# Economics of vegetable production under protected cropping structures in the Eastern Visayas, Philippines

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*Abstract*

Growing vegetables in the Eastern Visayas has always been problematic, especially in the wet season, due to heavy winds and rain. Protection from this harsh environment can be provided by various means, but there are obvious trade-offs between protection and cost. The practical reality is that there is minimal uptake of protected cropping in the region, and focus group discussions indicated that this was primarily due to the cost of the protective structures. Thus, in the project reported here, economics research, combined with agronomic and engineering, plays a significant role in trying to achieve a cost-effective, protected-cropping production system. The results of farmer-cooperator trials show that protected cropping can be economically feasible, and there has already been uptake beyond the auspices of the project. Farmer skill levels (including crop selection) are important in contributing to productivity and revenue. Also, basic inputs such a fertiliser and pest control are important. There is a negative correlation between rainfall and vegetable productivity. As experience is gained by farmers and local-government units in the region, economic feasibility should be further enhanced.

## Introduction

The Eastern Visayas (Region 8) in the Philippines produces about 50,000 tonnes of vegetables per year. However, this production is only 45% of the consumption of vegetables in the region, and this consumption level at under 100 g/person/day is one of the lowest in the Philippines (FNRI 1993).

One reason for the inability of the Eastern Visayas to satisfy demand for vegetables is that year-round production is significantly limited by high rainfall (average 2.4 metres per year) and typhoons between June and February. This weather can also bring destructive winds in excess of 150 km/h, which physically damage leaves, flowers and fruit, encourage disease, and pose difficulties in planting, spraying and harvesting operations.

Due to these damaging winds and rain, vegetable prices tend to rise significantly in the wet season (Menz and Armenia, undated a). High costs of inter-island transportation and poor road transport infrastructure in the Visayas hamper the import of vegetables from other islands. While vegetable self-sufficiency for the Eastern Visayas is not an end in itself, these weather and transportation factors do provide an economic incentive for seeking a means of cost-effective vegetable production under a protective cropping regime.

The overarching aim of the research between Visayas State University (VSU) and Applied Horticultural Research (Australia) is to develop, evaluate and implement a protected-cropping production system, with a view to helping farmers gain

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higher farm incomes. If successful, this technology would enable farmers to produce crops (including high-value crops) during the wet season when prices are high.

There are many examples of economic analyses of protected-cropping and greenhouse structures in the developed world but few in the developing world and less than a handful in the Philippines. Sace (undated) analysed the economics of structures for vegetable growing in Central Luzon. These structures appeared to be profitable, but it must be said that the analysis was rather isolated from practical on-farm realities. A more realistic analysis was undertaken in the same area of the Philippines by Ramos (2008) and the economic outcomes were poor, apparently due to excessively high temperatures inside the structures. (The latter was not a serious problem in the project described in this paper since the structures were not fully enclosed which allowed for some ventilation and temperature reduction.) Some economic analysis of production under structures was undertaken by Asantos and Mocampo (2005) but the focus of their work was primarily on the growing medium for the plants rather the structure per se.

The objectives of the project reported here were:

1. to develop and test appropriate and effective protected-production systems for annual crops
2. to determine whether the production of vegetable crops using protected cropping systems in the province of Leyte in the Eastern Visayas is economically viable at both farm and market levels
3. to promote adoption/modification of protected cropping systems in Leyte.

## Review of literature

Greenhouse technology or protective cultivation in temperate regions has been widely applied due to the adverse climatic conditions unfavourable to warm-season vegetable production. For instance, greenhouse designs (El-Aidy 1984; Brun and Lagier 1985; Bailey and Richardson 1990; Castilla et al. 1992) and the influence of greenhouse technology on the growth and performance of vegetables (e.g. Caruso 1986; Bakker 1990; Castilla 1994; Al-Kadi et al. 2000) have been documented and discussed in the scientific community for some time.

In tropical Asia, a review of the opportunities and constraints to protected vegetable cultivation (Everaarts and de Putter (2009) reported that, in India, production of vegetable crops in plastic houses was employed (Singh and Sirohi 2006; Singh et al. 2007). The review pointed out the 'utilization of plastic or net houses required relatively higher investments than open field cultivation but it was attractive to reduce pesticide use and to increase profits'. In Indonesia, a survey of sweet-pepper growers (Gunadi et al. 2007) also showed the utilisation of traditional, bamboo-framed plastic houses. It was also observed that relatively well-off farmers use a combination of wood and light metal for framing. In the Philippines, Aganon and Aganon (2009) articulated the required technical considerations on vegetable production and the economic potential of protected cultivation, based mainly from their research experiments conducted in Nueva Ecija and related studies.

The economics of protected vegetable cultivation have been widely addressed in more-advanced countries. Waterer (2003) looked into the viability of high and low tunnels to produce warm-season vegetables in Canada, and showed that the most economically attractive cropping option was peppers, primarily because of superior yields of mature red fruit, which commanded a price premium. The study concluded that it would take 2–5 years for the gross returns obtained with the high tunnels to cover their capital costs. In the UK, Schmutz et al. (2011) observed that organic protected cropping can be very profitable but that the economic returns are very sensitive to changes in price and yield. In India, Singh et al. (2007) found that the benefit:cost ratio of greenhouse cucumber cultivation was 2.29. They concluded that low-cost, naturally ventilated greenhouses were the most suitable and economical for year-round cucumber cultivation on the northern plains of India. Likewise, Kumar et al. (2009) found during a 2004–06 field experiment in mid-level hill country of the north-west Himalaya, India, that selected cropping sequences resulted in 1.45–2.80 times higher crop yields inside a greenhouse than did open field conditions. The highest benefit:cost ratio of 3.14 was obtained for the cropping sequence capsicum–tomato–spinach.

Econometric analysis was also employed by Al-Kadi et al. (2000) to determine the costs of production of vegetables grown under protected cropping in the highland area of Jordan. The model developed enabled farmers to find the optimal amount of production, by equating the marginal cost of production with price. Using regression analysis from a survey of 145 vegetable growers in the Spanish Mediterranean coastline, Bertuglia and Calatrava (2012) found that a farmer's level of horticultural training, the adoption of a quality system, the use of family labour for the greenhouse work and, to a lesser extent, the type of crop and the area planted, were positively related to productivity.

Prior to a protected-cropping project funded by the Australian Centre for International Agricultural Research (ACIAR), the technical and economic viability of low-cost, protected vegetable cropping using locally available materials such as bamboo had not been tested in any area within Leyte, Southern Leyte or other areas of the Visayas islands. As one of the areas prone to prolonged rainfall and other unfavourable climatic conditions, significant findings on the technical and economic viability of protected cropping arising from this project represent new information regarding possibilities for increasing farmers' incomes and climate-change proofing in the region and other parts of the country with similar climatic conditions.

## Project approach

The functional and economic performance of low-cost protected-cropping production systems was assessed over a 4-year period from 2008. The investigations involved controlled field experiments at VSU (focusing on factors influencing performance) and commercially orientated systems on farmers' fields. More details are available in a companion paper in these proceedings (Capuno et al. 2012).

As a first step before the field work in the project began, a focus group discussion was held with farmers and representative local-government unit (LGU) staff in Cabintan and Ormoc to assess their knowledge levels and interest, and identify any constraints regarding protected cropping of vegetables. It turned out that some farmers were familiar with the concept, but many were not. Once exposed to the idea via photographs and diagrams, all farmers expressed an interest, but many said that the capital cost of building the structures would be a constraint. Consequently, the project went to great lengths to involve the farmers in the discussion about the building of the structures and they took primary responsibility for the construction, incorporating their own ideas about cost-saving or endurance-enhancing ideas for the structures.

Throughout the project, the assessment as to whether protected cropping would be an economically viable alternative to current practices was a major project driver. It was decided after about 18 months of the project that close monitoring of the economic performance of the VSU sites (i.e. non-farmer sites) would cease due to their more 'experimental' (i.e. less commercial) nature. Therefore, the economic data presented in this paper relate to farmer-cooperator sites only.

### Selection of project site and farmer-cooperators

By project end, 18 farmer-cooperators were directly involved in the project from the different farmers' field sites: Ormoc City and Bato of Leyte province; and Bontoc and Maasin City in Southern Leyte province. Of the 18 farmer-cooperators, 10 came from Ormoc, six from Maasin, one from Bato, and one from Bontoc. At the start of the project, only two farmer-cooperators from Ormoc and Maasin were identified. As the project expanded, seven additional farmer-cooperators were identified by the project personnel, whereas the remaining cooperators were identified by LGU counterparts of the project in Ormoc (5) and Maasin (4).

The city/municipal agriculture officer or officer in-charge was consulted by the project team on the selection criteria for sites and farmer-cooperators. The basic criteria for selecting a farmer-cooperator were good farming performance and positive attitude. The farm of the chosen cooperator was further evaluated by the project team for its suitability in terms of soil type, water source, social stability and accessibility (farm-to-market road) since the set-up would also serve as a model farm to the community.

### Farmers' field set-up

The project team provided advice on the design, establishment and other technical requirements in erecting the protective structures in the farmer-cooperator's field. However, farmers themselves made numerous suggestions in relation to the design, both at the initial design stage and establishment of the structures. The farmers' field sites were situated in lowland and upland areas as can be observed in Ormoc City and Maasin City. The project evaluated essentially two types of structures at the project sites (Figure 1): house-type structures, made mainly of bamboo or coco lumber covered with UV-proof plastic roofing and with an effective growing area of 200 $m^2$ (5 m × 40 m); tunnel-/igloo-type structures made of either bamboo or steel frames, with either plastic or net covering (Armenia et al. undated), and

**Figure 1.** Sample vegetable crops under a protective structure and in an open field, Bontoc, Southern Leyte

with a growing area of 60 $m^2$ (1.5 m × 40 m). Most of the sites used house-type structures and, except for the regression analysis results reported later in this paper, the economic data provided here relate to that type. The farmer sites were used to collect information to support the assessment of economic viability and to monitor for the emergence of new production challenges. At all field sites, plants in open field or a control set-up were provided for comparison with the protected crops. Drip irrigation systems were used at some of the pilot farms at Ormoc and Bontoc sites. Temperature, relative humidity and light intensity were monitored using either electronic sensor with loggers, or by manual recording of temperature from thermometers. Rainfall data were also collected.

## Decisions on what vegetables to plant

The farmer-cooperators, in consultation with the project technical team and/or a field technician from the LGU, made the final decision on what vegetable crops to plant, when to produce them, and the planting plan for the successive croppings. In some instances, the technical project team intervened with advice on crop choice (e.g. to avoid pest build-up). Crops were grown under structures throughout the year—typically this meant that three crops were planted, but this was not always so.

## Materials and technical assistance provided

The project provided all the materials, labour and related expenses for the protective structures at no cost to the farmer-cooperators. Also, material inputs for the first cropping, such as fertilisers and seeds, were provided by the project, as was technical advice regarding cultural management aspects, from land preparation to harvesting, and for controlling insect pests and diseases in preventive and curative control measures. These included cultural (e.g. sanitation, crop rotation, pruning), mechanical (hand-picking and bagging as in the case of ampalaya), chemical control (contact and systemic pesticides) with observance of withholding periods, and the use of botanicals or organic sprays.

## Economic data collection and other farmer feedback

To backstop the technical component of the project, initial establishment costs of the protective structures at all project sites, including repairs and maintenance costs, were monitored and recorded. Labour and material inputs incurred by each farmer-cooperator relating to their vegetable production with and without a protective structure were regularly monitored and recorded. Farm receipts, expenses and gross margins were calculated for all farm sites.

Focus group discussions (FGDs) in which representative farmers and field technicians participated were conducted in Ormoc and Maasin sites, to solicit feedback on perceptions and experiences, as well as identify constraints to the adoption of the protective structures and vegetable production technology that were being introduced into farmers' fields. Subsequently, a number of further FGDs were held, such that there was considerable farmer input into the ultimate design of structures and crop management. With linkages to East-West Seeds and other related projects, such as the Enhancement of Food Security in the Visayas (EFOS), the project was also involved in the conduct of farmer field schools in Maasin, as well as in presentations on vegetable production under protected cropping made at VSU, which were attended by representative field technicians and farmers.

### Seasonal price trends

Market price data from the Bureau of Agricultural Statistics were collected throughout the life of the project. It was found that price increases during the wet season (mid-year around June–July), and turn-of-year prices (around November–February) were routinely about 20% higher than in other months. There had been some suggestion that, in more recent years, a breakdown in the traditional weather patterns had occurred, but this was not reflected in a comparison between the 2011 data (Menz and Armenia undated b) and that for years preceding 2007, as shown in Menz and Armenia (undated a). A typical example of the more recent price data is shown in Figure 2.

## Structure details and costs

Costs of structures varied with type and farmer/research sites. Full details of these can be obtained from the project working papers (http://www.protectedcropping.com/projects.php). However, to give an idea of the costs entailed, the initial (first year) set of cost data is presented in Table 1.

Initial establishment costs ranged from 14,000 pesos (igloo-type structures) to a maximum of 43,000 pesos (coco lumber-type houses) at the VSU experimental site, with the two initial farmers' sites costing 36,000 and 22,000 pesos in Ormoc and Maasin, respectively (Table 1). The bamboo structures in farmers' fields were generally less expensive than those at the university, due to design changes or lower input costs. The igloo structure costs at VSU were lower than the house-type structures, but the crop area was considerably smaller. The house-type (both coco lumber and bamboo) had an area of 200 m$^2$, while the area available for crops in the igloo type was 48 m$^2$.

After the first year, many additional structures were built within and beyond the auspices of the project, with the average cost of farmer-built structures being around 30,000 pesos to cover 200 m$^2$. The cost components of a fairly typical bamboo structure at Maasin, Southern Leyte, are shown in Table 2.

### Economic analysis

A summary of the average receipts, expenses and gross margins for 3 years with and without a protective structure for the four most commonly preferred crops (tomato, sweet pepper, ampalaya and watermelon) grown by farmers is presented in

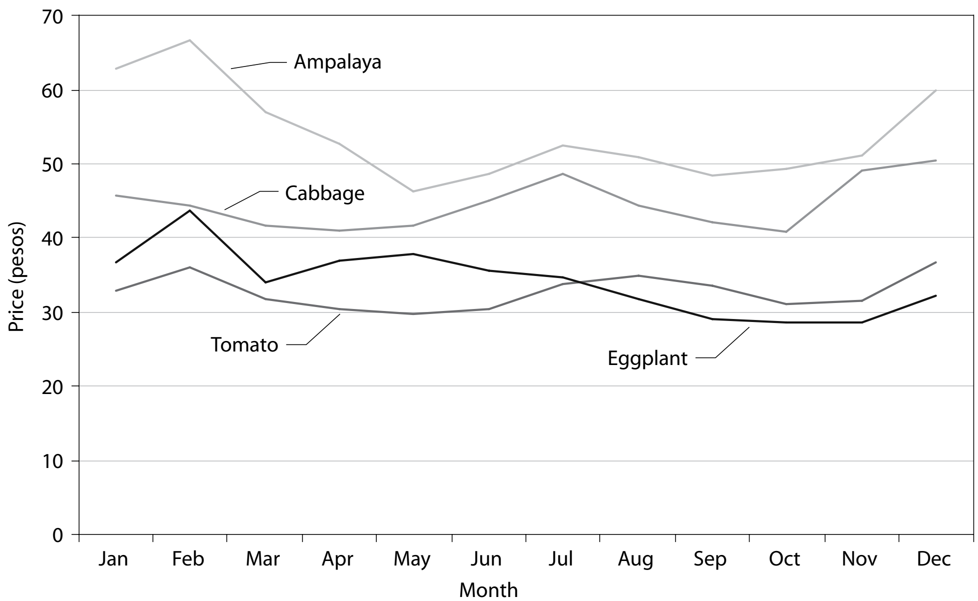


**Figure 2.** Monthly average prices of major vegetables in Southern Leyte, 2007–11

**Table 1.** Summary of initial costs incurred for establishing protective structures at the Visayas State University (VSU) site and in farmers' fields

| Type of structure | Costs incurred in pesos | | |
|---|---|---|---|
| | Materials | Labour | Total |
| **VSU** | | | |
| Coco lumber | 34,081 | 8,311 | 42,392 |
| Bamboo | 14,931 | 13,719 | 28,650 |
| Igloo net | 12,912 | 773 | 13,685 |
| **Farmers' field** | | | |
| Bamboo (Ormoc) | 25,573 | 10,313 | 35,886 |
| Bamboo (Maasin) | 11,285 | 10,442 | 21,727 |

**Table 2.** Cost components (synthesised from various examples) of a bamboo house protective structure

| Qty | Unit | Item description | Unit cost (pesos) | Extension (pesos) |
|---|---|---|---|---|
| Materials: | | | | |
| 34 | pieces | Bamboo posts (Gu-od) | 39 | 1,326 |
| 86 | pieces | Bamboo poles (Kayali) regular | 30 | 2,580 |
| 34 | pieces | Bamboo poles (Kayali) small | 15 | 510 |
| 5 | bundles | Rattan ties | 120 | 600 |
| 3 | bundles | Rattan ties | 150 | 450 |
| 2.5 | kg | Common nails 4 inch | 96 | 240 |
| 1.5 | kg | Common nails 4 inch | 93 | 140 |
| 2 | kg | Common nails $2^1/_2$ inch | 102 | 204 |
| 1.5 | kg | Common nails $1^1/_2$ inch | 102 | 153 |
| 0.75 | kg | Common nails $1^1/_2$ inch | 90 | 675 |
| 1.5 | kg | Common nails 1 inch | 90 | 135 |
| 5.89 | pieces | Used tyres | 30 | 177 |
| 105 | metres | Polyethylene UV film 110 inch × 0.005 inch × 150 m | 100 | 10,500 |
| | | Subtotal | | 17,690 |
| Labour: | | | | |
| 41.63 | person-day | Construction of structure | 250 | 10,407 |
| 9.38 | person-day | Installation of UV plastic film | 250 | 2,345 |
| | | Transportation cost for PE UV film | | 239 |
| | | Subtotal | | 12,752 |
| | | TOTAL COSTS (materials + labour) | | 30,681 |

Table 3. Gross margins were calculated for the test crops both within and outside the structures. Over the life of the project, the highest receipt and gross margin for a crop grown under structure were from sweet pepper. The information in Table 3 indicates the potential for significant gains (beyond what have been recorded to date) with an appropriate choice of crop and good management skills. It can be seen that watermelon gained no advantage from being grown under a structure and is therefore not an appropriate crop choice, yet it was tried by some farmers, thereby lowering the average economic advantage due to the structure. Comparing crops grown under structure with those outside, the highest average gross margin difference over the life of the project was 79 pesos/m$^2$ for sweet pepper followed by tomato at 30 pesos/m$^2$ and ampalaya at 23 pesos/m$^2$.

Table 3 covers the four most popular crops grown by farmers. Table 4 gives the results for the crop mix actually grown by farmers (not just the four 'most popular'). The results indicate that, over the 3-year period, the average gross margin for crops grown under a protective structure was 112 pesos/m$^2$, approximately double the gross margin for crops grown outside a structure.

## Financial viability of protective cropping

Table 5 shows the 5-year cash flow based upon the average performance of cooperators (3 years

**Table 3.** Average receipts, expenses and gross margins (3 years) per cropping in pesos/m$^2$ for the four most-preferred crops (ampalaya, tomato, sweet pepper and watermelon), grown with or without a protective structure

| Structure | Number of comparisons | Receipts (pesos/m$^2$) | Expenses (pesos/m$^2$) | Gross margins (pesos/m$^2$) |
|---|---|---|---|---|
| A. With | | | | |
| Ampalaya | 16 | 60 | 20 | 40 |
| Tomato | 14 | 57 | 21 | 37 |
| Sweet pepper | 11 | 159 | 36 | 123 |
| Watermelon | 5 | 76 | 31 | 45 |
| B. Without | | | | |
| Ampalaya | 14 | 34 | 18 | 17 |
| Tomato | 13 | 25 | 17 | 7 |
| Sweet pepper | 9 | 69 | 26 | 44 |
| Watermelon | 3 | 75 | 25 | 51 |
| C. Mean difference (A–B) | | | | |
| Ampalaya | 30 | 26 | 2 | 23 |
| Tomato | 27 | 32 | 4 | 30 |
| Sweet pepper | 20 | 90 | 11 | 79 |
| Watermelon | 8 | 1 | 7 | –6 |

**Table 4.** Annual receipts, expenses and gross margins (pesos/m$^2$) for vegetable crops grown with or without a protective structure

| Item | Receipts | Expenses | Gross margins |
|---|---|---|---|
| A. With structure | | | |
| Year 1 | 122 | 59 | 63 |
| Year 2 | 142 | 41 | 100 |
| Year 3 | 174 | 44 | 130 |
| Mean | 156 | 44 | 112 |
| B. Without structure | | | |
| Year 1 | 56 | 49 | 7 |
| Year 2 | 107 | 39 | 67 |
| Year 3 | 93 | 34 | 58 |
| Mean | 95 | 38 | 57 |
| C. Mean difference (A–B) | | | |
| Year 1 | 66 | 11 | 55 |
| Year 2 | 35 | 2 | 33 |
| Year 3 | 81 | 10 | 71 |
| Mean | 61 | 6 | 55 |

Note: The number of observations made each year was not the same. More farmer-cooperators entered the project over time, therefore the mean of all observations does not equal the average of years 1, 2 and 3.

**Table 5.** Projected cash flow and investment returns (pesos) from protected cropping of vegetables under a 200 $m^2$ structure

| Item | Year | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Cash inflow: | | | | | |
| Gross returns | 24,016 | 32,410 | 34,770 | 34,770 | 34,770 |
| Cash outflows: | | | | | |
| Establishment cost | 30,681 | | | | |
| Materials | 4,717 | 2,914 | 3,951 | 3,951 | 3,951 |
| Labour | 6,814 | 5,929 | 4,938 | 4,938 | 4,938 |
| Transport and marketing | 438 | 468 | 564 | 564 | 564 |
| Repair and maintenance | 110 | 689 | 12,142 | 142 | 142 |
| Total cash flows | 42,760 | 10,000 | 21,595 | 9,595 | 9,595 |
| Net cash flows | –18,744 | 22,410 | 13,175 | 25,175 | 25,175 |
| Net present value (@ $r$ = 20%) | 29,824.91 | | | | |
| Internal rate of return | 103% | | | | |

Note: The table above incorporates the cost of replacing the plastic covering after 3 years and is based on the average returns achieved by farmer cooperators; high-achieving farmers obtained approximately double these returns

actual and 2 years projected). At a discount rate at 20%, the results indicate that it is financially viable to grow vegetables under protected cropping given the structure design and costs. The average net present value (NPV) from investment in structures is approximately 30,000 pesos, with an internal rate of return of approximately 100%. If we examine the results of the top three cooperators, they obtained higher gross margins both inside and outside the structures compared to the average, but their additional gross margin from investing in the structure is also twice that which was obtained by the average farmer-cooperator (112 pesos/$m^2$ as compared to the 55 pesos/$m^2$) as shown in Table 4.

## Regression analysis on factors affecting productivity

The data in Table 4 are figures from the farmer-cooperators. Table 5 gives figures for 3 years (i.e. up to April 2012), and the projections for the remaining 2 years coincide with a total expected structure life of 5 years. In the previous paragraph, it was indicated that more-skilled farmers (as assessed by the project team) can gain more from investment in structures than can average farmers. And it was further suggested above that crop selection is an important component of success. In order to better elucidate the contribution that these and other various factors make, a multiple regression model (based upon individual crop input–output data) was utilised and subjected to rigorous diagnostic tests (Table 6). This approach also allows a more refined estimate on the relative contribution of the protective structures.

The results from the model indicated that, for the intercept shifter variables, the dummies for protective structure and sweet pepper crop planted by farmers were positive and considered statistically significant factors that affect productivity among farmers (Table 6). The management skills variable also has a positive coefficient and is statistically significant. As expected, rainfall and pest incidence variables have negative coefficients and were statistically significant. The coefficient for the ampalaya dummy variable, the farmers' second-most preferred crop, was positive but not statistically significant. The other relevant variables such as fertiliser and pesticides costs had positive coefficients and likewise were not statistically significant.

The coefficient of the 'structure' dummy variable is 0.61 but, because the dependent variable (total revenue) was specified in logarithmic form, the interpretation of this coefficient is as follows: take the exponential of 0.61 = 1.84, implying that under a structure and with other variables held constant, vegetable revenue is 84% higher than without a structure. This number is broadly comparable to figures shown in Table 4 for the raw data (i.e. raw data without any attempt to isolate the effect of the various individual inputs). The other dummy variables representing

**Table 6.** Multiple regression on factors affecting productivity (pesos/m$^2$) of protected-cropping systems for vegetables in Leyte and Southern Leyte, Philippines

| Variable | Coefficient | *t*-values |
|---|---|---|
| Constant | 2.564*** | 7.98 |
| Dummy variable: | | |
| With structure | 0.610*** | 3.85 |
| Sweet pepper | 0.539** | 2.24 |
| Ampalaya | 0.296 | 1.51 |
| Management skills index (%) | 0.010*** | 2.72 |
| Pest incidence (%) | –0.012** | –2.20 |
| Log of average daily rainfall (mm/day) | –0.184* | –1.85 |
| Log of fertiliser cost (pesos/m$^2$) | 0.321*** | 4.11 |
| Log of pesticides cost (pesos/m$^2$) | 0.194*** | 3.27 |
| No. of observations = 107 | | |
| $R$-squared = 0.50, Adj-$R$-squared = 0.46 | | |

*significant at 10% level, **significant at 5% level; ***significant at 1% level

sweet pepper and ampalaya crop can be interpreted in similar manner.

The coefficients of non-logarithmic management skills variable (0.010) can be interpreted as that a unit increase in skills index would bring about 1% increase in productivity or revenue. However, for pest rating variable with a negative coefficient (–0.012), a unit increase in pest incidence would reduce revenue by 1.2%.

The variables specified in logarithmic form can be interpreted directly as elasticities; thus, a 10% increase in daily rainfall would, on average, reduce vegetable revenue by 1.8%. Fertiliser and pesticide expenditure increases of 10% would increase revenue by 3.2% and 1.9%, respectively.

There are therefore various ways in which significant further economic gains can be made by using protected-cropping technology. With the available dataset, we were not able to discriminate between the (percentage) effects of some of these variables on protected versus non-protected cropping, but insofar as the percentage increases were found to be a similar, this implies a much greater absolute effect with protected cropping.

## Discussion and conclusions

Investment in protected-cropping structures for vegetables is economically feasible in the Eastern Visayas, especially for skilled growers who apply appropriate inputs. Not all crops perform in a superior fashion under structures, so the investment in structures will have potential only if high-performing crops such as sweet pepper and ampalaya are chosen. These crops give above-average returns both within structures and in the open field, but they perform relatively better within structures.

Since there is little history of protective cropping in the Eastern Visayas, farmers are quite unfamiliar with the management techniques required to maximise returns. Based upon the regression results, a 10% increase in management ability would increase returns by around 10%, equivalent to about a 33% increase in NPV of the investment, or 10,000 pesos for a 200 m$^2$ structure (given the NPV from structures at current levels of skill of around 30,000 pesos, as shown in Table 5). This gives a strong indication of the value of farmer training. Strong economic benefits can be expected from increases in other inputs as well.

All farmer cooperators in the project had individual control over activities undertaken within the structure. Some efforts outside of the project have involved responsibility by farmer groups (rather than individuals), and some of these have foundered, because of the difficulties in equitable sharing of responsibilities and rewards.

With the dearth of empirical knowledge on the technical as well as the economic feasibility of low-cost protected-cropping system for vegetables in Leyte and Southern Leyte provinces, and the Philippines in general, the findings of this study have contributed to the existing pool of scientific knowledge about protected-cultivation of vegetables in the Philippine setting. The findings of the study may be used for further field verification in other areas and for possible dissemination to researchers and potential adopters. The findings may also serve as possible input to craft related research policy actions and recommendations pertinent to climate-proofing strategies.

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