Final report C2

project

Enhancing profitability of selected vegetable value chains in the southern Philippines and Australia

Component 2: Development of a cost-effective protected cropping system in the southern Philippines and Australia

project number	HORT/2007/066-2
date published	2013
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final report number	FR2019-64 C2
ISBN	Refer to FR2019-64 C6
published by	ACIAR GPO Box 1571 Canberra ACT 2601 Australia

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1 Acknowledgments

The project entitled *"Development of a cost-effective protected cropping system in the Southern Philippines and Australia"* would not have been implemented and completed without the guidance and contribution of several partner institutions/agencies and individuals:

The Australian Centre for International Agricultural Research (ACIAR) which generously provided fund and whose expertise and constant guidance helped put many aspects of the study into perspective;

The Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCAARRD) which helped in the review of programs that fits into a number of national and regional research priorities and for being very supportive;

The Visayas State University (VSU) team members led by Dr. Jose L. Bacusmo, the University President, who invested their expertise and time in the project;

The Local Government Units (LGUs) of Maasin City, Ormoc City and the Energy Development Cooperative (EDC) for their facilitative support;

The farmer co-operators whose willingness and participation proved a crucial component in the completion of the project;

The Research Assistants of the project, Mr. Jonathan Mangmang, Ms. Elsie Tausa, Mr. Dhenber Lusanta, and Mr. Hubert Dimabuyu whose untiring work, enthusiasm, understanding of field situations and realities, and their research skills made the data gathering and data analysis of the project more effective and efficient;

For the untiring support of Ms. Maria Lilia P. Vega as Administrative Officer in the facilitation and coordination of project operations;

The project staff for the technical and administrative assistance provided.

Inputs from Australian team, Jeremy Badgery-Parker, Josh Jarvis and Lorraine Spohr is gratefully acknowledged, especially for the new curved-roof structure designs which have formed the basis for subsequent designs.

The support of the ACIAR management team is gratefully acknowledged, in particular Les Baxter and David Hall in Australia, and John Oakeshott, Celia Honrado and Mara Faylon in the Philippines.

2 Executive summary

This project aimed to develop and test an appropriate and effective protected annual crop production system in Leyte, determine whether the production of vegetable crops using protected cropping systems in Leyte is economically viable at both farm and market level, and promote adoption/modification of protected cropping systems.

The project with the support from LGUs constructed and evaluated 34 structures across five project sites in Ormoc, Maasin, Bontoc, Bato, and at VSU. Two types of structures were evaluated: the *house-type structures*, built from either bamboo or coco lumber with an effective growing area of 200m^2 (5m x 40m) or *tunnel-type/igloo type structures* made of either bamboo or steel frames, with either plastic or net coverings and with a growing area of 60m^2 (1.5m x 40m). The VSU sites were mainly used for experimentation of crop suitability, pests and disease impacts and nutrition. The farmer sites were mainly used to collect information to support the assessment of economic viability, and to monitor the emergence of new production challenges.

House-type structures made of bamboo are stronger than that of coco lumber and are more suited for taller crops such as tomatoes, sweet pepper, ampalaya and beans. Low tunnels have great potential for low growing crops such as lettuce, pechay and muskmelon especially when covered with fine netting rather than plastic.

The Australian team (NSW DPI) designed a modular curved roof bamboo greenhouse and this was tested in the Philippines at three sites and found to be successful under local conditions in the Philippines. A new greenhouse was then designed by the Philippine project team and farmers, based on the NSW DPI design. The new locally-designed curved roof bamboo greenhouse has out performed all other designs. It is highly resistant to wind damage and the plastic and bamboo structure lasts for longer than all other structures.

Vegetables crops grown under protective structures regardless of design and type overwhelmingly yielded higher compared to those grown in the open field. Average yields were higher under protected cropping for cauliflower, green onion, lettuce, chilli pepper, tomato, sweet pepper, bitter gourd, pechay, muskmelon, broccoli and string beans. There was no impact on yield for sweet corn, cabbage, watermelon, bottle gourd, cucumber or winter squash. Protected cropping can result in higher yields in both the wet season and the dry season. Foliage diseases were easier to control under protected cropping structures but whiteflies, aphids and mites were more difficult to control.

The magnitude of this extra yield was highly dependent on crop management, especially in relation to the choice of crop, irrigation management and pest control.

The yield improvement under the protective structures, especially in the wet season usually resulted in higher gross margins as well. Economic analysis of data collected from commercial farmer co-operators showed that positive and higher gross margins were achieved for crops grown under the protective structures as compared to crops grown in the open fields, but there were some exceptions to these especially during the dry seasons. Moreover, growing vegetables in the open field during the wet season is either not possible or not economically viable in most circumstances.

Higher profits from top performing farmer co-operators were attributed to timing of planting, choice of crop planted, and good management skills which enabled them to attain higher yields and prices of vegetables sold. This observation was confirmed by a regression analysis of economic data, and this showed that, in addition to the positive effect of protective structures, other important factors that affect farmer profitability are: (a) choice and timing of crop (e.g., sweet pepper), (b) management skills of the farmers, (c) control and prevention of pests/diseases, and (d) rainfall (cropping season). The analysis showed that a 10% increase in management ability would increase returns by around 10%, equivalent to about a 33 % increase in net present value of the investment or PhP 10,000 for a 200 m structure. This gives a strong indication of the value of farmer training.

Strong economic benefits can be expected from increases in other inputs including additional fertilizer and expenditure on better pest control.

Protected cropping is an important adaptation to climate change and had great potential in this area irrespective of positive productivity and profitability impacts

Some efforts outside of the project have involved structures being shared among groups of farmers, with the groups having more responsibility than individuals, and some of these have foundered, because of the difficulties in equitable sharing of responsibilities and rewards.

Australian project activities evaluated common low technology systems to reduce excessive heat, which is a major productivity constraint in low-tech structures in Australia. Modifications to existing greenhouses (exhaust fans and screen doors) were shown to be economically feasible and effective at reducing excessive heat. The screening had the added benefit of excluding insects from the crop, potentially reducing the need for insecticide.

3 Background

Eastern Visayas (Region 8) produces about 47,000 tons of vegetables per year. However, this production is only 45% of the consumption of vegetables in the region. The balance is imported from Mindanao or Luzon (BAS). One reason for the inability to meet the demand for vegetables in Leyte is that year round production is significantly limited by high rainfall (which averages at 2.4 metres per year) and typhoons from June through to February. This weather can also bring destructive winds in excess of 150km/h which physically damage leaves, flowers and fruit, encourages disease, and makes planting, spraying and harvesting operations very difficult.

With approximately 50 thousand tons of vegetables being imported to the region per year, and even using a low dry season average price of 0.50 cents per kg, the potential revenue would be in the order of $25 million per year (of course net gain would involve subtracting costs), but clearly the overall economic potential is high relative to project cost. In a scoping study by Rogers (2007), information was collected on the cost of some simple, low-cost, protective cropping structures. The information indicated that, if these structures can be functionally effective, they can clearly be profitable.

Protected cropping offers two key advantages for farmers producing annual crops, i.e., protection from adverse weather and the opportunity to produce high quality vegetables. Protected cropping can involve a range of systems from screens and windbreaks to crop covers, and greenhouse structures which can be linked to soil-based or soil-less production systems. This diversity in systems can make the selection of appropriate and cost effective technology complicated. It is also essential for the development of an appropriate protected cropping production system to address the entire production system from plant protection to irrigation nutrition and varieties.

Low cost protected cropping may not only be appropriate in the Philippines because of low farmer incomes it may also be attractive to Australian vegetable producers because it will allow the production of higher quality, low pesticide crops with minimal increase in production cost. Visayas State University (VSU) had shown after a four year project (2002-2006) that high quality lettuce and tomato crops can be produced at these times using various structures that protect crops from wind and rain.

Importing vegetables from other parts of the Philippines would negate some of the potential benefits of protective cropping of vegetable production in the Visayas, but high inter-island shipping costs, and poor road transport infrastructure in the Visayas, make this a costly proposition. Undoubtedly, some vegetables consumed in the Visayas will continue to be sourced from other islands; self-sufficiency for the Visayas is not an end in itself. However, the import costs do provide an economic incentive for seeking a means of cost effective vegetable production under a protective cropping regime, and wet season production is hindered by wind and rain in other islands, too, albeit to a lesser extent than in Leyte.

The project fitted the following collaborative ACIAR / Philippines research priorities: (i) Protected cropping technologies for annual crops; (ii) Nutrient and pesticide management, particularly fertigation systems to save costs and reduce residues in vegetables and fruit (iii) Shelf life extension, product development, packaging, quality and sanitary and phytosanitary standards for markets for crucifers and salad vegetables. It also met the region specific priority to improve postharvest shelf life and handling of salad and semi-temperate vegetables; development and testing different protective cover designs and construction materials against high precipitation and strong wind.

The proposal was favourably reviewed and recommended by the Philippine Council for Agriculture, Aquaculture, Forestry and Natural Resources Research and Development (PCAARRD). It met a number of regional and national research priorities including

Integrated S & T Agenda for AFNR (2006-2010) and the Industry Strategic Plan (ISP) for VELERO 2004-2020.

4 Objectives

The overall aim was to improve farmer profitability by developing and testing a protected cropping system to produce high quality vegetables as a model for horticultural production in high-rainfall areas of the Philippines. These objectives were inherently interlinked and were carried out concurrently and not sequentially.

Objective 1. Develop and test appropriate and effective protected annual crop production systems in Leyte and Australia.

It was critical to develop protected cropping systems and options that work technically before they were evaluated economically. Activities:

- Evaluate how effectively alternative structures protect vegetable crops from wind and rain in Leyte whilst providing a suitable growing environment
- Evaluate feasibility of modifications and upgrades to low cost structures for integration into the Australian vegetable industry
- Develop an appropriate protected cropping irrigation system for the Philippines
- Develop and test an agronomic package including crop nutrition and vegetable varieties for the Philippines
- Evaluate techniques for monitoring and controlling pests, diseases and associated weeds under protected cropping structures.

Objective 2. Determine whether the production of vegetable crops using protected cropping systems in Leyte is economically viable at both farm and market levels.

The first thrust of this objective was to find out why farmers do not currently use protected cropping and to determine whether this would be an economically viable alternative to current practices. Secondly to develop market linkages that either pay farmers a premium for producing high quality/clean produce or allow them to produce when prices are high. Activities:

- Undertake a benefit-cost analysis of protected cropping systems in Leyte both from farm and marketing perspectives
- Elucidate and analyse seasonal price trends for key vegetables
- Liaise with other megaproject components, especially the marketing and economics components

Objective 3. Promote adoption/modification of protected cropping systems in Leyte and Southern Mindanao.

While the research was conducted in Australia and Leyte, the Component team aimed to establish links with DA and the farmer groups in Mindanao to facilitate the flow of information from Leyte to Mindanao. Activities:

- Undertake a constraints (to adoption) analysis
- Identify and develop market linkages
- Use benefit/cost analysis to guide research and farmer activity
- Participatory training of farmers/FFS when system shown to be viable in Leyte
- Exchange information with DA and farmer groups in Mindanao to support training activities.

5 Methodology

The following research methodology approach was used to the answer the two key questions embodied in the project:

> ***1. Technical feasibility of protected cropping***: Is it technically feasible to grow vegetables in the wet season and the dry season in the Visayas under low cost protected cropping structures and if so, what is the best type of structure to use?
>
> ***2. Economic viability of protected cropping***: Is it profitable for farmers to invest in low-cost protected cropping structures in the Visayas to produce vegetables, and if so which vegetables should they be growing?

5.1 Technical feasibility

The first step was to establish a research site at the Visayas State University (VSU) at Baybay City, Leyte to test the proposed structure designs and production techniques. Promising designs and techniques were then evaluated on commercial farms in an action (farmers' participatory) research approach. Resistance of the design against adverse conditions particularly to the damaging effects of heavy rains which often times is accompanied by strong winds was monitored. Likewise, incidence/severity of insect pest and diseases infecting vegetable crops under structures and open fields were assessed and compared. An important part of this project was to test the technical feasibility of protected cropping under actual on farm conditions; hence the activity focus was on the farm-based trials.

5.1.1 *Project Site Identification and Selection*

The identification of the project sites in Ormoc and Maasin were based on the results of the scoping study undertaken in Leyte and Southern Leyte on February 2007 by the Australian Centre for International Agricultural Research (ACIAR) (Rogers (2007). The project team coordinated first with the Local Government Units (LGUs) especially the mayor and the Office of the City/Municipal Agriculture Officer in each identified project site to formalize linkages including the administrative and technical requirements. This included the identification of specific project sites and selection of farmer co-operators.

The City/Municipal Agriculture Officer (MAO) or officer in-charge in each region was consulted by the project team in establishing the selection criteria for location sites and farmer co-operators. The basic criteria for selection were farming performance, attitude to the project, soil type, availability of water, security and accessibility from farm to market. Farmers with a range of skill levels were chosen, however the team was careful to include some innovative leading farmers who were likely to lead adoption should the protected cropping techniques evaluated show positive results.

A Memorandum of Agreement (MOA) was signed by the project proponents and LGUs to formalize the project implementation. The MOAs included the functions and responsibilities of participating institutions, and under this arrangement, the project proponent from VSU provided the technical expertise for the project implementation. LGUs helped with the supervision of farm sites and also took on a coordinating role, especially in relation to Farmer Field School training.

5.1.2 Structures

The project team provided the required technical expertise on the design, establishment, and other technical requirements of building the protective structures in the farmer co-operators' field. The project field sites were situated in lowland and upland areas in Ormoc and Maasin. The project tested three house type structures and low tunnel structures at the project sites:

a) ***house-type structures***, mainly made up of bamboo or coco lumber with an effective growing area of 200m^2 (5m x 40m) (Photo 1).

b) ***tunnel-type/igloo type structures*** made of either bamboo or steel frames, with either plastic or net coverings, and with a growing area of 60m2 (1.5m x 40m) (Photo 2).

c) ***Curved roof structure – NSW DPI design.*** Curved roof structure with a split roof modular design by NSW DPI (Photo 3).

d) ***Modified curved roof design*** - developed by Philippine team (Photo 4).

The house type structure was used for taller and climbing vegetable crops such as tomatoes, sweet pepper and ampalaya while the low-tunnel was used for low growing crops such as leafy vegetables and melons. The farmer sites were used to collect information on yield differences under structure and open field to support the assessment of economic viability, and to monitor for the emergence of new production challenges. The VSU site was mainly used for experimentation on crop suitability, pests and disease impacts, and nutrition.

Photo 1. House type structure made of Bamboo

Photo 2. Low tunnel structure

Photo 3. Curved roof design (NSW DPI)

Photo 4. New curved roof design (with sides enclosed)

A total of 34 protective structures of various types were constructed across all project sites at VSU, Ormoc, Cabintan (high altitude site), Maasin and Bontoc. An open field control site was included at each site. Drip irrigation systems were used at the VSU site and also in some of the farmer co-operators' fields at Ormoc and Bontoc sites. Data on temperature, relative humidity, light intensity and rainfall were collected at each site using either electronic sensors with loggers or manually. Rainfall data was collected at the VSU, Maasin and Bontoc sites. The project team provided technical support to the farmers on crop selection and timing, crop rotations as well as pest and disease control, and other production issues.

All the materials for the protective structures such as bamboo, nails, UV-stabilised plastic, labour, and related expenses were paid for from project funds for the first two cooperators; one in Ormoc and one in Maasin. In all later constructions costs were supplemented with funds from LGUs. Materials and labour for minor repairs of the structure were borne by the farmer co-operators and major repairs were borne by the LGU. Cropping inputs such as fertilizer and seeds were paid for by the project for the first cropping cycle. Subsequently, farmers provided their own inputs, but would be subsidised if there was a crop failure due to the experimental nature of the production.

5.1.3 Agronomic, pest and disease assessment

Technical assistance was also provided by the project team for the cultural management aspects from land preparation to harvesting, and for controlling insect pests and diseases in a preventive and curative control measure program. These include cultural control (e.g. sanitation, crop rotation, and pruning), mechanical (hand picking and bagging as in the case of bitter gourd), and chemicals, botanical or organic sprays. In total, there were 18 farmer co-operators directly involved in the project at the various sites: Ormoc (10), Maasin (6), Bato (1), and Bontoc (1).

The experimental sites at VSU and farmer sites were set up as Randomized Complete Blocked Designs (RCBD) with four replications. Yield was separated into marketable and unmarketable, then numbers and weights of harvestable parts were recorded at each harvest. Individual treatment comparisons were analysed using ANOVA and the mean separations were tested at $P<0.05$ least significant difference.

Crops were harvested multiple times according to normal commercial practice. Soil samples were taken before each crop was established and tested for total N, P and K, pH, EC, exchangeable cations (K, Na, Ca, Mg) and micronutrients. Plant tissue samples were taken during crop growth and the nutrient content measured as a guide to the nutritional status of the crops. The incidence (counts) of pests and diseases were recorded on crops in years 2 and 3 of the project.

5.1.4 Linkages with other organisations

Local Government Units

A conscious effort was made to link with LGUs both to secure funding and to provide input into their technical extension service. Training was provided to LGU staff and LGU extension staff in turn helped to support farmers involved in the project.

East West Seeds

East west seeds were key partners in the project. They helped by providing technical support to the project team members especially on current commercial vegetable growing practices. They also provided highly valuable 16-week farmer field schools which trained project farmers and LGU staff in basic commercial vegetable production skills.

Energy Development Corporation (EDC)

The EDC (formerly known as PNOC) were highly supportive of the project. They provided in-kind support for the project, built structures and also provided sites and farmers to collaborate with the project team in the Philippines. The VSU team evaluated the performance of two EDU structures at Cabintan, and assisted with the construction of a curved roof structure near Maasin.

Public Private Partnership

The above organisations including East West Seeds, EDC, Ormoc and Maasin LGUs, VSU president (Dr Joe Bacusmo) and the Australian team formed a committee aimed at coordinating activities and coming up with new initiatives. This group arranged a highly successful 16-week farmer field school held at Maasin and various other initiatives during the project.

5.2 Economic viability

5.2.1 *Social aspects*

The functional and economic performance of low cost protected cropping production systems were assessed over a four-year period from 2008. The work involved investigation via controlled field experiments at VSU and commercially-oriented production in farmers' fields. As a first step before the field work started, focus group discussions (FGDs) were held with farmers and representative LGU staff in Cabintan and Ormoc to assess their knowledge levels, interest, and constraints regarding protected cropping for vegetables.

Some of the farmers were familiar with the concept of protected cropping, but many were not. Once exposed to the idea via slides 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 team involved the farmers in discussions about the building of the structures and the farmers took primary responsibility for the construction. The farmers also incorporated their own ideas in relation to cost-saving and measures that would prolong the life of the structure.

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 one and one-half years 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 report relates only to farmer co-operator sites.

5.2.2 Seasonal Price Trends

Market price data was collected throughout the life of the project from the Bureau of Agricultural Statistics (BAS). It was found that price increases during the wet season (mid-year around June/July) and end of year prices (around November to February) were routinely about 20% higher than in other months. There is a suggestion however, that in more recent years (2010-2012 compared to 2007), frequent rain in the "dry season" has resulted in the pattern of seasonal prices becoming less clearly defined.

5.2.3 Economic analysis

To assess the economic viability of growing vegetable crops under protected cropping compared to open field, a benefit cost analysis was conducted and considered the following: (1) a five-year estimated life span of the protective structure as estimated by the Project Team Engineer; (2) two top performing farmer co-operators, (3) one average performing co-operator (data used were taken from averages), and (4) 15% opportunity cost of capital.

Since field observations and results of the preliminary economic analysis showed that benefits from adoption of protected vegetable cropping are affected by several factors that are contributory to higher profitability among farmer co-operators, a multiple regression model with gross margins as the dependent variable was formulated and estimated using available data from farmers' fields to determine the technical, economic, and environmental factors that affect the profitability of using protective structures across farmers' sites. The following are the variables and their corresponding definitions:

Variables	**Definition**
Lg_grmargin_a	Log of Gross margin per sq.m.
Dummy Variables:	
d_withstruc	1 = with protective structure, 0 = otherwise
d_ampalaya	1 = if crop planted is ampalaya, 0 = otherwise
d_tomato	1 = if crop planted is tomato, 0 = otherwise
d_sweet pepper	1 = if crop planted is sweet pepper, 0 = otherwise
Lg_educ	Log of Education attainment (completed yrs of formal

	schooling)
Pct_skills	Average rating cooperators’ managerial skills (%) 0=nil, 100 high
Pct_pestrating	Average rating on pests’ incidence (%) scores
Pct_diseaserating	Average rating on diseases’ incidence (%) scores
Lg_averainfall	Log of average daily rainfall for whole crop duration (mm)
Lg_fertcost_a	Log of fertilizer cost per sq m (Pesos)
Lg_pestcdcost_a	Log of pesticides and other related costs per sq m (Pesos)

5.2.4 Who did what

The overall project leader in the Philippines was Othello B. Capuno. The agronomic team was led in the Philippines by Dr Zenaida Gonzaga. The pest and disease aspects were covered by Reny G. Gerona and Dr Lucia M. Borines. Soils aspects were handled by Anabella B. Tulin and the research into structures by Manolo B. Loreto, Jr. The field work was carried out by research assistants Dhenber C. Lusanta and Hubert Dimabuyu with two field staff.

The socioeconomic team was led by Dr Pete Armenia. The social science research was managed by Lilian B. Nuñez and research assistant Elsie R. Tausa. Administrative matters were expertly handled by Ma. Lilia P. Vega.

Ken Menz assisted the economics team, Gordon Rogers focussed more on the agronomics and Jeremy Badgery-Parker helped with the structure designs and physical assessments.

6 Achievements against activities and outputs/milestones

Objective 1: Develop and test appropriate and effective protected annual crop production systems in Leyte and Australia

No.	Activity	Outputs/ Milestones	Completion	Comments
1.1	Evaluate how effectively alternative structures protect vegetable crops from wind and rain in Leyte whilst providing a suitable growing environment	Specifications for effective protected cropping structures for growing vegetables in Leyte	Completed. Refer paper on design evaluations (attached)	A total of 34 house type and low tunnel type structures have been built and tested at VSU and farmers sites. 6 self-funded structures built by 3 adopters and currently growing vegetable crops. Yields and gross margins measured at farmer sites with the VSU sites mainly used for experimentation. Typhoon damage to VSU structures repaired and resulted in design modifications. The designs and costings of the initial structures being evaluated have been published on the project website (www.protectedcropping.com) as Working Paper No. 6. Further design modifications were made during a workshop conducted mid of February 2011 and resulting structure built and evaluated at one farmer site at Bontoc and another one at Maasin. The new structure designs have been published on the project website as Working Paper No. 14. The environmental conditions inside structures are being measured using sensors with loggers and supplemented by manual measurements. In 2012, a new design of the structure was conceptualized and was used in the repair of the two bamboo house-type new structures at VSU. The design is now a continuous curved roof, and plastic roofing was installed with the use of black strap and binder instead of nails which rusted quickly and served as the entry point of rain water into the structure. This method of attachment will result in a longer life for the plastic.
1.2	Evaluate feasibility of modifications and upgrades to low cost structures for integration into the Australian vegetable industry	Report on the feasibility of modifications to low cost cropping structures for growing vegetables in Australia	Completed – refer report on Australian component)	The Australian component involved evaluation of low technology systems in terms of low-cost protected cropping modifications for Australian vegetable growers. These are basically modifications to the ventilations systems of low-tech igloo greenhouses. The experiments compare various combinations of additional venting and exhaust fans retrofitted to existing igloos. The results are showing that increased ventilation can limit summer temperature increases above ambient to 8ºC

				compared to traditional vented system where the temperature increase can be up to 15ºC.
1.3	Develop an appropriate protected cropping irrigation system for the Philippines	Irrigation system demonstrated at VSU and farmer sites	Completed but more work could be done in this area.	At VSU, Ormoc (Noel) and Bontoc sites were using drip line systems for water to flow from a faucet and/or water pump and drip efficiently at nearby plant roots. A rainwater catchment was also built at VSU using gutters attached at the edges of the roof along its length and collected by 200L drum which made possible drip irrigation systems for plants under structure. This serves as a model particularly for farmers with scarce water supply at their farm and also for ease of watering. Some sites were provided with a water pump to convey water from a deep well or directly from waterway or river and stored in 200L drums or directly flood the area and/or watered manually to plants. Diverting water from irrigation canals to irrigate vegetable plots thru furrows or alleyways was also done particularly at Maasin site.
1.4	Develop and test an agronomic package including crop nutrition and vegetable varieties for the Philippines	Appropriate irrigation, nutrition and varieties system documented and demonstrated at VSU and farmer sites in the Philippines and in Australia	Completed. Agronomic modules being developed as part of project HORT-2012-020	Trials have been conducted on 11 crops types (sweet corn, ampalaya, broccoli, tomato, lettuce, sweet pepper, watermelon, cabbage, string beans, bottle gourd and muskmelon) including varietal work to assess their suitability for protected cropping in the Visayas under tunnel and house-type structures. Soil analyses have been made continually before cropping for fertilizer use efficiency. Inorganic and organic fertilizers were used in combination. A nitrogen organic vs. inorganic rate experiment was conducted at VSU in collaboration with component 1. Soil and tissue testing is being conducted at farmer and VSU trial sites to assess the nutrient status of crops grown under structures and in the open field. Crop rotations are also being tested for disease control and crop performance. This data is being used to develop best practice crop agronomic guides for protected cropping. These guides are still in draft form and will be completed as an initial activity of project HORT/2012/020 using funds already allocated for the purpose. The guides will be published in English the Visayan dialects of Cebuano and Waray-Waray.
1.5	Evaluate techniques for monitoring and controlling pests,	Appropriate methods for the monitoring and management of	Completed.	Appropriate methods for the monitoring and management of key pests, diseases and weeds have been developed and tested in Leyte. Data was collected on

	diseases and associated weeds under protected cropping structures	key pests, diseases and weeds developed, tested and demonstrated in Leyte and Australia.		the incidence of bacterial wilt and some pest problems. Major diseases observed to date include bacterial wilt, target spot (tomatoes). Major pests are diamond back moth (brassicas), and Helicoverpa (tomatoes and peppers). Data was collected on the incidence of pests and diseases under structures compared to the open field and is written up as working paper 16. Detailed data in the pest incidence under structures and in the open field is reported in this final report and will be used as starting point for project HORT/2012/020. Grafting has been evaluated as a means of controlling bacterial wilt in tomatoes by grafting tomatoes onto resistant eggplant rootstocks. The technique has also been evaluated on muskmelons by grafting them onto winter squash rootstocks. Both techniques have proved to be highly effective. The results will be incorporated into the agronomic guides. Dr Len Tesoriero visited sites and structures in August 2010 and assessed the disease situation.

Objective 2: Determine whether the production of vegetable crops using protected cropping systems in Leyte is economically viable at both farm and market levels

No.	Activity	Outputs/ Milestones	Completion date	Comments
2.1	Undertake a benefit-cost analysis of protected cropping systems in Leyte both from farm and marketing perspectives	Key benefit and cost parameters identified and quantified	Completed and presented in economics paper 18	Input cost and income data have been collected for the project and published on the project website as: Working Paper No. 9 – Profitability of Vegetable Crops in the First Full Year (3 Cropping Periods) Grown under Protective Structures and in Open field Working Paper No. 15 – Yield and Gross Margins Profitability of Vegetable Crops in the Second Year Grown under Protective Structures and in Open Field Working paper 18 – Economics of Protected cropping: conclusions. A robust multivariate analysis across all farms of the impact of structures, crop, management skills, pests and disease interaction, fertilzer and pesticide costs, rainfall and season on yield and gross margin has also been carried out and has quantified the gross margin and yield benefits of protected cropping in the Visayas. The analysis indicates that the annual contribution to gross margin from having a structure, after accounting for these other variables, is approximately

				half of the average initial construction cost. In other words, structures, anticipated to have life of five years have a ‘payback period’ of two years (based upon a straight line depreciation calculation). Another way of looking at the results is to say that average, farmers are getting 51% more gross margin per m2 for producing vegetables under protective structures compared to the open field.
2.2	Elucidate and analyse seasonal price trends for key vegetables	Monthly price data obtained and analysed using primary and secondary sources	Completed – working paper 17	A seasonal price trend analysis for key vegetables in Leyte and Cebu was conducted. Detailed vegetable price data has been collected in Ormoc as well as in Maasin in coordination with the City Agriculture Office In-Charge. Data collection shall continue for the duration of the project. The available time series data collected in Ormoc and in Maasin is still not suitable and appropriate for seasonal price trend analysis. (The City Agriculture Office of Ormoc as well as Maasin LGUs decided to discontinue their collection of price data in late 2010 until recently) Detailed vegetable price data in Leyte (represented by Ormoc, Tacloban, and Baybay) and Southern Leyte (represented by Maasin City) has been collected in coordination with the Bureau of Agricultural Statistics (BAS) located at Tacloban City. The available time series data collected is on the process for seasonal price trend analysis. The seasonal price trend analysis has been done and published as a Working Paper 17. To complement the absence of appropriate data series specifically for Ormoc and Maasin, a seasonal price trend analysis was conducted. The data for Cebu is included since it is a major market and source of vegetables sold in Leyte.
2.3	Liaise with other megaproject components, especially the marketing and economics components	Role of protected cropping within the milieu of high value vegetable products, as determined by other project components, will be defined	Ongoing with reports on interaction with other projects due annually	A study comparing nitrogen supplied from organic and inorganic sources for protected cropping has been conducted jointly with C1 and has been reported by the vegetable C1 component. Our project team co-operated fully with vegetable component 5. The project team subsequently produced a report entitled “*Economic Impacts of Component 2: Protected Cropping technology for vegetable production in the Southern Philippines*” McClintock et al, which is based on preliminary data and interviews only and was too early in

				the project cycle to provide advice on possible farmer benefits. Our peer-reviewed final economic analysis based on a full 3 years of data (Working Paper 18: "*Economics of Protected cropping: conclusions*" by Menz et al. confirms the economic viability of protected vegetable cropping in the Visayas. **Important note**: It is important to discriminate between the economic viability of the low cost structures developed as part of this project and the steel-framed plastic covered structures that have been widely distributed by the Department and Agriculture and others in the Philippines. The smaller steel-framed structures are unlikely to be economically viable due their high cost. These structures also have problems with excessive heat as a result of poor ventilation and the overall design. This project ***does not endorse*** the use of these steel-frame structures for vegetable production in the Philippines.

Objective 3: Promote adoption/modification of protected cropping systems in Leyte and Southern Mindanao

No.	Activity	Outputs/ Milestones	Completion date	Comments
3.1	Undertake a constraints (to adoption) analysis	Report on actual and perceived constraints to adoption by farmers	Preliminary completed in year 1 and final in year 4 (refer working paper 18)	Focus group discussions (FGDs) with both farmer co-operators and non co-operators were conducted to determine the farmers' views and experience in growing vegetables under structures. Result of the farmers' feedback was published in Working Paper No. 1 and Working Paper No. 4. Highlights of participants' feedback are: • Farmers were impressed with the productivity of the vegetable crops; • The protected structure design does protect crops and facilitates husbandry activities; • Potential irrigation problems due to lack of water in farmers' fields; and • The overall viability and performance of vegetables in the longer term remains to be seen. Farmer-collaborators in Ormoc, Bontoc, and Maasin had their two to three croppings of vegetable crop during the period under review. Additional new farmer co-operators whose structures were from the LGU Maasin counterpart just established their structures and still have ongoing first vegetable crop. They provided feedback on observed and perceived

				constraints which were found similar to other farmers Two (2) representative farmer co-operators in Bontoc and Ormoc City joined the field tour on established protected cropping in Mindanao for further exposure and information to enhance adoption of protected cropping on June 7-12, 2010. Further focus group discussions were conducted in year 4 to collect farmer's views and experience for growing vegetables under structures and the results incorporated in working paper 18.
3.2	Identify and develop market linkages	Actual and potential linkages between market and key farmers identified and developed	Completed an potential linkages form part of HORT-2012-020	The marketing strategies of farmer co-operators have been documented in the different project sites and market assistance such as finding new market outlets was provided. A Public Private Partnership working group has been formed between VSU, East West Seeds, the Energy Development Corporation (EDC, formerly PNOC) and Massin City and Ormoc City administrations, with the first meeting held in Ormoc in August 2010. The FFS in Maasin was the first outcome from this group. The new project HORT/2012/020 and the proposed value chain project should focus in this area, especially in the area of supporting farmer groups.
3.3	Use benefit/cost analysis to guide research and farmer activity	Continuous interaction between biophysical and economic project Components to plan/revise research and extension program	This was ongoing and used to inform the direction of project activities	Benefit/cost analysis has guided the project throughout. The technical and socioeconomic teams have operated essentially as one. The economic results have been determined coincident with technical research output (not sometime later as often occurs) and the technical team have been very receptive in taking the feedback and modifying their research plans accordingly on an ongoing basis. This has been variously manifested in structure design, crop choice, and agronomy.
3.4	Participatory training of farmers/FFS when system shown to be viable in Leyte	Farmers trained in how to grow vegetable crops successfully under protected cropping in Leyte	Ongoing throughout the project	There is evidence of true adoption by farmers. One farmer in Kananga, near Ormoc, Leyte has built 3 house-type structures and these are being used to grow ampalaya. A poultry farmer at Concepcion, Ormoc City converted 7 poultry houses into protective cropping structures and they are being used to successfully grow vegetable crops. At Bontoc, Boie Gerona has built a new fully enclosed structure that was jointly

				by collaborating farmers and project staff. A new project funded by GTZ and local LGUs has resulted in another 48 structures having been built and supported in Leyte. This brings the total number of structures to about 100 including project structures, adoption and GTZ structures. There is now a new large EDC / VSU project focussed on protected cropping which is building and supporting many new structures in Leyte. A Farmer field school (FFS) was run jointly by East West Seeds, Maasin city council and VSU over a full season (15 weeks). Training was provided on improved technologies of vegetable production which was launched in Libhu, Maasin City last October 2010. More than 30 farmers were involved in the said training of which 15 were sponsored by the ACIAR project from the Australian budget, while 10 farmers were paid for by LGU-Maasin. East West Seeds provided the training modules and most of the training on topics pertaining to vegetable production which included a segment for protected cropping system.
3.5	Exchange information with DA and farmer groups in Mindanao to support training activities	Results from Leyte studies communicated to Mindanao farmers	Ongoing throughout the project	An excellent video on protected cropping was produced and has been widely distributed to farmers, LGU staff and policy makers, and as of January 2013 **the video has been viewed 13,859 (May 2013) times with 32 "likes" on YouTube**. The video was launched by ACIAR CEO, Nick Austin during the Farmers and Fisherfolks day at VSU in August 2010. 600 DVD copies have been distributed to LGUs, farmers, DA, industry members and other interested parties. City Agriculturists of Maasin and Baybay, DA technicians, and farmer co-operators participated in the workshop to improve the design of low-cost protective structures in mid February 2011 at VSU. Five vegetable farmers from Mindanao visited three protected vegetable farming sites on April 12-13, 2011 to personally interact with farmer co-operators on how protected cropping system was implemented in Leyte. Bohol farmers visited Leyte and Southern, Leyte on August 9-11, 2010 and were shown project sites in VSU, Ormoc, Bontoc, and Maasin. A delegation of farmer-colLabourators

				from Leyte and Southern Leyte visited ACIAR project LWR/2004/078 sites in Bohol on October 27-30, 2010. Both the Mindanao and Bohol groups have built their own structures following cross visits to the project structures in Leyte. Different sites were visited including the high strength protective structures of Harbest Corporation. Links have been formed with the Energy Development Corporation (EDC) through their farmers' cooperative and have built two protective structures and had undergone the first cropping, which lasted for more than a year. Concepts of PC used with clusters by component 4 in Mindanao.

7 Key results and discussion

Thirty four (34) functioning protected cropping structures were built and supported by the project across five regions, including the VSU site at Baybay, and these were used for experimentation for the assessment of economic viability of protected cropping. Two types of structures were evaluated: the *house-type structures*, built from either bamboo or coco lumber with an effective growing area of $200m^2$ (5m x 40m) or *tunnel-type/igloo type structures* made of either bamboo or steel frames and with a growing area of $60m^2$ (1.5m x 40m). Structures were covered in either plastic or fine net. The VSU sites were used mainly for experimentation on crop suitability, pests and disease impacts and nutrition. The farmer sites were mainly used to collect information to support the assessment of economic viability, and to monitor for the emergence of new production challenges.

In all project field sites, an open field control set-up was provided for comparison. Drip irrigation systems were used at the VSU site and also in some of the farmer co-operators at Ormoc and Bontoc sites. Temperature, relative humidity and light intensity were being monitored using either electronic sensors with loggers, or by manual recording of temperatures from thermometers. Rainfall and wind velocity data were collected.

The incidence of pests and diseases were monitored. The prevalence of pests was generally moderate. Pests were managed using a combination of preventive and curative control measures such as cultural (e.g. crop rotation, pruning), mechanical (hand picking, fruit bagging) and chemical (contact and systemic pesticides), and the use of botanical or organic sprays. Withholding periods were observed when pesticides were used.

The following sites were developed:

(i) *VSU site* with 4 house-type structures and 2 tunnel-type/igloo type structures

(ii) *Ormoc sites*, spread over several barangays, with 15 structures, 9 house-type, 1 of which is a vent house type & 1 curved roof type structures and 2 bamboo tunnel and 2 steel tunnel-types

(iii) *Maasin sites*, situated in 6 barangays, with 8 structures, 6 house-type, 1 vent & 1 curved roof type;

(iv) *Bontoc site* with 1 vent and 1 curved roof type, one new farmer- designed structure, and several low tunnels.

(v) *Bato site*, with 1 house-type structure

7.1 Evaluation of structures

7.1.1 Split roof structure

A third design was developed with a curve roofing system (Figure 1 and Photo 5). This design was an improvement over the straight roof conventional house type but it was difficult to attached the plastic without nails or fixtures that penetrated the plastic sheeting.

The roof truss system was also modified to strengthen it then it was compared to the straight roof system and compensate for different sized bamboos in the construction. The roof design with modified trusses is shown in figure 1. The cost of the construction was slightly more than for the straight roof bamboo structure. The total cost was about PhP 4,000 due to the increase in the labor cost for the curved roofing system.

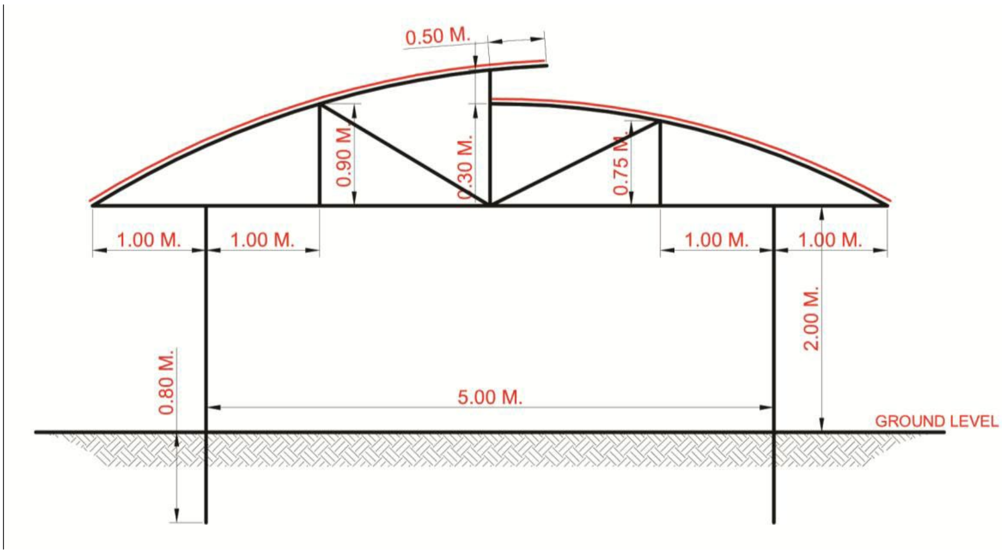

Figure 1. Modified curved roof system.

Photo 5. Modified curved roof system.

7.1.2 Full curved roof design – farmers' design

There were number of times that the structures required major repairs. Damage included

- rotten bamboo rafters due to the penetration of rain water
- blowing off of the plastic roof during windy season or slight storm due the wind that passing through the roof ventilating system
- rotten bamboo posts due to constant wetness of the soil during production.

When a roof is blown off it needs to be replaced with a new plastic since the nailing and other pointed materials causes the plastic to be torn or presents of large holes.

Because of the above experience, the fourth design was made, as shown in Figure 2 and Photo 6. This house followed the dimensions of the previous designs. However, it used the dome roofing system all through its length without any ventilation slots to avoid the rushing of wind at the roofing that may cause the damage of the structure. The temperature inside the structure did not differ with the other design on the same site. Also, instead of laying out the plastic for roofing in longitudinal manner, crosswise installation is employed. This was decided to minimize the plastic that will be used to replace if damage will happen. Further, binder clips were used to fixed at the edge of the plastic roofing material in the bamboo rafters; thus, the plastic roof is fixed in its position by pulling it through the rafters and strapping with nylon string or black strap. Nails were not use in the roofing to avoid penetration of rain water.

Finally, concrete footing for the posts were put to use to increase the strength of the structure and to avoid damage of the posts due to rotting. However, test is made whether to install concrete footing in all posts or in alternating manner. In the latter method, post without concrete footings were wrapped with plastic hoping water will not sipped? into the bamboo posts.

Due to the adaption of dome type roofing and concrete footing, the cost of constructing the structure was observed to increase by more or less 20%. This increase was due to additional bamboo materials, footing materials and labour.

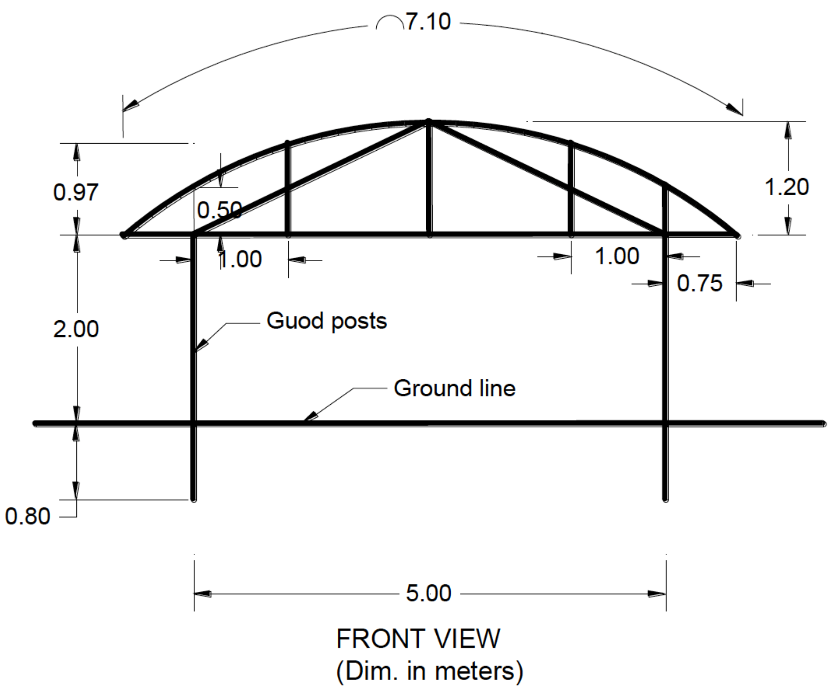

Figure 2. New locally–designed curve roof structures

Photo 6. One piece curved roof design

7.1.3 Evaluation of the Structures

The use of nails at the plastic roof

Common nails with rubber pads were used to hold the plastic roof in place. However, in less than a year these nails rusted, probably due to sap from the bamboo and the moisture in the environment. The result was that rainwater leaked through the plastic roof and caused rotting of the rafters and consequently damage the plastic roof during strong winds.

Photo 7 Nails used to attached plastic

Rotting of bamboo posts

Despite the treatment of the bamboo post with a coal tar, the posts rotted within 3 years due to the constant wetting of the ground during production period. The base of the posts were encased in concrete which helped, or replaced.

Photo 8. Rotten bamboo posts

Mold/Algae on plastic roof

Molds or algae developed on the plastic roof and reduced the penetration of sunlight through the plastic. This was common to all structures in all sites. The molds and algae can be removed by scrubbing the plastic roof light with water.

Photo 9 Cleaning the plastic roof

Standardized of bamboo poles

The selection of the bamboo poles to be used in the construction of the structure is a very critical stage of the project. Different varieties of the bamboo were identified with high strength and these have been used. Nevertheless, the maturity of the bamboo and the source has not yet been standardized. This is because even when the same variety of bamboo at the same maturity the strength still varies and thus is probably due to the growing conditions. For example bamboo of the same variety but where one is planted in an open area while the other not so exposed to sun, the latter contains water inside the pole. Thus, using this kind of bamboo affects the durability of the structure.

Curve and dome-type roofing

The adaption of a curve roofing system appeared to resist wind. This is because the curve roof allows the plastic roof to be well tightened at the rafters when a nylon or black strap is laid tight over the plastic. Wobbling of the plastic during windy times is almost eliminated.

Roof plastic position

In the setting of the plastic roof, the previous method used is to attach the plastic lengthwise along the structure. This method is very expensive and when the plastic is damaged by the wind, the whole length of the plastic has to be replaced due to many torn parts. Thus, in the latest design of dome type roofing, the plastic is laid across the roof frame. In this way, only the damage portion will be replaced while the other parts are spared.

Use of binder clip

Instead of using nails to hold the plastic roof, a binder clip is used at the end of the each plastic sheet in the doom type structure. Thus, there is no way that rain water will damage the bamboo rafters. Besides, it is easy to remove the plastic roof if it so desired during summer time and windy time.

7.1.4 Maintenance

Cleaning of the roof

Cleaning of the roof to remove the molds and algae can be done by scrubbing gently the plastic with soft cloth and water. It can also be removed by using a power sprayer if it available and cheaper to use.

Protection against termites

Termite or “bokbok” is a common pest that damages the bamboo. In order to protect the bamboo, apply used oil (from a diesel engine) preferably during the period that there is no production underneath the structure.

Photo 10 Termites attacking the bamboo

Damage rafters and beams

Due the penetration of rain water through the rusted nails, a rafter or a beam can be damaged. This should be replaced immediately to avoid further damage in the plastic roof.

Photo 11 Damage to bamboo from water leaking

7.1.5 Temperatures inside the structures

Maximum temperatures within the house type structures were generally about 5-8 ^{o}C above ambient temperature (Figures 3 and 4).

The low tunnel structures are about 5^{o}C warmer than the house types (Figure 5) whereas the maximum temperatures inside the net covered low tunnels are somewhere in between the plastic covered house type and tunnel type structures (Figures 6 and 7).

The temperature differences are likely to be a result of the increase in air volume and air exchange within the house type structures, which moderates the temperature compared with the low tunnels. The tunnels offer a low cost means of protecting a crop during rain events, but the cover may need to be removed at other times to avoid excess temperatures which will reduce plant productivity.

Conditions within both types of low tunnels can be detrimental to crop growth. The net low tunnel does have a potential advantage over the plastic covering in that whilst protecting crops from heavy rain and consequent damage, netting permits entry of water which reduces the need for irrigation compared with the plastic low tunnel.

The use of the low tunnels to reduce pests and diseases has the same basic limitations as the house type rain-shelters but with the added problem of increased heat and poor access. Even with relatively low labour costs, labour supply has to be considered and the regular installation and removal of these covers to provide better growing conditions is likely to be unsustainable. Subsequently, farmers using low tunnel type structures will tend to keep covers in place which will adversely affect crop management.

The primary reason for the use of any type of structure, whether a rain-shelter (house type structure), a low tunnel or even a fully closed protective structure is protection of the crop from rain and to some extent wind. It is important to recognise however, that this use of a structure impacts on the growing environment within. The environment within the protected structures is generally warmer than ambient conditions and is strongly influenced by the amount of air exchange.

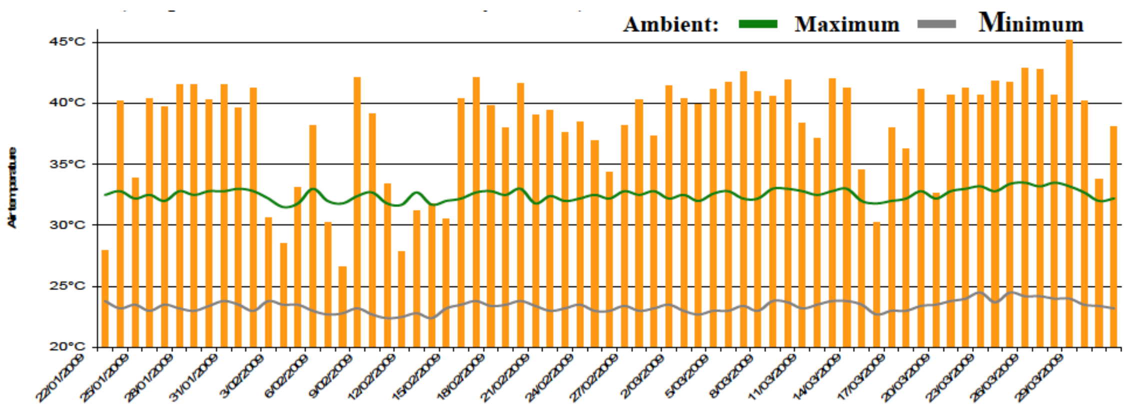

Figure 3. Average maximum temperatures January - March 2009 for generic house structure

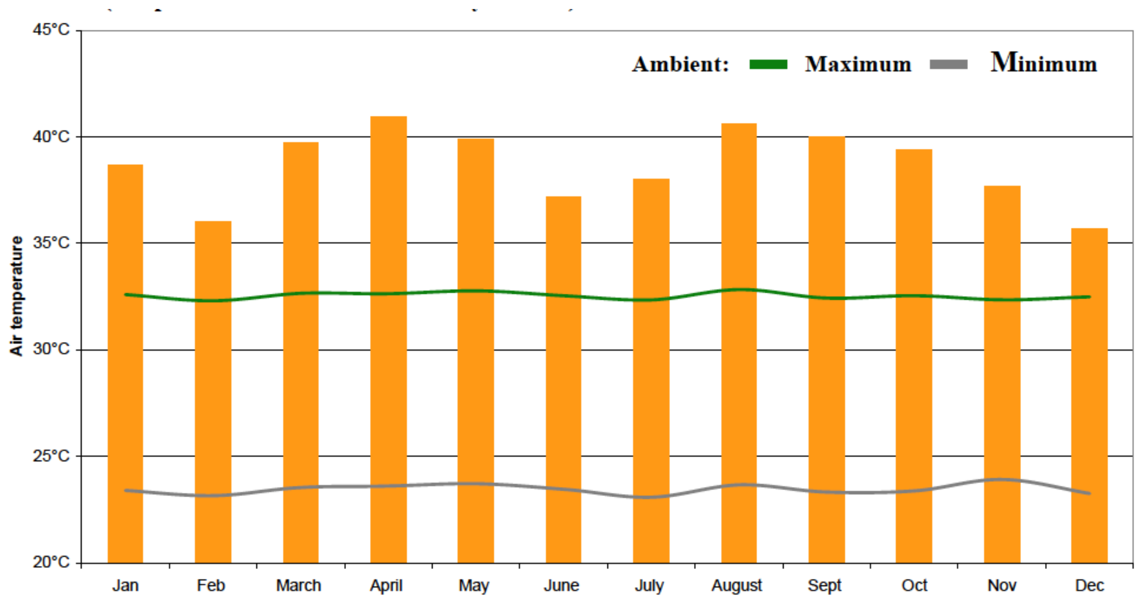

Figure 4. Summary of the average maximum temperatures for a generic house type structure from VSU for 2009

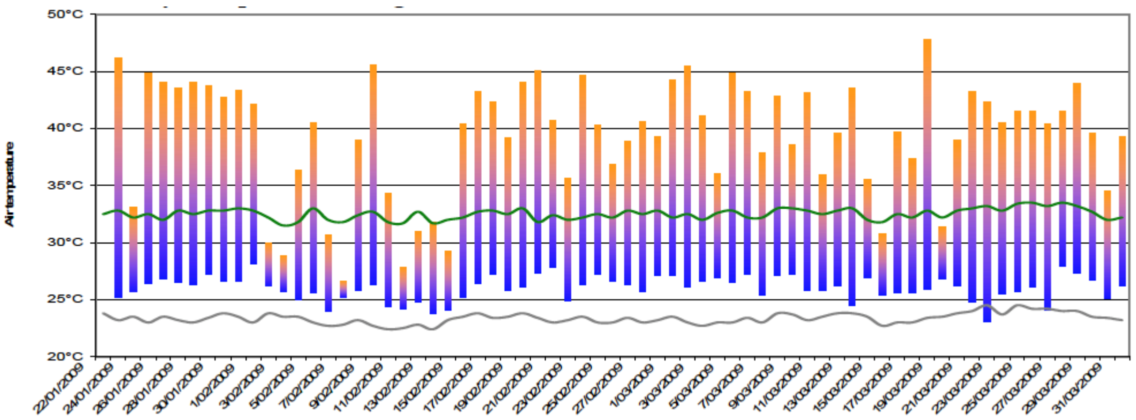

Figure 5. Plastic cloche type: Daily Temperature range, Jan-Mar 2009

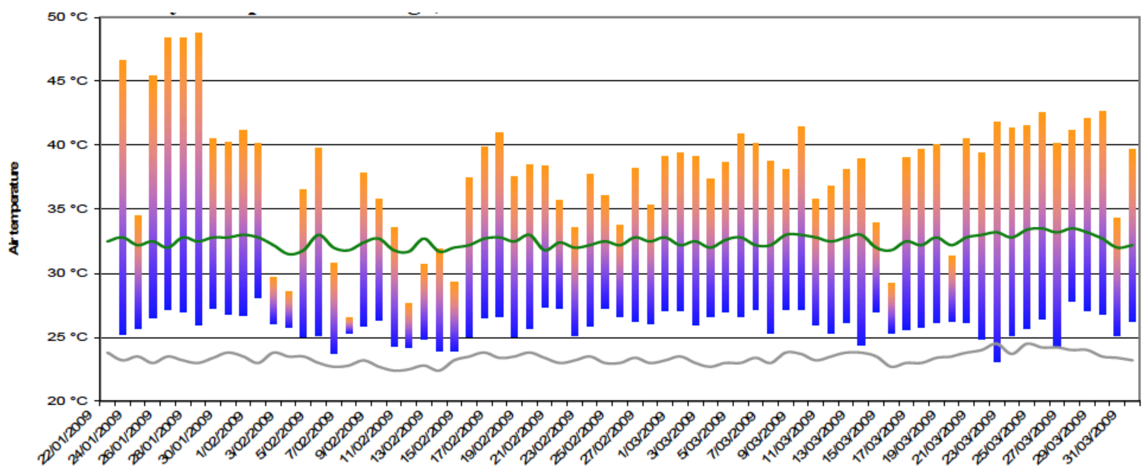

Figure 6. Net covered tunnel (cloche) type structure: Daily temperature range, Jan-Mar 2009

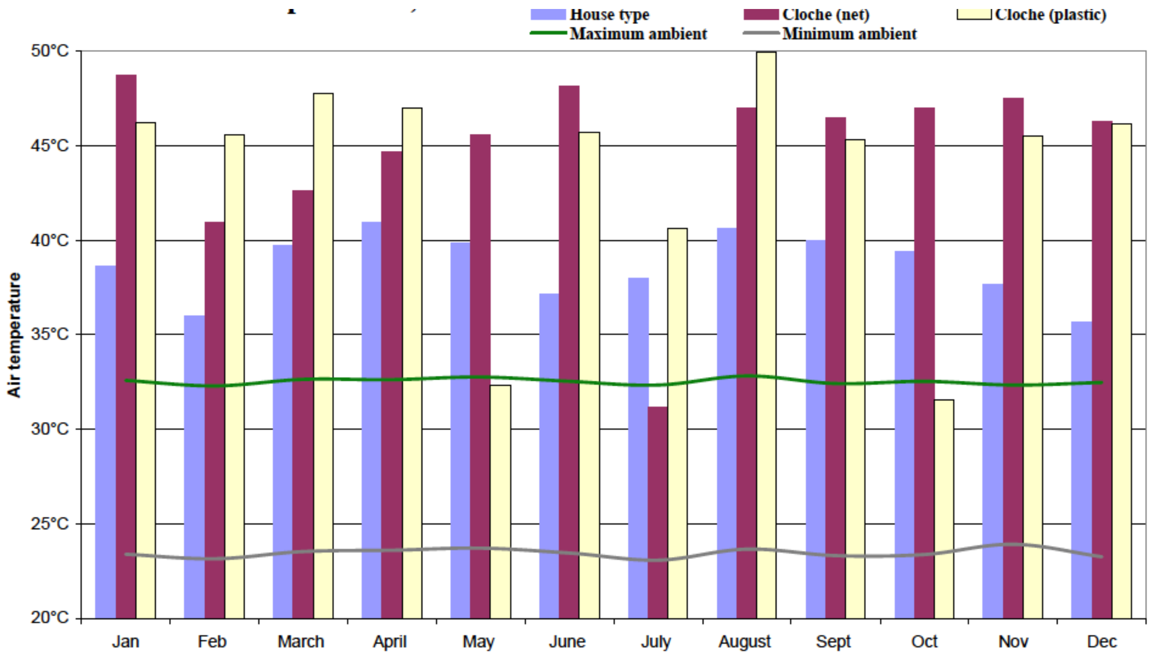

Figure 7. Comparison of house and cloche structures: Maximum temperatures, 2009

7.1.6 Recommendations

- Adopt a dome-type structure with the use of binder clips to attach the plastic.
- The footing of the posts must be concrete to extend the life of the structure.
- Only matured and good varieties of bamboo poles should be used in the construction.
- Wind breaker plants or trees at a distance from the structure should be planted to reduce the impact of wind on the plastic roof.
- Before using the bamboo poles, they should be treated with used sump oil for a week to avoid termite infestation.
- Drying of the bamboo poles may be done for a week or more to remove the sap. There is some suggestion this will reduce or prevent termite attack.

7.2 Agronomy and pest interactions

7.2.1 Yield and quality

The average yield of vegetable crops grown under protected cropping over three years under house type structures are shown in Table 1, which is a summary of over 134 separate comparisons. Each trial included an open field control, and crops were harvested and the harvested part classified as either marketable or non-marketable. Examples of yield outcomes from individual trials are shown in Tables 2 and 3 for tomato, and Tables 4 - 6 for sweet pepper, bitter gourd and lettuce, respectively. The pooled yields show an increase in average yields under protected cropping for cauliflower, green onion, lettuce, chilli pepper, tomato, sweet pepper, bitter gourd, pechay, muskmelon, broccoli and string beans. There was no improvement in yield for sweet corn, cabbage, watermelon, bottle gourd, cucumber or winter squash.

Comparisons within sites for the four most "successful" crops under protected cropping: tomato, sweet pepper, bitter gourd and lettuce have generally shown significantly higher yields under protected cropping, and the data shown in Tables 2-6 are typical. However, in some cases yields for these four crops were lower under protected cropping, or there were no significant differences. These results were included in the overall yield averages presented in this paper and could be attributed to either a low level of farmer skill especially ineffective irrigation or to uncontrolled pest or disease outbreaks. This issue has been addressed and quantified by another paper in this series (Armenia *et al*. 2012).

Table 1. Average yearly data of vegetables grown in Leyte during cropping years 2009, 2010 and 2011 under house-type protective structures and in the open field.

Crops	Marketable Yield (tons/ha*)						Number of Comparisons **
	2009		2010		2011		
	Open	Under Structure	Open	Under Structure	Open	Under Structure	
Cauliflower	0	6.4	2	2.7	-	-	4
Green Onion	-	-	-	-	17	60	2
Lettuce	4.6	13.3	21.3	22.7	-	-	10
Chilli pepper	-	-	6.9	16.8	-	-	2
Tomato	16.9	35.9	22.6	33.8	12.6	39.4	21
Sweet Pepper	-	-	17.2	30	14	31	23
Bitter gourd	-	-	8.2	11.2	15.2	32.5	26
Pechay	-	-	7.1	29.7	-	-	3
Muskmelon	10.2	21.3	-	-	7	10.1	7
Broccoli	0.9	0.9	3	3.7	-	-	6
String Beans	-	-	17.5	16.4	17.8	23.6	5
Snap Beans	-	-	-	-	8	16	2
Sweet Corn	-	-	2.9	3.3	-	-	2
Cabbage	8	8.1	8.8	12.2	-	-	5
Watermelon	-	-	17.1	8.6	57.4	56.2	8
Bottle Gourd	-	-	41	41.1	-	-	3
Cucumber	-	-	-	-	89	76	2
Squash	-	-	44	36.5	-	-	3
Total							134

* - average yield per plot (kg/plot) from each crop converted to tons/hectare pooled in three years across all sites
**- separate setups in three years across all sites
– No trials conducted

Photos 12 and 13: Examples of sweet pepper crops under protective structures in Leyte.

Four crops performed consistently better under protected cropping than in the open field: tomatoes, sweet pepper, ampalaya and lettuce (Figure 9). The average yields for these crops were consistently higher under protective structures compared with open field over the three-year trial period in the Visayas.

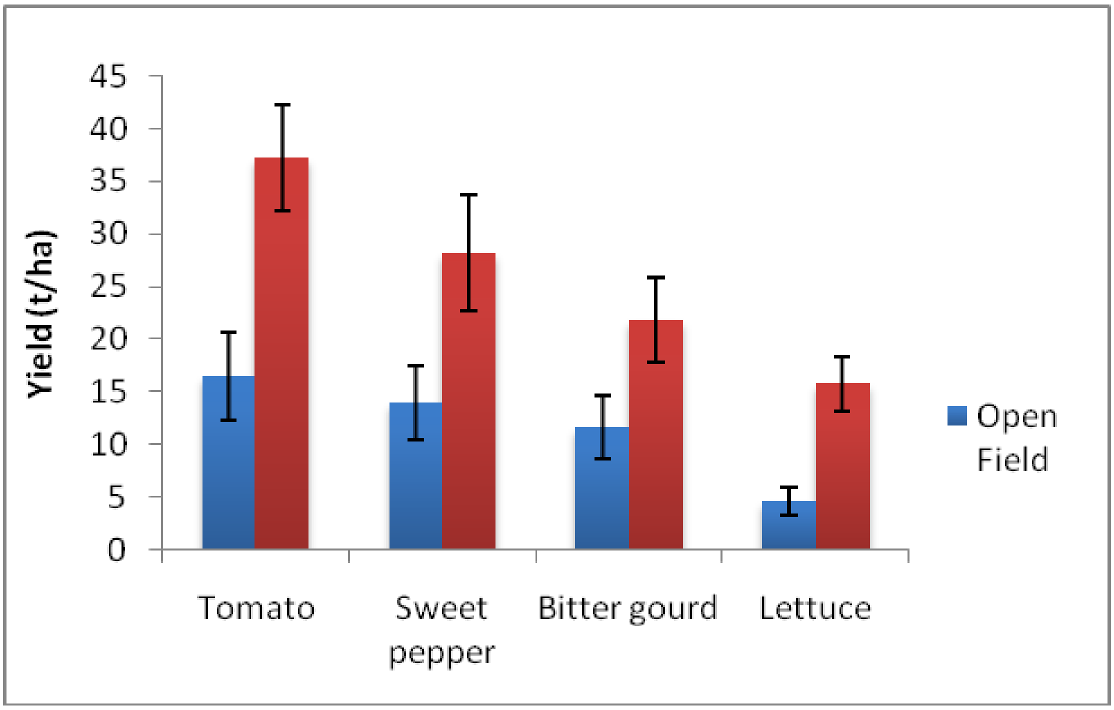

Figure 9. Yield of tomato, sweet pepper, bitter gourd and lettuce under house type protected cropping and in the open field, Leyte, Philippines, (average of 3-year data). The vertical bars are standard errors (SE P<0.05) and give an indication of the estimate of the amount that an obtained mean may be expected to differ by chance from the true mean.

Growing vegetables crops under protective structures is not new. The explanations for yield increases are well documented and include reduced periods of leaf wetness creating less favourable conditions for diseases to infect, fruits protected from direct contact with soil, reduced weed growth, moderate soil and air temperatures, reduced leaching of nutrients from soils (De La Pena & Hughes, 2007). Lower yield obtained from open field grown crops was mainly attributed to direct exposure to rain especially during months with heavy precipitation (Figure 1). In tomato, clear plastic rain shelters prevent water logging and rain impact damage on developing fruits and consequently improved tomato yields (Apilar, 2002; Mangmang, 2002; Midmore *et al.,* 1992).

Table 2. Yield data of tomato under bamboo structure and in the open field (Feb 8 – Jun 24, 2011) at Lao, Ormoc

Treatments	Marketable fruit/40m^2		Non-Marketable fruit/40m^2		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	
Under Structure	10769^a	401^a	79^b	1.9	100.79^a
Open Field	4145^b	133^b	371^a	6.8	34.88^b
CV (%)	10.91	7.99	26.29	40.904	8.27

Means within a column having the same letters and those without letters are not significantly different at 5% level of significance based on DMRT.

Table 3. Yield data of Tomato 'D' max' under bamboo structure and in the open field (Jul 15 – Oct 21, 2011) at Curva, Ormoc

Treatments	Marketable fruit/40m²		Non-Marketable fruit/40m²		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	
Bamboo	4640[a]	211.00[a]	200.33	4.55	53.89[a]
Open field	1522[b]	54.83[b]	84.33	2.17	15.52[b]
CV (%)	3.47	14.78	51.52	38.48	9.19

Means within a column having the same letters and those without letters are not significantly different at 5% level of significance based on DMRT

Table 4. Yield data of Sweet pepper under bamboo structure and in the open field (Jun 22 – Mar 21, 2012) at Lao, Ormoc

Treatments	Marketable fruit/40m²		Non-Marketable fruit/40m²		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	
Under Structure	8592.00[a]	230.03[a]	368.67[a]	6.23[a]	59.06[a]
Open Field	1020.33[b]	23.55[b]	198.67[b]	2.35[b]	6.47[b]
CV (%)	0.50	3.20	17.90	18.90	3.30

Means within a column having the same letters and those without letters are not significantly different at 5% level of significance based on DMRT.

Table 5. Yield data of Bitter gourd var. 'Galaxy' under bamboo structure and in the open field (Mar 23, 2011 – Jul 12, 2011), Curva, Ormoc

Treatments	Marketable fruit/100m²		Non-Marketable fruit/100m²		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	
Bamboo	1895.00[a]	456.25[a]	69.50[b]	7.30	26.60
Open field	1116.00[b]	255.00[b]	70.00[a]	6.02	15.55
CV (%)	2.86	3.44	12.19	10.88	49.82

Means within a column having the same letters and those without letters are not significantly different at 5% level of significance based on DMRT.

Table 6. Yield data of Lettuce var. 'General' grown under Coco house 1 and in the open field (May 25 – Jun 28, 2010) at VSU site

Treatments	Marketable yield/39.5m²		Head size (cm)		Total yield (t/ha)
	Number	Weight (kg)	Polar	Equatorial	
Coco 1	269a	41.37a	13.75	12.40	10.47a
Open field	142b	22.04b	12.95	11.77	5.58b
CV (%)	4.65	15.44	2.80	2.78	15.62

Means within a column having the same letters and those without letters are not significantly different at 5% level of significance based on DMRT.

7.2.2 Impact of season

Despite the general trend for higher yields under protected cropping (Figure 9), the assumption has been that the main benefits occurred in the wet season, and that there was little advantage to growing crops under structures in the dry season since there is no heavy rain or typhoon at this time of the year. To test this idea, the authors grouped crop yield data according to whether they had been grown predominantly in the dry season or the wet season (Figure 10).

Wet season crops were those grown between July and January, and dry season crops were those grown between February and June. For tomato the highest yields were obtained in the dry season rather than the wet season. While a reasonable yield of 22 t/ha could be obtained in the dry season in the open field, a much more impressive yield of 45 t/ha was obtained, on average, under protected cropping.

During the wet season, open field grown off season tomatoes yielded less than 10 t/ha while under protective covering, the same tomato cultivar produced 30 kg per hectare, which was even higher compared with the regular dry-season tomato cropping at farmers' field. Very similar trends were observed for bitter gourd and lettuce.

The result for sweet pepper was different from the other three crops when the greatest benefit of protected cropping was achieved during the wet season. The average yield of 30 t/ha was attained compared to only 12 t/ha in the open field. This was because *Cercospora* leaf spot, the serious disease of sweet pepper during wet season was not able to infect since the dry and warm condition under the structure are not conducive to its proliferation.

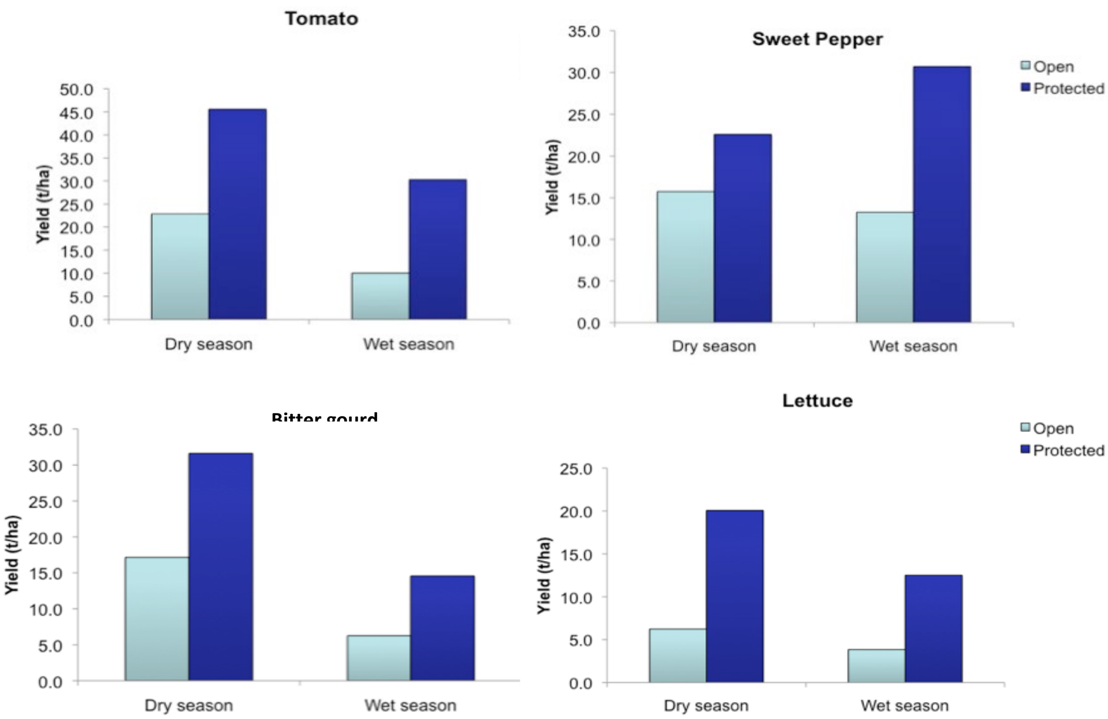

Figure 10. Yields of tomato, sweet pepper, bitter gourd and lettuce under house type protected cropping and under the open field during the wet and dry seasons in Leyte, Philippines. The data in Figure 3 10? is an average of 3-year trials with 21, 23, 26 and 10 data sets for tomato, sweet pepper, ampalaya and lettuce, respectively. The wet season is from July to January and the dry season from February to June.

A possible factor in explaining the seasonal affect on crop yields could be due to the rainfall pattern in the eastern Visayas. While there is a less rainy season between February and March, and a period of high rainfall of between 400 and 1000 mm per month for the rest of the year, there is still sufficient rainfall during the so-called dry season to cause significant problems for growing susceptible (water logging) vegetable crops such as tomato, lettuce, sweet pepper and bitter gourd (Figure 11).

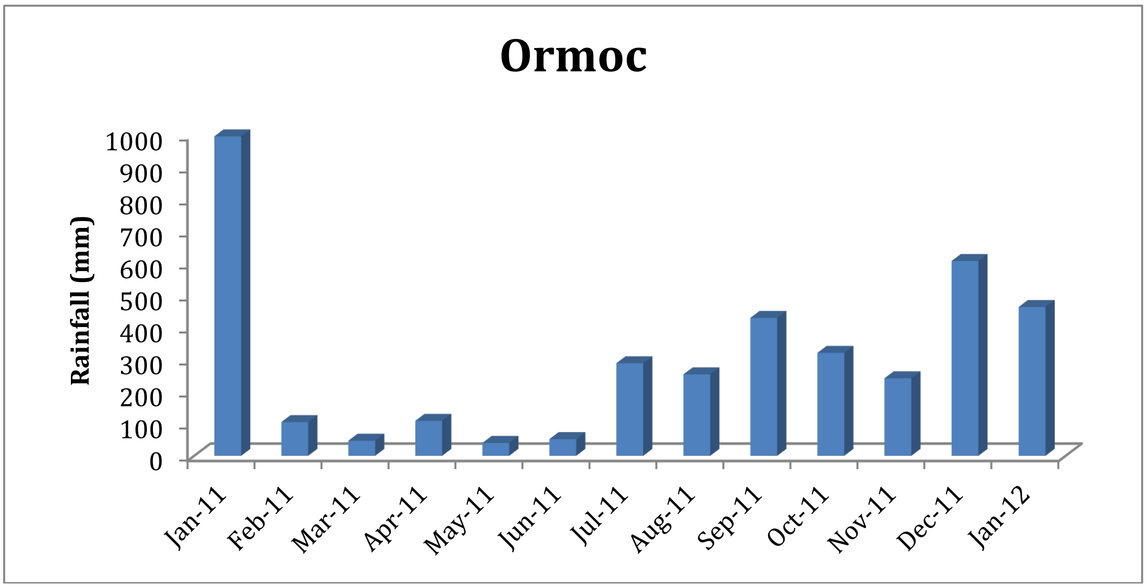

Figure 11. Total monthly rainfall from January to December 2011, Ormoc City, Leyte

Another factor could be that the environment inside greenhouses is generally more favourable to plant growth and development, especially for warm season crops. Environmental stress is the primary cause of crop losses worldwide, reducing the average yields for most major crops by more than 50% (Boyer 1982, Bray *et al.,* 2000). The lower yield in wet season particularly plants grown in the open field was likely due to high amounts of rainfall. During the three year trials the rainfall distribution followed a distinct trend which was higher from July to January (wet) and lower from February to June (dry). Frequent heavy rain during the wet season would mean high soil moisture which enhances the development of soil-borne pathogens (Magdoff and van Es, 2000). In addition, rain splashing or flooding can help to disperse disease spores and infect plants (Graham and Timmer, 2003).

7.2.3 Pests and diseases

Table 7 shows the major arthropods pests (insect and mites) which where commonly infesting vegetable in both under structure and in the open field. The data revealed that the incidence of most of the arthropod pests were generally higher under structure than in the open field grown plants. The red spider mite (*Tetranychus kanzawai*) and broad mite (*Polyphagotarsonemus latus*) were found to be the most damaging in the sweet pepper especially under structure. In string beans, the pod borer (*Maruca vitrata*), thrips (*Thrips tabacci*) and leafhopper (*Empoasca sp*.) were the dominant species encountered with the first two species seriously attacking the flowers and the newly formed pods. In the ampalaya, the aphid (*Aphis gossypii*) and the leaf folder (*Diaphania indica*) were consistently observed in all the croppings which greatly affected the performance of the crop when left unchecked. In the case of water melon, the broad mite was observed to be very damaging which greatly affected the growth of the crops at the early vegetative stage. On the other hand, the leaf miner was found to be quite serious in the musk melon, however the data were more or less comparable under structure and the open field. Moreover, in the tomato, the major species were the leaf miner and the fruitworm (*Helicoverpa armigera*). However, data show that their incidence were lower under structure than in the open field which could be due to the use of net enclosure in one of the structure at the farmer sites.

Major diseases which were commonly found affecting vegetable crops inside structures and open fields include leafspots caused by mainly *Cercospora* spp. which had affected ampapaya and sweet pepper; downy mildew caused by *Pseudoperonospora cubensis* mainly in the cucurbits including ampalaya, squash and cucumber. Bacterial wilt caused by *Ralstonia solanacearum* was also a major problem in tomato and sweet pepper crops. In lettuce, sclerotium wilt caused by *Sclerotium rolfsii* was the main problem.

The incidence of these diseases was generally higher in the open field than inside protective structures (Table 8). This was because too much moisture in the open field especially during heavy rains in the form of excess surface water is conducive to the motile bacterial wilt pathogen *R. solanacearum*. Surface water run-off to other areas of the field also favours the dissemination of the water-borne inoculum to a bigger part of the area planted. Inside protective structures moisture extremes are regulated and this is unfavourable to soil-borne pathogens like *R. solanacearum*.

In the case of downy mildew and Cercospora diseases, high moisture in the leaves of the plants favours fungal spore germination and infection for these air-borne fungal diseases. Inside structures, drip or trickle irrigation was usually practiced such that the water was directly applied to the roots and direct application of water to the foliage of the plants was minimized. This also minimized the germination, penetration and infection of wind-borne inoculum of fungi which might have landed on the foliage. Rain splashes are also not present inside structures and rain splashing is another way whereby inoculum from the soil is introduced to the leaves or upper parts of the plant or transfer of pathogen propagules such as fungal spores from leaves to leaves or from one plant to another plant.

Table 7. Major arthropod pest (insects and mites) attacking vegetables under protective structure. (Incidence is the percentage of plant which the pest was observed from random samples of 40 plants per plot)

Crops	Insect Incidence (%)		
Sweet Pepper	***Spider Mite*** *(Tetranychus kanzawai)*	***Broad Mite*** *(Polyphagotarsonemus latus)*	
Under Structure	23.5	31.4	
Open Field	9.9	23.2	
String Beans	***Pod Borer*** *(Maruca vitrata)*	***Thrips*** *(Trips tabacci)*	***Leafhopper*** *(Empoasea sp.)*
Under Structure	25.0	24.0	20.0
Open Field	22.5	25.0	10.0
Ampalaya	***Aphids*** *(Aphis gossypii)*	***Leaf Folder*** *(Diaphania indica)*	
Under Structure	38.5	13.5	
Open Field	19.5	12.8	
Water Melon	***Broadmite*** *(Polyphagotarsonemus latus)*		
Under Structure	25.0		
Open Field	10.0		
Muskmelon	***Leaf miner*** *(Liriomyza sp.)*		
Under Structure	24.0		
Open Field	25.1		
Tomato	***Leaf Miner*** *(Liriomyza sp.)*	***Fruit Worm*** *(Helicoverpa armigera)*	
Under Structure	9.2	3.0	
Open Field	14.3	18.0	

Drier leaves inside structures is the main cause of the lower disease incidence compared to outside and largely explains the longer harvest period and higher yield of crops grown under protective structures.

The incidence of virus diseases inside or outside depends on the incidence of insect. Sooty mould occurs more often inside structure because this fungus is attracted to the honeydew secreted by some insects like aphids.

Table 8. Incidence of major diseases infecting vegetables under protective structure. (Incidence is the percentage of plant which the pest was observed from random samples of 40 plants per plot)

Crops/structure	Disease incidence (%)		
Ampalaya	***Cercospora Leaf Spot*** *(Cercospora spp)*	***Downy Mildew*** *(Pseudoperonospora cubensis)*	***Virus***
House-type Structure	11.1	68.2	21.08
Open Field	23.8	96.6	48.59
Sweet Pepper	***Cercospora Leaf Spot*** *(Cercospora spp)*	***Bacterial Wilt*** *(Ralstonia solanacearum)*	***Virus***
House-type Structure	10.8	0.1	4.16
Open Field	21.9	33.1	7.06
Tomato	***Bacterial Wilt*** *(Ralstonia solanacearum)*		
House-type Structure	1.9		
Open Field	30.6		
Squash	***Downy Mildew*** *(Pseudoperonospora cubensis)*		
House-type Structure	6.1		
Open Field	42.4		
Cucumber	***Downy Mildew*** *(Pseudoperonospora cubensis)*		
House-type Structure	20.0		
Open Field	100.0		
Lettuce	***Sclerotium wilt*** *(Sclerotium rolfsii)*		
Tunnel Plastic	0.6		
Tunnel Net	9.7		
Open field	15.3		

Potential of low tunnel structures

Low tunnels can be used for low-growing crops such as muskmelon, cabbage, lettuce and cauliflower where yield increases can be achieved especially when covered with fine netting (Figure 12). These structures have great potential because they are cheap to construct, can be removed during the dry season and, the net covering allows water to penetrate, reducing the need to irrigate. For the above mentioned crops, the plastic covering was no better than open field, and this may have been due to a temperature impact.

Temperatures were higher under the tunnel structure covered with plastic compared to net covered tunnels and the open field (Figure 7) and this appeared detrimental to the growth of lettuce which is a cool season crop. Air temperatures under plastic tunnels were about

2°C higher than under net and 5°C higher than the open field. This observation is similar to the one reported by Baudoin and Nisen (1990) that tunnels covered with plastic increased the air and soil temperature by 2-10 °C during daytime, much higher than the temperature under house-type structure (Figure 7). It is clear that the use of net covering has potential for growing vegetables since it is ventilated compared to the plastic roofing, hence the lower temperature. In times of heavy rain, the net also minimizes the impact of the rainwater as it reaches to the plant but at the same time allows adequate penetration of light rain into the structure.

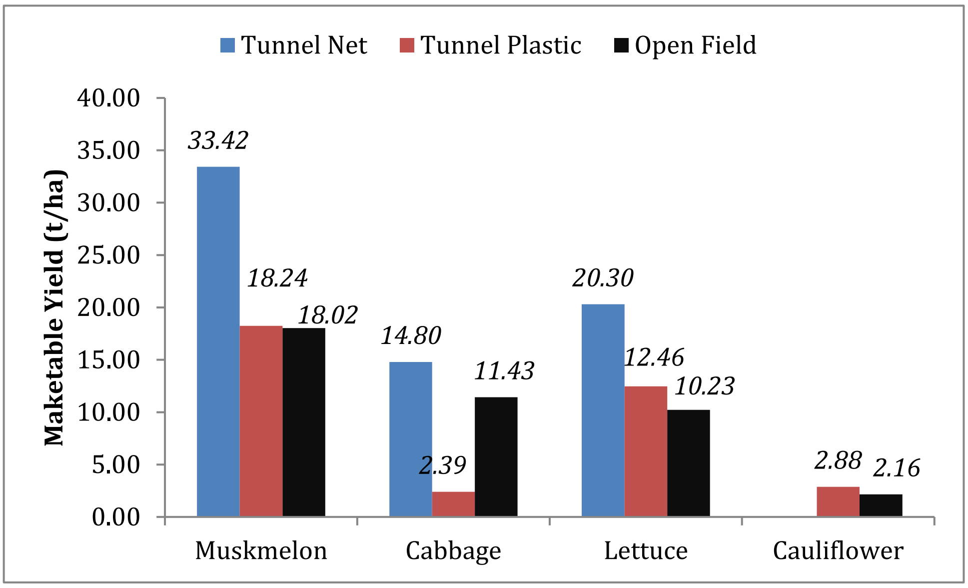

Figure 12. Yield data of muskmelon, cabbage, lettuce and cauliflower under low tunnels covered with plastic and net.

7.3 Socio economic results

Economic Data Collection and Other Farmer Feedback

To support the technical component of the project, initial establishment costs of the protective structures in all project sites including repairs and maintenance costs were monitored and recorded. Labour and material inputs incurred by each farmer co-operator related to their vegetable production with and without protective structure were also regularly monitored and recorded. Farm receipts and expenses were used to calculate gross margins for all farm sites.

Focus group discussions (FGDs) with representative farmers and field technicians were conducted in Ormoc and Maasin sites to solicit feedback on perceptions, experiences, as well as constraints to the adoption of protective structures and vegetable production technology which are introduced in farmers' fields.

Seasonal Price Trends

Market price data was collected throughout the life of the project from the Bureau of Agricultural Statistics (BAS). It was found that price increases during the wet season (mid-year around June/July) and end of year prices (around November to February) were routinely about 20% higher than in other months. There had been some suggestions that in more recent years, a breakdown in the traditional weather patterns was observed but this was not reflected in a comparison between the 2011 data (Menz and Armenia Working paper No.17, undated) and that for years preceding 2007, as shown in Menz and Armenia Working paper No. 2 (undated). A typical example of the more recent price data is shown below in Figure 13.

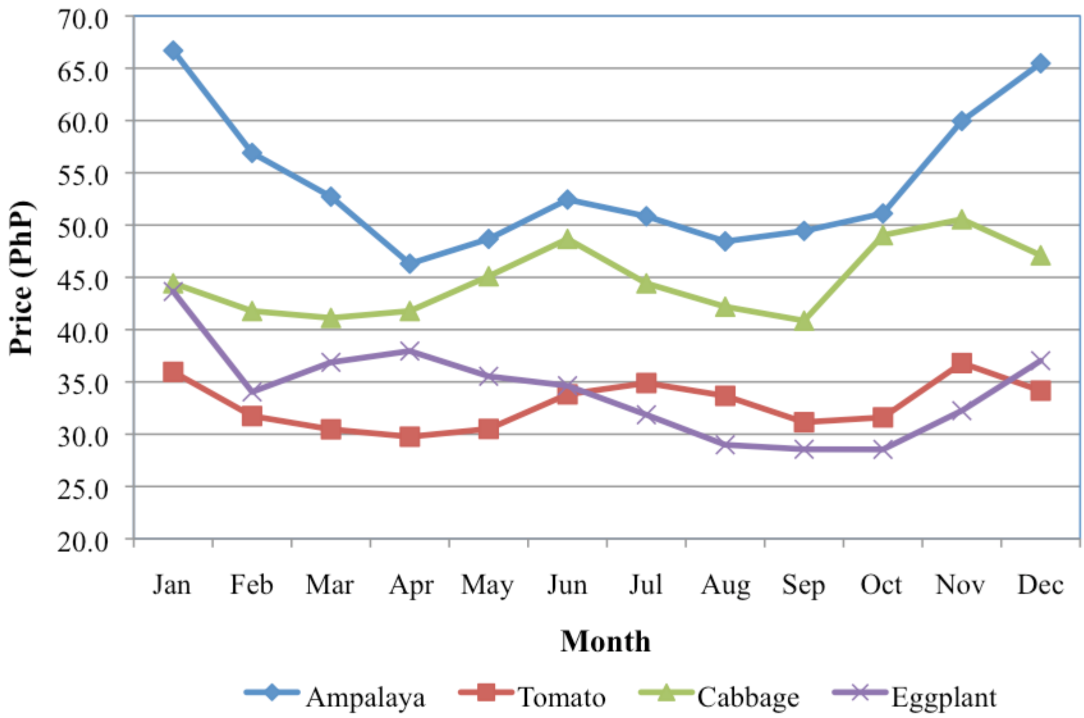

Figure 13 Monthly average price of major vegetables in Leyte 2007-2011

Structure Details and Costs

Costs of structures varied across structure type and farmer/research sites. Full details of these can be obtained from the project working papers however, to give a flavour of the costs, the initial (first year) set of cost data are presented in Table 9 below.

Initial establishment costs ranged from PhP14,000 (igloo) to a maximum of PhP43,000 (coco lumber houses) at the VSU experimental site, with the two initial farmers' sites costing P36,000 and P22,000, in Ormoc and Maasin, respectively (Table 9). The bamboo structures in famers' fields were generally less expensive than 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 square meters, while the igloo type had an area available for crops of 48 square meters.

Subsequent to the first year, many additional structures were built within and beyond the auspices of the project, with the average cost of farmer–built structures costing around PhP30,000 to cover 200 sq metres. The cost components of the fairly typical bamboo structure at Maasin, Southern Leyte are shown in Table 10.

Table 9. Summary of initial costs incurred for establishing protective structures at the VSU site and farmers' fields

TYPE OF STRUCTURE	COSTS INCURRED IN PESOS		
	Materials	Labour	Total
VSU:			
Coco Lumber ($200m^2$) ($200m^2$)	34,081	8,311	42,392
Bamboo ($200m^2$)	14,931	13,719	28,650
Igloo Net (48 m^2)	12,912	773	13,685
Farmers' Field:			
Bamboo (Ormoc) ($200m^2$)	25,573	10,313	35,886
Bamboo (Maasin) ($200m^2$)	11,285	10,442	21,727

Economic Analysis

A summary of the average receipts, expenses, and gross margins for three years with and without protective structure for the four most commonly preferred crops (tomato, sweet pepper, ampalaya and watermelon) grown by farmers is presented in Table 11. Gross margins were calculated for the test crops both within and outside the structures. The highest receipts per crop grown under structure over the project and gross margin were from sweet pepper. The table indicates the potential for quite significant gains (beyond what have been recorded to date) with an appropriate choice of crop and management skill. It can be seen in the table that watermelon did not gain any advantage from being grown under the structure and therefore, it is not an appropriate crop choice, yet it was tried by some farmer 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 PhP79/m^2 for sweet pepper followed by tomato at PhP30/m^2 and ampalaya at PhP23/m^2.

Table 10. Cost components (synthesised from various actual examples) of bamboo house structure

Qty	Unit	Item Description	Unit Cost (PhP)	Amount (PhP)
Materials:				
34	pcs	Bamboo posts (Gu-od)	39	1,326
86	pcs	Bamboo poles (Kayali) regular	30	2,580
34	pcs	Bamboo poles (Kayali) small	15	510
5	bundles	Rattan ties	120	600
3	bundles	Rattan ties	150	450
2.5	kgs	C.W. Nails 4"	96	240
1.5	kgs	C.W. Nails 4"	93	140
2	kgs	C.W. Nails 2 $^{1}/_{2}$"	102	204
1.5	kgs	C.W. Nails 1 $^{1}/_{2}$"	102	153
0.75	kgs	C.W. Nails 1 $^{1}/_{2}$"	90	675
1.5	kgs	C.W. Nails 1"	90	135
5..89	pcs	Used tires	30	177
105	meters	PE UV film 110"x0.005"x150m	100	10,500
		Sub-total		**17,690**
Labour:				
41.63	man-day	Construction of structure	250	10,407
9.38	man-day	Installation of UV plastic film	250	2,345
		Transportation cost for PE UV film		239
		Sub-total		**12,752**
		TOTAL COSTS (materials + labour)		**30,681**

Table 11. Average receipts, expenses, and gross margins (three years) per cropping in PhP/m^2 for four most preferred crops (ampalaya, tomato, sweet pepper, and watermelon)

Structure	Number of comparisons	Receipts (PhP/m^2)	Expenses (PhP/m^2)	Gross Margins (PhP/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 11 referred to four specific (most popular) crops grown by farmers. Now look at the results for the actual crop mix grown by farmers (not just the four 'most popular') in Table 12. This table indicates that over the three year period, the average gross margin for crops grown under protective structure was PhP112/m^2, approximately double the gross margin for crops grown outside the structure.

Table 12. Annual receipts, expenses, and gross margins with and without structure (PhP/m^2)

Item	Receipts (PhP/m^2)	Expenses (PhP/m^2)	Gross Margins (PhP/m^2)
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 each year was not the same. More farmer co-operators entered the project over time, therefore the mean of all observations does not equal the average of year 1,2,3.

Financial Viability of Protective Cropping

Table 13 shows the five-year cash flow based upon average performance of co-operators (3 years actual and 2 years projected). With a discount rate at 20%, the results indicated that it is financially viable to grow vegetable under protected cropping given the structure design and costs. The average net present value from investment in structures is approximately PhP30,000, with an internal rate of return of approximately 100%. If we examine the results of the top three co-operators, 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 co-operator (112 pesos per sq m as compared to the 55 pesos per sq m) as shown above in Table 12.

Table 13. Projected cash flow and investment returns from vegetable protected cropping, 200 m^2 structure in Pesos

Item	Year				
	1	2	3	4	5
Cash Inflows:					
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**
NPV (@ r=20%)	29,824.91				
IRR	103%				

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

Regression Analysis on Factors Affecting Productivity

The data in Table 12 are actual figures from the farmer co-operators. Table 13 are actual figures for three years (i.e., up to April 2012) and the projections for the remaining two years coincide with a total expected structure life of five 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 model diagnostic tests (Table 14). This approach also allows a more refined estimate on the contribution of the protective structures *per se.*

Results of the model indicated that for the intercept shifter variables, the dummy for protective structure and sweet pepper crop planted by farmers were positive and considered statistically significant factors that affect productivity among farmers (Table 14). The management skills variable has also 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 second most preferred crop by farmers, was positive but not statistically significant. The other relevant variables such as fertilizer and pesticides costs had positive coefficients and likewise 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 with figures shown in Table 12 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 sweet pepper and ampalaya crop can be interpreted in a similar manner.

The interpretation of the coefficients of non-logarithmic management skills variable (0.010) would be 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 the average, reduce vegetable revenue by 1.8%. Fertiliser and pesticide expenditure increases of 10% would increase revenue by 3.2% and 1.9%, respectively.

Table 14. Multiple regression on factors affecting productivity (PhP/m^2) on vegetable protected cropping systems 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 Ave. Daily rainfall (mm/day)	-0.184*	-1.85
Log of Fertilizer Cost (P/m^2)	0.321***	4.11
Log of Pesticides Cost (P/$m^{2)}$	0.194***	3.27
No of observations=107		
R-squared=0.50, Adj-R-Squared=0.46		

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

Factors Affecting Gross Margin

A multiple regression model was estimated to determine what factors contributed to the gross margins/profitability among farmer co-operators (Table 8). As a preliminary step, the model was subjected to the necessary regression diagnostic tests such as multicollinearity, heteroskedasticity, and other relevant tests using the Stata Statistical Package. The diagnostic tests show that the model as defined was found to be acceptable.

Results of the model indicate that for the intercept shifter variables, the dummy for protective structure and sweet pepper crop planted by the farmer were positive and considered statistically significant factors that affect gross margin among farmers. Although with positive coefficients, the dummy for tomato and ampalaya, two of the most preferred crops among farmers, were not statistically significant. The management skills variable has also a positive coefficient and is statistically significant. As expected rainfall and pest incidence variables had negative coefficients and were statistically significant. The other variables such as education, fertilizer and pesticides costs were not significant.

The above results imply that, on the average:

1. Farmers are getting 51% higher gross margins for producing vegetables under protective structures compared with those without the structures;

2. Farmers are getting 124% higher gross margins for growing sweet pepper under protected cropping compared to the open field;
3. A 1% increase in management skills would increase gross margin per sq m by about 1.7%;
4. A 1% increase in pest rating would reduce gross profit margins by 2.8%; and
5. A 10% increase in average daily rainfall would bring about a 3 % reduction in gross margins (open field).

7.4 Australian component

The program undertaken with the Australian industry involved evaluation of low technology systems in terms of low-cost protected cropping options for Australian vegetable growers. The Australian industry provides a glimpse of potential development stagnation of which the protected cropping industry in the Philippines needs to be aware.

In Australia, many growers have invested in low technology structures (tunnel houses) which underperform. With low margins, growers have become constrained and find it difficult to progress. This project component started the assessment of the cost-benefit of basic modifications to existing low cost greenhouses used commercially in Australia.

A significant problem encountered with low technology protective cropping structures is that while specific benefits in environmental management or mitigation are attained, the gains are generally achieved by way of a trade-off of other important considerations for a healthy and productive, sustainable cropping system. A major problem with tunnel houses is excessive temperatures building up within the structures in the warm seasons. At best, these structures have roll-up ends and the plastic sheets can be pulled apart at the top to provide a series of small roof gap vents.

Photo 14. A typical tunnel house

7.4.1 Tunnel house retrofit

The aim of this project was to determine whether some small cost effective retrofit options could be applied to low technology structures. Two aspects were investigated. The first was to improve venting capacity to better manage high temperature extremes. The second aspect was, while mitigating for temperature, add insect screening to improve preventative pest and disease management and thereby enable chemical use to be reduced and facilitate progress towards a more integrated pest management strategy.

Data monitoring was installed into 3 identical tunnel houses (igloo greenhouses) in the Sydney basin. Two of the three structures – Tunnel 2 and 3 – were modified. The first modification is the fitting of screened end walls. These are designed as double sliding doors which are insect screened. Both of these structures were also fitted with an exhaust fan.

7.4.2 Key Findings

The main impact of the intervention on maximum temperatures inside structures is shown in Figure 14. A detailed explanation of the results of this aspect of the project is available in the full report of the Australian subcomponent[1].

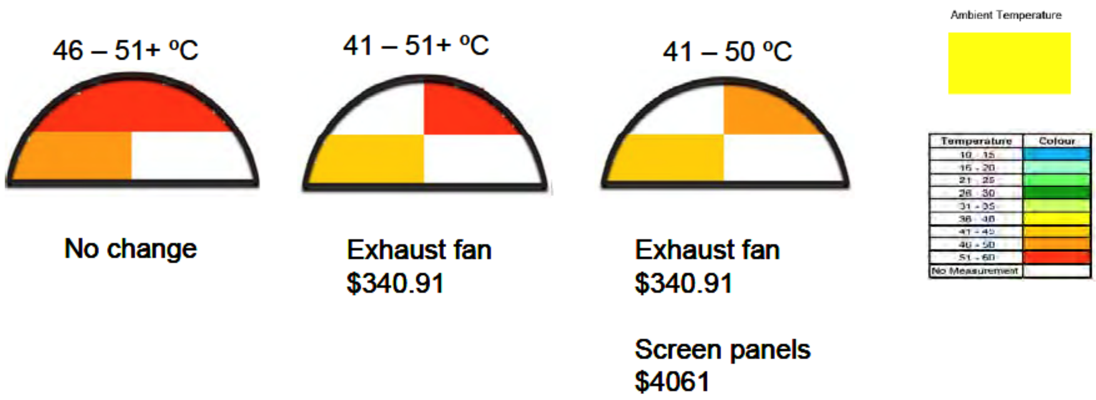

Figure 14 Summary of impacts of the interventions on the temperature distribution inside the structures and the average cost of each modification.

Roof gap vents

Roof gap vents are a low cost feature of many tunnel house structures but a significant number of structures are not set up with this type of venting. At a minimum, these vents are recommended for all tunnel structures. The use of roof gap vents can enable the insect screening of end walls with no significant decline from current conditions within the structures. This could improve pest and disease management.

Exhaust fans

The installation of a single exhaust fan provides several degrees of cooling in a common tunnel house and the pay back period for this retrofit is less than a year, including operating costs. Not all tunnel structures have electricity available which creates a barrier to their potential uptake, though even the supply of electricity to all but the most remote of structures would generate a net benefit to growers.

It is recommended that tunnel houses be retrofitted with exhaust fans. Although the demonstration trial used a single exhaust fan, higher temperatures evident towards the middle of the structures suggests that an exhaust fan at each end of the tunnel house could substantially improve crop health and productivity and provide net economic benefit in little more than a year.

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[1] *Development of a cost-effective protected vegetable cropping system in the Philippines. Protected cropping project (Australian subcomponent) Final Report, May 2012. Jeremy Badgery-Parker and Josh Jarvis.*

Insect screened side vents

The retrofitting of side vents (unscreened) in tunnel structures has previously been regarded as uneconomical in this industry. Screening of these vents would further increase costs and reduce airflow. This strongly held position in this industry is despite there being no trials or data available.

Through this project, retrofitting and screening of these vents has been shown to significantly reduce internal temperatures. This simple trial found that the benefit resulting from reduced temperatures within the structures through increased ventilation could be paid for within two years. When average industry production values are used in the economic analysis, screened side vents would provide a net return within a year. It is recommended that where an existing tunnel house is to be used for more than another two years, the retrofitting of insect screened side vents be undertaken.

8 Impacts

8.1 Scientific impacts – now and in 5 years

There is potential impact associated with development, construction and testing of highly innovative and inexpensive modular structures in the Visayas with adaptations for redirecting rainfall for irrigating crops. These are likely to have potential for adoption in other parts of the Philippines and in Australia. Impacts include:

- A new modular greenhouse design that can be extended as required.
- A new curved roof low-cost greenhouse design that resists the impact of strong winds and will last for 5 years in the Visayas.

8.2 Capacity impacts – now and in 5 years

Proliferation of protected cropping structures: There has been a proliferation of structures inspired by the current ACIAR project. Funds have been provided by contributions from Local Government Units (LGUs), Energy Development Corporation (EDC), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Catholic Diocese in Ormoc and importantly, by farmers themselves.

John Allwright Fellows

1. Jonathan Mangmang (C2 research assistant) started a JAF in June 2011 and is studying for his PhD at the University of Sydney under the supervision of Gordon Rogers
2. Elsie Tausa (C2 research assistant) was awarded a JAF in 2011 to study for a research Masters in Economics at the University of Sydney starting in June 2012

John Dillon Fellows

1. Dr Zenaida Gonzaga (VSU project leader) was awarded a John Dillon Fellowship in 2011
2. Dr Roberto Acosta (East West Seeds and project team member) was awarded at John Dillon Fellowship in 2011.
3. Reny Gerona (VSU leader of entomology) was awarded a John Dillon Fellowship in 2013.

- 131 farmers participated in training, visits/study tours.
- 34 VSU faculty and staff were trained and /or involved in study tours and cross visits both in the Philippines and in Australia.
  Six graduate and undergraduate students were supported to conduct their thesis research.
- Four farmers were given awards by VSU while 48 farmers were given scholarships for study tours.
- 3,000 farmers, 1,500 students and 300 LGU staff have visited the VSU trial sites
- At the 2011 VSU Anniversary, 1,000 farmers visited the PC display

Funding source	Number of structures
Project funds + LUGs	34
GIZ project	48
Energy Development Corporation (ECDC)	5
Catholic Diocese (Ormoc)	25
Farmer funded	7
Bohol and Mindanao	2
Ormoc LGU	8
EDC, DA, VSU, NABCOR	40
Total	**169**

Adoption by farmers

In Bontoc, Boie Gerona has built a new fully enclosed structure which is a product of the collaboration between the farmer and project staff. This is a significant innovation that can be attributed to the project, and a further indication of the project's success.

Importantly, the construction of new structures is now being undertaken by farmers themselves without financial support from the project or from LGUs. This is an indication that true adoption is taking place, and is occurring in Kananga, near Ormoc, Leyte where three house type structures have been built and are being used to grow ampalaya.

Another farmer-adopter at Concepcion, Ormoc City initially converted his two poultry houses into protective vegetable cropping structures and is successfully growing vegetable crops in them. At present, he stopped growing broilers and converted all his poultry houses into protected structures for his year-round vegetable production. There is also an ongoing construction of one house type structure in Cambantog, Ormoc site.

The project capacity outputs are summarized in the following table.

Component Impacts – Estimates of capability and capacity building per component

Component: ***Protected Cropping (C2)*** Component: Leader: ***Gordon Rogers***

Number of farmers trained (attending workshops/field days/and other events)	Number of students trained (under- and postgraduate)	Number of faculty members trained (specific component related study tour/training workshop etc)	Number of Scholarships received	Number of study tours (tour name and number of participants)	Number of farmers and students visiting trial sites	Other capability and capacity building impacts	Estimate of the number of adopters of new strategies
Farmer Field School (Maasin); 30 farmers trained 2010). ***Workshops***: 15 farmers trained in structure workshop October 2011. **Field Day** 50 farmers attended field day in Maasin city, march 2010 . ***Cross visits***: 12 farmers and LGU staff from Bohol visited Leyte (August, 2010). 15 farmers from Leyte visited ACIAR soil erosion project Bohol (October, 2010).	2 PhD and 2 MSc (research), 1 Honours & 1 high school ***Jonathan Mangmang*** (C2 research assistant) started a JAF in June 2011 and is studying for his PhD at the University of Sydney under the supervision of Gordon Rogers. ***Elsie Tausa*** (C2 research assistant) was awarded a JAF in 2011 to study for a research Masters in Economics at the University of Sydney starting in June 2012. ***C. Limbaga.*** PhD Horticultural and Physiological Responses of Lettuce (Lactuca sativa L.) with Phycocolloid as Foliar	***Workshops*** 10 VSU staff – in 2 Structure design workshops (2010 and 2011). ***Farmer Field School*** (Maasin); 5 VSU staff trained in 2010). ***Cross visits***: 8 VSU staff and 2 LGU staff visited ACIAR soil erosion project Bohol (October, 2010). 7 VSU staff visited vegetable growing areas in Cagayan de Oro in June 2010. Dr Gonzaga and Dr Acosta visited Australia as part of JD Fellowship in 2011.	***Othello. Capuno*** - Exchange Experts/Mission" Technologies in Small and Medium Scale Vegetable Production in South Korea" on .August 29-September 7, 2011. ***Amelito Aragon***. 2011 Outstanding vegetable farmer. P10,000 from East West Seed Company and P10,000 from Ormoc LGU. ***Noel Morales***. 2010 Outstanding vegetable farmer, With cash prize worth P10,000 from VSU and P10,000 from Ormoc LGU. ***Lucio Gerona***. 2010 Outstanding vegetable farmer finalist with a cash prize worth	***2 John Dillon Fellowships:*** ***Dr Zenaida Gonzaga*** (VSU project leader) 2010. ***Dr Roberto Acosta*** (East West Seeds and project team member) 2010. ***Cross visits***: 12 farmers and LGU staff from Bohol visited Leyte (August, 2010). 15 farmers from Leyte visited ACIAR soil erosion project Bohol (October, 2010). 9 farmers from Cotabato Landcare project visited Leyte April, 2011.	***VSU Trial sites***: The trial sites at VSU are very popular; virtually all VSU visitors also visit the structures. Estimated number over the project = 3080 farmers, 1550 students and 320 LGU staff. ***Farmer sites***: There are 15 farmer cooperators, and many farmers visit. If each sites attracts 15 visitors = 150 farmers.	***Protected Cropping Video***: 1700 views on YouTube and 500 DVD copies. ***Protected cropping website***: about 10,700 visits to date. ***VSU Open days***: 2175 Farmers being exposed to PC and vegetable issues at the 2010 VSU Anniversary. 1000 farmers visit the PC display at the 2011 VSU open day. ***Public Private Partnership group***: A working group has been formed between VSU, East West Seeds, the Energy Development Corporation (EDC, Massin City and Ormoc City. EDC structure project and	***Total structures=143*** ***Total farmers=372*** ***Farmer funded adoption = 21 structures***: 7 new structures (Ormoc, poultry farmer) 3 new structures for Ampalaya (Kananga, Ormoc) 3 new farmer designed structures (Bontoc, Maasin, Ormoc) 8 low tunnel types built by farmers. **GIZ Project**: 48 new structures now built involving 240 farmers (5 per structure) under an "Enhancement of

9 farmers from Cotabato Landcare project visited Leyte April, 2011. 10 Leyte Protected vegetable cropping farmers visited vegetable growing areas in Cagayan de Oro in June 2010. 16 AT's & 64 farmers for 8 municipalities visited protected vegetables site in Bontoc on March 22, 2012 **Training** Conducted training (March 20-21, 2012) on "Enhancement of farmers capability in protected vegetable production" – 16 AT's & 64 farmers were trained	Supplementation Grown Under Protected and Conventional Cultivation Systems (2011). ***H.C. Dimabuyu***. (4th year honours) Growth and Yield Of Pruned Ampalaya (Momordica charantia L.) Grown Under Protective Structure and in the Open Field. (2011). ***N.M. Sta. Iglesia***. MS. Post harvest Behaviour Of Tomato (Lycopersicon esculentum) as Influenced By Cultivation Systems And Modified Atmosphere Packaging- will be completed March 2012. **C. Villamor** won 1st place in VSU Science fair held on September 2012 with her study "The Morphometrics Of Zucchini *(Cucurbita pepo L.)* Grown Under Tunnel-Type Structure And Open Field"		P5,000 from VSU.	10 Leyte Protected vegetable cropping farmers visited vegetable growing areas in Cagayan de Oro in June 2010. 16 AT's & 64 farmers for 8 municipalities visited protected vegetables site in Bontoc on March 22, 2012 Dr. Gonzaga visited Cambodia on Feb 28-29, 2012 and talked about results of protected vegetable cropping in their vegetable forum		FFS in Maasin are the result. ***Working Papers***: 19 papers published on the website. ***Book chapter***: 1 book chapter on plant protection including PC written by team member at VSU.	Food Security in the Visayas" (EFOS) project with funding from the European Union (GIZ) with supporting funds from eight LGUs. ***EDC***: Energy development corporation funding 15 new structures in Ormoc region. Each involves 2-3 farmers (40 farmers in all). ***Catholic Diocese***: 25 medium tech. structures built in Ormoc, with 3 farmers per structure. ***ACIAR Project***: Project built 34 structures with co-funding from LGUs involving 15 farmer cooperators.

8.3 Community impacts – now and in 5 years

There has been strong support for the project from Ormoc and Maasin City administrations with associated counterpart financial support for the project. In early 2012, other LGUs on their own initiative and funding (e.g., Palo, Leyte and Javier, Leyte) sought technical assistance from the project concerning construction and related assistance on their LGU-initiated production of vegetables under protective structures.

A group of vegetable farmers and growers from Region 8 (Leyte, Southern Leyte, Samar, Biliran) and even from other regions in Philippines visited the vegetable cropping under protective structure at VSU. Other officials and institution in the region (e.g., RDCC and DA) now include plans to adopt the project scheme of growing vegetables in protective structures since it is suitable in many areas of the region with more rains all year round.

Bohol farmers visited Leyte and Southern, Leyte on August 9-11, 2010 and were exposed to different project sites in VSU, Ormoc, Bontoc, and Maasin. They were impressed with the productivity of the vegetable crops grown under structures but their main concern was the cost of the structures since they cannot afford to build one by themselves.

Likewise, all farmer-collaborators from Leyte and Southern Leyte adopted protected cropping through a cross visit in Bohol on October 27-30, 2010. Different sites were visited including the high strength protective structures of Harbest Corporation. They were also trained on their instruments used in gathering weather data, soil erosion, as well as visiting selected vegetable farms.

The other key linkage established is with the EDC which shared the goals of the project. These linkages have been further strengthened and implemented during year 3 and resulted in the development of a new project between Ormoc city LGU, VSU and EDC.

Training Activities

- 9 farmers from Cotabato Landcare project visited Leyte April, 2011.
- 16 agricultural technicians and 64 farmers for 8 municipalities visited protected vegetables site in Bontoc on March 22, 2012.
- Conducted training (March 20-21, 2012) on “Enhancement of farmers capability in protected vegetable production” – 16 agricultural technicians and 64 farmers were trained.
- ***Workshops***: 15 farmers trained in structure workshop October 2011.
- Dr Gonzaga and Dr Acosta visited Australia as part of JD Fellowship in 2011.
- Mrs Reny Gerona was awarded a John Dillon fellowship in 2013 and visited Australia.

  VSU Trial sites**:** The trial sites at VSU are very popular; virtually all VSU visitors also visit the structures. Estimated number over the project = 3080 farmers, 1550 students and 320 LGU staff.

8.3.1 Economic impacts

The project has proven that protected cropping can he highly profitable but there is a requirement for a higher level of management than that generally existing in the farming community at present.

Protected structures appear to be technically feasible and financially viable based on gross margins, gross margin ratio, and return on investment analyses. Yield and gross margin data have been collected in over 34 sites, with 84 comparisons possible to date. The data indicate that there is yield and financial impact for both house and tunnel-type protected structures. The average gross margin ratio between house-type structures and the open field shows that profitability of producing vegetables in protected structure is high. Farmers are getting *51% more gross margin* per m^2 for producing vegetables under protective structures ($P<0.05$); *124% higher gross margin* for growing sweet pepper *($P<0.01$).* Each 1% increase in management skill increases gross profit margin per m^2 by 1.7% *($P<0.05$)* and each 1% increase in pest incidence reduces gross profit margins by 2.8% *($P<0.001$).*

8.3.2 Social impacts

There is evidence of real adoption of protected cropping by farmers in Leyte. Poultry grower Jun Mindosa has converted 7 sheds to protected cropping at his own expense, a farmer in Ormoc has built 3 sheds for ampalaya, Boie Gerona at Bontoc has built two new structures at his own expense, Joseph Sanchez has built a new house from his profits, Amie Aragon paid off debts and paid for his daughters' college education.

There is now a new large EDC / VSU project focussed on protected cropping which is building and supporting many new structures in Leyte.

The project has strengthened the capability of the farmer co-operators in managing their farms including record keeping, pest and disease management, and marketing. Since the first cropping, they have kept records of inputs, crop performance, production, temperature, and other necessary parameters. They also learned how to manage pest and disease infestation through reducing the use of chemicals. The farmer co-operators also learned to employ different marketing strategies for their vegetables. One noteworthy tactic of a successful farmer co-operator was visiting schools and giving short lectures to students on the importance of vegetables which was followed with the selling of lettuce. This same farmer co-operator packed vegetables in small quantities to make them affordable to the consumers.

Through the project, the farmer co-operators have gained confidence in teaching other farmers. They were given the opportunity to share their experiences to other farmers through cross farm visits and workshops. Apparently, this has increased their self esteem especially when their work was appreciated by other farmers. One farmer co-operator attributed to the project to his being recognized as an outstanding and progressive farmer in the community and by the Department of Agriculture. For this, he was elected president of the vegetable growers association.

Another impact of the project is the increased purchasing power of the farmer co-operators. One farmer co-operator built a house while another was able to install water system in his farm. Moreover, from his vegetable farm income in the first cropping, one farmer co-operator constructed another protective structure and requested for partial assistance only. One couple also revealed that they were able to pay their long-time debt which they could not achieve without the project because they had not ever tried holding a relatively large sum of money earned in one cropping. Meanwhile, the wife of one progressive farmer was diagnosed with cancer, and the farmer was use his increased farm income to cover part of the cost of his wife's medication.

8.3.3 Environmental impact

No environmental impacts

8.4 Communication and dissemination activities

Website: A project website has been developed www.protectedcropping.com. It is intended as a showcase for the project and as a platform for project team members to exchange files and information, with a section for general public. The website has had 3927 visits over the past 12 months, and over 10,000 for the whole project.

Video: A highly successful video was produced as part of the project. It is mainly in the local Filipino language spoken in Mindanao and The Visayas (Cebuano) with English subtitles, and runs for 9 minutes. The video on protected cropping has had 13,859 views (May 2013 on YouTube and 600 DVD copies were distributed. The video can be viewed at http://www.youtube.com/watch?v=jFI_94S4OIs

ACIAR Vegetable Component 2: Accomplishments/achievements

Workshop

Improvement of Protective Structure Design participated in by farmer cooperators, LGU representative and VSU project staff on Feb. 15, 2011.

Farmers Field Day

The project in coordination with the Office of the City Agricultural Services (OCAS) conducted a farmer's field day at Libhu, Maasin City, Southern Leyte on March 20, 2010

Farmers Field School

The Local Government Unit of Maasin, East-West Seed Company, ACIAR and VSU conducted the Farmers' Field School on Season-Long Training on Improved Technologies on Vegetable Production in Brgy. Libhu, Maasin City on October 1, 2010 to April 7, 2011

Awards received from Poster/paper presentations:

Gonzaga ZC, OB Capuno, PT Armenia, RG Gerona, Mbloreto, LB Nunez, LM Borines, AB Tulin, JS Mangmang, ER Tauza, DC Lusanta, HB Dimabuyu, LP Vega, KM Menz, And GS Rogers. (2012). "Development Of A Cost-Effective Protected Vegetable Cropping System In The Philippines. **Outstanding Development Project**". Paper presented during the 24th Joint ViCARP and RRDEN Regional Research, Development and Extension symposium on November 21-23, 2012.

Gonzaga ZC, OB Capuno, PT Armenia, RG Gerona, MBLoreto, LB Nunez, LM Borines, AB Tulin, JS Mangmang, ER Tauza, DC Lusanta, HB Dimabuyu, LP Vega, KM Menz, And GS Rogers. 2012. "Development Of A Cost-Effective Protected Vegetable Cropping System In The Philippines". **Best Paper** during the 24th Joint ViCARP and RRDEN Regional Research, Development and Extension symposium on November 21-23, 2012.

Abrantes OF, DC Lusanta, HB Dimabuyu and Gonzaga ZC. 2012 Kamlong: An Effective strategy for the Control of Bacterial Wilt (*Ralstonia solanacearum)* in Tomato (*Lycopersicon esculentum* Mill). **Best Poster.** Paper presented during the Phytopathological Society, Inc.-Visayas Division Meeting and Regional Scientific

Conference on October 25-26, 2012 at the Center for Continuing Education, Visayas State University, Visca, Baybay City, 6521-A Leyte

Gonzaga ZC, OB Capuno, PT Armenia, MB Loreto, RG Gerona, LB Nunez, LM Borines, AB Tulin, JS Mangmang, ER Tauza, DC Lusanta, HB Dimabuyu, LP Vega, KM Menz, And GS Rogers. 2012. Low-Cost Protected Cultivation: Enhancing Year-Round Production Of High Value Vegetables In Eastern Visayas, Philippines. **Qualifier for the AFMA R&D BEST PAPER AWARD.** Awarded during the 24th National Research Symposium, RDMIC Building, Diliman, Quezon City on October 17-18, 2012)

Gonzaga ZC, OB Capuno, PT Armenia, MBLoreto, RG Gerona, LM Borines, LB Nunez, LP Vega, AB Tulin, JS Mangmang, ER Tauza, DC Lusanta, HB Dimabuyu, KM Menz, and GS Rogers. 2012. PROTECTED VEGETABLE CROPPING: HEAVEAN SENT. **1st Place- Best Poster Paper** Presented during the ACIAR-PCAARRD End-Programs in the Southern Philippines on July 2-3, 2012 at the Cebu Parklane International Hotel, Cebu City, Philippines

Gonzaga ZC, OB Capuno, PT Armenia, RG Gerona, Mbloreto, LB Nunez, LM Borines, AB Tulin, JS Mangmang, ER Tauza, DC Lusanta, HB Dimabuyu, LP Vega, KM Menz, and GS Rogers. 2012. “Development of a Cost-Effective Protected Vegetable Cropping System in the Philippines”. **Outstanding Paper - Development Category.** Paper presented during the Level 2 Research and Development/Extension (RDE) Review – Cluster 4 on June 21-22, 2012 at the OVPRE, Visayas State University, Visca, Baybay City, Leyte.

Villamor, C.S., Z.C. Gonzaga and D.C. Lusanta. The morphometrics of Zucchini (*Cucurbita pepo* L.) grown under low-tunnel type structure and open field. VSU Laboratory High School local science fair (Life Science Category) on September 12, 2011 at the Convention Center, VSU, Visca, Baybay City, Leyte. **First Place Best Paper**

Limbaga, C.A and Z.C. Gonzaga. Seaweed Foliar Fertilizer for Lettuce (*Lactuca sativa* L.) under Protected and Conventional Cultivation System. Asian for academic journals and higher education research at Pryce plaza, Cagayan De Oro City on August 17-20, 2011. **First Place Best Paper**

Capuno OB, ZC Gonzaga, PT Armenia, MBLoreto, RG Gerona, LB Nuñez, AB Tulin, LM Borines, JS Mangmang, ER Tausa, DC Lusanta, LP Vega, KM Menz and GS Rogers. Enhancing Productivity and Profitability of Sweet Pepper (*Capsicum anuum* L.) Using Low-Cost Protected Cropping Technology in Pamahawan, Bontoc, Southern Leyte” during 23rd Regional Research and Development/Extension Symposium on held in Biliran, Leyte on August 3-4, 2011. **Fourth Place Best R&D Poster**

Capuno OB, ZC Gonzaga, PT Armenia, RG Gerona, MB Loreto, LB Nuñez, AB Tulin, LM Borines, JS Mangmang, ER Tausa, DC Lusanta, LB Vega, K Menz and GS Rogers. LOW-COST PROTECTED CULTIVATION: *An Approach of Enhancing Year-Round Production of High Value Vegetables under Leyte and Southern Leyte Conditions* during the Annual Meeting of ACIAR-PCARRD Fruits and Vegetables Programs held on 20-21, July 2011 at Tagbilaran City, Bohol. **First Runner –up Research Poster Competition**

Limbaga, C. A and Z.C. Gonzaga. Horticultural and Physiological Reponses of Lettuce (*Lactuca sativa* L.) with Phycocolloid Foliar Supplementation Grown under

Protected and Conventional Cultivation System. Research review on July 12, 2011 at SPAMAST-CAS, Matti, Digos City, Davao. **First Place Best Paper**

Capuno OB, ZC Gonzaga, PT Armenia, MBLoreto, RG Gerona, LB Nuñez, AB Tulin, LM Borines, JS Mangmang, ER Tausa, DC Lusanta, LP Vega, KM Menz and GS Rogers. Off-season Production of Tomato (*Lycopersicon esculentum* Mill.) under Protective Structure in Cabintan, Ormoc City" during 22nd Regional Research and Development/Extension Symposium on August 18-19, 2010 at the Convention Center, Visayas State University, Baybay Leyte. **Fourth Place Best R&D Poster**

Capuno OB, ZC Gonzaga, PT Armenia, MBLoreto, RG Gerona, LB Nuñez, AB Tulin, JS Mangmang, ER Tausa, LP Vega, KM Menz and GS Rogers. "The Potential of Protected Vegetable Cropping Systems in Leyte" during 21st Regional Research and Development/Extension Symposium on July 7-8, 2009 at the RELC, DepEd Regional Office No. 8, Candahug Palo, Leyte. **Third Place Best R&D Poster**

Awards/Grants Received by Project Staff

Othello B. Capuno - Exchange Experts/Mission"Technologies in Small and Medium Scale Vegetable Production in South Korea" on August 29-September 7, 2011.

Zenaida C. Gonzaga - John Dillon Memorial Fellowship Award – Advanced Training in Agricultural Research Management from February 15 until March 26, 2011, Australia.

Robert Acosta - John Dillon Memorial Fellowship Award – Advanced Training in Agricultural Research Management from February 15 until March 26, 2011, Australia.

Reny Gerona - John Dillon Memorial Fellowship Award – Advanced Training in Agricultural Research Management from February 15 until March 26, 2011, Australia.

Jonathan S. Mangmang - John Allwright Fellowship for his doctoral degree at the University of Sydney, Australia from June 2011 to June 2014

Elsie R. Tausa - John Allwright Fellowship for her Masteral degree at the University of Sydney, Australia from June 2012 to June 2014

Awards/Grants Received by Farmer Cooperators

Amelito Aragon. 2011 Outstanding vegetable farmer. With cash prize worth P10,000.00 from East West Seed Company and P10,000.00 from Ormoc Local Government Unit .

Noel Morales . 2010 Outstanding vegetable farmer, With cash prize worth P10,000.00 from ACIAR and P10,000.00 from Ormoc Local Government Unit.

Lucio 'Boie" Gerona. 2010 . Outstanding vegetable farmer finalist with a cash prize worth P5,000.00 from ACIAR.

Leaflet

Protected vegetable cropping

Farmers Cross visits

Cotabato Landcare vegetable farmers visit to Leyte Protected vegetable cropping sites on April 12 – April 13, 2011

Leyte Protected vegetable cropping farmers visit to Vegetable growing areas in Bohol on Oct. 27 – 30, 2010

Bohol vegetable farmers visit to Leyte Protected vegetable cropping sites on August 8-10, 2010

Leyte Protected vegetable cropping farmers visit to Vegetable growing areas in Cagayan de Oro on June 9-12, 2010

Presentations:

Armenia, P.T. "Philippines Protected Vegetable Cropping Project" during the annual meeting of the 'ACIAR-PCARRD Fruits and Vegetables Programs' held on 9-11 August 2010 at Sabin Hotel, Ormoc City, Leyte.

Capuno, O.B. "Philippines Protected Vegetable Cropping Project" during the annual meeting of the 'ACIAR-PCARRD Fruits and Vegetables Programs' held on 9-11 July 2009 at Sabin Hotel, Ormoc City, Leyte.

Capuno, O.B. "Philippines Protected Vegetable Cropping" during the kick off workshop on July 15-16, 2008 at Marco Polo Hotel, Davao City.

Gonzaga, Z.C. "Development of a Cost-Effective Protected Vegetable Cropping System in the Philippines' during the Inter-Agency Research and Development/Extension (RDE) Review – Cluster 4 on May 3-4, 2011 at the Visayas State University, Visca, Baybay City, Leyte .

Gonzaga, Z.C. "Development of a Cost-Effective Protected Vegetable Cropping System in the Philippines" during the Level 2 Research and Development/Extension (RDE) Review – Cluster 4 on June 7-8, 2010 at the Visayas State University, Visca, Baybay City, Leyte .

Gonzaga, Z.C. "Philippines Protected Vegetable Cropping Project" during the annual meeting of the 'ACIAR-PCARRD Fruits and Vegetables Programs' held on 20-22 July 2011 at Tagbilaran City, Bohol

Gonzaga, Z.C. "Protected Vegetable Cropping in Leyte" during the second UP Mindanao Farmers and Partners Learning Alliance on July 7-8, 2011 at Lorenzo Hall, UP Mindanao, Mintal, Davao City.

Gonzaga, Z.C. "Update of the Protected Vegetable Cropping Project" during the visit of the John Dillon Fellows on March 3, 2011 at the Division of Primary Industries, Industry & Investment, Gosford NSW, Australia.

Panelists during the Farmers' and Fisherfolks' Forum on August 10, 2010 in celebration of the 86th Founding Anniversary of the Visayas State University

- Zenaida C. Gonzaga - Horticulturist
- Lucia M. Borines - Plant Pathologist
- Reny G, Gerona – Entomologist
- Lucio 'Boie" Gerona - Farmer cooperator (experienced on protected vegetable cropping)
- Noel Morales - Farmer cooperator (experienced on protected vegetable cropping)
- Joseph Sanchez - Farmer cooperator (experienced on protected vegetable cropping).

Len Tesoriero also contributed to the discussions

Resource Person

Lucio Gerona , on the topic: Low-cost Protected structure for vegetable production during the Agro and Fisherfolks Field Day in celebration of the 50th founding anniversary of Southern Leyte held on July 1, 2010 in Maasin City Southern Leyte sponsored by the sponsored by the Provincial Agriculture Office of Southern Leyte

Lucio Gerona on Marketing Strategies on the topic: Marketing and Strategies on August 11, 2011 during the Farmers' Forum on the Farmers' and Fisherfolks Field Day at VSU, Visca, Baybay City, Leyte

9 Conclusions and recommendations

9.1 Conclusions

9.1.1 Agronomic aspects and structures

House-type structures made of bamboo are stronger than that of coco lumber and are more suited for taller crops such as tomatoes, sweet pepper, ampalaya and beans. Low tunnels have great potential for low growing crops such as lettuce, pechay and muskmelon especially when roofed with fine netting rather than plastic.

Generally, the crops grown under protective structures regardless of design and type of structures have higher yields compared to those grown in the open fields. Yields obtained, however, were found to be highly dependent on crop management, especially in relation to the choice of crop, irrigation management and pest control.

Protected cropping resulted in higher yields of vegetables in both wet and dry season. Disseminating this technology to other impoverished areas in Region VIII would help alleviate poverty and malnutrition, vegetables being a source of income and having a vital role in human nutrition and health promotion.

9.1.2 Economic aspects

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 only have potential 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 percent increase in net present value of the investment or PhP10,000 for a 200 sq m structure (given the NPV from structures at current levels of skill of around PhP30,000). 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 co-operators 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. The lesson here is that structures work best when managed by individual farmers rather that groups.

With the dearth of empirical knowledge on the technical as well as the economic feasibility of low-cost protected vegetable cropping systems in Leyte and Southern Leyte provinces and the Philippines in general, the findings of this study has contributed to the existing pool of scientific knowledge about protected vegetable cultivation under 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 develop related research policy actions and recommendations related to climate proofing strategies. Protected cropping is an important adaptation to climate change and should be viewed in terms of its potential to protect farmers in the regions from adverse impacts of climate change.

The study concludes that over and above the positive effect of protective structures, the important factors that affect farmer profitability are: (a) choice and timing of crop, (b) management skills of the farmers, (c) control and prevention of pests/diseases, and (d) rainfall (cropping season).

9.2 Recommendations

1. The use protected cropping is recommended to ensure year-round supply of vegetables. House type structures are suited for growing taller vegetable crops while the low tunnels are for low lying crops;
2. For maximum benefit and to ensure success in the adoption of vegetable protected cropping systems, timing and choice of crop to plant, management skills, control and/or prevention of pests/diseases control as well as water for proper irrigation must be available.
3. That further funds be sought to investigate protected cropping as a means of adapting to climate change, in particular in areas where there is increased risk of heavy rain and wind.
4. The value of extra farm skills on increased profitability (and production?) be promoted widely to education and training institutes in the Philippines.
5. That a best bet management guide on PC be prepared. [this now being developed as part of HORT 2012/ 020]

There were two main recommendations from the project review and these have been incorporated into a new ACIAR funded project HORT/2012/020[2]:

1. Expansion within and outside Leyte

Expand the project in Leyte and into other areas. VSU should collaborate with other state colleges and universities to replicate the successful experience in other poor nearby provinces such as Southern Leyte, Samar, Biliran and Bohol. Alternatively, a phase two project should be considered to involve these four additional provinces. A subsequent project could consider locating co-operator farms close to big towns where there are large population/consumption areas. This would bring the production sites closer to consumers and also reduce transport costs and provide potential markets such as the Panglao Island resorts near Tagbilaran, Bohol. Successful long-term expansion will require agronomic support and training from expert farmers, LGUs and MOA and the private sector[2]

2. Investigate low tunnels, net coverings and improved irrigation

While the structures used plastic roofing to protect the crops from the rain during the rainy season, a subsequent project could conduct research on how to lower the temperature during the summer months, i.e. use of nets (to replace the plastic over the roof) to provide partial shade and enable farmers to protect the crops against excessive sunlight and heat

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[2] *Chapman and Batugal (2011) Project review*

during the summer months, possibly involving research by the Australian counterparts in reducing temperatures through enhanced ventilation under structures. Many farmers do not produce vegetables during the hot summer months, this technology, if successful, may open up another opportunity for off-season production and high off-season price. The project should consider tapping nearby creeks and rivers upstream to provide a head for gravity irrigation system and use PVC pipes to bring water by gravity to the farm, especially in the off-season when vegetables are grown under under protected structures during the summer months.

10 References

10.1 References cited in report

Apilar, E.G. (2002). Horticultural and morphological responses of two (2) tomato (*Lycopersicon esculentum* Mill) varieties to open field and protected cultivation. PhD dissertation. LSU, ViSCA, Baybay, Leyte. 97 pp.

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10.2 List of publications produced by project

Research Papers and Book Chapters

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1. Focus group discussion with farmers on protected vegetable cropping: Working Paper No. 1 (2009) L. Nuñez, Pedro Armenia and L.A. Maurillo. Seasonal vegetable price data for Leyte, Philippines: Working Paper No. 2 (2009) K. Menz and P. Armenia.
2. Seasonal Vegetable Price Data for Leyte, Philippines, Working Paper No. 2 Ken Menz and Pedro Armenia
3. Soil management for vegetable growing in the Philippine uplands: A bio-economic analysis Working Paper No. 3 Sanzida Akhter and Ken Menz

4. Soil management for vegetable growing in the Philippine uplands: A bio economic analysis. Working Paper No. 3 (2009) S. Akhter and K. Menz. Farmers' practices, initial feedback and constraints to adoption of vegetable production under protected structures. Working Paper No. 4. (2009) P. Armenia, L. B. Nunez and E. R. Tausa.

5. A case study on vegetable production and marketing assistance project, Maasin, Leyte. Working Paper No. 5 (2009) S. P. Sarno and J. R. Teves.

6. Design and costings for some protected cropping structures for vegetable production, Leyte. Working Paper No. 6 (2009) P. Armenia, L.B. Nunez, E.R. Tausa, M.B. Loreto, Jr., J. Jarvis, O.B. Capuno, Z.C. Gonzaga, E.D. Briones, B.T. Mandras, A.B. Tulin, J.S. Mangmang, K. Menz and G. Rogers.

7. Gross margins for the first vegetable crop grown under the protected structures and in open field. Working Paper No. 7 (2010) E.R. Tausa, P.T. Armenia, L.B. Nunez and K. Menz.

8. Physico-Chemical Characteristics and Nutrient Dynamics of Soils used for protected cropping, Working Paper 8. (2010) A. B. Tulin, Z.C. Gonzaga, J.S. Mangmang, G. Rogers.

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18. Economics of Vegetable Production Under Protected Cropping Structures in the Eastern Visayas,
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PhD, Masters and Honours Theses

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11 Appendixes

11.1 Appendix 1:

Appendix Tables

Year 1 (October 2008 – February 2010)

VSU SITE

Table 15. Yield data of cabbage varieties grown under different tunnel structures and in the open field (Jan 16 to Mar 2009)

Treatments	Marketable heads		Non-marketable heads		Head size (cm)		Total Yield (tha^{-1})
	Number	Weight (kg)	Number	Weight (kg)	Polar	Equatorial	
Production Options							
Plastic tunnel	9.33	2.92	2.00	0.61	13.67	14.62	12.58
Net tunnel	8.00	2.20	2.67	0.57	13.69	14.53	9.92
Control	8.00	2.51	3.33	0.70	13.64	14.64	11.45
Varieties							
KK cross	8.00	1.86b	2.67	0.51	13.90a	14.48	8.47b
Apo verde	8.89	3.23a	2.67	0.74	13.44b	14.72	14.17a
CV (%) a	22.34	32.36	69.31	60.00	4.49	3.53	21.23
B	15.03	11.71	50.78	72.20	2.10	2.05	12.33

Table 16. Yield data of lettuce varieties grown under different tunnels and in the open field (Feb 25 to Mar 2009)

Treatments	Marketable		Non-marketable		Total Yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	
Production options					
Tunnel plastic	18.22	2.08ab	6.44	0.08	11.87b
Tunnel net	19.89	3.18a	4.67	0.49	20.35a
Open field	16.67	1.16b	6.44	0.44	8.95b
Varieties					
General	17.44	1.77b	4.67	0.35	11.63b
Grande	17.89	2.27a	3.89	0.34	14.05a
Tension	19.45	2.37a	3.78	0.47	15.49a
CVa	19.31	41.43	85.04	113.7	28.48
B	18.23	17.68	53.88	89.56	16.41

Table 17. Yield data of tomato 'Atlas' grown under bamboo house structure and in the open field at Gutosan, Maasin site (Jan 9 to Apr 24, 2009)

Production Options	Marketable/plot		Non-marketable/plot		Fruit size (cm)		Total Yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	Polar	Equatorial	
Bamboo house	5178.33	166.11	244.67	2.87 b	4.25	4.29 a	43.66
Open field	3898.33	99.49	311.00	4.55 a	4.16	3.90 b	26.68
CV (%)	25.24	22.10	41.10	13.57	2.86	2.47	21.12

Table 18. Yield data of lettuce 'General' grown under coco house 2 and in the open field (May 19 –Jun 25, 2009)

TREATMENT	Head weight (g/plant)	Head size (cm)		Marketable Yield (t/ha)	Herbage weight (g/plant)
		Polar	Equatorial		
Coco house 2	116.48	13.17	13.02	29.87	110.00 a
Open field	69.24	12.52	13.10	17.75	70.93 b
CV (%)	21.49	3.94	4.91	21.48	8.85

Table 19. Yield data of Lettuce 'General' grown under different tunnel structures and in the open field (May 21 - Jun 26, 2009)

TREATMENT	Head weight (g/plant)	Head size (cm)		Marketable Yield (t/ha)	Herbage weight (g/plant)
		Polar	Equatorial		
Bamboo tunnel-net	132.41 a	13.68	13.12	22.07 a	105.17 c
Steel tunnel-net	130.93 a	13.28	12.96	21.82 a	156.90 a
Open field	69.37 b	12.58	11.83	11.56 b	131.10 b
CV (%)	11.62	4.18	3.42	11.62	12.69

Table 20. Yield data of lettuce 'General' grown under structure and in the open field at Gutosan, Maasin site (Jun 9 –Jul 23, 2009)

TREATMENT	Head weight (g/plant)	Head size (cm)		Herbage weight (g/plant)
		Polar	Equatorial	
Bamboo structure	87.57	10.76	9.61 a	72.60
Open field	71.90	10.06	7.30 b	73.47
CV (%)	14.91	3.44	2.77	9.93

Table 21. Yield data of broccoli 'Top green' grown under bamboo house 1, steel tunnel net and in the open field (Aug 23, 2009 to Nov 20, 2009)

TREATMENT	Mean curd weight (g)	Curd diameter (cm)	Herbage weight (g/plant)
Bamboo house 1	152.82	10.78	604.18
Bamboo tunnel-net	137.09	10.70	507.22
Open field	139.10	10.13	411.45
CV (%)	10.95	9.72	21.01

Table 22. Yield data of cabbage 'Apo verde' grown under steel tunnel net and in the open field (Oct 08, 2009 to Jan 12, 2010)

TREATMENT	Marketable curds/11m^2		Non-marketable curds		Mean head weight (g)	Head size (cm)		Total Yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)		Polar	Equatorial	
Steel tunnel net	32.00	16.24	6.33	1.21	512.97	12.37 a	14.30 a	15.87
Open field	33.67	11.71	7.00	0.94	336.90	11.33 b	13.29 b	11.51
CV (%)	16.31	20.52	44.16	85.00	16.72	0.74	7.09	19.02

Table 23. Yield data of cauliflower 'White shot' grown under steel tunnel plastic and in the open field (Oct 09, 2009 to Jan 08, 2010)

TREATMENT	Marketable curds/11m^2		Non-marketable curds		Mean curd weight (g)	Curd diameter (cm)	Total Yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)			
Steel tunnel plastic	20	3.60	5.33	0.85	181.06 a	8.53	4.10
Open field	18	2.70	14.00	2.14	150.67 b	8.30	4.40
CV (%)	17.05	15.97	40.29	47.73	6.26	2.02	7.23

Table 24. Yield data of Tomato 'Diamante max' grown under bamboo house structure and in the open field at Cabintan, Ormoc site (Sep 21, 2009 – Feb 20, 2010)

TREATMENT	Marketable fruits/39.2m^2		Non-marketable fruits		Fruit size (cm)		Total Yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	Polar	Equatorial	
Bamboo house	8,027.33a	334.03a	232.67b	5.16b	5.26a	5.02a	86.53a
Open field	3,335.67b	151.57b	1,984.33a	84.25a	4.83b	4.80b	60.16b
CV (%)	3.27	3.20	25.98	30.46	2.38	2.38	7.08

Table 25. Yield data of Sweet pepper 'Emperor' grown under structure and in the open field at Gutosan, Maasin site (Sep 27 2009 – Jan 07, 2010)

TREATMENT	Weight of marketable fruits/37.5m^2	Weight of non-marketable fruits/37.5m^2	Total yield (t/ha)
Bamboo structure	6.07 b	2.43	2.27
Open field	19.53 a	2.29	5.82
CV (%)	15.40	31.28	58.79

Year 2 (March 2010 – February 2011)

VSU SITE

Table 26. Yield data of Lettuce var. 'General' grown under Coco house 1 and in the open field (May 25 – Jun 28, 2010)

Treatments	Marketable yield/39.5m^2		Head size (cm)		Total yield (t/ha)
	Number	Weight (kg)	Polar	Equatorial	
Coco 1	269a	41.37a	13.75	12.40	10.47a
Open field	142b	22.04b	12.95	11.77	5.58b
CV (%)	4.65	15.44	2.80	2.78	15.62

Table 27. Yield data of Ampalaya var. 'Galaxy' grown under Coco house 1 and in the open field (Jul 8 – Nov 6, 2010)

Treatments	Marketable yield/90m^2		Non-marketable yield/90m^2		Fruit size (cm)		Ave. fruit weight (g)	Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	Length	Diameter		
Coco 1	993	204.63	303.5	34.04	33.00	5.34	273.20a	26.52
Open field	266	66.47	188.0	17.01	31.97	4.72	248.19b	8.16
CV (%)	25.73	28.46	18.51	14.65	3.86	1.19	1.31	26.18

Table 28. Data of Lettuce var. 'General' grown under steel tunnel net and in the open field (Mar 10 – Apr 07, 2010)

Treatments	Plant height (cm) 2 WAT	Number of leaves 2WAT	Marketable yield/12m^2		Head size (cm)		Total yield (t/ha)
			Number	Weight (kg)	Polar	Equatorial	
Steel tunnel net	12.35a	6.53	116.33	22.24a	14.92a	15.27a	18.53a
Open field	10.92b	6.03	110.33	15.70b	13.06b	13.56b	13.08b
CV (%)	1.31	2.98	6.57	1.58	1.39	0.59	5.28

Table 29. Data of Lettuce var. 'Grande' grown under bamboo tunnel net and in the open field (Mar 13 – Apr 07, 2010)

Treatments	Plant height (cm) 2 WAT	Number of leaves 2WAT	Marketable yield/12m^2		Head size (cm)		Total yield (t/ha)
			Number	Weight (kg)	Polar	Equatorial	
Bamboo tunnel net	12.23a	5.87a	103.67	12.47	11.82	11.45	10.39
Open field	11.54b	5.60b	108.33	14.88	11.94	12.77	12.40
CV (%)	1.22	0.71	8.01	12.84	4.71	7.00	12.68

ORMOC SITE

CABINTAN DATA (Noel)

Table 30. Data of Broccoli var. 'Top green' and 'Marathon' grown under different type of bamboo house structure and in the open field (Feb. 22 – May 26, 2010)

Treatments	Plant height (cm) 4 WAT	Marketable yield/19m^2		Non -marketable yield/19m^2		Herbage weight kg/ 19m^2	Total yield (t/ha)
		Number	Weight (kg)	Number	Weight (kg)		
Factor a							
Vent*	48. 60a	64.00a	14.82a	0.00b	0.00b	72.33a	7.80ab
Curved roof*	47.55a	59.00ab	16.61a	0.00b	0.00b	64.70ab	8.74a
House	36.80b	43.75b	6.79b	0.00b	0.00b	33.11c	3.57c
Open	35.70b	41.50b	8.52b	26.50a	4.20a	43.02bc	6.63b
Factor b							
Top green	40.37b	72.75a	15.56	8.87a	1.49a	56.79a	8.70a
Marathon	43.95a	31.37b	7.81	4.37b	0.61b	49.79b	4.40b
CV (%) a	3.49	14.72	9.93	7.55	38.09	16.61	10.83
b	2.33	3.75	5.15	15.09	50.00	8.32	4.73

Table 31. Data of watermelon var. 'Formosa' grown under bamboo house structure and in the open field (Jul 14 – Oct 7, 2010)

Treatments	Marketable yield/90m^2		Non -marketable yield/90m^2		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	
Bamboo house	36.0	67.42	22.0	21.47	9.87
Open field	37.5	79.47	7.0	7.52	9.66
CV (%)	6.80	8.30	27.59	36.90	13.00

Table 32. Data of bottle gourd var. 'Mayumi' grown under curved roof, vent type bamboo structures and in the open field (Jun 24 – Oct 16, 2010)

Treatments	Marketable yield/100m^2		Non -marketable yield/100m^2		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	
Curved roof type	444.0	447.5	75.5	49.64	49.71a
Vent type	375.5	386.6	44.5	25.20	41.18b
Open field	393.5	407.2	70.0	39.00	44.62b
CV (%)	4.98	4.09	19.68	19.43	2.43

LAO DATA (Joseph)

Table 33. Yield data of Tomato var. 'Diamante max' under bamboo house and in the open field (Jan 09 - Apr 15, 2010)

Treatments	Marketable yield (kg/40m^2)	Non-marketable yield (kg/40m^2)	Fruit size (cm)		Total yield (t/ha)
			Polar diameter	Equatorial diameter	
Bamboo	229.09	6.02	5.57a	4.89	58.77
Open field	214.67	4.2	5.26b	4.63	54.72
CV (%)	2.96	12.19	0.83	4.14	3.07

Table 34. Yield data of String beans var. 'Galante' under bamboo house and in the open field (Jun 29 - Aug 13, 2010)

Treatments	Marketable yield/40m^2		Pod length (cm)	Total yield (t/ha)
	Number	Weight (kg)		
Bamboo	4336.33	109.38	68.18	28.96
Open field	5105.33	115.85	64.50	27.34
CV (%)	23.08	20.94	2.59	20.94

Table 35. Yield data of Ampalaya var. 'Galaxy' under bamboo house and in the open field (Sep 07, 2010 to Jan 07, 2011)

Treatments	Marketable fruits/100m^2		Non-marketable fruits/100m^2		Fruit size (cm)		Total Yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	Length	Diameter	
Bamboo	731.0a	166.75a	62	9.42	34.92a	5.34a	17.61a
Open field	349.5b	67.37b	71	6.77	31.40b	4.81b	7.41b
CV (%)	3.79	6.30	13.53	23.46	0.24	0.10	7.43

CURVA DATA (Amelito)

Table 36. Yield data of Ampalaya var. 'Galaxy' grown under Bamboo house and in the open field (Feb 17 - May 02, 2010)

Treatments	Marketable yield/100m^2		Non-marketable yield/100m^2		Fruit size (cm)		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	Length	Diameter	
Bamboo	623.00	121.50	30.00a	2.54	33.97	5.07	12.40
Open field	373.50	57.90	5.50b	0.25	33.32	4.49	5.81
CV (%)	8.93	12.10	2.82	27.24	5.18	4.12	12.29

LAO DATA (Edmond)

Table 37. Yield data of Ampalaya var. 'Galaxy' under bamboo house and in the open field (Jul 15 - Oct 04, 2010)

Treatments	Marketable fruit/100m^2		Non-marketable fruit/100m^2		Fruit size (cm)		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	Length	Diameter	
Bamboo	295.00	79.32	63.00	7.00	29.49	4.34	8.63
Open field	243.50	40.90	81.00	5.86	26.44	4.09	4.68
CV (%)	25.81	39.30	26.39	39.50	1.88	2.49	39.31

GUINTIGUI-AN DATA (Marilyn)

Table 38. Yield data of Tomato var. 'Diamante max' under bamboo house and in the open field (Jul 10 - Oct 21, 2010)

Treatments	Marketable fruit/35m^2		Non-marketable fruit/35m^2		Fruit size (cm)		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	Length	Diameter	
Bamboo	1080.67	50.58a	182.00	3.17	5.17	4.75	15.36a
Open field	409.67	13.00b	154.67	2.45	4.90	4.13	4.41b
CV (%)	39.10	31.56	27.59	21.30	4.95	6.17	30.29

MAASIN SITE

GUTOSAN DATA (Raymundo)

Table 39. Yield data of Ampalaya var. 'Galactica' under bamboo house 1 and in the open field (Feb 4 - May 18, 2010)

Treatments	Marketable fruit/97m^2		Non-marketable fruit/97m^2		Fruit size (cm)		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	Length	Diameter	
Bamboo 1	647.50	161.32	67.00	16.72	34.77	5.40	18.26
Open field	744.50	180.87	48.50	11.25	37.03	5.32	19.70
CV (%)	11.78	9.26	12.99	10.90	2.01	0.59	9.40

Table 40. Yield data of Sweet corn var. ‘Super sweet’ under bamboo house 1 and in the open field (May 27 - Aug 12, 2010)

Treatments	Marketable fruit/57.75m^2		Non-marketable fruit/57.75m^2		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	
Bamboo 1	193.67	21.67	62.67	4.67	4.47
Open field	178.33	18.50	75.00	5.92	4.23
CV (%)	38.41	42.53	15.96	21.91	36.67

Table 41. Yield data of Ampalaya var. ‘Galaxy’ under bamboo house structures and in the open field (Oct 02, 2010 to Jan 08, 2011)

Treatments	Marketable fruit/96.25m^2		Non-marketable fruit/96.25m^2		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	
Bamboo 1*	340	78.25	99.5	17.25	9.92
Bamboo 2**	352	84.25	96	33.12	12.19
Open field	332.5	88	111	21.87	11.41
CV (%)	15.17	17.09	7.98	51.23	22.45

Table 42. Yield data of Tomato var. ‘Diamante max’ under bamboo house 2 and in the open field (Jun 4 - Sep 18, 2010)

Treatments	Marketable fruit/97m^2		Non-marketable fruit/97m^2		Fruit size (cm)		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	Length	Diameter	
Bamboo 2	1090.33a	58.50a	81.00	4.83	5.57	4.65	16.24a
Open field	170.00b	24.90b	45.33	2.83	5.41	4.68	2.86b
CV (%)	24.40	23.12	30.56	30.99	1.74	1.14	23.53

LIBHU DATA (Victor)

Table 43. Yield data of Tomato var. ‘Diamante max’ under curved roof type structure and in the open field (Mar 2 - May 13, 2010)

Treatments	Marketable fruit/97m^2		Non-marketable fruit/97m^2		Fruit size (cm)		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	Length	Diameter	
Curved roof type	11255.33a	388.15a	412.33a	11.95	5.14	4.60a	100.02a
Open field	6943.67b	228.25b	364.33b	10.90	4.79	4.28b	59.79b
CV (%)	6.73	9.31	1.59	10.24	3.00	1.61	8.80

Table 44. Yield data of Sweet pepper var. 'Majesty' under vent type structure and in the open field (Mar 22 - Sep 10, 2010)

Treatments	Marketable fruit/97m²		Non-marketable fruit/97m²		Fruit size (cm)		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	Length	Diameter	
Vent type	7581.33a	197.45a	373.00	7.78	9.16	4.45	51.31a
Open field	6857.33b	181.42b	337.33	6.58	8.66	4.11	47.00b
CV (%)	2.69	1.95	22.69	6.66	10.82	10.43	1.99

Table 45. Yield data of Cucumber var. 'Big C' under curved roof type structure and in the open field (May 2 - Sep 7, 2010)

Treatments	Marketable fruit/40m²		Non-marketable fruit/40m²		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	
Curved roof type	539.67b	177.33b	163.67b	57.00b	58.58b
Open field	1161.00a	337.67a	383.00a	87.58a	106.31a
CV (%)	10.19	5.85	1.72	5.17	4.65

Table 46. Yield data of Ampalaya var. 'Galaxy' under curved roof and vent type structures and in the open field (Oct 26, 2010 to Jan 09, 2011)

Treatments	Marketable fruit/96.25m²		Non-marketable fruit/96.25m²		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	
Curved roof type	187.00a	38.12	42.50	4.87	4.30
Vent type	181.50a	37.75	29.50	3.12	4.08
Open field	164.00b	35.50	25.00	3.62	3.91
CV (%)	1.28	2.79	4.55	46.82	5.92

BONTOC SITE

PAMAHAWAN DATA (Boei)

Table 47. Yield data of lettuce var. 'Grand rapid' under curved roof type structure and in the open field (Jan 21 - Mar 13, 2010)

Treatments	Marketable yield/17m²		Non-marketable yield/17m²		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	
Curved roof type	204.00	23.15a	0.00b	0.00b	13.61a
Open field	172.33	15.40b	8.00a	0.68a	9.05b
CV (%)	8.10	11.06	30.62	29.94	11.05

Table 48. Yield data of Ampalaya var. 'Galactica' under curved roof type structure and in the open field (Dec 8, 2009 - Mar 25, 2010)

Treatments	Marketable fruit/47.5m^2		Non-marketable fruit/47.5m^2		Fruit size (cm)		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	Length	Diameter	
Curved roof type	703.50a	106.43a	51.00	4.52b	31.70	4.78	23.36a
Open field	473.50b	55.66b	97.00	8.00a	28.06	4.02	13.40b
CV (%)	0.85	1.43	13.51	2.79	1.76	3.29	1.50

Table 49. Yield data of Sweet pepper var. 'Sultan & Emperor' under curved roof & vent type structures and in the open field (Mar 28 to Dec 15, 2010)

Treatments	Marketable fruit/20m^2		Non-marketable fruit/20m^2		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	
Production Option					
Curved roof type	4565.33a	182.79a	266.50b	9.86b	96.32a
Vent type	4594.50a	183.77a	239.67b	8.25b	96.01a
Open field	2232.50b	86.76b	450.83a	14.83a	50.80b
Variety					
Emperor	4185.33a	154.99	344.78a	10.79	82.87
Sultan	3409.55b	147.23	293.22b	11.17	79.20
CV (%) a	6.77	4.64	6.22	8.98	4.05
B	7.62	5.64	9.13	13.53	5.09

BATO SITE

BAGO DATA (Nenen)

Table 50. Yield data of Sweet pepper var. 'Sultan' under bamboo house and in the open field (Jan 07 - Apr 17, 2010)

Treatments	Marketable fruit/20m^2		Fruit size (cm)		Total yield (t/ha)
	Number	Weight (kg)	Length	Diameter	
Bamboo	796.67b	27.50	9.91a	4.53a	13.75
Open field	922.67a	28.92	9.07b	4.29b	14.46
CV (%)	2.59	2.61	2.28	1.30	2.64

Year 3 (March 2011 – February 2012)

VSU SITE

Table 51. Yield data of Sweet pepper 'Emperor' under bamboo structure and in the open field at VSU site

Treatments	Marketable fruit/40m²		Non-Marketable fruit/40m²		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	
Bamboo 1	2761.33	59.0433	1224.67	15.2200	18.5658
Open field	2166.67	46.5600	1197.00	12.5433	14.7758
CV (%)	10.8	13.5	28.8	19.3	7.6

Table 52. Yield data of Tomato under coco structure and in the open field VSU site

Treatments	Marketable plant/100m²		Non-Marketable plant/100m²		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	
Coco 1	8502.33	288.362a	899.000	10.28	74.66a
Open field	9687.67	173.233b	1122.33	11.47	46.17b
CV (%)	51.0	7.1	9.4	5.4	6.9

Table 53. Yield data of watermelon under coco structure and in the open field at VSU site

Treatments	Marketable fruit/100m²		Non-Marketable plant/100m²		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	
Coco 2	87.0000	322.950a	5.50000	13.5000	33.6450a
Open field	26.0000	42.4125b	11.5000	14.8500	5.72500b
CV (%)	10.6	6.7	82.4	1.8	6.1

ORMOC SITE

CABINTAN DATA (Noel)

Table 54. Yield data of green onion (on-going) under bamboo structure and in the open field (Feb 22, 2011- Feb 13. 2012) at Noel's site, Cabintan, Ormoc

Treatments	Marketable fruit/40m²		Total yield (t/ha)
	Number	Weight (kg)	
Bamboo	15139.70[a]	238.92[a]	59.73[a]
Open field	4705.33[b]	68.95[b]	17.24[b]
CV (%)	2.00	5.00	5.00

Table 55. Yield data of Sweet pepper (on-going) under bamboo structure and in the open field (October 5, 2011 – March 23, 2012) at Noel's site, Cabintan, Ormoc

Treatments	Marketable fruit/40m²		Non-Marketable fruit/40m²		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	
Vent Type	1375.33[b]	46.53[b]	174.00[b]	4.38[b]	12.73[b]
House Type	1799.00[a]	61.87[a]	740.67[a]	21.18[a]	20.76[a]
Open Field	204.333[c]	4.68[c]	276.000[b]	6.13[b]	2.71[c]
CV (%)	13.40	11.80	16.80	20.60	10.00

CURVA DATA (Amelito):

Table 56. Yield data of sweet pepper 'Emperor' under bamboo structure and in the open field (June 8, 2010 – Feb 6, 2011) at Ame's site, Curva, Ormoc

Treatments	Marketable fruit/40m²		Non-Marketable fruit/40m²		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	
Bamboo	6475.33[a]	117.33[a]	731.00	11.70	32.26[a]
Open field	4621.33[b]	79.42[b]	964.00	11.85	22.82[b]
CV (%)	6.30	10.10	33.70	56.90	7.70

Table 57. Yield data of Ampalaya var. 'Galaxy' under bamboo structure and in the open field (Mar 23, 2011 – Jul 12, 2011) at Ame's site, Curva, Ormoc

Treatments	Marketable fruit/100m²		Non-Marketable fruit/100m²		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	
Bamboo	1895.00[a]	456.25[a]	69.50[b]	7.30	26.60
Open field	1116.00[b]	255.00[b]	70.00[a]	6.02	15.55
CV (%)	2.86	3.44	12.19	10.88	49.82

Table 58. Yield data of sweet pepper 'Emperor' under bamboo structure and in the open field (August 12, 2011 – March 2-12) at Ame's site, Curva, Ormoc

Treatments	Marketable fruit/40m²		Non-Marketable fruit/40m²		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	
Bamboo	12667.500[a]	178.500	421.000	3.600	45.52
Open field	8827.500[b]	108.375	401.500	3.375	27.94
CV (%)	9.33	10.72	10.82	10.75	10.72

CURVA DATA (Arni):

Table 59. Yield data of ampalaya 'galaxy' grown under bamboo house structure and in the open field (Feb 25 to Jun 15, 2011) at Curva-arni

Treatments	Marketable fruits/100m^2		Non-marketable fruits/100m^2		Total Yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	
Bamboo	516.000^a	127.525^a	60.000^a	8.450^a	13.597^a
Open field	39.500^b	6.725^b	5.500^b	0.550^b	0.728^b
CV (%)	17.82	24.95	1.53	0	23.39

Table 60. Yield data of Tomato 'D' max' under bamboo structure and in the open field (Jul 15 – Oct 21, 2011) at Arni's site, Curva, Ormoc

Treatments	Marketable fruit/40m^2		Non-Marketable fruit/40m^2		Total yield (t/ha)
	Number	Weight	Number	Weight	
Bamboo	4640.33^a	211.00^a	200.33	4.55	53.89^a
Open field	1522.33^b	54.83^b	84.33	2.17	15.52^b
CV (%)	3.47	14.78	51.52	38.48	9.19

LAO DATA (Joseph)*:*

Table 61. Yield data of Tomato under bamboo structure and in the open field (Feb 8 – Jun 24, 2011) at Joseph's site, Lao, Ormoc

Treatments	Marketable fruit/40m^2		Non-Marketable fruit/40m^2		Total yield (t/ha)
	Number	Weight	Number	Weight	
Bamboo	10769.33^a	401.25^a	79.00^b	1.90	100.79^a
Open Field	4145.00^b	132.75^b	371.00^a	6.75	34.88^b
CV (%)	10.91	7.99	26.29	40.904	8.27

Table 62. Yield data of Sweet pepper under bamboo structure and in the open field (Jun 22 – Mar 21, 2012) at Joseph's site, Lao, Ormoc

Treatments	Marketable fruit/40m^2		Non-Marketable fruit/40m^2		Total yield (t/ha)
	Number	Weight	Number	Weight	
Bamboo	8592.00^a	230.03^a	368.67^a	6.23^a	59.06^a
Open Field	1020.33^b	23.55^b	198.67^b	2.35^b	6.47^b
CV (%)	0.50	3.20	17.90	18.90	3.30

LAO DATA (Edmond):

Table 63. Yield data of tomato 'D' max' under bamboo structure and in the open field (Nov 20, 2012 – Feb 10, 2011) at Edmond site Lao, Ormoc

Treatments	Marketable fruit/40m²		Non-Marketable fruit/40m²		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	
Bamboo	2789.67	85.53	142.67	3.07[a]	22.15
Open field	1275.33	48.00	100.00	2.43[b]	12.61
CV (%)	24.20	22.80	13.50	6.60	21.70

Table 64. Yield data of string beans under bamboo structure and in the open field (Mar 16 – Jul 20, 2011) at Edmond site Lao, Ormoc

Treatments	Marketable fruit/40m²		Non-Marketable fruit/40m²		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	
Bamboo	6123.00[a]	122.92[a]	1005.33[a]	21.07[a]	35.99[a]
Open field	4343.67[b]	71.25[b]	764.00[a]	12.68[a]	20.98[b]
CV (%)	2.49	9.88	2.64	8.32	9.47

Table 65. Yield data of Ampalaya under bamboo structure and in the open field (Aug 13 – Dec 7, 2011) at Edmond site Lao, Ormoc

Treatments	Marketable fruit/40m²		Total yield (t/ha)
	Number	Weight (kg)	
Bamboo	931.000[a]	201.283[a]	50.320[a]
Open field	102.333[b]	15.267[b]	3.816[b]
CV (%)	14.46	17.75	17.75

MAASIN SITE

GUTOSAN DATA (Raymundo):

Table 66. Yield data of Cucumber var. under bamboo structure and in the open field (Sep 23 – Dec 16, 2011) at Mundo's site, Gutosan, Maasin, So. Leyte

Treatments	Marketable fruit/100m²		Non-Marketable fruit/100m²		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	
Bamboo	1115.00	302.50	214.00	89.50	91.06
Open field	1225.00	355.00	240.00	90.00	111.25
CV (%)	8.80	4.71	1.32	2.79	2.41

LIBHU DATA (Victor):

Table 67. Yield data of Squash var. under bamboo structure and in the open field (Mar 16 – July 4, 2011) Victor's site, Libhu, Maasin, So. Leyte

Treatments	Marketable fruit/100m^2		Non-Marketable fruit/100m^2		Total yield (t/ha)
	Number	Weight (kg)	Number	Weight (kg)	
Curved roof	44.50	124.00	4.00	0.41[b]	12.43
Vent type	71.00	176.00	3.00	1.12[a]	17.71
Open field	65.00	176.80	1.00	0.12[b]	17.69
CV (%)	17.63	24.08	81.01	2.21	24.03

BONTOC SITE

BONTOC DATA (Boie):

Table 68. Yield data of watermelon grown under vent type and curved roof type structure 1 and in the open field (Jan 26 – May 7, 2011) at Boie's site, Bontoc, Southern Leyte

Treatments	MARKETABLE FRUITS		NON-MARKETABLE FRUITS		Total yield (t/ha)
	Number	Weight	Number	Weight	
Vent type	168.50	285.80	5.70[b]	0.00[b]	28.58
Curved roof type	131.00	206.65	20.50[a]	17.85[a]	22.45
Open field	142.00	274.95	3.00[b]	4.12[b]	27.91
CV (%)	6.80	11.80	16.30	40.70	11.00

Table 69. Yield data of watermelon grown under vent type and curved roof type structure 1 and in the open field (Jun 20 – Sep 22, 2011) at Boie's site, Bontoc, Southern Leyte

Treatments	MARKETABLE FRUITS		NON-MARKETABLE FRUITS		Total Yield (t/ha)
	Number	Weight	Number	Weight	
Vent type	139.00	193.20	12.50	13.90	20.71
Curved roof type	147.50	214.30	10.50	8.05	22.23
Open field	111.00	183.85	13.00	16.30	20.01
CV (%)	13.23	9.96	9.00	4.45	7.20

Table 70. Yield ratio of vegetable grown under protected and in the open field

Crops	**Yield (t/ha)**		**Ratio**
Green onion	59.73	17.24	3.47
Lettuce	15.75	4.65	3.39
Tomato	37.22	16.44	2.26
Sweet pepper	28.22	14.01	2.01
Ampalaya	21.88	11.71	1.87
Pechay	31.37	17.05	1.84
Muskmelon	10.39	5.73	1.81
Broccoli	3.03	1.95	1.55
Beans	19.54	12.90	1.51
Cabbage	9.48	8.39	1.13
Watermelon	46.72	43.92	1.06
Cucumber	75.63	88.75	0.85
Squash	36.50	44.00	0.83

Table 71. Insect pest incidence of vegetable crops

Crops	**Insect Incidence (%)**	
Tomato	Leaf miner	Fruit Worm
Protected	1	5
Open field	20	21
Sweet Pepper	Broad mite	
Protected	46	-
Open field	36	-
Chili pepper	Spider Mite	
Protected	24	-
Open field	10	-
Muskmelon	Leaf miner	
Protected	0	-
Open field	18	-
Watermelon	Broad mite	
Protected	18	-
Open field	10	-
Cauliflower + Broccoli	Diamond-Back moth	
Protected	100	-
Open field	100	-

Table 72. Disease incidence of vegetable crops

Crops	**Disease Incidence (%)**				
Ampalaya	Sooty Mold	Cercospora Leafspot	Bacterial Wilt	Downy Mildew	Little Leaf
Protected	24	39.475	1.05	50.5	50.2
Open field	0	50.44	19.65	61.31	100
Tomato	Cercospora Leafspot	Bacterial Wilt	Nematod e		
Protected	76.25	3.12	0		
Open field	46.53	23.3	24.7		
Sweet Pepper	Cercospora leafspot				
Protected	50				
Open field	100				
String beans	Leaf Blight				
Protected	27.5				
Open field	40				
Squash	Downy Mildew				
Protected	12.015				
Open field	64.8				
Cauliflower + Broccoli	Soft Rot				
Protected	4.59				
Open field	100.00				

Table 73. Summary of yield, receipts, variable costs (expenses), and gross margins of crops grown in protective structures and in the open fields, 1st cropping (in PhP)

TYPE OF STRUCTURE	CROP ****	YIELD (kg)	RECEIPTS	EXPENSES Materials	EXPENSES Labour	GROSS MARGIN
BY CROPPING PERIOD AND FIELD SITE:						
1. Cropping Period: November 2010 to May 2011						
Ormoc Site:						
*A. Lao **(Tomato)*** - Nov 20, 2010 to Feb 10, 2011*						
1. Bamboo	Tom	255.50	10,113	1,431	2,225	**6,457**
2. Open field	Tom	144.00	5,463	1,020	1,487	**2,955**
*B. Cabintan **(Tomato)**** - Nov 21, 2010 to Mar 28, 2011*						
1. Vent-type	Tom	327.55	9,198	2,259	1,638	**5,301**
2. Bamboo	Tom	256.30	8,373	1,909	1,542	**4,922**
3. Open field	Tom	9.00	450	1,840	1,065	**-2,455**
Bontoc Site:						
*A. Pamahawan **(Watermelon)***** - Jan 26 to May 07, 2011*						
1. Curved roof-type	WMe	571.60	22,864	4,425	6,168	**12,271**
2. Vent-type	WMe	413.30	16,532	3,645	6,109	**6,777**
3. Open field	WMe	549.90	21,996	4,070	4,617	**13,310**
Ormoc Site:						
*C. Lao **(Tomato)*** - Feb 08 to June 24, 2011*						
1. Modified VSU Bamboo	Tom	1203.75	23,504	1,178	2,309	**20,017**
2. Open field	Tom	398.25	7,965	1,103	1,830	**5,032**
Maasin Site:						
*A. Gutosan **(Tomato)*** - Feb 12 to May 10, 2011*						
1. Bamboo-1	Tom	250.50	3,867	740	1,229	**1,898**
2. Open field	Tom	70.50	1,019	568	1,014	**-563**
Ormoc Site:						
*D. Curva **(Ampalaya)*** - Feb 25 to June 15, 2011*						
1. Modified VSU Bamboo	Amp	255.05	10,649	1,811	791	**8,047**
2. Open field	Amp	13.45	546	2,176	523	**-2,153**
Maasin Site:						

B. Libhu ***(Squash)**** *- Mar 16 to July 04, 2011*						
1. Curved roof-type	Squ	247.75	2,794	362	475	**1,956**
2. Vent-type	Squ	352.00	4,426	362	481	**3,583**
3. Open field	Squ	353.00	4,068	362	481	**3,225**
Ormoc Site:						
E. Lao ***(String beans)**** *- Mar 16 to July 20, 2011*						
1. Bamboo	Stb	374.00	7,480	887	2,499	**4,094**
2. Open field	Stb	213.50	4,270	608	1,258	**2,404**
F. Curva ***(Ampalaya)**** *- Mar 23 to July 12, 2011*						
1. Modified VSU Bamboo	Amp	912.50	41,918	3,213	2,516	**36,189**
2. Open field	Amp	510.00	23,171	2,902	2,409	**17,860**
2. Cropping Period: February 2011 to March 2012						
Ormoc Site:						
G. Cabintan ***(Green Onion)***** *- Feb 22, 2011 to Mar 24, 2012*						
1. Curved roof-type	GrO	716.75	32,254	3,264	4,766	**24,225**
2. Open field	GrO	413.70	18,617	3,228	3,635	**11,754**

* without plastic mulch and drip irrigation, ** with plastic mulch and drip irrigation

*** without plastic mulch but with drip irrigation

**** Tom - Tomato, Amp- Ampalaya, WMe - Watermelon, Stb - String beans, GrO - Green onions, and Squ – Squash

Table 74. Summary of yield, receipts, variable costs (expenses), and gross margins of crops grown in all protective structures and in the open field, 2nd cropping (in PhP)

TYPE OF STRUCTURE	CROP ****	YIELD (kg)	RECEIPTS	EXPENSES Materials	Labour	GROSS MARGIN
BY CROPPING PERIOD AND FIELD SITE:						
1. Cropping Period: June to August 2011						
Ormoc Site:						
*A. Cabintan **(Snap beans)**** - June 10 to Sep 24, 2011*						
1. Vent-type	SnB	193.20	5,796	1,029	1,194	**3,573**
2. Bamboo	SnB	177.45	5,324	1,029	1,104	**3,190**
3. Open field	SnB	199.40	5,982	1,031	909	**4,042**
Bontoc Site:						
*A. Pamahawan **(Watermelon)***** - June 20 to Sep 22, 2011*						
1. Curved roof-type	WMe	428.60	17,144	2,202	2,608	**12,334**
2. Vent-type	WMe	386.40	15,456	2,122	2,486	**10,848**
3. Open field	WMe	367.70	14,708	2,082	2,486	**10,139**
Ormoc Site:						
*B. Curva **(Tomato)*** - July 15 to Oct 21, 2011*						
1. Modified VSU Bamboo	Tom	633.00	17,434	178	2,341	**14,915**
2. Open field	Tom	179.75	4,477	173	1,419	**2,885**
*C. Lao **(Sweet pepper)*** - July 26, 2011 to Mar 31, 2012*						
1. Modified VSU Bamboo	SPe	755.83	66,933	1,344	3,664	**61,924**
2. Open field	SPe	70.65	5,985	1,210	2,697	**2,077**
*D. Curva **(Sweet pepper)*** - Aug 12, 2011 to Feb 09, 2012*						
1. Modified VSU Bamboo	SPe	353.75	28,157	2,777	3,256	**22,124**
2. Open field	SPe	216.75	17,479	2,192	1,853	**13,434**
*E. Lao **(Ampalaya)*** - Aug 13 to Dec 07, 2011*						
1. Bamboo	Amp	603.35	25,608	2,311	2,966	**20,332**
2. Open field	Amp	46.30	2,018	1,370	1,802	**-1,154**

* without plastic mulch and drip irrigation, ** with plastic mulch and drip irrigation

*** without plastic mulch but with drip irrigation

**** Tom - Tomato, Amp- Ampalaya, SnB - Snap beans, WMe - Watermelon, and SPe - Sweet pepper

Table 75. Summary of yield, receipts, variable costs (expenses), and gross margins of crops grown in all protective structures and in the open field, 3rd cropping (in PhP)

TYPE OF STRUCTURE	CROP ***	YIELD (kg)	RECEIPTS	EXPENSES Materials	Labour	GROSS MARGIN
BY CROPPING PERIOD AND FIELD SITE:						
1. Cropping Period: September 2011 to March 2012						
Maasin Site:						
*A. Gutosan **(Cucumber)*** - Sep 23 to Dec 16, 2011*						
1. Bamboo-1	CBe	665.00	11,970	465	986	**10,519**
2. Open field	CBe	710.00	12,780	467	857	**11,456**
Ormoc Site:						
*B. Cabintan **(Sweet pepper)**** - Oct 05, 2011 to Mar 24, 2012*						
1. Vent-type	SPe	139.60	10,470	1,854	2,025	**6,591**
2. Bamboo	SPe	185.60	13,920	4,654	2,076	**7,190**
3. Open field	SPe	28.10	2,108	1,065	1,541	**-499**

* without plastic mulch and drip irrigation, ** with plastic mulch and drip irrigation

*** CBe - Cucumber, and SPe - Sweet pepper

12 Attachments

Appendix 1: Economics of vegetable production under protected cropping structures in the Eastern Visayas, Philippines.

Appendix 2: Low-cost protected cultivation: Enhancing year-round production of high-value vegetables in the Philippines.

Appendix 3: Development of a cost-effective protected vegetable cropping system in the Philippines Protected cropping project (Australian subcomponent). Final Report, May 2012.