. 2011. Important and Underutilized Edible Fruits of the Philippines. College, Laguna: University of the Philippines Los Baños Foundation Inc. and Department of Agriculture - Bureau of Agricultural Research, Diliman, Quezon City, Philippines. 283 p.

Dela Cruz, RT. 2012. BAR Digest October-December 2012 Issue (Vol. 14 No. 4)

Department of Agriculture - Agriculture and Fisheries Market Information System (DA AFMIS). 2009. Mango Profile. Retrieved from afmis.da.gov.ph/index.php/component/.../897-mangoprofile2009-3.html.Accessed on 4 May 2016.

Department of Agriculture – High Value Crops Development Program (DA-HVCDP). Pineapple. Retrieved from http://hvcc.da.gov.ph/pineapple.htm.

Department of Trade and Industry. 2015. Agri-business Industries and Opportunities. Retrieved from http://investphilippines.gov.ph/industries/agri-business. Accessed on 25 April 2016.

Espino, RRC and MRC Espino. 2013. The Status of the Fruit Industry in the Philippines. Food and Fertilizer Technology Center. Taipei, Taiwan. Retrieved from http://www.agnet.org/library.php?func=view&id=20150810090507&type_id=4. Accessed on 25 April 2016.

Philippine National Standard/Bureau of Agriculture and Fishery Standards (PNS/BAFS). 2015. Good Agricultural Practices for Papaya. PNS/BAFS 171:2015 ICS 67.080.20. Bureau of Agriculture and Fishery Standards, Department of Agriculture. Diliman, Quezon City.

Philippine Statistics Authority (PSA). 2014. Philippine Agriculture in Figures, 2014. Retrieved from http://countrystat.psa.gov.ph/?cont=3. Accessed on 02 May 2016.

PSA. 2015. Selected Statistics on Agriculture 2015. Philippines Statistics Office: Diliman, Quezon City.

PSA. 2016. CountryStat – Other Crops. Retrieved from http://countrystat.psa.gov.ph/?cont=10&pageid=1&ma=A50PNVOP. Accessed on 20 April 2016.

Rivera, Rex A. 2005. A guide to papaya growing and marketing. Retrieved from http://cms.cnr.edu.bt/cms/files/docs/File/Jeanette/PDF/papaya.pdf. Accessed on 25 May 2016.

The Research and Development, and Extension Agenda and Programs for the Fruit Industry

System	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
Input	Loss of soil nutrients	Development of location specific soil fertility rehabilitation guidelines (SSNM concept)	Mango, Pineapple, Lanzones, Citrus, Papaya, Guyabano, Dragonfruit, Durian, Mangosteen, Jackfruit	Location specific soil fertility guides	BPI, SUCs, DA RFOs, BSWM	2016-2022
	Limited or absence of recommended variety(e.g. thick peel variety for red blush, sweet and sour variety for guyabano)	Development of new/improved variety	Mango, Banana, Pineapple, Lanzones, Citrus, Papaya, Guyabano, Durian, Mangosteen, Jackfruit, Underutilized indigenous fruits	Improved varieties	BPI, SUCs, DA RFOs, NCPC	2016-2022
	Limited collections of varieties	Germplasm collection, characterization and conservation, and utilization	Banana, Pineapple, Lanzones, Citrus, Papaya, Guyabano, Dragonfruit, Durian, Mangosteen, Jackfruit;	(Inventory of) Characterized, evaluated, and conserved germplasm for climate resiliency and disease tolerance	BPI, SUCs, DA RFOs	2016-2022

System	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
			Underutilized indigenous fruits			
	Limited supply of quality planting materials	Development of micro- and macro-/mass propagation techniques and protocols	Banana (saba and latundan), Pineapple, Citrus, Jackfruit	Micro and macro-propagation protocols	BPI, SUCs, DA RFOs	2016-2022
			Dragonfruit	Quality planting materials	BPI, SUCs, DA RFOs	2016-2022
		Establishment of protocols for grading planting materials	Pineapple	Grading protocols for planting materials	BPI, SUCs, DA RFOs	2016-2022
	Limited or questionable true-to-type planting materials (i.e. Poor quality/inferior quality, limited quantity of planting materials, non-traceable)	Authentication of variety and development of appropriate mass propagation technique	Mango	True-to-type quality planting materials	SUCs, BPI, NMRDC, DA-RFOs	2016-2022
		Assessment of nursery regulatory measures to ensure true-to-type planting materials	Mango	(Guides/ manuals) of Credible marketing system of true-to-type planting materials	BPI	2016-2022
				Assured true-to-type quality planting material		

System	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
		Improvement of management production system as regards to planting, cropping system, nutrition, irrigation and crop protection	Mango, Underutilized indigenous fruits	(Procedures) of Optimized mass propagation techniques (in vitro and micro cuttings/genetic engineering) Protocols on production of true-to-type planting materials	SUCs, DA-RFOs, LGUs, BPI	2016-2022
		Yield variability as affected by climatic changes	Mango	Study of yield variability as affected by climatic changes	SUCs, DA-RFOs , LGUs	2016-2022
		Inventory of resilient varieties to climate change	Mango	Germplasm evaluated, collection, characterized, conserved	BPI, SUCs, DA-RFOs	2016-2022
		Determine adaptive mechanisms to climatic variability through biotechnology	Mango	(varieties/clones /breeds) that have Adaptive capacities (of mango) in response to different climatic variabilities	BPI, SUCs, DA-RFOs	2016-2022

System	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
		Varietal and crop improvement through biotechnology (e.g. export quality, thick peel, red blush)	Mango	Improved cultivars Fingerprints of varieties/ cultivars	BPI, SUCs, DA-RFOs	2016-2022
		Development of regulatory measures to ensure true-to-type planting materials	Underutilized indigenous fruits	Regulatory measures	SUCs, BPI,	2017-2022
	Low adoption of technology (production and postproduction)	Assessment of the degree of adoption of technologies	Banana, Pineapple, Citrus	Assessment report of the causes of poor adoption and recommendation	PhilMech, BPI, DOST, SUCs, DA- RFOs,	2016-2022
	Limited knowledge on the phytochemical properties	Determination of phytochemical contents	Jackfruit	Information on phytochemical contents of jackfruit	BPI, SUCs, DA- RFOs	2016-2022
Production	High incidence of pests and diseases	Development of effective pest and disease management control and strategies, use of bio-pesticides, bio control	Mango, Banana, Pineapple, Dragonfruit, Durian	Pest and disease management strategies, and decision support models	BPI, NCPC, SUCs, DA-RFOs	2016-2022

System	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
		Development of decision support models for pest and disease occurrence and management -Epidemiological studies on pest and diseases -Etiology of diseases -Development of alternative methods for controlling disease vectors				
		Development of POT for pests and disease management	Lanzones	POT for pest and incidence management	BPI, SUCs, DA-RFOs, NCPC	2016-2022
		Crop improvement for disease resistance or tolerance and adaptation to climate change	Banana, Citrus	Improved cultivars	BPI, SUCs, DA-RFOs, NCPC	2016-2022
		Documentation of emerging pests and diseases	Papaya	Management strategies for pest and diseases	BPI, SUCs, DA-RFOs	2016-2022

System	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
			Underutilized indigenous fruits	Pamphlets/brochures of common pests and diseases	SUCs, NGAs, DA-RFOs,BPI	2017-2023
	High cost of production attributed to the massive use of pesticides	Identification of cost-effective pesticides/cost effective POTs for the management of pest and diseases	Mango	Cost effective POTs	BPI, SUCs, DA-RFOs, LGUs	2016-2022
	Lack of management practices	Recommendations on sustainable production management	Mango	Sustainable production management practices	BPI, SUCs, DA-RFOs, LGUs	2016-2022
		Procedures for organic mango production	Mango	POT for Organic Mango Production	BPI, SUCs, DA-RFOs, LGUs	2016-2022
		Regulation of mango flowering	Mango	Procedures for the regulation of mango flowering	BPI, SUCs, DA-RFOs, LGUs	2016-2022
	Non-compliance to GAP	Development of sanitizing protocols for microbial hazards or microbial contaminants	Mango	GAP-compliant protocols	BPI, SUCs, DA-RFOs, LGUs, BAFS	2016-2022

System	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
		and adherence to GAP Development of acceptable compliant protocols				
	Climate change impacts	Climate-resilient production system (e.g. biotechnology, breeding/selecti on)	Mango, Banana, Pineapple, Lanzones, Citrus, Papaya, Guyabano, Dragonfruit, Durian, Mangosteen, Jackfruit	Climate-resilient technologies	BPI, SUCs, DA-RFOs	2016-2022
	Low productivity	Development of appropriate cropping system	Pineapple	Appropriate cropping system	BPI, SUCs, DA-RFOs	2016-2022
		Development of sustainable production management	Pineapple	Sustainable cropping system	BPI, SUCs, DA-RFOs, NCPC	2016-2022
		Development of POTs to increase yield and enhance quality (e.g. flower induction technologies,	Lanzones, Jackfruit, Underutilized indigenous fruits	Enhanced POT	BPI, SUCs, DA-RFOs	2016-2022

System	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
		control and regulation measures on fruit/flower drop)				
		Benchmarking of production and utilization	Jackfruit, Underutilized indigenous fruits	Baseline data on the production and utilization	BPI, SUCs, DA-RFOs	2016-2022
	Quality does not meet market requirement	GA3 technology for increased fruit size	Pineapple	Improved variety	BPI, SUCs, DA-RFOs, NGAs	2016-2022
		Pollination interventions, regulation of flowering through the use of natural pollinators and chemicals (Plant Growth Regulators)	Guyabano	Enhanced POT for guyabano production	BPI, SUCs, DA-RFOs	2016-2022
		Establishment of the harvesting index	Guyabano	Harvesting index procedures	BPI, SUCs, DA-RFOs	2016-2022
	Limited flower-inducers	Screening and optimization of protocols for flower induction	Citrus	Protocols for flower induction	BPI, SUCs, DA-RFOs, NIA	2016-2022
	Limited knowledge on the therapeutic properties	Evaluation of phytochemical properties of Guyabano	Guyabano	Phytochemical contents of different tissues of Guyabano	BPI, SUCs, DA-RFOs, DOST	2016-2022

System	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
	Limited supply of leaves for tea production	Development of POT for herbage production of Guyabano	Guyabano	POT for herbage production	BPI, SUCs, DA-RFOs	2016-2022
Postharvest/ Processing	High post-harvest losses	Development of technology to address tissue hardening or uneven ripening	Guyabano	Methods to prevent or avoid the tissue hardening	BPI, SUCs, DA-RFOs	2016-2022
		Physiological and morpho-anatomical studies	Guyabano, Dragonfruit, Underutilized indigenous fruits	Physiology and morpho-anatomy characteristics of Dragonfruit	BPI, SUCs, DA-RFOs, PhilMech	2016-2022
		Development of technologies to minimize fruit cracking	Durian	Postharvest technologies to minimize fruit cracking	BPI, SUCs, DA-RFOs, PhilMech	2016-2022
		Development of appropriate packaging material for transport and marketing	Durian	Packaging material	BPI, SUCs, DA-RFOs, BSWM	2016-2022
		Development of postharvest disease-control measures/ protocols	Citrus	Technologies/protocols for postharvest disease control	PhilMech, BPI, SUCs, DA-RFOs	2016-2022

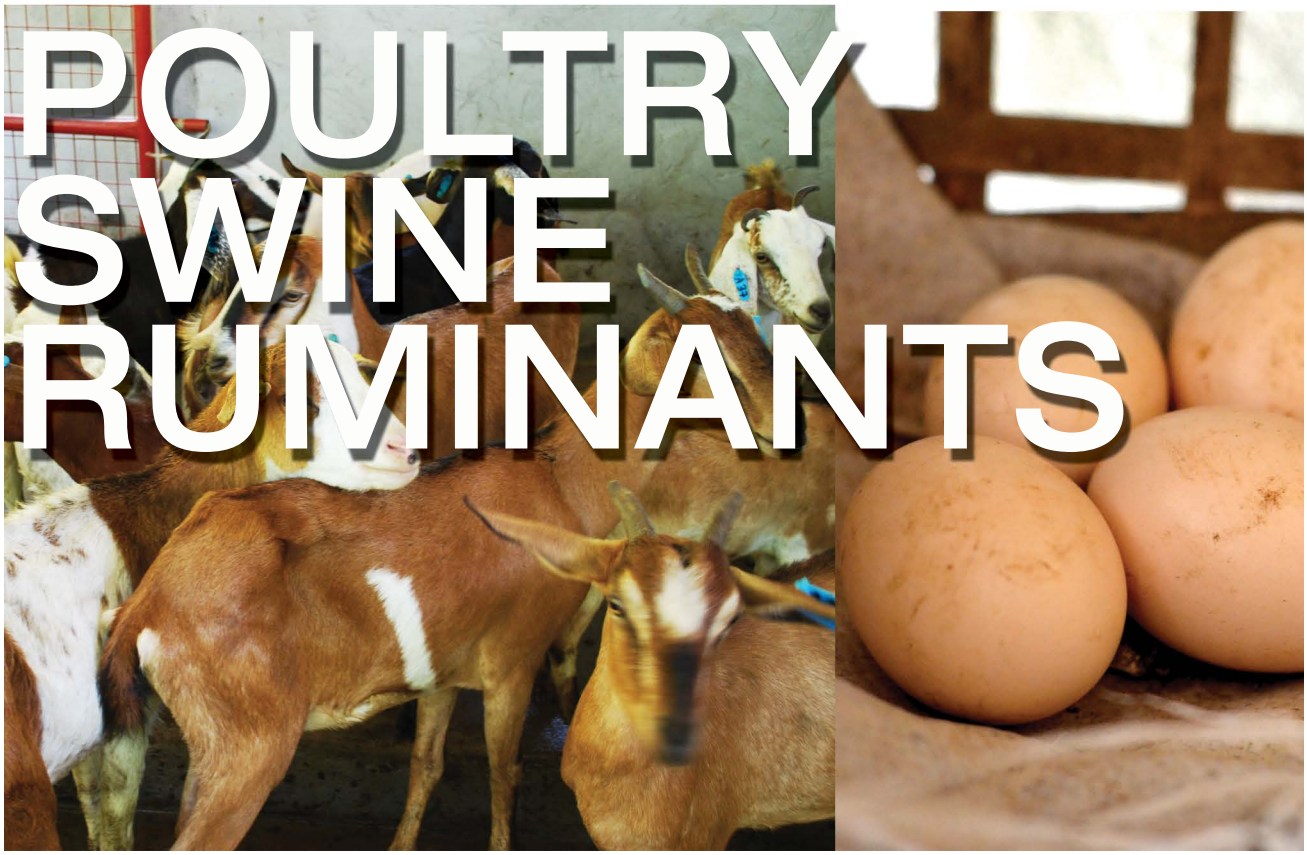
System	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
		Determination of harvesting index for citrus cultivars produced	Citrus	Harvesting index procedures	PhilMech, BPI, SUCs, DA-RFOs	2016-2022
		Postharvest Disease management (i.e. fruit coatings, bio-pesticides)	Mango	Postharvest pests and diseases management strategies	SUCs, NCPC, DA-RFOs	2016-2022
		Development of pest disinfestation control	Mango	Disinfection methods/protocols (i.e. chlorine dioxide, ozonated water)	SUCs, DA-RFOs	2016-2022
	Short shelf life	Development of efficient and cost-effective handling, storage system, and extension of shelf life	Mango, Banana, Pineapple, Lanzones, Guyabano, Dragonfruit, Mangosteen, Jackfruit, Underutilized indigenous fruits	Efficient and cost-effective handling and storage system	SUCs, NCPC, DA-RFOs	2016-2022
				Technologies for extension of shelf life	PhilMech, SUCs, DA-RFOs,	2016-2022
		Development of long shelf-life cultivar through biotechnology	Mango, Citrus	Improved cultivars	SUCs, DA-RFOs, PhilMech	2016-2022

System	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
	Limited value added products	Development of more processed products	Banana, Guyabano, Underutilized indigenous fruits	Value-added products	PhilMech, BPI, SUCs, DA-RFOs,	2016-2022
	Poor quality of processed products	Improvement of raw material handling practices and technologies	Pineapple	improved raw material handling protocol	PhilMech, BPI, SUCs, DA-RFOs	2016-2022
	Lack of processing and handling tools, facilities, equipment and infrastructure	Design/Development and Fabrication of processing equipment and packing line	Pineapple, Citrus	Fabricated processing tools and processing line	PhilMech, BPI, SUCs, DA-RFOs	2016-2022
	Lack of objective method of determining harvest maturity	Establishment of maturity determination protocols/procedures	Papaya	Procedures for determining maturity	BPI, SUCs, DA- RFOs	2016-2022
Marketing	Low competitiveness of produce in terms of quality and price	Development of strategies to reduce production cost (e.g. reducing cost in crop protection)	Mango	Strategies to reduce production cost	SUCs, DA-RFOs	2016-2022
		Conduct market studies	Citrus	Market studies	BPI, SUCs, DA- RFOs, BAFS	2016-2022

System	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
	Low compliance to food safety and quality standards	Development of detection kit for food safety-related contaminants	Mango	Detection kits	SUCs, DA-RFOs	2016-2022
		Impact assessment of GAP and GMP non-adoption and implementation	Mango, Underutilized indigenous fruits	Assessment report of the status of GAP and GMP adoption and its drivers	BPI, SUCs, DA- RFOs	2016-2022
		Assessment of acceptable GAP compliant protocols	Pineapple	Recommendations of GAP-compliant protocols	BPI, SUCs, DA- RFOs	2016-2022
	Incidence of pest of quarantine importance (e.g. fruitfly)	Development of quarantine and phytosanitary procedures/protocol or export	Mango, Lanzones	Quarantine and phytosanitary procedures/protocol	BPI, SUCs, DA- RFOs, NCPC	2016-2022
	Limited packaging technologies	Development of alternative retail packaging material	Mangosteen	Alternative retail packaging material	BPI, SUCs, DA- RFOs, PhilMech	2016-2022
	Lack of knowledge in the supply chain	Market studies on underutilized crops	Underutilized indigenous fruits	Reports/Assessment of supply chain	SUCs, NGAs, DA-RFOs	2017-2023

System	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
By-product utilization and Waste Manageme nt	Limited by-product utilization	Development and promotion of value-added products	Mango, Banana, Citrus, Papaya, Durian, Jackfruit, Underutilized indigenous fruits	Value-added products	BPI, SUCs, DA- RFOs,	2016-2022
Policy	Presence of Smuggled Inputs	Improve regulatory measures to prevent	Mango	Policy guidelines on smuggled inputs	SUCs, DA-RFOs, BAFS	2016-2022

Poultry and Livestock


POULTRY
SWINE
RUMINANTS

Economic Importance

Livestock and poultry production has increased from 1,171,130 metric tons in 1980 to 4,138,850 metric tons in 2014, growing at an average of 4% with value growing at 7% for the same duration (PSA, 2015a). Twenty percent of this growth occurred in the past 10 years (since 2005). In 2012, livestock and poultry accounted for 30% (PhP 234B) of the total value of production in agriculture at constant price, and almost 27% (PhP 381B) at current price (Jarmin, 2012). The sector's contribution increased in 2014 to 30.64%, with livestock and poultry contributing 5.6% and 7.84%, respectively (BAI, 2014).

This consistent expansion has contributed to reducing the contraction in agriculture output in the country. While agriculture in general, contracted in the fourth quarter of 2015 for instance, livestock and poultry expanded by 3.72% and 4.17 %, respectively (PSA, 2015b). This trend was consistent throughout 2015 with average increase in quarterly contribution at 3.85% for livestock and 5.77% for poultry, while crops and fisheries contracted on the average by 2.24% and 1.90%, respectively.

Figures 13 and 14 show the volume of production of livestock and poultry over ten years from 2005 to 2014. The growth in each of the subsectors can be attributed mostly to increase in production of hogs and chickens. Based on percentage contribution, these commodities rank second and third among the top ten commodities in agriculture in the country (Jarmin, 2012).

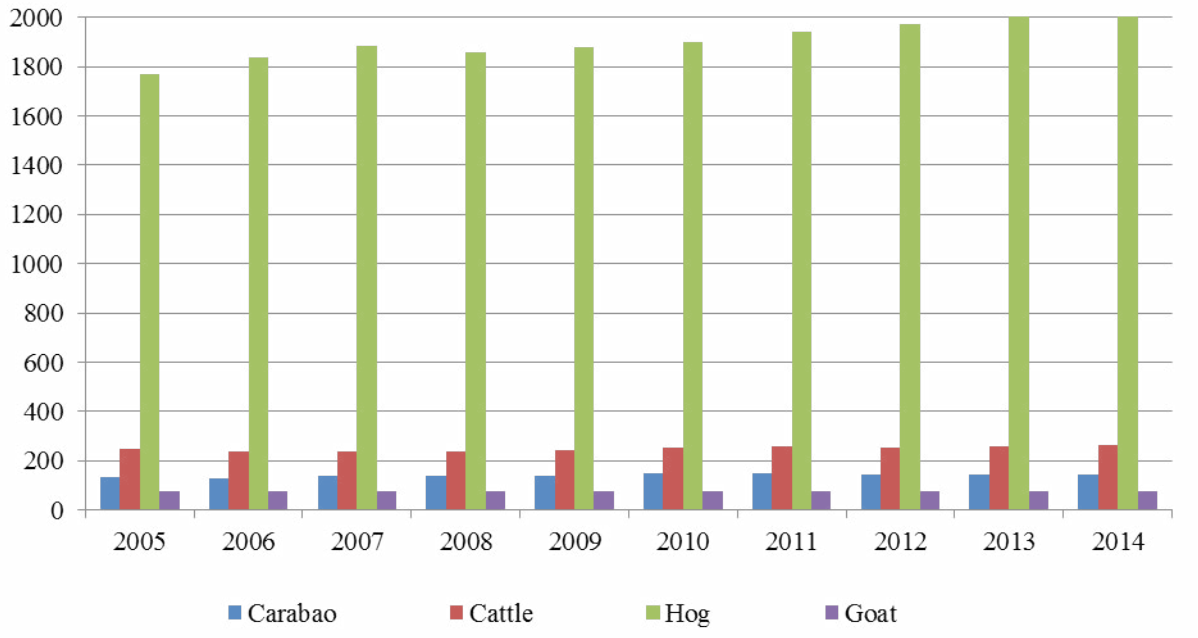


Figure 13. Volume of production of livestock by animal type and year, 2005-2014 (thousand metric tons) (Source: PSA, 2016).

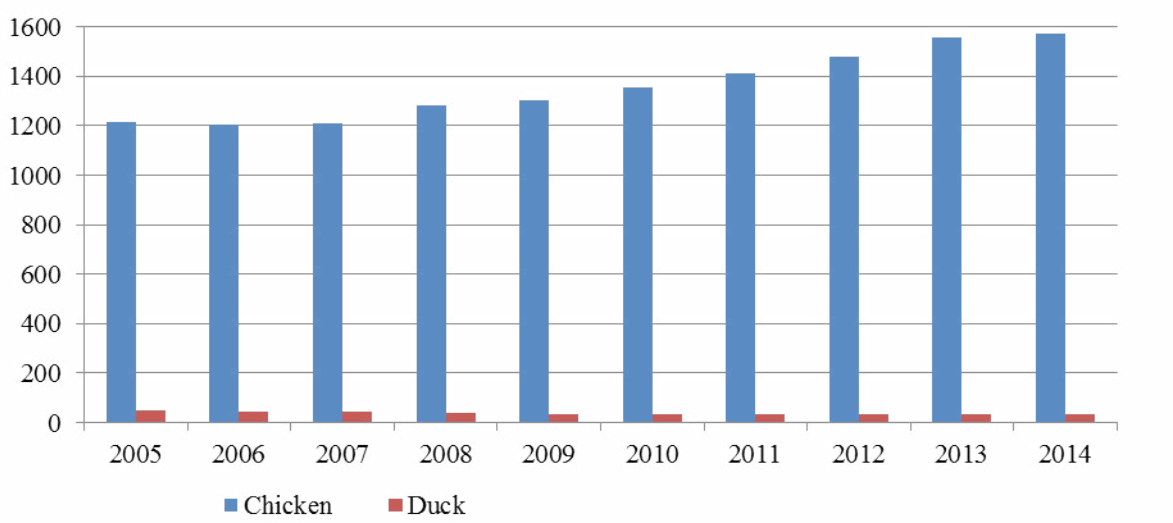


Figure 14. Volume of production of poultry by animal type and year, 2005-2014 (thousand metric tons) (Source: PSA, 2016).

Despite the increases posted by the sector, there is still room for improvement especially in surmounting key challenges (Gonzales et al., 2012) mainly around increasing competitiveness and retaining/increasing the share of the sector in the domestic and international markets.

Outputs from the industry is mainly from backyard farms, which produce 64-65% of the total number of heads for hogs and 40-45% of native chickens (PSA, 2015c, d). Backyard production are typicaly characterized with high inefficiencies: technical and infrastructure, which needs to be addressed. According to Sonaco (2015), there is a lack of facilities for the industry (abattoirs, dressing plants, cold storage, etc.) as well as a dearth in investments to enhance the value chain (e.g. transport facilities, logistics, etc.). Addressing these challenges would create significant effects on improving farm efficiency and profitability.

Moreover, native animal production, also a traditionally backyard activity poses a number of challenges and opportunities. Native animals are considered as important components of the local agricultural production systems especially in the rural areas (FFTC, 2010). They fit the limited capability and capacity of small-scale farmers in terms of cash capital, technical know-how and access to technical services. Hence, their contribution to the economic well-being of the producers are limited as well.

However, with the recognition of viable livelihood opportunities from native animals, there is a need to conserve and explore their various uses. There is a need to recognize that native animals remain popular against the commercial and widespread production of modern and improved breeds. This may be due to the following: their high potential adaptability to the environment, their unique meat flavor preferred by consumers; and the other functions they perform, in support of the cultural, social and economic life of farming communities especially of the indigenous groups throughout the country. Hence, their potential and opportunities to help improve economic conditions of small-scale farmers is promising. The two major concerns which needs to be addressed for the native animal production are: poor efficiency in the use of locally available feed materials, and generally low production efficiency and productivity (FFTC, 2010).

Current and Available Technologies

R&D in the country is largely private sector led with 64-73% of investments coming from the private sector from 2002-2011 (Aquino et al., 2014). This is true for the livestock and poultry sector as well, with most of the commercial scale farms funding their own research.

The recent years' public funding for research to benefit mostly the backyard growers has produced the following technologies:

Feeds and feeding system

- Indigenous feed resources (e.g. sprouted pigeon pea meal, snail meat meal, worm meat meal, trichantera leaf meal, sweet sorghum)
- Organic selenium, probiotics and prebiotics
- Resource-based feeding management system
- Feed supplements (e.g. malunggay and aloe vera leaf extract)

Breeds and breeding stock

- Dorper breeding management system
- PMD responses to abiotic stresses

Health and disease management

- Biodewormer
- Ethanolic extracts as larvicide
- Seroprevalence of CAEV in goats
- E. coli prevalence rates in native goats
- Hemosept Test Kit
- Ethnoveterinary practices manual

Postharvest practices, processing and marketing

- Dairy industry supply chain analysis in Region 2
- Native pig value chain analysis
- Skin and meat processing standards

Industry and RDE Sector Goals

To improve competitiveness, the industry aims to address inefficiencies through a two-pronged strategy: 1) increasing integration, scale and technical efficiency; and 2) developing cheaper feed, that can lead to improved farm efficiency and profitability. Toward this end, Gonzales et al. (2012) stressed the need for appropriate R&D on the following:

- Quality genetic materials
- Indigenous feeds
- Cost-competitive animal housing

- Water recycling
- Meat quality and safety

In response, the Department of Agriculture National Livestock Program (DA-NLP) aims to help ensure food security, alleviate poverty, enhance incomes and profitability and achieve global competitiveness for the livestock and poultry sub-sector.

Specifically, the DA-NLP aims to:

1. Increase livestock production and improve productivity to help ensure availability, accessibility and affordability of livestock products.
2. Invigorate the rural economy by promoting enterprise development and increase farmer's income.
3. Ensure the compatibility of practices in the livestock and poultry enterprises with environmental standards.
4. Work for the global competitiveness of the domestic poultry and livestock enterprises and venture into the export markets.

With regard to the native animals industry, the Department seeks to formulate, promote, and implement policies and programs for the development, conservation, production, and marketing of native animals through the Philippine Native Animal Development (PNAD) Program (Cresencio, 2015).

Under the aegis of the DA-AO No. 15 series of 2010 – "Establishing a Program for Conservation and Utilization of Domesticated Native Food Animals" on which PNAD is founded, the project envisions to: "provide pride, health and wealth to Filipinos by conserving, producing and marketing our native animals under a sustainable environment".

Further, the PNAD program aims to accomplish the following objectives:

1. Develop programs, projects and activities (PPA) for conservation, production and marketing of native animals.
2. Promote the domesticated native animals as regular food for the Filipinos.
3. Expand the contribution of the domesticated food animals in the GDP in general and to agriculture in particular
4. Develop and promote enterprises from domesticated native food animals and as potential export niche product of the Philippines.
5. Develop farming standards and good practices on domesticated native food animals.

References

Aquino, Albert P., Correa, Aleta Belissa D., Manalo, Jose Raymond A. and Faylon Patricio S. 2014. Public Sector Investments in Science, Technology and Innovation for Inclusive Growth and Competitive Economy in the Philippines: A Focus on Agriculture. FTTC Agricultural Policy Articles. Retrieved from http://ap.fftc.agnet.org/ap_db.php?id=215&print=1 . Accessed on 15 January 2016.

Bureau of Animal Industry. 2014. 2014 Annual Report. Bureau of Animal Industry, Visayas Avenue, Diliman, Quezon City. 68pp.

Cresencio, Rubina O. 2015. Philippine Native Animal Development (PNAD) as In Vivo Genetic Animal Conservation. Presentation given on June 5, 2015. Retrieved from file:///C:/Users/User/Downloads/PNAD%20as%20In%20Vivo%20Genetic%20Animal%20Conservation.pdf. Accessed on 25 May 2016.

Food and Fertilizer Technology Center (FFTC). 2010. Utilization of Native Animals for Building Rural Enterprises in Warm Climate Zones. Retrieved From http://www.agnet.org/library.php?func=view&id=20120103110958. Accessed on 09 April 2016.

Gonzales AA, DR Macabasco, FM Sevilla, MAG Dacul, and LA Gonzales. 2012. Benchmarking the Livestock and Poultry Industries: A cross Country Analysis of the Philippines and Four other Southeast Asian Countries. SIKAP/STRIVE Foundation: Los Baños, Laguna.

Jarmin, Manuel R. 2012. Livestock Industry Situationer. Presented at the Agri-Investment Forum: Opportunities and Prospects in the Livestock and Poultry Sector.

Philippine Statistics Authority. 2015. Selected Statistics on Agriculture 2015. PSA-CVEA Building, East Avenue, Diliman, Quezon City, Philippines. Pp 21-24. ISSN 2012-0362

PSA. 2015b.CountrySTAT Philippines (Performance of Philippine Agriculture, various years). Retrieved from http://www.countrystat.psa.gov.ph. Accessed 09 April 2016. ISSN 2012-0451.

PSA. 2015c.Swine Industry Performance Report 2015. Retrieved from http://www.agstat.psa.gov.ph/?ids=swinesituation. Accessed 22 April 2016.

PSA. 2015d.Chicken Industry Performance Report 2015. Retrieved from http://www.agstat.psa.gov.ph/?ids=chickensituation . Accessed 22 April 2016.

PSA. 2016.CountrySTAT Philippines (Livestock and Poultry: Volume and value of Production) Retrieved from http://www.countrystat.psa.gov.ph. Accessed 18 March 2016.

Sonaco, Ruth M. 2015. Agri-Pinoy National Livestock Program. Presentation accessed at http://www.angrin.tlri.gov.tw/meeting/2015TaiPhi2/2015TaiPhi_1-1.pdf on 21 April 2016.

The Research and Development, and Extension Agenda and Programs for the Poultry and Livestock Industry

System	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
Input - feeds and feeding systems	Insufficient data on quality and supply of locally-available and indigenous feed stuff and ingredients	Profiling and evaluation of different indigenous / locally available feed stuff / ingredients	Native and Backyard (chicken, duck, swine, goat, sheep, buffalo and cattle)	Identified nutritional value ex. potential protein digestibility, toxicity levels) POT of indigenous feed crop production	SUCs,DA-RFOs, BAI, PCC	2016-2022
		Feed processing procedures/methods to increase digestibility and bioavailability of indigenous ingredients	Native and Backyard (chicken, duck, swine, goat, sheep, buffalo and cattle)	Feed processing procedures/methodologies/technologies	SUCs, DA-RFOs, BAI, PCC	2016-2022
	Improper feeding practices of native and backyard animal raisers	Identification, development and validation of effective models/platforms to improve current feeding management practices	Native and Backyard (chicken, duck, swine, goat, sheep, buffalo and cattle)	Established and validated techno-transfer protocols (recommended feeding practices)	SUCs, DA-RFOs, BAI, PCC	2016-2022

System	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
	Decreasing pasture areas	Development of improved pasture/forage species for increased carrying capacity in various agro-climatic conditions	Goat, sheep, buffalo and cattle	Recommended POT for pasture development	PCC, BAI, DA-RFOs, SUCs, NDA	2016-2022
	Inadequate supply of quality feeds: concentrates and forages	Improved forage species adaptation and strata systems in relation to climate change, and exploring weeds as feed for livestock	Goat, sheep, buffalo and cattle	Identified adaptable/climate-resilient forage species and developed forage strata systems for various farming domains vulnerable to climate change	PCC, BAI, DA-RFOs, SUCs, NDA	2016-2018
		Improving the utilization of fibrous crop residues as livestock feeds	Goat, sheep, buffalo and cattle	Recommendations/Techniques in the utilization of fibrous crop residues as livestock feed	PCC, BAI, DA-RFOs, SUCs, NDA	2016-2017

System	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
Input-Breeds and breeding stock	Limited availability of good quality animal	Conservation, management, propagation and utilization of established native breeds	Native Chicken, Native Pig, Goat, Sheep, Buffalo, Cattle	Native animal germplasm collected and preserved (nucleus/breeding and multiplier farms) Performance records (physiological) Gene map	BAI, PCC, SUCs, DA-RFOs	2016-2022
		Development of a uniform/predictable and superior breeding stocks	Native Chicken, Native Pig, Goat, Sheep, Buffalo, Cattle	Available purified stocks /standard native breeds	BAI, PCC, SUCs, DA-RFOs	2016-2022
		Screening of potential/economically viable native animals	Native Chicken, Native Pig, Goat, Sheep, Buffalo, Cattle	Suitable strains/traits for specific market demand	BAI, PCC, SUCs, DA-RFOs	2016-2022
		Genetic improvement of native animals	Native Chicken, Native Pig, Goat, Sheep, Buffalo, Cattle	Recommended genetically improved breeds	BAI, PCC, SUCs, DA-RFOs	2016-2022
		Development of cryopreservation protocol	Goat	Cryopreservation protocols	PCC, SUCs, DA-RFOs	2016-2022

System	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
	Absence of local dairy breed	Development of a Philippine dairy breed of buffalo	Buffalo	Increased population of upgraded buffalos for milk production	BAI, PCC, SUCs, DA-RFOs, NDA	2016-2022
	Low milk production	Evaluation and selection of purebred riverine and crossbred buffaloes	Buffalo	Identified breeding objective traits and selection index traits Estimated economic weights per breeding objective trait	SUCs, DA-RFOs, PCC	2016-2022
Input - Housing and cooling systems	Unsuitable housing designs and conditions	Development and evaluation of climate-resilient housing systems	Chicken, duck, swine, goat, sheep, buffalo and cattle	Prototypes of climate-resilient standardized housing designs	SUCs, DA-BAAs	2016-2022
	High cost of egg incubation	Development and evaluation of alternative sources of heat/power for egg incubation	Chicken and Ducks	Cost-effective incubator prototype	PhilMech, SUCs	2017-2019

System	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
Production - Health and Nutrition	Poor production performance of native animals	Performance evaluation at different physiological stages using locally available/indigenous feed stuff / ingredients	Native and Backyard (chicken, duck, swine, goat, sheep, buffalo and cattle)	Cost-effective / Formulated diet and rations Nutrient requirement recommendations Established protein utilization and energy requirements Identified levels of inclusion and toxicity (quality)	SUCs, DA-RFOs, BAI, PCC	2016-2022
	High cost of production	Development of cost-reducing technologies	Native and Backyard (chicken, duck, swine, goat, sheep, buffalo and cattle)	Cost-effective POT and recommendations	SUCs, DA-RFOs, BAI, PCC	2016-2022
	Insufficient data on indigenous/ ethno-veterinary practices	Documentation and validation of ethno-veterinary/ indigenous practices of native animals	Native and Backyard (chicken, duck, swine, goat, sheep, buffalo and cattle)	Profile and recommendation of location-specific ethno-veterinary practices	DA-RFOs, SUCs	2016-2018

System	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
	Insufficient data on diseases in the animal industry	Profiling and validation of endemic and prevalent diseases	Chicken, Duck, Swine, Goat, Sheep, Buffalo and Cattle	Regional disease profiles and maps	SUCs, DA-RFOs, BAI, PCC	2016-2022
		Development and establishment of biosecurity for new and emerging diseases	Chicken, Duck, Swine, Goat, Sheep, Buffalo and Cattle	Policy recommendations on the national biosecurity systems on imported and introduced animals	SUCs, DA-RFOs, BAI, PCC	2016-2022
	Difficulty in rapidly detecting disease-causing organisms	Development of rapid detection methods	Chicken, Duck, Swine, Goat, Sheep, Buffalo and Cattle	Cost-effective, rapid, and reliable diagnostic/test kit Developed control and preventive measures for diseases	SUCs, DA-RFOs, BAI, PCC	2016-2022
	Insufficient data on animal-climate interaction	Determination of climate change threats on animal productivity	Native and Backyard (chicken, duck, swine, goat, sheep, buffalo and cattle)	Baseline information on the effect of environmental changes to animal physiology, behavior, and performance	BAI, PCC, SUCs, DA-RFOs	2016-2022

System	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
	Lack of data on zoonotic parasites on native pigs	Determination and profiling of zoonotic parasite load incidence	Native pigs	Recommendations for management and parasite control	NMIS, BAFS, BAI, DA-RFOs, SUCs	2016-2022
Production-By-product utilization and waste manage-ment	Poor waste management practices	Development and expanded utilization of waste management technologies	Chicken, Swine, Buffalo and Cattle	Cost-efficient waste management technologies	SUCs, DA-RFOs, BAI, PCC	2016-2022
Postharvest / Processing	Low quality animal products and by-products	Quality evaluation of animal products and by-products	Native and Backyard (chicken, duck, swine, goat, sheep, buffalo and cattle)	Recommendations for PNS on animal products an by-products	BAI, SUCs, DA-RFOs	2016-2022
		Product development including standards, packaging, shelf life, and fabrication	Native and Backyard (chicken, duck, swine, goat, sheep, buffalo and cattle)	Cost-effective and good processing practices Cut and grading standards Recommendations for PNS on animal products an by-products	NMIS, BAFS, BAI, DA-RFOs, SUCs	2016-2022

System	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
	Exposure to microbial and chemical hazards due to lack of information on presence/incidences of such	Development of quick/rapid methods/procedures to identify presence of microbiological/chemical hazards from food	Chicken, Duck, Swine, Buffalo and Cattle	Cost-efficient and quick/rapid risk assessment methods/procedures	NMIS, BAFS, BAI, DA-RFOs, SUCs	2016-2022
		Exposure assessment of identified microbiological/chemical hazards	Chicken, Duck, Swine, Buffalo and Cattle	Scientifically-sound risk management recommendations	NMIS, BAI, DA-RFOs, SUCs	2016-2022
		Development and evaluation of alternative anti-microbials	Chicken, Duck, Swine, Buffalo and Cattle	Natural bactericidals, organic acids, and other alternative anti-microbials	BAFS, BAI, DA-RFOs, SUCs	2016-2022
	Lack of technologies for small to medium scale postharvest facilities	Development of POT on processing and handling facilities	Chicken, Duck, Swine, Buffalo and Cattle	Cost-efficient technologies for small to medium scale processing and handling facility	NMIS, BAFS, BAI, DA-RFOs, SUCs	2016-2022
Marketing	Insufficient information on markets for native animals	Market structure conduct and performance study (i.e. VCA)	Native chicken, Native Pig, Native Goat, Native Sheep, Native Buffalo, Native Cattle	Policy recommendations (price, commerciable volume,	DA-AMAS, SUCs, BAI, DA-RFOs	2016-2022

System	Problems	Researchable Areas	Specific Commodity	Expected Outputs	Possible Implementing Agencies	Timelines
				organized market suppliers/ players)		
				Niche market for native animals	DA-AMAS, SUCs, BAI, DA-RFOs	2016-2022
		Establishment of market-driven animal production	Native chicken, Native Pig, Native Goat, Native Sheep, Native Buffalo, Native Cattle	Established consumption patterns on animal products	DA-AMAS, SUCs, BAI, DA-RFOs	2016-2022


APICULTURE

Economic Importance

Bees significantly increase crop yield and farm productivity through pollination. Nearly 85% of the world's flowering plants and 35% of crop production are supported by bees and other pollinators. Enhancing the bee industry then will contribute to food security and biodiversity maintenance.

On top of the importance of beekeeping in agriculture and environment, it can also provide livelihood opportunities to various communities by producing honey, pollen and other valuable hive products. In the country, 152.3 metric tons of honey was produced in 2015 by five domestic species, namely Apis mellifera, Apis dorsata breviligula, Apis dorsata dorsata, Apis cerana and Tetragonula spp. Of these, A. mellifera produces 70 mt while the two dorsata species together produce 80 mt.

There is a very high potential for increasing the production of honey in the country mainly because current production cannot meet local demand. In fact, the country imported 612 metric tons in 2015 amounting to USD 1,576,512.00 (NSO, 2015), mostly from Australia, United States, Austria, Argentina and U.K. (Fig. 15). Worldwide production from A. mellifera alone amounted to 930,000 mt.

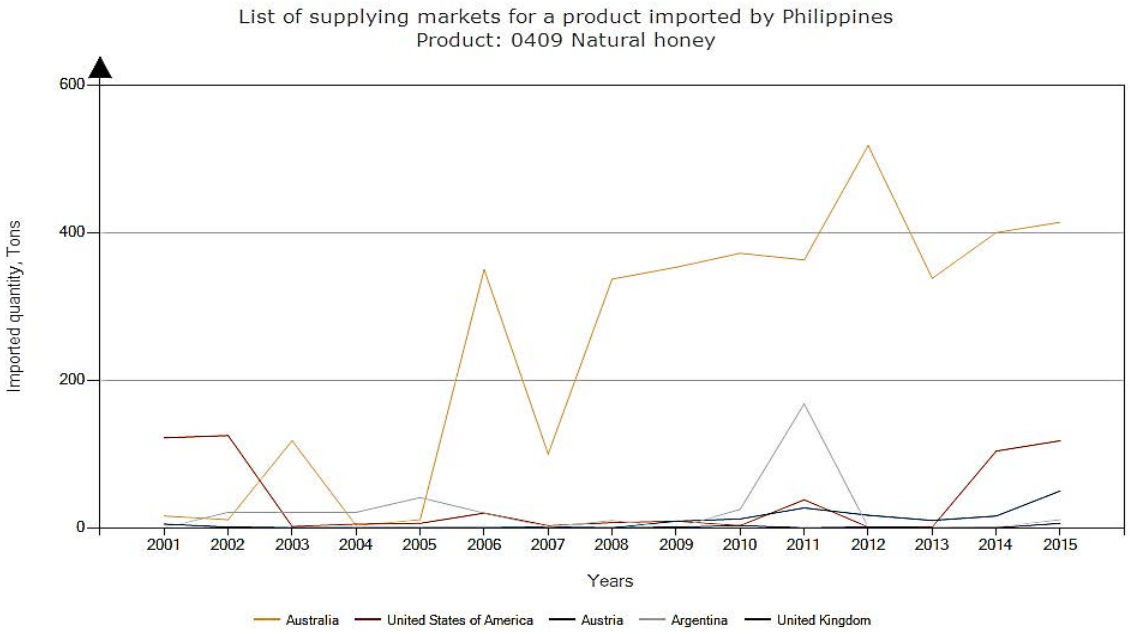


Figure 15. Philippine honey import values per country supplier.

The data for the industry showed good opportunities in both local and international markets. The current deficit in local supplies provides long term potential on which to anchor the further development of the bee industry roadmap. There is a need to further upgrade cost–efficiency in various operations in the input supply and distribution (queens and nucleus colonies etc.), production, post-harvest, processing and marketing.

The total annual honey production from the European bee (A. mellifera) has considerably declined from 103 mt tons in 2013 to 70mt in 2014-2015. This is attributed to the decline in bee population due to climate change that negatively affected the vegetation that provides nectar and pollen sources for the bees. Other factors are the use of pesticides, especially those applied in the coconut during the "cocolisap infestation", pest and diseases such as predatory birds, mites and diseases, especially the chalk brood. Most importantly, the incursion of the

small hive beetle (SHB), Aethina tumida in Mindanao in 2014 was a major setback to the bee industry. Hundreds of colonies were wiped our due to SHB. The situation was compounded by the absence of quality queens to restore the colonies.

However, the giant bees (Apis dorsata dorsata and Apis dorsata breviligula) produced 80 mt following the Organic Production System promoted by UPLB and DA-BAR. The local species, Apis cerana and stingless bees produced 300,000 and 2 mt, respectively.

Current and Available Technologies

Technologies for local bee species were developed in support to organic agriculture and natural farming systems, as follows:

- Use of stingless bees for pollination
- Harvesting honey from giant honey bees in the Philippines
- How to harvest honey, pollen and propolis from stingless bees
- Propagation of stingless bees using coconut shells
- Available information:
    - Production system for organic honey
    - PNS standard for organic honey
    - PNS standard for best management practices
    - PNS standard for Philippine honey
    - Bee disease management
    - Bee product development
    - Management of native bees

Industry and RDE Sector Goals

The beekeeping industry should be sustained to meet the local demand for bee products, especially honey and enhance crop production through conservation management of bee populations. The National Bee Industry Roadmap (Anon,2005) presents a vision of “A Philippine bee industry capable of supplying quality bees and bee products to local and foreign markets.”

In the same roadmap, the goals and objectives in Table 5 are highlighted.

Table 5. Goals and specific objectives of Philippine beekeeping industry.

Goals	Specific Objectives
To increase annual production of quality honey and other bee products	1. To train more beekeepers and beekeeping technicians 2. To develop management practices for the improvement of bee pastures and native bee stocks 3. To produce quality queens and stocks 4. Import new queens to improve genetic pool of existing production and breeding colonies
To develop cost effective support services for the bee industry	1. To establish regional centers for basic and advance beekeeping training, bee product processing and analysis, bee disease diagnosis, breeding, financial and consultancy assistance. 2. To enhance policies and advocacies relevant to the bee industry.
To increase industry and government participation in the conduct of relevant researches on pollination, bee product, development, management and genetic diversity in support to the industry	1. To conduct genetic diversity studies 2. To develop technologies for utilizing non-Apis species in pollination 3. To conduct research on bee product development 4. To provide package of technologies for the management of native honey bees

In addition, the following concerns must be addressed:

- Incursion of the small hive beetles (SHB) in Mindanao. There is a need to issue a moratorium on inter-island movement of bees.
- Quality control of bees and bee products
- Biosecurity (quarantine measures, financing, insurance)
    - Unclear quarantine procedures for queen bee importation
    - Selling of sub-standard starter colonies
    - Proliferation of adulterated honey
- Research and Developmental needs on the following areas:
    - Pollination initiatives
    - Genetic diversity of local bee species (solitary bees and stingless bees)
    - Bee pest and diseases
    - Bee pasture development

- Advocacy and Legislation
    - Legislation in support of biological research and intellectual property
    - Development of educational materials to promote beekeeping and its role in the environment
    - A review of existing laws and regulations governing plant and animal health must be done in earnest to avoid overlap in jurisdiction. Strict implementation of biosecurity protocol is imperative to protect and conserve bee genetic resources.

For the development of the industry, the following targets must be met:

- Continuous supply of quality queen bees and bee stocks
- Increased production of quality bees and bee products
- Strict quarantine of imported queen bees and bee products
- Designation of bee inspectors per region
- Available channels for financing of industry and research needs
- Creation of bee insurance
- Development of human resource for research and development in beekeeping and for entrepreneurial income generating endeavor

References

Anonymous. 2005. The Bee Industry Roadmap. Retrieved from http://marinduqueland.com/products/downloads/BEEINDUSTRYROADMAP.pdf. Accessed on 25 May 2016.

Cervancia, C.R., A.C. Fajardo JR., A.C. Manila-Fajardo and R.M. Lucero. 2012. Management of Philippine Bees: Stingless Bees and Honey Bees. With Bibliography of Philippine Bees. University of the Philippines Los Banos. ISBN 978-971-547-272-2. 71pp.

Fajardo, Jr. A.C. and Cervancia C.R. 2012. Philippine Apiculture: Status and RD&E Agenda -2012-2016 (A Roadmap for Policy Makers and Stakeholders). pp. 99. UP Los Banos, Laguna. ISBN 978-971-547-308-8.

Harvesting honey from giant honey bees in the Philippines. Retrieved from: http:teca.fao.org/technology/harvesting-honey-giant-honey-bees-Philippines

How to Harvest Honey, Pollen and Propolis from Stingless Bees. Retrieved from: http://teca.fao.org/technology/how-harvest-honey-pollen-and propolis-stingless-beesPhilippine Statistics Authority 2015. Selected Statistics on Agriculture 2015. PSA-CVEA Building. East Avenue, Diliman, Quezon City. Philippines. ISSN 2012-0362.

Propagation of Stingless Bees Using Coconut Shells. Retrieved from: http://teca.fao.org/technology/propagation-stingless-bees-using –coconut-shells

The Research and Development, and Extension Agenda and Programs for the Apiculture Industry

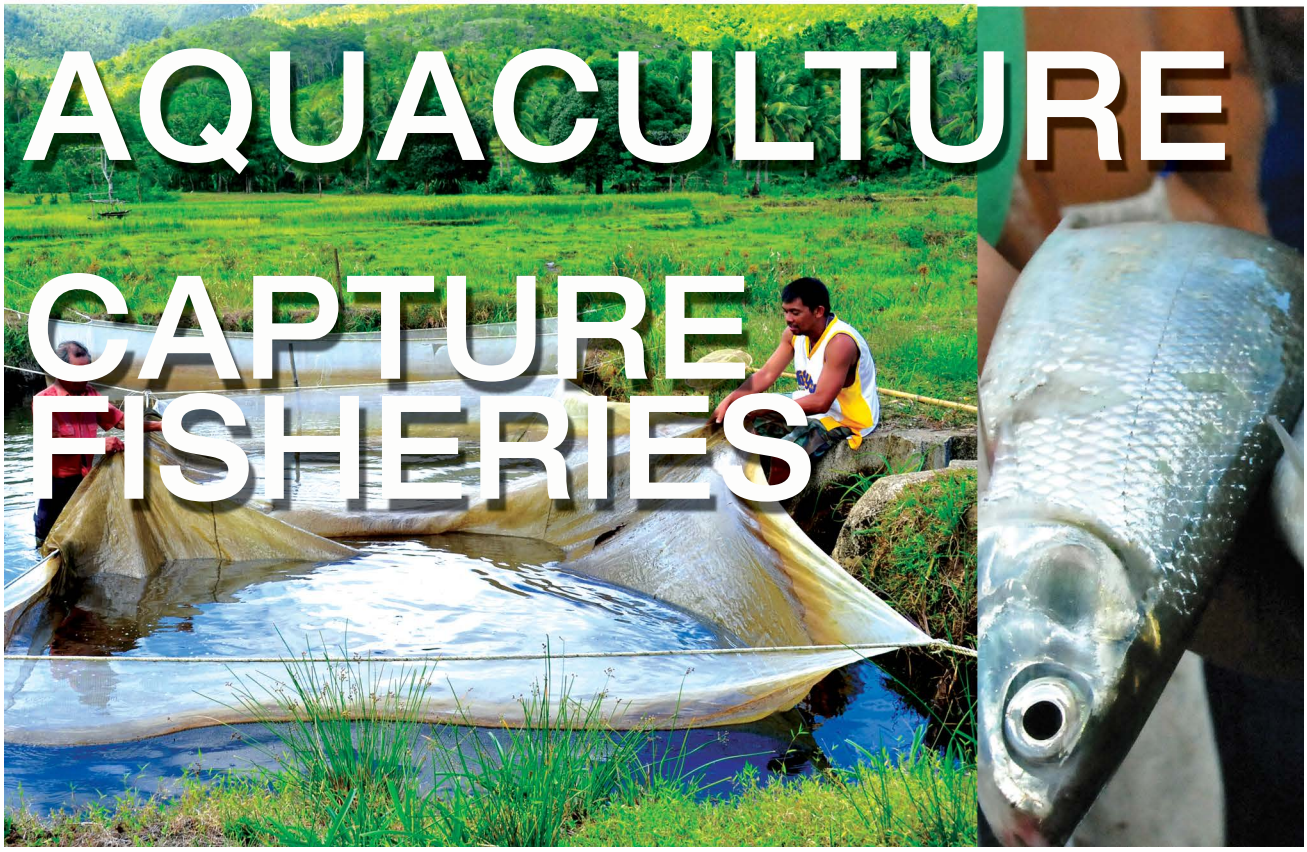
Subsystem	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
Input	Lack of hive designs for various indigenous species	Development of hive designs for *Melipona*	Appropriate hive designs	SUCs, NGO	2016-2017
	Insufficient bee pasture	Development of bee pasture Identify and catalogue annual and perennial bee plants Economic valuation studies on beekeeping	Catalogue/Compendium of bee plants Sustained population of wild and managed pollinators Documentation on the economics of beekeeping	SUCs, DA-RFOs, NGOs	2016-2022
Production	Insufficient colony holdings for native bees	Improvement of mass production techniques	Mass productions techniques Higher number of colonies	SUC, DA-RFOs, NGOs	2017-2019
	Insufficient information on starter colonies	Development of standardized parameters and protocols for tradition and new hive designs (i.e. pollen and honey pots, size of brood)	Established parameters and protocols for starter colonies strength	SUC, DA-RFOs, NGOs	2017-2018
	Occurrence of pest and diseases	Disease profiling (i.e. Ecology, biology and epidemiology of bee pest and diseases in different ecosystems) Development of disease control protocols	Protocols on pest and disease management of bees New lines of miticides, Primer for SHB Control	SUC, DA-RFOs and NGOs	2016-2022

Subsystem	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
		Integrated management of pest (mites, SHB, birds) and diseases (EFB, AFB, chalkbrood)			
	Insufficiency of quality queen supply of *A. mellifera*	Development of quality queens Performance evaluation of queens Establishment of queen rearing program	Package of technology (POT) on queen rearing program Queen and nucleus/starter colonies for dissemination	NARTDI, SUCs	2016-2022
	Lack of information on pollination of native bees with common crops (i.e. solanaceous) under field and controlled conditions	Harnessing the potential of native bees for greenhouse pollination and field conditions Economic valuation studies on pollination	Pollination data Quantified effect on yield Inventory of pollinator species	SUCs, NGOs	2017-2018
Postharvest/ Processing	Unknown composition and functions of stingless bee products	Characterization and standardization of products and by-products (i.e. propolis, wax, bee venom, pollen)	Primer on developed products	SUCs, DA-RFOs and NGOs	2016-2022
	Presence of adulterants/contaminants in bee products	Identification of adulterants/contaminants (i.e. microorganisms, pesticides, heavy metals, veterinary drugs) Identification of maximum residue limit (MRL) of honey	Primer/brochure on identified adulterants and contaminants Safe bee products for animal and human consumption	SUCs, DA-RFOs and NGOs	2016-2022

The Research and Development, and Extension Agenda and Programs for the Apiculture Industry

Subsystem	Problems	Researchable Areas	Expected Outputs	Possible Implementing Agencies	Timelines
Others	Inappropriate, overlapping and unimplemented policies and guidelines for the bee industry	Review, streamlining and removal of redundant policies and guidelines (i.e. quarantine regulation, pollination guidelines, IPR)	Policy recommendations for the bee industry	SUCs, DA-RFOs and NGOs	2016-2022
	Unclear government policies on queen bee importation/regulation	Review of existing policies which cause confusion and difficulty to the industry	Applicable /relevant guideline on Technical SPS regulation	SUCs	2016-2022

Fisheries and Aquaculture


AQUACULTURE
CAPTURE FISHERIES

Economic Importance

Philippine fisheries production, combined from capture and aquaculture, has steadily increased since the 1950s. From 0.230 million tons in 1950, the production steadily increased to 5.160 million tons by 2010, an equivalent average growth of 22.4-fold (PSA, 2015). Since then, total production has been gradually decreasing (2011-2014) attributed to the almost stagnant capture fisheries and declining aquaculture production (Fig.16).

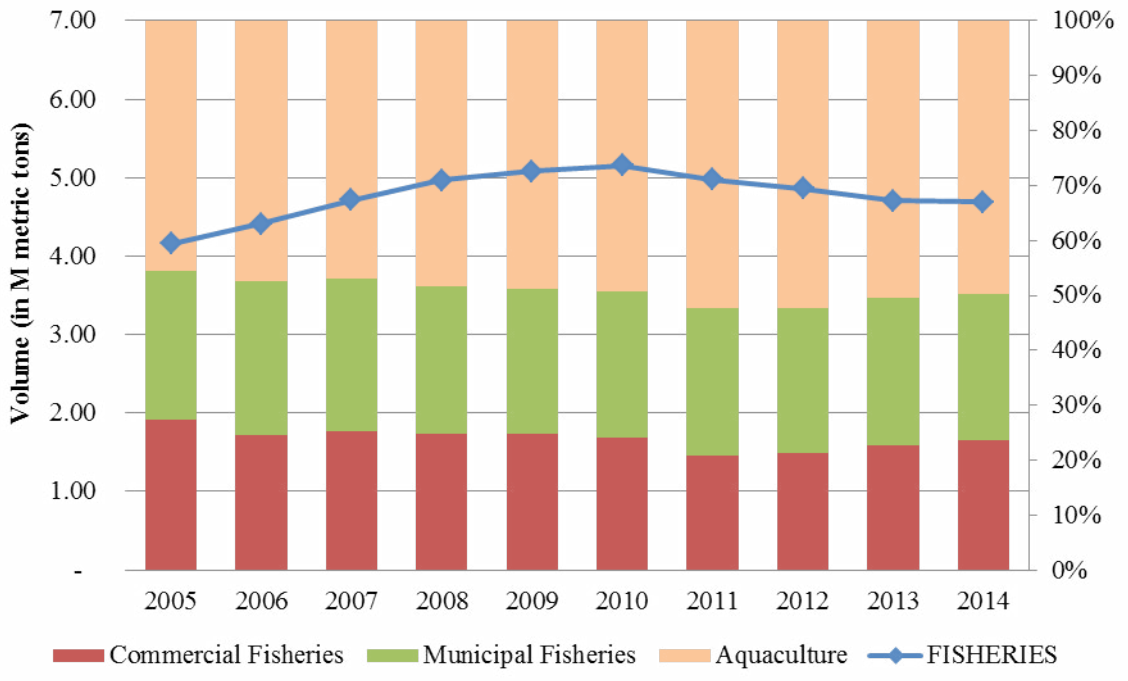


Figure 16. Fisheries and aquaculture production, by subsector, 2005-2014 (Source: PSA, 2015).

The contribution of aquaculture to the country's production has increased dramatically from just 10.7% (25,649 metric tons) in 1950 to 49.85% (2,337.6 metric tons) in 2014, including aquatic plants. Despite advances in aquaculture, there was 1% decline in the fisheries sector production for the period 2013 to 2014 compared to 1.2% growth in the agriculture and forestry sector for the same period (PSA, 2015).

Nevertheless, the fisheries sector contributed almost 242 million pesos in 2014 to the country's economy (BFAR, 2014). In terms of Gross Value Added contribution, the fisheries sector contributed 18.3% in 2014, with a high of 24.4% in 2009 (since 1988) and an average of 20% at constant prices (BFAR, 2014).

Globally, the percentage contribution of Philippine fisheries to world production ranged from 1.2% in 1950 to 2.46% in 2013 (BFAR, 2015). The country's world ranking also improved with its percentage contribution, from 17th place in 1950 to 1965, moving to 5th place in 2010. In 2013, the country ranked 7th in the world.

Fishery exports far exceeded imports with a balance of trade of 1,274 million US$ in 2014. Major exports in terms of value are tuna, seaweeds, crabs and shrimps equivalent to 34.78%, 20.74%, 10.44%, and 9.43%, respectively as of 2014 (BFAR, 2014).

About a million people are employed in the fisheries and fish farming sector. Available census data shows that in the 1990's, 990,872 were under this sector which is estimated at 5% of the country's population. Fishers in the municipal fisheries sector consisted 68% (675,677) while those involved in aquaculture and commercial fisheries sectors comprised 258,480 (26%) and 56,715 (6%), respectively (BFAR, 1995). In the 2002 census, the number of people involved in fisheries increased to more than 1.6 million. There was a marked increase in the number employed in the municipal fisheries sector at close to 1.3 million people (85%), while aquaculture was slightly down to 226,195 (14%) and the commercial sector further reduced to just 16,497 (1%) (BFAR, 2014).

In addition to providing employment, the sector also provides a cheap source of protein to the growing Philippine population. In fact, the country's population grew from 30.9 million in 1965 to 92.3 million in 2010 (NSCB, 2015). This increase in population is accompanied by increase in fish consumption. In 1965, fish consumption of Filipinos was at 23.09 kg/capita/yr. This increased to 39.8 kg/capita/year by 2013. This translates to a total fish consumption of 3.1 tons in 2013 (BFAR, 2015). Fortunately, the continued increase in the country's population was accompanied by an increase in total fish production with aquaculture's contribution increasing significantly in the last decade. If the country's population grows as expected, with a population projection of 110.97 million in 2020, fish consumption would reach 3.5 tons using the average consumption for the last four decades which is close to 32 kg/capita/yr.

Current and Available Technologies

Research and development for the fisheries and aquaculture sector has been improving for the past years. Technologies were developed and created to improve aquaculture techniques and protocols. These technologies include cost-effective feeds, culture techniques, and equipment upgrading. There are also post-harvest technologies that focus on by-product utilization and value addition. Resource assessments, physiological evaluation, and traceability studies are the main knowledge products being generated when it comes to capture fisheries.

Aquaculture

Input (feeds)

- Identified and developed alternative feeds and feed ingredients for commercially important species

Production

- Improved different production systems in ponds, pens and cages (monoculture and polyculture)
- Developed culture techniques for seaweeds
- Improved and developed hatchery and grow-out techniques for blue swimming crabs, oyster, abalone and sea cucumber
- Information on the adaptability of saline and cold-tolerant tilapia
- Enhanced tagging protocols/ techniques for small pelagic fishes

Postharvest and processing

- Developed value-adding technologies for sardines
- Enhanced product development techniques for seaweed and shrimp
- Identified appropriate packaging materials for sea cucumber products
- Developed techniques and protocols for detection of pathogens and toxins
- Information on heavy metal contaminations of some commercially important fishery commodities
- Developed extraction techniques for chitosan production
- Product promotion and commercialization of Window Pane Oyster
- Developed protocols/techniques in ensuring food safety of some commercially important fishery commodities

Capture Fisheries

- Data on resource assessment and profiling
- Fishing gear and fish catch assessment data
- Documentations on reproductive biology of high value species
- Toxicological studies on aquatic species and locations
- Information on heavy metal contaminations of some commercially important fishery commodities

Industry and RDE Sector Goals

To attain the vision of a sustainable and competitive fisheries industry, the Medium-Term (2016-2020) Comprehensive National Fisheries Industry Development Plan (CNFIDP) identified the following objectives:

- sufficient contribution to national food security,
- inclusive growth within the industry,
- sustainable, science-based fisheries and aquatic resources management practices,
- compliance to international laws, policies, and standards, and enforcement of local laws and regulations,
- strengthened capacities in infrastructure, technologies, human resource, and information sharing, and
- resilience to environmental hazards

To achieve these goals, targets were developed through the combination of science-based information as presented by resource persons from the academe and research institutions, and actual observed situational information from industry front liners (CNFIDP-BFAR, 2016).

In support of these objectives, the Fisheries and Aquaculture RDE sector will be able significantly contribute to the sectoral development targets (as indicated in the CNFIDP) by continuously engaging in demand-driven and outcomes-based RDE initiatives in the areas of:

- technology development, innovation, and commercialization,
- capacity building of human resources and strengthening of institutions,
- knowledge-products and information systems development, and
- documentation and assessments of fisheries and aquatic resources, technologies, programs and policies

The RDEAP for fisheries and aquaculture is also consistent and supportive of national priorities and programs and considers cross-cutting concerns such as (1) climate change, (2) gender and development, (3) biotechnology, (4) organic aquaculture, (5) inclusivity, (6) infrastructure, and (7) mechanization.

References

Bureau of Fisheries and Aquatic Resources. Comprehensive National Fisheries Industry Development Plan Medium-Term Update 2016-2020. Diliman, Quezon City, Philippines. pp 16-20.

Bureau of Fisheries and Ocean Sciences. Retrieved from: http://www.bfar.da.gov.ph.Accessed 17 March 2016.

National Statistics Coordination Board. Retrieved from: http://www.nap.psa.gov.ph.Accessed 17 March 2016.

Philippine Statistics Authority. Retrieved from: http://www.psa.gov.ph. Accessed 17 March 2016.

Philippine Statistics Authority. Selected Statistics on Agriculture 2015.PSA-CVEA Building, East Avenue, Diliman, Quezon City, Philippines. pp 25-30.

The Research and Development, and Extension Agenda and Programs for the Aquaculture Industry

System	Problems	Researchable Areas	Specific Commodities	Expected Outputs	Possible Implementing Agencies	Timelines
Input - seeds	Disease Outbreak	Site characterization for seaweeds nursery sites to hold tissue-cultured propagules	Seaweeds	Maps of suitable sites for seaweeds nursery	BFAR-NFRDI, SUCs	2016-2017
		Assessment of population of crablets in specific spawning areas	Crabs	Spawning maps and patterns for policy recommendations	BFAR-NFRDI, SUCs	2016-2018
		Refinement/adaptation of existing shrimp rearing procedures for small/medium-scale farmers	Shrimps	Small/medium-scale hatcheries adapt refined protocols (10% more)	BFAR-NFRDI, SUCs	2016-2018
		Development of disease management strategies	Seaweeds, Shrimps & Crabs	Diagnostic kits and vaccines	SUCs, PhilMech, SEAFDEC	2016-2022
	Limited volume and accessibility of planting materials and seeds	Development and refinement of nursery systems for tissue-cultured and farm-grown seaweeds	Seaweeds	Maps of suitable sites for seaweeds nursery and protocol for nursery establishment and operation for seaweeds	BFAR-NFRDI, SUCs, SEAFDEC	2016-2018

System	Problems	Researchable Areas	Specific Commodities	Expected Outputs	Possible Implementing Agencies	Timelines
		"Resource need" mapping	Milkfish & Seaweeds	Resource gap maps	BFAR-NFRDI, SUCs, SEAFDEC, WorldFish	2016-2018
		Characterization for seaweeds nursery sites to hold tissue-cultured/farm-produced propagules before transferring to grow-out farms	Seaweeds	Maps of suitable sites for seaweeds nurseries; site characterization and protocol for characterization	BFAR-NFRDI, SUCs, SEAFDEC	2016-2018
		Refinement of nursery system for milkfish to ensure sufficient supply for grow-out production	Milkfish	Protocol to reduce mortality rate of milkfish (25% from fry to fingerling)	SEAFDEC, SUCs	2016-2018
	Limited source of quality broodstock	Selection of disease-resistant strains	Seaweeds	Disease-resistant parent stocks	BFAR-NFRDI, SUCs	2016-2018
		Development of parent stocks (e.g marker assisted breeding)	Shrimps, Tilapia & Crabs	Genetically diverse source of parent stocks; Protocol for broodstock maintenance and documentation; Germplasm collection	BFAR-NFRDI, SUCs, SEAFDEC, WorldFish	2016-2022

System	Problems	Researchable Areas	Specific Commodities	Expected Outputs	Possible Implementing Agencies	Timelines
		Development of disease management strategies	Milkfish, Shrimps, Crabs, Seaweeds & Tilapia	Diagnostic kits and vaccines	BFAR-NFRDI, SUCs, SEAFDEC	2018-2022
Input - Feeds	Low nutritional value of feeds for larval rearing and hatchery	Validation/piloting of existing protocols and formulation to enhance growth and quality of seedstock (e.g. probiotics, nutraceuticals, etc)	Crabs & Shrimps	Manuals and protocols on enhancing nutritional value of feeds for larval rearing	BFAR-NFRDI, SUCs, SEAFDEC	2016-2018
	Feed contamination (e.g. heavy metal, antibiotic residues, aflatoxin, non halal)	Traceability studies for fish feeds and other related inputs	Milkfish, Tilapia, Shrimps	Policy recommendations; standards	BFAR-NFRDI, SUCs	2016-2018
	Unavailability in the market of low cost, high quality feeds for grow out (e.g lugworm)	Validation/piloting of existing cost effective feed formulations using alternative feed materials	Shrimps	Manual and protocol on low cost, high quality feeds; feasibility study on cost effective formulation production	BFAR-NFRDI, SUCs, SEAFDEC, WorldFish	2016-2022

System	Problems	Researchable Areas	Specific Commodities	Expected Outputs	Possible Implementing Agencies	Timelines
Input - Fertilizer	Limited source of organic fertilizer for natural food production in ponds and tanks	Identification of potential sources of organic fertilizers (e.g. seaweed-base)	Milkfish, Tilapia, Shrimps	List of potential organic fertilizers; maps of sources	BFAR-NFRDI, SUCs	2016-2017
Production	Inefficient and low production	Refinement of site specific protocols for improving productivity	Seaweeds, Milkfish, Tilapia, Shrimps & Crabs	Improved site specific production protocols and manuals	SEAFDEC, BFAR-NFRDI, SUCs, WorldFish	2016-2018
		Validation and piloting of existing IMTA and other integrated aquaculture systems	Seaweeds, Milkfish, Tilapia, Shrimps & Crabs	Manuals and protocols on establishment of Integrated multi-trophic aquaculture (IMTA) systems	SEAFDEC, BFAR-NFRDI, SUCs	2016-2022
	Unsuitable sites for production	Suitability assessment/site characterization to open areas for production	Seaweeds and Crabs	Maps	SEAFDEC, BFAR-NFRDI, SUCs, WorldFish	2016-2018
	Unknown carrying capacity of production areas	Assessment of carrying capacity	Seaweeds, Milkfish, Tilapia, Shrimps & Crabs	Standards (area and stocking density)	SEAFDEC, BFAR-NFRDI, SUCs, WorldFish	2016-2018

System	Problems	Researchable Areas	Specific Commodities	Expected Outputs	Possible Implementing Agencies	Timelines
	Disease Outbreak	Development of disease management strategies	Seaweeds, Shrimps & Crabs	Diagnostic kits and vaccines	BFAR-NFRDI, SUCs, SEAFDEC,	2018-2022
Postharvest/ Processing	Low quality processed fish products (as per CNFIDP species) resulting to low competitive-ness	Assessment of the knowledge, attitude, and practices of food handling, food safety and processing systems including shelf-life	Seaweeds, Milkfish, Tilapia, Shrimps & Crabs	IEC, policy recommendations, standards	SUCs, BFAR-NFRDI	2016-2017
		Development of product standards	Crabs & Seaweeds	Policy recommendations and standards	SUCs, BFAR-NFRDI	2016-2018
		Packaging development using alternative materials	Seaweeds, Milkfish, Tilapia, Shrimps & Crabs	IP on packaging materials	SUCs, BFAR-NFRDI	2016-2019
		Value chain analysis and development	Seaweeds, Milkfish, Tilapia, Shrimps & Crabs	Policy recommendations; strategies for commercialization and marketing	SUCs, BFAR-NFRDI, WorldFish	2016-2020
Marketing	Lack of management of post-harvest wastes	Development and utilization of fish waste	Seaweeds, Milkfish, Tilapia, Shrimps & Crabs	Policy recommendations, manual and protocol, IP	SUCs, BFAR-NFRDI	2016-2018

System	Problems	Researchable Areas	Specific Commodities	Expected Outputs	Possible Implementing Agencies	Timelines
	Insufficient / Limited access to marketing information on fishery products	Value chain analysis and development of fresh and processed fishery products	Seaweeds, Milkfish, Tilapia, Shrimps & Crabs	Policy recommendations; IEC	SUCs, NGOs, WorldFish	2016-2019
	Limited knowledge on market and marketing systems and trends	Effectiveness of different modalities (e.g. online, media, product marketing networking, eco-tourism, market intelligence) of product promotion	Seaweeds, Milkfish, Tilapia, Shrimps & Crabs	Policy recommendations; IEC	SUCs, NGOs	2016-2019
		Market (MSMEs) research/assessments	Seaweeds, Milkfish, Tilapia, Shrimps & Crabs	Policy recommendations	SUCs, BFAR-NFRDI	2016-2018
		Development of decision support systems for efficient marketing strategies (e.g Technologies for real time information)	Seaweeds, Milkfish, Tilapia, Shrimps & Crabs	Application tools (e.g. Software)	DOST, SUCs, BFAR-NFRDI	2016-2018
		Understanding small and medium scale enterprises (capacitation, involvement of financial institutions)	Seaweeds, Milkfish, Tilapia, Shrimps & Crabs	Policy recommendation, socio-economic profile, training program, modules	SUCs	2016-2018

System	Problems	Researchable Areas	Specific Commodities	Expected Outputs	Possible Implementing Agencies	Timelines
Policy and Governance	Limited information/knowledge on impacts of R&D projects	Impact assessment, project benefit monitoring and evaluation, and benchmarking based on the industry.	Seaweeds, Milkfish Tilapia, Shrimps & Crabs	Policy recommendations	BFAR-NFRDI, SUCs, NGOs	2016-2022
Cross-cutting Concerns	Threats from invasive and alien species	Assessment of Ecological and economic implications;	Seaweeds, Milkfish, Tilapia, Shrimps & Crabs	Policy recommendations	SUCs, BFAR-NFRDI, SEAFDEC	2017-2022
		Risk assessment for potential invasive and alien species; assessment of sources of invasive and alien species (e.g ballast water)	Seaweeds, Milkfish, Tilapia, Shrimps & Crabs	Policy recommendations	SUCs, BFAR-NFRDI, SEAFDEC	2017-2022
		Control / Preventive measures	Seaweeds, Milkfish, Tilapia, Shrimps & Crabs	Protocols, manuals	SUCs, BFAR-NFRDI, SEAFDEC	2017-2022
	Lack of updated and comprehensive assessment on socio economic conditions of	Assessment of the socioeconomic conditions of fish workers; gender production gaps analysis and trade-offs	Seaweeds, Milkfish, Tilapia, Shrimps & Crabs	Policy recommendations, updated baselines	BFAR-NFRDI, SUCs	2016-2022

System	Problems	Researchable Areas	Specific Commodities	Expected Outputs	Possible Implementing Agencies	Timelines
	fish workers including gender concerns					
	Lack of information on traceability of fish and fish related products (e.g IUU)	Traceability studies for all fish and fish related products	Seaweeds, Milkfish, Tilapia, Shrimps & Crabs	Policy recommendations, protocol for establishing traceability	BFAR-NFRDI, SUCs	2017-2019
	Contamination (e.g. heavy metal, antibiotic residues, aflatoxin, non halal materials)	Assessment of the sources, extent and implications of contamination	Seaweeds, Milkfish, Tilapia, Shrimps & Crabs	Policy recommendations	BFAR-NFRDI, SUCs	2016-2019

The Research, Development, and Extension Agenda and Programs for the Capture Fisheries Industry

System	Problems	Researchable Areas	Specific Commodities	Expected Outputs	Possible Implementing Agencies	Timelines
Production	Unknown status of natural population of important marine and inland commodities and emerging species.	Law enforcement security strategies undertaken by the government	Marine: Tuna, Small Pelagics, Swimming Crabs, Shellfishes, Cephalopods, Live reef fishes; Inland: Goby, Sinarapan, indigenous and emerging species	Maps of major fishing grounds to ensure protection and maritime security	BFAR-NFRDI, NGOs, SUCs	2016-2017
		Application of stock assessment results for fisheries management		Reference points (MSY, CPUE), Maps/Atlases, (at least 13 FMAs)	BFAR-NFRDI, NGOs, SUCs	2016-2017
		Population structure in major fishing grounds (e.g using genetics, tagging, biology)		Policy recommendations Information on population structure of major fishing grounds	BFAR-NFRDI, NGOs, SUCs	2016-2018
	Declining production from the wild of important marine and inland commodities and emerging	Impact assessment of Fish Aggregating Devices	Marine: Tuna, Small Pelagics, Swimming Crabs, Shellfishes, Cephalopods,	Policy recommendations for fisheries management	SUCs, NGOs	2016-2018
		Impact assessment of existing fishing gears and methods		Policy recommendations	SUCs, NGOs, BFAR-NFRDI	2016-2018

System	Problems	Researchable Areas	Specific Commodities	Expected Outputs	Possible Implementing Agencies	Timelines
	species.		Live reef fishes; Inland: Goby, Sinarapan, indigenous and emerging species	for fisheries management		
				Policy recommendations	SUCs, NGOs, BFAR-NFRDI	2016-2018
		Productivity and population abundance assessment on major spawning grounds		Information on Productivity and population abundance; Policy recommendations	BFAR-NFRDI, SUCs	2016-2018
		Development of appropriate gear technology		Improved gear design and method	BFAR-NFRDI, SUCs	2016-2022
		Reproductive Biology		Policy recommendations to serve as aquaculture input Policy recommendation for implementation of closed season	BFAR-NFRDI, SUCs	2016-2022

System	Problems	Researchable Areas	Specific Commodities	Expected Outputs	Possible Implementing Agencies	Timelines
	Overexploited traditional fishing grounds	Characterization of other potential fishing grounds (e.g West Phil Sea, Benham Rise, Batanes Waters)	Marine: Tuna, Small Pelagics, Swimming Crabs, Shellfishes, Cephalopods, Live reef fishes; Inland: Goby, Sinarapan, indigenous and emerging species	Profile of alternative fishing grounds	BFAR-NFRDI, SUCs	2016-2019
		Impact assessment of close fishing season		Policy recommendations; indicators of performance	BFAR-NFRDI, SUCs, WorldFish	2016-2022
		Development and/or identification of technology (boat and gear) appropriate for alternative fishing grounds		Policy recommendations	BFAR-NFRDI, SUCs, NGOs	2016-2022
Postharvest/ Processing	Inadequate postharvest technologies - land based	Postharvest technologies for value adding/processing	Marine: Tuna, Small Pelagics, Swimming Crabs, Shellfishes, Cephalopods, Live reef fishes; Inland: Goby, Sinarapan, indigenous and emerging species	Value-adding technologies	SUCs, BFAR-NFRDI	2016-2022
	Low quality processed fish products (as per CNFIDP species) resulting to low competitiveness	Assessment of the knowledge, attitude, and practices of food handling, food safety and processing systems including shelf-life		IEC, policy recommendations, standards	SUCs, BFAR-NFRDI	2016-2017

System	Problems	Researchable Areas	Specific Commodities	Expected Outputs	Possible Implementing Agencies	Timelines
		Development of product standards		Policy recommenda-tions and standards	SUCs, BFAR-NFRDI	2016-2018
		Packaging development using alternative materials (double check)		IP on packaging materials	SUCs, BFAR-NFRDI	2016-2019
		Value chain analysis and development		Policy recommendatio ns; strategies for commercializati on and marketing	SUCs, BFAR-NFRDI, WorldFish	2016-2020
	Post harvest losses for small and medium scale fishing operations	Baseline study (including commercial)		Baseline information on post-harvest losses	BFAR-NFRDI, SUCs	2016-2018
		Appropriate gears, boat designs, and systems to reduce postharvest losses		Policy recommendatio ns, protocols	BFAR-NFRDI, SUCs	2016-2019
Marketing	Limited knowledge on market and marketing systems and trends	Market (MSMEs) research/ assessments	Marine: Tuna, Small Pelagics, Swimming Crabs, Shellfishes, Cephalopods,	Policy recommenda-tions	SUCs, BFAR-NFRDI	2016-2018
		Development of decision support systems for efficient marketing strategies (e.g Technologies for		Application tools (e.g. Software)	DOST, SUCs, BFAR-NFRDI	2016-2018

System	Problems	Researchable Areas	Specific Commodities	Expected Outputs	Possible Implementing Agencies	Timelines
		real time information)	Live reef fishes; Inland: Goby, Sinarapan, indigenous and emerging species			
		Understanding small and medium scale enterprises (capacitation, involvement of financial institutions)		Policy recommendations, socio-economic profile, training program, modules	SUCs	2016-2018
		Effectiveness of different modalities (e.g. online, media, product marketing networking, eco-tourism, market intelligence) of product promotion		Policy recommendations, IEC	SUCs, NGOs	2016-2019
By-product utilization and Waste Manage-ment	Lack of management on post-harvest wastes	Development and utilization of fish waste	Marine: Tuna, Small Pelagics, Swimming Crabs, Shellfishes, Cephalopods, Live reef	Policy recommendations, manual and protocol, IP	SUCs, BFAR-NFRDI	2016-2018

System	Problems	Researchable Areas	Specific Commodities	Expected Outputs	Possible Implementing Agencies	Timelines
			fishes; Inland: Goby, Sinarapan, indigenous and emerging species			
Policy and Gover-nance	Lack of traceability system (domestic)	Electronic-based system technology for monitoring and regulation of port-state, flag-state and market-state of the fisheries resources	Marine: Tuna, Small Pelagics, Swimming Crabs, Shellfishes, Cephalopods, Live reef fishes; Inland: Goby, Sinarapan, indigenous and emerging species	Manual, database, and certification for the traceability system	BFAR-NFRDI, SUCs, NGOs	2016-2022
		Low cost Vessel Monitoring System (VMS)		Improved, low-cost equipment for VMS	SUCs, NGOs	2016-2022
	Limited knowledge/skills of personnel in markets, ports and boats (domestic)	Needs assessment of fish workers and other		Policy recommendations, Training programs	BFAR-NFRDI, SUCs, NGOs	2016-2020
	Limited information/knowledge on impacts of R&D projects and of management strategies	Impact assessment, project benefit monitoring and evaluation, and benchmarking based on the industry.		Policy recommenda-tions	BFAR-NFRDI, SUCs, NGOs	2016-2022

System	Problems	Researchable Areas	Specific Commodities	Expected Outputs	Possible Implementing Agencies	Timelines
		Impact assessment of closed season for specific commodities		Policy recommenda-tions	BFAR-NFRDI, SUCs, NGOs	2016-2022
	Lack of scientific basis for the 15km municipal waters	Biophysical profiling (bathymetry, continental shelf, current)		Maps, policy recommenda-tion	SUCs, NGOs, NAMRIA, Coast guard	2016-2022
Cross-cutting concerns	Threats from invasive and alien species	Assessment of Ecological and economic implications;	Marine: Tuna, Small Pelagics, Swimming Crabs,	Policy recommenda-tions	SUCs, BFAR-NFRDI, SEAFDEC	2017-2022
		Risk assessment for potetial invasive and alien species; assessment of sources of invasive and alien species (e.g ballast water)	Shellfishes, Cephalopods, Live reef fishes; Inland: Goby, Sinarapan, indigenous and emerging species	Policy recommenda-tions	SUCs, BFAR-NFRDI, SEAFDEC	2017-2022
		Control / Preventive measures		Protocols, Manuals	SUCs, BFAR-NFRDI, SEAFDEC	2017-2022
	Lack of updated and comprehensive assessment on socio economic conditions of fish workers including	Assessment of the socioeconomic conditions of fish workers; gender production gaps analysis and trade-offs	Marine: Tuna, Small Pelagics, Swimming Crabs, Shellfishes,	Policy recommendatio ns, Updated baselines	BFAR-NFRDI, SUCs	2016-2022

System	Problems	Researchable Areas	Specific Commodities	Expected Outputs	Possible Implementing Agencies	Timelines
	gender concerns		Cephalopods, Live reef fishes; Inland: Goby, Sinarapan, indigenous and emerging species			
	Lack of information on traceability of fish and fish related products (e.g IUU)	Traceability studies for all fish and fish related products		Policy recommendations, Protocol for establishing traceability	SUCs, BFAR-NFRDI	2017-2019
	Contamination (e.g. heavy metal, antibiotic residues, aflatoxin, non halal materials)	Assessment of the sources, extent and implications of contamination		Policy recommendations	SUCs, BFAR-NFRDI	2016-2019
	Limited information on toxic marine species	Profiling of toxic marine commodities with reference to species, area, market-supply chain, and traceability		Policy recommendations, Profile of toxic marine species	BFAR-NFRDI, SUCs	2016-2018

ANNEX

LIST OF RDEAP 2016-2022 PARTICIPANTS

DA-Regional Field Offices (Research Divisions/Centers)

Regional Field Office CAR
Regional Field Office I
Regional Field Office II
Regional Field Office III
Regional Field Office IVA
Regional Field Office IVB
Regional Field Office V
Regional Field Office VI
Regional Field Office VII
Regional Field Office VIII
Regional Field Office IX
Regional Field Office X
Regional Field Office XI
Regional Field Office XII
Regional Field Office CARAGA
Regional Field Office ARMM
Negros Island Region

BFAR-Regional Offices (Regional Fisheries Research and Development Centers)

Regional Office CAR
Regional Office I
Regional Office II
Regional Office III
Regional Office IVA
Regional Office IVB
Regional Office V
Regional Office VI
Regional Office VII
Regional Office VIII
Regional Office IX
Regional Office X
Regional Office XI
Regional Office XII
Regional Office CARAGA
Regional Office ARMM

State Universities and Colleges (SUCs)

Aurora State College of Technology (ASCoT)
Benguet State University (BSU)
Bicol University (BU)
Camarines Norte State College (CNSC)
Cavite State University (CvSU)
Central Bicol State University of Agriculture (CBSUA)
Central Luzon State University (CLSU)
Central Mindanao University (CMU)
Isabela State University (ISU)
Mariano Marcos State University (MMSU)
Mindoro State College of Agriculture and Technology (MinSCAT)
Nueva Vizcaya State University (NVSU)
Pampanga State Agricultural University (PSAU)
Partido State University (PSU)
Southern Luzon State University (SLSU)
Tarlac College of Agriculture (TCA)
University of the Philippines Diliman (UPD)
University of the Philippines Los Baños (UPLB)
University of the Philippines Visayas (UPV)
University of Southern Mindanao (USM)
Visayas State University (VSU)
Western Philippines University (WPU)

DA-Bureaus, Agencies, Corporations and other Offices

Agribusiness and Marketing Assistance Services (AMAS)
Agricultural Training Institute (ATI)
Bureau of Agriculture and Fisheries Standards (BAFS)
Bureau of Animal Industry (BAI)
Bureau of Fisheries and Aquatic Resources (BFAR)
Bureau of Plant Industry (BPI)
Bureau of Soils and Water Management (BSWM)
National Corn Program
National Dairy Authority (NDA)
National Fisheries Research and Development Institute (NFRDI)
National Food Authority–Food Development Center (NFA-FDC)
National High Value Crops Development Program
National Livestock Program
National Meat Inspection Service (NMIS)
National Tobacco Administration (NTA)
National Organic Agriculture Program
National Rice Program
Philippine Carabao Center (PCC)
Philippine Center for Postharvest Development and Mechanization (PhilMech)
Philippine Coconut Authority (PCA)
Philippine Council for Agriculture and Fisheries (PCAF)
Philippine Fiber Industry Development Authority (PhilFIDA)
Philippine Rice Research Institute (PhilRice)
Philippine Rubber Research Institute (PRRI)
Sugar Regulatory Administration (SRA)
Systems-Wide Climate Change Office (SWCCO)
Biotechnology Program Implementation Unit (Biotech-PIU)
Crop, Fisheries and Livestock Biotech Centers

NGAs

Climate Change Commission (CCC)

National Economic and Development Authority (NEDA)

Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCAARRD)

NGOs/CSOs/Private Sectors & Other Partners

Agricultural Sector Alliance of the Philippines (AGAP)

Centro Saka Inc.

Inang Lupa Movement

National Mango Action Team (NMAT)

OCEANA

Organization for Partnership, Teamwork & Initiatives on Opportunities for Nature Stewards, Inc. (OPTIONS Inc.)

Philippine Maize Federation (PhilMaize)

Philippine Rural Reconstruction Movement (PRRM)

Philippine Veterinary Drug Association (PVDA)

Rice Watch and Action Network

Southeast Asian Fisheries Development Center (SEAFDEC)

Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA)

Tambuyog Development Center (TDC)

The WorldFish Center

TRACSYS Incorporated

UPLB Foundation Inc. (UPLBFI)

Republic of the Philippines
Department of Agriculture
BUREAU OF AGRICULTURAL RESEARCH

Visayas Ave.cor.Elliptical Road, Diliman, Quezon City
TRUNKLINES: (632) 928-8624, 928-8505, 920-9791, 928-4907
FAX: (632) 927-5691
Website: www.bar.gov.ph

This RDEAP 2016-2022 was prepared in collaboration with the
Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA)
and WorldFish.