The Role of Weather Information on Carrot Yield Performance- Empirical Evidence from Field Data in Chinese Taipei

Presented at APEC Climate Symposium (APCS) 2012 on "Harnessing and Using Climate Information for Decision Making-An In-Depth Look at the Agriculture Sector", St. Petersburg, Russia, Oct. 8-11,2012

by

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Outline

- Introduction
- Empirical Analysis
- Major Findings
- Conclusions

Vegetables create more jobs and higher income than staple for smallholders

Introduction- 1

- In a county government budget meeting, proposals from farmers' groups are reviewed
- One co-op chairman raised a request to setup a **local weather monitoring station**

- **WHY**?(quoted from the chairman)
  - "My father told me we cannot make money every year, but we can break-even if we can win twice in every 5~10 years."
  - "Weather forecast do not have to be correct every time. If it is correct one time, I can make money out of it."
  - "My friends in watermelon business know how to use cumulated temperatures to decide when to harvest, so I need to learn how I can use weather info to produce good quality carrots for my client."
  - "I cannot control how farmers manage their crops, but I need a systematic way to predict how much risk is involved before signing my contract."

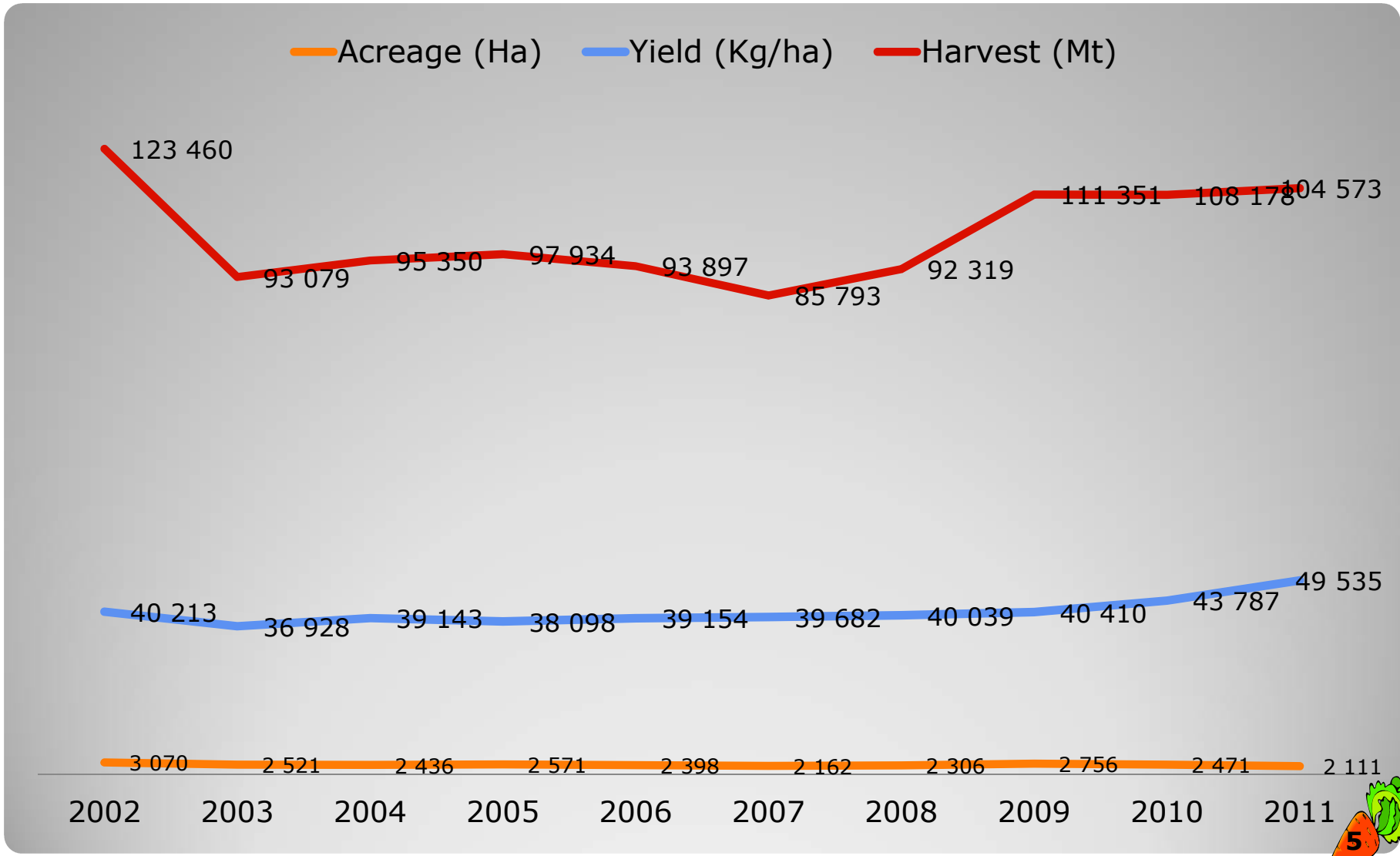
Introduction-2

Why Carrot?

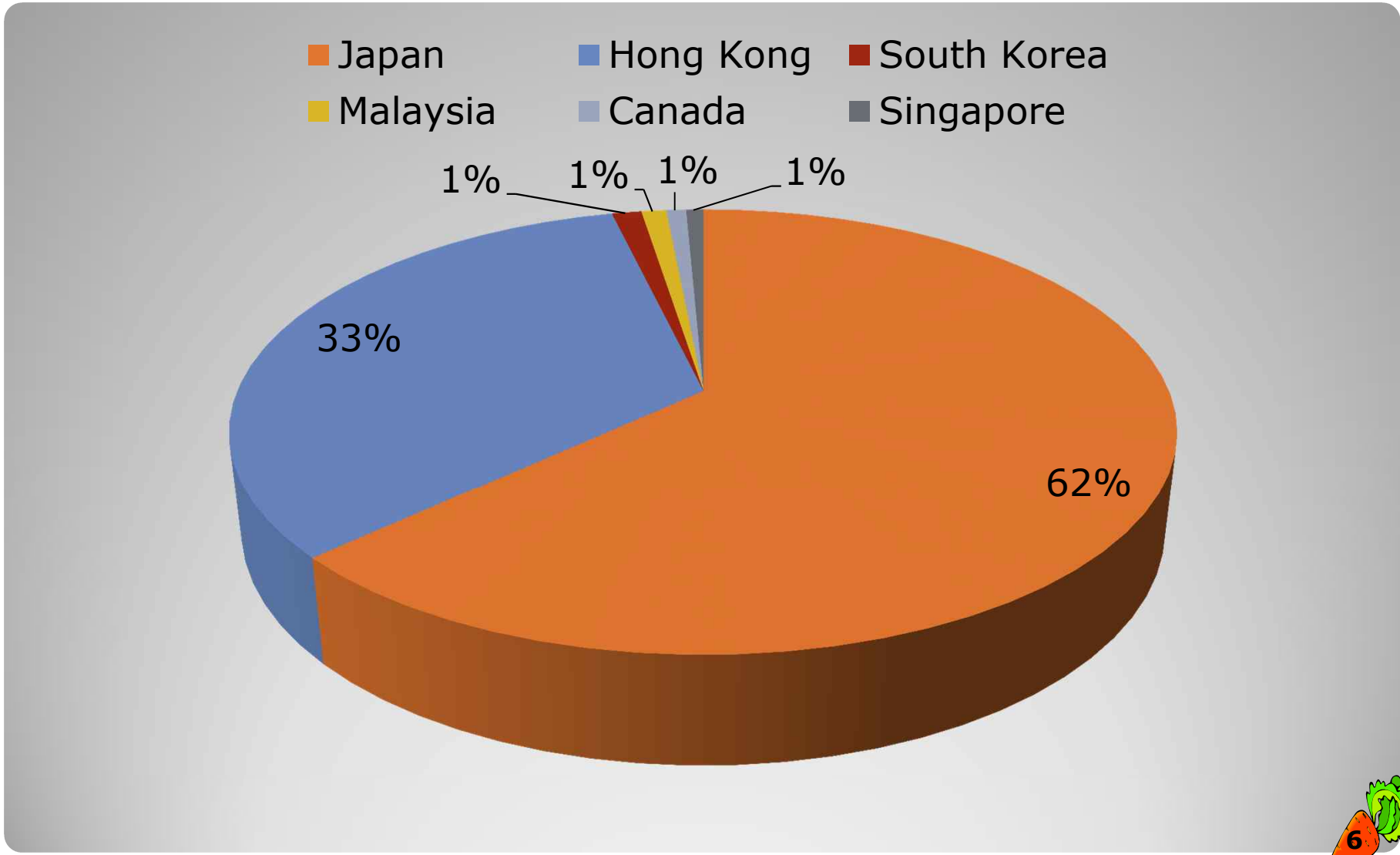
- ✓ **Agronomy Side**
  - **Root crops** are produced in **open field**
  - Most vegetables prefer cooler temperatures, thus warming will lower their productivity
  - Management on **chemical residues** is critical
  - ➔ **Need to work with nature, not against nature**
- ✓ **Economics Side**
  - Important cash crop in 2nd/3rd crop season for small farms.
  - **Export Contracts**
    - Seasonal difference from Japan
    - Require specific quantity, quality, and date of delivery.

➔ **Intensify needs for timely weather information**

Intorduction-3
Carrot Production, Acreage and Yield



Export market



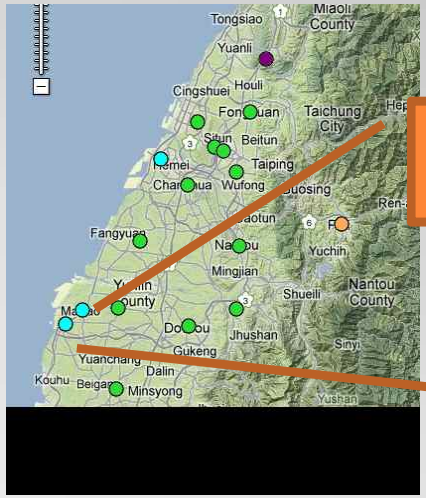
Introduction-4
Objectives

Key Question ➔How to customize weather info services to meet demand?

- Link **field data** and local weather data **directly**
  - Public-funded R&Ds are done on staple and main export crops
  - Growing demand in emergent markets from:
    - contract farming
    - index-based crop insurance contract
- Identify **Temperature and precipitation thresholds** affecting crop yield performance
  - Not all forecasts are accurate
  - Preventive measures can be developed to reduce losses

Empirical Analysis-1
Study sites

- Located at central Taiwan and marked in blue
- Belongs to 2 counties divided by a river



Er-lin village

Dong-shih village

Empirical Analysis-2 Data

- Field data of carrot
  - Collected from 275 farms of a carrot co-op
  - locations
  - Planting/Harvest date
  - Irrigation type
  - Carrot yield
  - Class (by size)
- Climatic data
  - 2 EPA monitoring stations
  - Temperature: hourly averaged
  - Precipitation: hourly accumulated

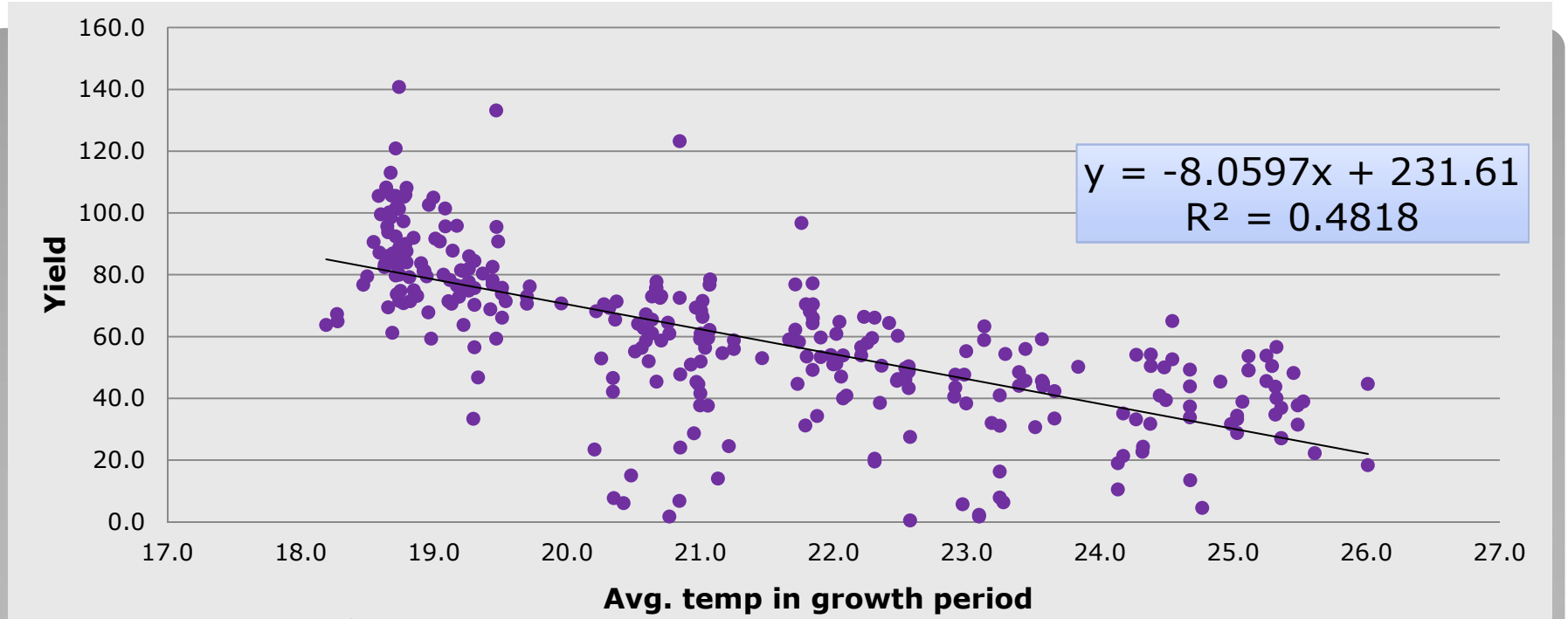
Empirical Analysis-3
Factor analysis

Location	Yield	Temp.	Prec.	Sowing date	Irrigation	Soil
Er-lin Village	**High**	Low	High	August September October	Canal, Spray	Loam, Sand
Dong-shih village	**Low**	High	Low	August September	Canal	Loam

*: Indicated statistical significant differences (P<o.oo1)

Empirical Analysis-4

Does temperature have impacts on yield?

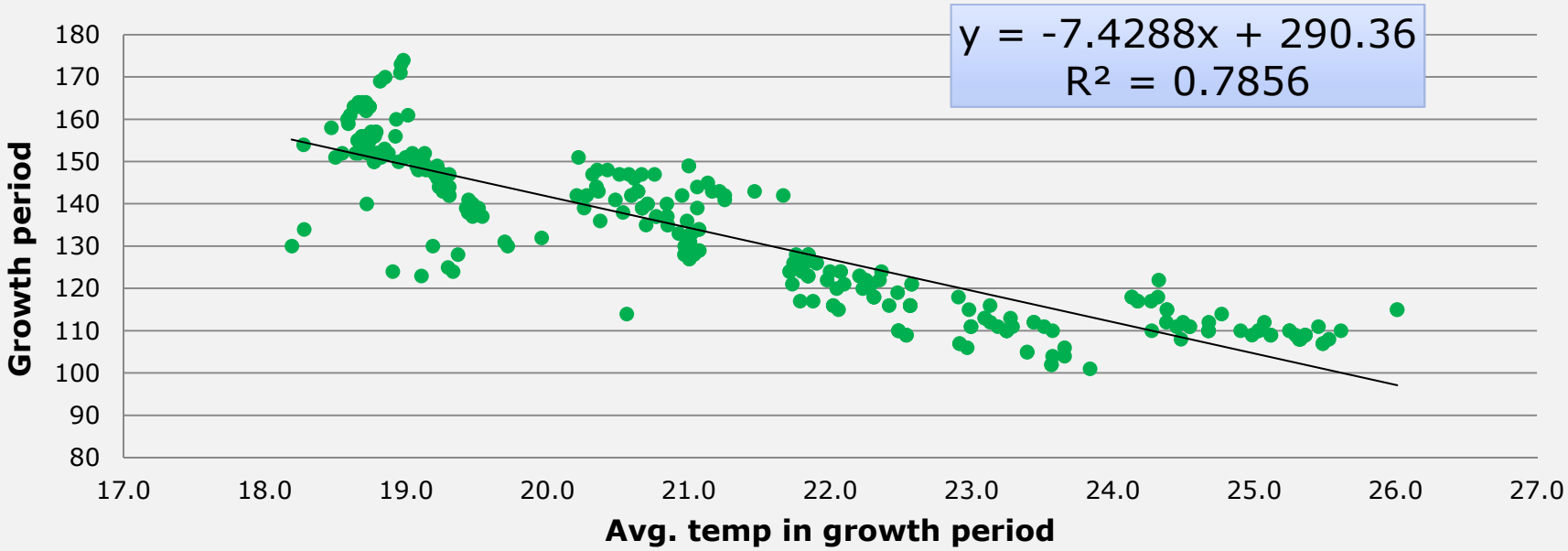


➔Cooler weather have positive impact on yield

	ANOVA				
	df	SS	MS	F	P-value
迴歸	1	90319.19	90319.19	271.4633	1.4E-43
殘差	292	97152.02	332.7124		
總和	293	187471.2			

Empirical Analysis-5

Does temp have impact on the length of growing period?



Warmer weather shorten the length of growing period

ANOVA					
	df	SS	MS	F	P-value
迴歸	1	76732.38	76732.38	1070.16	1.2E-99
殘差	292	20936.95	71.70188		
總和	293	97669.33			

Empirical Analysis-6 Methodology

- **Thresholds of growing temperature** can be estimated by **the maximum Pearson Correlation coefficients** of
  - Observed yield and Hours of Growing Degree (HGD)
  - Observed yield and Hours of Growing Rainfall (HGR)

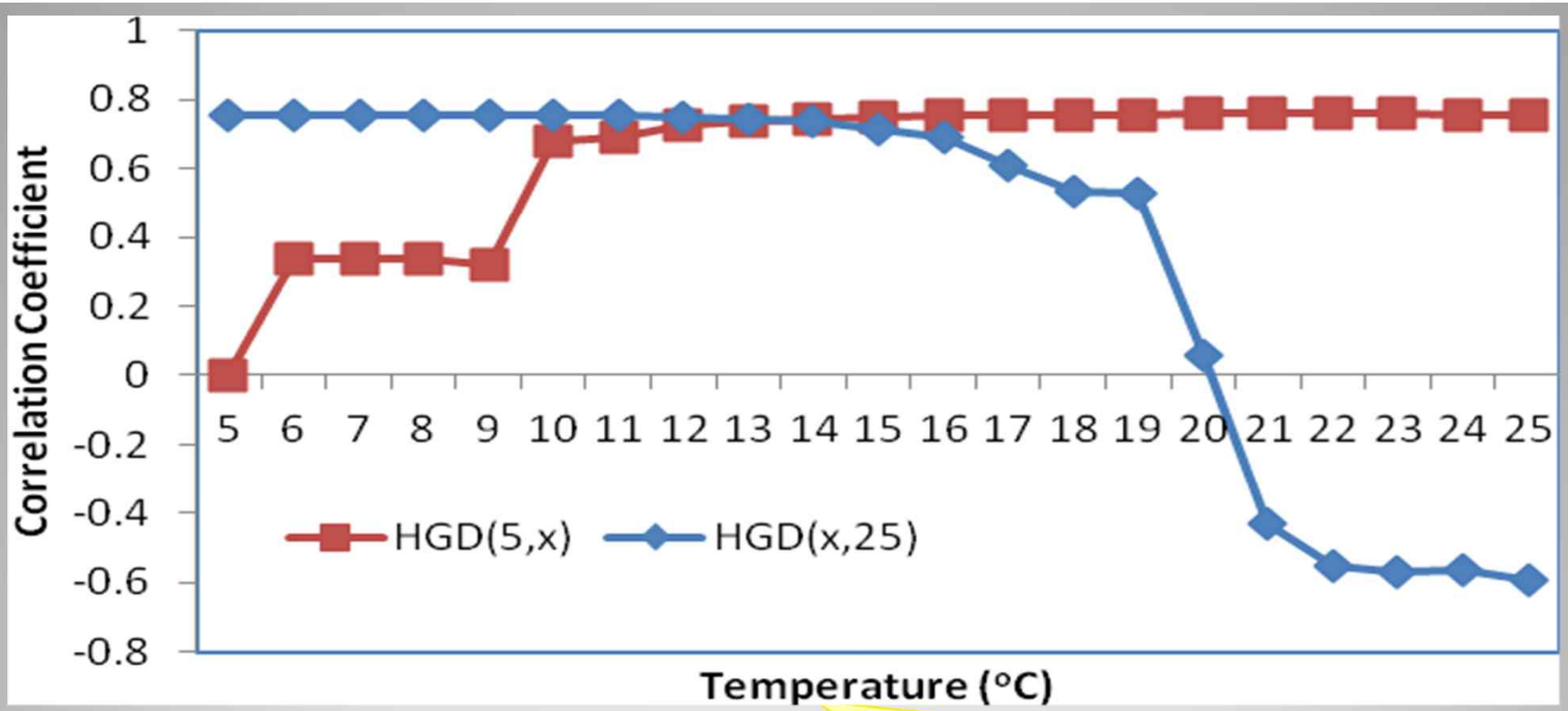
$$HGD_{min,max} = \sum_{t=1}^{N} H_t \,, \quad H = \begin{cases} 0 & \text{if } T_t < T_{min} \text{ or } T_t > T_{max} \\ 1 & \text{if } T_{min} \le T_t \le T_{max} \end{cases}$$

- t: an individual hour within the growing season
- T_t: observed average temperature during the hour
- N: number of hours between sowing and maturity, i.e. length to maturity

Example:

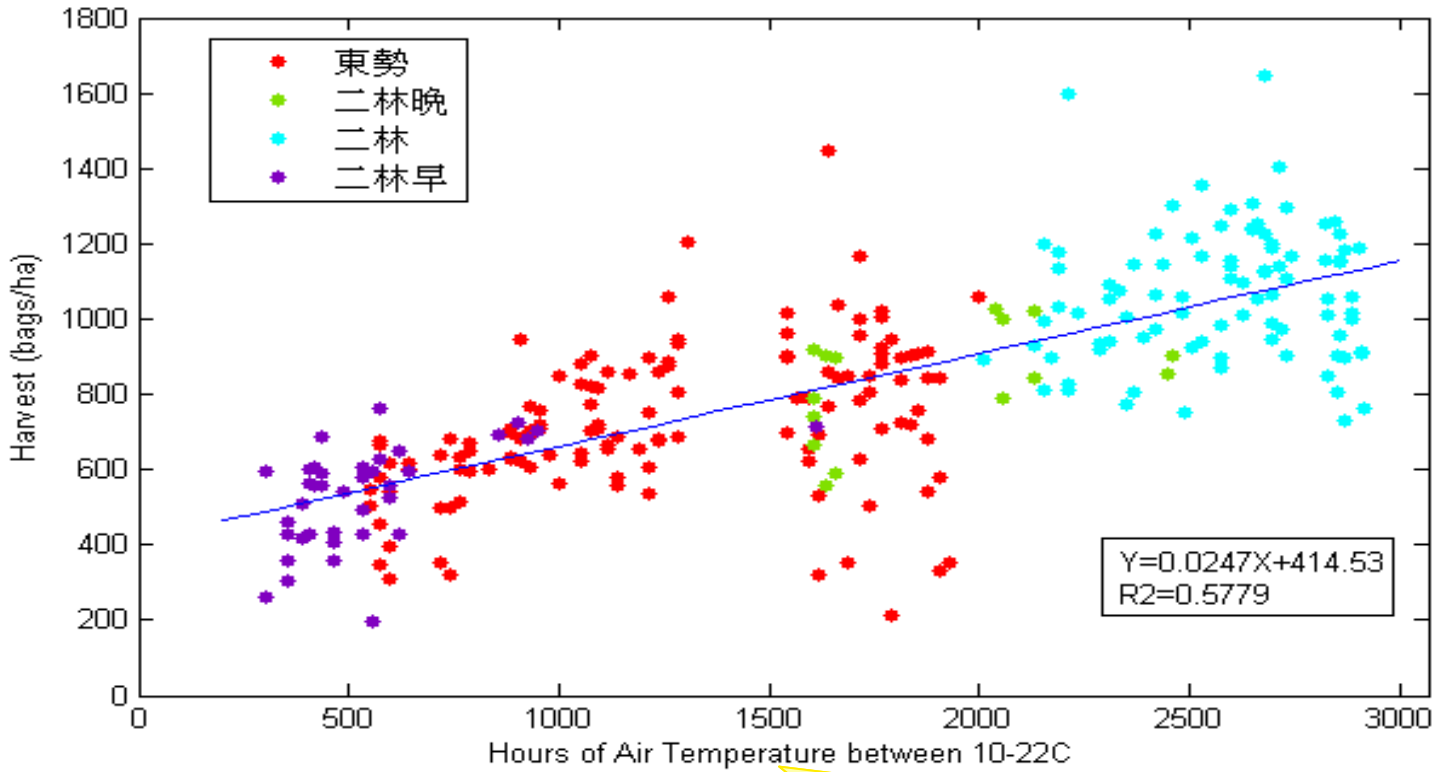
- **$HGD_{5,30}$** corresponds to equation with T_{min}=5°C and T_{max}=30°C
- **$HGR_{0,2.5}$** is the total hours of accumulated rainfall between 0mm and 2.5mm.

Major Findings-1
Optimum Temperature Range



- **Optimum growing temperature is between 10-17C.**
- **Temperature below 10C and above 21C may reduce yields**

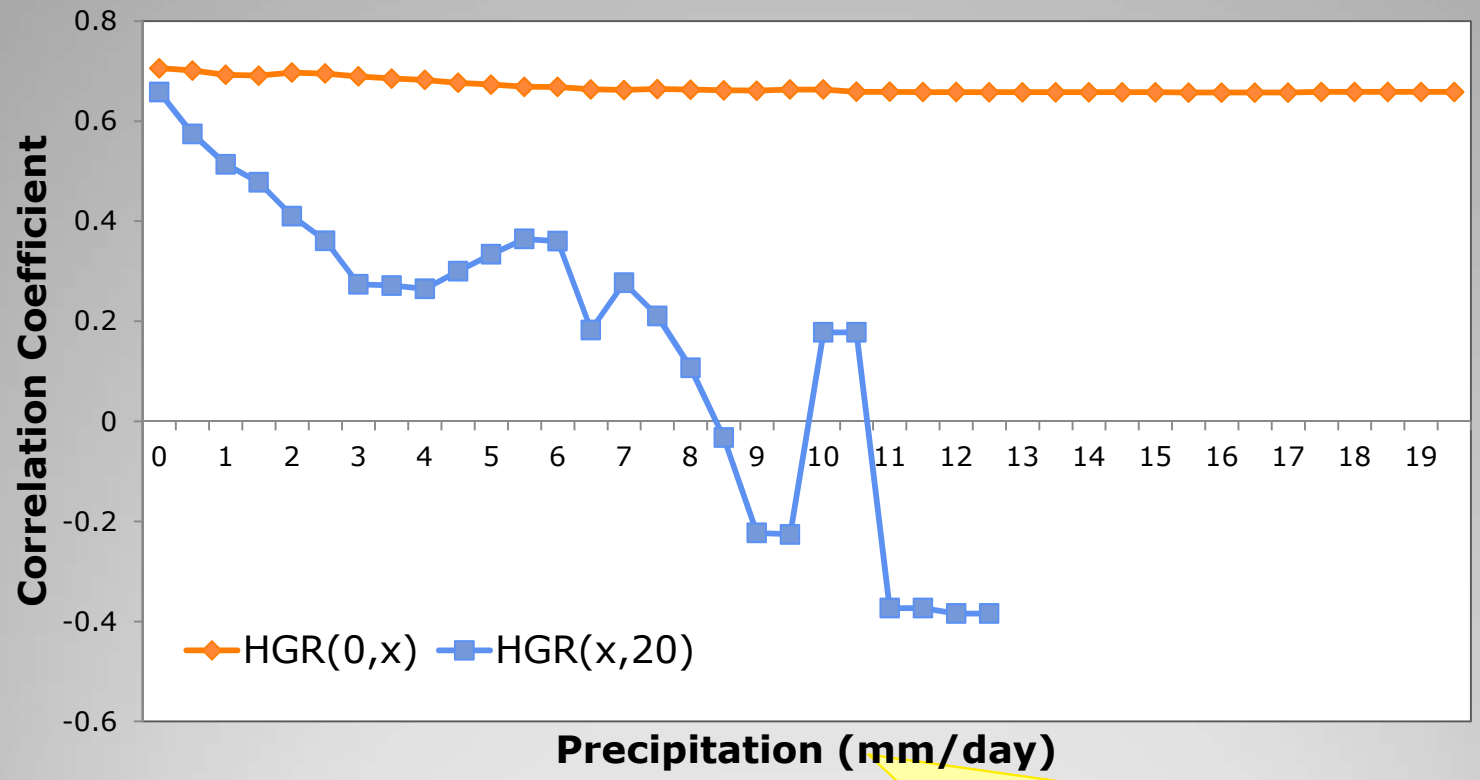
Major Findings-2
Yield and $GDH_{10,21}$ are positively correlated



Scatter distribution of yield and $GDH_{10,21}$

➔Carrot yield is positively related to the no of hours in the optimal temperature range (10-21°C).

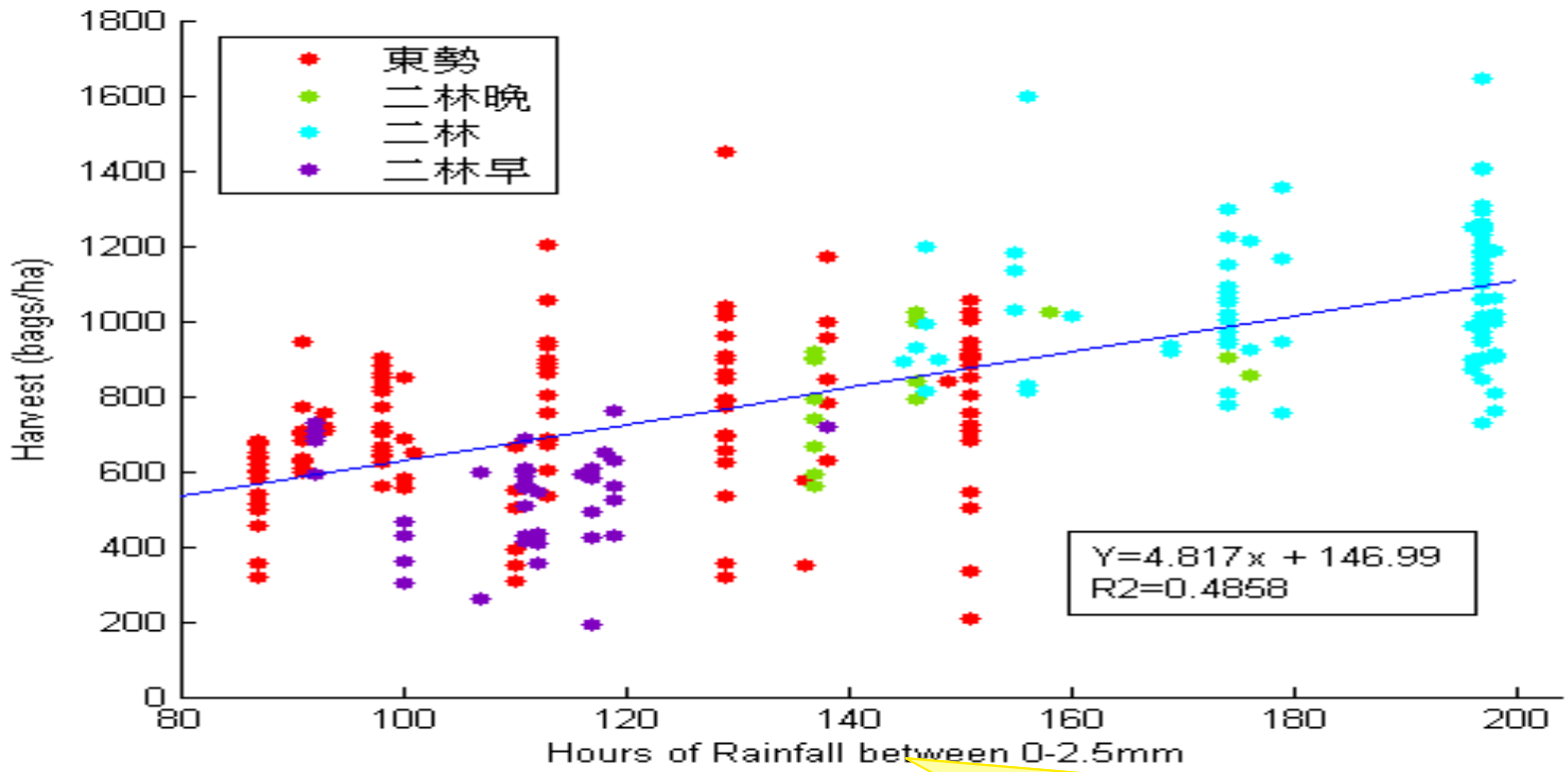
Major Findings-3
Optimum Rainfall Range



- Cannot identify the optimal range for precipitation
  - No direct correlation between HGR and yield.
- Rainfall strength larger than **8~10mm/hr** may cause damage on yield

Major Findings-4

Yield and $HGR_{0,2.5}$ are positively correlated



- Despite irrigation control, hours of rainfall less than 2.5mm **($HGR_{0,2.5}$)** are **positively** related to final yield

Major Findings-5
Multiple regression analysis

	Coefficient estimates	Standard Deviation	t -statistics	P-value
Intercept	92.11766	19.33655	4.76391	0.00000
$HGD_{10,21}$	0.02885	0.00509	5.67146	0.00000
$HGR_{0,2.5}$	-0.01231	0.00769	-1.59994	0.11078
Irrigation (Canal)	-11.30040	3.61583	-3.12526	0.00197

- **$HGD_{10,21}$** is a **positive** contributor to yield → **confirmed**
- **$HGR_{0,2.5}$** is negative but insignificant → **need better indicators**
- **Canal irrigation** is **negatively** associated with yields significantly.

Conclusions – Value Come from Downstream Users

- **Farming is sensitive to weather**
  - ✓Optimal temperature can be identified ➔ No risk
  - ✓**Uncertainty in rainfall** becomes a major risk factor
- **Weather forecasts can be instrumental in:**
  - ✓Reduce potential losses from natural hazards
  - ✓Stabilize **farm income**
- **Value of weather information depends upon:**
  - ✓**How** to transform local weather info into agron info?
  - ✓**When/How** to disseminate this information?
  - ✓**Who** should be the targeted recipient?
  - ➔**Who determines the price farmers received?**
  - ➔**Is customized weather info still "public " goods?**

Conclusions – Implication for Decision Making

1. Decision-Making "Before Planting"

- **Traditional wisdom**
  - ➔ Need vegetable germplasm to reduce environmental stress
  - ➔ Need seasonal forecast to select crop variety
- **New challenges**
  - ➢ Market offers better prices for off-seasonal harvests
  - ➢ Market demands safe/organic products

➔How to provide farmers "advanced knowledge" to meet conflicting demand?

Conclusions – Implication for Decision Making

Decision Making "After Planting"?

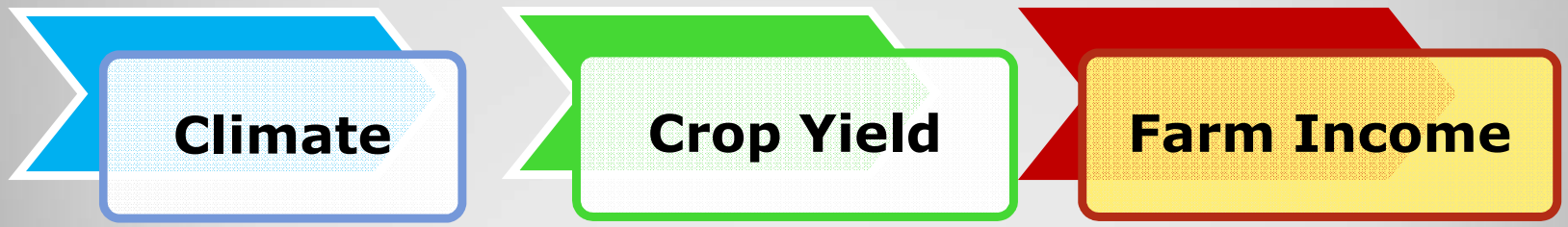
- Raised beds
- Mulching
- Nets, shelters

➔**Need to decide whether to invest**

➔**Need innovations to reduce labor and costs**

Conclusions :
Public or Private Goods?

- Weather is critical in all stages of crop growth and market value.
  - Scientific Side
    - Will climate change enhance environmental stress on crop?
    - Can weather info offer an opportunity to raise farm income?
  - Policy Side
    - Who should pay-Is customized weather info public or private goods?
    - What kind of public-private partnership is needed?
    - How should the supply chain be involved?



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COMMENT WELCOME


辛苦採收。


篩選。


自動化清洗。


分級包裝。