附件一、WWF5 會議節目表

FORUM WEEK PROGRAMME

Day 1 — Monday - March 16

BLOCK NAME	ROOM NAME	09:30-11:00	11:00-12:00	LUNCH	14:30-16:30	17:00-19:00	19:00-22:00
MAIN BLOCK	HALİÇ	Opening Ceremony			Thematic Openings		Concert Melody of Water
REGIONAL BLOCK	SADA BAD	Opening Ceremony Video			Heads of State Summit (Video)	World Water Development Report	Youth Forum Opening
THEMATIC BLOCK	KAĞIT HANE				Water Issues of Small Islands		
THEMATIC BLOCK	EYÜP				Running Dry!		
THEMATIC BLOCK	AYVAN SARAY			Side Event	Session on Health, Dignity and Economic Progress		
CARPARK BLOCK	AYNALI KAVAK I					Session 4.4.1	
CARPARK BLOCK	AYNALI KAVAK II				Partnership Session		
FESHANE BLOCK	FESHANE I						
FESHANE BLOCK	FESHANE II						
FESHANE BLOCK	FESHANE III						
FESHANE BLOCK	FESHANE IV	Youth Theme 1 Coordination			Youth Theme 2 Coordination	Youth Theme 5 Coordination	
FESHANE BLOCK	FESHANE V	Youth Theme 4 Coordination			Youth Theme 3 Coordination	Youth Theme 6 Coordination	
FESHANE BLOCK	BEDESTEN I-VI				Major Groups		
FESHANE BLOCK	BEDESTEN VII						
VIP BLOCK	HASKÖY						
VIP BLOCK	KASIM PAŞA						
HOTEL					Heads of State Summit	Heads of State Closed Meeting	
FAIR AREA FESHANE II. MAHMUD HALL				Fair Opening	Water Fair		
SÜTLÜCE EXPO TENTE				EXPO Opening	EXPO		

Day 2 — Tuesday - March 17

BLOCK NAME	ROOM NAME	08:30-10:30	11:00-13:00	LUNCH	14:30-16:30	17:00-19:00	19:00-22:00
MAIN BLOCK	HALİÇ	Keynote Lecture by HIH the Crown Prince of Japan	Panel Water and Disasters		Panel on Finance		Istanbul ECC 2010 Concert
REGIONAL BLOCK	SADA BAD	Region Americas			Region Europe		
THEMATIC BLOCK	KAĞIT HANE	Launch of the OECD Report on Pricing and Financing	Technical Experts Panel Water and Financial Crisis	Side Event	Session on Water Management 2020		Side Event
THEMATIC BLOCK	EYÜP	Session 4.1.1		Side Event	Session 4.1.2	Session 4.1.3	
THEMATIC BLOCK	AYVAN SARAY	Session 4.2.1		Speakers' Corner	Session 4.2.3		
CARPARK BLOCK	AYNALI KAVAK I	Session 4.3.1			Session 4.3.2		Youth Theme 2 Coordination
CARPARK BLOCK	AYNALI KAVAK II					Session 4.4.3	Youth Theme 5 Coordination
FESHANE BLOCK	FESHANE I	Session 1.1.2			Session 1.1.3		
FESHANE BLOCK	FESHANE II	Session 1.2.1			Session 1.2.2		
FESHANE BLOCK	FESHANE III	Session 4.2.4			Inland Waterborne Transport		
FESHANE BLOCK	FESHANE IV	Drop for Crops (Joint Venture 2.3&5.2)			Session 1.3.0	Session 1.3.3	
FESHANE BLOCK	FESHANE V	Side Event					
FESHANE BLOCK	BEDESTEN I-VI	Major Groups					
FESHANE BLOCK	BEDESTEN VII	Youth Theme 6 Coordination	Youth Workshops				
VIP BLOCK	HASKÖY	Side Event					
VIP BLOCK	KASIM PAŞA	Side Event					
HOTEL			Senior Officials Meeting				
FAIR AREA FESHANE II. MAHMUD HALL		Water Fair					
SÜTLÜCE EXPO TENTE		EXPO					

Day 3 — Wednesday - March 18

BLOCK NAME	ROOM NAME	08:30-10:30	11:00-13:00	LUNCH	14:30-16:30	17:00-19:00	19:00-22:00
MAIN BLOCK	HALİÇ		Panel Water, Food and Energy		Panel Sanitation	From Mexico to Istanbul Session	
REGIONAL BLOCK	SADA BAD	Region Africa			Country Group Turkey+		Turkey and Around Event
THEMATIC BLOCK	KAĞIT HANE	Parliamentarians			Parliamentarians		Side Event
THEMATIC BLOCK	EYÜP	Session 4.1.4	Session 4.1.5	Side Event	Session 2.2.0	Session 2.2.3	Side Event
THEMATIC BLOCK	AYVAN SARAY	Session 4.2.2	Session 4.2.5	Speakers' Corner	Session 2.3.1		
CARPARK BLOCK	AYNALI KAVAK I	Session 4.3.3	Session 4.3.4		Session 2.1.1	Session 2.1.2	Youth Theme 3 Coordination
CARPARK BLOCK	AYNALI KAVAK II	Session 4.4.2			Session 2.4.1		Youth Theme 5 Coordination
FESHANE BLOCK	FESHANE I	Session 5.1.1	Session 5.1.2		Session 1.1.4		
FESHANE BLOCK	FESHANE II	Session 1.2.3	Session 1.2.4		Session 5.1.3	Session 5.1.4	
FESHANE BLOCK	FESHANE III	Local Authorities			Local Authorities		
FESHANE BLOCK	FESHANE IV	Session 1.3.1	Session 1.3.2	Side Event	Session 5.3.1		Side Event
FESHANE BLOCK	FESHANE V	Side Event					
FESHANE BLOCK	BEDESTEN I-VI	Major Groups					
FESHANE BLOCK	BEDESTEN VII	Youth Theme Coordination Meeting	Youth Workshops				
VIP BLOCK	HASKÖY	Side Event					
VIP BLOCK	KASIM PAŞA	Side Event					
HOTEL			Senior Officials Meeting				
FAIR AREA FESHANE II. MAHMUD HALL		Water Fair					
SÜTLÜCE EXPO TENTE		EXPO					

Ceremony
Political Process
Regional
Theme I
Theme II
Theme III
Theme IV
Theme V
Theme VI
Panels
Side Event*
Major Groups
Youth Forum
Art & Culture**

Day 4 – Thursday - March 19

BLOCK NAME	ROOM NAME	08:30-10:30	11:00-13:00	LUNCH	14:30-16:30	17:00-19:00	19:00-22:00
MAIN BLOCK	HALİÇ		Panel Adaptation (Regional part)		Thematic Warp-up 4	Thematic Warp-up 1	
REGIONAL BLOCK	SADABAD	Dialogue between Local Authorities and Parliamentarians			Country Group Arab		
THEMATIC BLOCK	KAĞIT HANE	Country Group Mediterranean			Parliamentarians		Side Event
THEMATIC BLOCK	EYÜP	Session 2.2.2		Side Event	Session 2.2.1	Session 2.2.4	Side Event
THEMATIC BLOCK	AYVAN SARAY	Session 2.3.2		Speakers' Corner	Session 2.3.4	Session 4.4.4	
CARPARK BLOCK	AYNALI KAVAK I	Session 2.1.3			Session 2.1.4	Session 2.1.5	Youth Forum Thematic Synthesis
CARPARK BLOCK	AYNALI KAVAK II	Session 2.4.2			Session 2.4.3	Country Group Arab Ministerial Meeting	
FESHANE BLOCK	FESHANE I	Session 4.2.6	Session 1.3.4		Mega Natural Disasters		
FESHANE BLOCK	FESHANE II	Session 5.2.1	Session 5.2.2		Session 5.3.4	Session 5.3.5	
FESHANE BLOCK	FESHANE III	Session 2.3.3			Local Authorities		
FESHANE BLOCK	FESHANE IV	Session 5.3.2	Session 5.3.3		Session 1.3.5	Session 5.2.3	Side Event
FESHANE BLOCK	FESHANE V	Side Event					
FESHANE BLOCK	BEDESTEN I-VI	Major Groups					
FESHANE BLOCK	BEDESTEN VII	Youth Theme Coordination Meeting	Youth Workshops				
VIP BLOCK	HASKÖY	Side Event					
VIP BLOCK	KASIM PAŞA	Side Event					
	HOTEL						
	FAIR AREA FESHANE II. MAHMUD HALL	Water Fair					
	SÜTLÜCE EXPO TENTE	EXPO					

Day 5 – Friday - March 20

BLOCK NAME	ROOM NAME	08:30-10:30	11:00-13:00	LUNCH	14:30-16:30	17:00-19:00	19:00-22:00
MAIN BLOCK	HALİÇ	Thematic Warp-up 5	High Level Trialogue		Ministerial Conference Opening	Panel Adaptation (High Level part)	
REGIONAL BLOCK	SADABAD	Region Asia-Pacific				Closing of Youth Forum	
THEMATIC BLOCK	KAĞIT HANE	Session 3.1.1	Session 3.1.2	Major Group Events	Session 3.1.3		Side Event
THEMATIC BLOCK	EYÜP	Session 6.5.1	Session 6.5.2	Side Event	Session 6.5.2	Session 6.5.3	Side Event
THEMATIC BLOCK	AYVAN SARAY	Session 3.4.1		Speakers' Corner	Session 3.4.2		
CARPARK BLOCK	AYNALI KAVAK I	Session 3.2.1	Session 3.2.3		Session 3.2.2		
CARPARK BLOCK	AYNALI KAVAK II	Session 3.3.1			Session 3.3.2		
FESHANE BLOCK	FESHANE I	Session 6.2.1			Session 6.2.2		
FESHANE BLOCK	FESHANE II	Session 6.3.1			Session 6.3.2		
FESHANE BLOCK	FESHANE III	Session 6.4.1			Session 6.4.2		
FESHANE BLOCK	FESHANE IV	Session 6.1.0	Session 6.1.1		Session 6.1.2	Session 6.1.3	Side Event
FESHANE BLOCK	FESHANE V	Side Event					
FESHANE BLOCK	BEDESTEN I-VI	Major Groups					
FESHANE BLOCK	BEDESTEN VII						
VIP BLOCK	HASKÖY	Side Event					
VIP BLOCK	KASIM PAŞA	Side Event					
	HOTEL						
	FAIR AREA FESHANE II. MAHMUD HALL	Water Fair					
	SÜTLÜCE EXPO TENTE	EXPO					

Day 6 – Saturday - March 21

BLOCK NAME	ROOM NAME	08:30-10:30	11:00-13:00	LUNCH	14:30-16:30	17:00-19:00	19:00-22:00
MAIN BLOCK	HALİÇ	Thematic Warp-up 2			Thematic Warp-up 3	Thematic Warp-up 6	Invitation Event Istanbul ECC 2010
REGIONAL BLOCK	SADABAD	3 Way Dialogue			Irrigation: Efficient Use of Water in Agriculture		
THEMATIC BLOCK	KAĞIT HANE	Session 3.1.4	Session 3.1.5	Major Group Events	Climate Related Disasters		
THEMATIC BLOCK	EYÜP	Session 6.5.4	Session 6.5.5	Side Event	Side Event		
THEMATIC BLOCK	AYVAN SARAY	Session 3.4.3	Session 3.4.4	Speakers' Corner			
CARPARK BLOCK	AYNALI KAVAK I	Session 3.2.4	Session 3.2.5		Partnership Session		
CARPARK BLOCK	AYNALI KAVAK II	Session 3.3.3	Session 3.3.4				
FESHANE BLOCK	FESHANE I	Session 6.2.3	Session 6.2.4				
FESHANE BLOCK	FESHANE II	Session 6.3.3	Session 6.3.4				
FESHANE BLOCK	FESHANE III	Session 6.4.3	Session 6.4.4				
FESHANE BLOCK	FESHANE IV	Session 6.1.4	Session 6.1.5		Side Event	Side Event	
FESHANE BLOCK	FESHANE V	Side Event					
FESHANE BLOCK	BEDESTEN I-VI	Major Groups					
FESHANE BLOCK	BEDESTEN VII						
VIP BLOCK	HASKÖY	Side Event					
VIP BLOCK	KASIM PAŞA	Side Event					
	HOTEL	Ministerial Roundtables					
	FAIR AREA FESHANE II. MAHMUD HALL	Water Fair					
	SÜTLÜCE EXPO TENTE	EXPO					

Day 7 – Sunday - March 22

BLOCK NAME	ROOM NAME	08:30-10:30	11:00-13:00
MAIN BLOCK	HALİÇ	Ministerial Conference Closing	Closing Ceremony
REGIONAL BLOCK	SADABAD		
THEMATIC BLOCK	KAĞIT HANE	UN-Water Day	
THEMATIC BLOCK	EYÜP		
THEMATIC BLOCK	AYVAN SARAY		
CARPARK BLOCK	AYNALI KAVAK I	Partnership Session	
CARPARK BLOCK	AYNALI KAVAK II		
FESHANE BLOCK	FESHANE I		
FESHANE BLOCK	FESHANE II		
FESHANE BLOCK	FESHANE III		
FESHANE BLOCK	FESHANE IV		
FESHANE BLOCK	FESHANE V		
FESHANE BLOCK	BEDESTEN I-VI	Major Groups	
FESHANE BLOCK	BEDESTEN VII		
VIP BLOCK	HASKÖY		
VIP BLOCK	KASIM PAŞA		
	HOTEL		
	FAIR AREA FESHANE II. MAHMUD HALL	Water Fair	
	SÜTLÜCE EXPO TENTE	EXPO	

* Please refer to daily programme pages for the detailed schedule.

** Please refer to Art & Culture Booklet for the detailed schedule.

附件二、WWF5 會場水利署參展海報

Topic 1.1- Adopting to Climate Change

Potential Benefits of Value-Adding Applications from Extra Water in Paddy Fields

The International Society of Paddy and Water Environment Engineering (PAWEES)

Introduction

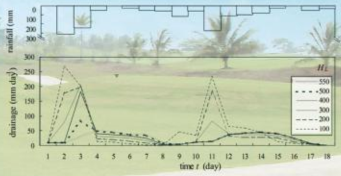
During the last 30-40 years the rapid industrialization, economic growth and rise in living standard resulted in a dramatic increase in domestic and industrial demands for water. Our voracious appetite for water imposes significant pressure to the agricultural sector (e.g. it currently uses 80% of available water resources in Taiwan) to sharply curtail its water consumption. Furthermore, as members of the World Trade Organization (WTO), PAWEES countries have to face the challenge of competing with foreign rice farmers with lower-cost and higher quality, as well as substantial decrease in paddy field acreage. However, in time like this, some concepts that were once seemingly far-fetched and impractical have begun to appear logical and worth exploring.

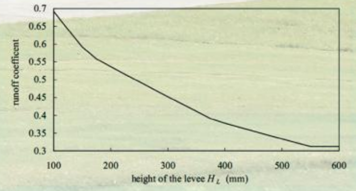
Potential Benefits of "Value-Adding" Applications from Extra Water in Paddy Fields

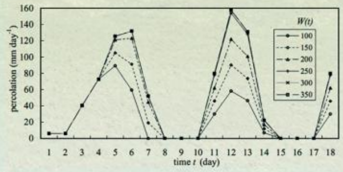
Owing to the reduced rice field acreage in the future, PAWEES focused on exploring one particular idea: to grow paddies using excessive water (Lee et al., 1995). The idea is based on the following hypotheses:

1. The increased water depth for the rice plants may improve the productivity and rice quality. For instance, the required water depth in paddy field in Taiwan is 6 cm in average but it is as much as 22 cm in Japan. The difference seems to explain the fact that the Japan's rice output ranks among the top in the world (Kan et al., 1997).
2. To store more water and increase water depth, height of levees around paddy fields. Then they can act as cisterns effectively collecting rainwater during wet months (Hayase, 1994).
3. Increased water depth in paddy fields will increase percolation of water through soil and hence increase the recharging of groundwater aquifers (Wen, 1995).
4. Extra water will elevate groundwater table and increase runoff from paddy fields. The effects will improve the crop yield and the overall ecological conditions of the adjacent areas (Sekiya, 1992).

Under the premise of the above hypotheses are correct, PAWEES's research aims to present project results to show potential benefits of "value-adding" applications from extra water in paddy fields.

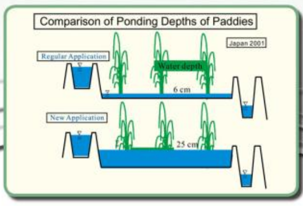


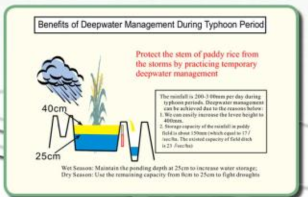


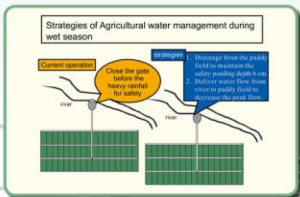


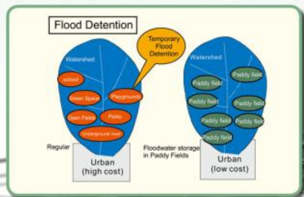
An Innovative Solution to Many Problems

Irrigation water differs substantially from industrial or domestic water. Its purpose is to satisfy the evapotranspiration needs for maintaining the crop's normal growth. However, from the viewpoint of effective utilization of water resources, instead of storing water just during wet months, adequate amount of water from the rivers should be delivered to the paddy fields through the year. As results, paddy fields can not only store and regulate excess water from the rivers, but also maintain percolation and replenish groundwater. Lastly, water conservation can be naturally achieved using existing resources instead of enforcing strict measures or constructing new and single-purposed facilities with limited applications.









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Topic 1.1- Adopting to Climate Change

Pond Irrigation System

The International Society of Paddy and Water Environment Engineering (PAWEES)

Introduction

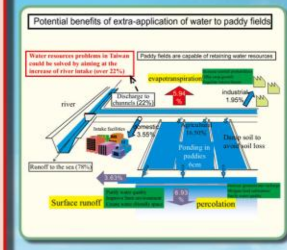
Roughly, water in wetland paddy irrigation can be categorized by its functions as follows:

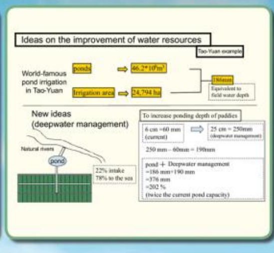
- Consumption in ETcrop(t) (i.e. evapotranspiration) and the growth of plant bodies (Brouwer and Heibloem, 1986).
- Movement towards downstream after infiltrating into the soil or flowing directly into the adjacent drain (Masayoshi and Akira, 1999).

Wetland paddy has two significant advantages:

- It is a buffer zone which improves water quality (Sekiya, 1992), and
- Higher water reuse ratio in wetland paddy reduces the net runoff load to zero (National Institute for Rural Engineering, 2004).

Consequently, downstream water users can easily reuse the filtered water.





Can Pond Irrigation System Achieve Optimal Water Allocation?

Problem: Limited Land Resources

→ Competition between industrial development and agricultural activities.

→ Large-scale industrial park causes water shortage in nearby area.

Solution: Wetland Paddy

→ It is basically a cistern which can effectively collect rainwater.

→ It can purify water and improve water quality

Therefore, if we can construct treatment plants and a sound reuse system using the irrigated water processed by wetland paddy, we can satisfy urban and industrial water needs.

The concept of water reuse between wetland paddy and industrial park is showed as figure on the right

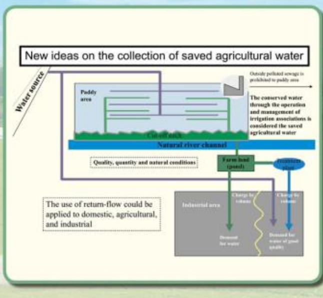
I(t) is the return flow rate from wetland paddy at time t (m^3 10-days-1);

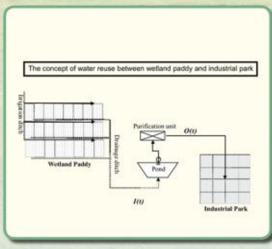
O(t) is the reuse water rate from pond through collecting return flow (m^3 10-days-1);

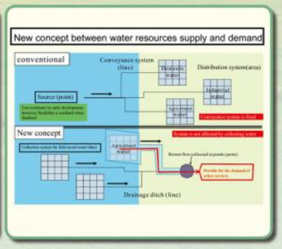
DP_{max} is the maximum water storage of pond (m^3); and

DP_{min} is the minimum water storage of pond (m^3).

Through the simulation of the reuse of return flow, the potential benefits of the reuse system is estimated.







Conclusions

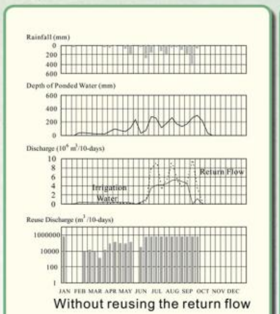
1. Increase maximum ponding depth → Increase return flow and the effective rainfall
2. Increase rate of reusing return flow → Alleviate local water needs
3. Increase paddy field areas during crop seasons → Decrease drought frequency
4. More paddy fields → More water storage → Close up the supply-and-demand gap between wet and dry season

Benefits of reusing of return flow from wetland paddy:

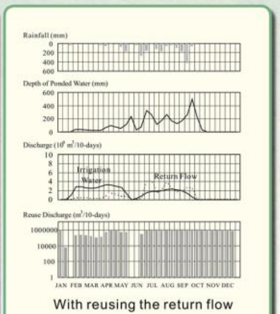
※Quick-response supply solution: meeting water needs at peak demand periods

※Better water management: achieving stable supply of irrigation water and crop security

The effects of practicing deepwater management, enlarging water storage capacity, and different scale of paddy fields are respectively presented in figures at the bottom right (Chang et al., 2009).



Without reusing the return flow



With reusing the return flow

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Topic 1.1- Adopting to Climate Change

From Coastal Area Conservation to Field Application in Lake Chad

The International Society of Paddy and Water Environment Engineering (PAWEES)

Introduction: Coastal Area Conservation

Sand dune of Chiting Coast are sand and gravel deposits within a marine beach system, including beach berms, frontal dunes, back dunes, and other sand and gravel systems deposited by waves or winds. The coastal sand dunes extend into the paddy fields. Artificial windbreak tree and lawns have been planted at some of the sand dunes. Some sand dune systems also include local and native vegetation. In order to improve the soil texture and conserve the costal arable land , plenty of field experiments were conducted by the Water Resources Agency (WRA) in Chiting Working Station from 2003 to 2009. Those experiments integrate global experiences of the groundwater recharge movement in the Indus basin in India, the "Creek Irrigation" technology of paddy fields at coastal area in Japan's Kiu-Shiu areas for 300 years and the 80-year-old "3-year crop rotation system" by Chia-Nan Irrigation Association in Taiwan. They are shown in the pictures below.

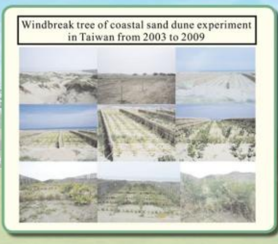
Background: Field Application at Lake Chad

Experts and professionals from Taiwan and Chad have been working on several field application are explore from those experiments which may be able to be used in the conservation of Lake Chad Basin. In the past 50 years, West Africa has experienced large land-use changes including deforestation, overgrazing, land reclamation and a persistent drought since the 1960s. In the short run, destructive land use change may result in the dramatically change in water flow, or even eliminating the low flow in some area. In the long run, the decrease in evapotranspiration and water recycling may trigger unwanted feedback mechanisms that ultimately reduce rainfall. In Sahelian countries, the persistent drought has already reduced the rainfall. In countries of the Sahel, the persistent drought has reduced the area of Lake Chad from 23,500 km^2 to about 1,500 km^2.

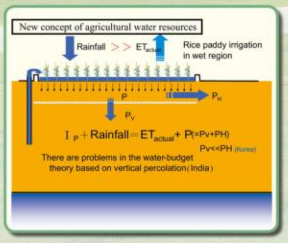
Goals and Method of the Lake Chad Project

Land conservation strategies developed from the experiences from Chiting Working Station are shown as figures on the right. The goals of this field application at Lake Chad can be summarized as follows:

1. To avoid unnecessary discharge to the desert, horizontal percolation from paddy area is collected and properly stored.
2. The blocking wall, which is formed by fertile sludge, are used to provide nutrients and foundation for the growth of windbreak forests.
3. To improve soil texture of the Sahelian land.
4. To make effective use of the sludge from Lake Chad.
5. To mitigate sand storms at Sahelian areas.

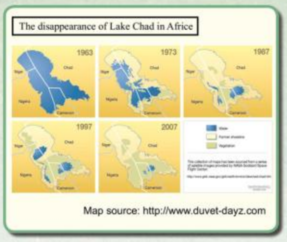

Windbreak tree of coastal sand dune experiment in Taiwan from 2003 to 2009


Consultation of experts and professionals from Chad, Japan and Taiwan

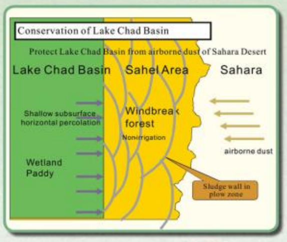


New concept of agricultural water resources

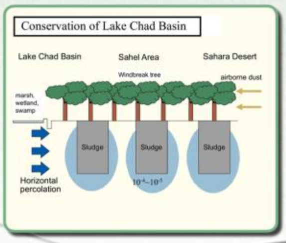
Land conservation with irrigation technology



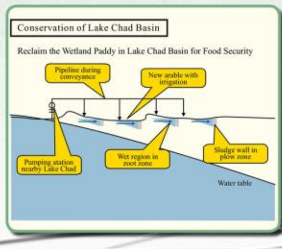
The disappearance of Lake Chad in Africe



Conservation of Lake Chad Basin



Conservation of Lake Chad Basin



Conservation of Lake Chad Basin

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5th WORLD WATER FORUM
ISTANBUL 2009
BRIDGING DIVIDES FOR WATER
March 16-22, 2009

Topic 1.3 – Managing Disasters

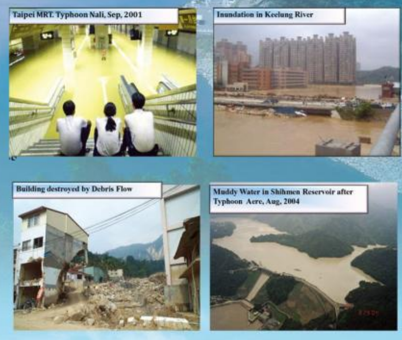
Flash Flood Mitigation in Taiwan

Introduction

The main types of disasters in Taiwan are as follow:

1. Extremely rainfall, 1~24hr duration are 85%~95% of world records
2. Earthquake, e.g. Jiji earthquake measured 7.3 on the Richter scale
3. Flash Floods, e.g. Typhoon Nari inundation
4. Landslides and debris flow, e.g. Shihmen Reservoir Sediment deposition

This poster will introduce Taiwan's experiences mitigating the tropical cyclone induced flash flood and excessive sediment into reservoirs by two unique examples.



Flood Response System - DRAINS

Pro:

- provide 3-hour effective warning lead-time for typhoon rainfall induced mountainous flash flood

Content:

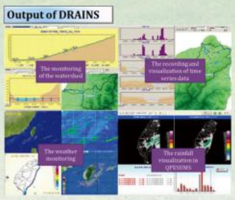
- Climatologic Typhoon QPF Module
- Geomorphologic Runoff Module
- NewC Channel Routing Module
- XML-Based I/O files, Adapters & Workflows

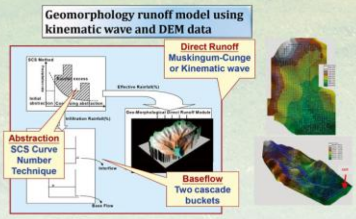
Application:

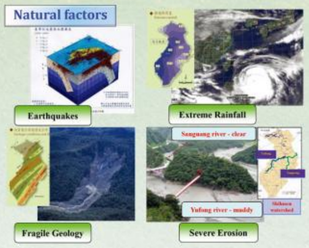
- This system had successfully forecasted and issued warning hours before the over-levee incidence during typhoon Nari in 2001. Over 20,000 people were evacuated and no human mortality during the up to 6-meter depth inundation in that area .

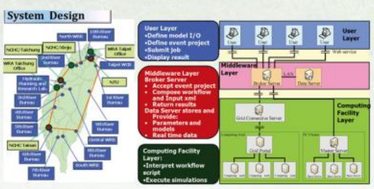
Dealing with Excessive Reservoir Sedimentation

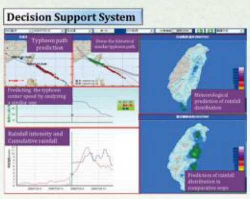
Excessive sediment caused by the basin averaged 967mm rainfall within 36 hours over the 760km^2 watershed had broken down the power plant of the 3rd largest reservoir in Taiwan, and failed the water treatment system during high flood periods ever since. New engineering facilities are added to the operating reservoir and new flood-period operation rules are developed to secure water supply and to reduce sedimentation.











First ,drain muddy water through low-level gate when flood arriving.
Drain water from spillway when the operational discharge is over the maximum discharge of the low-level gate

Contact information: Dr. Tim Hau Lee (E-Mail: thlee@ntu.edu.tw)

附件三、PAWEES 論文內容

PAWEES' Special Topics in 5^{th} World Water Forum

The International Society of Paddy and Water Environment Engineering (PAWEES),
5^{th} World Water Forum, Istanbul, Turkey, 16-22 March, 2009

The General Assembly of the United Nations (UN) declared 2004 as the International Year of Rice with the slogan "Rice is Life." This is an extraordinary focus for a single crop to acquire such international recognition. As rice is a staple food for majority of developing countries, especially in Asia, it acknowledges the importance of rice linked to food security and poverty alleviation and also the significance of its management and development for our society and the natural environment. The establishment of the International Society of Paddy and Water Environment Engineering (PAWEES) is initiated from the same acknowledgement by scientists and engineers in the Asian region.

Since its establishment, the Society has achieved some short-term goals and progressed beyond. At present, the members of the Society have expanded to nearly 15,000, including scientists and engineers from a variety of universities, government agencies, and private sectors. The official international journal of PAWEES is *Paddy and Water Environment* (PWE), being published periodically as planned, and the number of manuscript submissions from non-Asian regions has been increasing. This is an indication of a successful recognition of PWE journal outside of Asia. Because of its rapid popularity and advancement, many international organizations such as FAO, World Bank, IWMI, and IRRI are giving great attention to this unique publication.

Dr. Shen-Hsien Chen, the president of PAWEES during 2007-2008, has some expectations that each member of the PAWEES catches the trend of new technology, share their excellent experience, develop innovative pattern of thoughts, and actively participate in international activities in agricultural engineering development. One of the important international activities in the short term is the fifth World Water Forum (WWF5) which will be held in March 2009. In addition, facing the challenges of climate change and in order to turn the crisis into an opportunity, PAWEES is also expected to employ the appropriate adaptation strategies and modern thinking to assist its members to reach the goal of sustainable development. Over the past years, the main member countries of PAWEES have already transformed from an agricultural society into an industrial one and now are heading towards a society of sustainable development. The future focal point would be transformed from "water for agriculture" and "water for the industry" to "water for sustainability" and "water for life".

Contents

Climate Change Impacts on Paddy and Water Management

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1. INTRODUCTION

Climate changes due to global warming may affect considerably paddy cultivation. Changes of climate directly have effects on rice plant growth, with changes of air temperature, precipitation, evapotranspiration as well as water temperature. They may cause changes of hydrological regime of an area or basin of the paddy cultivation, including changes of flood pattern and water availability for paddy irrigation, and drainage condition. The future increased CO_2 concentration in air, which is one of the causes of global warming, also may the plant growth, since it is an essential element of photosynthesis of plant.

The impacts of climate change on agriculture are really complicated processes and are difficult to be predicted precisely. Especially, assessing the impacts on paddy cultivation is much hard since the indirect impacts through the hydrological behavior of the basin should be dealt with too much extent. The impacts of climate change on paddy cultivation may differ place to place, from the tropic to the temperate regions, and then the adaptations to reduce the negative impacts are to be modified with these conditions.

In this paper, being conscious of these varieties of the impacts, the discussions on the Japanese paddy cultivation and related hydrology are outlined.

2. IMPACTS OF CLIMATE CHANGE ON HYDROLOGY AND AGRICULTURE IN JAPAN

2.1 Climate change impacts on climate and hydrological regime of Japan

It is projected that the climate change due to the global warming will cause the decrease of snow fall and accumulation in winter, and earlier and reduced runoff of snow melt in spring. Extremely rainfall events will increase, resulting in increased frequencies of much serious flood and drought, of which trends are similar to the prediction for the whole Asian region. The future sea-level rise might cause increase of ill-drainage and even inundation of farmland near the sea coast and sea water intrusion to estuary and groundwater.

The Japan Meteorological Agency projects the future possible changes of the climate of

Japan at the end of 21st Century as summarized as below.

1) The average temperature will increase by 2.0 to3.2 degree, while the increase would be one degree at 2030. In the region of higher latitude, it will increase much more.
2) Frequency of abnormal higher temperature is increased. Hot day with more than 30 ℃ may continue for almost four months in summer.
3) Annual precipitation will increase except southern Kyushu Area, while seasonal precipitation of winter and spring will decrease in most regions. The number of no-rain day will increase in almost all over Japan.
4) Snow fall will decrease in whole Japan except the coast of the Sea of Okhotsk.
5) The magnitude of Typhoon will become larger.

2.2 Predicted climate change impacts on agriculture of Japan

Ministry of Agriculture, Forestry and Fishery of Japan predicts the impacts of climate change on agriculture. The major points are outlined as follows.

1) Higher temperature will affect physiology and growth of the crops resulting reduction of production and degradation of quality. Area suitable for particular crop may shift to other regions. For example, with higher temperature of 3 degree, in Hokkaido Region in the north, rice yield would increase by 13%, while 8 to 15 % decrease of yield would be observed in southern regions. The suitable area for apple would expand to north to the Hokkaido Region, while the area from the Kanto Region southward would be not appropriate for apple.
2) To adapt to or mitigate these impacts as well as precipitation change impacts, measures in cultivation are to be developed including changes of water management practices, breed improvement, alternative cropping pattern.
3) The much serious droughts might require re-allocation of reduced available water resources. The frequent heavy rainfall might cause disaster like flood and land slide with destruction of hydraulic structures of agriculture.

2.3 Resent observations of higher temperature damages in agricultural production in Japan

In these days, many abnormal climate events have been observed in Japan. The events are not to be connected directly with global warming, but they could be experienced often when climate changes are realized due to global warming. With these unusual climate, some adverse effects have been observed, of which examples are listed below.

1) With very high temperature of maturing stage, fertility and quality of rice grain decreased.
2) Harmful insects have increased in levee or bund overgrown with weed.
3) With hot and dry condition of maturing stage, production and quality of soybean has decreased.
4) Tea and fruit trees have frost damages in early spring, when they grow rapidly with warmer condition in winter.
5) Higher temperature causes some disease on orange, apple and grape.
6) With extremely heavy rainfall, inundation damage of farmland and land slide in hilly areas has increased.
7) Opportunities for reducing irrigation diversion have been increased due to severe drought.

2.4 Necessary assessment of climate change impacts and establishment of adaptations

Taking the facts introduced in the previous sections into account, adaptation and mitigation strategies are needed to be discussed and established urgently. Then, the Japanese Ministry of Agriculture, Forestry and Fishery is expressing the necessity to assess urgently the impacts and establish adaptation strategies in the following major fields and topics. One of the most important works is to detect the most vulnerable areas, periods, and crops to climate change caused by global warming.

a. Assessment of impacts of higher temperature
b. Assessment of impacts of changes in precipitation regime
c. Assessment of impacts of sea-level rise

The assessment of climate change impacts depend its accuracy and reliability on the accuracy and resolution of the future climate change scenario, which are usually generated by climate models. The climate models, including GCM(General Circulation Model) and the methodology for downscaling its outputs to regional level, are being innovated rapidly day by day, and the development of the model should be reviewed at right moments.

3. ASSESSMENT OF GLOBAL WARMING IMPACTS ON RICE PRODUCTION IN JAPAN

Rice is staple crop in Japan, and climate change impacts on rice production attract the attention of the researcher and engineers as well as the public. Many researches are now going on, and due to the complexity of the topic, which was descried at the introduction of this paper; they are not able to provide any definite conclusions. Here, one of the interesting research results is to be outlined, which predicts the future possible changes of rice production in Japan, using the generated scenarios of future local climate generated by RCM (Regional

Climate Model) nested with GCM.

The research group of Dr. Iizumi of Japan (Iizumi, T. et al. 2006) projects the climate change impacts on rice production in Japan in the 21st Century, based on five Atmos-phere-Ocean General Circulation Models (AOGCMs) using a regional-scale rice model, which they developed. The rice model simulations proved the following points:

1) Model ensemble of 54-area mean heading day tends to be about 5 days earlier in year 2050 and about 10 days earlier after year 2100 in comparison with the current one.
2) Model ensemble of 54-area mean yield in future years in-crease slightly or stay in the range of inter-annual variability of yield in the present climate.
3) Model ensemble mean regional heading days are earlier than the 25-year mean re-gional heading day in the present climate with large consistency among all AOGCMs.
4) Model ensemble mean regional yields in northern part of Japan tend to increase and consistency of projection varies from year to year. Changes in regional yields in central part of Japan differ according to the location of prefecture, but the changes in each prefecture are mostly consistent in the future years. In southwestern Japan, significant decrease in yield is simulated for 2050 and 2100, but simulated yield change is indistinct in other years. The yield decrease due to heat stress emerges as new hazard in these areas with global warming.

The impact projection depends on the emission scenario strongly. The SRES-A2 of IPCC may lead more catastrophic influence on the rice production. Its SRES-A1B adapted in this study locates in middle range in the emission amount of greenhouse gases. The projections are still to be improved, introducing the moderate scenarios as the authors mentioned.

To assess the impacts with higher reliability, water resources availability and irrigation conditions should be included into the model simulation. As mentioned above, decrease in winter snow amount under due to global warming scenario may results in water shortage during springtime, when paddy fields are puddled with much water application and after that rice seedlings are transplanted to the field. Alternative cultivation management practices and infrastructure improvement are to be included as well.

The team of Dr. Iizumi predicted the future possible changes in rice cultivation (Iizumi, T., et al. 2007). **Figure 1** depicts future changes of rice mean yield and total production of rice in Japan for the 2070s, predicted by rice crop model with generated future regional climate change. It shows the rice yield and production could be increased in years with cool summer in the 2070s, while it is to be decreased with hot summer. **Figure 2** shows regional variations of changes in yield and its deciding elements for years with cool summer and hot summer. This figure shows that more precise prediction of climate change impacts on crop can be carried out with higher spatial resolution of climate scenario.

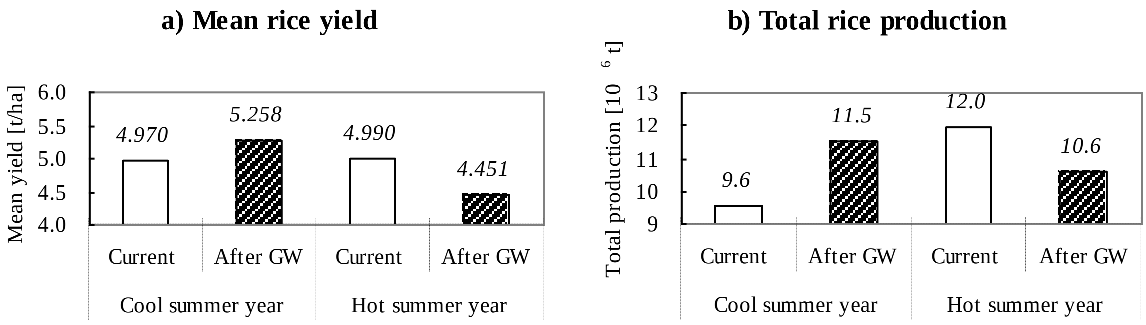

Figure 1. Future changes of rice mean yield and total production of rice in Japan for the 2070s (Iizumi, T. et al. 2007)

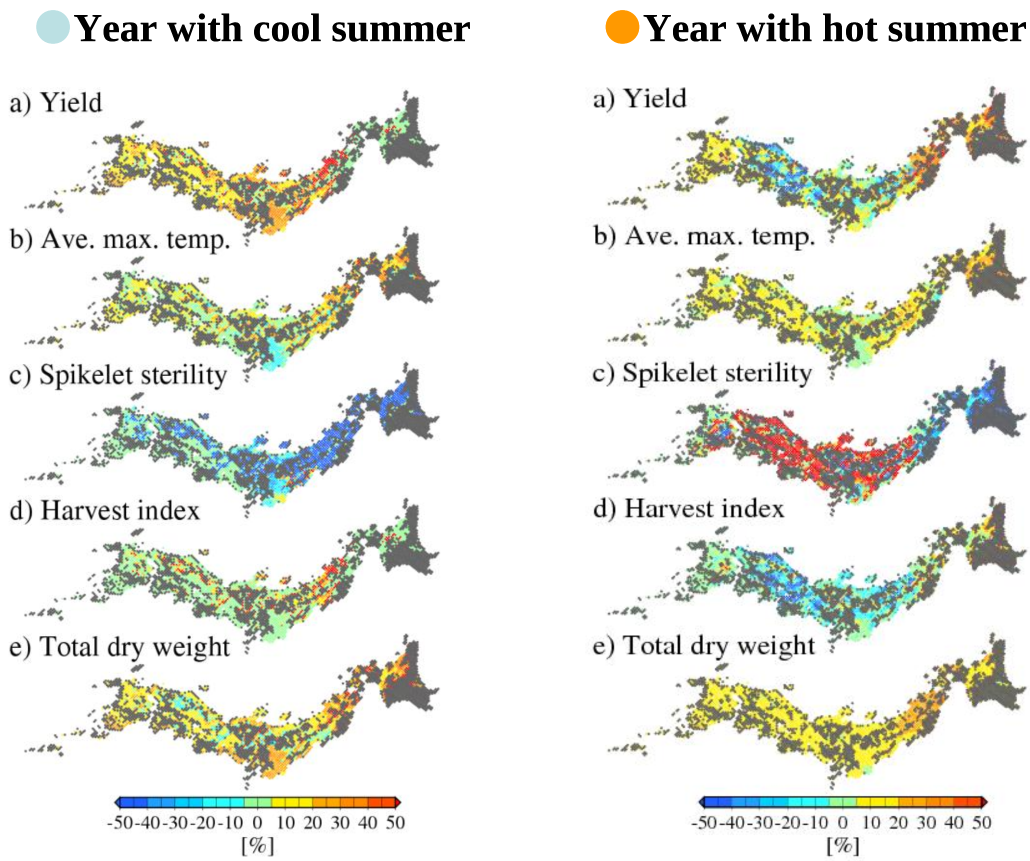

Figure 2. Regional variations of future changes in rice yield and its deciding elements (Iizumi, T. et al. 2007)

4. BASIC STRATEGY FOR CLIMATE CHANGE

Basically the phenomena or factors associated with climate change and its attendant impacts are recognized as difficult to appraise. We have a problem of natural events that are difficult to simulate or examine quantitatively in the laboratory or computer. To this kind of issue, how can our society respond or react?

One of more effective and feasible measures for such a dilemma are to take actions incrementally, as in trial-and-error manner, utilizing the best available current knowledge and past experiences, and collecting additional information as needed. For adaptation and mitigation in agriculture against global warming, farmers and their associations or cooperatives, and other organizations interested in climate, water resources, and agriculture need to be involved jointly.

Taking advantage of adaptive management into account, for improved human and water relationship, the following approaches must be recommended: a) diagnose current water use system and its significance in the regional hydrological regime, b) monitor the water dynamics among human activities and regional hydrological regime, c) predict the changes in hydrological environment, including the eco-system, d) employ incremental or gradual development and note feedback responses, and e) obtain the participation and decision making of the stakeholders.

At present, the future events or happenings can be predicted to some extent and with certain accuracy, by advanced technology and tools for observation and prediction, while in the past we had to wait for actual occurrences to happen. Now, with combination of the advanced prediction and the traditional knowledge, the local wisdom for wise water management and improvement of regional environment could be established. Such an approach might be effective in solving the problems caused by global changes in climate, and, at the same time, result in humans living in harmony with nature.

In this paper, climate change impacts on agriculture, especially on rice production, and adaptation are discussed. In addition to these questions, possible contribution of paddy cultivation and water management to mitigating global warming reducing emission of the greenhouse gasses and storing carbon in soil profile of fields. Another aspect of paddy cultivation as the source of carbon dioxide or methane is to be discussed.

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Impact Assessment and Adaptation Strategies of Paddy and Water Management Due to Global Climate Change for South Korea

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1. Introduction of case study

In South Korea, 17,743 agricultural reservoirs have played a role in supplying consumptive use of water for paddy rice. Now it is now rapidly recognized that these reservoirs are very vulnerable to climate change. Thus recently a case study was conducted to assess the future potential impact of climate change on the inflow from agricultural watershed and its temporal variation of reservoir storage, and to find an adaptation strategy by controlling reservoir release to maintain the present temporal pattern of reservoir storage. A 366.5 km2 watershed which has two agricultural reservoirs was adopted for the case study (Fig. 1). The watershed annual average precipitation is 1,295.1 mm, and the mean temperature is 11.5 ℃ over the last 30 years (1977 - 2006).

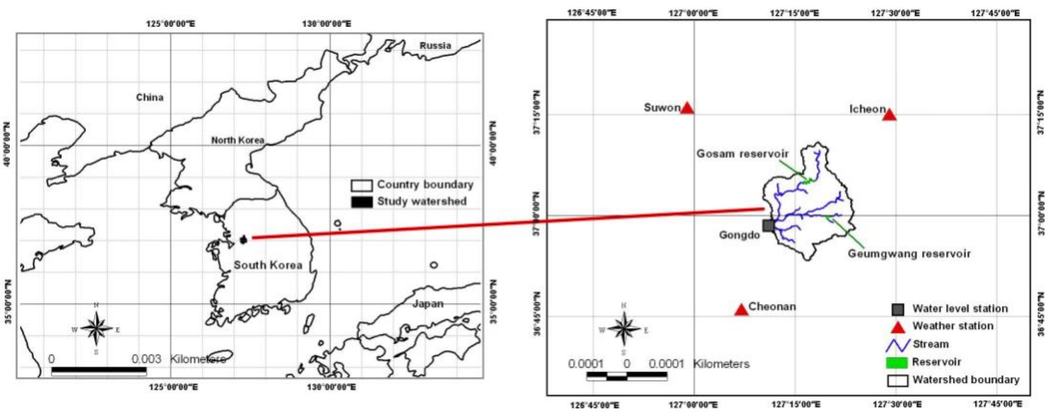

Figure 1. The Case Study Watershed.

For the future evaluation, the SLURP (semi-distributed land use-based runoff process) model (Kite, 1975) was set up using 9 years (1998-2006) reservoir water level and daily streamflow records at the watershed outlet. The average Nash-Sutcliffe model efficiencies for calibration and validation were 0.69 and 0.65 respectively. For the future climate condition, the NIES MIROC3.2 hires data by SRES (special report on emissions scenarios) A1B and B1 scenarios of the IPCC (intergovernmental panel on climate change) was adopted. The 2020s, 2050s and 2080s data were downscaled by applying Change Factor method (Diaz-Nieto and Wilby, 2005) through bias-correction (Alcamo et al., 1997) using 30 years (1977-2006) weather data of 3 meteorological stations of the watershed. The annual results of the future temperature shows that there was + 1.5 ℃, + 3.2 ℃ and + 4.5 ℃ temperature increase in case of A1B scenario, and + 1.6 ℃, + 2.6 ℃ and + 3.4 ℃ temperature increase in case of B1 scenario for the 2020s, 2050s and 2080s respectively. The precipitation changed range from - 0.4 %, + 12.5 % and + 22.0 % in case of A1B scenario and + 7.5 %, + 10.3 % and + 10.7 % in case of B1 scenario for the 2020s, 2050s and 2080s respectively.

The future climate change impacts on reservoir inflow and temporal reservoir storage were evaluated for 2020s, 2050s and 2080s scenarios based on 2005 data (Fig. 2). The future reservoir inflow for A1B and B1 scenarios increased in winter and spring periods ranging from + 2.30 % (+ 0.01 m3/s) - + 9.12 % (+ 0.04 m3/s) and + 33.59 % (+ 0.15 m3/s) - + 63.88 % (+ 0.29 m3/s) respectively, and in summer period ranging from + 0.31 % (+ 0.01 m3/s) - + 16.78 % (+ 0.43 m3/s) except for 2020s A1B scenario and 2050s B1 scenario. While the reservoir inflow of autumn period decreased from - 1.79 % (- 0.03 m3/s) to - 23.52 % (- 0.39 m3/s) except for 2080s A1B scenario and 2050s B1 scenario. The future decreased inflows in autumn affected the reservoir storage of its period and subsequently the following winter period. The future reservoir storage in spring period showed almost no changes maintaining full reservoir storage. The future reservoir storages of autumn and winter periods decreased from - 0.29 % to - 25.92 % for A1B and B1 scenario. The un-recovered reservoir storage at the end of the year carried over to the next year causes a severe spring drought if future spring rainfall is not sufficient to fill the reservoir storage until the time of water supply for paddy rice transplanting (the end of May).

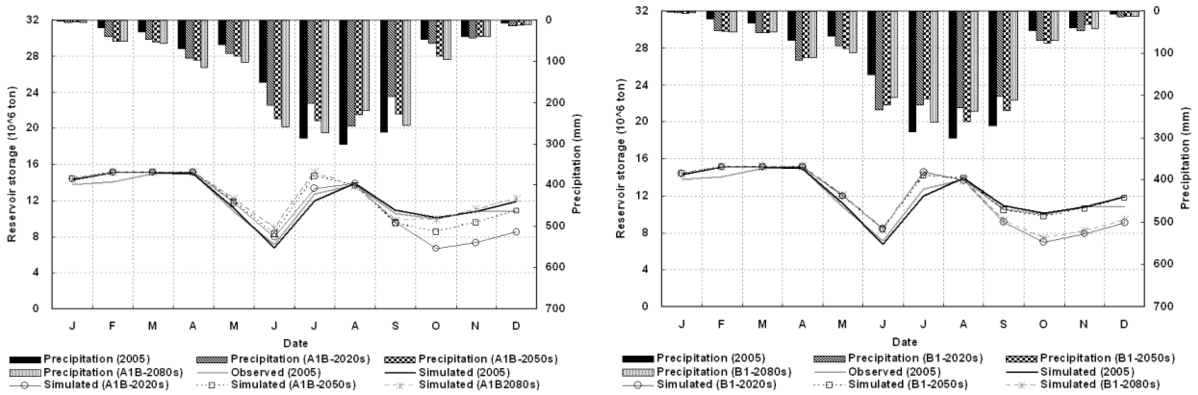

Figure 2. The Future Predicted Reservoir Storages for 2020s, 2050s and 2080s A1B (left) and B1 (right) Scenarios.

2. Future strategies

Until now, some experiments and/or current measures for the above evaluated results on agricultural reservoirs are not tried by the government because the case study is the only research recently accomplished in South Korea. A summarized case study results will be reported to the government in the near future.

As the future strategies for the adaptation to agricultural reservoirs by climate change impact, methods such as temporal control of reservoir release, reinforcement of bank height, reallocation of rice cultivation area, adjustment of cultivations periods (advancing the transplanting time) can be considered.

In the case study, the temporal control of reservoir release against as the future climate change impact was tried as an example of relevant adaptation strategy. In the future, the decrease of reservoir water level occurred from August for A1B and B1 scenarios. Therefore the control of reservoir release by decreasing from - 0.27 m3/s to - 0.74 m3/s in August and - 0.20 m3/s to - 1.37 m3/s in September could secure the reservoir water level in autumn and winter season by reaching the water level to 100 % like the present management (Fig. 3).

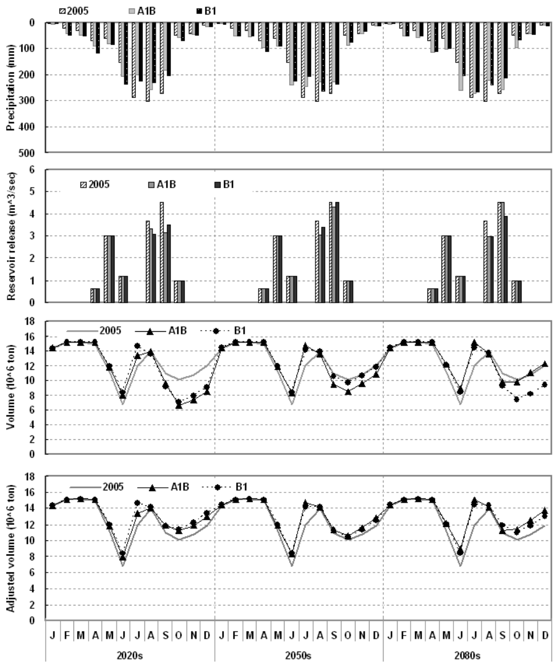

Figure 3. The Case Study Result for the Temporal Control of Reservoir Release as the Future Adaptation Strategy of Reservoir Operation.

Acknowledgements

The case study was supported by the Korea Science and Engineering Foundation (KOSEF) grant funded by the Korea government (MOST) (No. R01-2006-000-10343-0).

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Impact Assessment & Adaptation Strategies for Paddy and Water Management Due to Global Climate Change

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The Nature of Water in Taiwan

If the water of nature in Taiwan was explained in a few words, they would be “plentiful water but unevenly distributed both in area and time.” There is not only great variation in seasonal distribution but also quite large differences over a long term period of many years. This kind of hydrological conditions causes great difficulty for water resources development.

The major rainfall in Taiwan is from three main sources. The northeastern monsoon occurs during winter time from October through February, where the rainfall occurs mainly in the northeastern part of Taiwan. The second one must be the rainfall occurring during a typhoon passing over the Taiwan region, but the difference is very great. The third would be the rainfall occurring during the end of the northeastern monsoon, namely the rainy season on the island of Taiwan, especially in the western and the southeastern parts of Taiwan. Also, minor convective rainfall occurs during summer time called “northwestern rainfall” though the rainfall amount is not much. Snow in Taiwan only occurs on the highest of mountain peaks, so the amount of snow water is mostly ignored in precipitation analysis.

Figure 1. Floods caused by Typhoon (in the Urban area)

Figure 2. Paddy Rice in the drought period.

The average annual rainfall in Taiwan due to the above mentioned causes is 2,510 mm based on the mean value of annual rainfall records of past 50 years. It seems very abundant, though it is unevenly distributed. Seasonally speaking, 62 % of annual rainfall falls in the wet season from May through October in Northern Taiwan, while 78 % falls in central area, 90 % in southern area and 79 % in eastern part of Taiwan. The average annual rainfall on the whole island is about 78 % occurring during the so-called wet season.

Since water resources are attributable to the above mentioned causes. There is great variation both in region and time. Accordingly, the difficulties of water resources development vary from north to south. In the northern region of Taiwan, the rainfall ratio between wet and dry season is 62/38=4.63, while it is 78/22=3.55 for the central region, 90/10=9.00 for the south, and 79/21=3.76 for the east. The higher the ratio, the greater the reservoir storage capacity is needed for water resources regulation. The lower the ratio, the higher the efficiency of reservoir operation could be acquired.

The seasonal hydrological condition has been discussed previously indicating the variation of water in a year has severe impact on the water resources environment causing great difficulty for the water management in Taiwan. Not only the seasonal distribution has great differences, but also there is a high variation in long-term rainfall occurrence. In the northern region near Taipei, the ratio of annual rainfall in a wettest year to a driest year is 2.168, while the same ratio in the south near Kaohsiung is 5.689. The lowest annual rainfall in the south is only 0.328 of the average annual rainfall showing that the water uses in the southern part requires more reservoir storage than the north of Taiwan.

Figure 3. Shihmen Reservior in the drought and regulation.

The Raising of Paddy Rice in Taiwan

Almost all the people living in Taiwan have ancestors who emigrated from mainland China either centuries ago or more recently. Before the Yuan Dynasty (1367) in China, early emigrated Chinese took water for irrigation by using simple methods. After this island was occupied by the Dutch from 1622 to 1661, some farm ponds and irrigation wells were dug by the Dutch to sell water to the Chinese farmers to supplement the water use for rice paddies which were dependent only on rainfall, the so-called “rain-fed field” to assure the production. The early water resources development was almost all for rice paddy irrigation in order to ensure and increase the productivity of the rice crop. After Taiwan was restored to China by the Ming Dynasty, General Cheng Chen-Kung in 1661, the organization of intensive irrigation measures was initiated. The major work for water resources development and management in different period is described in the following paragraphs.

(1). Ming Dynasty (General Cheng) 1661-1683:

During the rule of General Cheng, his son and his grandson in Taiwan, land reclamation have intensively progressed and extensively increased the rice production. As a result, several irrigation systems were created, though the size of the systems created during this period was relatively small.

(2). Ching Dynasty (1684-1895):

In this period some large scale irrigation systems were completed and are still being operational today. The most famous systems are the Liu-Kung Canal in Taipei, the Hu-lu-don Canal in Taichung, the Bar Paw Canal in Chang-Hua and the Tzau-Kung Canal in Kaohsiung. In addition to the various river intake systems which were completed and fully operational for the rice paddy irrigation during wet season, there was also a reservoir created by erecting a 15 meters high dam in Tainan County. This dam and reservoir, the Hu-Tou Be, was completed in 1712 and has been in use for 298 years that is still functioning efficiently nice. Before the Japanese occupation of this island, the area of irrigated farm land had already reached 107,000 ha for rice paddy.

(3). Japanese Occupation (1895-1945):

During the period of Japanese occupation seven more reservoirs were developed for the purposes of hydropower, water supply, irrigation and industrial uses. The reservoirs constructed before 1945 are totally eight. The major irrigation systems created during this period are the Tau-Yen Canal and the Chia-Nan Canal systems. In this period of time, most of the water resources were used for rice paddy irrigation. Until 1942, about 560,000 ha of agricultural land were irrigated. Unfortunately the irrigation systems and facilities were severely damaged by bombing in World War II between 1943 and 1945. The irrigated area was reduced from 560,000 ha to 263,234 ha by 1945 when the War ended. Due to the limitation of water resources, the paddy rice irrigation was almost for the so-called second rice crop which is raised in the wet season.

Figure 4. Paddy rice in Taiwan presently.

(4). After the Restoration to the Present (1945-2009):

After the restoration of this island to the government of the Republic of China, the major work was the repairing of the old irrigation systems and water resources facilities. The last reservoir which was constructed specially for rice paddy irrigation is the Tzen-Wen Reservoir. This reservoir was completed in 1973 when the need for further irrigation was essential for the production increase of food crops, such as rice, sweet potatoes and sugar cane. Since then, the revenue from agricultural sector has decreased year by year due to the rapid industrialization on this island. Therefore, the water resource development was becoming for the water supply of industrial and municipal uses. It was not only without any new water resources developed for rice paddy irrigation, but also the existing agricultural water sources were faced the serious competitive uses from other purposes.

The Impacts of Climate Change and the Adaptation for Rice Paddy

If the water availability and the soil fertility were not considered, the climate and weather are both suitable for three crops of paddy rice producing in Taiwan. Taiwanese ancestors emigrated from mainland China several hundred years ago, they have raised rice completely rain- fed without any irrigation which is called up-land rice though the productivity was very low. The nature of water in Taiwan is clear-cut divided into wet and dry seasons. In compliance with the nature of water, the rice paddy could be operated rice in wet season which is called second-crop, and other up-land crops during dry season which is called first-crop. Namely, the rice and other up-land crops are planted in rotation following the water availability of the nature.

Currently, the paddy rice production area in Taiwan is about 190,000 ha including two crops respectively resulting the so-called crop-area is 380,000 ha a year. The irrigation of paddy rice for first crop during dry season needs more water than second crop during wet season because more effective rain water could be used for the growing of second crop. The available water in dry season is not only stressed by the competition of other uses, but also faced the climate change impacts causing more frequent drought during dry season. For the adaptation of both climate change impacts and industrialization, the first crop of paddy rice should be considered to adopt other up-land crops, such as corn, soybean and sweet potatoes to conserve the scarce water in dry season for other high productivity uses. The adaptation policy for the crop pattern may consider the changing the two rice crops to one paddy rice and one other

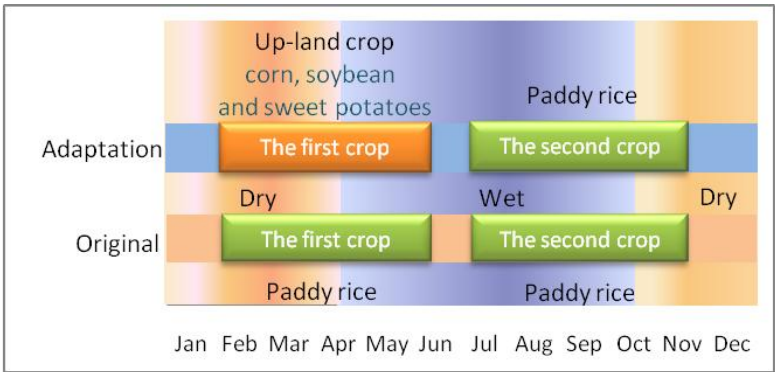

Figure 5. Original and adapted crop pattern

up-land crop compliance with the nature of water. The policy is just in study, discussion and public hearing process though it is not yet decided. The decision might be made in the coming near future otherwise the water shortage during dry season in Taiwan will be more serious. The changing of crop pattern may affect the revenue of farmers, therefore some compensation policy is also considered.

After the adaptation, the crop pattern for the rice paddy in Taiwan will be rice for wet season and up-land crop; such as corn and soybean for dry season respectively in rotation except eastern Taiwan where two rice crop a year will be still maintained due to the plentiful water available for irrigation.

The Contribution of PAWEES's Experiences to the Global Society

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I. Foreword

The International Society of Paddy and Water Environment Engineering (PAWEES) was established in January 2003 prior to the 3rd World Water Forum (WWF3). Its mission is to build and disseminate a new system of science and technology in agricultural engineering that deals with water issues linked to the environment, food security, and poverty in more comprehensive perspective, and the future status of PAWEES is dependent on sustainable management of agricultural systems.

Global climate change has been an important issue, especially in recent years when many countries of the world have suffered from severe flood and drought disasters. In this regard, the "PAWEES Conference 2008 and International Conference on Paddy and Water Environment", held in Taipei, Taiwan on October, 2008, focused its theme on the impact assessment and strategy adaptation to cope and mitigate the impacts of global climate change. Other than the exchange of conclusions and experiences, the conference also made a joint-statement stressing the urgency to engineer and improve current irrigation techniques to prepare for the future. Three significant topics can be drawn from the experiences of PAWEES countries to contribute to WWF5 and the international society. The contributions are discussed in more details as follows.

II. Potential Benefits from Extra Water in Paddy Fields

Rice is an important food source in many parts of the world. In all member countries of PAWEES, rice is grown in paddy fields where arable lands are bordered by bunds with suitable height and then filled with suitable level of water. The border height is determined by the depth of water required for rice to grow and may vary between areas and countries. For example, the regular water-depth is 6 cm in Taiwan.

The idea of "value-adding" application of irrigation is to suggest an increase of the water-depth (and accordingly, the field border height) from 6 cm to 25 cm. By doing so, water depth is gradually increased up to 25 cm according to the growing stages of rice (Figure 1).

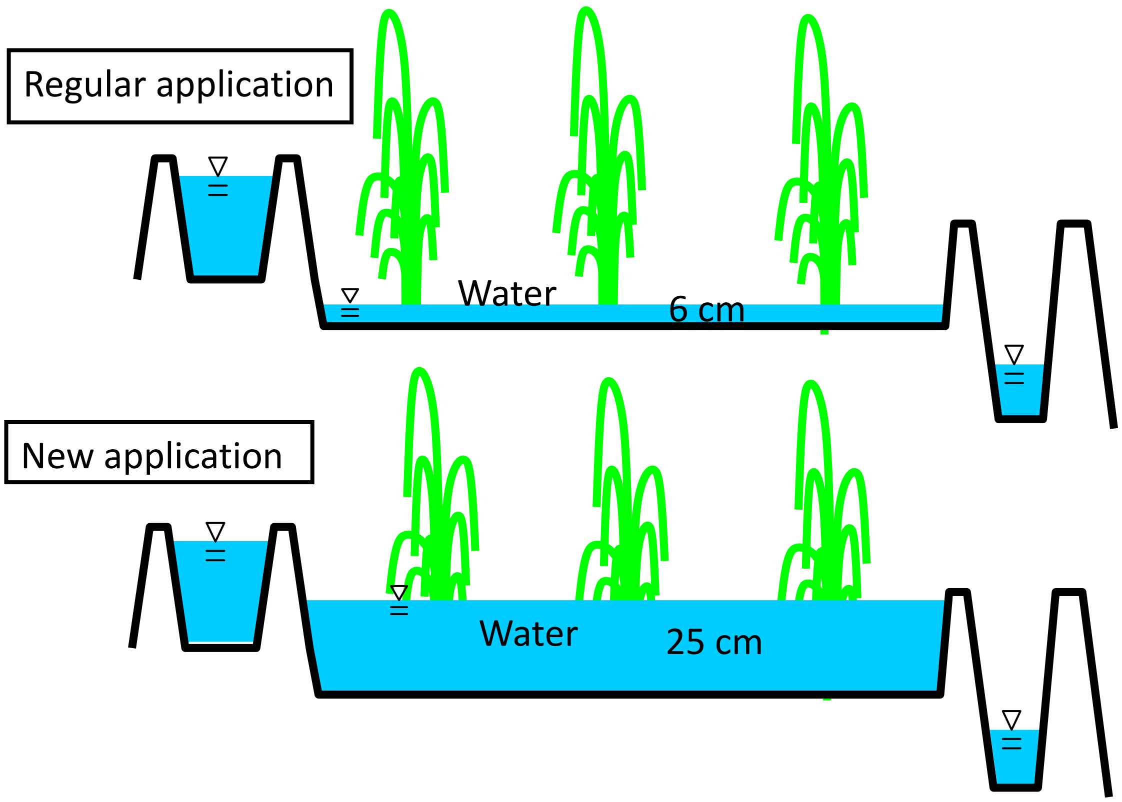

Figure 1. Comparison of “regular” application versus “new” value-adding application

Nonetheless, the idea of “value-adding” application is not entirely new. The method is a result from trials and errors from past experiences and adaptation to the changing environment. It can be described as follows:

1) Mountainous countries in the western Pacific Rim, such as Japan and Taiwan, not only have higher runoff discharge also more reservoirs with limited capacity compared to countries in other regions of the world. Owing to the distinct precipitation difference between wet-seasons and dry-seasons, water resource management is a challenge to countries like Taiwan. For instance, rainfall in Taiwan is abundant but quite unevenly distributed over time. About 75% of average annual rainfall in Taiwan occurs during wet season (from May through October), yet over 83% of runoff is unexploited and discharged into the sea. In addition, failing to meet the needs for water resources in dry-seasons has led to adverse consequences. For example, land subsidence caused by over-pumping groundwater. As a result, efforts have been made to retain as much water as possible during wet seasons. A series of experiments aims to maintain extra high water level in the paddy fields has been conducted in the central part of Taiwan in the 1990’s in an attempt to save the excessive water resources in aquifers (reservoirs for groundwater). Moreover,

paddy fields also provide room for storing excessive water resources and hence the idea of "value-adding" application of irrigation from extra water in paddy fields is brought up.

2) In the past 40 years, rapid industrialization, economic growth and rise of living standard have resulted in a dramatic increase in water demands from the domestic and industrial sectors. This situation pressured the agricultural sector, which presently accounts for about 80% of available water resources in Taiwan, to sharply curtail its water consumption. Furthermore, since the accession of Taiwan to the World Trade Organization (WTO) in 2002, a considerable amount of rice from foreign countries with lower cost or higher quality has been able to be imported. The effect is further compounded by the fact that a substantial reduction in paddy field acreage in Taiwan. Consequently, local rice farmers face a more imminent threat. Under such conditions, some concepts that were once rejected have now begun to appear as logical solutions worth exploring, for example, the concept to grow rice in excessive amount of water. The technique will be more prevalent owing to the reduced rice field acreage in the future (Lee et al., 1995).
3) While average water-depth is currently 6 cm in Taiwan's paddy fields, the depth in Japan has been as deep as 22 cm. Doubts still remain in the rice yield of the new technique using a higher water depth, but Japan shows that water-depth has little or no effect on the yield. Japan's rice output ranks among the top in the world (Kan et al., 1997).
4) With steep slopes and high runoff discharges, flooding is a much bigger problem than storage. Higher border height in the new irrigation technique can help transform paddy-fields into mini-reservoirs which can not only store water resources, but also to detain surface runoff for flood control.

To better understand the potential benefits of "value-adding" applications as opposed to the older and "regular" application of irrigation water, a series of experiments have been conducted in Taiwan since 1998. A conceptual model was developed to simulate the hydrologic system in the paddy field (Chang et al., 2001, Figure 2). Field experiments concerning the impacts of water level on crop productivity were also performed (Chang et al., 2006). The irrigation water regimes for the experiment are shown in Figure 3 where the paddy grew in 25cm of water. Results were observed as the followings:

1) Drainage is substantially reduced as the border-height is increased, as shown in Figure 4.

2) Runoff coefficient is greatly decreased as the border height increases, as shown in Figure 5.

3) Percolation increases as the number of "value-adding" applications increases, as shown in Figure 6.

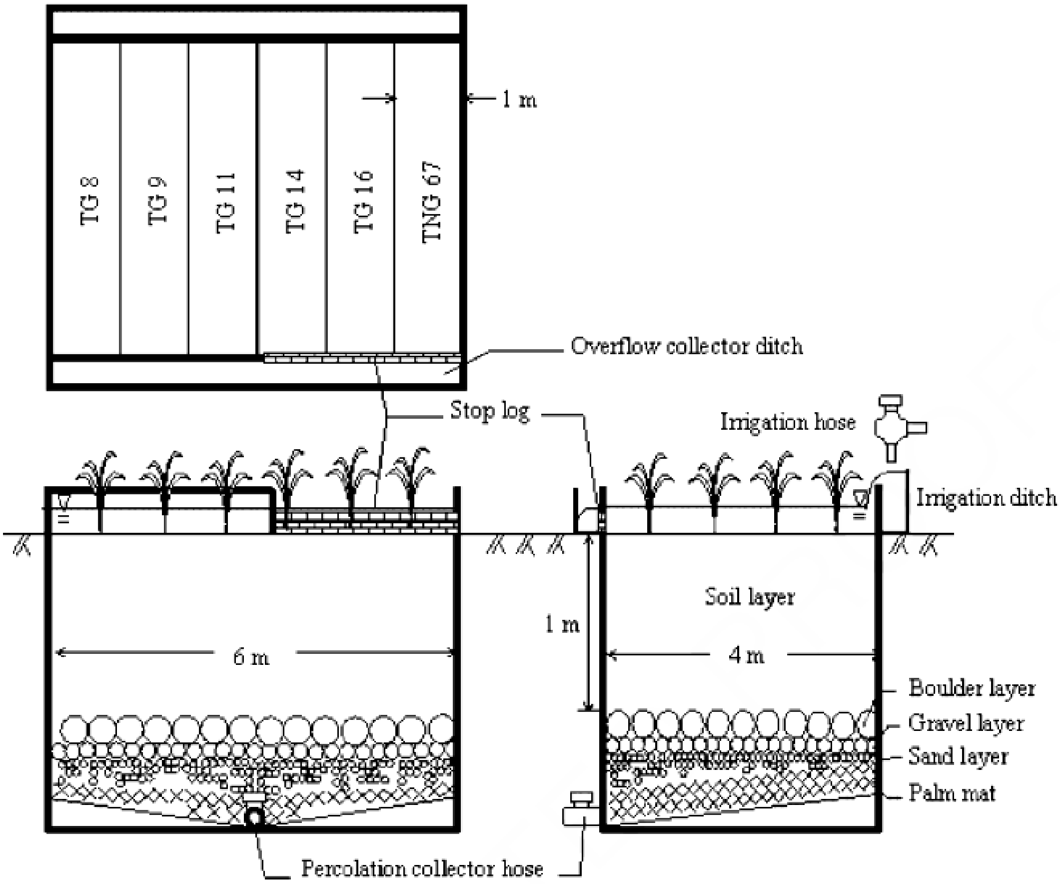

Figure 2. Schematic diagram of the experiment set-up of the lysimeter.

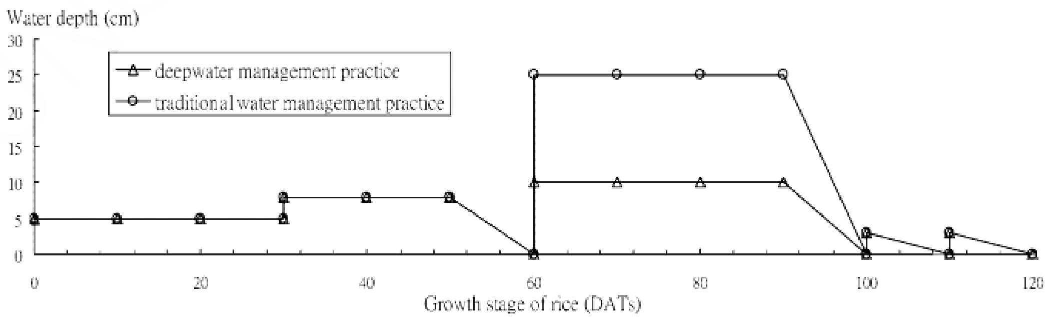

Figure 3. Schematic diagram of the different water regimes created for the experiment study.

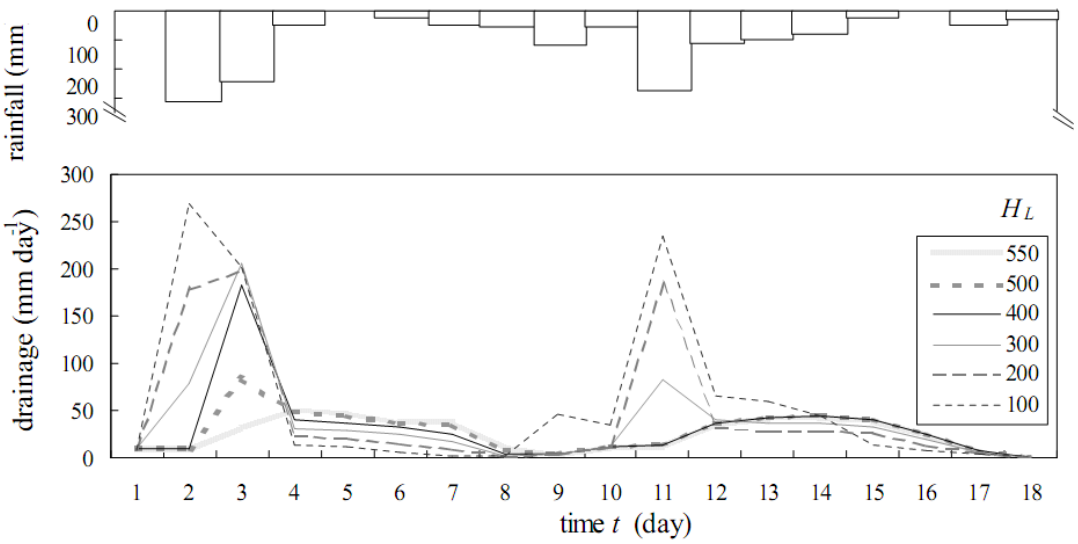

Figure 4. Effect of the border height on drainage.

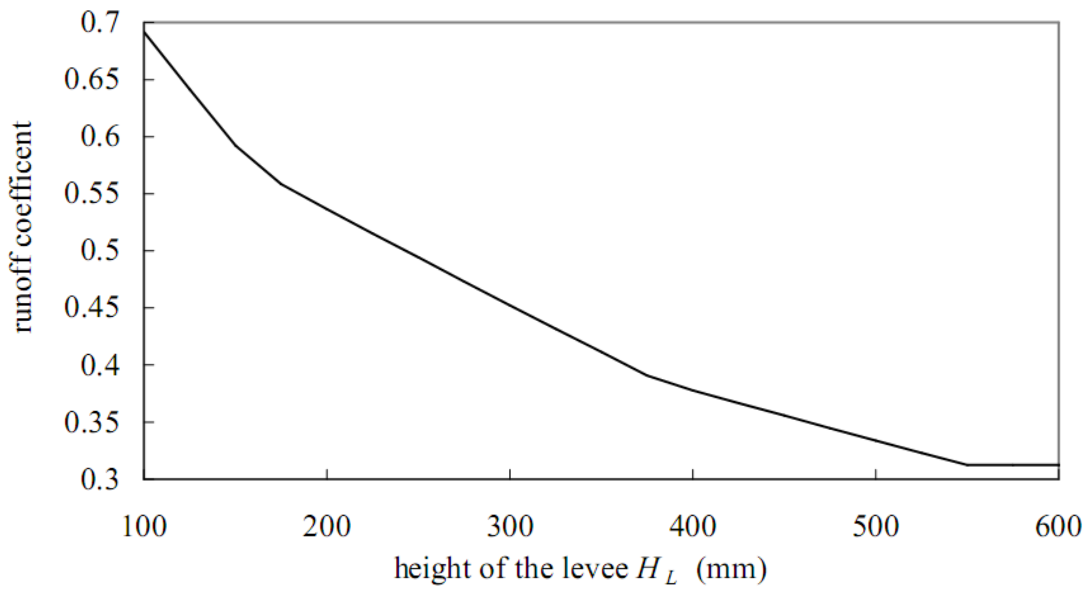

Figure 5. Runoff coefficient versus border height

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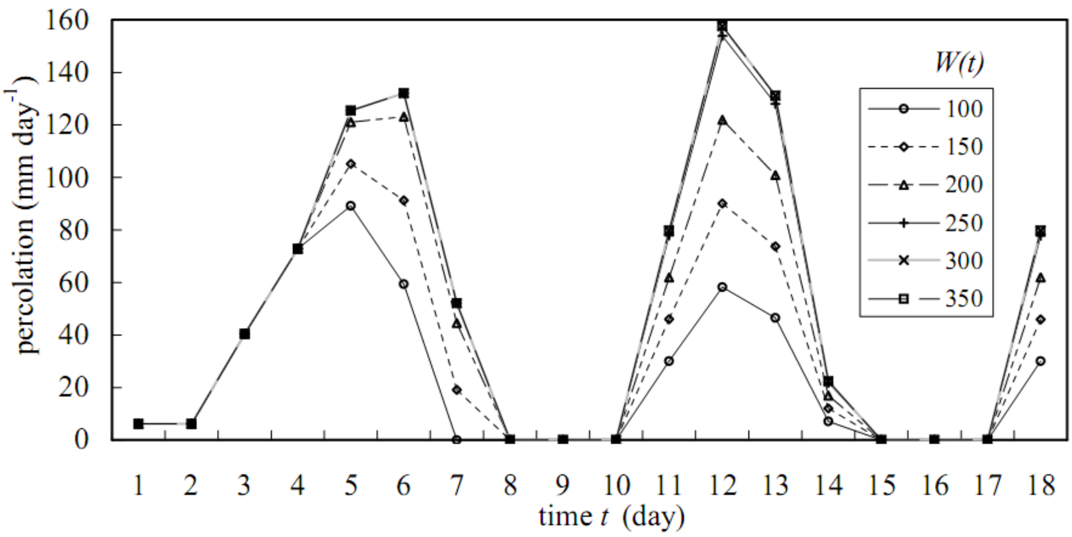

Figure 6. Effect of the number of "value-adding" application of irrigation on percolation.

In short, the potential benefits of "value-adding" application of irrigation water can be summarized as follows,

1) Environmentally, extra water obtained during wet seasons is stored in paddy fields as well as underground aquifers.

2) The new approach achieves the same level of rice quality and production as in the past. However, even though the volume of irrigation water had increased, deepwater management can still generate high water productivity.

3) The new application will be significant in future flood control. Taller border means more space for detaining or storing floodwater. By raising the border height from 6 cm to 25 cm in the 180,000 ha of paddy fields in Taiwan, about 450 million tons of water can be retained.

III. Agricultural Return Flow Reuse and Pond Irrigation System

In conventional sense of water supply and demand, agricultural sector is the passive consumer on the demand side. However, the fact is that the majority of irrigation water, which comprises the major portion of agricultural water, would become agricultural water surplus return to the system through horizontal percolation in the form of return flow. The rest of irrigation water moves downstream after infiltrating into the soil or flowing directly into the adjacent drain (Masayoshi and Akira, 1999).

Wetland paddy has a buffer function for water quality (Sekiya, 1992). Higher water reuse rate in wetland paddy can reduce the net runoff load to zero (NIRE, 2004). In addition to the significant amount of agricultural water surplus, the purification function of paddies would produce high-quality water and stable return flow in paddy fields is helpful to the distribution of water resources. Hence, if the agricultural water surplus is properly collected, it could be used as another source of the water supply. In other words, in areas with agricultural water surplus, the water supply and demand relationship could be shown as in Figure 7.

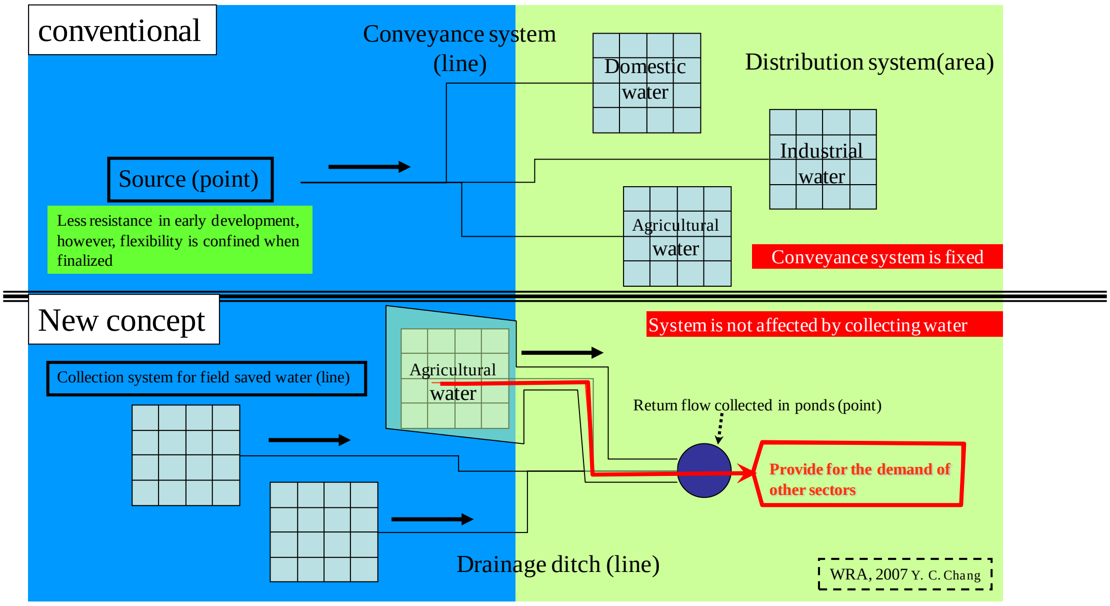

Figure 7. New concept of water supply and demand

This new idea can further improve the current structure of water supply and demand. Demand of water sectors can be met by the acreage of nearby upstream paddies. The scale of the conveyance facility and the transportation cost can both be reduced as a result of shorter distance between the supply-end and consumer-end. Furthermore, disputes among sectors regarding water transfer can be reduced, and saved agricultural water and irrigation water can be available to meet the needs at downstream during non-irrigation periods.

The pond irrigation system is the product of ancient wisdom. It effectively collects rainfall for future use, uses geographic advantage of island countries to overcome specific climate pattern, and is a perfect example of the above-mentioned contribution. The pond irrigation system makes use of the rainfall to cut down agricultural water consumption from reservoirs and to promote efficient water usage in farmland. A specific model of water pond irrigation system was carefully studied in Taoyuan area, Taiwan. In the study, the prospect of pond irrigation system and benefits obtained from adopting “value-adding” application were both assessed. The pond irrigation system model can simulate water distribution and find the crucial area to estimate water pond system. However, deepwater irrigation method uses rainfall and runoff more efficiently. It makes paddy fields reservoirs store more rainfall and provide crop sufficient water required to grow. Further, it increases the potential water supply by changing the backup rate of water pond in upstream and downstream areas.

In Taiwan, limited land resources have forced certain number of industrial development to take place on agricultural land. In the future when large-scale industrial park increases their water demands, the water shortage will become more critical in local area. The wetland paddy, acting as a buffer for water quality and quantity, is like an effective rainwater cistern system. Therefore, linking up a water reuse system in wetland paddy can greatly supplement the industrial water needs. Since the water need in urban and industrial water use is growing dramatically, the reuse of return flow from wetland paddy will be critical. Figure 8 illustrates the concept of water reuse between wetland paddy and industrial park.

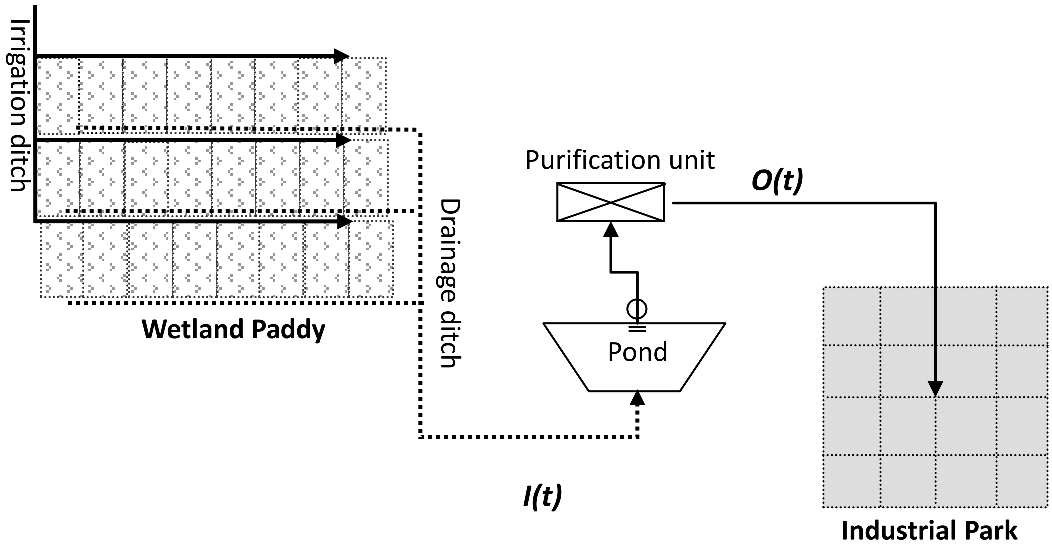

Figure 8. The concept of water reuse between wetland paddy and industrial park

Based on simulation of the reuse of return flow, the effects of practicing the deepwater management, enlarging the capacity of regulated pond in the downstream, and probing a suitable cultivated paddy scale are presented in Figures 9, 10, 11, and 12 (Chang et al., 2009) respectively. In general, the return flow and the effective rainfall increase as the maximum ponding depth of deepwater management increases. As the pond capacity in downstream increases, the rate of reusing return flow increases and the local needs for water are alleviated. A narrower supply-and-demand gap between seasons can be achieved when the area ratio increases at the first harvest season and the drought frequency is decreased as a result. Apart form meeting the water needs at peak demand periods, the reuse of return flow is a quick-response water supply solution. Accompanied by robust water management strategies, water reliability and crop security can be maintained through the reuse of return from wetland paddy.

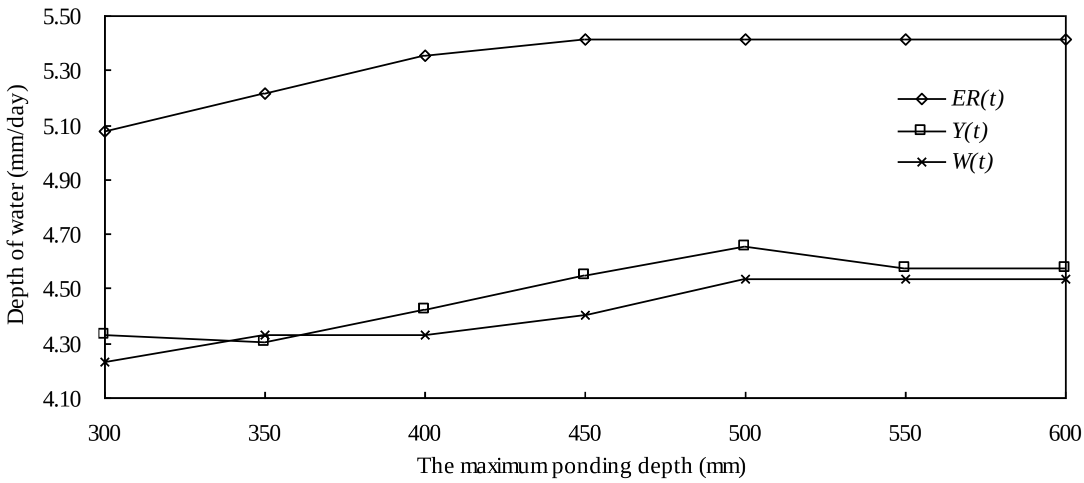

Figure 9. Effect of the maximum ponding depth on the effective rainfall, the return flow and the irrigation water

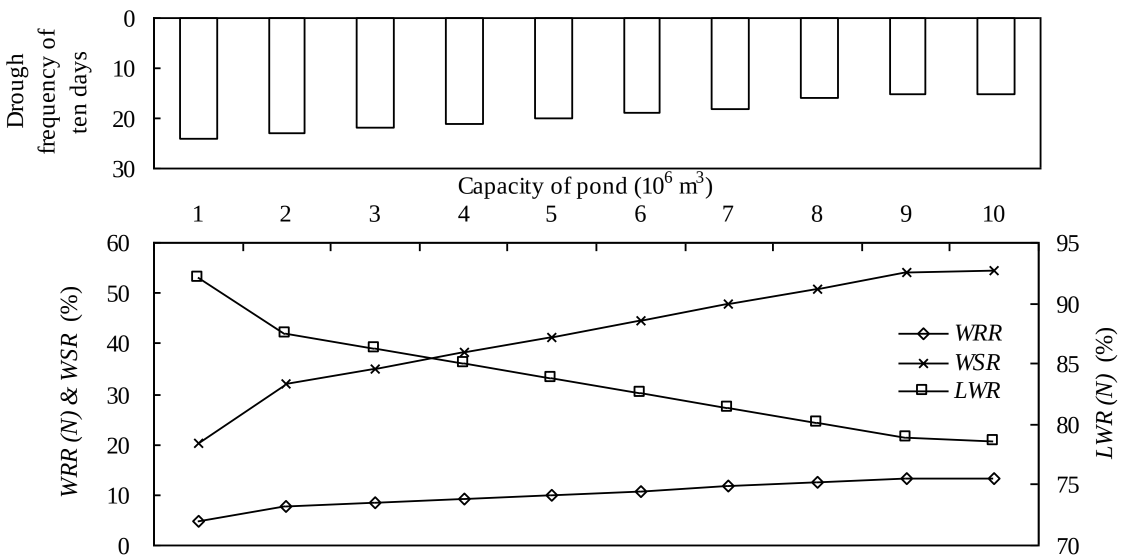

Figure 10. Effects of enlarging the capacity of pond on the reuse of return flow

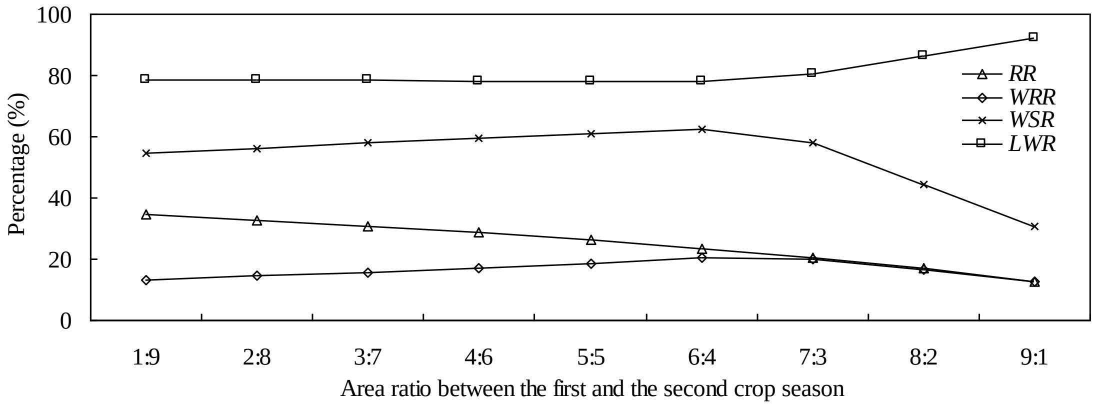

Figure 11. Effects of the cultivated paddy scale on the reuse of return flow

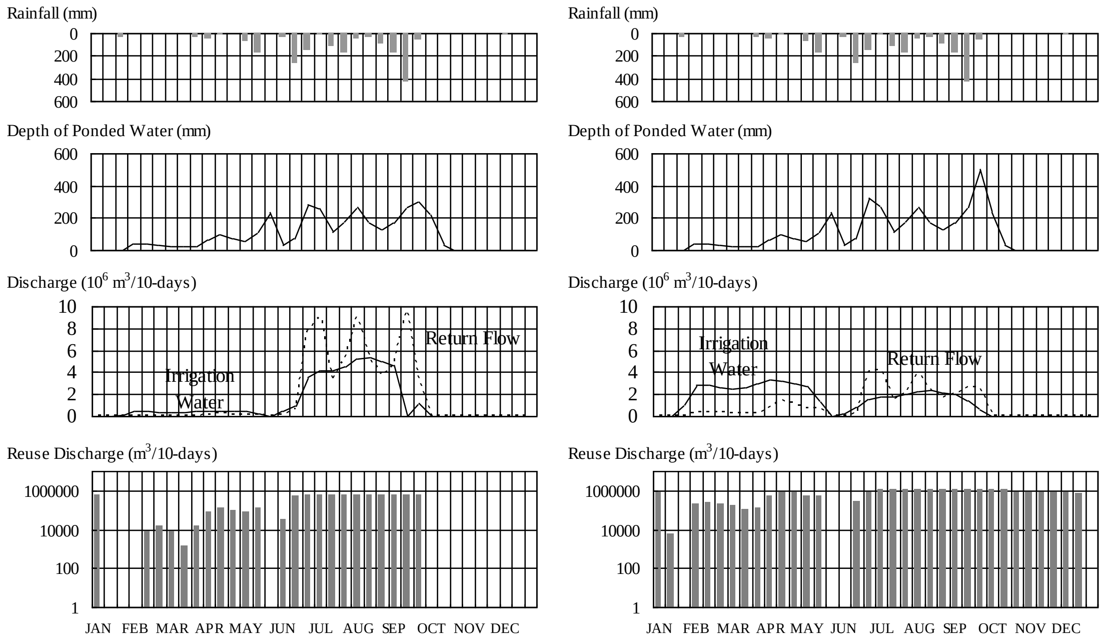

Figure 12. The reuse discharge flow before and after above-mentioned strategies

IV. Sustainable Field Application from Sandy Farmland at Coast of Taiwan

Sedimentation has long been a problem for reservoirs in Taiwan. Putting past treatment of reservoir sedimentation aside, a recent lysimeter test regarding the improvement of water-holding capacity using reservoir sedimentation was conducted in 2003 by the Water Resources Planning Institute in Taiwan. Reservoir sediments were used to mix with or layer in sandy soil. Test results indicated a significant ratio of horizontal seepage as illustrated in Figure. 13.

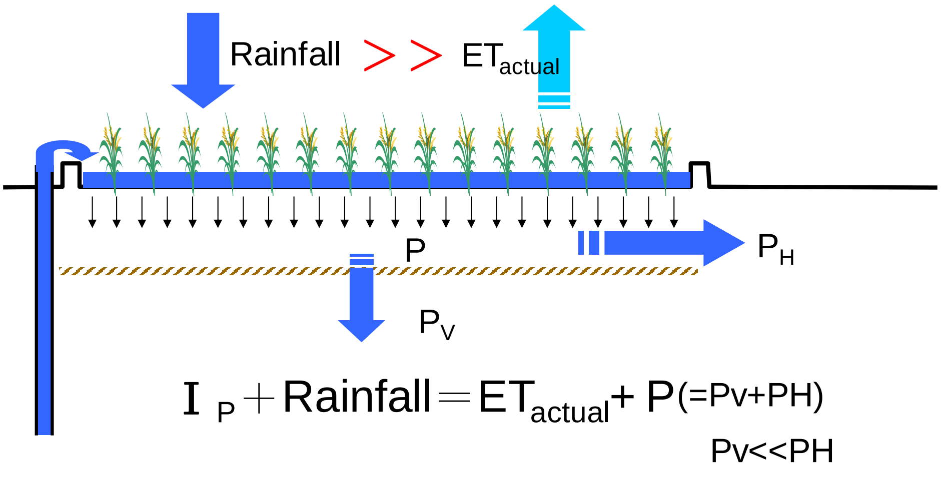

Figure 13. Schematic diagram of percolation in paddy fields

This finding was applied in a pioneer experiment to grow windbreak forests in coastal areas. This experiment is being conducted in the coastal area of Chi-Ting, Taiwan, where the coastal sand dunes extend into the paddy fields with irrigation system from local Irrigation Association. Part of the sand dune includes areas which have been covered by artificial windbreak tree and lawns. Sand dune systems also include all native and local vegetation. In the experiment, reservoir sediment are buried 30cm underground parallel to the coastal line. Then suitable saplings were planted on cut-off walls at the upstream side. The aim of the experiment was to retain horizontal seepage from upstream rivers or irrigation return flow by reservoir sedimentation, then to provide for the growth of windbreak saplings. Although verification of the experiment takes time, the saplings growth after 10 months without rain or irrigation was amazingly well, as shown in Figure 14.

PAWEES wishes to put the idea of sandy farmland irrigation into further applications to improve the land-use in Chad. With the help and consultation from experts and professionals in Taiwan and Chad, land conservation of Lake Chad Basin has been made possible by studying similar experiments across the world. For example, the groundwater recharge projects in the Indus basin in India, the 300-year “Creek Irrigation” technology of paddy fields develop from the coastal area in Kiu-Shiu area in Japan, and the 80-year-old “3-year crop rotation system” conducted by Chia-Nan Irrigation Association in Taiwan, as shown in Figure 15.

Figure 14. Experiments of growing windbreak saplings by collecting horizontal percolation

Crop Rotation in Taiwan for 80 years

New arable land in Lake Chad Basin

Creek Canal in Japan for 300 years

Figure 15. Experiences of land management through irrigation agriculture

In the past 50 years, West Africa has experienced large land-use changes including deforestation, overgrazing, land reclamation and a persistent drought since the 1960s. In the short run, destructive land use change may result in the dramatically change in water flow, or even eliminating the low flow in some area. In the long run, the reductions in evapotranspiration and water recycling may trigger unwanted feedback mechanisms that ultimately reduce rainfall. In Sahelian countries, the persistent drought has already reduced the area of Lake Chad from 23,500 km^2 to about 1,500 km^2 (Figure 16).

The extended application of the land conservation strategies in Lake Chad generalized as the followings: appropriate amount of water is pumped and conveyed through pipelines to irrigate the arable land in an attempt to reclaim the wetland paddy, as shown in Figure 17; then in order to improve the Sahelian soil, a series of cut-off blocking walls are built as shown in Figure 18; finally, windbreak forests on top of the sludge can rely on horizontal percolation from upstream to grow, as shown in Figure 19.

In brief, it can be concluded as follows:

1. The horizontal seepage from paddy area is collected to avoid discharging to the desert.
2. The blocking wall made from fertile sludge can help the growth of windbreak forests.
3. The soil texture of the Sahelian land could be improved.
4. An effective way to make use of the sludge.
5. The project will mitigate sand storms in Sahelian.

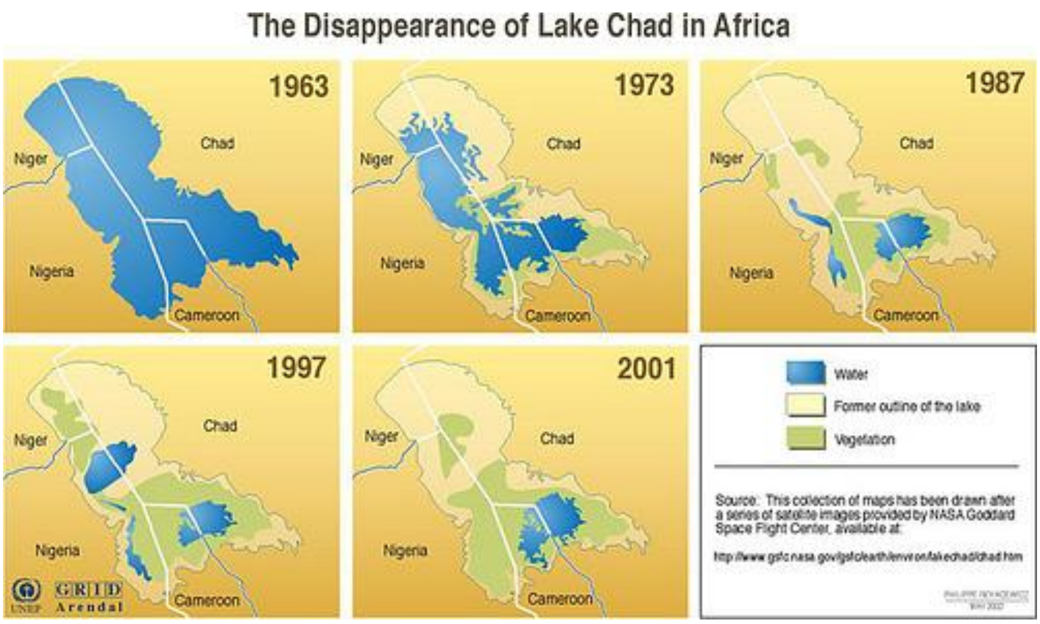

Figure 16. The disappearance of Lake Chad in Africa

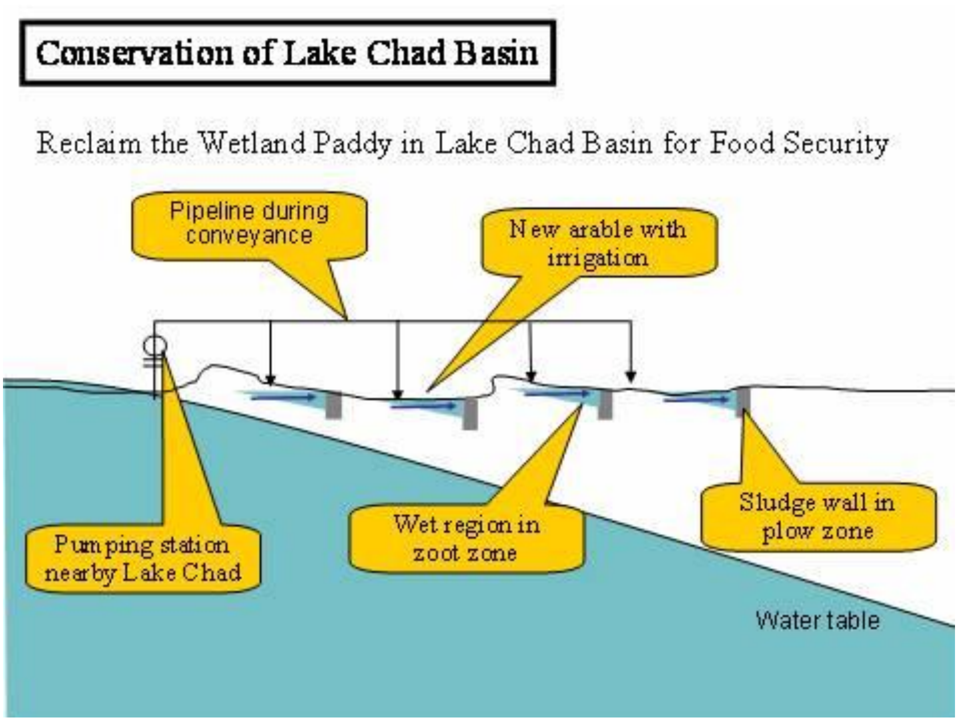

Figure 17. The horizontal seepage from paddy area is collected to avoid discharging to the desert

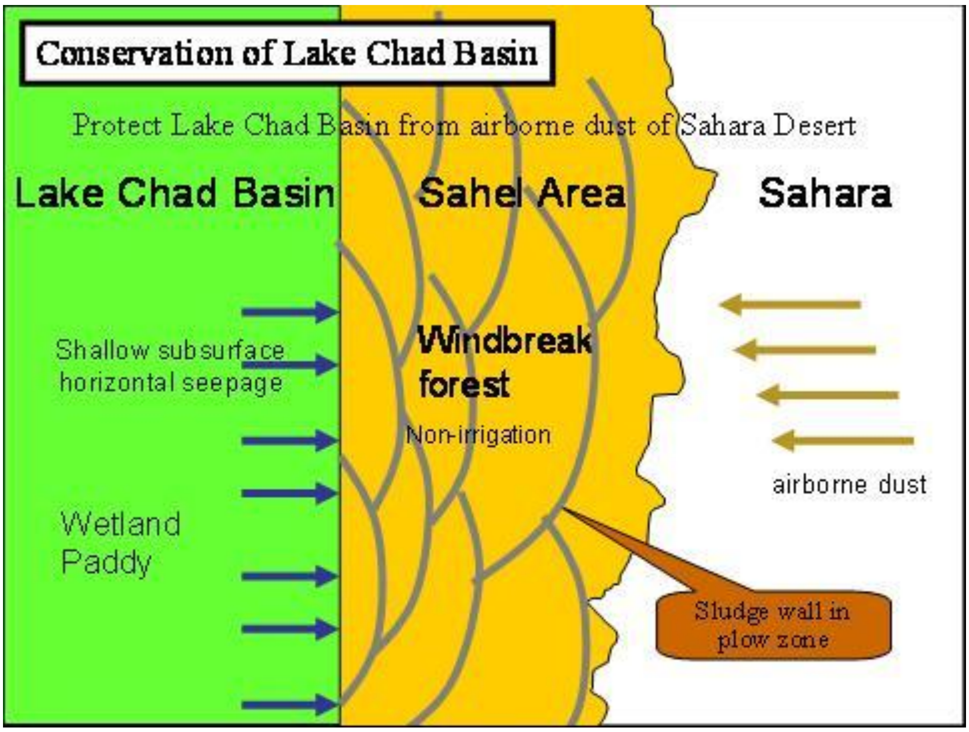

Figure 18. The soil texture of the Sahelian land could be improved and the sludge can be reused in an effective way

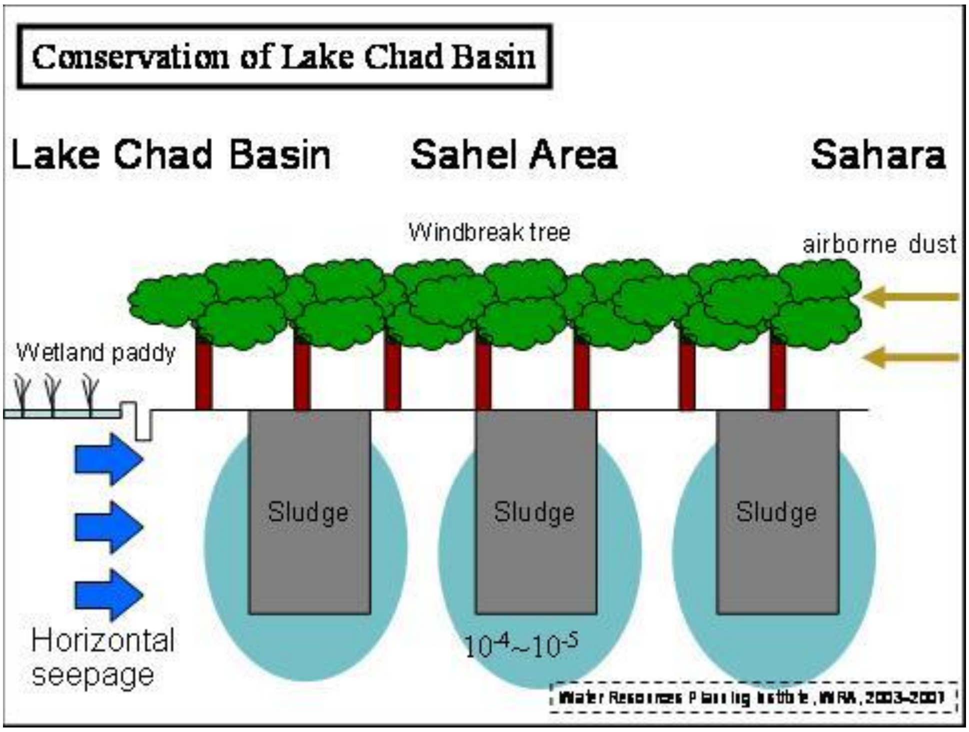

Figure 19. The blocking wall, which is formed by fertile sludge, would be good for the growth of windbreak forests which can mitigate sand storms in Sahelian

VI. Concluding Remarks

Facing the challenges of climate change and in order to turn the crisis into an opportunity, PAWEES is expected to employ the appropiate adaptation strategies and modern thinking to assist its members to reach the goal of sustainable development. Over the past years, the main member countries of PAWEES have already transformed from an agricultural society into an industrial one and now is heading towards a society of sustainable development. The future focal point would be transformed from "water for agriculture" and "water for the industry" to "water for sustainability" and "water for life".

In this paper we present some PAWEES's novel concepts and successful experiences, which includes (1) potential benefits from extra water in paddy fields, (2) agricultural return flow reuse and pond irrigation system, and (3) sustainable field application from sandy farmland at coast of Taiwan. We greatly look forward to seeing them being successfully applied to other places in the world.

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附件四、WWF5 會場與我國交流之專家資料

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