Climate Proofing and Integrated Crop Management (ICM) to enhance Vegetable profitability and food security in the Southern Philippines

Zenaida C. Gonzaga
Department of Horticulture
Visayas State University
Visca, Baybay City, Leyte
Outline

Climate Proofing/Protected Cultivation

- Rationale
- Methodology
- Promising results
- Impacts
- Summary and Next steps
Outline

Integrated Crop Management (ICM)

- Methodology
- Promising results
- Impacts
- Summary and Next steps
What is a Vegetable?
Why vegetables?

• Rich source of vitamins, minerals, dietary fibers and phytochemicals, hence a solution to malnutrition and micronutrient deficiency problem.

• Strongly associated with reduced risk for some forms of cancer, heart disease, stroke, and other chronic diseases.

• Generate income and create job opportunities.

• Highly seasonal; hence difficulty in meeting consumers' demand.
The issue

- High rainfall and Typhoons – Nov to Feb which makes vegetable growing difficult
- High vegetable prices during this time (double dry season prices)
- Only 45% of vegetable consumption is produced in Leyte – imports from Mindanao and Luzon
- Opportunity for higher quality under shelter
- Needs to be low cost for farmers to adopt
Advantages of Protected Cropping

- Produces vegetables year round
- Production of healthy and quality seedlings
- Less diseases
- Less weeds
- Less leaching of nutrients
- Allows reduction of fertilizers
- Better crop establishment
- Better soil conditions for plant growth
- Increase yield and income
- Supports production of safe and clean vegetables
Objectives – Climate Proofing/Protected Cultivation

Contribute to the development of profitable horticultural production in high-rainfall areas of the Philippines

- Develop and test protected cropping systems
- Economics and marketing
- Adoption
Methodology
Overview

➢ 34 protected-cropping structures at five project sites in Leyte were constructed
➢ Two types of structures were evaluated:
  • House-type structures (bamboo or coco lumber) of 200 m² (5 m × 40 m)
  • Tunnel-/igloo-types (bamboo or steel frames) with either plastic or net coverings of 60 m² (1.5 m × 40 m).
➢ The experimental sites at the Visayas State University were used mainly for research on crop suitability, pest and disease impacts, and nutrition.
➢ The farmer test sites were used mainly to collect information on yield differences between crops grown under structures and in the open field to support the assessment of economic viability, and production challenges.
Promising Results
Climate Proofing
• VSU Site

Ampalaya grown under coco house structure 2 and open field at VSU site
### VSU Site

**Number and weight of marketable and non-marketable fruits (kg) of ampalaya “Galaxy”**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Marketable fruits</th>
<th>Non-Marketable fruits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Weight (kg/95m²)</td>
</tr>
<tr>
<td>Coco-house</td>
<td>337.50a</td>
<td>84.67a</td>
</tr>
<tr>
<td>Open</td>
<td>60.00b</td>
<td>10.57b</td>
</tr>
</tbody>
</table>
• Ormoc Site at Cabintan, Ormoc (Noel)

Cauliflower “Albarich” at harvestable stage

Open field

House-type structure
**Ormoc Site at Cabintan**

**Number and weight of marketable and non-marketable curds (kg) of cauliflower “Albarich”**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Marketable curds</th>
<th>Non-marketable curds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Weight (kg/23.2m²)</td>
</tr>
<tr>
<td>Bamboo-house structure</td>
<td>122</td>
<td>21.47</td>
</tr>
<tr>
<td>Open field</td>
<td>0</td>
<td>0.00</td>
</tr>
</tbody>
</table>
- Ormoc Site at Cabintan

*Quality of broccoli curd “Top green”*
• Ormoc Site at Cabintan (Noel)

**Number and weight of marketable and non-marketable curds (kg) of broccoli “Top green”**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Marketable curds</th>
<th>Non-marketable curds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Weight (kg/23.2m²)</td>
</tr>
<tr>
<td>Bamboo-house structure</td>
<td>61.67</td>
<td>13.125</td>
</tr>
<tr>
<td>Open field</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>
• Ormoc Site at Cabintan (Noel)

Open Field

Bamboo house structure

Tomato grown under bamboo house structure and open field in Cabintan, Ormoc site
### Ormoc Site at Cabintan

**Number and weight of marketable and non-marketable fruits (kg) of tomato “Diamante max”**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Marketable fruits</th>
<th></th>
<th>Non-Marketable fruits</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Weight (kg/39.2m²)</td>
<td>Number</td>
<td>Weight (kg/39.2m²)</td>
</tr>
<tr>
<td>Bamboo-house</td>
<td>7,898.33a</td>
<td>312.28a</td>
<td>176.67b</td>
<td>4.49b</td>
</tr>
<tr>
<td>Open</td>
<td>3,335.67b</td>
<td>151.57b</td>
<td>1,984.33a</td>
<td>84.25a</td>
</tr>
</tbody>
</table>
Amie Aragon – in Curva, Ormoc

Open field

House-type structure
• Maasin Site at Gutosan (Mundo)

Tomato “Atlas” at flowering stage

Open field

House-type structure
Maasin Site at Gutosan (Mundo)

Number and weight of marketable and non-marketable fruits (kg) of tomato “Atlas”

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Marketable fruits</th>
<th>Non-Marketable fruits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number (kg/37.5m²)</td>
<td>Weight (kg/37.5m²)</td>
</tr>
<tr>
<td>Bamboo-house</td>
<td>4,152a</td>
<td>128.37a</td>
</tr>
<tr>
<td>Open</td>
<td>2,868b</td>
<td>69.48b</td>
</tr>
</tbody>
</table>
• Maasin Site at Gutosan (Jason and Mundo)

Open field

House-type structure
• Bontoc Site at Pamahawan (Engr. Boie)

Raised type structure

Open field
Jun Mendoza - Ormoc

Bamboo house structure

Open field
Joseph Sanchez - Ormoc

Bamboo house structure

Open field

Mr Joseph Sanchez new house and baby
• Maasin Site at Libhu (Victor)
Yield ratio protected cropping : open field
Location Map of Protective Structures in Leyte & Southern Leyte

LEGEND

- Barangay with Protective structure
- Municipalities with established Protective structure
Adoption and Expansion of Low-Cost Protective Structures

A total of 121 different protective structures have been built across Leyte and Southern Leyte:

- 29 by ACIAR/VSU/PCAARD
- 48 by EFOS
- 9 for LGUs
- 2 between LGU and EDC
- 7 poultry houses in Brgy. Concepcion converted into protective structures for vegetable production
- 8 structures personally funded
- 18 medium tech. structures built by Catholic Diocese in Palo
What’s Next?

Integrated Crop Management (ICM)
Objectives - ICM

Improved livelihoods and food security of smallholder vegetable farmers

• To develop component technologies for management of key insect pests and diseases

• To develop component technologies for management of key agronomic constraints for each target site

• To increase vegetable farmer profitability through integrated crop management (ICM) in Leyte, Bohol, Samar and Mindanao

• To capacitize farmers and researchers
Methodology
Methodology

✓ Multi-disciplinary project team included scientists from five Philippine Universities or institutes (VSU, BISU, UTSP, UPLB, NwSSU)

✓ Training teams from East West Seeds and Landcare Foundation Philippines

✓ Scientists from two Australian State Departments of Primary Industries and an Australian private research provider.

✓ The project team scientifically evaluated various components of an ICM system for field and protected cropping of key high value vegetables in the Southern Philippines with 110 experimental trials conducted.
Promising Results on Integrated Crop Management (ICM)
Disease Inventory

Major diseases

- Tomato: Bacterial canker (*Clavibacter michiganensis*)
- Tomato: Septoria leaf spot (*S. lycopersici*)
- Tomato: Target spot (*Corynespora cassiicola*)
- Ampalaya: little-leaf (*Phytoplasma*)
- Ampalaya: Bacteria wilt (*caused by Ralstonia, not Erwinia*)

New records

- "Namamarako" and Downy Mildew
- Bacterial wilt

Cercospora leaf spot

Phytophthora sp
**Fusarium wilt incidence (%) in tomato with biofumigation, *Trichoderma*, cabbage rotation and fungicide application (season 2)**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>21 DAT</th>
<th>28 DAT</th>
<th>35 DAT</th>
<th>42 DAT</th>
<th>49 DAT</th>
<th>56 DAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biofumigation</td>
<td>8.5 b</td>
<td>8.5 b</td>
<td>14 a</td>
<td>17.5 b</td>
<td>28.5 b</td>
<td>35 b</td>
</tr>
<tr>
<td><em>Trichoderma</em></td>
<td>10 ab</td>
<td>11.5 ab</td>
<td>13.5 a</td>
<td>20 ab</td>
<td>32.5 ab</td>
<td>42.5 ab</td>
</tr>
<tr>
<td>Crop rotation¹</td>
<td>11.5 ab</td>
<td>11.5 ab</td>
<td>15.5 a</td>
<td>18 b</td>
<td>27.5 b</td>
<td>34 b</td>
</tr>
<tr>
<td>Fungicide</td>
<td>14 a</td>
<td>14 a</td>
<td>19 a</td>
<td>24 a</td>
<td>41.5 a</td>
<td>50.5 a</td>
</tr>
</tbody>
</table>

¹Plots were previously planted corn and sweet potato
Efficacy of Wood vinegar and neem leaf extract on fruit and shoot borer (*Leucinodes orbonalis* Guenee) of eggplant

Number of borer-damaged fruits under protected and open field cultivation as influenced by different treatments based on 12 plants
Efficacy of wood vinegar and neem leaf extract on the fruitworm (*Helicoverpa armigera* Hubner) of tomato

- **T0-** Tap water
- **T1-** Neem
- **T2-** Wood vinegar
- **T3-** Insecticide
Horticultural/agronomic studies

Variety recommendations made for sweet pepper, head lettuce, leaf lettuce and fresh/processing tomatoes
**Lettuce: varieties – open field/protected VSU**

✓ Grand Rapid, Green Span or Green Tower recommended

<table>
<thead>
<tr>
<th>Variety</th>
<th>Yield (T/ha)</th>
<th>Open field</th>
<th>Protected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Rose</td>
<td>c</td>
<td>c</td>
<td></td>
</tr>
<tr>
<td>Grand Rapid</td>
<td>ab</td>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>Green Span</td>
<td>a</td>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>Green Tower</td>
<td>a</td>
<td>a</td>
<td></td>
</tr>
<tr>
<td>Sunny Red</td>
<td>bc</td>
<td>b</td>
<td></td>
</tr>
</tbody>
</table>

Note: Open field and Protected yields compared for each variety.
Vegetable grafting
Sweet pepper: varieties and grafting - VSU

- Grafting increases tolerance to bacterial wilt
- Emperor and Sultan highest yielding

![Bar chart showing yield and plant survival for different pepper varieties. Emperors and Sultan have the highest yield, and grafted plants have higher survival rates.]
KAMLONG (*Kamatis* grafted to *Talong*): Yield (ton/ha)
KAMLONG : Percent (%) Bacterial Wilt Infection

Percent (%) Bacterial Wilt Infection

- T0: Ungrafted
- T1: Grafted w/out lateral
- T2: Grafted with one lateral
Ampatola (Ampalaya grafted to Patola): Varieties

- Mestisa – consistent high yield
- High survival for ampatola

Grafted

Yield (t/ha)  % Plant Survival

Mestisa  Moon Beauty  Poseidon

Mestisa  Moon Beauty  Poseidon

Grafted

Non-Grafted

✓ Mestisa – consistent high yield
✓ High survival for ampatola
Pruning technique

T0- no pruning
T1- main stem pruned at 3rd node
T2- main stem pruned at 7th node
T3- laterals w/in the first 0.5m of the main vine pruned

Yield (t/ha) Ampalaya
Yield (t/ha) Watermelon

T3 enhanced ampalaya yield
Table 3. Number and weight (t/ha) of fruits of the selected vegetables as influenced by different water delivery systems planted in house-type protective structure of ACIAR-ICM project, VSU, Visca, Baybay City, Leyte.

| Water delivery system | Yield (t/ha) |   |
|-----------------------|--------------|
|                       | Tomato       | Sweet pepper |
| Sprinkler             | 7.33 b       | 15.15 c      |
| Drip Bottle           | 13.80 a      | 28.09 a      |
| Drip Hose             | 8.75 b       | 21.69 b      |
Tomato Irrigation and **yield**: Claveria

<table>
<thead>
<tr>
<th>TREATMENTS</th>
<th>FRUIT SIZE (cm)</th>
<th>NUMBER OF FRUITS PER PLANT</th>
<th>YIELD PER PLANT (kg)</th>
<th>YIELD (t ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Polar</td>
<td>Equatorial</td>
<td>Marketable</td>
<td>Non-marketable</td>
</tr>
<tr>
<td>Irrigation System (A)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manual</td>
<td>4.80 b</td>
<td>3.55 b</td>
<td>47.54 b</td>
<td>12.62 a</td>
</tr>
<tr>
<td>Drip</td>
<td>5.39 a</td>
<td>3.97 a</td>
<td>60.77 a</td>
<td>8.01 b</td>
</tr>
<tr>
<td>Overhead</td>
<td>5.15 b</td>
<td>3.93 a</td>
<td>49.10 b</td>
<td>11.14 a</td>
</tr>
<tr>
<td>F-test</td>
<td>*</td>
<td>*</td>
<td>**</td>
<td>**</td>
</tr>
</tbody>
</table>

✓ Drip irrigation increases yields and fruit size
## Tomato Irrigation and disease: Claveria

<table>
<thead>
<tr>
<th>TREATMENTS</th>
<th>DISEASE INCIDENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 DAT</td>
</tr>
<tr>
<td>Irrigation System (A)</td>
<td></td>
</tr>
<tr>
<td>Manual</td>
<td>1.04 b</td>
</tr>
<tr>
<td>Drip</td>
<td>1.03 b</td>
</tr>
<tr>
<td>Overhead</td>
<td>1.22 a</td>
</tr>
</tbody>
</table>

**F-test**

** Drip irrigation reduces disease incidence

### Disease Incidence Rating:

- **0** – none of the total population
- **1** – 1-25 % of the population
- **2** – 26-50 % of the population
- **3** – 51-75 % of the population
- **4** – 76-100 % of the population
Net covered low tunnels

- VSU trials: 6 x lettuce and pechay
- Bohol: 2 trials
- Samar: 1 trials
Leafy vegetables under low tunnels:
Good weather during the dry season = No effect of protected cropping, however…

![Graph showing yield comparison between open cultivation and netted tunnel for various leafy vegetables.](image-url)
**Rainy season**: low tunnels are much better

**Lettuce (Yield/3.33m² plot (kg))**

<table>
<thead>
<tr>
<th></th>
<th>OPEN FIELD</th>
<th>PROTECTIVE STRUCTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seedling</td>
<td>4.5</td>
<td>13.1</td>
</tr>
<tr>
<td>Seedbed</td>
<td>2.4</td>
<td>6.9</td>
</tr>
</tbody>
</table>

**Kankong Yield (t/ha)**

<table>
<thead>
<tr>
<th></th>
<th>OPEN FIELD</th>
<th>PROTECTIVE STRUCTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct sowing</td>
<td>32.9</td>
<td>58.3</td>
</tr>
<tr>
<td>Seedling tray</td>
<td>30</td>
<td>51.7</td>
</tr>
</tbody>
</table>
Protected cropping in Samar and Bohol

Benefit of house type protected cropping confirmed for Leyte.

Poor pest and disease control in Bohol and Claveria masked results (very low yields and high variability)

• Trials:
  – VSU: 7 trials
  – Samar: 1 trial
  – Bohol: 2 trials
  – Clavaria: 6 trials
Tomato yield under house type protected cropping across three sites

Higher tomato yields under structures at VSU.

Poor pest management and bacterial wilt at other sites confused results.
Tomato: open field v’s protected cropping at VSU

Yield

<table>
<thead>
<tr>
<th></th>
<th>Marketable yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabbage Waste</td>
<td>35</td>
</tr>
<tr>
<td>Control</td>
<td>20</td>
</tr>
<tr>
<td>Forest Leaf Litters</td>
<td>15</td>
</tr>
<tr>
<td>Chromolaena odorata</td>
<td>10</td>
</tr>
</tbody>
</table>

Open Field       | Protected

**Gross margin**

- 1. Cabbage waste
- 2. Leaf litter
- 3. Siam Weed
- + Protected cropping

*Less Bacterial Wilt*

**Marketable yield (t/ha)**

- Cabbage Waste: 35
- Control: 20
- Forest Leaf Litters: 15
- Chromolaena odorata: 10

**Gross margin (x1000 PhP/ha)**

- Cabbage Waste: 460
- Control: 360
- Forest Leaf Litters: 314
- Chromolaena odorata: 294
Crop establishment

- Seedling trays, seedbox to field, seedbox to trays, direct seeding

- Lettuce: Seedling trays
- Pechay: Seedling trays
- Kangkong: Direct sowing
Seedling trials: Pechay across three sites

![Graph showing yield (t/ha) for different regions (Leyte, Samar, Bohol) and treatments (Open field, Protected) with bars indicating pricked out seedlings, seedling trays, and direct seed.]
Seedling trials: Lettuce

Marketable yield

- Seedling trays
- Seedbox to field
- Seedbox to trays
- Direct seed

Gross margin

- Seedling trays
- Seedbox to field
- Seedbox to trays
- Direct seed

✓ Use of Seedlings trays is the best
Seedling trials: Kangkong

Open field

✓ Direct sowing gave similar result

Protected
Mulches and amendments

- 18 trials across VSU, BISU and MOSCAT
- Coloured plastic mulches, organic amendments; hagonoy (Chromolaena odorata), rice straw and hull, sunflower (Helianthus annus L.), wedelia (Wedelia trilobata L.), kakawate (Gliricidia sepium Jacq.)
- Sweet pepper, tomato, ampalaya, cabbage, pechay and lettuce
Organic amendments: tomato - VSU

- Higher yields with soil amendments
- Increased plant survival
Organic amendments: Pechay (low tunnels)

- Hagonoy and ricehull best under structures
Organic mulch and *weed control*

---

### Open field

- **Tomato**
  - Bare soil: a
  - Rice hull: c
  - Rice straw: bc
  - Kakawate: b
  - Hagonoy: b

- **Sweet pepper**
  - Bare soil: a
  - Rice hull: c
  - Rice straw: b
  - Kakawate: b
  - Hagonoy: b

- **Ampalaya**
  - Bare soil: a
  - Rice hull: c
  - Rice straw: bc
  - Kakawate: b
  - Hagonoy: b

### Protected

- **Tomato**
  - Bare soil: a
  - Rice hull: b
  - Rice straw: b
  - Kakawate: b
  - Hagonoy: b

- **Sweet pepper**
  - Bare soil: a
  - Rice hull: c
  - Rice straw: bc
  - Kakawate: b
  - Hagonoy: b

- **Ampalaya**
  - Bare soil: a
  - Rice hull: b
  - Rice straw: bc
  - Kakawate: b
  - Hagonoy: b
Plastic mulch: Sweet pepper

Silver and black plastic resulting in higher yields in open field only

Bar chart showing yield (t/ha) for different types of plastic mulch in open field. The chart indicates that silver and black plastic resulted in higher yields compared to other colors.
Plastic mulch: Tomato yield open field

Mindanao Yied (t/ha) Bare soil Black Silver Green Red Blue c ab a c bc a

ACIAR
Structures: new developments/modifications

High tunnels: light bamboo or steel frames.

Light framed house type structures with easily detachable plastic roof
Protective structure served as trellis
# GROSS MARGIN ANALYSIS OF VSU SET-UP

<table>
<thead>
<tr>
<th>Crop</th>
<th>Revenue</th>
<th>Variable Cost</th>
<th>Gross Margin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Materials</td>
<td>Labor</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweet Pepper grafted to Chili Pepper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protected</td>
<td>22,904.00</td>
<td>3,884.10</td>
<td>9,546.88</td>
</tr>
<tr>
<td>Open Field</td>
<td>21,308.00</td>
<td>3,884.10</td>
<td>10,684.38</td>
</tr>
<tr>
<td>Lettuce</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protected</td>
<td>32,266.67</td>
<td>872.31</td>
<td>4,401.04</td>
</tr>
<tr>
<td>Open Field</td>
<td>26,400.00</td>
<td>872.31</td>
<td>4,713.54</td>
</tr>
<tr>
<td>Tomato</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protected</td>
<td>25,940.00</td>
<td>3,000.44</td>
<td>8,527.08</td>
</tr>
<tr>
<td>Open Field</td>
<td>4,990.00</td>
<td>3,000.44</td>
<td>9,102.08</td>
</tr>
</tbody>
</table>
ICM skills and research capacity building

ICM Master Class

Dr. Gordon Rogers presentation on plant nutrition

Dr. Len Tesoriero showed pictures of different diseases and other stresses of vegetables

Dr. Sukhvinder Singh presentation on food safety

Hands-on collection of soil samples by participants
Chrysanthemum – Organic Amendments under 2 types of Cultivation
Impacts

- **Integrated crop management** developed best practice materials, pest and disease and agronomic methods to produce high quality vegetables.

The project improved annual farm income by 50% with farmers participating in project-run farmer field schools (FFS).
What’s next?

• Developing vegetable value chains to meet evolving market expectations in the Philippines

• Vegetable-GAP
THANK YOU!