TAIWAN INT'L WATER WEEK

Oct. 12 ‣ 14

綠色永續下 創新水戰略

Innovative Strategies for Water Sustainability

International Forum 2022

中華民國經濟部 Ministry of Economic Affairs, R.O.C.(Taiwan)

經濟部水利署 Water Resources Agency, MOEA

Taiwan External Trade Development Council TAITRA

TAIWAN INT'L WATER WEEK

Paddy Irrigation System and Smart Irrigation Management

Dr. Frederick N.-F. Chou
Adjunct Professor,
Department of Hydraulic and Ocean Engineering,
National Cheng-Kung University

TAIWAN INT'L WATER WEEK

Acknowledgement

To sponsors and all partners collaboratory working on

Precise Irrigation Projects, 2017~2020

1
Paddy Irrigation in Taiwan

Paddy Irrigation in Taiwan

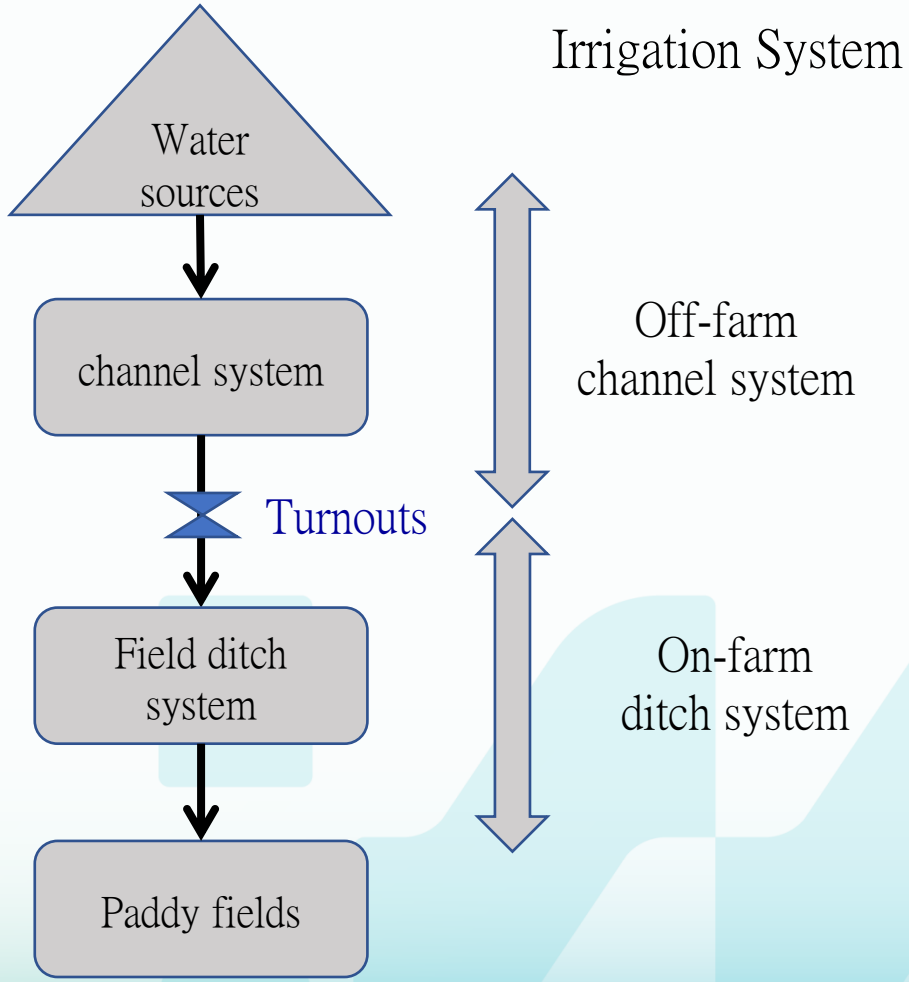
(Cited from Dr. Chih-Hung Tan)

Agricultural Water Use

- Agricultural water consumption accounts for 62.4% of the total water use in Taiwan
- The largest percentage of agricultural water use is paddy field irrigation
- One of the major concern of water saving in Taiwan is to improve the water use efficiency of paddy fields

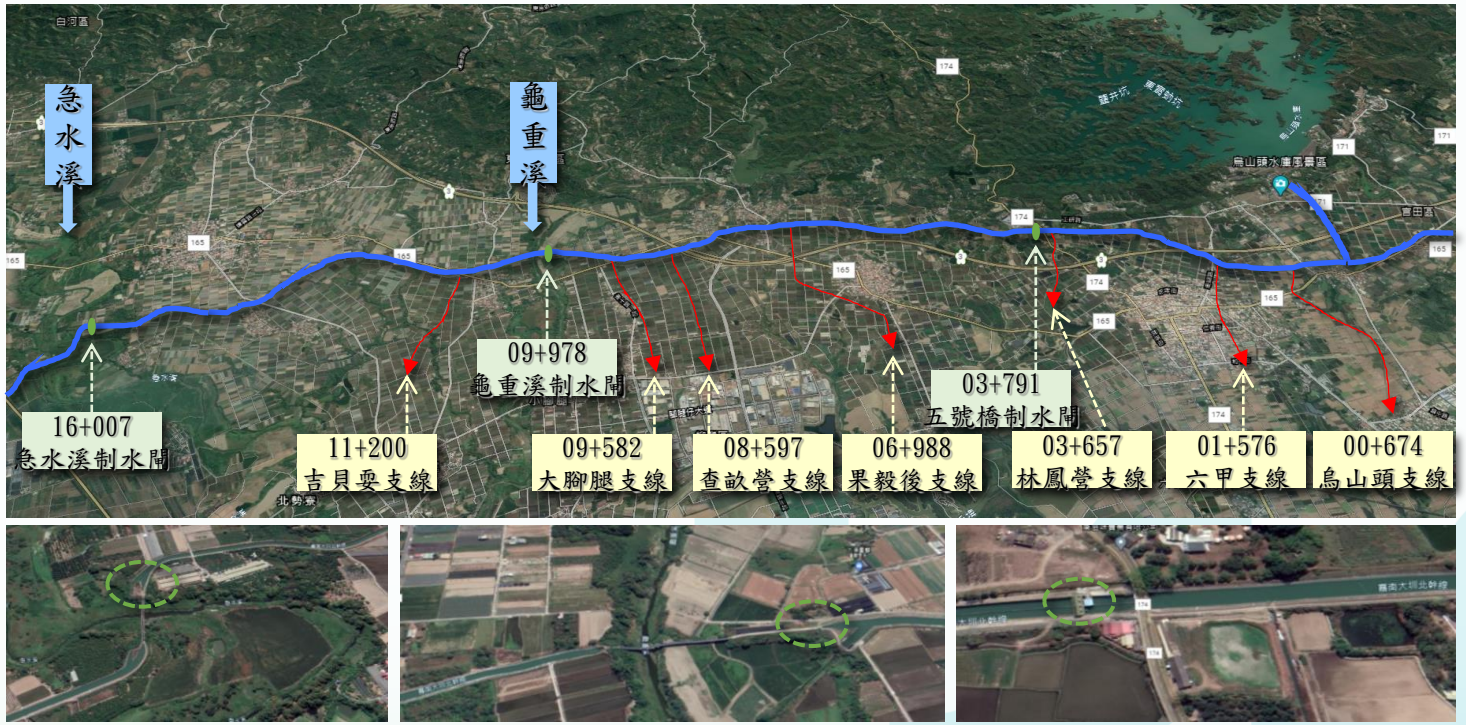
Irrigation Systems

- Irrigation water supply and operation practice are divided into two consecutive systems in general:
  - water delivery of off-farm channel system, and
  - field irrigation of on-farm ditch system



Goal of Conveyance Water Management

- Water delivery channel system: Reduce water discharge error of channels
- Operators: professional official of irrigation management office
  - control the opennings of check and intake gates from diversion weir till last turnouts, to keep accurate water discharge in all channels

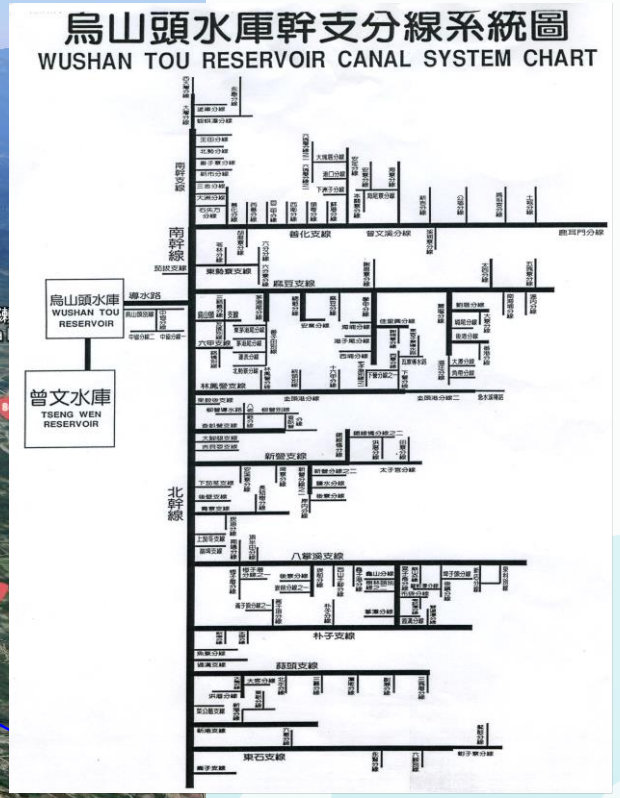


Goal of Field Irrigation Water Management

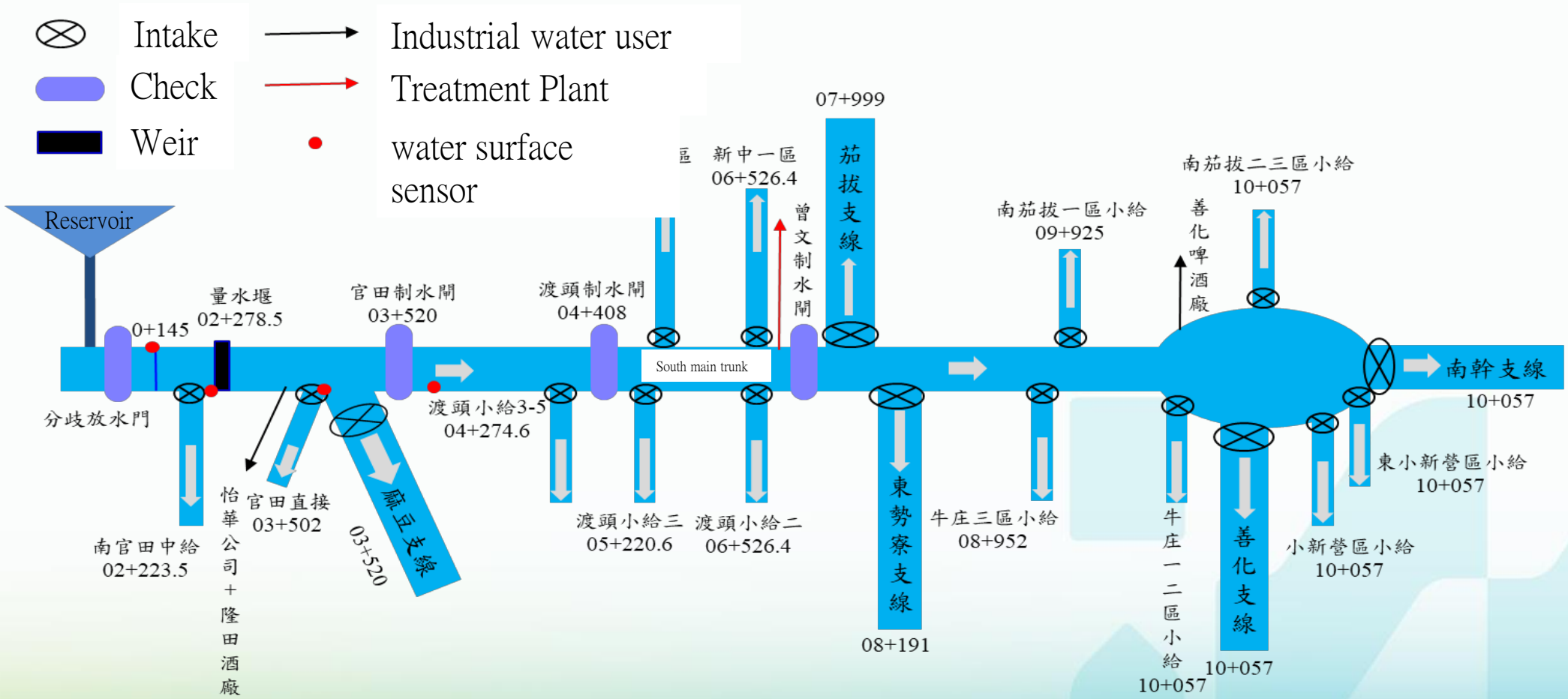
- Field irrigation ditch system: Reduce water losses in field
- Irrigator: Farmer
  - mostly old man, more than 70 years old in average (2016)
  - distribute water based on experience
  - need to precisely allocate required water to different fields

2
Smart Management of Paddy Irrigation

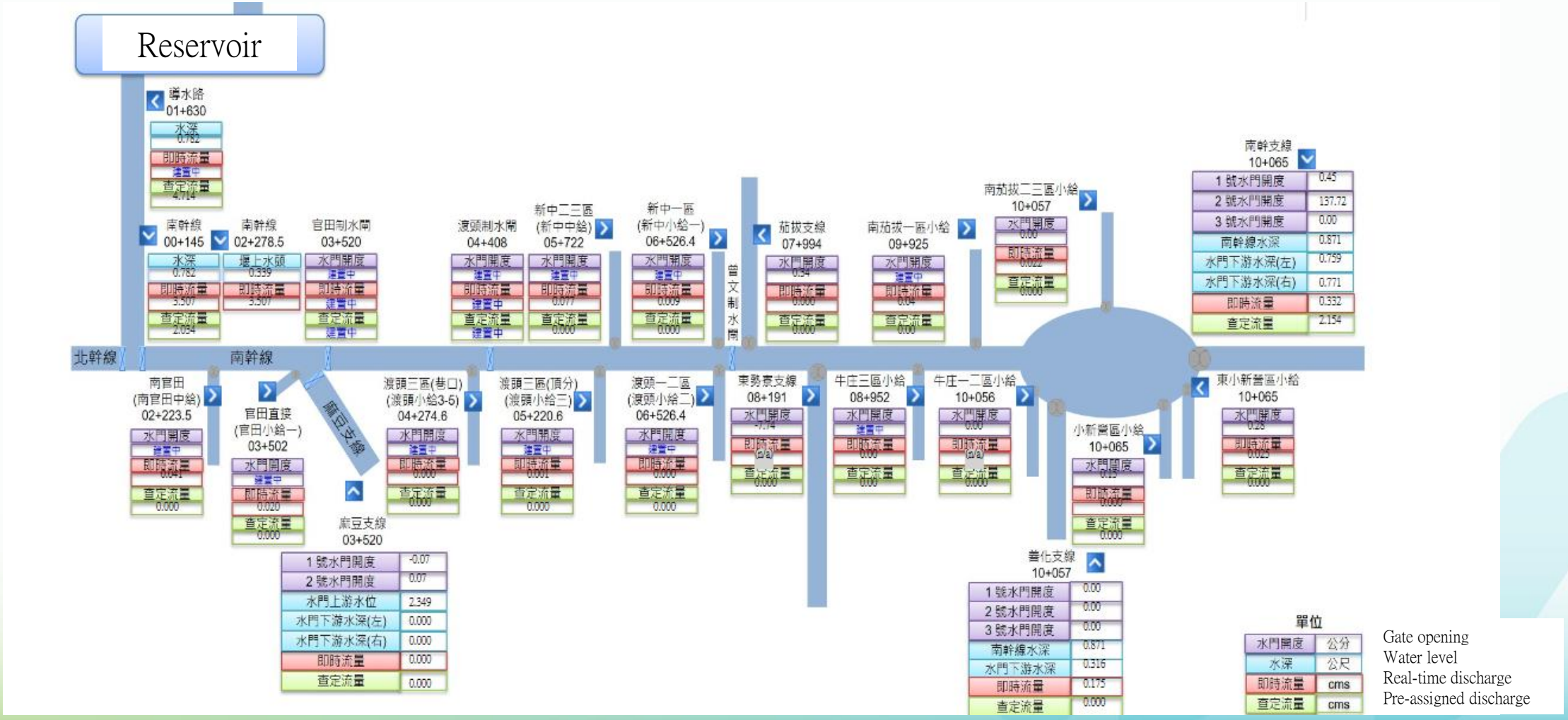
Off-farm System: Water Delivery channels



Flow Control Devices of Trunk channel



Intelligent Management Platform



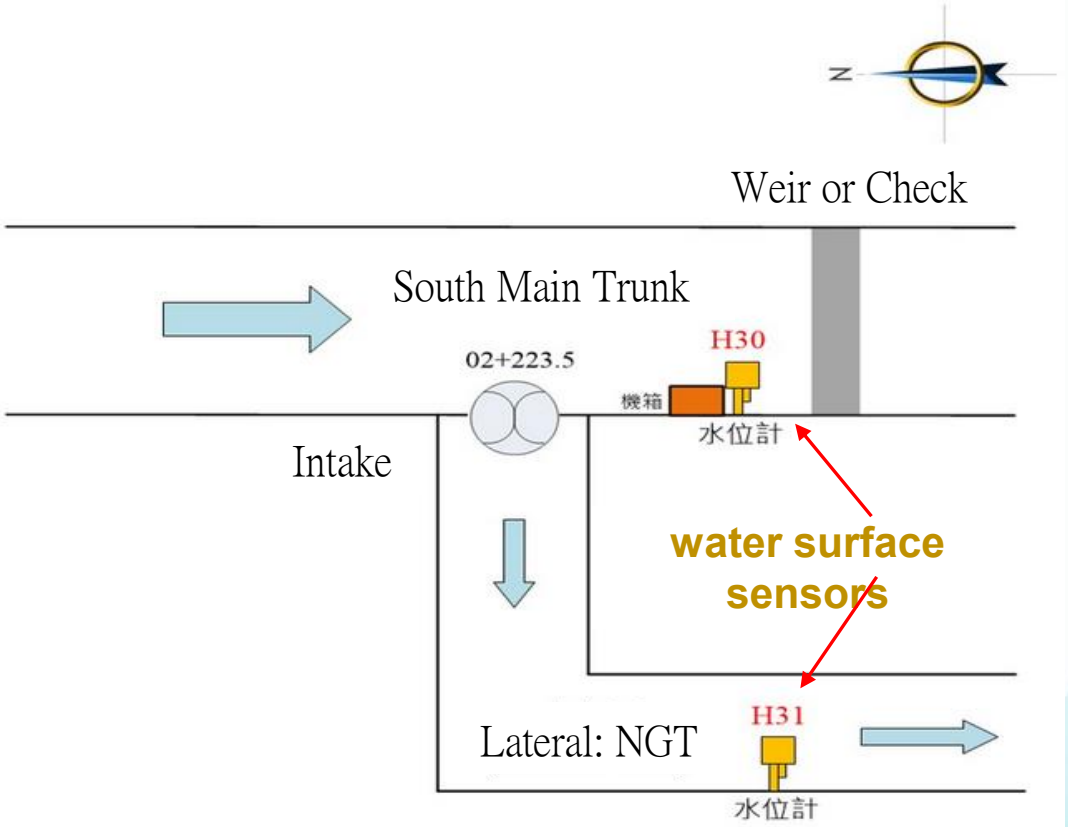
water surface(Discharge) Observation System

Lateral: NGT

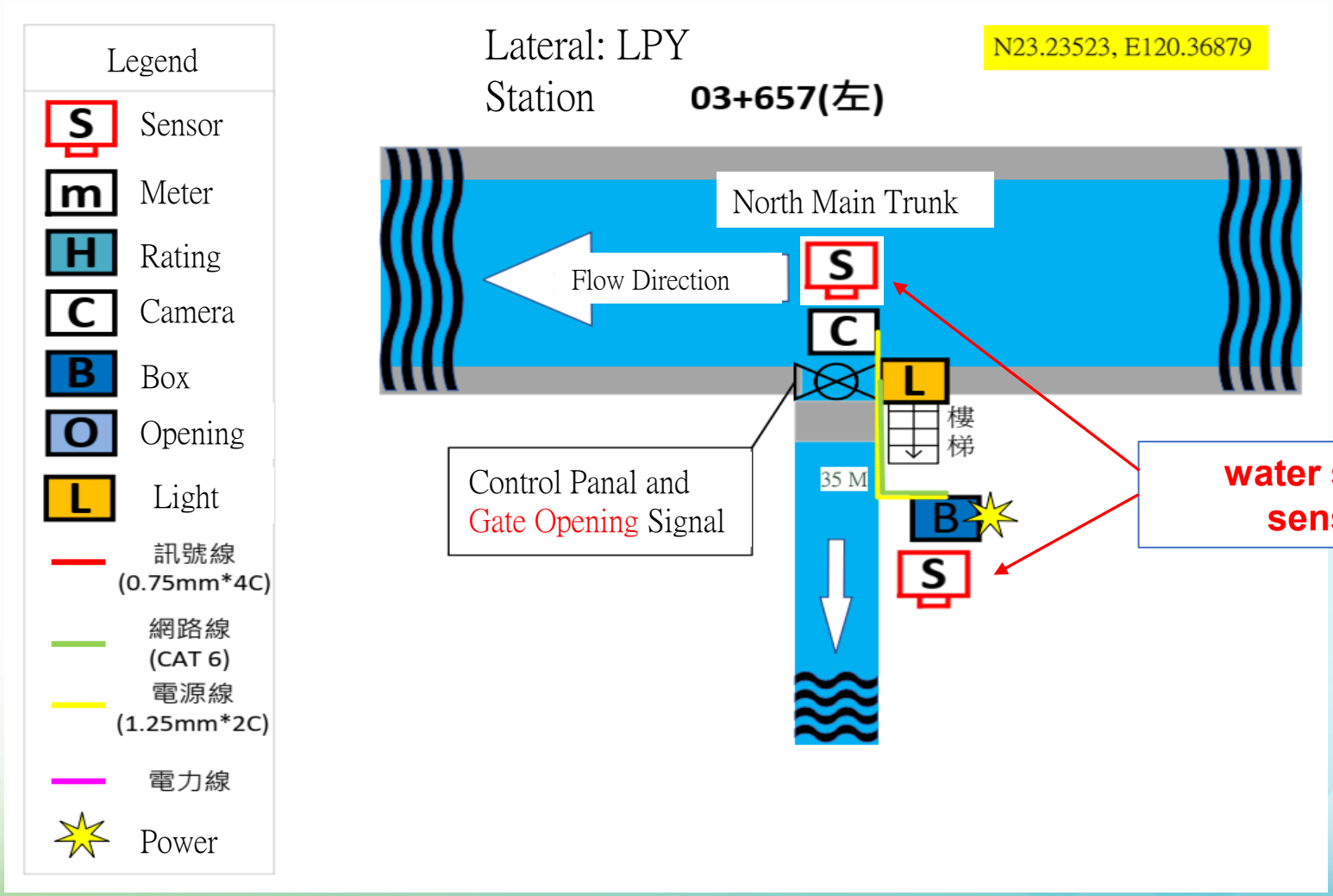
Water surface South Trunk	0.339	m	(H30)
Gate Opening	5	cm	
Water surface NGT Lateral	0.211	m	(H31)
Actual Discharge	0.041	cms(率定)	
Pre-assigned Discharge	0.045	cms	

設備狀態

Power	NB訊號	4G訊號	Warning
			



water surface (Discharge) Observation System



Video and Camera

Gate Opening Measurement

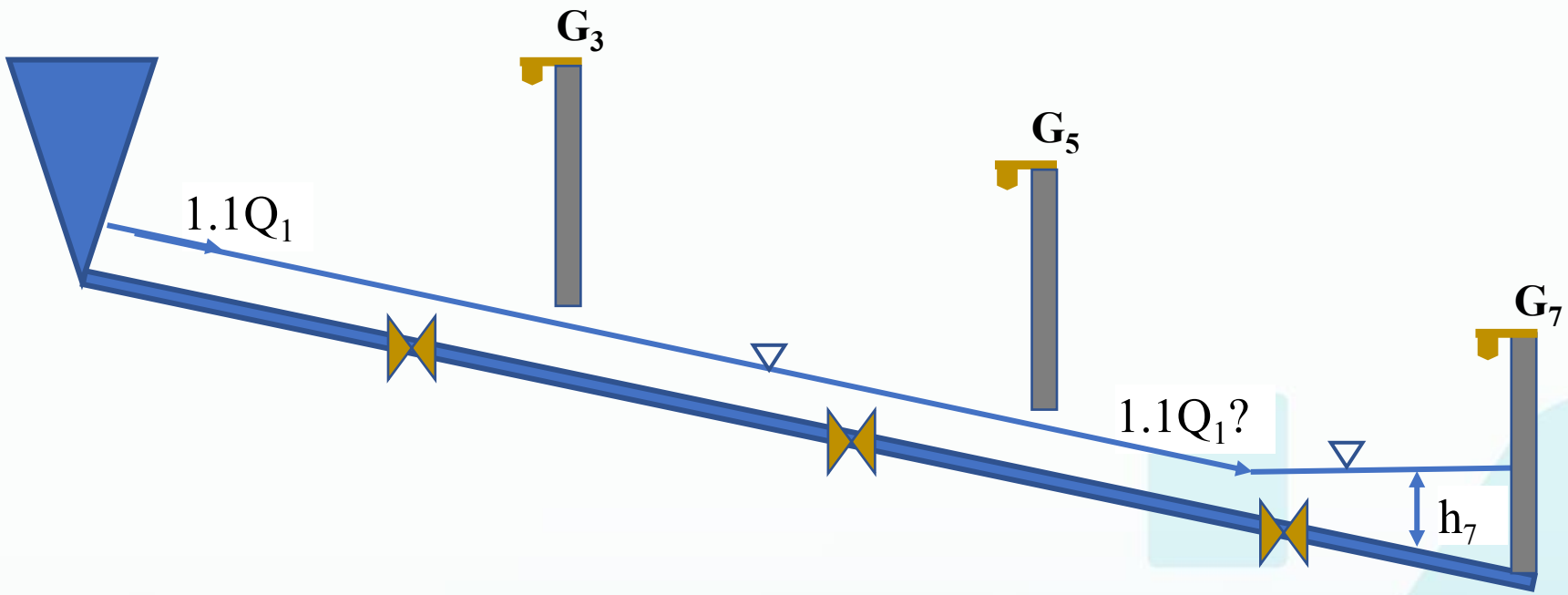
Automatic Control of Gates

Operation of Intake and Check Gates

- Discharge error will cause irrigation water of some channels exceed the demands, and eventually loses in the field
- Goal of the sluice gate operation is to release the "pre-assigned discharge" as close as possible and reduce the discharge error
- Operation in-site is based on experience currently
  - "correct" channel discharge is accomplished by iteratively manually fine-tuning the opening of gates several times

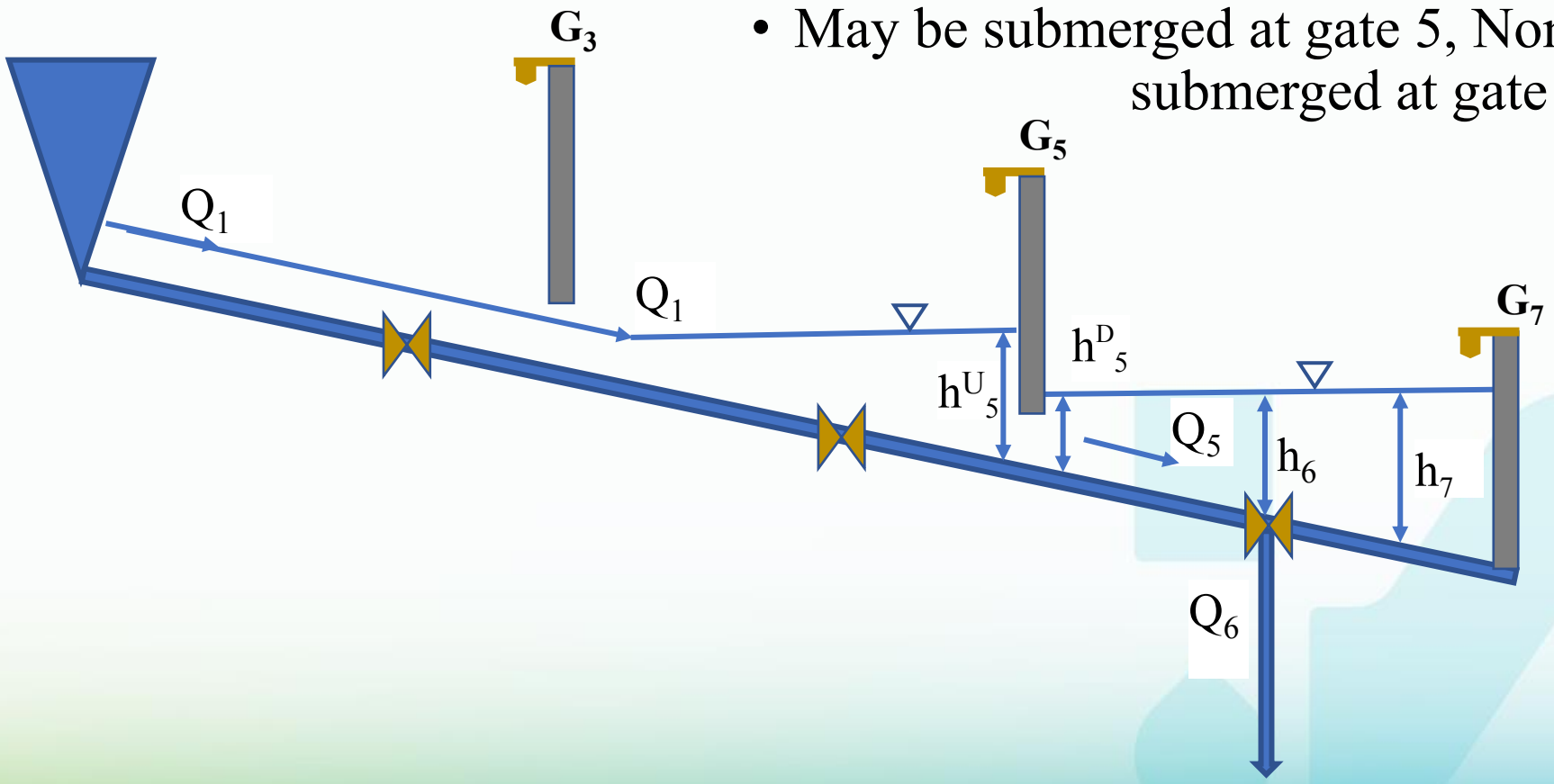
Gate Operation (Phase I)

- Non-submerged at all upstream fully opened gates



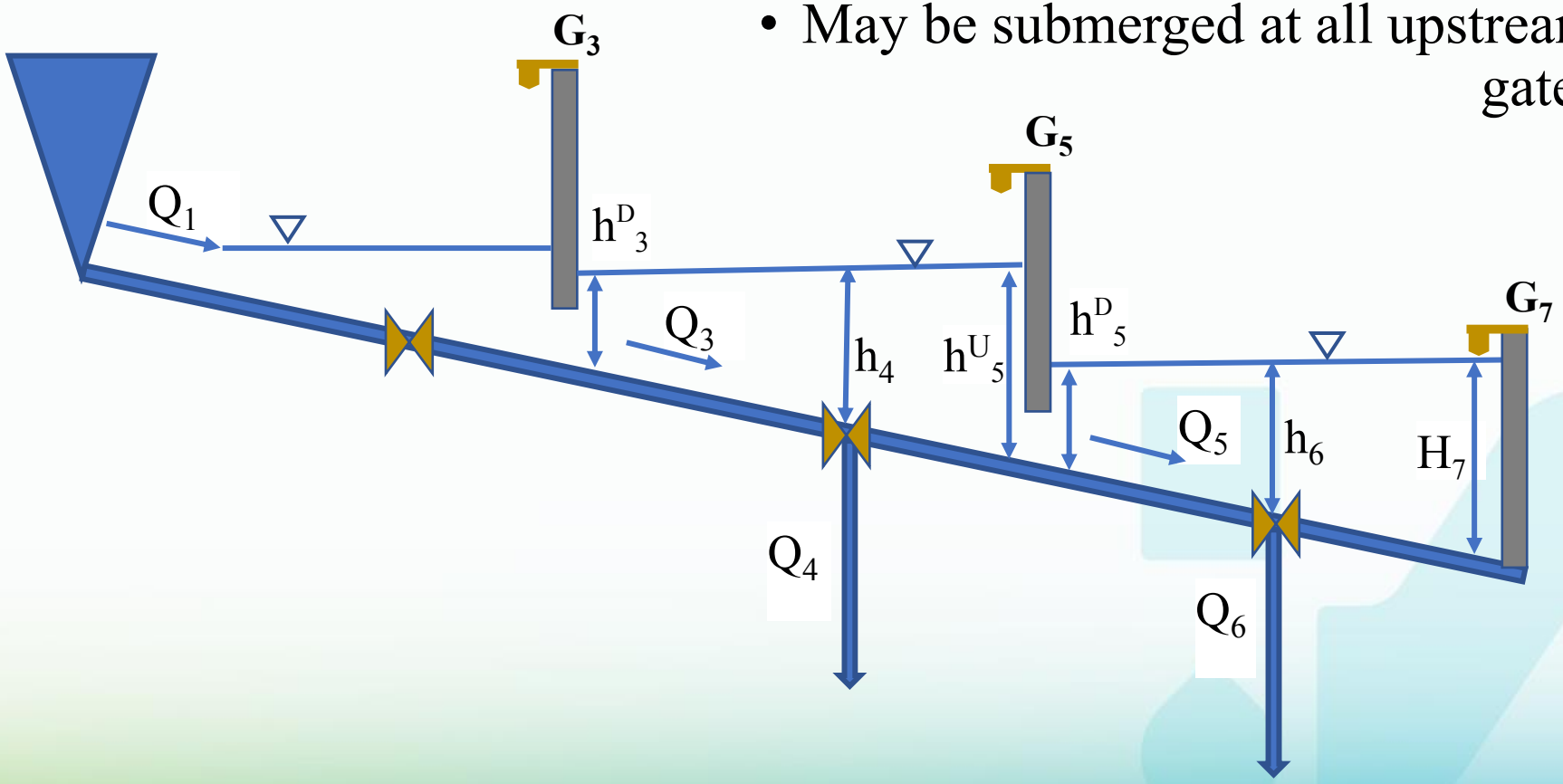
Gate Operation (Phase II)

- $h_7 > \underline{0.6}\ H_7$, open intake gate 6
- May be submerged at gate 5, Non-submerged at gate 3



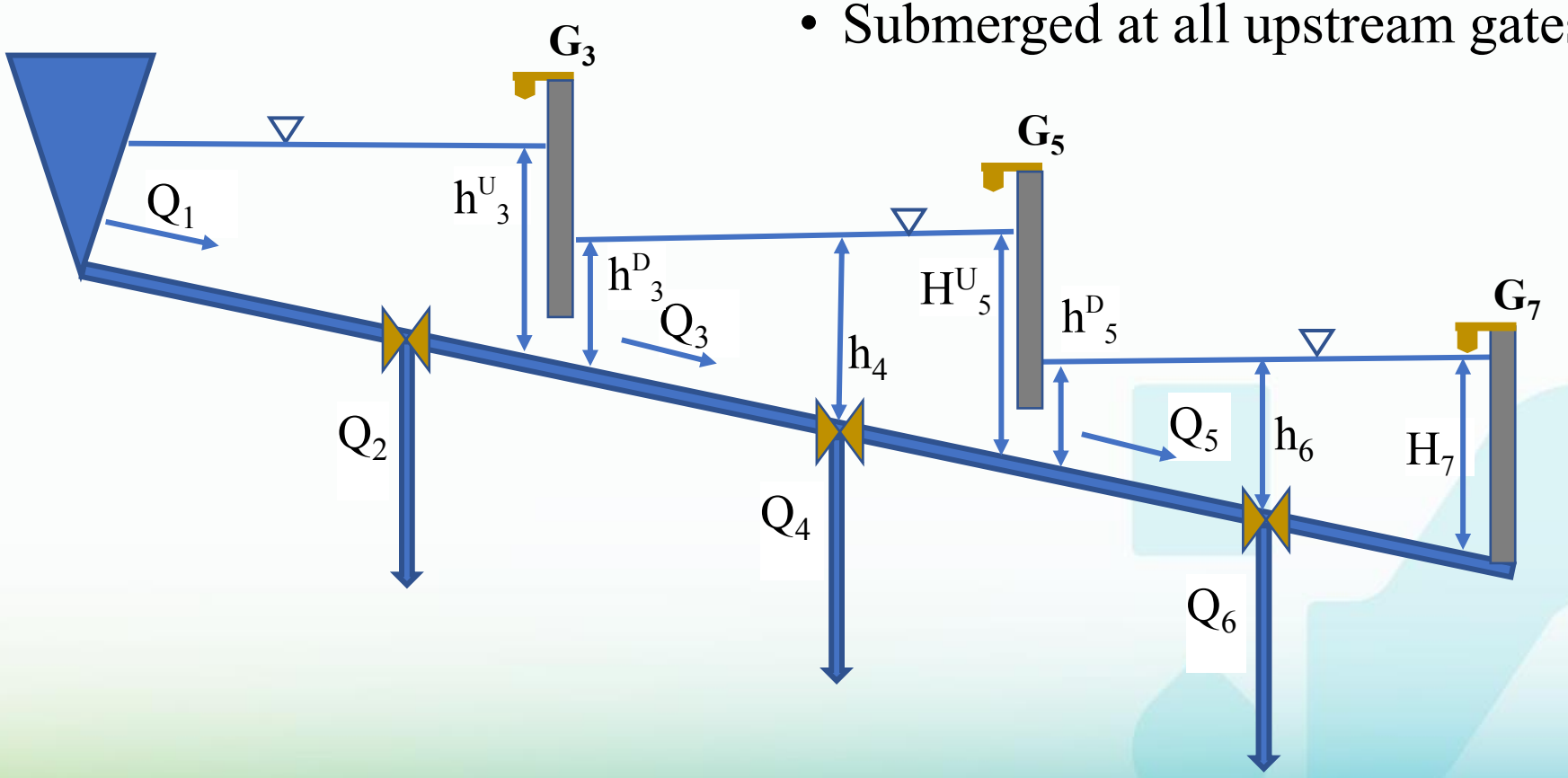
Gate Operation (Phase III)

- $h^U_5 > \underline{0.6}\ H^U_5$, open intake gate 4
- May be submerged at all upstream gates



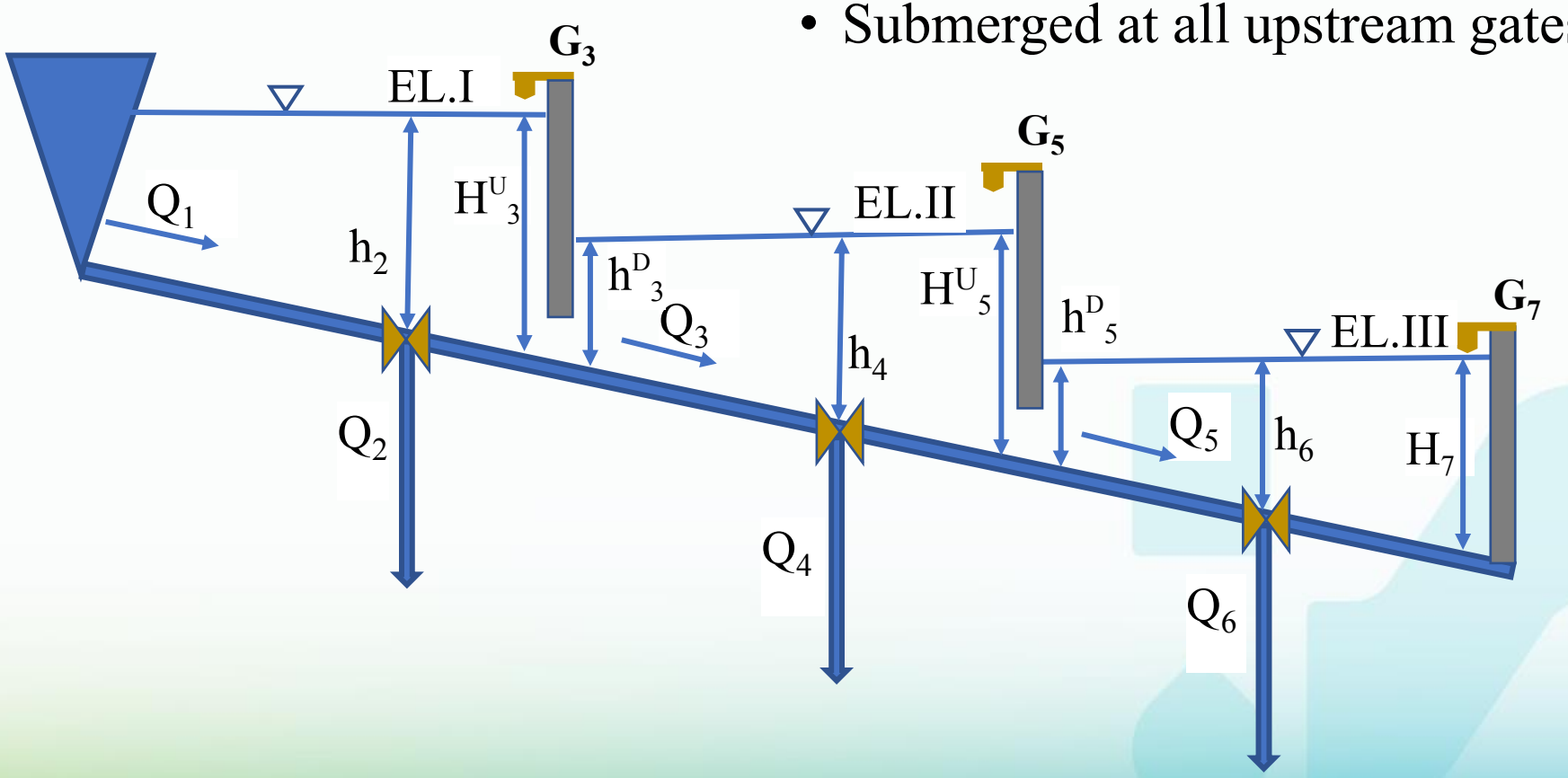
Gate Operation (Phase IV)

- $h^U_3 > \underline{0.6}\ H^U_3$, open intake gate 2
- Submerged at all upstream gates



Gate Operation (Phase V) – Steady State

- Intake gate 2, 4 and 6 opened
- Submerged at all upstream gates



Discharge Computation and Gate Control

- Flow computation with observed water surface and gate opening
  - Discharge of weir, sluice gate
  - Normal flow discharge
  - Backwater flow profile
  - Check continuity of water and discharge error, etc.
- Modify the “pre-assigned discharge” with discharge error
- Compute gate opening with modified discharge and flow profile
- Site operation to fine tune the gate opening

Benefits and Conclusion

- Save man power and operation time of fine tuning the gate opening, at least 12 hours
- Percentage of discharge error is reduced compared to the case of initial gate opening
  - error of the Madou lateral decreased from 10.8% to 1.9%, a decrease of 8.9%
  - error of the Shanhua lateral decreased from 15.6% to 7.4%, a decrease of 8.2%
  - initial opening may be set up by referring the simulated steady flow condition
- Smart management with remote control can reduce the discharge error and improve the overall water distribution efficiency

3

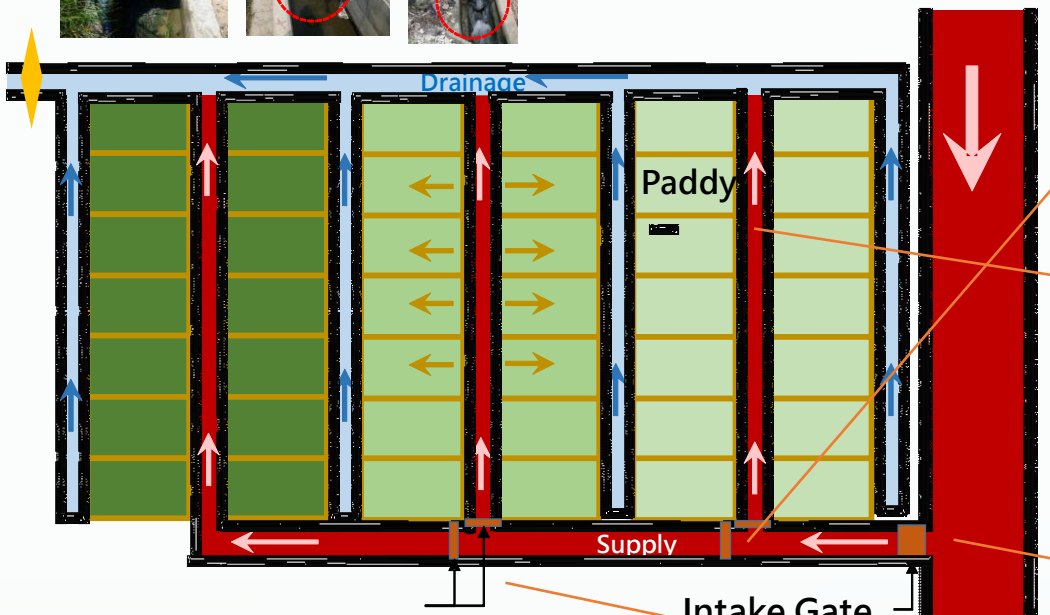
Smart Management of channel Water Delivery

On-Farm Ditch System & Irrigation Practice



System losses

Sub-lateral Channel



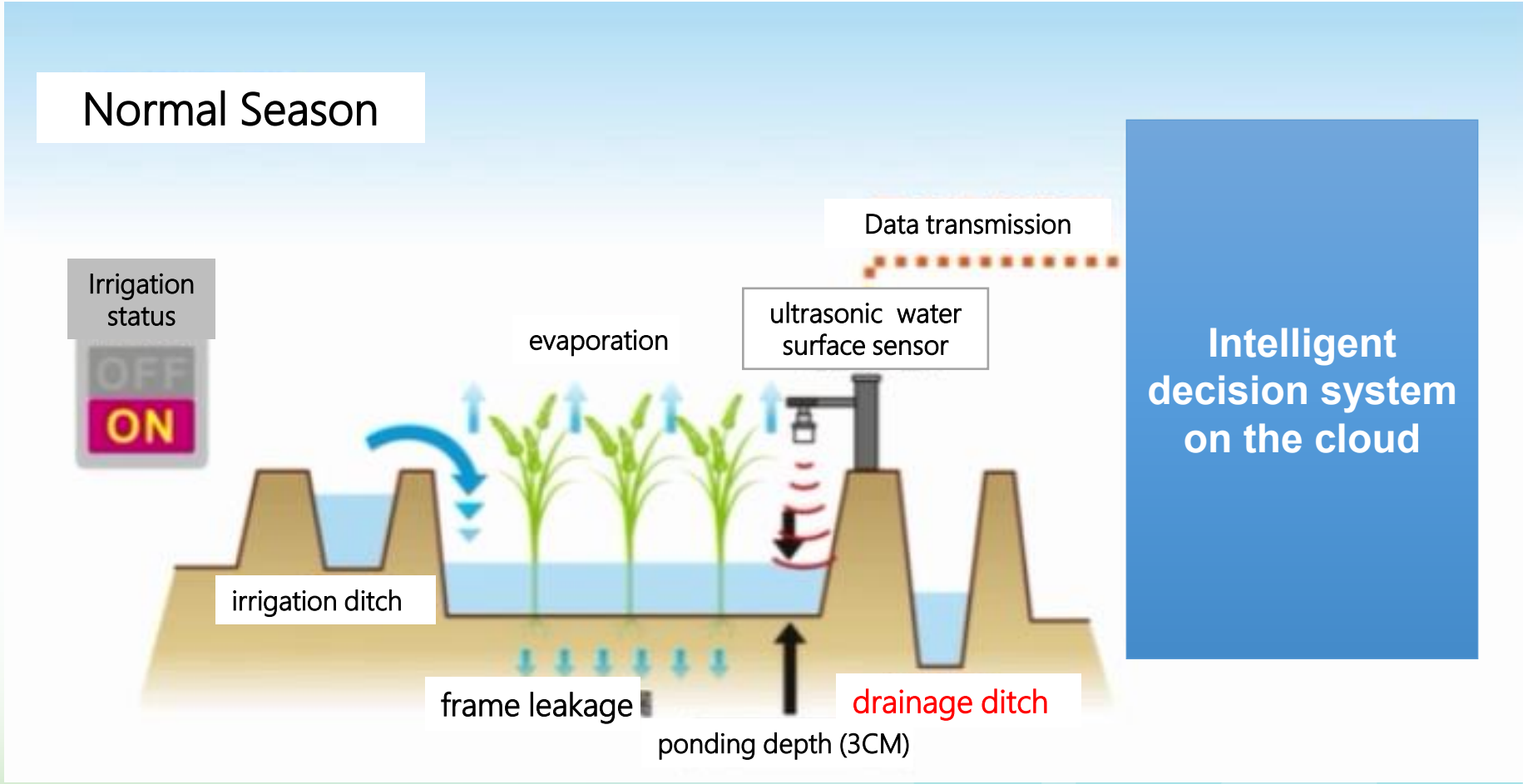

- 中小給水路分水設備(移動式閘版)，由掌水工現地操作控制，無監測設備

- 坵塊取水設備(6吋水管)，由農民或掌水工手動啟閉，無監測設備


- 水路控制設備：輪區水門(機械式)
  控制方式：水利會工作站人員現地
- 水路監測設備：量水堰
  監測方式：水利會工作站人員現地

Water Save Measures of Paddy Irrigation (1/2)

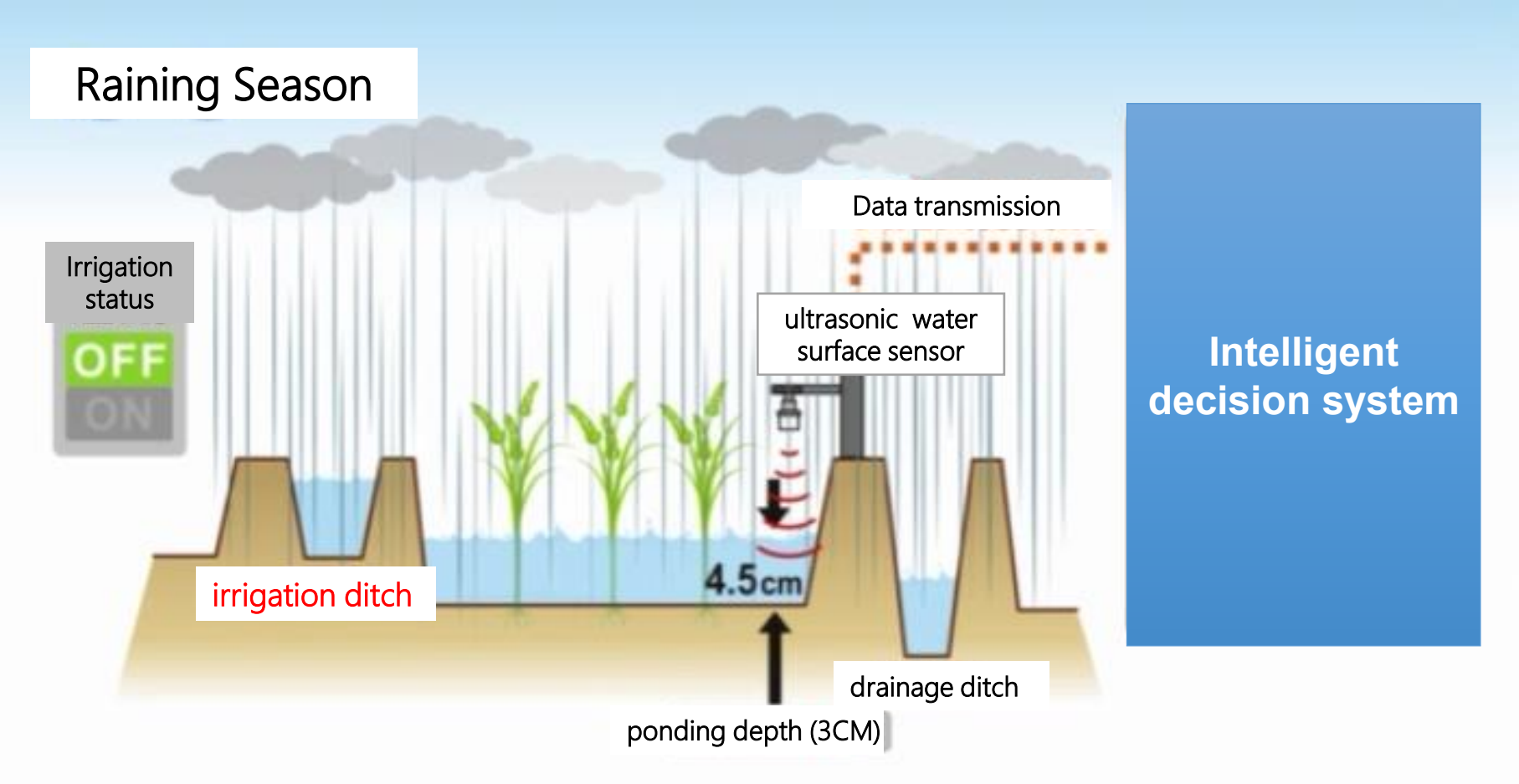
- Normal season
- Save water by reducing water losses in drainage ditches



(Cited from Dr. Sheng-Feng Kuo)

Water Save Measures of Paddy Irrigation (2/2)

- Raining season
- Stop irrigation real-time to save water in reservoir



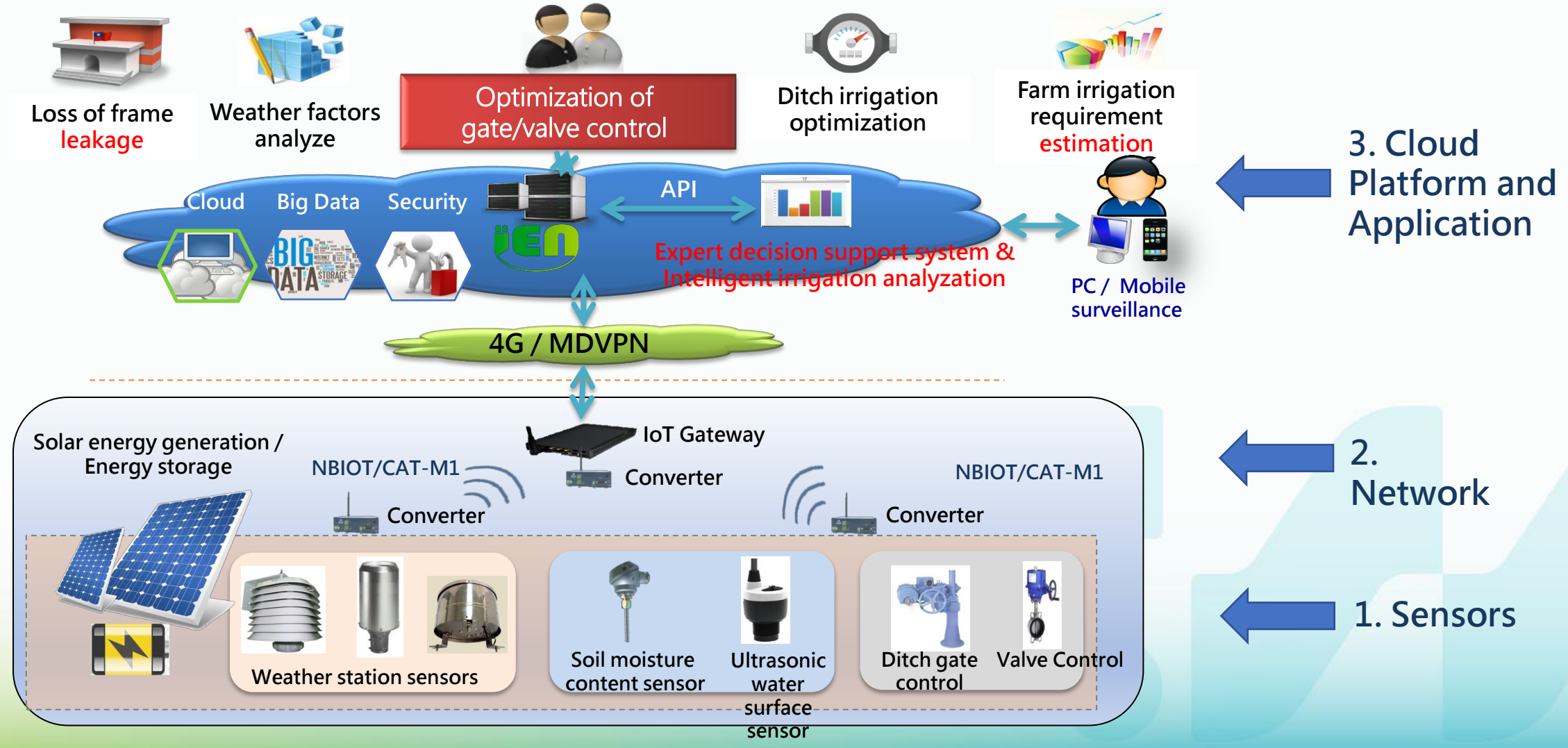
(Cited from Dr. Sheng-Feng Kuo)

Smart Field Irrigation Management

- Large scale paddy field experiment
- Integrate weather forecast, water sensors, IoT, cloud computing, gate control, etc.

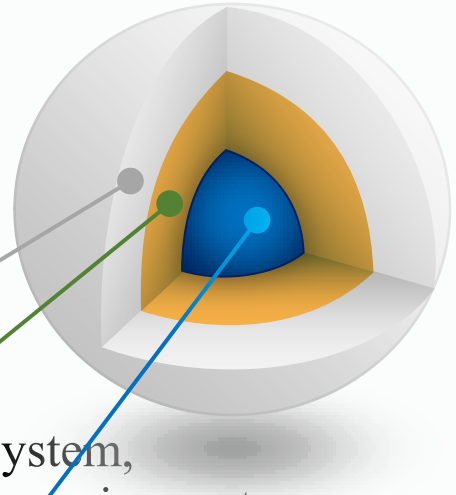
(modfied from Dr. Chih-Hung Tan)

Framework of Smart Management System



(Modified from Dr. Sheng-Feng Kuo)

Study of the Smart Field Irrigation

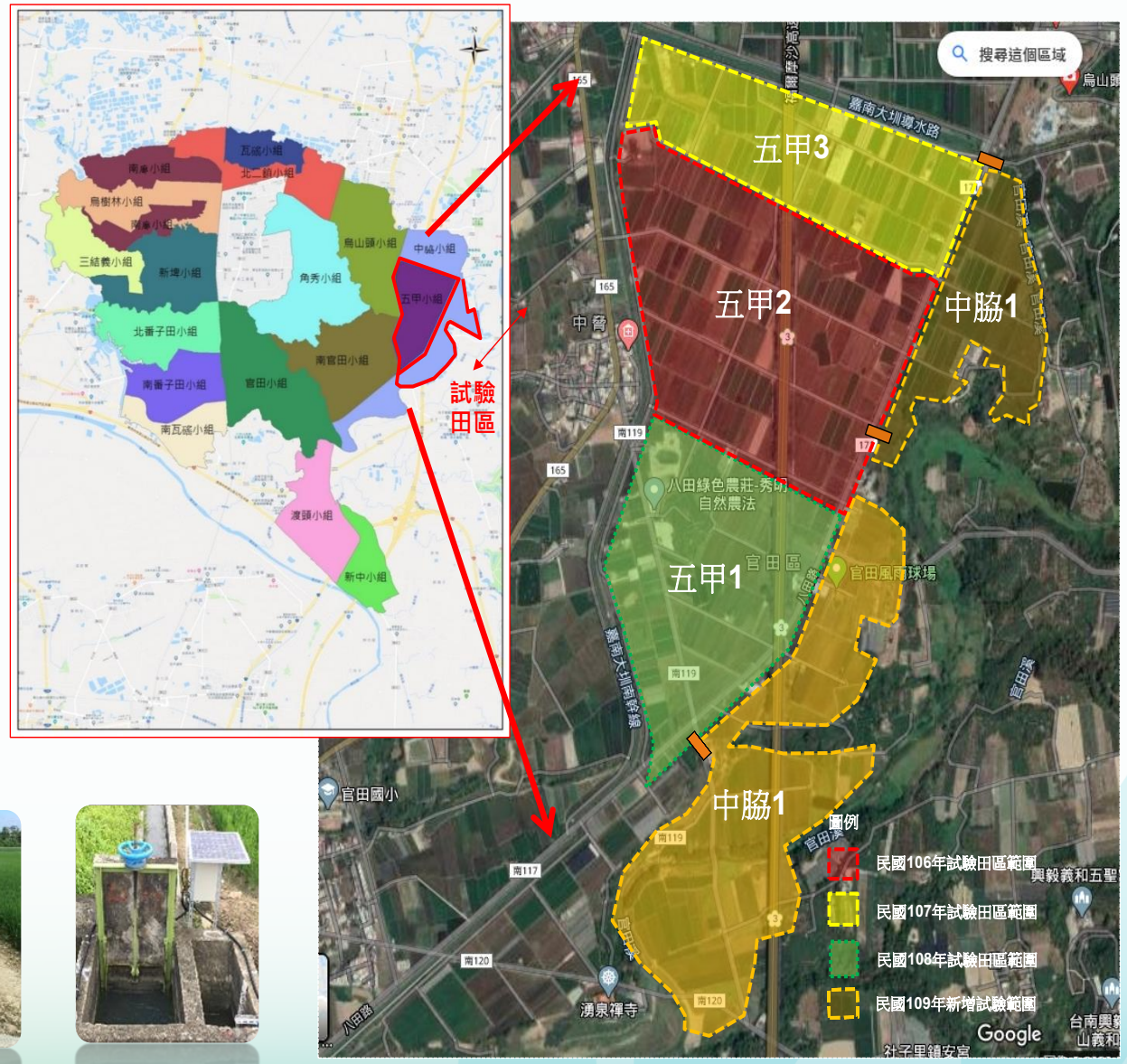


- Purpose
  - Optimization of the irrigation requirement to avoid the over-irrigation
  - Intelligent management to reduce the impact of global weather issues
- To do
  - Building a cloud System for monitoring the irrigation fields
  - Transmit the device data to the cloud and integrate the big data and smart decision logic to control the devices
- Expectation
  - Farm irrigator can carry out the irrigation plan more efficiently

- Plan framework
  - Experiment:
    - set up the irrigation system,
    - farm irrigation water requirement
  - Develop:
    - sensor, equipment, components with
      - acceptable accuracy
      - weather durability
      - low cost
  - Prospective:
    - central intelligent management system, with
      - real-time status monitoring
      - intelligent decision making
      - mobile remote control

Experiment Site

- Four year periods
  - 2017: 56/45 ha
  - 2018: 88/67 ha
  - 2019: 130/93 ha
  - 2020: 170/114 ha

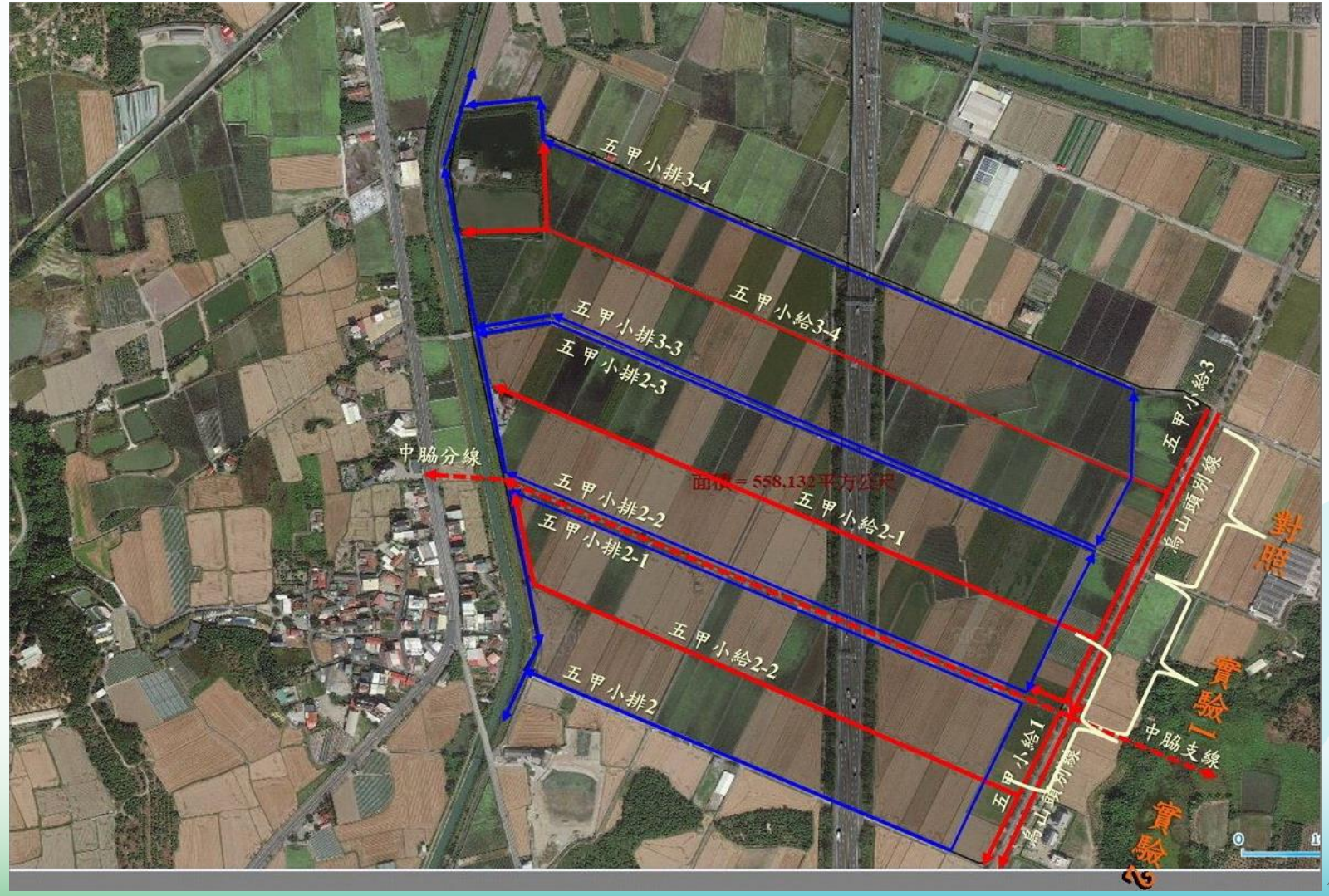


(Cited from Dr. Sheng-Feng

First Year Experimental Site

System losses

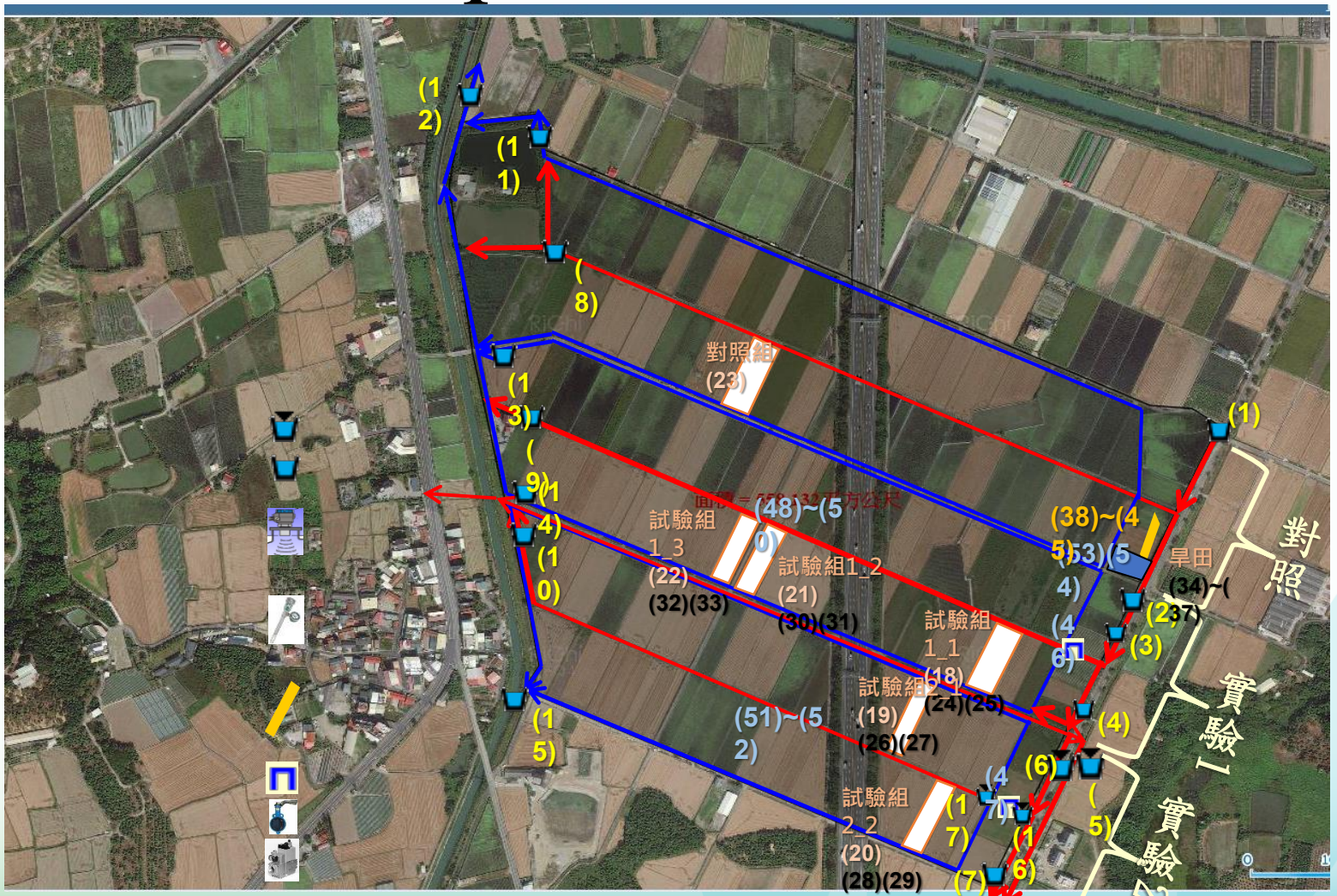
- 56 hectares
- Field ditches
  - irrigation (red line)
  - drainage (blue line)



(Modified from Dr. Sheng-Feng Kuo)

Field Plan - Sensors Setup

Devices	Number
water surface sensor	* 4 * 13
field water level sensor	* 6
soil moisture content sensor	* 7
weather station sensor	* 1
ditch check gate and valve motor	* 2 * 5 * 2



(Modified from Dr. Sheng-Feng Kuo)

Intake Sluice Gate

- Cost down from NT$465K down to $200K
- Reduce 43%

Division Box

- Cost down from150K down to 145K


第三期


第四期

water surface sensors

Year	2017	2018	2019	2020	2020
Type	Ultrasonic	Ultrasonic	Radar	Resistent	Ultrasonic
Picture					
Site					
Power	0.5W	0.001W	0.0005W	0.5W	0.075W
Cost	$50,000	$35,000	$25,000	$25,000	$25,000

Power is 1/6 of 2017

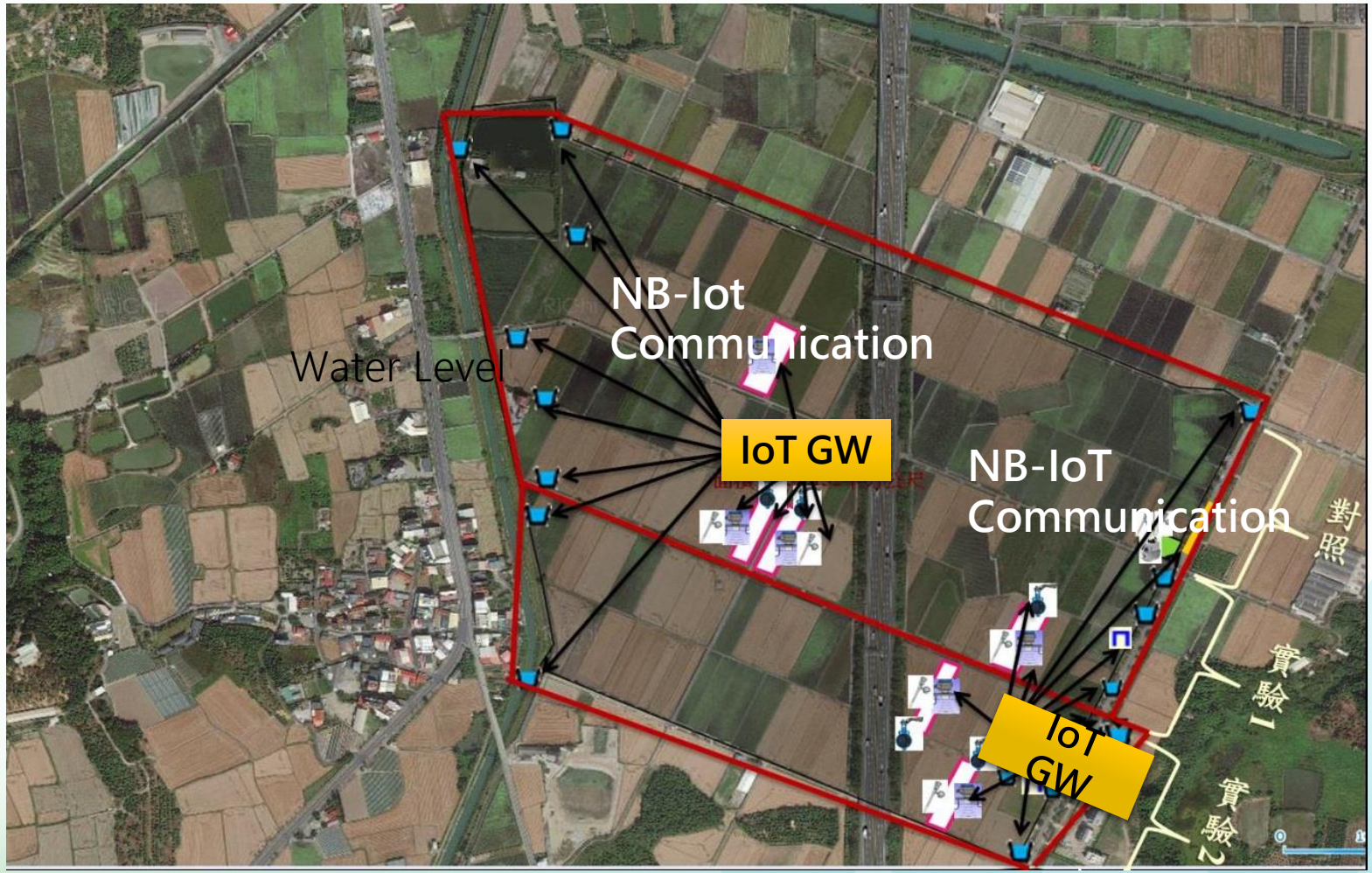
50% cost down

Paddy Inlet

	第一期(106年)	第二期(107年)	第三期(108年)	第四期(109年)
水門尺寸	φ 0.15m	0.15m*0.15m	0.15m*0.15m	φ 0.15m
吊門機	蝶閥	齒桿式吊門機	齒桿式吊門機	球閥型
速度	0.3 m/min	0.1 m/min	0.1 m/min	100s內完成啟閉
直流馬達	40W	5W	5W	5W
太陽能板	265W	20W	15W	20W
電池	24V-100AH	12V-7.2AH	12V-5AH	12V-3AH
控制器	市售模組整合	MCU控制	MCU控制	市售模組整合
傳訊方式	LoRa	NBIoT	NBIoT+CatM1雙模	Sub-GHz Mesh網路架構
操作方式	現場手動、電動；遙控	現場手動、電動；遙控	現場手動、電動；遙控	現場手動、電動；遙控
控制設備成本	19萬元(含1年保固)	10萬元(含1年保固費)	5萬元(含1年保固費)	1.5萬元(含1年保固費)

Cost down NT$175K

Field Plan - Communication



(Modified from Dr. Sheng-Feng Kuo)

Communication

	2017	2018	2019	2020	2020
通訊	LoRa	NBIoT	NBIoT/CatM1	NBIoT/CatM1	Sub-GHz Mesh
Picture					

Mostly adopt NBIoT/CatM1

Independent

Stable

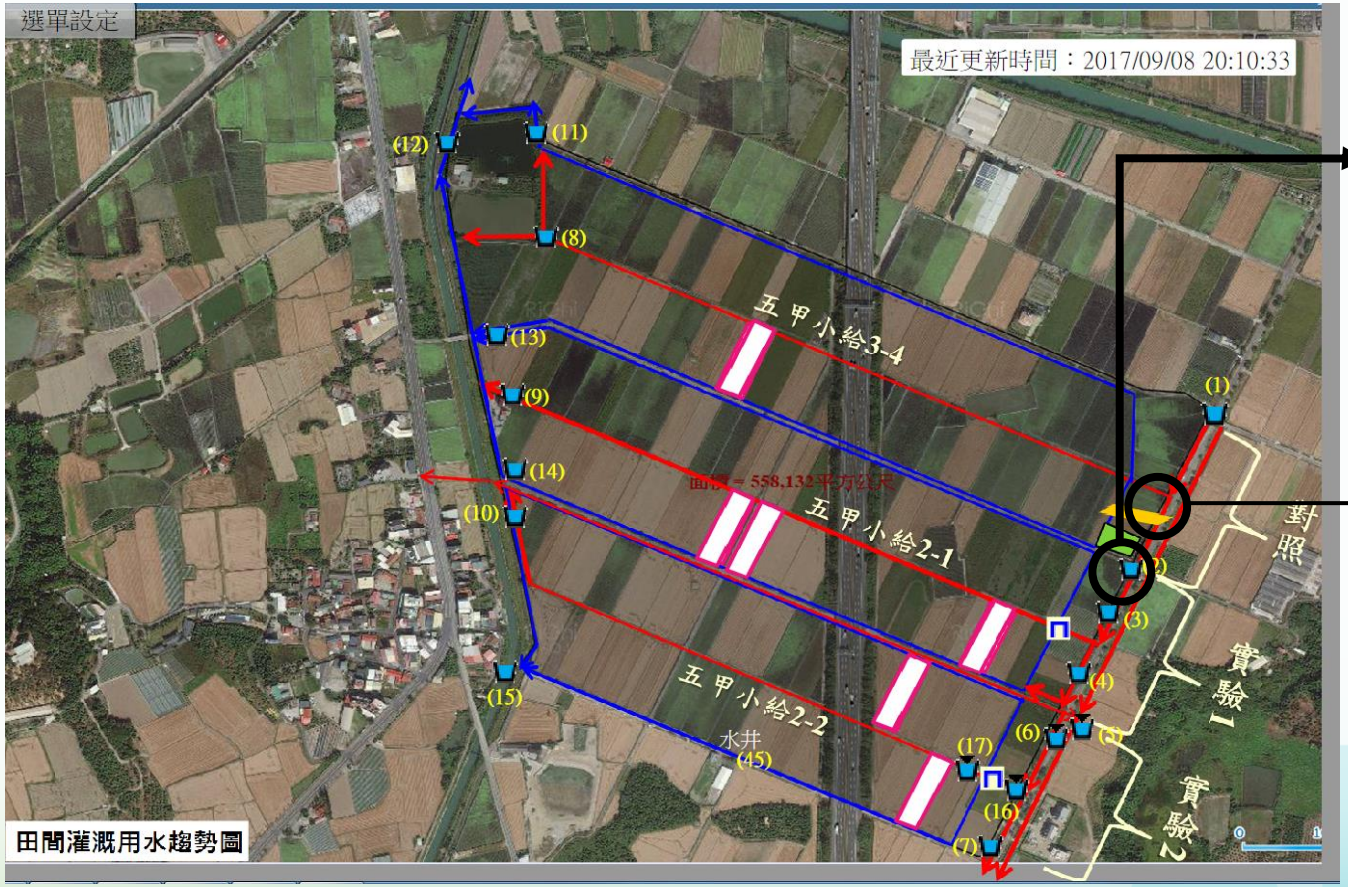
Sub-GHz Mesh

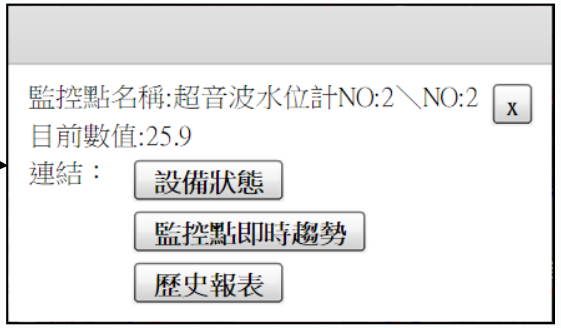
4G large band width

Good for real-time obse4voiration

Intelligent Decision Platform

- Manager can check the real-time device status and historical report from the graphic control panal





(Cited from Dr. Sheng-Feng Kuo)

Monitoring Interfaces

Mobil

Decision Platform – Device status

Irrigation ditch:
- Water Level
- Estimated water flow

監控項目:

名稱	目前狀態
NO:1	33.274(cm)
流量	26.531(cms)

Dry field:
Soil moisture content sensor

監控項目:

名稱	目前狀態
土壤張力計1	4.006(cb)
土壤張力計2	26.538(cb)

Paddy field:
- Soil moisture content sensor
- Field water level

設備階層：精進灌溉_2 > 水田1-1 > 水田1-1
控制伺服器時間：2017/09/11 11:07:56

立即更新 | 5秒

監控項目:

名稱	目前狀態
土壤張力計1	1.237(cb)
土壤張力計2	1.621(cb)
水位計	3.020(cm)

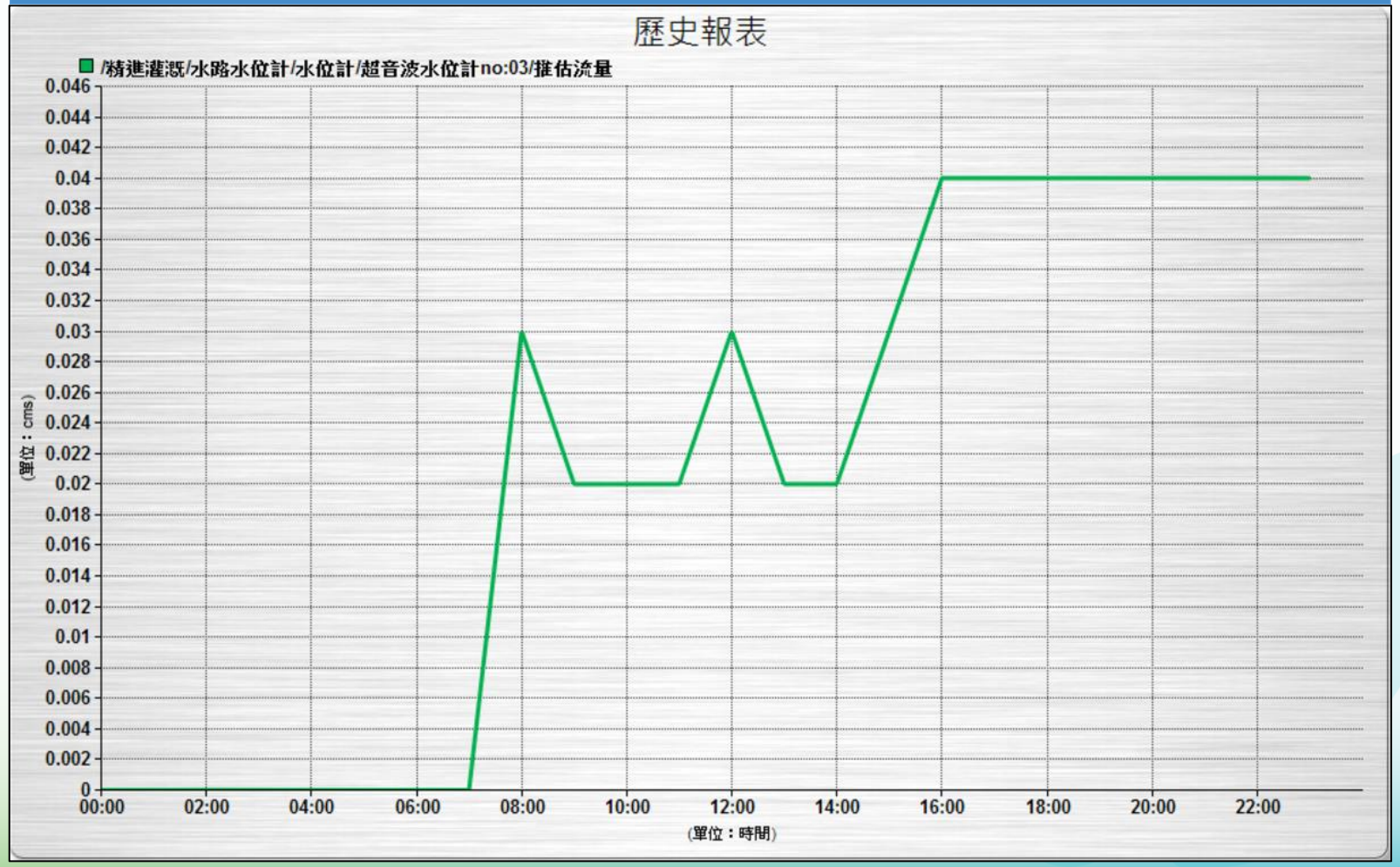
Paddy field: Check Valve

控制項目:

名稱	目前設定	控制方式
蝶閥開關	OFF	設定

Decision Platform – Statistical Report

Ditch estimated water flow report

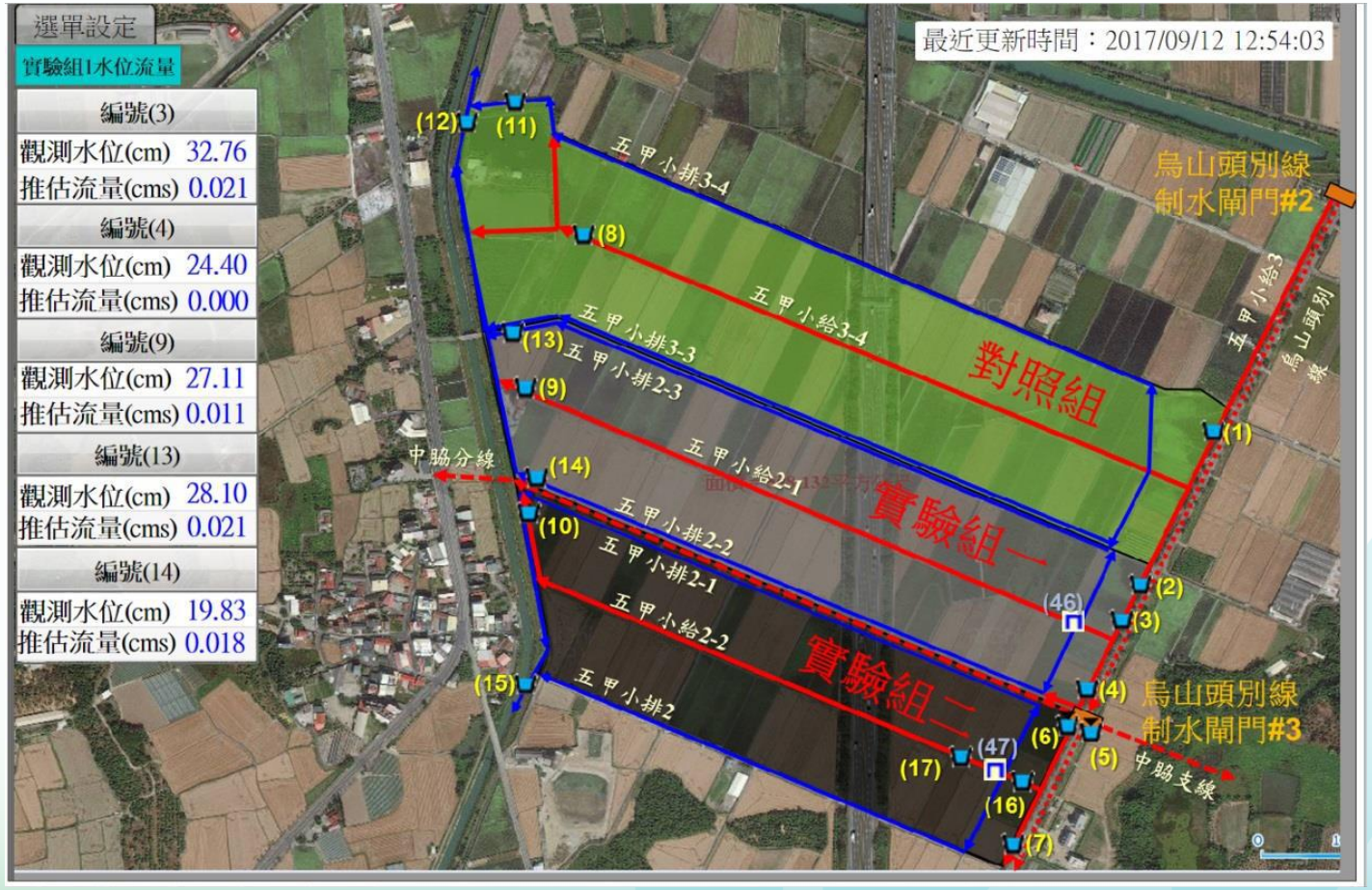


Decision Platform – Alarm Management

When the water surfaceis higher than the threshold, it will send the message to the alarm group

Intelligent Irrigation Decision

- Expert decision: recommend the required irrigation water and distribution based on observed water losses, by
  - monitoring ditch water surfaceand estimate water flow
  - controlling the opening of gates and valves



(modified from Dr. Chih-Hung Tan)

Water Savings

Project Demand

1st crop season 13K m³/ha
2nd crop season 14K m³/ha

Irrigator Aspect

20~25% for 1st season
25~30% for 2nd season

System Management

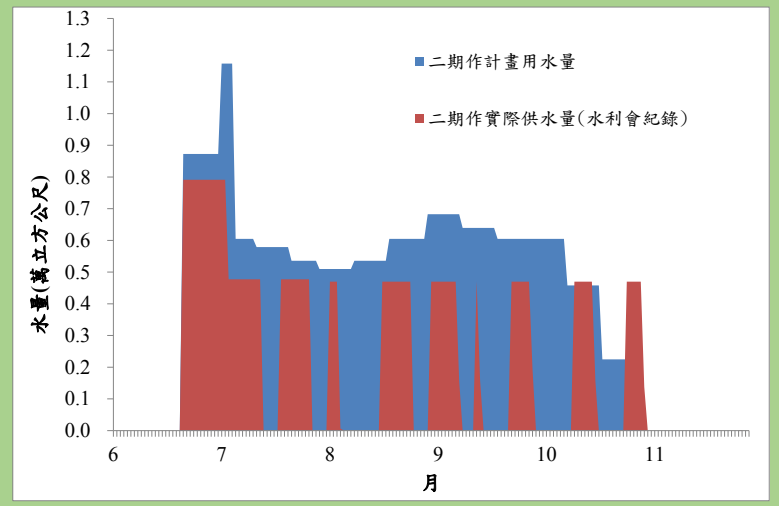
3% more for 1st season
6% more for 2nd season

Save

平均約再節
4.5%

Save more

Enhanced Irrigation Management



Water saving due to
Enhanced Irrigation management

Project Vision

Chianan Irrigation management office/farm irrigator, can control water distribution and save water, reduce labor cost by immediate warning message from APP

(Cited from Dr. Sheng-Feng

Project Vision

Farm irrigator
69 years old

Soil Moisture content of dry field is under standard, suggest to increase the opening percentage of the ditch gate, estimate to close in 4 hrs

No problem

After one day.....

paddy field water height average rises, suggest to close water ditch gate.

Ok !

Does not have to work at the late night, even people in my age can easily qualify and expert the job with this system

Intelligent Decision System

(Cited from Dr. Sheng-Feng

Project Vision

- Precisely control the water distribution, swiftly react, reduce the work load of farm irrigator
- Base on the ditch and crop irrigation requirement, to provide optimized irrigation plan for the farm irrigator, to help them taking rest in ordinary schedule
- Develop low-cost flow valves, water surface sensor for future mass promotion

(Cited from Dr. Sheng-Feng

4
Conclusion

Conclusions

- Smart irrigation management can greatly improve the water distribution efficiency of irrigation and reduce field water losses
  - promote the feasibility of agricultural water saving
- Saved water can be transferred to Tainan Science Based Industrial Park
  - agriculture and industry are not necessarily to compete for water, but collaborate to save water (win-win situation)
- A solution to climate change and extreme weather condition?
- Smart irrigation need to balance the water savings and costs

(Cited from Dr. Chih-Hung Tan)

Question and Recommendation

Question and Recommendation

Climate smart agriculture with innovative geodata tools

13th October, Jonna van Opstal

WAGENINGEN
UNIVERSITY & RESEARCH

Intro

- Agricultural Water Management Expert
- >10 years experience in irrigation and remote sensing in USA, Middle East, African continent
- Research, consultancy, and capacity building activities with FAO, IHE Delft, and Dutch embassies

Climate smart farming

UP 42

The Future of Farming:

Drive crop and business growth with satellite imagery, weather data, and deep learning

BBC

IN ASSOCIATION WITH CORTEVA agriscience

FOLLOW THE FOOD

The farms being run from space

Smart Agriculture: The Next Agricultural Revolution

NOVEMBER 26

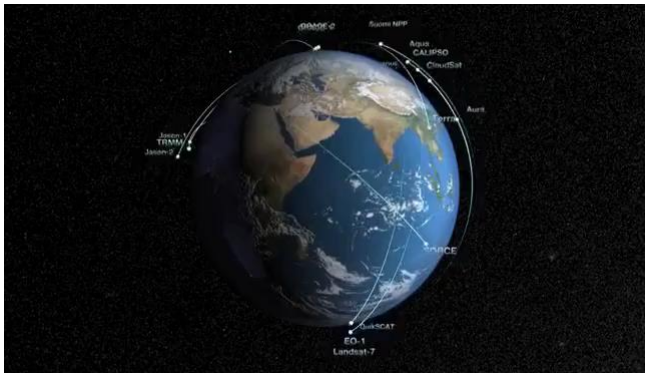
SMART AGRICULTURE

The world's appetite is growing rapidly. To feed nine billion people in 2050, the world will need to produce 70 percent more food than it did in 2006. Farming methods have always evolved with the increasing demand for agricultural products. From simple, handheld farm tools from before the Industrial Revolution, to the mechanized farm equipment and the use of satellites for better monitoring, agriculture has always adapted to produce more at a lower cost. Smart agriculture combined with innovative technology is key to the future of farming.

SEARCH

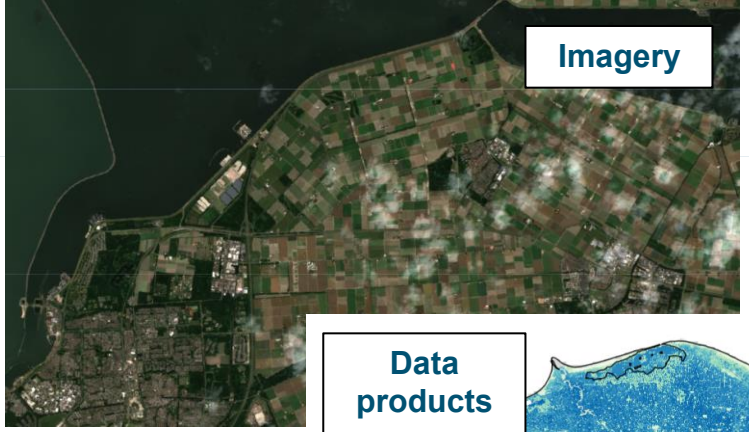
Upcoming Webinars

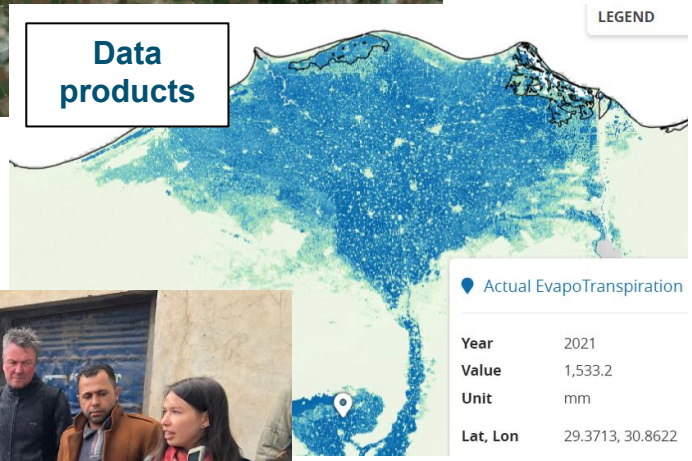
Geodata (tools)



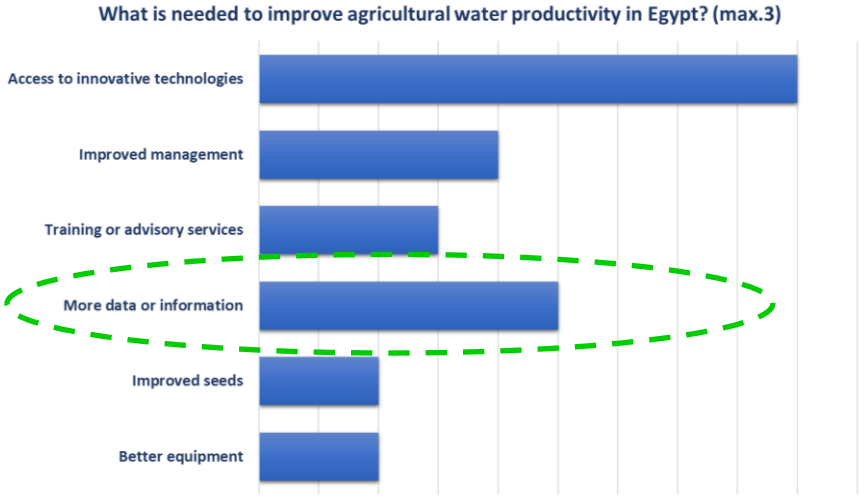
Satellite data products

Flying Sensors





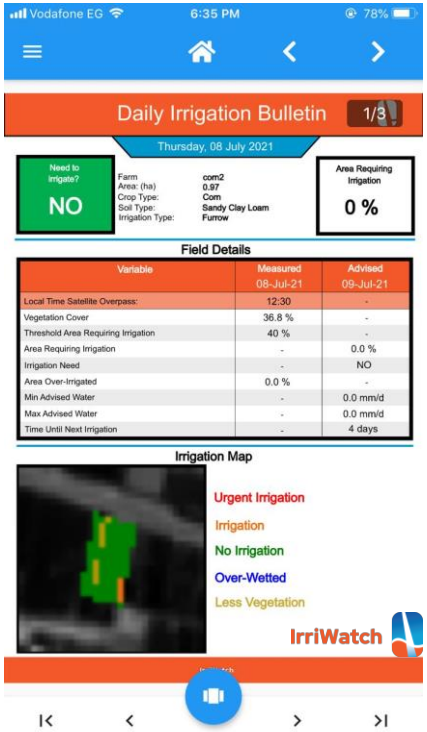
Why use geodata tools?

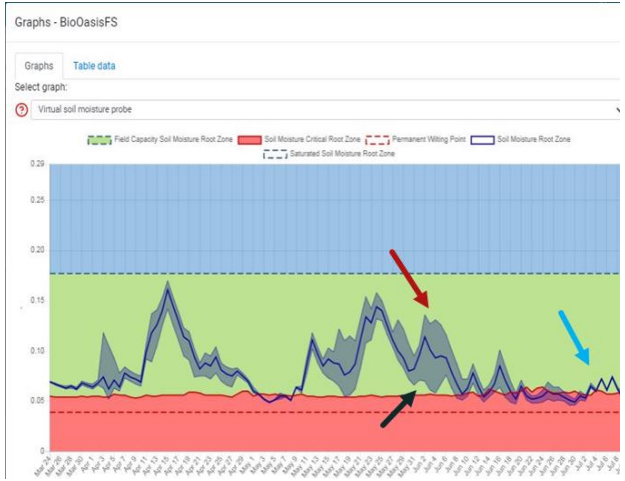


- Fill knowledge / data gaps
- Agricultural water manager:
  - Impact at field and regional scale
  - Monitoring water balance and consumption
- Challenges:
  - Knowledge transfer
  - Is it worth investing €€ and time?

Practical Applications

Irrigation advisory – Field uniformity



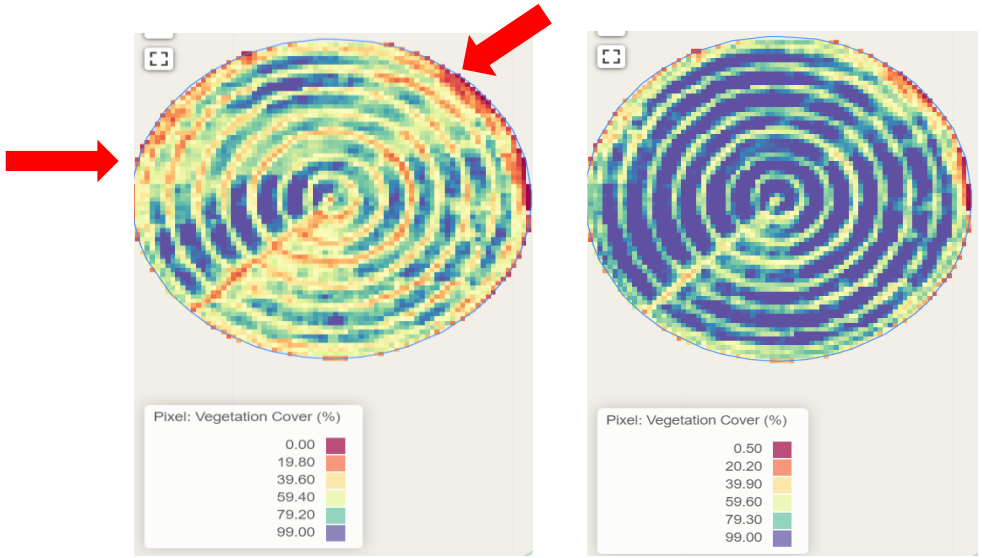


Management strategy:

adjust location of sprinklers

WAGENINGEN
UNIVERSITY & RESEARCH

Irrigation advisory - Optimizing irrigation

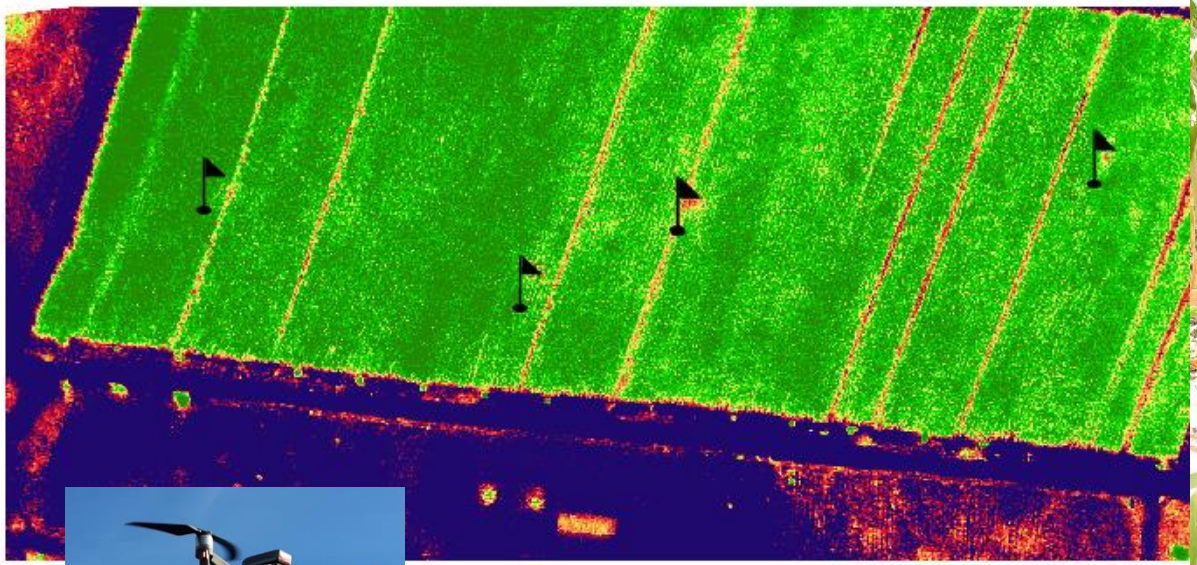


Pivot NO.12
Planting Date: 15.Sept.21
Crop Age-Day: 82
Crop: SugerBeet

Management strategy:
adjustment of pivot speed

WAGENINGEN
UNIVERSITY & RESEARCH

Drone imagery – Problem detection

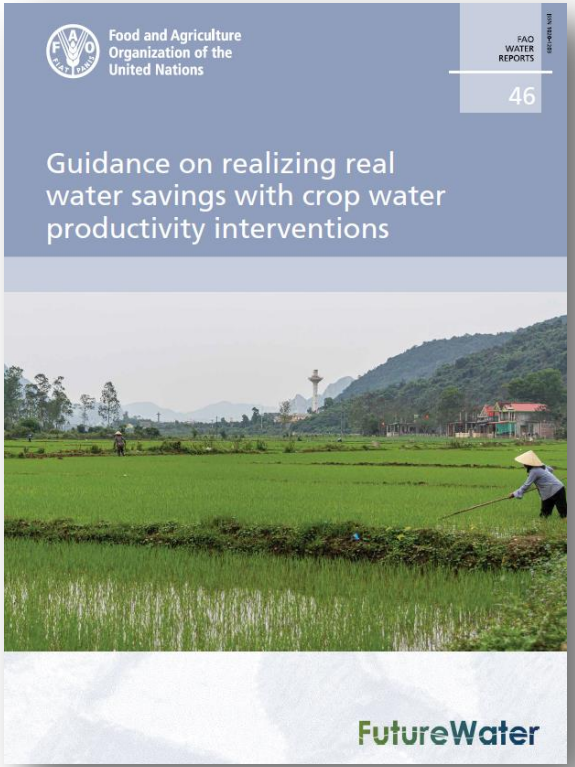


Management strategy:

locate clogged driplines

WAGENINGEN
UNIVERSITY & RESEARCH

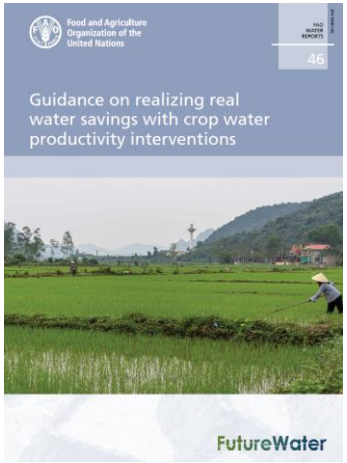
Real Water Savings - Monitoring water balance

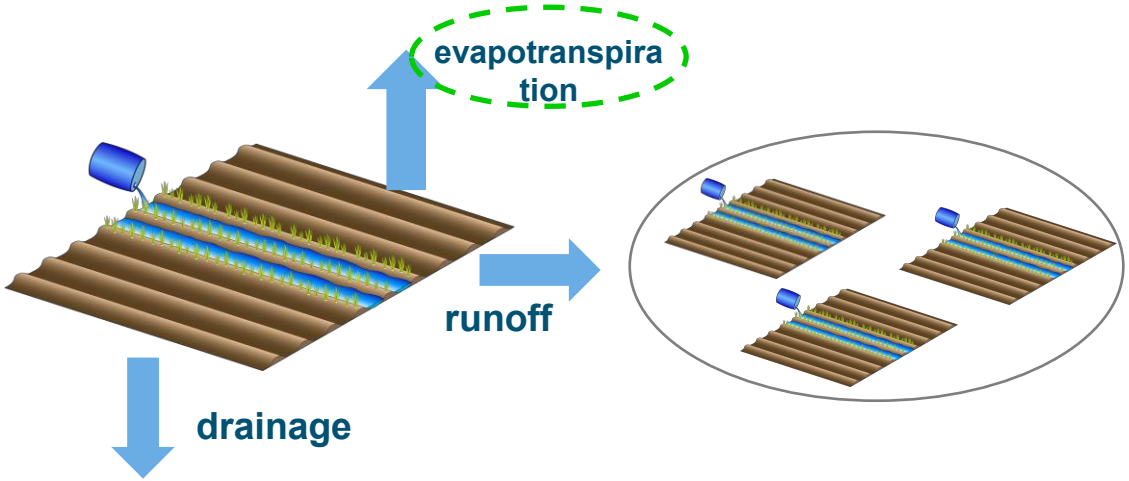


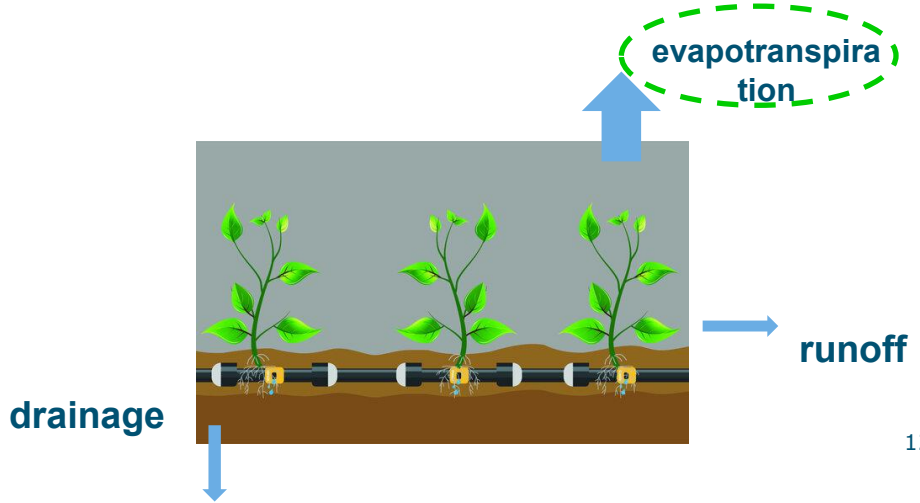
Theme	Category	Intervention
Water	On-field irrigation methods	Border/furrow irrigation
		Sprinkler irrigation
		Drip irrigation
		Sub-surface irrigation
	On-field irrigation management	Supplemental irrigation
		Regulated deficit irrigation
		Surge irrigation
		Alternate wetting and drying
	Irrigation infrastructure	Canal lining
		Pipes
	Moisture recycling	Greenhouse
		Hydroponics
Soil and Land	Tillage Soil and Land	Zero tillage
		Tillage
	Land grading	Field levelling
		Terracing
		Block-end or soil bunds
Agronomy	Supplements	Fertilizers
		Growth enhancers
	Crop selection	Crop rotation
		Cultivars: high yields
		Cultivars: short duration
		Cultivars: rooting depth
		Timing of planting / sowing
		Planting density
	Coverage	Mulching
		Shading
		Weed control
		Cover crops
	Disease control	Pesticides
		Biological
	Salinity management	Leaching
		Salt-tolerant crop types

WAGENINGEN
UNIVERSITY & RESEARCH

Real Water Savings - Monitoring water balance

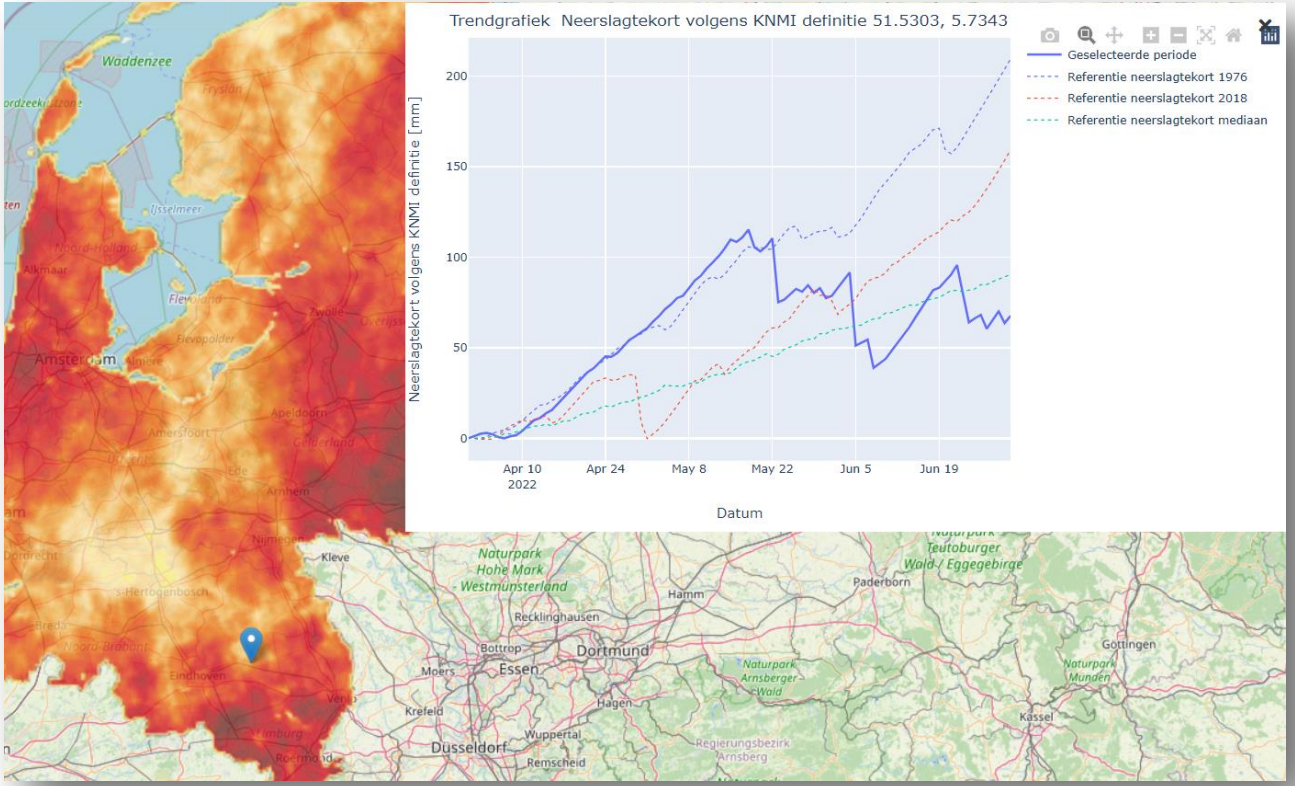






WAGENINGEN
UNIVERSITY & RESEARCH

Drought monitoring in the Netherlands



[Droogtekaart.nl]

Knowledge sharing

From innovation to practice

- Who will use the apps / tools?
- Make tools simple, practical, context-specific
- Demonstration of tools in Field Schools
  - Understand
  - Interpret
  - Believe
  - Adopt

WAGENINGEN
UNIVERSITY & RESEARCH

Key points

- Netherlands is data rich country with many innovative (geodata) platforms available
- (Future) water challenges: too much, too little, too salty
- Explore practical usability and benefits of innovations and increase adoptability

Questions & Discussion

Contact:

jonna.vanopstal@wur.nl

WAGENINGEN
UNIVERSITY & RESEARCH

TAIWAN INT'L WATER WEEK

Oct. 12 ‣ 14

以科技方法擴大灌溉服務

Expanding Irrigation Services by Technological Means

Chih-Hung Tan, PhD

Technology Director
Agricultural Engineering Research Center

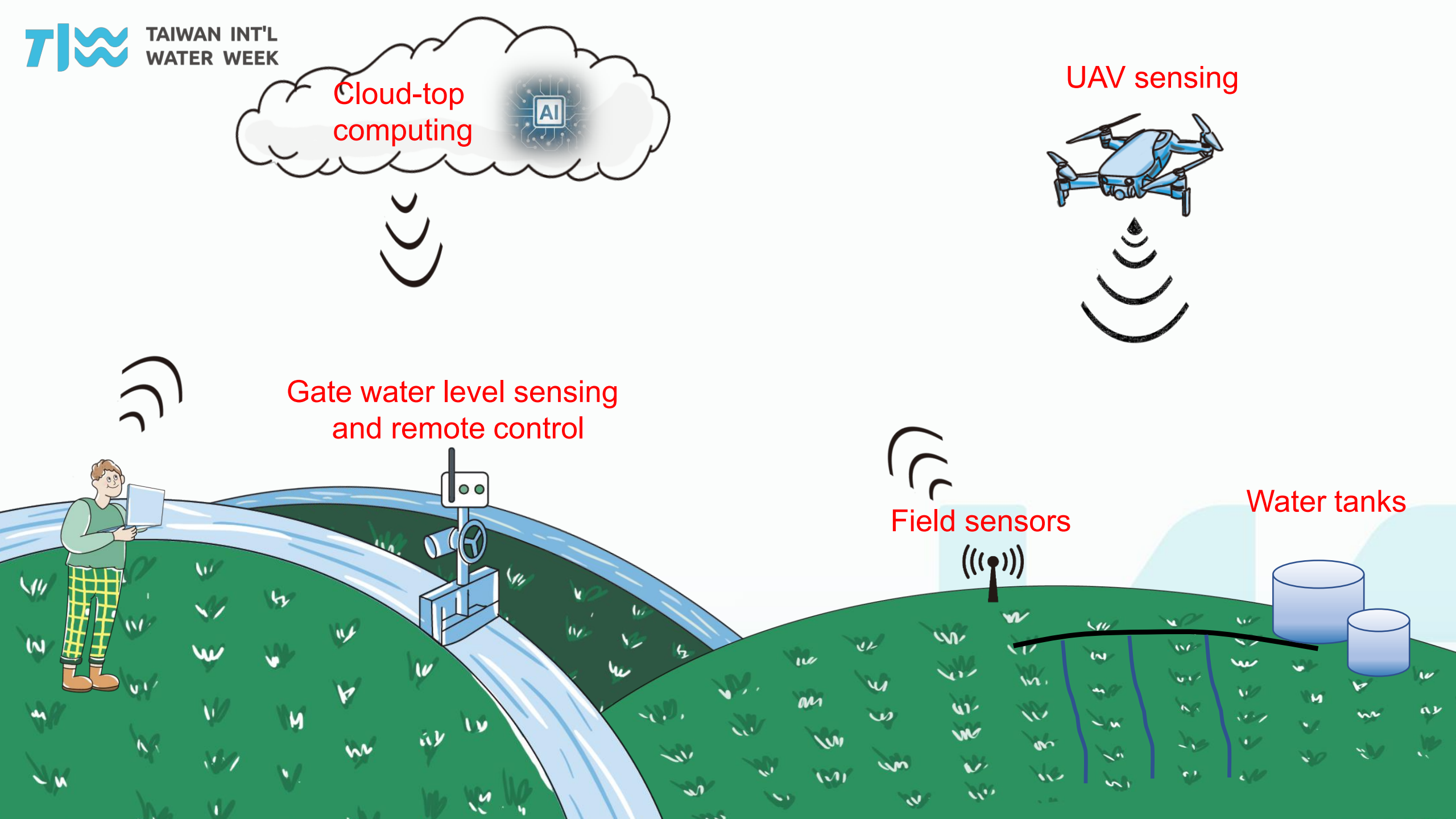
International Forum 2022

TAIWAN INT'L WATER WEEK

Introduction

- Agricultural water consumption near 70%
- Irrigation authority restructured in 2020
- Expanding irrigation services
- 360k ha to 680k ha with limited water resources
- Mission impossible?

TAIWAN INT'L WATER WEEK



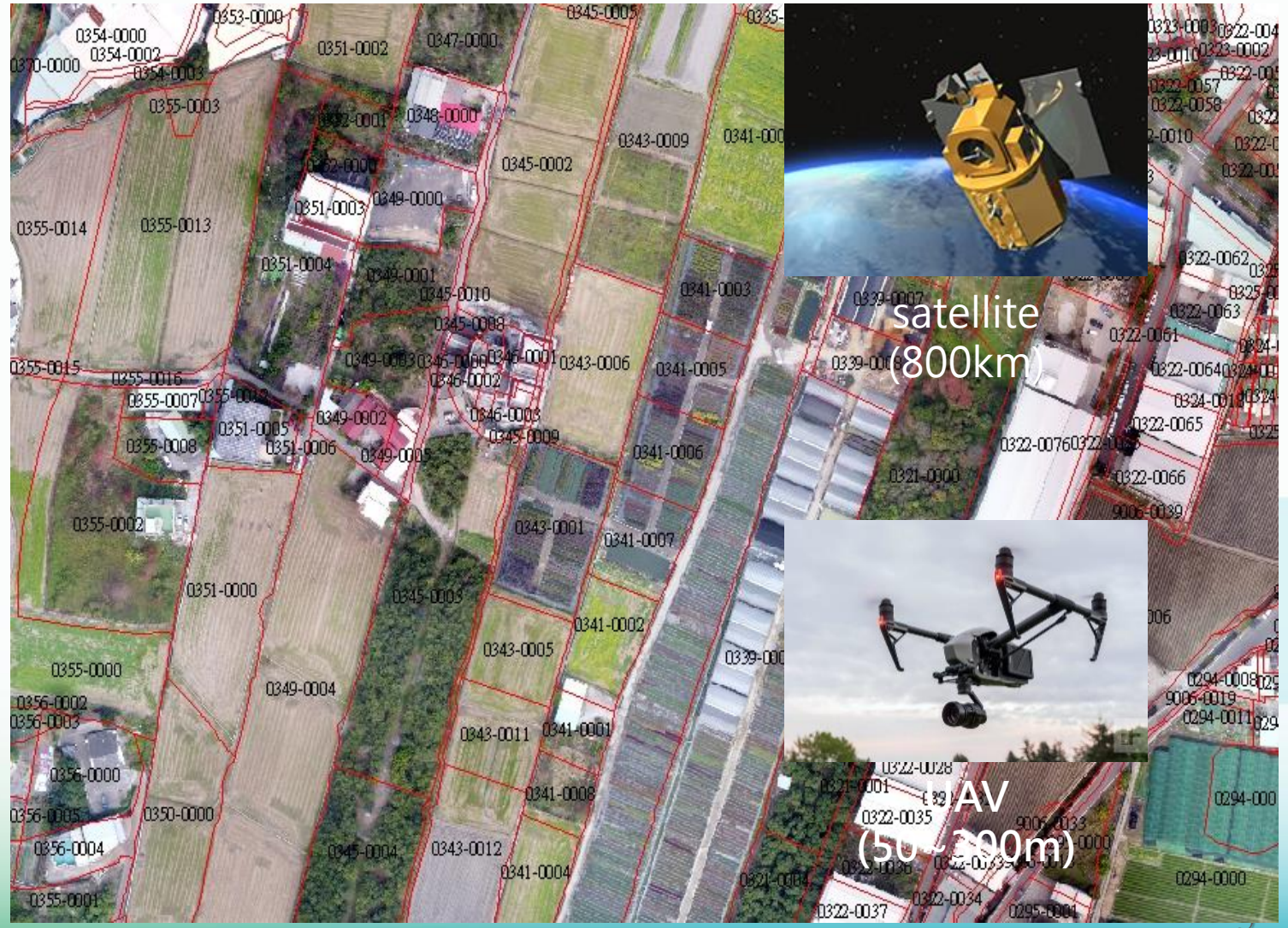
TAIWAN INT'L WATER WEEK

Precision Irrigation Water Requirement Assessment by UAV and GIS

Field data collection Tech – UAV

UAV advantages

- Low cost
- Hi spatial res.
- High mobility
- Easy to use



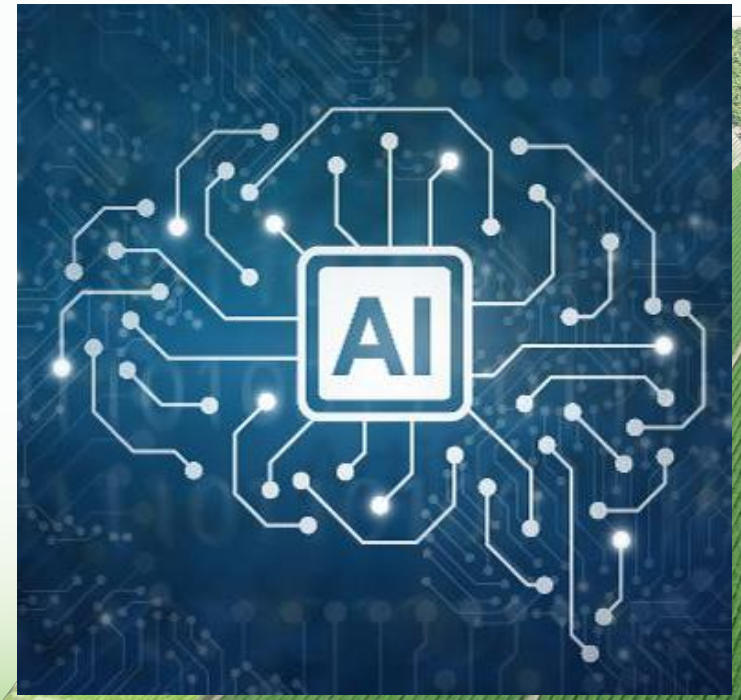
TAIWAN INT'L WATER WEEK

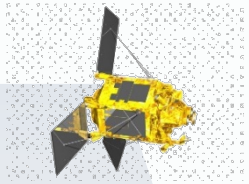
Exact Field data by UAV

TAIWAN INT'L WATER WEEK

Various data source and AI

AI image interpretation Crop identification





Satellite image

Aerial photography

UAV or Drone

Panoramic street view

Ground mobile phone app

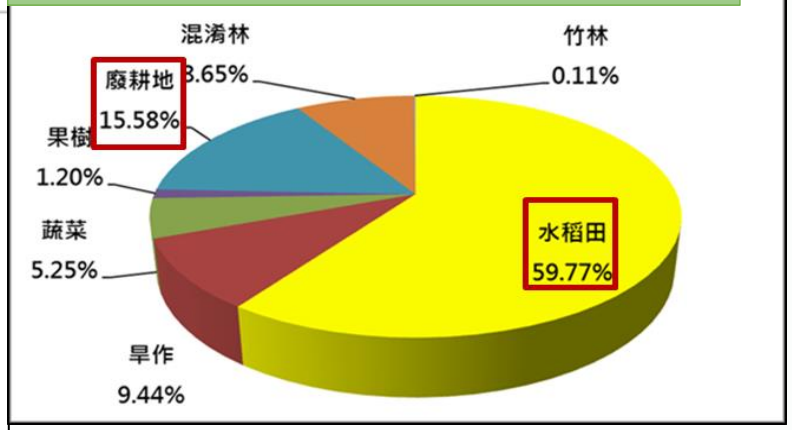
TAIWAN INT'L WATER WEEK

GIS cultivation management

TAIWAN INT'L WATER WEEK

Crop type and cultivation area

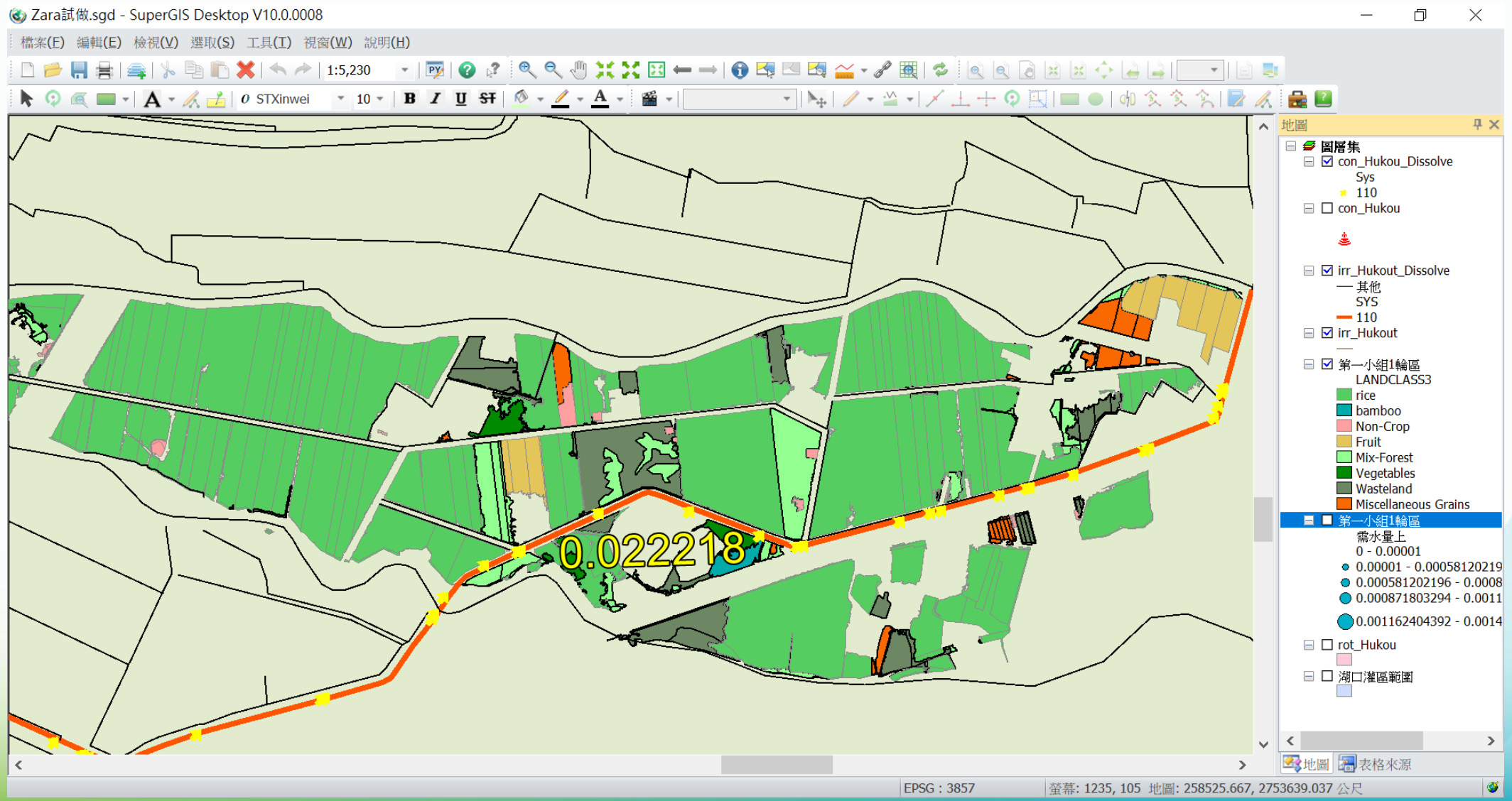
Crop Statistics



attribute database

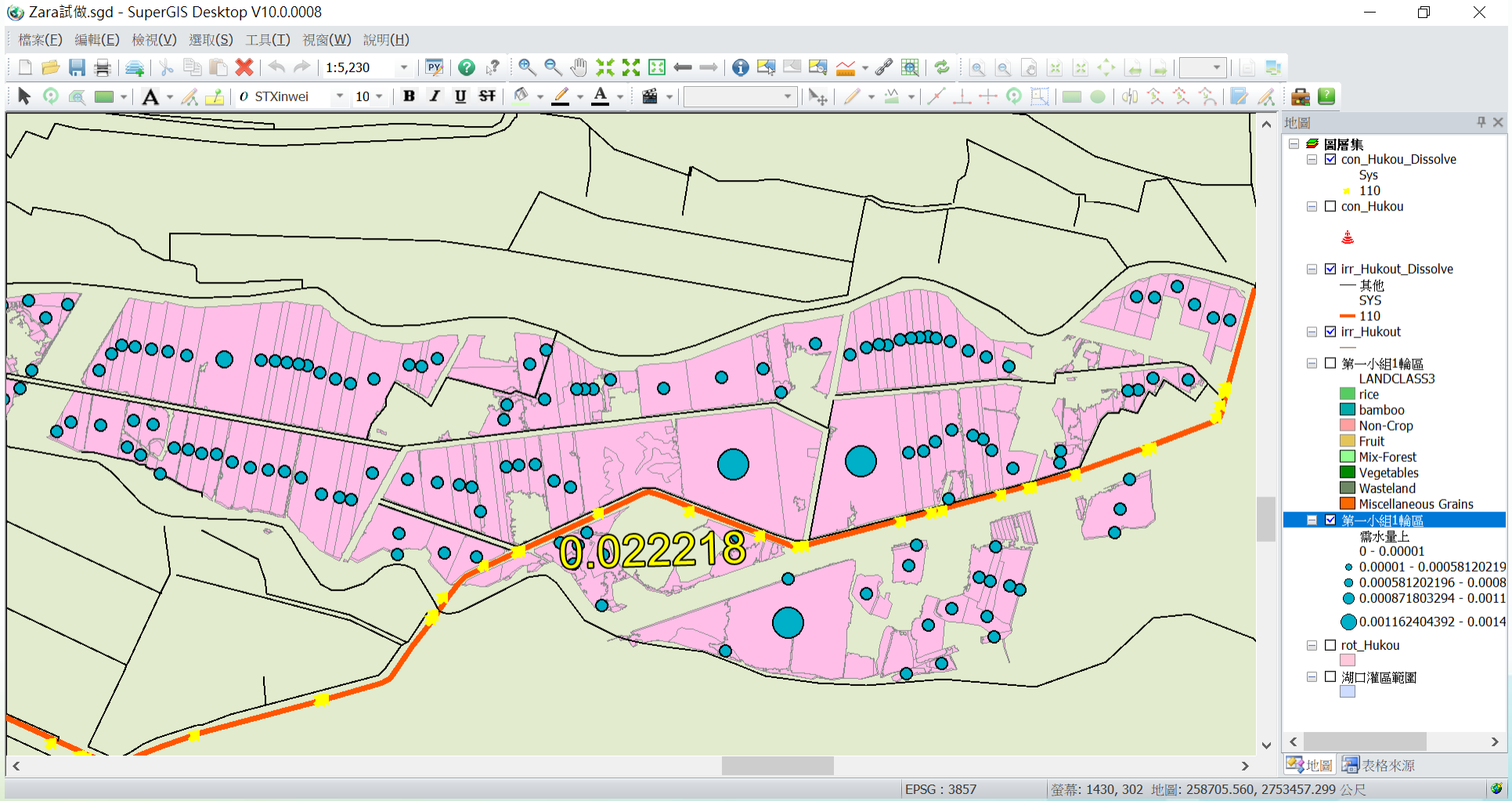
TAIWAN INT'L WATER WEEK

GIS-based Irrigation water assessment



TAIWAN INT'L WATER WEEK

Crop water consumption on GIS

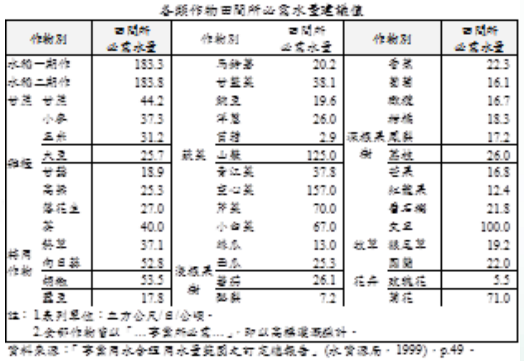


System irrigation water requirement

❶ Crop identification → Various crop water → ❷ Crop water requirement estimation → Transfer water loss → ❸ Sub-system water requirement → ❹ Irrigation water supply

❶

Crop ID map

❷

各類作物田間所必需水量建議值

作物別		田間所必需水量	作物別		田間所必需水量	作物別		田間所必需水量
水稻一期作		183.3		馬鈴薯	20.2		香蕉	22.3
水稻二期作		183.8		甘藍菜	38.1		葡萄	16.1
甘蔗	甘蔗	44.2		豌豆	19.6		枇杷	16.7
	小麥	37.3		洋蔥	26.0		柑橘	18.3
	玉米	31.2		蘆筍	2.9	深根果樹	鳳梨	17.2
雜糧	大豆	25.7	蔬菜	山葵	125.0		荔枝	26.0
	甘藷	18.9		青江菜	37.8		芒果	16.8
	高粱	25.3		空心菜	157.0		紅龍果	12.4
	落花生	27.0		芹菜	70.0		番石榴	21.8
	茶	40.0		小白菜	67.0		文旦	100.0
	菸草	37.1		絲瓜	13.0	牧草	狼尾草	19.2
特用作物	向日葵	52.8		西瓜	25.3		盤固	22.0
	胡麻	53.5	淺根果樹	草莓	26.1	花卉	玫瑰花	5.5
	豌豆	17.8		鳳梨	7.2		菊花	71.0

註：1.表列單位：立方公尺/日/公頃。
2.全部作物皆以「…事業所必需…」，即以高標準灌溉估計。

資料來源：「事業用水合理用水量範圍之訂定總報告」(水資源局，1999)，p.49。

Various crop water consumption

❸


System irrigation water supply are based on sub-system requirement and water loss

❹


TAIWAN INT'L WATER WEEK

Expanding Upland Crop Areas by Smart Water Control

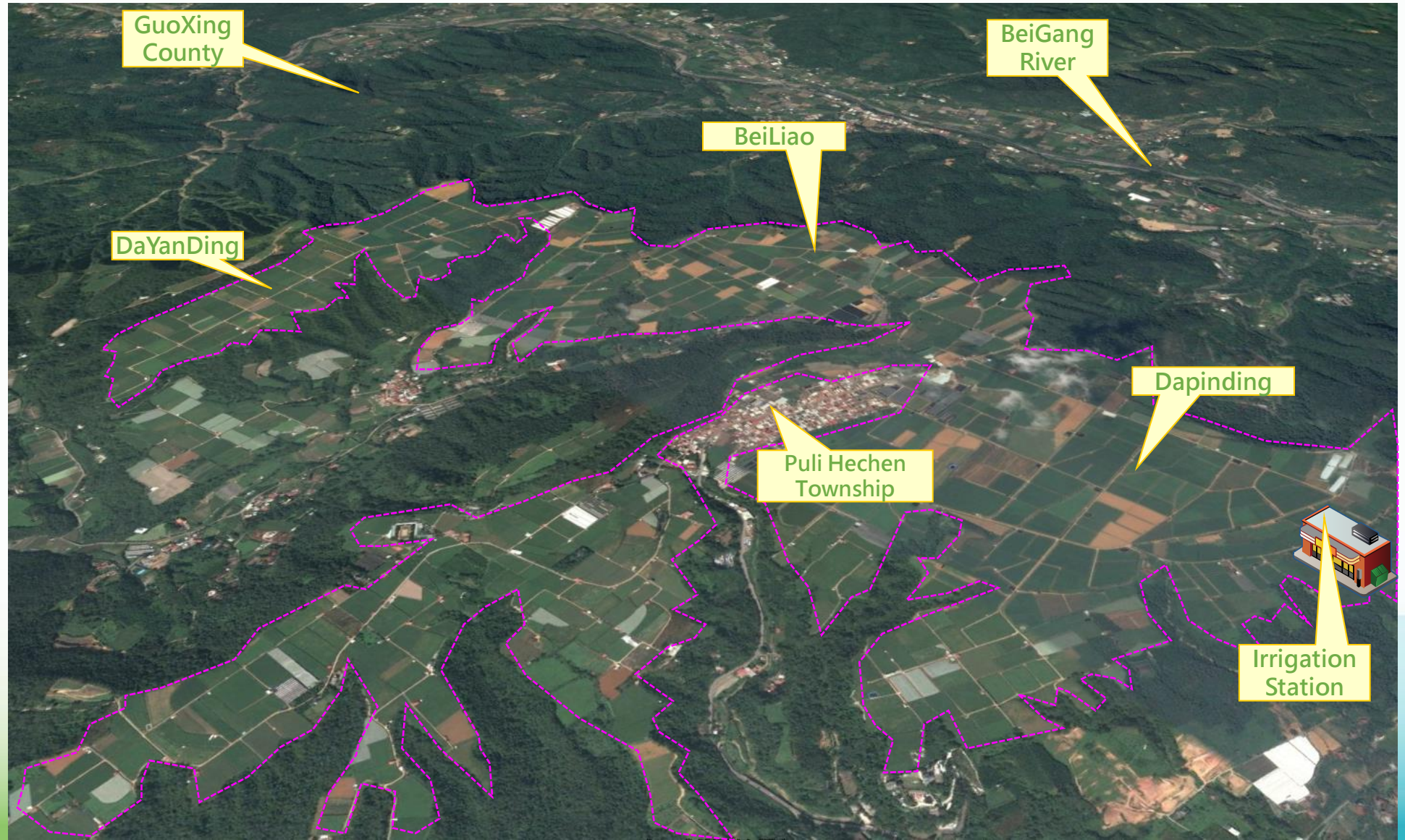
TAIWAN INT'L WATER WEEK

Water resource conditions

- Elevation 550m – 750m
- a prominent independent hills and tablelands
- No watershed for surface water source
- Farmers used to dig wells and pump for irrigation

TAIWAN INT'L WATER WEEK

Expand upland crop areas



TAIWAN INT'L WATER WEEK

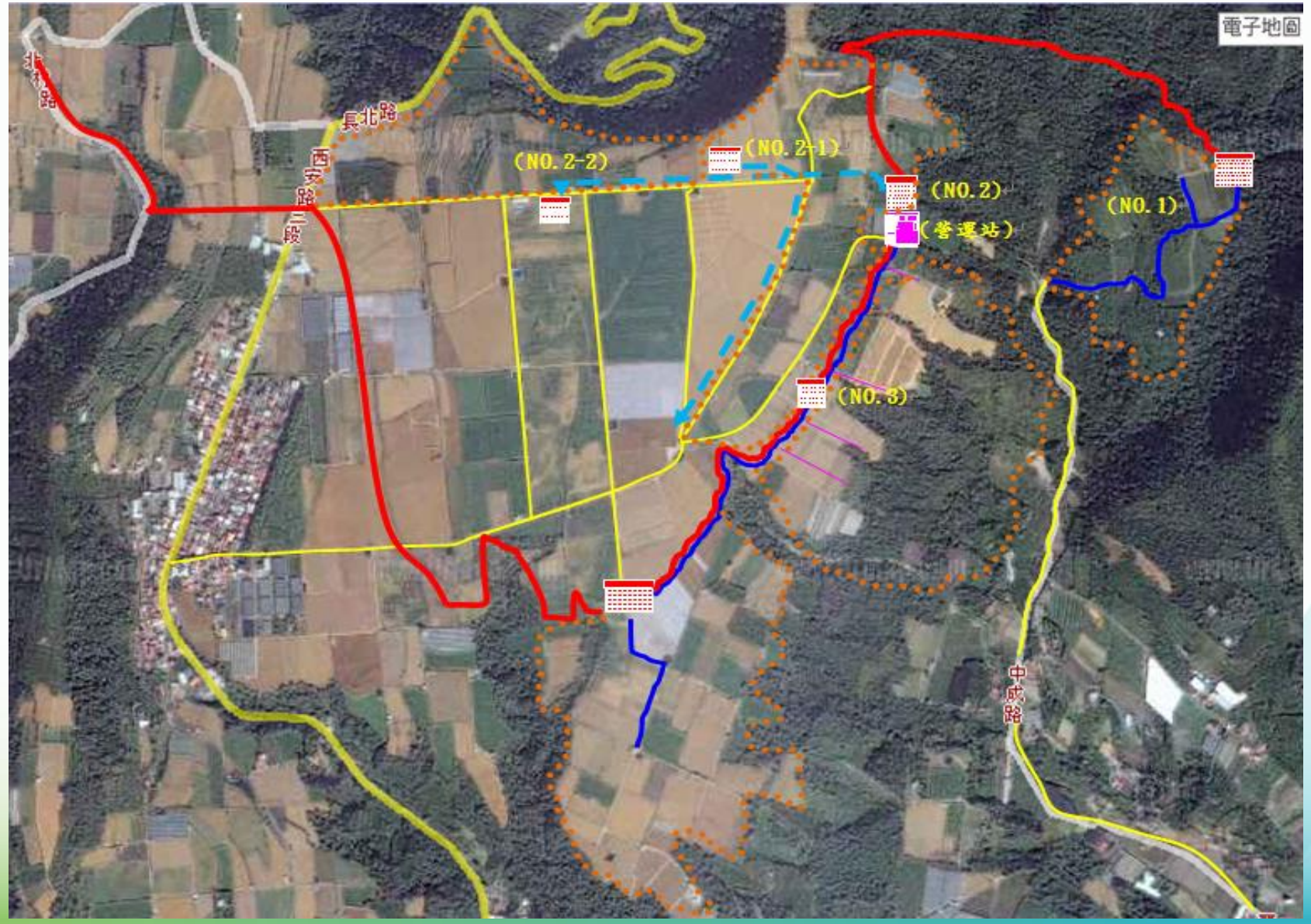
Area and major crops

Dapindin Area 386 ha
Bei-liao Area 248 ha

Major Crops:
radish, bitter gourd, papaya, passion fruit, and vegetables

TAIWAN INT'L WATER WEEK

Water supply diagram



營運站	
蓄水池	
管路幹線	
管路支線	
加壓支線	
管路分線	
輸水輪區	
既設道路	

TAIWAN INT'L WATER WEEK

Water supply equipment

Upper tank

Pump station

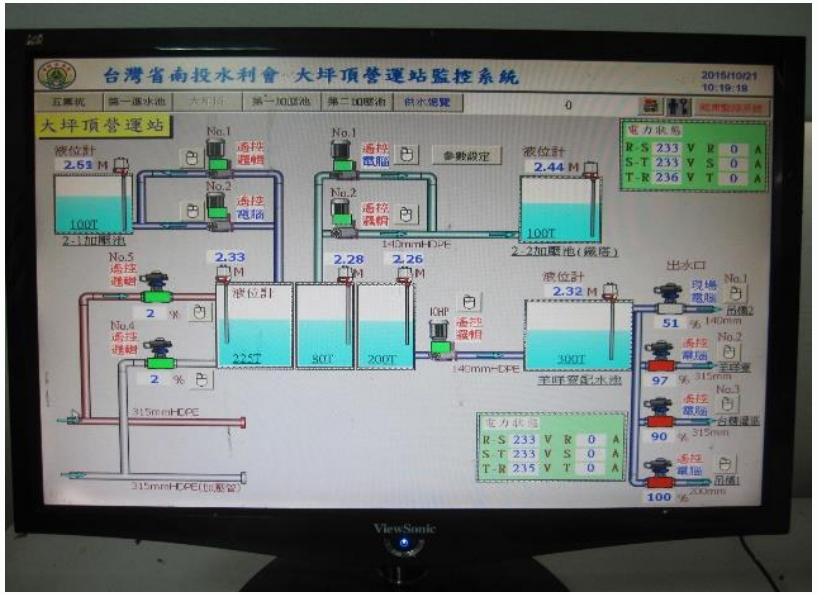
Lower reservoir

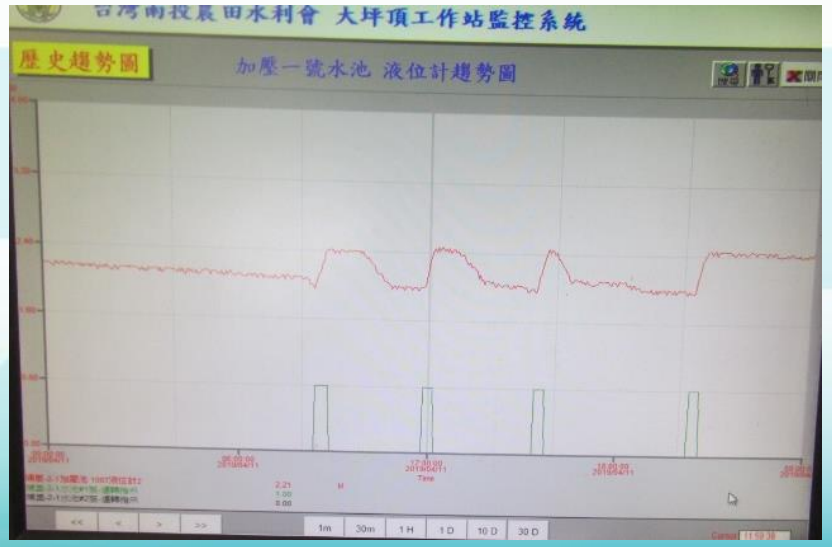
Pump systems

HDPE Pipelines

TAIWAN INT'L WATER WEEK

Smart water control system

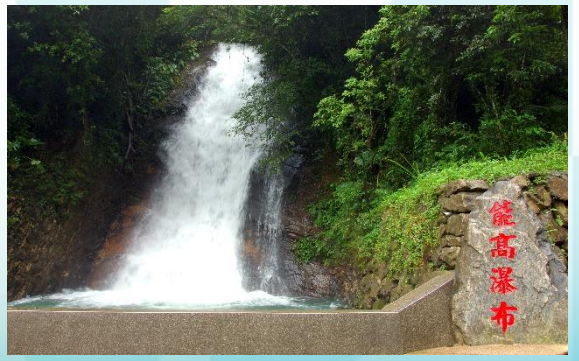




TAIWAN INT'L WATER WEEK

Expanding experiences

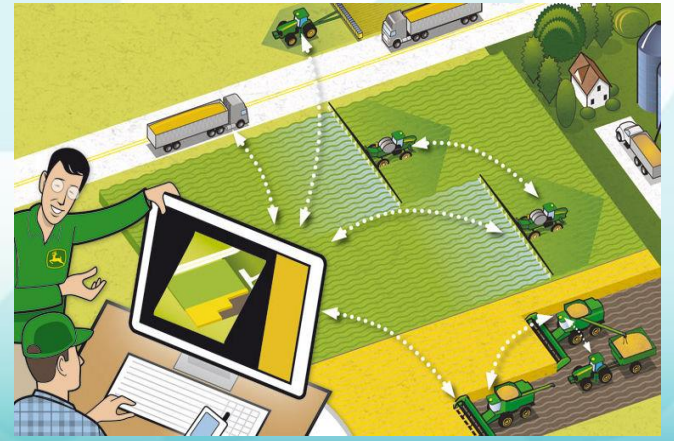
- Water intake from up-stream by gravity
- Using surplus water from nearby canal
- Smart use of up and low reservoirs
- Precision water supply and control
- Expanding areas by high efficient irrigation



TAIWAN INT'L WATER WEEK

Concluding Remarks

- Use sensing technologies, including hi-res satellites, UAV, mobile app, and ground sensors to collect field data
- Use AI and GIS to identify crop types and areas
- Use various water storage such as ponds, reservoirs, and water tanks to keep rainwater
- Use pressurized pipeline to deliver irrigation water
- Use cloud-top computing to decide the best irrigation strategy, so as to expand the irrigation services efficiently.



TAIWAN INT'L WATER WEEK

Thank You