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Assessment of Prospective Impact of Fruits and Vegetables Research at the Industry Level in the Philippines: the Case of the ACIAR-PCAARRD Horticulture Project

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Philippine Institute for Development Studies
Surian sa mga Pag-aaral Pangkaunlaran ng Pilipinas

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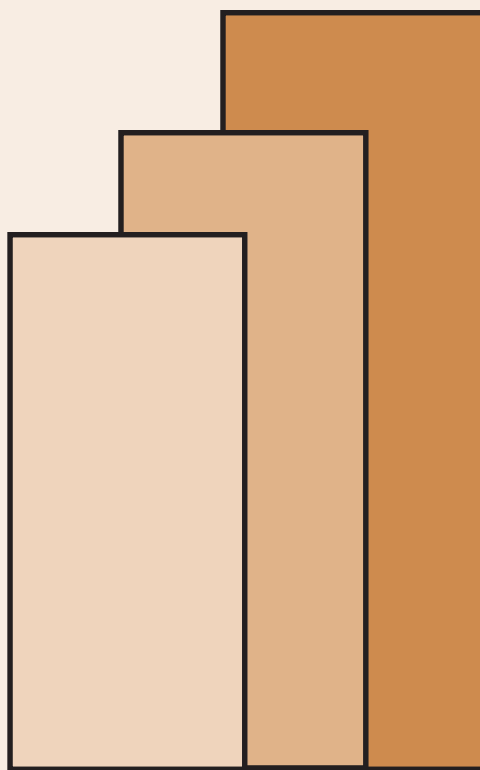
Roehlano M. Briones and Ivory Myka R. Galang

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ASSESSMENT OF PROSPECTIVE IMPACT OF FRUITS AND VEGETABLES RESEARCH AT THE INDUSTRY LEVEL IN THE PHILIPPINES: THE CASE OF THE ACIAR – PCAARRD HORTICULTURE PROJECT¹

Roehlano M. Briones², Ivory Myka Galang³

Abstract

The fruits and vegetables sub-sector shows great dynamism despite lack of government support compared to other sub-sectors within agriculture. To further realize the potential of the fruits and vegetables sector, one promising instrument is investment in research and development (R&D). The government is the primary source of funding for agricultural research and development efforts due to the “public good” character of such kind of research. However, the Philippines lags behind its neighbors in Asia in terms of agricultural research investment. Moreover, current R&D investments are skewed towards traditional commodities. This paper assessed the prospective impact at the industry level of fruits and vegetables R&D using ACIAR-PCAARRD horticulture project as case study. An economic surplus model running on a spreadsheet is used to evaluate measures of project worth for R&D investment. Application of the model shows the high social returns from raising investments in horticulture R&D.

Keywords: ex ante impact assessment, agricultural policy, R&D, horticulture, economic surplus

Introduction

A major subsector within agriculture is horticulture, which includes fruits and vegetables, regarded as high-value commercial crops. Nevertheless, farmers of fruits and vegetables confront numerous challenges, such as high working capital requirement, pests and diseases, and post-harvest losses. Traditional crops such as rice, corn, and sugar remain to be prioritized by policymakers, budget-wise and policy-wise. These contribute to the disappointing pace of diversification of the agricultural sector.

One of the many ways to hasten diversification is by investing in research and development (R&D) in nontraditional crops, such as fruits and vegetables. This paper aims to: 1) analyze the contribution of the fruits and vegetables sector in the country’s agricultural development; 2) evaluate the potential impact of R&D in selected fruit and vegetable crops, and 3) draw implications for investment allocation and institutional framework for the agricultural R&D system.

¹ This report is part of the project “Enhancing profitability of selected fruit and vegetable value chains in the Southern Philippines and Australia, Component 5: Economic Impacts of New Technologies and Policy Constraints in the Production of Vegetables in the Philippines and Australia”, funded by the Australian Centre for International Agricultural Research (ACIAR) and Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCAARRD). The opinions expressed here are those of the authors and implicate none of the institutions to which they are affiliated.

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Agricultural development and diversification

Agricultural diversification

Among the basic sectors, agriculture has the slowest output growth from 1980s to 2000s. Poor performance of agriculture affects the welfare of many impoverished households. In 2009 (Table 1), the poverty incidence among households who derived their livelihood from agriculture was 40%; while among nonagricultural households, it was just 19% (Reyes *et al.*, 2010). Meanwhile for 74% of all poor households, the primary occupation of the head was in agriculture 74% of the time; of the chronically poor, the primary occupation of the household head was in agriculture 77% of the time.

Table 1. Profile of poor households by temporal poverty and occupation, Philippines, 2009

	Occupation of household head	
	Agriculture	Non-agriculture
Percent of sample households		
All poor households	39.9	18.7
Under chronic poverty	27.6	10.8
Under transient poverty	12.3	7.8
Percent of poor households		
All poor households	73.8	26.2
Under chronic poverty	77.1	22.9
Under transient poverty	67.4	32.6

Source: Reyes et al., 2010

The government has not attained its goals of poverty reduction and of improvement of welfare of rural households despite the increasing public expenditures on agricultural development. Aside from insufficient funding, another possible reason causing this is the faulty selection, design, and implementation of programs. If such is the case, then the solution lies in finding the right program and in proper implementation.

The policy thrust should take into account the inherent dynamics of agricultural development. Agricultural development is generally accompanied by diversification; as an economy grows, it tends to move out of subsistence food-crop production to a diversified market-oriented production system (Briones, 2009). According to Hutagaol (2006), agricultural diversification is not new for many developing countries. However, because the attainment of food self-sufficiency outshone the popularity of agricultural diversification in mid-1960s, most countries adopted food self-sufficiency programs. He also pointed out that hunger and poverty were never solved by the food self-sufficiency program even if it was successful in producing food surpluses. One contributing factor is the lack of access to food by the rural poor.

Promoting agricultural diversification does not mean abolishing the food self-sufficiency program entirely. Hutagaol (2006) suggested that agricultural diversification should be integrated

in the food self-sufficiency program. The government has to relax its food self-sufficiency program by not relying on a single food crop only. There are basically three types of agricultural diversification—horizontal, vertical, and regional. *Horizontal* diversification occurs at the farm level. Small-scale farmers commonly practice this in forms of intercropping (planting of different crops on the same plot at the same time) and sequential cropping (planting of different crops in sequence on the same plot). This allows farmers to generate higher income and to manage risk by making better use of their farm resources. In *vertical* diversification, farmers undertake beyond farm-level activities like processing, storing and distribution. These add value to their products. However, one problem with this is that it requires huge amount of investment for the equipment and/or marketing. One way to overcome this hurdle is to develop partnerships with commercial agricultural institutions. The last type is the *regional* diversification, in which regions specialize in crop/s which it has a comparative advantage; such specialization entails free trade among regions.

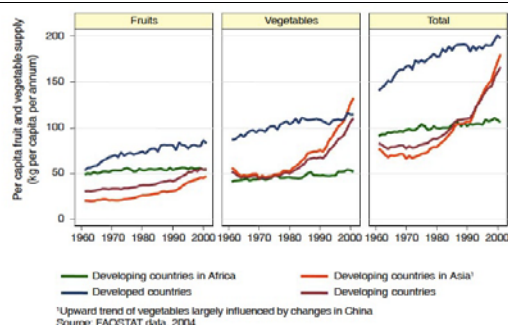
Box 1. Agricultural Diversification Trends

Table 2 and the Figure below show that there is an upward trend in fruit and vegetable diversification globally. Latin America and Caribbean, China, and, East Asia and Southeast Asia are net exporters of fruits and vegetables. In the contrary, developed countries incur deficit in fruits and vegetables. The demand for fruits and vegetables in developed countries brings great opportunities for fruit and vegetable exporters in developing countries (Weinberger and Lumpkin, 2005).

Table 2. Net trade in fruit and vegetable and food products (billion US\$)

Year	China	South Asia	East and SE Asia	Latin Amer and Caribbean	Sub-Saharan Africa	Developed countries
<i>Fruit and vegetables</i>						
1970	0.38	0.04	0.10	0.51	0.05	-2.54
1980	1.04	0.20	1.04	1.02	0.07	-8.19
1990	1.97	0.05	1.60	5.68	-0.01	-18.67
2000	2.56	0.03	1.24	8.30	0.32	20.04
<i>All food products</i>						
1970	0.52	0.03	-0.49	4.27	1.52	-7.65
1980	-1.07	1.35	-0.24	15.26	1.96	-16.26
1990	1.84	0.92	0.58	15.27	0.76	-24.38
2000	3.11	1.93	3.21	16.08	0.44	12.85

Source: (FAOSTAT data, 2004). Three year averages.



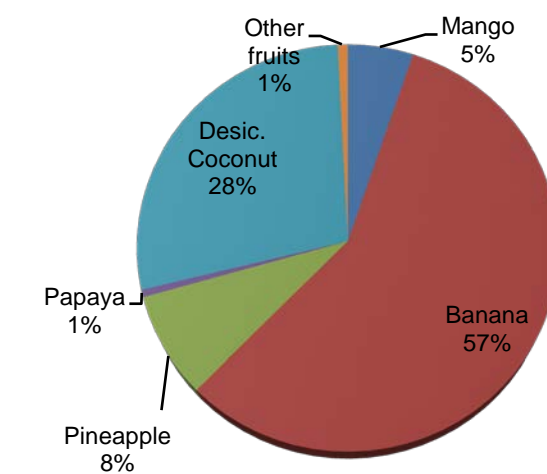
Horticulture includes several important crops in which the country exhibits comparative advantage, as indicated by export trends. Table 3 shows the average value of exports and shares of Philippine agricultural products from 2008 to 2010. Next to coconut oil, the top agricultural export product of the Philippines is edible fruits, nuts, etc. which comprise 17.6% of the total export value. Of the total USD 635 million value of edible fruits, the big chunks of the pie are banana (57%) and desiccated coconut (28%). Pineapple is 8%, mango 5%, papaya 1% and other fruits, 1% (Figure 1).

Table 3. Exports and export shares of Philippine agricultural products, average of 2008-2010

	Value (USD in millions)	Share s (%)
Coconut	967	26.8
Edible fruits, nuts, etc.	635	17.6
Food preparations	336	9.3
Rubber	329	9.1
Meat, fish and seafood food preparations	319	8.8
Fish, crustaceans, molluscs, etc	305	8.4
Tobacco	220	6.1
Sugars	132	3.7
Cereal, flour, starch, milk products	113	3.1
Others	255	7.2
Total	3611	100

Source: www.trademap.org

Figure 1. Shares per commodity in Philippine exports (edible fruits), average of 2008 to 2010, in %



Source: www.trademap.org

Fruits and vegetables play an important role in agricultural diversification. They are produced within organized supply chains and are considered as “high-value” crops. This diversification not only helps in producing a sizeable agricultural output but also boosts rural development. Because of this agricultural diversification, income of workers and smallholders tends to increase (Briones, 2008). This increase in income is brought about by the higher labor requirements for non-rice crops such as onion and other high-value crops (Pingali, 2005).

Rural growth caused by the improvement in agricultural productivity reduces poverty both in rural and urban areas. A cross-country study done by Thirtle *et al.*, (2001) showed that an improvement of one percent in the yield reduced the number of the population who are living on less than a dollar per day by 0.91 percent. Aside from employment and income effects, diversification also gives way to lesser environmental, ecological and economic risks mainly because of the varied mix of activities (Barghouti *et al.*, 2004).

Agricultural policy

In the Philippines, the government persists in focusing on the development of the traditional crops, namely, rice, corn, sugar and coconut. There are certain government interventions, specifically those restricting trade domestically and globally, which hinder agricultural diversification. Examples of which are policies targeting self-sufficiency and food security. This leaning towards traditional crops is reflected on the budgetary allocation of public funds and on price policies.

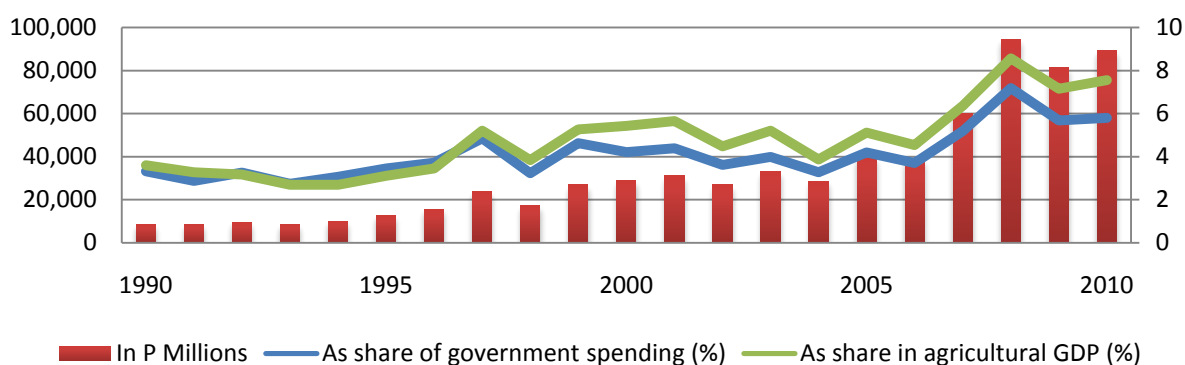
Box 2. Price Policy of the Philippine Government

The government has been supportive of the liberalization of foreign trade since mid-1980s. It abolished export taxes and government trade monopolies for agriculture. In 1994, as the World Trade Organization was ratified, quantitative restrictions were removed and ceiling rates on tariffs slowly went down. The Philippines has been engaged in different agreements like the ASEAN Free Trade Agreement (AFTA) and Japan-Philippines Economic Partnership Agreement (JPEPA). Tariff Reform Programs (TRPs), a unilateral trade liberalization, was pursued by the country and led it to target a uniform 5% tariff in 2000s. However, almost all of these liberalization efforts exempt the “sensitive” agricultural commodities. The considered “sensitive” agricultural commodities are the traditional crops—rice, corn, sugar and others (Briones, 2009).

Figure 2 shows the trend in public expenditures. Agricultural expenditure is increasing throughout the years 1990 to 2010. It peaked at PhP 94 billion (USD 2.1 B) in 2008. The latter part of 2000s appears to have faster growth. Also, agricultural expenditure, both as share of government spending and as share in nominal agricultural GDP, is also increasing.

Out of the PhP 48.6 billion (USD 1.1 B) appropriated budget for the Office of the Secretary of the Department of Agriculture (OSEC-DA) as stated in the General Appropriations Act (GAA) for 2012, the “Development of the Crop Sector” item (under program operations) has PhP 10 billion (USD 233 M). The agricultural intensification and diversification program, technology generation and dissemination for the growth and development of the vegetable industry, and the National High Value Commercial Crops program all account for 13% of the said PhP 10 B. On the other hand, the National Rice Program and National Corn Program account for 60% and 9%, respectively (DBM, 2012).

Figure 2. Trends in public expenditures: Obligation data

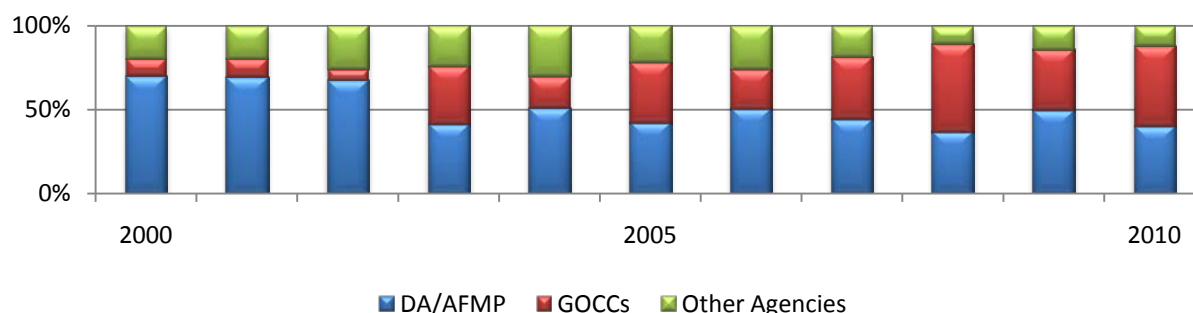


The budget of the agricultural sector for the years 2000 to 2010 is summarized in Figure 3⁴. The sectoral budget allocation for agriculture is apportioned among DA, Department of Agrarian Reform (DAR), Department of Science and Technology (DOST), and some government corporations. The bulk of the agricultural budget is under the DA, which is combined with the

⁴ Budget of Expenditures and Sources of Financing (BESF); Tables B.7a Details of the Sectoral Allocation of National Government Expenditures; actual obligation

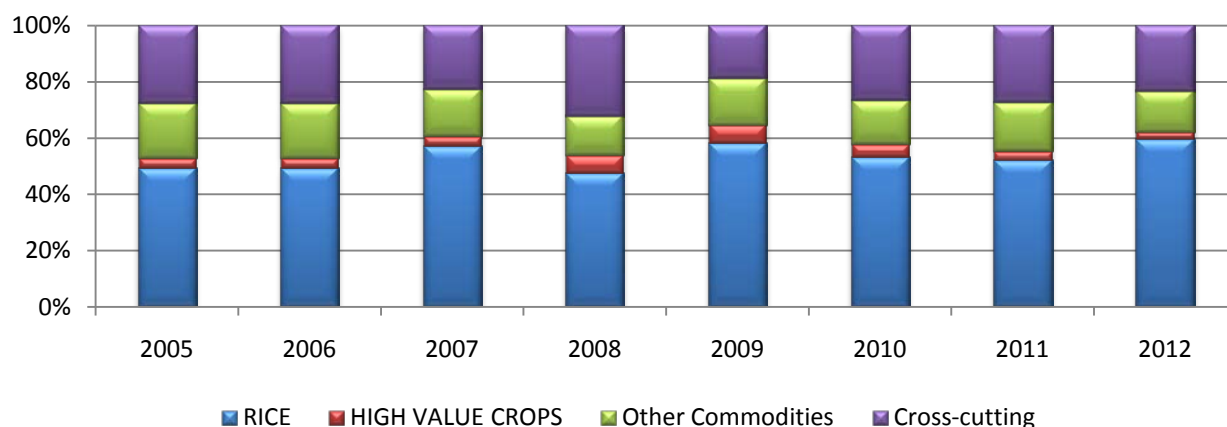
Agriculture and Fisheries Modernization Plan. “Other agencies” refers to the DAR and the DOST. As the Figure 3 shows, the share of the GOCCs⁵ is increasing, and is particularly large in 2008. This increase in the budget of the GOCCs can be attributed to the increasing budget of the National Food Authority (NFA). On the average, 83% of the GOCCs fund is mostly for NFA. This spending is in line with the past and present administrations’ program for food security, largely equated with rice self-sufficiency.

Figure 3. Agricultural sector: Budget composition by agency, 2000-2010



The GAA entries can be sorted by commodity. As Figure 4 shows, from years 2005 to 2012, rice has been dominating the budget of the whole agricultural sector. As for high value crops, the allocation increased somewhat in 2008 and 2009. “Other commodities” refers to corn, coconut, fisheries, and livestock while cross-cutting refers to line items in the GAA that cannot be placed under a single commodity (e.g. agricultural crop research, production of seeds, agricultural statistics, etc.).

Figure 4. By commodity (using GAA entries; in PhP millions)



⁵ Government Owned and Controlled Corporations— (section in the GAA: budgetary support to government corporations)

Research and Development

Budgetary allocation trend

Another way of assessing the budgetary concerns in the agricultural sector is by taking a look at the major final output (MFO). An MFO is either a good or a service provided by an agency for its clients in accordance with its mandate. Support services, regulations, and plans and policies are the MFOs of DA. Table 4 shows the breakdown per MFO. The MFO 1 is further subdivided into different kinds of support service (Table 5). These are production support, market development, credit facilitation, irrigation development, other infrastructure and post-harvest development, extension support, education and training services, and research and development.

Table 4. By Major Final Output (OPIF; World Bank ; in PhP millions)

	2001	2002	2003	2007	2008	2009	2010
MFO 1 Support services	20,199	21,758	18,702	14,748	20,803	36,006	33,858
MFO 2 Regulations	512	2,257	2,244	689	1,186	1,197	1,353
MFO 3 Plans and policies	2,076	1,382	1,103	3,059	1,767	2,469	2,617
TOTAL	22,787	25,397	22,049	18,496	23,756	39,672	37,828

Table 5. Breakdown of MFO 1 (OPIF; World Bank; in PhP millions)

	2001	2002	2003	2011
Production Support Services	2,523	2,468	4,608	4,975
Market Development Services	267	143	115	242
Credit Facilitation Services	312	124	184	23
Irrigation Development Services	9,981	13,124	9,044	12,552
Other Infra and/or Post Harvest Development Services	2,800	2,012	1,667	716
Extension Support, Education & Training Services	2,630	2,514	2,126	1,853
Research and Development	1,686	1,373	958	1,185

Irrigation is the top support service offered by DA. Again, irrigation services are mostly, if not entirely, for rice fields. In 2001, research and development only had PhP 1.7 billion (USD 33.2 M) as opposed to almost PhP10 billion (USD 195.5 M) for irrigation. R&D's share in the support services was eight percent while irrigation accounted for a 49% share of the support services. R&D continued to decline down to PhP 958 million (USD 17.7 M), which was equivalent to five percent of the total support services, in 2003. In 2011, its share was maintained at five percent (PhP1.2 billion or USD 27.7 M).

The Philippine agriculture continues to lag behind to that of its neighboring countries. The low productivity it is encountering may be attributed to the low investments placed in the agricultural sector. Investment in agricultural R&D is considered as one of the major drivers of agricultural productivity (Pascual-Gapasin, 2006). Hence, under-investment in agricultural research and development will result to low productivity.

The Department of Science and Technology once identified the weaknesses of the S&T in the country. Among the identified weaknesses are low levels of investment, lack of technology transfer, qualified staff and private-sector participation, and low attention to market demand. However, their proposed measures were not realized particularly the five-fold increase in investments in R&D. It wanted to raise the 0.2 percent share of R&D in the GDP (in 1991) to 1.0 percent in 2000 (Stads *et al.*, 2007).

In terms of growth rates in agricultural R&D expenditures, the National Irrigation Authority (NIA) was the only government agency that consistently experienced growth in agricultural R&D expenditures from 1986-2002. Other national agencies experienced a negative spending growth during the same period. Such agencies are the Ecosystems Research and Development Bureau (ERDB-DENR), Bureau of Soils and Water Management (BSWM), Bureau of Fisheries and Aquatic Resources (BFAR), and National Fisheries and Research Development Institute (NFRDI). Among the national government agencies, ERDB-DENR received the highest allotment for agricultural R&D (USD6.2 million). Given the importance of rice to the Philippine agriculture sector, PhilRice received the single largest funding allotment to a Philippine research agency. Its spending actually doubled during 1996-2002 (Stads *et al.*, 2007).

Spending on agricultural R&D declined during the Aquino Administration in late 1980s because of the fiscal restraints implemented. In early 1990s, there was a rapid increase in agricultural R&D expenditures when the Philippine Carabao Center was established and PhilRice aggressively increased its research spending. Nevertheless, from 1986 to 2000, the trend of national government agencies spending was decreasing (Stads *et al.*, 2007).

Global Trends

There was an increase of 51% in inflation-adjusted terms in the worldwide public investments in agricultural R&D, from USD 15.2 billion in 1981 to USD 23 billion in 2000 (Table 6). Out of the USD 10.2 billion of public research carried out by developed countries, US, Japan, France, and Germany accounted for about two-thirds of it. Likewise, China, Brazil, India and South Africa accounted for 50% of the public agricultural research budget of the developing countries. Growth in research spending has been slow for Africa and for the developed countries. As shown in Table 7, in 2000, the research spending of developed countries shrank. This was not the case for China and India with an average growth in spending by 5.04 and 6.3%, respectively, in the 1990s. The smaller and poorer countries had difficulty in sustaining the growth for agricultural research funding (Alston and Pardey, 2006).

The increase in the research intensities of developing countries was uneven. Agricultural workers in rich countries got USD 700 R&D spending per worker while each agricultural worker in poor countries only received USD 10.21 R&D spending in 2000. On the average, agricultural research spending per capita of developed countries increased by only 9% while that of developing countries increased by 29% (Alston and Pardey, 2006).

Table 6. Global public agricultural research spending, 1981-2000

Expenditures (\$ million 2000)	1981	1991	2000
Developing countries	6,904	9,459	12,819
Sub-Saharan Africa	1,196	1,365	1,461
China	1,049	1,733	3,150
Asia and Pacific	3,047	4,847	7,523
Latin America and the Caribbean	1,897	2,107	2,454
Middle East and North America	764	1,139	1,382
Developed countries	8,293	10,534	10,191
Total	15,197	19,992	23,010

Source: Alston and Pardey, 2006

Table 7. Global public agricultural research-intensity ratios, 1981-2000

Region/country	Expenditures as a % of AgGDP			Expenditures per capita (\$, 2000)			Expenditures per economically active member of agricultural population (\$, 2000)		
	1981	1991	2000	1981	1991	2000	1981	1991	2000
Developing countries	0.52	0.50	0.53	2.1	2.3	2.7	7.0	8.3	10.2
Sub-Saharan Africa	0.84	0.79	0.72	3.1	2.7	2.3	11.2	10.5	8.2
China	0.41	0.35	0.40	1.0	1.5	2.5	2.5	3.5	6.2
Asia and Pacific	0.36	0.38	0.41	1.3	1.7	2.4	3.8	5.2	7.6
Latin America and Caribbean	0.88	0.96	1.16	5.5	6.6	5.9	45.1	50.5	60.7
Middle East and North Africa	0.61	0.54	0.66	3.2	3.6	3.7	19.2	27.3	30.2
Developed countries	1.41	2.38	2.36	10.9	13.0	11.9	316.5	528.3	691.6
Total	0.79	0.86	0.8	3.8	4.2	4.1	15.1	17.2	18.1

Source: Alston and Pardey, 2006

One indicator to help a country attain the internationally recommended level for agricultural R&D expenditure is by setting public spending as a percentage of agricultural output or public sector intensity ratio. The estimated public-sector intensity ratio of the Philippines in 2002 was 0.46%, and if private-sector agricultural investments were to be included, it would be up to 0.54%. It was higher than Vietnam, Indonesia and Laos, with 0.17%, 0.22% and 0.24%, respectively. This ratio also is higher than the overall average for Asia (0.41%) in 2000. However, the ratio for developing countries during 2002 was 0.53%, which is higher than the Philippines ratio (0.46%) (Stads *et al.*, 2007).

From 1992 to 2003, the country's trend for both agricultural and non-agricultural R&D expenses as percentage of GDP was downward. The total research spending of the Philippines in 2003 was 0.11% of the GDP. This is very low compared to Malaysia with 0.69% and Thailand with 0.24% (Stads *et al.*, 2007).

R&D Returns

The results from the economic surplus analysis are expressed in NPV (positive), BCR (ratio greater than 1) and IRR (greater than the social cost of capital). Determining the “social rate of return” or the percentage of return on each dollar spent on R&D has been the interest of many economic studies (which analyze benefits from public investment on agricultural R&D). It is called “social” because of its benefits may not be appropriable by a private commercial entity. Furthermore, Pardey *et al.*, (2000) explained that social rates of return are higher than private rates because it also includes positive spillovers. The extent of the benefits from the investments in agricultural R&D reaches the food industry level. Consumers are able to purchase more commodities at low prices. Although other studies apply different method and provide a range of estimates of returns to agricultural research, conclusions are the same—return on public investment in agricultural R&D has been high (Fuglie and Heisey, 2007).

There are a number of R&D success stories that show how R&D helps in improving productivity. Among these are tilapia farming in the Philippines, hybrid rice in China, baby corn in Thailand and oil palm in Malaysia (SEARCA, 2009). There is empirical evidence that high levels of R&D improve productivity and economic performance of the agricultural sector. A study done by Cororaton (1998) substantiates this claim. Up to 60 percent, R&D can be translated significantly into high rates of return in the primary and service sectors (Stads *et al.*, 2007). This indicates the worth of investing in agricultural R&D.

Misallocation of scarce R&D resources

R&D resources are scarce, thus it is important to look at the allocation of these scarce resources (Table 8).

Table 8. Research Intensity Ratio (Philippines), 1994-1996

Commodity	Ratio
Rice	0.25
Corn	0.05
Sugar	0.5
Coconut	0.3
Fiber Crops	2.5-3.0
Cotton	2.5
Abaca	1
Other fiber crops	-
Vegetables	Nil
Tobacco	1.1
Livestock	0.15
Carabao	3.60
Other livestock	0.02
Fruits	
Banana	Nil
Other fruits	Nil
Fisheries	

excl. SEAFDEC	0.12
incl. SEAFDEC	0.35
Forestry	3.5

Source: David, 1998

Commodities, such as cotton and forestry, which the Philippines had little comparative advantage and had declining output, had very high research intensity ratios. On the contrary, more productive commodities like livestock, fishery, fruits, and vegetables received no or too little government research support (SEARCA, 2009).

The focus of many agricultural R&D done by government agencies is on crops and forestry. In 2002, 30% of the research conducted on crops was about rice, 33% for banana and 11% for other fruits. Both maize and vegetables accounted for 9% each (Stads *et al.*, 2007).

Public investment vs. private investment

It has been argued that, given poor record of government in making investments, activities such as R&D should be relegated to the private sector. In fact however, most agricultural R&D in the country is still done by government agencies (e.g. DOST, BAS, BAR, BSWM, PhilRice, PCC, etc.)⁶, and for good reason. This is partly because of the nature of the agricultural research being a “public good” and because of the structure of agriculture sector with many poor workers and farmers. The rural workers and farmers have no resources to conduct researches. Even their cooperatives and organizations cannot afford to invest in agricultural R&D. Another reason is the extent of the benefits from agricultural R&D. Farmers can only get small fraction of the benefits so they cannot be expected to exert much effort in undertaking R&D. Once a new technology is introduced, farmers do not wholly accept or adopt it. They are skeptical about it and would tend to focus only on a specific practice which they find suitable to their daily farm work. In addition to that, there are some crop-specific farmers who are hesitant to support researches, which assert benefits over several commodities (SEARCA, 2009).

Furthermore, emphasizing the need for government investments in R&D does not mean that private sector has no significance on R&D investments. Most of the private sector’s investments are more into applied research and technologies that do allow patenting, branding, and other options to obtain returns of their investment. Again, marketable end-products and intellectual property protection are the incentives for greater private investment. If such conditions are not met, (e.g. technology development geared towards social purposes or goals, patenting is difficult, low probability of successful commercialization) then incentives for private investment would be very limited. There are only few commodities (pineapple, cavendish bananas, yellow corn, etc.) where the private sector participated in R&D efforts. The works done by the private sector should help the government put more focus on commodities other than those already being

⁶ Department of Science and Technology, Bureau of Agricultural Statistics, Bureau of Agricultural Research, Bureau of Soils and Water Management, Philippine Rice Research Institute, Philippine Carabao Center

supported. However, there is still a need for the government to continue R&D on commodities already supported by the private sector. This is to address possible under-investment by the private sector on research projects which exhibit public good character.

Another government intervention that could help stimulate private investment for agricultural R&D is the strengthening of the intellectual property protection (SEARCA, 2009). Aside from the government and the private sector, agricultural R&D also involves international agencies. This linkage can help the country in obtaining financial and technical support, in exchanging research findings and technologies, and in developing the capacity of the research staff. Given the indispensable role of the public sector in R&D, the utmost effort should be exerted to allocate scarce investment funds wisely.

Assessment Method

The foregoing uses the congruency or parity model to assess the allocation of research resources. This means that funds will be allocated to the research areas in proportion to their respective contribution to the agricultural production value. An example of this is when the value of rice output were twice that of maize, research funding for rice must receive twice as much funding as maize. This model explains that an additional dollar spent on R&D would have a higher return if invested on research areas with low ratio of funding to output value (Stads *et al.*, 2007).

An alternative method that can be used is the economic surplus analysis. The extent of the research, development, and extension (RDE) costs is weighed against the benefits from technology adoption measured in their “present value”. It measures ex-ante benefits and measures effects of technologies. Because of research, the commodity supply curve against a demand curve may shift to the right. This leads to an increase on quantity produced and consumed, thus price tends to be lower (Alston, 2010). Such industry-level repercussions should be taken into account in the evaluation of prospective research benefits.

According to Alston *et al.* (1995), the change in economic surplus arises from farm productivity improvement due to innovation (k-shift), which propagates by a diffusion process. The economic efficiency of a research project is measured in terms of net present value (NPV), benefit-cost ratio (BCR), and internal rate of return (IRR). The IRR is the discount rate or interest rate that equates NPV to zero. The discount rate reflects the time preference of society for current consumption. This is also called social time-preference rate.

The k-shift is commonly conceptualized as the research-induced downward shift of the supply curve. It is also called k-factor (Aw-Hassan *et al.*, 2003). There are many ways to estimate the k-shift. One is estimating commodity-supply functions directly using data on past research costs. Another is to estimate production functions and extrapolate the k value from the production function shifter. However, these two methods would need comprehensive time-series data on the inputs and outputs. For this reason, the k-factor is often deduced based on this formula: $K_t = \alpha_t k_t$,

where α_t is the adoption rate of the technology in a given year t and k_t is the per-unit cost reduction in year t as a result of technological change.

The k -value is very crucial in determining the total benefits from research. It is usually estimated as the yield increase per unit area caused by technology. Changes in input use and the industry supply elasticity must be incorporated in the k -factor if it would not just be a measure of yield increase but cost saving. On-farm trial results can be very useful in estimating the k -value for a particular technology (Maredia *et al.*, 2000).

Box 3. K-shift of the cotton industry in Senegal due to adoption of new varieties and agronomic treatments⁷

The k -shift values shown in the table below are computed using this formula: $k = (j / \varepsilon) - c$, where j is the data on increased production, ε is the supply elasticity, and c is the adoption costs. The k -shift estimates are not in percent. The proportional supply shifts (k) in Senegal are:

Year	j	ε	c	k
1985	0.0771	0.3	0.28477	-0.02792
1986	0.1103	0.3	0.24098	0.12653
1987	0.1126	0.3	0.16390	0.21152
1988	0.2022	0.3	0.12879	0.54508
1989	0.2579	0.3	0.12400	0.73565
1990	0.2234	0.3	0.10261	0.64195
1991	0.2616	0.3	0.11577	0.75632
1992	0.2359	0.3	0.10424	0.68215
1993	0.2533	0.3	0.11224	0.73210

A model named Welfare Impact Simulator for Evaluating Research or WISER⁸ has been developed to automatically calculate the prospective impact of a new technology generated from fruits and vegetables R&D. It is available as a spreadsheet and is based on the framework presented by Alston, Norton, and Pardey (1995) for economic surplus analysis. Explanations and steps on how to use WISER can be found in a user's manual available upon request.

One advantage of WISER is its reliance on supply demand modeling, which allows for price adjustments once a technology generated by R&D propagates among farmers. Given the research cost and on-farm k -shift estimates, the measures of project worth—NPV, BCR, and IRR—are calculated using WISER. It can be applied for prospective assessments of new R&D investments, as well as retrospective assessments of the impact of past R&D investments. Also, the user can compare scenarios which vary key assumptions such as farm-level productivity impact, rate of adoption, discount rate, and so forth.

⁷ Masters, W. Coulibaly, B., Sanogo, D., Sidibe, M., Williams, A., Sanders, J., Lowenberg-DeBoer, J. 1996. The Economic Impact of Agricultural Research: A Practical Guide. Department of Agricultural Economics, Purdue University.

⁸ WISER is developed by Roehlano M. Briones of Philippine Institute for Development Studies with financial support of the Australian Centre for International Agricultural Research. The spreadsheet is available upon request but use of WISER requires proper acknowledgement and citation.

The **threshold k-shift**, which is the minimum value to justify the amount invested in the research, may also be computed if k-shift estimates are still unavailable. Instead of using k-shift estimates to come up with results in terms of NPV, BCR and IRR, the NPV, BCR and IRR are used to compute for the threshold k-shift. This can be done by setting NPV to 0, BCR to 1, and the discount rate equal to the target IRR.

Background on the horticulture project and on focus crops

Fruit and vegetable farmers in the Southern Philippines experience difficulty in maximizing their profit and in being competitive in the market. To address these issues (e.g. pests and diseases and postharvest losses), the Australian and Philippine Governments are working together in their four-year R&D initiative, the Philippines Horticulture Program, which is ending this year.

The Philippines Horticulture Program consists of four components each for fruits and for vegetables and one component that covers both. For the fruits, the components are:

- C1. analysis of papaya supply chain constraints
- C2. durian/jackfruit phytophthora integrated management
- C3. papaya integrated crop management
- C4. improved and sustainable mango value chain.

For the vegetables, the components are:

- C1. Integrated soil and crop nutrient management
- C2. Development of a cost-effective protected cropping system
- C3. Management of bacterial wilt and other wilting diseases in Solanaceous crops
- C4. Analysis of selected vegetable value chains

The “umbrella” component is C5 which focuses on the economic impacts of new technologies and policy constraints. Research cost was financed by the Australian Centre for International Agricultural Research (ACIAR) with in-kind contribution by the Philippines. Among the numerous fruits and vegetables planted in the Philippines, the focus crops for this program are:

- Fruits:
 - jackfruit
 - durian
 - mango
 - papaya
- Vegetables:
 - cabbage
 - tomato
 - lettuce
 - broccoli
 - native *pechay*
 - radish

- cauliflower
- white potato
- eggplant
- stringbeans
- ampalaya

Jackfruit

The national production of jackfruit is around 50,000 to, but has been declining (Figure 5). On the average, 94% of the national gross supply of jackfruit is consumed while six percent are used as feed and waste. The share of exports is almost negligible, 0.04 percent.⁹

Durian

The production volume of durian in the Philippines is expanding (Figure 5). In 2001, 31,638 mt were produced and volume peaked at 73,250 mt in 2007. Although the decrease in production in 2008 was striking, the rapid recovery in 2009 continued until 2010 with a volume of 77,549 mt. This expansion in volume is also reflected in the area of production of durian. During 2001, the area intended for durian production was only 9,600 ha. By year 2010, that figure has almost doubled—18,800 ha (Figure 6).

Mango

Mango is one of the most important fruits in terms of value and volume of production in the Philippines; 5.2% of the total edible fruit exports of the Philippines are mangoes (see Figure 1). Because of increased competition in mango, the Philippines try to increase its production. The highest volume of mango produced by the Philippines was in 2007, i.e. 1,023,907 mt but sharply went down to 771,441 mt in 2009. In 2010, the mango production appeared to be heading upwards again (Figure 7).

Papaya

The total papaya production started to fall in 2009 with 176,656 mt, from 182,907 mt in 2008. This is also reflected in the land area of papaya production as shown in Figure 8. A decrease of 272 ha in the total papaya production area happened in 2008 to 2009. Most of the top papaya-producing regions are in Mindanao. Of its total production, only two percent is exported fresh and dried, 92% are consumed domestically and six percent are used as feeds.¹⁰ Papaya accounts for 0.6% of the total edible fruit exports of the Philippines, averaged from 2008 to 2010. The major export markets of papaya are Japan, China, Hong Kong, Saudi Arabia, United States and others (Vawdrey *et al.*, 2007).

⁹ BAS Data

¹⁰ BAS Data

Tomato

The production of tomato in the Philippines is growing as shown in Figure 9. In 2001, the national tomato production is estimated at 146,000 mt and in 2010 it reached about 204,000 mt. About 78% of the tomato produced in the Philippines are being consumed, 15% are used as input or raw material for food manufacturing and seven percent as feeds and wastes. Unlike other vegetables, the area of tomato production is increasing in a slow pace (Figure 10). From 16,500 ha in 2001, the total area for tomato was 17,600 ha in 2010.

Figure 5. Jackfruit and Durian Volume of Production (mt)

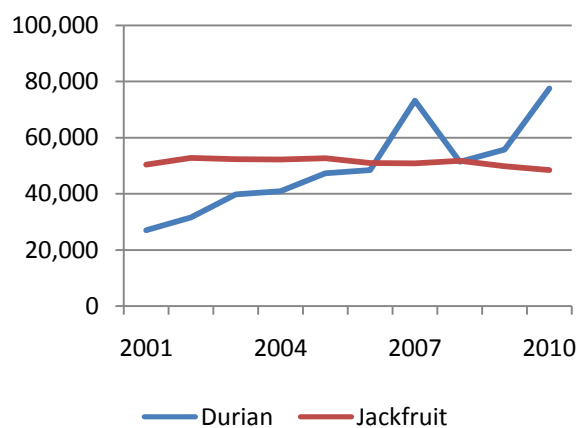


Figure 6. Durian Area of Production (ha)

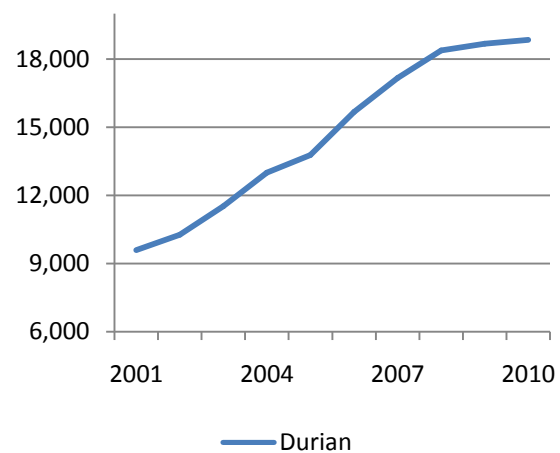


Figure 7. Mango Production

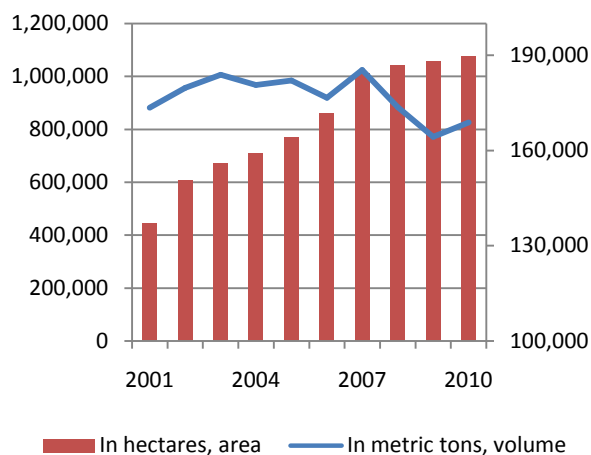
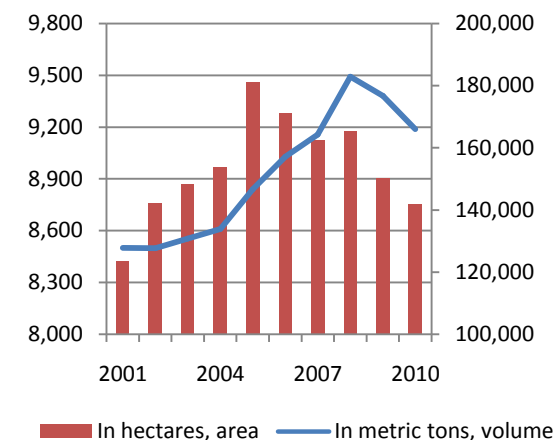


Figure 8. Papaya Production



Cabbage

In 2006, the area of cabbage production dropped to 7,300 ha but increased sharply after a year, i.e. 2007, which was 8,500 ha (Figure 10). Cabbage production has increased significantly. In 2001, the cabbage production was about 89,500 mt. Total cabbage production has increased by 44 % in 2010 amounting to 127,500 mt (Figure 9). The top cabbage-producing region is Cordillera Autonomous Region (CAR) where about 80% of the cabbages are produced. In terms of consumption, 92% of the cabbages produced are consumed, while the remaining eight percent are either wasted or used as feeds.

Potato

The national production of potato increased dramatically from 66,000 mt in 2001 to about 124,600 mt in 2010 (Figure 9). However, importation also increased during the decade (2001-2010). From a 2.2% share in the gross supply of potato in 2001, it became 13% in 2005 but decreased to 5.2% in 2010. The sudden increase in the volume of potato can also be observed in the increase of land area where it is planted. The total area for potato production was just 5,450 ha in 2006 but it grew close to 8,000 ha in 2007. The growth in area continued until 2010, at 8,100 ha (Figure 10). The average consumption of fresh potato accounts for a 71.7% share in the total utilization. 23.5% are used for processing while 4.7% are used as feed and waste.

Lettuce

The total area for lettuce production more than doubled in a span of 10 years. In 2001, the area was only 211 ha but in 2010, it grew as much as 466 ha (Figure 10).

Broccoli

Since 2001 up to 2010, the production of broccoli grew by 68% (Figure 9). The top region to produce broccoli is CAR which has a 70% share in the total broccoli production. It is followed by Northern Mindanao with a 25% share. The area of production also increased as shown in Figure 10.

Cauliflower

In 2001, there was 12,300 mt but in 2010, it was only 11,100 mt. The national production of cauliflower has fallen by 10% from 2001 to 2010 (Figure 9). CAR produces 47% of the total native pechay production. It is followed by Ilocos region which also has a large share—41%. 92% of the total volume of cauliflower is for consumption and only 8% are used as feeds.

Stringbeans

In 2001, the national production of stringbeans was 26,490 mt (Figure 9). After a decade, it grew by more than 300%. Its production area almost doubled as well, from 7,500 ha to 14,600 ha (Figure 10). Central Luzon produces 31% of the stringbeans in the country. It is followed by Cagayan Valley which has a 15% share in the production in 2010.

Radish

The radish production has experienced minimal growth of only 3% from 2001 to 2010 (Figure 9). The area planted to radish grew but to a small extent only—6% (Figure 10). CALABARZON is the top region producing radish—35% of the total volume of radish. CAR and Davao region hold the second (16%) and third place (15%), respectively. About 92% of the radish production is consumed while feed and waste account for nearly 8%.

Pechay native

In 2001, there was only 37,400 mt while it was 44,900 mt in 2010. The national production of pechay native grew considerably by 20% (Figure 9). Bicol produces 29% of the total native pechay in 2001 and it increased to 31% in 2010. It is followed by CALABARZON and Cagayan. 92% of the total volume of pechay native is for consumption and only 8% are used as feeds. There was a small increase of 5% in the area of production of pechay native (Figure 10).

Ampalaya

The production of ampalaya grew by 88% since 2001 (Figure 9). Central Luzon is the top producer of ampalaya with a 36% share in 2001 but slowly decreased to 29% in 2010. The second top producer, CALABARZON, is getting close to the top spot with its 27% share in 2010 from just 22% in 2001. The area of production of ampalaya expanded to 34% (Figure 10), from 8,300 ha in 2001 to 11,100 ha in 2010. About 92% of the ampalaya produce are consumed, while 8% are used as feed or wasted.

Eggplant

The national production of eggplant has increased by 23% or 38,400 mt (Figure 9). In 2001, the production volume was only 169,800 mt, while in 2010, it was 208,200 mt. Feed and waste accounts for 8% of the total production as compared with consumption which accounts for 92%. The top region producing eggplant is the Ilocos region. It produces 35% of the total production. The area planted to eggplant increased by 5%. In 2010, it was 21,400 ha but it was 20,400 ha in 2001 (Figure 10).

Figure 9. Vegetables: Volume of Production (mt)

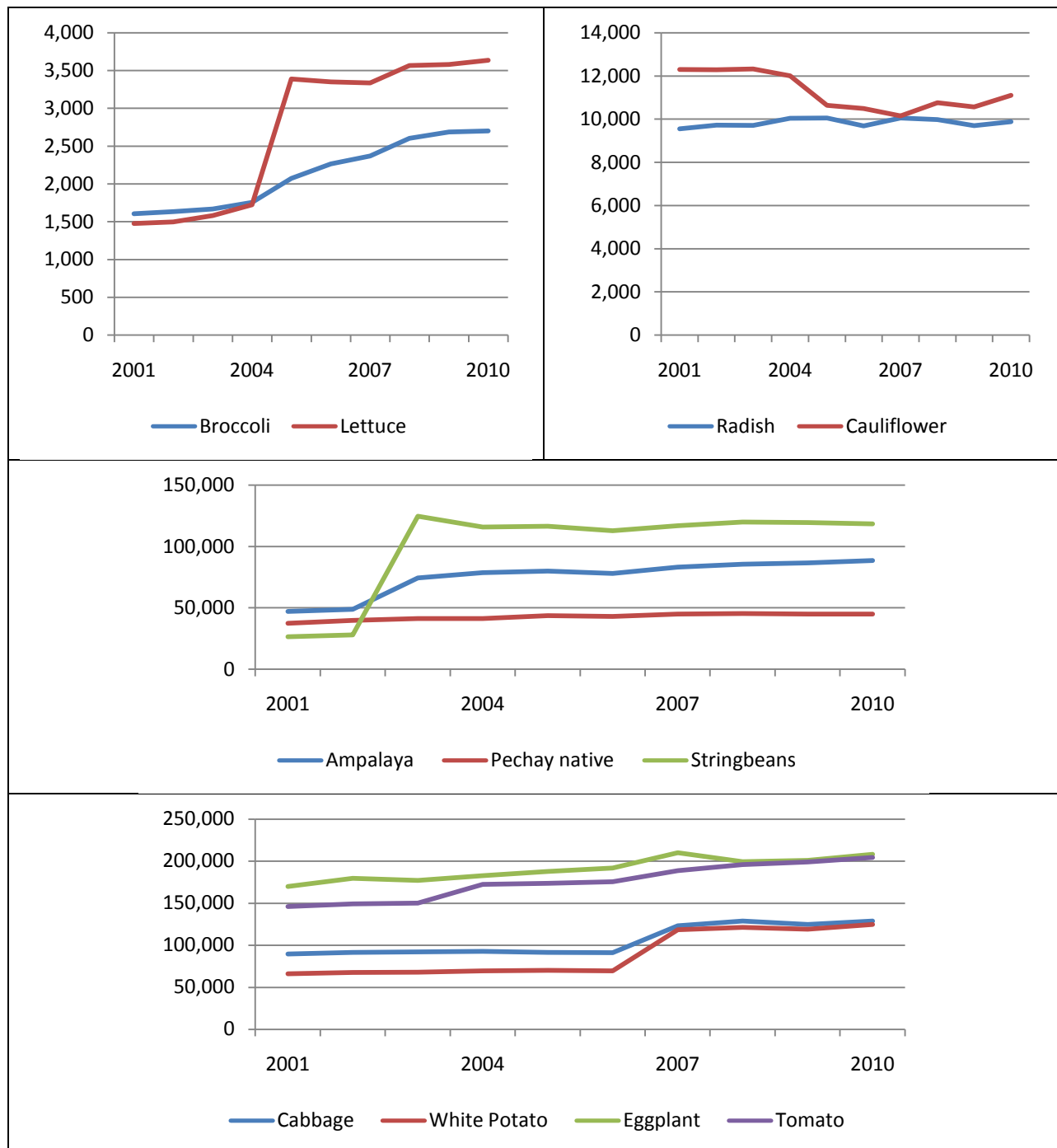
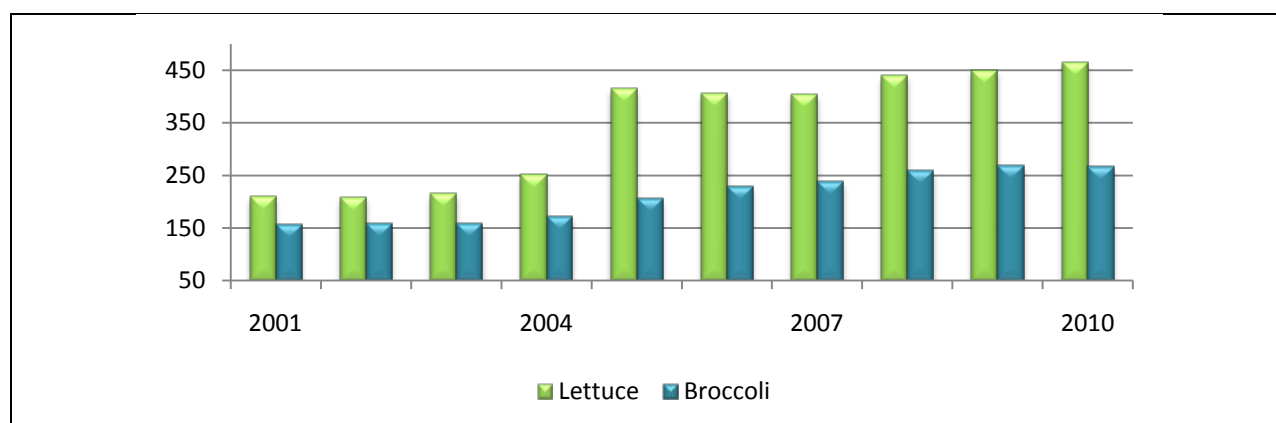


Figure 10. Vegetables: Area of Production (ha)





Results of the Assessment

The research costs (Table 9), k-shifts (Table 10), baseline data, and other information were inputted into the WISER model to compute measures of project worth of horticulture research, as exemplified by the ACIAR-PCARRD Horticulture project. The k-shifts are hypothetical farm-level impacts based on preliminary gross margin analysis, previous research research on R&D and expert opinion.

Table 9. Research Cost (over 4 years)

	Total investment in the Philippines (AUD)	Philippines in- kind (AUD)	Total
Vegetables	1,255,835	600,536	1,856,371
Durian and Jackfruit	201,345	18,200	219,545
Mango	430,091	56,504	486,595
Papaya	232,325	93,612	325,937
Total	2,119,596	768,852	2,888,448

Source: ACIAR-PCARRD Horticulture Project.

Table 10. K-shift estimates by focus crop

Commodity	K-shift	Commodity	K-shift	Commodity	K-shift
Cabbage	0.25	Pechay Native	0.25	Stringbeans	0.25
Tomato	0.25	Radish	0.25	Jackfruit	0.14
Lettuce	0.25	Cauliflower	0.25	Mango	0.37
Broccoli	0.25	Eggplant	0.25	Papaya	0.00
White Potato	0.25	Ampalaya	0.25		

Note that research cost data is available by component, separately for fruits and vegetables; allocation by crop for fruit is possible given correspondence between focus commodity and

component. This was not possible though for vegetables; hence for each vegetable focus commodity, the research cost is imputed as an equal share of the total vegetable research cost.

Results of the simulation are summarized in Table 11. Note that only the fruits have specific k-shift estimates. We lump together all the vegetables as the individual k-shifts are imputed rather arbitrarily, given the absence of specific k-shift estimates for these crops.

Table 11: Ex ante measures of project worth for the case of the ACIAR-PCARRD Horticulture Project

	Low Adoption			High Adoption		
	NPV ('000)	BCR	IRR	NPV ('000)	BCR	IRR
Jackfruit	2,943	1.57	7.52	20,314	4.92	13.55
Mango	1,063,464	47.27	45.55	3,355,576	147.00	51.05
Papaya	-15,397	0.00	0.00	-15,397	0.00	0.00
Vegetables	359,559	5.10	15.00	1,327,278	16.14	22.00
TOTAL	1,405,384	11.30	23.43	4,682,586	35.32	29.77

The responses to technology of all the commodities differ. Among the fruits, mango has the highest measure of project worth which amounts to PhP1 B under the low adoption scenario and PhP 3.4 B under the high adoption scenario. For vegetables, benefits are expected to be sizable as well, netting as much as 1.3 billion

Since the levels of adoption applied in this study is quite conservative, it is expected that actual values of the NPV, BCR and IRR are higher. The high adoption scenario assumes 20% maximum adoption while, in low adoption scenario, it is even lower—5%. In general, the higher the assumed adoption rate, the higher the NPV.

The threshold k-shifts of the commodities for low adoption scenario and high adoption scenario are summarized in Table 12, this time for all the focus commodities (including vegetables). The threshold k-shifts under the high adoption scenario (20% maximum adoption) reveal that most of the commodities need small k-shift values to positively respond to investments. Potato, eggplant, tomato, stringbeans, and mango obtained very high NPV, BCR and IRR. These commodities only needed small units of k-shift. This also means that investing on these commodities would likely be socially profitable. Even with modest k-shifts estimate (i.e. lower than the imputed 25%), R&D investment in most of the vegetable crops would likely be worthwhile. However lettuce, brocolli, radish, and cauliflower, would likely require large farm-level productivity shifts for R&D investment to be worthwhile; alternatively research investment in these commodities can be kept low if the same yield improvement can be achieved (e.g. by a knowledge product whose benefit spans across various focus commodities).

Table 12: Threshold k-shifts under low and high adoption scenarios (%)

Commodity	Low adoption	High adoption
Cabbage	0.06	0.02
Tomato	0.03	0.01
Lettuce	0.54	0.27
Broccoli	0.61	0.33
Potato	0.03	0.01
Eggplant	0.03	0.01
Ampalaya	0.05	0.02
Pechay Native	0.13	0.05
Radish	0.46	0.21
Cauliflower	0.34	0.14
Stringbeans	0.04	0.01
Durian	0.03	0.01
Jackfruit	0.09	0.03
Mango	0.01	0.00
Papaya	0.14	0.05

Note: in computing the threshold k-shift the following are imposed: discount rate of 5%; NPV = 0; and BCR=1. Setting IRR = 0.05 yields identical results.

Conclusion and recommendations

A key methodological contribution of this study is the development and application of a simple spreadsheet approach to evaluate the impact of R&D using a WISER model. With this model, researchers can generate data on the potential impact of their research and compare it with the cost of research investment. The value of the BCR, NPV, and IRR indicates how much impact a research can make, allowing researchers to justify funding for their research program. Likewise it also allows the funding agencies to gauge at the beginning the significance of a particular research.

The results indicate that horticulture research is supporting as indicated by the high NPV, BCR and IRR values obtained from our case study. Horticulture farmers benefit from technologies generated by the R&D projects. (e.g. yield improvement, reduction in postharvest loss, etc.). These improvements in farm productivity also help in alleviating rural poverty. Therefore, this paper recommends that policymakers should reallocate resources favoring public investment for R&D in horticulture.

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