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Agricultural Technology: Why Does the Level of Agricultural Production Remain Low Despite Increased Investments in Research and Extension?

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Agricultural Technology:
Why Does the Level of Agricultural Production Remain Low Despite Increased Investments in Research and Extension?

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Abstract

Adoption of new practices and technologies influences farm productivity and agricultural growth. Countries invest in research and extension to ensure continuous growth both at the farm and industry level. This chapter investigates agricultural technology production, its knowledge transfer, and farm and industry level performance. It is divided into three sections: (1) the structure and the financing of agricultural technology production and transfer, (2) technology promotion and adoption (3) conclusions and recommendations for the Philippine agricultural technology innovation systems.

The study used the agricultural innovation systems (AIS) as lens in investigating the agricultural performance of the country, focusing on rice and swine industry. AIS examines the institutions and policies that create and put innovations to economic use. In AIS, adoption studies cannot be separated from the research and extension functions of the government as they are presumed to directly affect the uptake of these innovations. The study used descriptive – explanatory research design to explain the agricultural performance by gathering official statistics from various government agencies and data repositories, reviewing published studies, and conducting key informant interviews. Secondary data review and key informant interviews were conducted to gather institutional and farm level data on rice farmers and swine raisers, two industries which contribute significantly to the gross value added.

The governance of RDE continues to be negatively affected by the overlaps among RDIs and fragmentation of extension. The government continues to underinvest in research, the bulk of which goes to the rice program. Extension programs focus primarily on the distribution of private goods. The promotion of hybrid rice and farm machinery represented sizable investments, but adoption of these had not been widespread. The swine industry, on the other hand, continues to rely on imported inputs for nutrition and biologics. Recommendations focus on further minimizing inefficiencies in the research and extension functions of the government institutions.

Keywords: technological promotion, adoption, agricultural growth, agricultural innovation systems, agricultural performance

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Agricultural Technology and Innovations: Why Does the Level of Agricultural Production Remain Low Despite Increased Investments in Research and Extension?

Rowena T. Baconguis*

1. Introduction

The growth of the Philippine agriculture in the early 19^{th} century onwards can be traced to the expansion of agricultural production of large tracts of unused land and exploitation of natural resources (Hayami, 2000). With increasing urbanization, the source of agricultural growth becomes more and more dependent on technological innovation and its adoption.

Crucial to agricultural development is the adoption of new technologies at the farm level. Adoption of technology, however, is a complex phenomenon. At the farmer level, adoption of technology is affected by demographic, socio-economic and cultural factors. At the institutional level, adoption is affected by the generation and dissemination of technologies that are critical tasks of research and extension institutions. Research and extension policies and operational efficiency are requisites in ensuring sustained innovations. Technology dissemination by the government is important in influencing adoption, which is then expected to translate to agricultural development of a particular industry. To validate the theory of change on technology generation, dissemination, adoption and agricultural performance, this study investigated research and extension institutions and dissemination of selected technologies which were prioritized by the government. Review of previous studies, secondary data, and key informant interviews were gathered to analyze how the research and extension institution influence farm level productivity and agricultural development.

2. Research Design and Methodology

The descriptive – explanatory research design was employed to seek explanation on adoption of technologies and resulting agricultural performance at the farm and industry level. Official statistics were gathered from various government agencies and data repositories, published studies were reviewed, and key informants were interviewed.

The study is guided by concepts of the agricultural innovation systems (AIS). Rajahati, Jannsen, and Pehu (2008, p.3) defines the innovation system as "a network of organizations, enterprises, and individuals focused on bringing new products, new processes and new forms of organizations into economic use, together with the institutions and policies that affect their behavior and performance".

The theory of change applied in this study is illustrated in Figure 1. Management factors related to intervention-related activities like planning, human resource complementation and financing of research and extension institutions were described in terms of adherence to efficiency principles.

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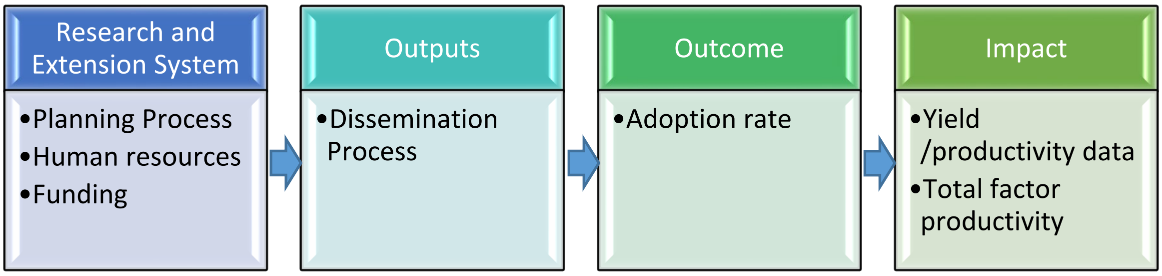
Figure 1. Theory of change



The research and extension governance system are assumed to influence the production and dissemination of priority technologies of the government. Cases on technology promotion and dissemination in the rice and swine industry were chosen to shed light on the how these have resulted to changes in farmer practices and total productivity of the agricultural sector. The government's investment in the distribution of subsidized seeds, conduct of farmer field schools, IEC dissemination will greatly influence farmer practices and lead to adoption of the technology. The rice and swine industry were chosen as these significantly contribute to the gross value added in agriculture. For the rice industry, studies about large-scale government programs involving dissemination of hybrid rice and farm mechanization were reviewed. The study also reviewed studies on the swine industry which rely more on technologies and extension services from the private sector. These cases provide better understanding of how research and extension programs influence farmer practices and impact agricultural performance. The theory of change serves as the analytical framework to identify policy directions to improve the agricultural innovation system of the country.

3. Agricultural Innovation System

Research is critical in the development of any agriculture sector. The establishment of public agricultural research institutions led to the transformation in the agricultural sector (Ruttan in Rawat, 2020). Literature affirms that investments in research and development (R&D) stimulated growth in total factor productivity and increased potentials to reduce poverty (Fuglie et al. 2020). In the Philippines, the research function is shared by several government agencies and state colleges and universities.

3.1 Agricultural Technology Production Sub-system

The Department of Agriculture (DA) performs policy making, regulation, research and extension functions on agriculture spread over the various bureaus, attached agencies, corporations, and regional field offices. DA is composed of 8 bureaus, 9 attached agencies, 8 attached corporations. DA has 10 commodity focused institutions such as FIDA, PCC, PRRI, PhilRice, PCA, BAI, BPI, NDA, NTA and SRA which conduct research and extension functions. At the regional level, DA operates 15 regional field offices which serve as the primary agency responsible for the promotion of agricultural development. Each regional office maintains a Regional Integrated Agriculture Research Center (RIARC) which focuses on research on farming systems for crops and/or livestock.

The Department of Science and Technology, (DOST) through the Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCAARRD), formulates policies, plans, and programs for S&T research in AANR. Supporting PCAARRD in its research thrusts are the regional consortia composed of SUCs, government agencies and members from the private sector. The consortia are PCAARRD's partners in its R&D and technology management. Another DOST council is the Philippine Council for Industry, Energy, and Emerging Technology Research and Development which supports the development of priority sectors, including AANR.

On the other hand, the Department of Environment and Natural Resources (DENR) manages the conservation and development of the country's natural resources. The Ecosystems Research and Development Bureau (ERDB) is the main R&D unit of DENR which focuses its research, development, and extension (RDE) activities on forests, upland farms, grasslands and degraded areas, coastal zones, and freshwater and urban areas. These three national agencies provide direction in the management of the issues affecting agricultural research, development and extension priorities of the country.

Cognizant of the technologies produced by muti-national and local private companies involved in the marketing of agricultural input supplies such as seeds, fertilizers, feeds, animal breeds, the government agencies partner with the private sector as it seeks to make important inputs affordable and accessible to the farmers through it special programs, such as the promotion of hybrid seeds. The government likewise engages international organizations in the conduct of research and extension programs, such as the World Bank, which funds the Philippine Rural Development Program or PRDP. PRDP is a project funded by the World Bank and implemented by the DA in partnership with local government units and the private sector which seeks to climate proof and modernize the agricultural and fisheries sector.

Actively supporting the research and extension functions of the executive branch are the higher educational institutions which, by nature of their functions, conduct research and extension. HEIs get funding support mainly from the line agencies and international private research organizations. Gert-Jan Stads et al. (2020) notes that the Philippines had the greatest number of agricultural research institutions dispersed in 24 government agencies and 55 active Higher Education Institutions (HEIs). This structure reflects the need for extensive coordination given that bigger countries such as Indonesia only have 15 government agencies and 44 HEIs and Thailand has 8 government agencies and 33 HEIs. Thus remains the nagging question of how these overlapping concerns are harmonized at the executive branch.

3.1.1 Coordination and planning within the sub-system

The Agricultural and Fisheries Modernization Act (AFMA) of 1997 is the major legislation which guides the agricultural sector. EO 127 of 1999 mandated the constitution of the Council for Extension Research and Development in Agriculture and Fisheries (CERDAF) which is tasked to oversee the implementation of a responsive research development and extension

(RDE)program for agriculture and fisheries through the National Research and Development System in Agriculture and Fisheries (NARDSAF) and the National Extension System for Agriculture and Fisheries. AFMA likewise recommended the creation of the National Information Network (NIN) which should consolidate and collect relevant information on agriculture fisheries to make it easy to access data and thus, serve as a link to research institutions. The potential of NINs as a data minefield that could link research institutions is much anticipated to this day.

The Department of Agriculture-Bureau of Agricultural Research (DA-BAR) and PCAARRD both sought to address the lack of a national agenda for AANR by crafting an RDE plan through multi-stakeholder consultations. The former used the value chain approach as the framework for priority RDE programs while the latter, while also concerned with commodity plans, emphasized the development of cutting-edge technologies. Both agencies also rely on regional presence, either through regional field offices of DA for DA-BAR and the consortia for DOST, to transfer technologies.

In 2016, BAR conducted a weeklong multi-stakeholder consultation to come up with priority programs for agriculture referred to as the Research, Development and Extension Agenda Program (RDEAP) for 2016-2022. This policy document focused on commodity plans for staples, commercial crops, plantation, poultry, livestock, apiculture, fisheries, and aquaculture using the value chain approach. Because of the time frame of the project, discussions on the long-term plan for the agriculture sector was not emphasized. The identified implementing agencies are mostly also from the Department of Agriculture (DA), except for biofuels where State Universities and Colleges (SUCs) were the dominant actors identified. Even in fruit crops such as pineapple, private sector partnership was not emphasized in the document.

In 2018, DA-BAR revitalized the Regional Research and Development Extension Network (RRDEN) to ensure complementation of RDE Programs and activities among research and development institutions, following the DA-BAR research priorities and the regional priorities set by DA-Regional Field Offices (RFOs) and BFAR-RFOs (DA AO 05 of 2018). Guided by the RDEAP, RRDENs formulates the Regional Integrated RDE Agenda and Program (RIRDEAP) and policies.

In 2017, DOST came up with the Harmonized National R&D Agenda (HNRDA) to provide a roadmap of research among R&D institutions. PCAARRD spearheaded the multi-stakeholder consultations for the agriculture, aquatic and natural resources (AANR) sector. In contrast to the value chain approach of BAR, HNRDA for AANR emphasized the use of emerging technologies such as "biotechnology, genomics, bioinformatics, nanotechnology, nuclear technology, space technology, electronics and automation and use of ICT as R&D tools (DOST 2017, p.26)" were emphasized to develop products to address AANR problems. It also specifies priority commodities where commonalities with RDEAP are observed. In contrast to DA-BAR, PCAARRD prioritizes commodities that have industry potential. Thus, its plans for the commodities are outlined in an Industry Strategic Plan (ISP).

Cognizant of the need to harmonize the research agenda of the country, PCAARRD organized interdisciplinary commodity R&D teams to evaluate research proposals where experts from agencies such as SUCs, private sector and DA are identified. Since DA experts form part of this interdisciplinary team as external reviewers, PCAARRD likewise funds proposals coming from DA. Regional and national R&D symposiums, where research results are presented and recognized, also serve as venues to determine overlaps and identification of complementary undertakings.

Key informants shared that recently (as of September 30, 2021), the leaders of DA-BAR and PCAARRD conducted the Technology Transfer Forum as a convergence initiative to showcase AANR technologies funded by both agencies that were ready for commercialization. Further activities have yet to be defined on how to proceed with the promotion of these technologies to possible investors. With the recent changing of guards at DA-BAR, PCAARRD experts share that new round table discussions will need to be conducted. Rawat (2020) stated that one way to counter R&D volatility is to reduce the fragmented decision making in research, where decisions on funding are made by numerous agencies.

3.1.2 Human Resource Complement

The development of innovations relies on the quantity and quality of human capital in the agricultural innovation system. The quality of research institutions has improved from a low of 106/144 in 2012-2013 countries to 75/137 (2017-2008) based on the Global Competitiveness Report or WEF (DOST, 2017). Through the scholarship programs, DOST hopes to improve the ratio of population and R&D researches, and concludes that with an estimated "10% attrition, 3,663 STEM graduates should be added to the R&D pool every year" (DOST, 2017) In addition, DOST supports RDIs through its Niche Centers in the Regions for R&D (NICER) through the provision of funds for capacity building and infrastructure development, and R& D Leadership Program, through the complementation of experts to support the RDIs. The headcount for full time equivalent of R&D personnel and researchers per million inhabitants exhibited a 265.2% increase from the 2015 data to 2018 (DOST, 2021).

The same increasing trend in the number of agricultural research was recorded by Gert-Jan Stads et al. (2020) among SEA countries where there was an increase of 15.59 % from 2013-2018 data. However, the number of Philippine PhD graduates in the executive branch, is only 8% and compares closely with that of Myanmar (7%), but better than Thailand (4%). These three countries have the lowest number of PhDs at the department/ ministry level. The Philippines is also the third country in Southeast Asia with the lowest number of PhDs among HEI based agricultural researchers with only 23% PhDs, and pales in comparison with that of Malaysia with 80%, Thailand with 60% and Indonesia with 55%.

The low figure of PhD graduates in the executive branch are supported by a nationwide consultation study with the Department of Agriculture research institutions where it was noted that most researchers have only undergraduate degrees (DA AMIA – UPLB 2016). Moreover, the study noted that R&D personnel are more than 50 years old and are ineligible for most technical training scholarships, and thus, perform many other functions related to administration and extension. Compounding this problem, as the study noted, is the fact that those who have PhDs are the ones who are 50 years old and above and near retirement. Thus, developing the replacements in the next few years would take a lot of time and investment. There is also the problem of the cap in the number of staff complement who can go on study leave and the competitive nature of accessing a limited number of scholarships, or the limited slots for attendance to international training programs for specialized skills development. The lack of access to international refereed journals and limited exchange of ideas among research peers exacerbates the problem of ensuring a globally competitive research staff complement.

While having a collaborative project with international organizations benefit the department and the staff members concerned, the long-term benefit of this engagement to the limited number of personnel involved may not be enough to ensure sustainable positive outcome to the implementing unit.

3.1.3 Research Funding

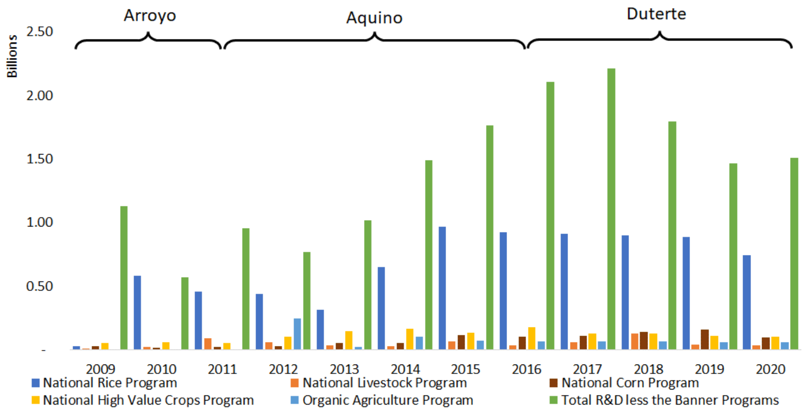
The share of agriculture related R&D activities in total R&D investment is estimated to be only 5% of the total R&D investments worldwide (Pardey et al in Rawat, 2020). Southeast Asian countries, the Philippines included, continue to underinvest in agricultural research. The Philippines in particular, spent only 0.41% of the total agricultural GDP, compared with 0.94% to that of Thailand and 0.85% with that of Malaysia in 2017(Stads et al. 2020). OECD (2017) noted that despite having the largest agricultural research system in Asia, the country's budgetary expenditure had been low at an average of 2. 88% of the share in the budgetary expenditure on agriculture.

While the percentage of the country's spending may be low, the figure may have improved granting that investments in research increased in absolute terms given the increases in DA budget starting in 2011 (Figure 2). Between 2004-2017 (Stads et al, 2020), recorded that agricultural research and development spending rose by 33% in the Philippines as compared to 58.77% in Thailand, which spent the highest R& D spending in Southeast Asia in 2017. These figures, however, are a far cry from the 2.7% agricultural research intensity of high-income countries (Stads et al. 2020). While the authors aver that there is no standard agricultural research intensity that fits all, the Philippines can quadruple its research intensity up to 1.79% to reap more benefits from its agricultural R&D.

Stads et al. (2020) noted that the bulk of the agricultural research funding is mostly allocated to selected agricultural research centers which gets 24% of the budget, the Philippine Rice Research Institute (PhilRice) 11%, the Ecosystems Research and Development Bureau (ERDB) 8% and the University of the Philippines 8%. The University of the Philippines – Los Baños (UPLB) is the leading institution in agriculture. While this may be so, UPLB competes with other universities in accessing funds based on the priorities of the current administration.

Figure 2 shows that of all the priority programs, the rice program consistently gets the bulk of the research and development budget. Regardless of political leadership, expenditure in the rice program consistently gets the highest share.

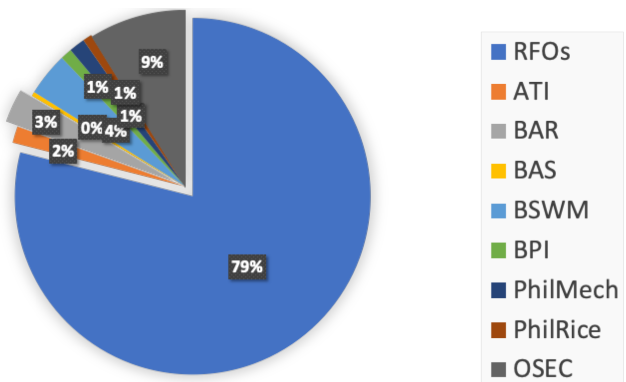
Figure 2. Research and Development Budget by Banner Program (2010-2018)



Source: Department of Agriculture

Of the total National Rice Program (NRP) budget, 79% goes to DA regional field offices which conduct research and extension services, and only 9% goes to the Bureau of Agricultural Research (BAR) and 1% goes to the Philippine Rice Research Institute (PhilRice) (Figure 3).

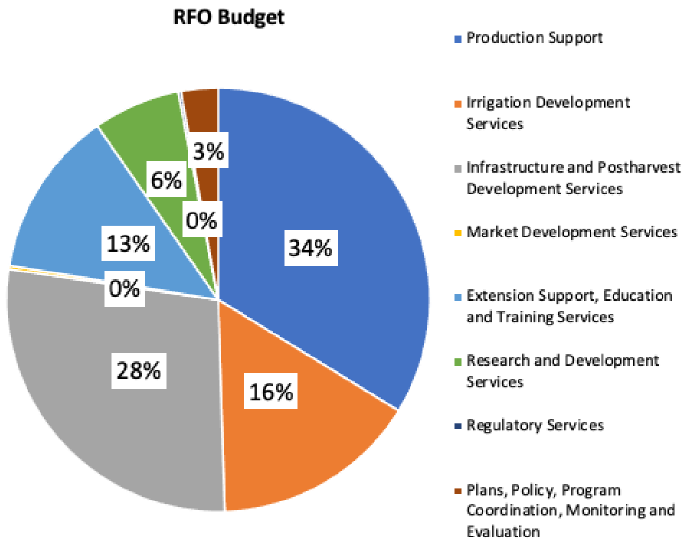
Figure 3. Distribution of National Rice Program (NRP) 2011-2016



Source: DA Budget Division

The NRP budget covers distribution of seeds, livestock for farm diversification, machinery, and funding for construction of rice mills (DA-RFO 2 2016). Part of the functions of the RFOs is to conduct and disseminate research studies. Examples of rice research include development and testing of farm machinery in rice production and drying, varietal field testing, pest and nutrient management, crop diversification. Fund allocation for research therefore, pales in comparison to all other components of the NRP as it comprises only 6% of the total budget (Figure 4).

Figure 4. Distribution of National Rice Program (NRP) budget in RFOs, 2011-2016



Source: DA Budget Division

In terms of major final outputs (MFOs), Ponce and Inocencio (2018) reported that the share of R&D to the total national rice program budget from 2009-2016 is 41%, second only to extension support, education and training services (ESETS) at 51%.

The Bureau of Agriculture Research (DA-BAR), which provides research grants to state colleges and universities (SUCs), disbursed 39% of its total budget to the National Rice program (Annual Report, 2020).

Rice research focused on development of new inbred varieties, development of healthier rice varieties, development, and pilot testing of machineries for production, harvesting drying, field testing of new varieties, development of new processed food and beverages from rice, development of nano biofertilizers, testing of rice straw as substrate mushroom production, and testing and improvement of climate-change resilient farming systems models (PhilRice, 2021).

Gert Jan Stads et al (2020) noted that compared to all other ASEAN countries, Philippines had the greatest number of new registered varieties for the years 2013-2018, indicating that varietal improvement is a priority of research institutions.With the budget of PhP 10 billion per year, starting in 2019, the Rice Competitiveness Enhancement Fund (RCEF) increases the allocation for mechanization (50% of fund), seed program (30%), credit (10%) and extension (10%) for rice farmers (https://ati.da.gov.ph/ati-main/PROGRAMS/RCEF).

Innovative research and extension programs are evident in the DA-IRRI partnerships such as the Philippine Rice Information System Management (PRISM) which is a monitoring system that provides timely data about rice information using remote sensing and crop modeling approach, Rice Crop Manager, a decision support tool that provides personalized crop and nutrient recommendations based on specific farm parameters of the farmer, Accelerating the Development and Adoption of Next-Generation Rice Varieties for the Major Ecosystems (Next-Gen) which aims to accelerate breeding and adoption of rice varieties and hybrids, Improving Technology Promotion and Delivery (IPaD), a capacity-building framework for the next generation of rice extension professionals & other intermediaries which includes enhancement of knowledge sharing activities.

3.2 Agricultural Technology Transfer Sub-system

Agricultural extension contributes to the development of the agricultural sector by improving productivity through the information dissemination, capacity strengthening and provision of support services to farmers and fisherfolks. It is, therefore, not surprising that government agencies invest in agricultural extension to facilitate technology transfer as means to improve the competences of farmers.

The main policy instruments guiding the agricultural extension system are the Local Government Code of 1991 and the 1997 Agricultural Fisheries Modernization Act. LGC devolved the extension staff to the local government units, with the national agencies supporting the LGUs.

Under the LGC of 1991, local government units (LGUs) formulate and implement agricultural development plans and is identified as the frontliner in the delivery of agricultural extension services. Provincial and municipal extension units are tasked to conduct extension and on-site research facilities and distribute seeds, seedlings, fingerlings, livestock, and poultry, and maintain demonstration farms. More than these activities, however, are all tasks related to agricultural development which include "quality control of copra and improvement and development of local distribution channels, preferably through cooperatives; interbarangay irrigation system; water and soil resource utilization and conservation projects; and enforcement of fishery laws in municipal waters including the conservation of mangroves" LGC, Section 17.b.2*)*.

AFMA defines extension services as the "provision of training, information, and support services by the government and non-government organizations to the agriculture and fisheries sectors to improve the technical, business, and social capabilities of farmers and fisherfolk". *(AFMA, Section 4)*. Section 87 of AFMA specified the following as extension *"*training services, farm and business advisory services, demonstration services and information, education and communication (IEC) support services through tri-media".

The current extension system is referred to as the National Extension System for Agriculture and Fisheries or NESAF which is composed of the national government, the local government units, and the private sector. The national government is composed of government agencies which include DA, DOST, DENR, DAR, TESDA, SUCs with the LGUs as the main unit that provides extension to farmers and fisherfolks. As there is no direct administrative link between LGUs and national line agencies, and with no mandate to conduct capacity building interventions to farmers, line agencies are constrained in ensuring the transfer of research results to farmers. LGUs, constrained by technical and financial problems, normally coordinates and partners with the national line agencies and regional field units in the provision of training programs for farmers.

Thus, line agencies actively partner with LGUs in the provision of training, information and support services to farmers and fisher folks. The agency with the most units performing the extension function is DA. Of the 8 bureaus, those active in extension include 5 of its 8 bureaus (ATI, BAI, BPI, BFAR, BSWM), 4 of the 9 attached agencies (FIDA, PCC, PhilMech, PRRI), 5 of its corporations (NDA, NTA, PCA, PhilRice, SRA) and all its 15 regional field offices. The Field Operations Division of the regional field offices conducts training and trade fairs for farmers and supports LGUs through capacity building, provision of information materials on technologies for dissemination, and operation of extension facilities. They also provide laboratory assistance to LGUs, such as the conduct of soil analysis.

Within DA, the Agricultural Training Institute (ATI) has the explicit and sole function of conducting non-formal education, a major component of extension. ATI operates 15 regional training centers and the International Training on Center on Pig Husbandry (ITCPH). They operate training and lodging facilities where they conduct training programs, seminars, and conferences. ATI manages the YouTube channel of mostly production and livelihood videos and hosts the e-extension of the Philippines where interested individuals can access or enroll in short courses or ask questions. Contributors of e-extension programs come from various AANR agencies. The challenge is to maximize the use of digital platforms in terms of monitoring of projects through remote sensing, promoting understanding of block chain, or collecting data and sharing of information.

DOST – PCAARRD develops extension modalities and funds the testing of these extension modalities through partner SUCs by channeling the research results to improve the capacities of the farmers to adopt new technologies from PCAARRD funded research.

DA-BAR encourages SUCs to allocate a portion of research funds for the dissemination of research results. By virtue of the trilogy of functions, SUCs conduct extension activities through the conduct of training, provision of technical assistance and policy review and formulation. DA-BAR also provides direction and technical assistance to RFOs to harmonize research priorities in line with the national DA priorities and guide the extension activities of the region.

DAR, on the other hand, conducts extension activities specific to DAR communities and these range from provision of technical assistance, production assistance, processing of agricultural and fishery produce.

3.2.1 Coordination and planning within the sub-system

At the institutional level, the main actors in the government extension system are the local government units and the national line agencies. All local government units are empowered to plan for and deliver agricultural extension services. As such, municipalities can set their priorities independently of the provincial agriculture office or that of the national line agency priorities. In reality, because of constraints, provincial and municipal offices actively partner with the national line agencies and their regional offices because of resource constraints.

To facilitate the attainment of agricultural targets, line agencies provide technical support to LGUs. Among the line agencies in the Department of Agriculture, ATI serves as the over-all coordinator of NESAF and leads the formulation of the National Extension Agenda and Programs (NEAP) and budget through a multi-stakeholder consultation consisting of LGU extension workers, farmer leaders, accredited extension providers, agricultural entrepreneurs. NEAP focuses on programs that promote extension competences such as the conduct of priority capacity building interventions, modes of information dissemination activities, extension policy review and advocacy. While NEAP is conducted in a participatory manner, attendance of other DA agencies to this event is poor. During the national and regional consultations for the NEAP conducted for 2016, there were very few participants from the other DA agencies or DA officials who graced the event. A key informant said that while they were invited, nobody came. The failure to get participants from other DA agencies in its planning session is also true as well during consultations managed by the ATI Centers. To improve the effectiveness of agricultural extension services, ATI is working on the strengthening of the Agriculture and Fishery Extension Network (AFEN) by organizing regional networks (RAFEN).

ATI has likewise been very active in forwarding and supporting bills to enhance the extension ecosystem of the country. In 2005, ATI worked with the Office of the then Senator Edgardo Angara who sponsored Senate Bill 2331 or the "Philippine Agriculture and Fisheries Extension Act of 2008. The bill proposes to transform the extension system by placing the planning and implementation of extension programs at the provincial level, professionalizing and standardizing the salaries and wages of extension workers and transforming ATI to Philippine Agriculture & Fisheries Extension Agency (PAFEA) to orchestrate, provide national directions, set standards of performance, and provide institutionalized financial and technical support to the LGUs. ATI would continue to work with various senators and congressmen to have the bill passed. ATI has vigorously also campaigned for the passage of the Magna Carta for Agricultural Development Workers (Bill 1486) originally filed by Senator Francis Escudero during the 14th Congress, now known as the Magna Carta for Agricultural Extension Workers (AEWs). ATI works closely with the Philippine Extension Advisory Services Network (PhilEASNet), a professional organization that seeks to strengthen the professionalization of extension workers and professionals through the conduct of policy seminars, biennial conferences and awarding of outstanding extension personnel, project and research paper.

Based on personal interviews in 2016, ATI relies on their own personnel, technical experts coming from SUCs or the Department of Agriculture, and their accredited farmers to discuss agricultural technologies. Based also on personal interviews, ATI has been very active in partnering with accredited farms in promoting agricultural competencies and technologies and does not consciously exert effort to share research results coming from DA-BAR and PCAARRD or SUCs. Unless the speaker comes from DA-BAR or RFOs, technologies promoted can be those practiced by the accredited farmer leader, principles and practices or research outputs taught by the SUC resource person.

DA-BAR encourages SUCs to incorporate an agricultural extension component in their research proposals to ensure such that research outputs can reach intended farmers. The RFOs promote agricultural research coming mostly from the Department of Agriculture. Other DA agencies and bureaus also provide extension support to local government units.

DOST-PCAARRD, just like ATI, develops agricultural extension modalities and funds these modalities to promote agricultural technologies from DOST funded research. To ensure that technologies developed by PCAARRD will reach the end users, development of extension modalities and technology commercialization were identified as key strategies in the HNRDA. PCAARRD works with its regional consortiums to ensure harmonization of its research and extension activities. DAR likewise is active in the provision of extension services to agrarian reform beneficiaries.

The apparent lack of institutional linkages between RDE institutions are exacerbated by the act that there is no direct link between RDIs and the local government units which provide for extension services to farmers. The autonomy of local government units gives them the latitude of what to invest in and how to maximize personnel and budget resources. Thus, with no direct line from any national government agency, it is a challenge to steer the implementation of an agricultural extension agenda. The lack of administrative links between the national and the local government makes it difficult to steer 81 provinces, 146 cities and 1,488 municipalities with varying needs and priorities.

An important change worth noting in the desire to address the fragmentation in the delivery of agricultural extension is the designation of ATI as the apex agency for extension through DA AO no. 28 of 2008. With this memo, ATI serves as the lead agency in providing leadership in the current fragmentation of the extension service system. Guided by NEAP, ATI then identifies training programs which they conduct or deliver in partnership with ATI accredited learning sites (LS) and schools for practical agriculture (SPA). ATI provides training programs for LGU extension workers and partners with LGUs in providing training programs for farmers.

Taking to heart the principles outlined in Section 91 of AFMA, ATI worked on the accreditation of progressive farmers as partners in the conduct of techno-demo sites and training programs. Starting with the *Magsasaka Siyentista* (farmer scientists) of the Techno-*Gabay* program, ATI identifies LS where they can bring farmers to learn about the technologies used by the progressive farmers. Once the owners and the workers of these learning sites express willingness to become trainers, a memorandum of agreement is signed between the ATI and the progressive farmer. The prospective LS owner attends training programs on training delivery and management, and technical courses related to the technology that he will promote. There is no accreditation fee charged by ATI. In fact, the farmer receives minimal support from ATI to refurbish a portion of his farm that can serve as a training venue. ATI then sends trainees to the accredited training site and the farmer receives payment as a trainer and program manager, as well as payment for the board and lodging of the participants.

ATI does not push for any technology during a training program. For organic agriculture production training, for example, the technologies used by the farmers, which had been either a result of his good practice, something he learned from the DA training programs or from other sources, is what is taught at the learning sites. The accredited partners receive priority for new training programs that ATI or the RFO will offer. Some of these ATI accredited training providers have become accredited farm tourism sites and TESDA accredited trainers, also with the help of ATI.

The most common capacity strengthening activities implemented include techno-demo, the conduct of training programs and farm visits, complemented by the E-extension managed by ATI and school on the air programs sponsored by either LGUs, ATI or SUCs. The pandemic provided an opportunity for ATI to maximize the use of school on the air, webinar and blended learning in the provision of capacity building programs as they saw the increased interest of people to join webinars and enroll in radio online learning through e-extension. Webinars and blended learning were made possible in partnership with the accredited LS and SPA partners.

Within DA, RFOs RRDEN also provides capacity building programs for LGUs and farmers upon request of LGUs. The main difference, as stated in the DA AO 5 of 2018, is that RRDEN will promote technologies that are priorities of DA-BAR.

Similarly, PCAARRD likewise promotes RDI collaboration and harmonization through its regional consortia. It promotes PCAARRD technologies through the extension modalities implemented by its members in the consortia or through DA agencies, the funding for such research of which came from PCAARRD.

Thus, DA Agencies and PCAARRD all attempt to address the disconnect between research and extension and the fragmentation of extension by improving their effectiveness through their respective networks. However, coordination is mostly between these line agencies and LGUs. The government recognizes the fragmentation in the delivery of the services for rural development. The National Convergence Initiative for Rural Development (NCI-SRD) sought to address this by providing joint management functions among DA, DENR, DILG and DAR using the ridge-to-reef approach. Thus, Joint Memorandum Order 1 of 2020 specifies that the convergence strategy be applied to rubber, fiber crops, coffee, cacao and high value crops.

3.2.2 Human Resource Complement

There are 9, 997 provincial and municipal local government extension workers in the country (ATI, 2016). Of these, 52% are women, 47% are between 46 – 59 years old and 13% are 60 - 65 years old. Majority (78%) handle crop specific tasks, most of whom are focused on rice, while the rest handle various commodities and a small percentage provide support to rural based organizations. Majority (57%) serve 10 barangays or less while around 10% serve 21-30 barangays. The same report notes that the salary of provincial agriculturist ranges from P17,285 – P36, 590, the city agriculturists from P12, 682 – P25,938, the municipal agriculturist from P14, 629 – P19, 960 and majority of the extension workers who have permanent appointment received an average of 20,000 per month.

The appointment of provincial agriculturist and veterinarian are mandatory, but the appointment of municipal agriculturist is not mandated by the LGC. With no document indicating the qualifications standards for extension personnel or technicians, educational background may or may not be directly related to agriculture. This results in wide variations in qualifications of extension personnel. Hiring of job orders, too, poses complications as hires do not go through the usual screening process for permanent items.

The organization of local government units reflects the national banner programs of the DA. Personnel are designated as rice, corn, livestock, high value crops and fishery coordinators. The influence in the structure reflects the commoditization of national programs from which LGUs receive program support. The size and organizational structure of extension offices vary depending on the capacity of the municipality to pay the salaries of the extension personnel and allocate funds for projects. The variation in the salary is reflective of the income of the municipality where the lower income LGUs earn less than their counterparts coming from higher income municipalities.

The national government offices support LGUs through capability building activities and conduct of extension services related to the banner programs of DA. These capacity building programs focus mostly on technical skills, with ATI providing program management skills. Because national offices have their own plans and targets, one municipal agriculturist opined that they have difficulty attending multiple and conflicting training programs.

3.2.3 Funding of the Extension Projects

It is difficult to come up with an estimated budget and expenditure for extension given the system's fragmentation. From the government side, major extension players include the DA line agencies and RFOs, DAR, PCAARD, SUCs and LGUs.

The budget of the Department of Agriculture reveals sizable expenditures devoted to extension support, education, and training services (ESETS) and production support (see Figure 1 of this chapter. To provide an example on an LGU expenditure, an appropriation and obligation expenditure for agriculture is provided.

The Department of Budget and Management - Local Budget Circular 98 of 2011 states that 4th -6th class municipalities allocate no more than 55% of their budget to personnel services while 1st-3rd class municipalities should not go beyond 45%. A second-class municipal office, represented by the municipality of Mercedes, Camarines Norte, reflects that of the P7, 109,766.00 annual budget, only 25.89% are allocated to programs, activities, and projects (PAP) while the biggest share goes to personnel services (62.15%). https://mercedes.gov.ph/wp-content/uploads/2021/02/2021-MUNICIPAL-AGRICULTURE-OFFICE.pdf.

What activities do the municipal agriculture office do then, based on their available funds? To provide us with an indicative understanding of agricultural activities of a municipality, we look at the 2019 actual expenditure of Mercedes. A major part of the expenditure went to PS (55%), 24% to PAPs, 17% to MOOE and 2% to capital outlay. For the rice program, the major expense goes to the distribution of seeds (64.63%), for the corn program 90.90% went to MOOE and for the livestock program, almost all (93.93 %) went to animal supplies expense and anti-rabies and vitamins/de-wormer. As such, most of the training program, information dissemination and farmer's forum are conducted in partnership with the national line agencies or the private sector such as input suppliers of seeds and animal biologics.

Lower municipalities, which have lower budgets, have difficulty maintaining a number of permanent extension workers, and thus, resort to hiring of job orders (contractual employees), who based, on the survey of ATI (2016) received as low P1,300 per month. This has implications to the consistency and the quality of the program outputs. With meager budgets to work on, agricultural offices from poorer municipalities rely mostly on projects and partnerships coming from the banner programs of the Department of Agriculture.

With the current *Mandanas – Garcia* Ruling, the share of the LGU will increase by 27.61%, up from the current 40% share from the national internal revenue taxes (DILG 2021). However, we need to consider the tasks that will be assumed by the local government units. Considering the differences in the human resource capacities, the level of poverty incidence of municipalities and the propensity to prioritize the distribution of private goods, the sufficiency of the growth equity funds (GEF) to counter the differences in attaining growth of provinces and municipalities with lower income, should be investigated.

4. Technology promotion, adoption, and productivity

4.1 Overview

Technology adoption is a desired outcome of any agricultural extension intervention. Agricultural extension focuses on addressing technology and management gaps to ensure adoption of a new technology or practice. The former refers to knowledge related to a specific technology, and the latter to the ability to manage farm operations. As such, technology gaps are those specific to improving knowledge and skills in the use of a particular innovation while examples of management gaps include management of farm systems such as crop management practices. For this section, rice production and swine raising are chosen as cases since both are significant contributors to the gross value added in agriculture.

In comparision to the previous decades starting with the 1960's, annual agricultural growth rates have been declining for countries such as Philippines and Thailand but continues to post a growth of 4% per year for Indonesia and Malaysia (Takeshima and Joshi, 2021). The Philippine's total factor productivity lags behind most of the SEA countries and remains ahead only of Timor Leste and Laos (Table 1).

Table 1. Total Factor Productivity (TFP) and Annual Agricultural Value Added growth rates (%) among selected SEA countries

Country	Annual growth rates of agricultural value added (in %, 2010's)**	TFP growth rate (in %, 2001-2014, USDA 2017)
Cambodia	2.1	4.5
Indonesia	3.9	2.5
Laos	2.8	1.5
Malaysia	3.7	2.7
Myanmar	1.2	2.5
Philippines	1.4	1.7
Thailand	.8	2.2
Timor Leste	-.4	-.8
Vietnam	2.5	2.4

*USDA 2017**WB, 2018 in Takeshima and Joshi, 2021

Liu et al. (2020) noted that the slowdown in technical progress led to the deterioriation of TFP of Philippines and Vietnam. Granting that nearly 60% of agricultural growth in developing countries is accounted for by TFP (Fuglie et al, 2020), the Philippines need to work harder to produce innovations in technology and ensure the adoption of new technologies and efficient farm practices.

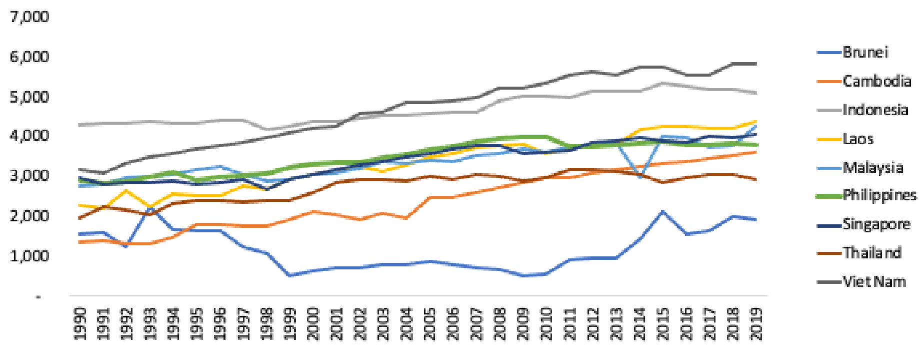
Increases in productivity hinges on several factors which include technological innovations and adoption. Thus, the governance of research and extension systems need to be enhanced to sustain improvement of the country's agricultural innovation system and ensure agricultural development.

4.2 The case of rice

4.2.1 Productivity trends

Yield per hectare for rice slightly increased in 2020 at 4.09mt/hectare compared to the 4.04 mt/ha in 2019. Rice yield for modern varieties crossed the 4.0 mt in 2014 and again in 2018 and 2019 and 2020. Yield for traditional varieties, however, remained relatively comparable to the 1998 level of 2.12 mt/hectare, posting the highest yield 2019 at 2.37 mt/ha (PhilRice 2021). Halos (2005), in her study of innovations in rice, stated that the slow rate of increase in productivity is not so much the lack of new technologies, but rather the slow adoption of these technologies. Compared to most ASEAN countries, the Philippines ranked third in terms of yield and ranked 8th in terms of growth rate, with Brunei, Cambodia and Laos posting the highest growth rate (Table 2).

Table 2. Palay productivity of ASEAN Countries, 1990-2019, kg/ha



Yield, kg/ha

Country	Average	Rank
Indonesia	4,702	1
Viet Nam	4,678	2
Philippines	3,494	3
Singapore	3,411	4
Malaysia	3,385	5
Laos	3,341	6
Thailand	2,747	7
Cambodia	2,404	8
Brunei	1,200	9

Growth Rate, %

Country	Average	Rank
Brunei	4.30	1
Cambodia	3.69	2
Laos	2.45	3
Viet Nam	2.13	4
Malaysia	1.83	5
Thailand	1.52	6
Singapore	1.12	7
Philippines	0.92	8
Indonesia	0.62	9

Source: FAOSTAT

FAO classifies the sources of rice productivity into physical, biophysical, socio-economic, and institutional factors (Duwayri et al. n.d.). A major interest for the agriculture sector is the adoption of technologies which is considered a factor in improving the yield performance of commodities. The Green Revolution illustrates how adoption and diffusion of technologies such as new varieties, use of fertilizers and pesticides, and adoption of farm machinery significantly improved yield and income of farmers. Since then, understanding farmer behavior has been a major research interest among agricultural researchers.

The green revolution was propelled by technological innovations. The development of new plant varieties, coupled with the use of fertilizer and pesticides and improved irrigation systems transformed the agricultural sector into a modern industry. To sustain such development, there has to be continuous investments in research and extension. Varietal improvement and farm mechanization are critical in enhancing farm productivity. However, while government research institutions produce a number of modern varieties, only a few of these are currently adopted by the farmers. New varieties in the future need to address evolving challenges related to evolving pest resistance, less favorable environmental systems, and farmer preferences.

Extension's success can be measured in terms of closing the gap between the potential and actual yield resulting from the use of a technology. Thus, for this to happen, the technology must demonstrate advantage over the previous technology used. Lack of competences in the use of this technology can be addressed by non-formal education and information support, while subsidy or credit can reduce problems related to cost. However, for a government extension program to assume the private sector's task in distributing a private good may not be the most efficient extension support.

This section reviews the adoption of certified seeds as a critical factor in rice productivity since the adoption of these are emphasized by both research and extension programs of the government. This is because modern varieties can address problems related to insects, pests and diseases, lodging, late maturity, seasonality of production (Halos 2005) which all affect yield. Using cross sectional data from 3,164 rice farming households in 2006-2007, Villano et al (2015, p.1) concludes that "adoption of certified seeds has a significant and positive impact on productivity, efficiency and net income in rice farming."

Laborte et al (2015) classified modern varieties into 5 types based on their date of release and distinct characteristics. MVs1 to MVs3 were modern inbred varieties while MVs4 and MVs5 were modern hybrid varieties released after 1995 and included varieties for adverse production environments noted that significant acceleration in production coincided with the release of MVs4 and MVs5. MVs5, however, do not have resistance to common pests and diseases such as rice blast, BLB, BPH, and tungro, which Laborte et al (2015) noted that breeders did not factor in since there had been no major outbreaks in the past due to MVs1 to MVs3 resistance to these common diseases. However, there are resurgence of outbreaks of these pests and diseases. Thus, continuous research on the development of new varieties remains an important agenda.

Moreover, extension support such as input assistance (Villano et al. 2014) and collective marketing (Digal and Placencia 2019) affect adoption. Policy interventions affect the overall agriculture productivity as noted by Fuglie et al (2020) who also stated that nominal rate of assistance such as subsidizing inputs and providing commodity support to farmers affect decisions. Studies also show that when farmers do not consider the investment profitable, adoption will not proceed.

4.2.2 Hybrid rice technology transfer program

In its bid to increase farmer's productivity, the government promoted the hybrid rice program, the seeds of which came from the private sector. Private sector R&D can help close the technological gap. However, the lack of demand for hybrid rice and the dissemination process adopted by the government led to additional costs on the part of the government. Worst, studies reviewed showed that widespread adoption did not occur.

More than 200 modern varieties have been developed and released, yet less than 10 varieties are planted in 75% of land area in Central Luzon (Laborte et.al., 2015). The authors noted that despite the existence of a government program to promote hybrid rice during the survey period, its adoption is much lower compared to other modern varieties. Takeshima and Joshi (2019, as noted by Spielman et al. 2012 and FAO 2018) noted the low adoption of hybrid rice in SEA countries with 10% adoption rate in Vietnam, 7% in Bangladesh and 5% in Philippines and Indonesia.

Flores et al, (2018) investigated the adoption of selected PhilRice recommended technologies from land preparation to threshing for the period 2006, 2011 and 2016 and in some cases where data was available from 1996. Their findings reveal that the use of hybrid rice varieties remained low in most parts of the country, and low to medium adoption of high-quality inbred seeds for 2016. Unfortunately, study of Flores et al. (2018) did not discuss the factors affecting the adoption rate. The low adoption of hybrid seeds also corroborates previous findings of Halos (2005), David (2006), Laborte (2015), Moya (2015) and Digal and Placencia (2019).

What factors affect adoption of hybrid seeds? Laborte et al (2015, p.16) found that farmers consider grain quality and prefer to adopt varieties that give "high yield, mature faster, and have long and slender grains, high milling recovery, and intermediate amylose content". Grain quality and high head rice yield and preferred because of resultant ideal texture of cooked rice (Mackill and Khush, 2018). Socioeconomic factors such as age (Villano et al 2014, Digal and Placencia, 2019,) and gender, household size and farm experience (Villano et al, 2014, Miguel et al 2021), training, education (Villano et al 2014, Digal and Placencia, 2019 Fuglie et al 2020) sources of income (Miguel et al 2021) and tenurial rights (Villano et al. 2014). Farm and biophysical characteristics affecting adoption include less favorable environments such as lack of availability of water supply (Villano et al, Digal, and Placencia, 2019, Fuglie et al. 2020). On the other hand, incompatibility with current practices may hinder adoption (David 2006).

The introduction of hybrid rice started in 1998 and was a centerpiece program of the Arroyo Administration (David 2006). In her study, she reported that the government spent approximately 10 billion pesos from 2001 to 2005 to promote imported hybrid rice varieties by providing seed subsidies, cash and other subsidies to inputs, cash incentives to farmers and extension workers, extension training, techno-demonstration, and educational tours. Thus, the program addressed both technology and management gaps and even addressed possible deterrents such as increased production cost by subsidizing the seeds. At the end of the program, David reports that HYV was planted only to 5% of the total land area.

Dropout rates of as high as 86% after one season of using hybrid seeds were recorded because of low average yield advantage coupled with observed lower quality compared with the inbred seeds (David 2006). Thus, the author concluded that despite the heavy subsidy to hybrid rice seeds starting in 2010, the low yield advantage over current seeds, observed lower quality and the corresponding lack of demand for hybrid rice, contributed significantly to the poor adoption of hybrid rice. These factors were compounded with quality issues where free hybrid seed failed to germinate. In this case, more than the biophysical and environmental characteristics, or socio-economic factors, the attributes of the technology and quality issues appear to be the major causes for the poor adoption of hybrid rice.

In terms of the management of the program, the government provided 50% subsidies for seeds which the government procured and distributed, cash benefits and subsidies for inputs, provision of monthly cash incentives to LGU personnel to promote the use of hybrid seeds, as well as other incentives for LGUs and farmers who attain high yields. David noted that these resulted to anomalies in behavior and opened rent seeking behaviors. Moreover, the regulatory functions were compromised because of the desire to roll out various hybrid seeds, one of which only underwent a few trials. Factoring all direct and indirect costs, the amount per bag of hybrid seeds distributed is P5,100 much higher than the actual cost of P2,400 per 20 kilos of the seeds.

4.2.3 Agricultural machinery technology transfer program

Adoption of farm machinery, too positively affects productivity. In terms of mechanization, the Philippines is characterized as having a middle level of farm mechanization, with very low mechanization during planting and low mechanization during harvesting (Soni and Ou, 2010). Starting in the mid-1950s, use of tractors reflected low but steady increases until 2001 compared to Thailand which registered very high increases in the same period (FAO 2021). Indonesia and Vietnam outstripped the Philippines in terms of number of combines used as the Philippines did not register increases from 1961-2001. Studies show that level of farm mechanization is at a low of 1.23hp/ha for all crop and averages at 2.31 hp/ha for rice, way below the 4hp/ha level of other ASEAN countries (DA Communications Group 2020). Delfin (2013) noted the low mechanization in rice, except in milling. He mentioned that this can be because parts of locally fabricated machines are imported and most manufacturers (50%) are located in Luzon.

AFMA (1997) stresses the importance of farm mechanization as a strategy towards agricultural modernization. The Agricultural Mechanization Law of 2013 (RA 10601) established a National Agricultural and Fisheries Mechanization which sought to ensure the availability, accessibilty and adoption of quality and safe agricultural machinery for farmers and fisherfolks. A major component of this is the research and development, regulation, and extension of agricultural machinery.

The Philippines launched the National Rice Mechanization program in 2011 in an effort to double the mechanization level from 1 hp/ha to 2.0 hp/ha by 2013 and increase farm production by 5% and reduce post-harvest losses by 15% (SEARCA 2020). OECD (2017) noted an average annual spending of US $124 from 2008 – 2014 for machinery and post harvest facilities compared to only US $17.86 from 2001 – 2007.

Hand tractors were the most preferred machinery followed by combine harversters. Least requested by the farmers were transplanting, harvesting and drying machines. Mechanization therefore, is higher in combined operations and land preparations. Moya (2015) reported a decrease in 5 person-days/hectare because of adoption of hand tractors among Central Luzon rice farmers. Given the low mechanization levels in all other operations, the study concluded that the current level of mechanization is still below the ideal to be able to achieve desired rice yield.

BAFE-DA (2020) reported that more than 7.2 B was spent for procurement of machinery and SPIS in regions 1,2,6,8 and 10,12 for 2015-2019. More than 17,000 machinery were distributed and around 100 SPIS projects were implemented in high and medium production areas. The program started with partial grants but shifted to total grants because of the difficulty of getting counterfunds from the beneficiaries. For the rice program alone, a total of 31,296 machinery were distributed rrom 2011-2016, the most distributed machinery of which were the two wheeled tractor/hand tractor, which were preferred because of easy use and helpful given that manual task associated with land preparation is heavy(BAFE-DA, 2020).

Around 20% of all machinery distributed for rice and corn were found to be under utilized or not utilized due to reasons such as mismatch in needs and what was distributed, poor performance of the machine, non-functional machines, poor mounting of parts, lack of service areas for repairs, lack of needed spare parts for replacement, inability of beneficiaries to pay for repairs. Because of the bulk of work and lack of manpower, established protocols, such as the inspection of machines prior to distribution was not conducted at the RFO. Thus, inspection prior to distribution could not be done to all machinery. In some cases (region 8), the RFO downloaded the funds to the LGUs who did not have the enough manpower and technical capability to identify the machines or inspect the machinery delivered for distribution. BAFE-DA (2020) further noted that monitoring of distributed machinery was not judiciously conducted and after sales care of producers of machinery were poor.

SEARCA (2020) noted that the lack of a GIS based inventory of farm machinery funded by the government has impeded the planning process and that Philippine Center for Postharvest Development and Mechanization (PHilMech) has started efforts on the inventory of production and postproduction machineries in the country. For the rice sector, SEARCA (2020) indicated that the target of 1% per annum increase in rice yield was exceeded in most years, except in 2015 and 2016 where there were strong typhoons that negatively affected production. This increase is a target of the mechanization program. However, whether the increase is due mainly in improved mechanization cannot be concluded as factors contributing to this registered growth in production, was not part of the study.

Recent studies reveal the increase in the use of power tiller hand tractors and combine harvesters in Central Luzon (Otsuka, 2021). However, compared to other ASEAN countries like Thailand, the country's farm mechanization remains low. The mechanization program of the government attempted to reverse this trend. Apparently, there are rooms for improvement in the program implementation because of procedural problems.

4.3 The case of swine

Delgado et al (1999 in Nin, Ehui, and Benin 2007) referred to the rapid worldwide growth in demand for food of animal origin as the "livestock revolution." While the livestock industry reflected a slowdown in growth, trends in East Asia were reportedly at a high of 7% per year for the past 30 years, with no significant price increases (Nin, Ehui, and Benin 2007).

Swine production is a 249.66 billion industry dominated mostly by backyard raisers (PSA 2020). Its national economic importance is substantial, as it contributes significantly to GVA, placing second to rice (PSA 2020). The swine production declined significantly in 2020 by -6.9% (PSA 2020) due largely to ASF. Import dependency ratio for swine is at 12.9% (2019), lower than the previous year at 13. 9% (psa.gov.ph). The reduced importation, due to the restrictions from the government to protect the industry from ASF, coupled with the reduced local production, has been driving the increased prices in pork. Briones and Espinelli (2021) has noted widening gap in the farm gate price of swine, which continued to soar, compared to countries such as Spain and USA.

Swine serves as a major source of protein among Filipinos and annual per capita consumption is at 14.9 kg (Statista 2020). Improving backyard raising practices can increase household income, address household food insecurity, and decrease prices.

This section investigates the swine production industry by reviewing existing studies and investigating how farmer practices may have compounded the spread of ASF in the country. Prior to this ASF, the swine industry was a robust industry participated in by commercial and backyard growers.

The previous growth in the swine industry is a result of advances in research in nutrition and the technical assistance provided for by HEI researchers to cooperatives and feed millers. However, the swine industry needs further research in the areas of nutrition and health as major raw materials of feeds are mostly imported. Feed represents one of the major expenses in swine raising and feed cost is higher in the Philippines than countries such as Vietnam or China (Briones and Espineli, 2021). Moreover, the same authors aver that compared to Thailand, Vietnam and China, the Philippines have higher feed conversion ratio which ranges from 2.8 to 3.3, with backyard raisers registering the higher rates given the poor nutrition management practices. Because of increasing prices of feeds, backyard raisers practice swill feeding in an effort to cut down production cost as feeds represents 54.64% of the cost for backyard raisers and 64.53% for commercial raisers (Curibot in Briones and Espineli 2021).

According to a key informant, local production of corn, the major carbohydrate ingredient for feeds, cannot supply the needs of the feed milling industry. The high tariff for imported corn is a driver in the increased prices of feeds. Soybeans, the major protein ingredient for feeds, is also mostly imported. Thus, there is a need to look for ways by which to improve nutrition efficiency by re-evaluating other traditional materials for feeds such as sorghum, azolla, or copra meal. On-going biotechnology research on enhancing the protein component of copra meal may lead to lowering cost of raw materials for feeds. Research on varietal improvement of cassava seeks to improve yield and ensure its availability as a feed ingredient.

Cabantac (2019), in a paper presentation, also identified the swine genomics application in production and health as a research priority. Part of this thrust is to study native pig characteristics and utilization to enhance the genetic pool of swine breeds and conserve native breeds which may have better qualities preferred by customers in terms of taste. Cabantac (2019) likewise reported that the government supports the establishment of triple A abattoirs for common use, standard inspection area in ports, and traceability system. Given the spread of ASF, disease prevention, monitoring and regulation are critical to ensure the robustness of the swine industry. The proximity of backyard swine raisers within a community, the practice of swill feeding, marketing of live animals through middlemen, and the demand for fresh meat in markets, the frequency of direct and indirect contact between herds and raisers increases the likelihood of disease outbreaks among backyard raisers.

Extension in swine raising is primarily private led (Baconguis, 2007). Private companies involved in nutrition and biologics sponsor swine production seminars in partnership with the local government units or with cooperatives to improve production efficiency. However, production efficiency varies among backyard growers, contract growers and commercial growers. In the study of Catelo (2017) she mentioned that the majority of these farmers who had higher productivity growth are into contract growing or have commercial operations. She implied that the other raisers, to include backyard raisers, may have been constrained in accessing technological innovations.

The asymmetry in information between commercial and backyard raisers was documented in a study by Baconguis (2007). Commercial raisers have consultants and constantly seek out information on their own and backyard swine raisers receive information mainly from feed millers and feed distributors who are most likely interested in clinching sales. Thus, backyard raisers receive less information on biosecurity measures, controlling the spread of diseases and management of effluent wastes. Moreover, there is no information on the rate of compliance among backyard raisers regarding vaccinations of their herds given the cost of the biologics and antibiotics. Baconguis noted that information sources include co-raisers and the private sector where biosecurity measures may not have been the priority topic.

As reported in Table 1 of this chapter, research funds for the national livestock program pales in comparison to the national rice program, despite the importance of livestock in the country's economy. Disease outbreaks such as FMD and ASF, calls for research and extension investments to ensure the reinvigoration of the swine industry. Research on alternative feed sources, development of competences and establishment of laboratories for the development of biologics, investment in breeding and support for breeding farms and increasing AI stations are critical in ensuring the vibrancy of this industry. Moreover, as emphasized in the paper presentation of Cabantac (2019), regulatory programs such as establishment of triple A abattoirs for common use, standard inspection area in ports, traceability system are priority programs of the government.

While the extension part on production may have been taken care of by the private sector, the government extension workers need to take part in promoting knowledge of biosecurity measures and disease monitoring. Biosecurity protocols need to be established and extension workers need to be capacitated in this aspect.

4.4 Technological innovations, adoption, and industry performance

The cost of swine raising is higher in the Philippines for small scale farmers compared to China, Thailand, and Vietnam. Cost of production is likewise higher for China and Thailand for large scale farmers where cost of feeds was noted to be higher for Philippines (Country report in Briones and Espineli, 2021). The feed production and dissemination activities are primarily a private sector engagement. Given the high cost of feeds, government research institutions need to develop alternative feed ingredients at the same time that it needs to strategize how to disseminate information and enforce policies related to biosecurity issues.

5. Conclusions and Recommendations

5.1 Synthesis of findings

The innovation system is critical in advancing agriculture. Research and extension are important ingredients in the innovation system as production of knowledge and strengthening the technical and managerial capacity of farmers to efficiently manage their farms using the latest technologies are crucial in ensuring agricultural growth. While it is difficult to quantify the contributions of research and extension because of the data gaps and the numerous agencies involved in this task, the conclusions below are forwarded.

The Philippines lags behind other Southeast Asian countries in terms of total factor productivity. The 2020 GDP posted a negative -9.6% at constant 2018 prices, with GVA contributions of agriculture, forestry and fishing posting a negative 0.2% at constant prices (PSA, 2021). Except for crops, where the value of production exhibited an increase of 1.5% growth rate, livestock posted the highest negative growth at -7.4%, poultry at -3.55 and fisheries at -1.3%. (PSA, 2021). Rice self-sufficiency ratio is down to 79.8% in 2019 from a high 96.8% in 2013 while annual growth rate of hog production went down from 2.4% in 2018 to -6.7 % in 2020.

Overlaps in research function continue to persist. The structure of agricultural research in the country is complex, with three big agencies in policy direction and research: DA, DOST-PCAARD for AFFNR and DENR for forestry and natural resources**.** Within the Department of Agriculture, there are several bureaus, attached agencies and regional field units which conduct AANR research while both DA and DOST fund SUCs AFFNR research based on their priority programs.

The crafting of a research agenda for agriculture is done by individual agencies through multi-stakeholder consultations. DA has RDEAP and DOST -PCAARRD is guided by HNRDA. There is also no available site that lists all research projects or at least their abstracts which can minimize duplication of research funding allocation.

Research priorities overlap but reflect specific interests. DOST-PCAARRD research priorities are crop based but influenced by industry needs and potentials of a technology to advance a specific industry. HNRDA focuses on the use of cutting-edge technologies and development of technologies that will help AANR industries. DA-BAR covers many crops but focuses funding mostly on rice research. Other research institutions under DA focus on their specific commodities. The priority of DA is also largely influenced by the priorities of the DA-Secretary. HEIs, which access research funds mostly from DOST-PCAARRD and DA-BAR, align their research to the priority program of the agencies. As such, HEIs mirror the priorities of the current DA administration or priorities of DOST. While UP is the national university, it competes with all other universities from the same fund source.

Given the research fragmentation, the overall impact of research and its attributions to the national goals is difficult to estimate. The absence of a well functional CERDAF and NIN impairs the potential of a coordinated direction for the agriculture sector and makes it difficult to estimate the impact of research.

Agricultural research continues to be underfunded and remains lopsided towards the rice program. Allocation for research funds remains meager as a percentage of GDP. The current research expenditure of 0.41% of the total agricultural GDP is way below the desired 1.7% agricultural research intensity. Across administrations, the priority in DA research allocation has been the same, with the rice program receiving most of the budget.

As emphasized by literature, new technologies need to address multiple problems that include tolerance to biotic and abiotic stresses, grain and eating quality. Advances in technologies can be facilitated by the use of cutting-edge technologies such as biotechnology and genomics which can be accomplished with increased investments in laboratories, training, or international partnerships.

The country still lags behind in terms of number of researchers. Compared to other ASEAN countries, the Philippines, which had the greatest number of agricultural research organizations, had one of the countries with the least agricultural research PhD graduates compare to its SEA counterparts. PhD graduates are critical in spurring innovations as they bring in new networks, new knowledge, and skills. The problem in the Department of Agriculture is compounded by the fact that those with PhDs are more than 50 years old and some, near retirement. Opportunities to send young researchers for PhD may take time and specialized training programs are available on competitive and limited slots.

Extension remains to be fragmented. The fragmentation of extension poses challenges in the formulation of an extension plan and coordination of agricultural extension services. As there is no administrative link between the national and the local government units, it is challenging to steer a national extension plan. With many actors coming from the national government agencies and SUCs, and the desire of these institutions to supplement the limitations of LGUs, observed duplications among national agencies are not surprising. It is of interest to determine the extent of how the convergence initiative of the government is solving this problem.

Linkage between research and extension remains weak. There is no mechanism to translate research results and mature technologies from research institutions to major extension institutions. Despite activating NESAF and coming up with NEAP, ATI is challenged to mainstream research results from the various research institutions**.** RDEN and RAFEN will need to work together in terms of achieving complementation and determine how to mainstream mature technologies coming from DA institutions with research functions or SUCs and other RDIs like PCAARRD.

LGUs suffer from the lack of financial resources to fund agricultural projects. LGUs, who are mandated to provide direct extension programs, have limited funds for Programs and projects (PAPs), especially those from low-income communities. Most LGUs resort to providing short training programs, conducting advisory services through farm visits, and distributing private goods such as seeds and seedlings. Partnership with the national line agencies, through the banner programs of DA, remains a main activity of the LGUs as these affords them not only funds, but also information and technological updates.

The Mandanas- Garcia ruling challenges the capacities of LGUs, especially those from low-income areas, to plan and finance PAPs. There is a need to study the absorptive capacity and the extent by which the increase of funds match with the tasks that will be fully devolved as a result of the Mandanas-Garcia ruling.

LGUs also suffer from human resource constraints. There is a wide disparity in the competences and pay structure of extension officers and workers. The LGC of 1991 does not specify the hiring of a municipal agricultural officer. There is no document that specifies the standard qualification for extension workers, pay structure nor career progression. Municipalities resort to hiring job orders which are paid lower and may or may not have the right qualifications.

Transfer of technology remains problematic. The engagement in the distribution of private goods like hybrid seeds and machinery are fraught with technical and managerial challenges. The impact of the billions spent on these large extension projects had not resulted in desired targets in terms of technology adoption. Moreover, farmers and extension workers are aging. This makes it imperative to encourage the youth to engage in farming.

Extension does not include the regulation function such as those that affect the livestock industry. Biosecurity practices and surveillance should be a top priority to ensure the control of the spread of diseases. Most LGUs focus on the conduct of seminars, workshops, technical meetings and training programs. Regulatory functions in relation to distribution of machines, implementation of biosecurity measures, and must be integrated in the LGU functions.

Inadequate investments in research and the continued overlaps in research priorities continue to hamper the efficient generation of technologies that is badly needed by the agriculture sector. Improvements in agricultural TFP can attained through innovative research outputs and adoption of technologies and efficient and sustainable farm practices. AFMA provisions, which outlined the need to increase fund allocation for research and development of research capacities and the creation of CERDARF to harmonize research priorities remain relevant more than ever as the country pursues agricultural modernization.

While no specific agency was identified in AFMA to spearhead the coordination of the fragmented extension system, ATI, has taken the lead in the formulation of a national agriculture and fisheries extension agenda and budget prioritization. ATI's leadership towards DA bureaus and agencies and the regional field offices remains limited, mainly consultative and coordinative among LGUs, and non-existent for agencies such as DOST and DENR. Thus, having a national extension agency, and a merit and promotion system for extension workers remain problematic.

5.2 Recommendations

Research and extension are critical in the development of the agricultural sector. The impact of the investments in these should be observed at the farmer's level and reflected in the overall growth of the agricultural sector. However, this chapter showed that there were limitations in achieving the impact of research and extension because of governance issues. Thus, the following action points can be pursued to improve technology adoption and farmer's income.

Streamline the research planning, monitoring and evaluation process. RDIs, particularly research granting institutions, should conduct joint planning prior to the planned agency multi-stakeholder agency research thrusts finalization. This will further minimize overlaps in research prioritization and funding. The joint planning should likewise take into consideration the monitoring and evaluation of the impact of research on the agricultural performance of the country. Moreover, the government should establish and maintain a database of all research thrusts and outputs from all RDIs. Research outputs should indicate the budget and the abstract of the study. This should be made accessible to all RDIs and HEI researchers.

Increase investment in agricultural research. AFMA specifies that 1% of GVA should be invested in agricultural research while Stads et al. (2020) recommend that the Philippines should increase the current 0.4% percentage to agricultural GDP to 1.7% to reap more benefits from agricultural research. RCEF increases funds available for rice varietal research. However, no such window for increased research investments had been outlined for other important research thrusts. Investments in the development of new technologies should be underlined by increased investments in laboratories and equipment to be able to produce cutting edge technologies.

Encourage partnership between private sector, international organizations and government research institutions in the development of cutting-edge technologies, improved agronomic practices and efficient supply chain. The private sector investment in research had increased over the years. This can open up opportunities for joint partnership in the development and/or dissemination of new technologies. Policies that encourage HEIs to enter into such partnership should be strengthened. Joint R&D ventures can facilitate the development of innovations that fit local needs.

Invest in capacity development of agricultural researchers. CHED and DOST should allocate funds for formal and non-formal education of researchers in the use of cutting- edge technologies to produce innovative researches and technologies. Research granting institutions should incentivize partnership among local and international HEIs/RDIs in the conduct of research for mentoring and cross-fertilization purposes. CHED, DOST, DA and DTI should work together to strengthen capacities of HEIs in technology commercialization. Lastly, the level of preparedness of laboratories of priority RDIs/HEIs that can be used to develop new technologies should be reviewed and correspondingly, upgraded.

Enhance agriculture research-extension linkage. DA-BAR and DA-ATI should closely work together in the crafting of the RDEAP and NEAP, which, at the moment are planned independently. A mechanism for mainstreaming matured technologies from AANR RDIs to extension institutions should be established. At the moment, RRDEN, managed by DA-BAR are mandated to transfer technologies prioritized by DA-BAR while ATI does not consciously carry specific technologies when they partner with LS and SPAs. On the other hand, DOST-PCAARRD ensures that matured research technologies from their funded researchers and incorporated in the proposals of their consortia members. Complementation between government and private research and extension providers should be strengthened.

Streamline extension function. Regional ATI centers and RFOs should increase coordination in the conduct of their extension activities at the regional level. Monitoring and evaluation capabilities of LGUs to improve program efficiency, as well as their regulatory capabilities of LGUs to prevent, monitor and control disease outbreaks in crops and livestock need to be strengthened. Established protocols should be communicated to AANR LGU staff members.

Introduce innovations in the management of extension programs. With the *Mandanas-Garcia* ruling, LGUs will assume more responsibilities in the management and implementation of AANR programs within their localities. It is important that DA, through ATI and RFOs, propose innovations in the governance of AANR programs to ensure the transfer of technologies to the farmers.

Capacity building should provide emphasis, as reflected in the budget allocation, to innovative practices and technologies along the supply chain. Moreover, skills training in monitoring and enforcing sanitary and phytosanitary standards should be emphasized. On the part of the fisheries and livestock, the importance of including the regulatory functions among LGUs should be a priority.

Extension institutions should provide focused capacity building programs for low-income municipalities as they assume full devolution of agricultural functions specified in the LGC of 1991. To facilitate the professionalization among extension workers, DA should support legislations such as the Magna Carta of Extension workers.

Learning from the studies reviewed in the implementation of large-scale technology transfer programs, the following innovations are proposed:

1. *Caution must be practiced in assuming the distribution of private goods.* As in the case of hybrid seeds, where viability decreases over time, direct payment to the private sector company and letting them distribute and promote the use of hybrid seeds would have been the better option rather than buying in bulk the seeds, storing, distributing, and promoting these to farmers. The same holds true in the distribution of machinery by RFOs and LGUs where storage and delivery to farmer groups resulted in increased cost on the part of the government. Assuming this role adds direct and indirect costs to the government and takes away time, effort and funds that could have been channeled to the conduct of research, or implementation and monitoring of regular programs.

2. *Clear advantage of the technology or need for the technology should be established prior to the technology transfer.* The studies reviewed in the promotion of hybrid rice pointed out that the technology did not have a clear advantage compared to registered seeds, considering the investments needed to reap the benefits of hybrid rice. Thus, adoption was poor, and diffusion did not take off. In the case of the distribution of machinery, the needs assessment was not judiciously conducted in some areas which resulted to the non-utilization of the distributed machine.

3. *Responsibilities of stakeholders in the implementation and monitoring of the program should be established.* While protocols were crafted for the distribution of machinery, these were not followed because of limited personnel, or in the case of the LGUs implementing the program, lack of technical skills. Appointment of local inspectors from the networks of implementing agencies made so they can can be tapped as program inspectors.

4. *Management of extension programs can be improved by partnering with the private sector and maximizing digital platforms.* The current e-extension modules on various technologies may be updated and translated to major dialects.

5. *Process monitoring and evaluation should be emphasized.* As the government embarks on various large scale technology transfer programs, it is important to take note of lessons that can help improve the process in future undertakings.

6. *Evaluation of the impact of the program should be part of the plan.* Baseline and monitoring of outputs should be gathered. Procurement and distribution are not the end goal, but rather, represent the start of these programs. The improvement in the yield and income of farmers as well as the performance of the AANR sector are the end goals. Thus, incorporating the impact assessment plan from the beginning is important.

While these are established good practices in program implementation, these were apparently glossed over in the large-scale technology transfer programs of the government. Thus, these are reminders for future program managers.

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