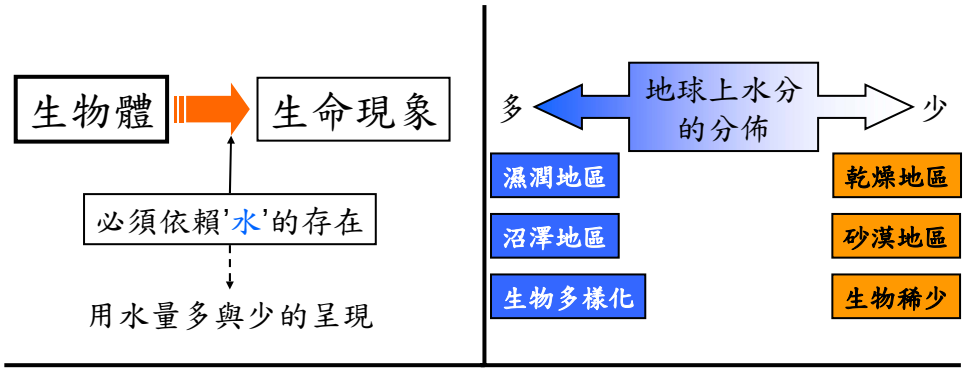
推動「烏山頭水庫水利系統登錄世界
遺產」連署演講會暨宣告記者會
2009-05-08

百年來台日水利技術傳承共創的成就

台北市七星農田水利研究發展基金會董事長
台灣大學名譽教授

甘俊二

2009/05/08



地球上水分移動的分佈

1、地球自轉所引起的氣流變化

2、太陽照射所形成的熱對流

3、由水分高程、濃度及溫度所引起的流動

4、土壤毛管水的引動

⋮

氣候變遷下利用水田灌溉的永續經營

以世界嚴重的非洲為例

•過去50年，世界經歷了大規模土地利用的改變，造成了森林濫墾、過度種植及不當開發土地的結果，導至1960年以來區域一連串嚴重的枯竭。

•短期來看，土地利用的急遽改變造成了水資源的極端化開發，導致部分地區原有水源的消失。

•長期來看，土地利用改變造成蒸發散量的消失，使得水循環中的回饋機制產生障礙，造成地區降雨機會的減少。

•例如在非洲最大湖泊的查德湖面積由23,500平方公里(1963年)萎縮到目前的1500 km^2 (2009年)，附近農地有繼續沙漠化的趨勢。

水資源技術的傳承與應用

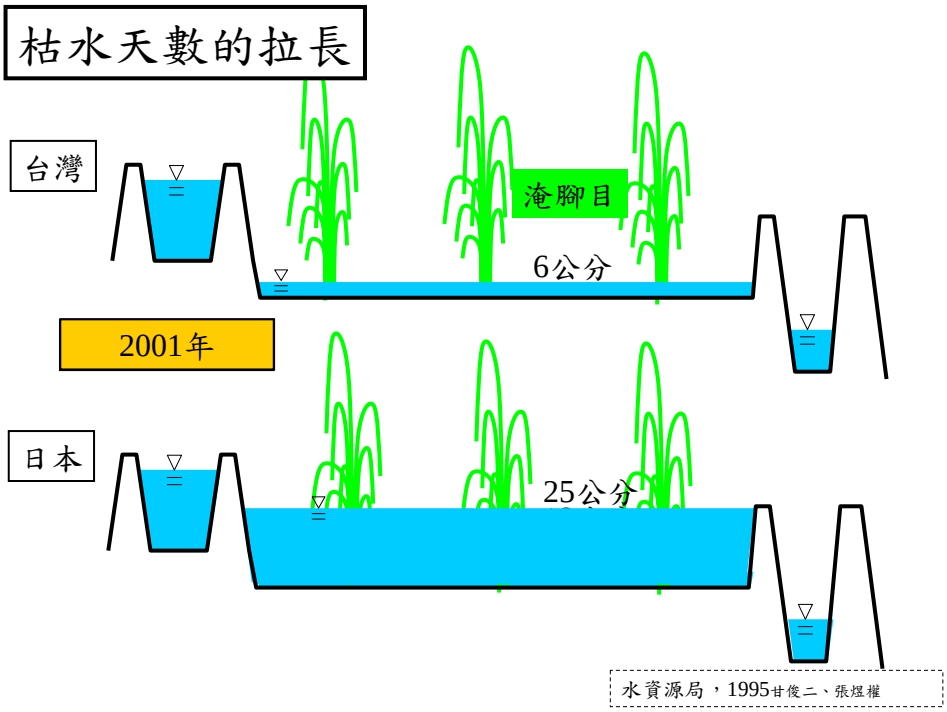
1. 氣候變遷豐枯兩極化的對應策略
2. 不可忽略的寶貴水資源(農業回歸水)
3. 沿海砂丘地的植生可行性

1. 氣候變遷豐枯雨極化的對應策略

a. 枯水天數的拉長

b. 集中暴雨的對策

枯水天數的拉長



水資源局，1995甘俊二、張煜權

水資源的改善構想

以桃園為例

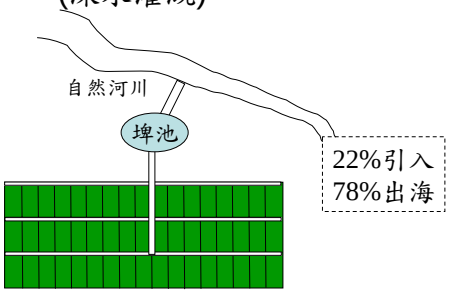
世界著名的
桃園池塘灌溉

桃園埤池 ⇨ 4620萬立方公尺

灌溉面積 ⇨ 24794公頃

186mm
相當於田間水深

新構想
(深水灌溉)



22%引入
78%出海

提高水田蓄水深度

6 cm =60 mm
(目前)
⇨ 25 cm = 250mm
(深水栽培)

250 mm – 60mm = 190mm

埤 十 深水田=186 mm+190 mm
=376 mm
=202 %
(相當於現有埤池容量的兩倍)

未發表，2002甘俊二、張煜權

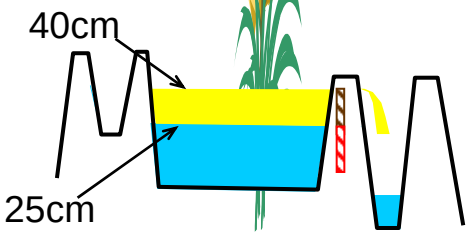
集中暴雨的對策

蓄洪防颱之功能

豐水期維持25cm田間水深

枯水期維持0~25cm田間水深

利用水深避免稻桿倒伏
短期泡水對稻作無害



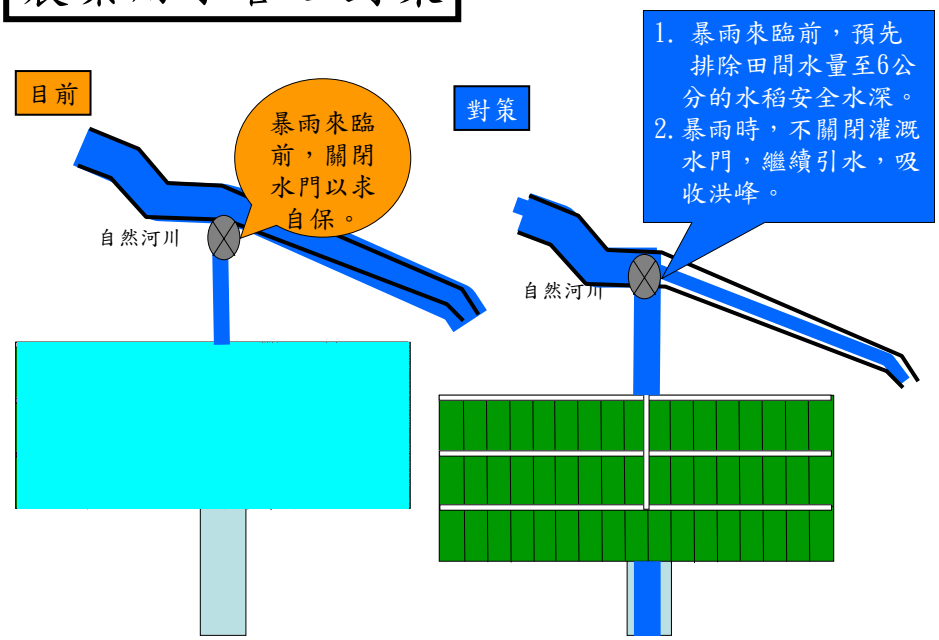
颱風日雨量約200~300mm

1、提高田面水深至40cm

2、150mm暴雨暫留於田間相當於蓄留住
17 ㍑/sec/ha的流量

現有設計為23 ㍑/sec/ha

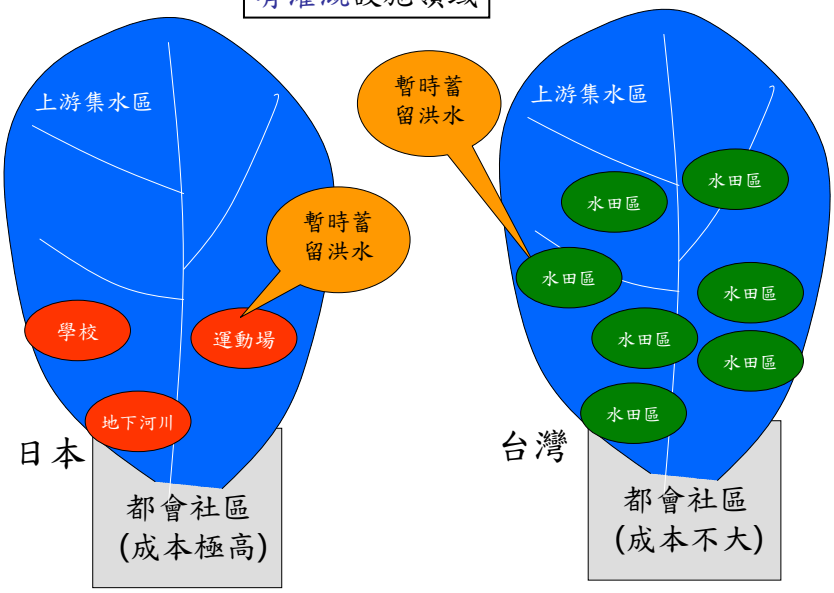
農業用水管理對策



台灣的對應策略構想

暴雨的暫時蓄留

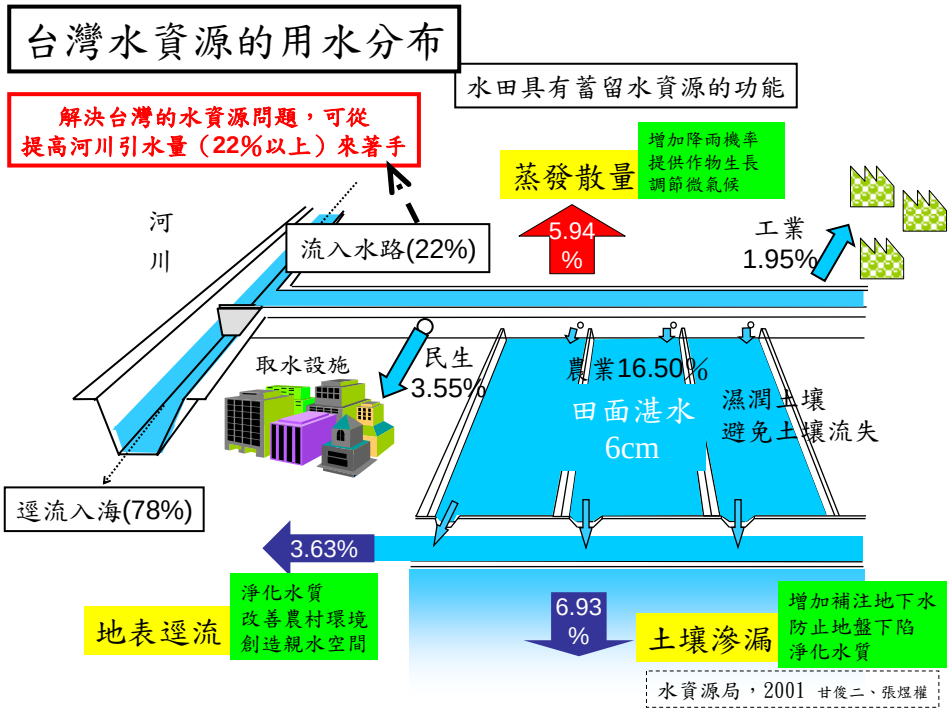
有灌溉設施領域

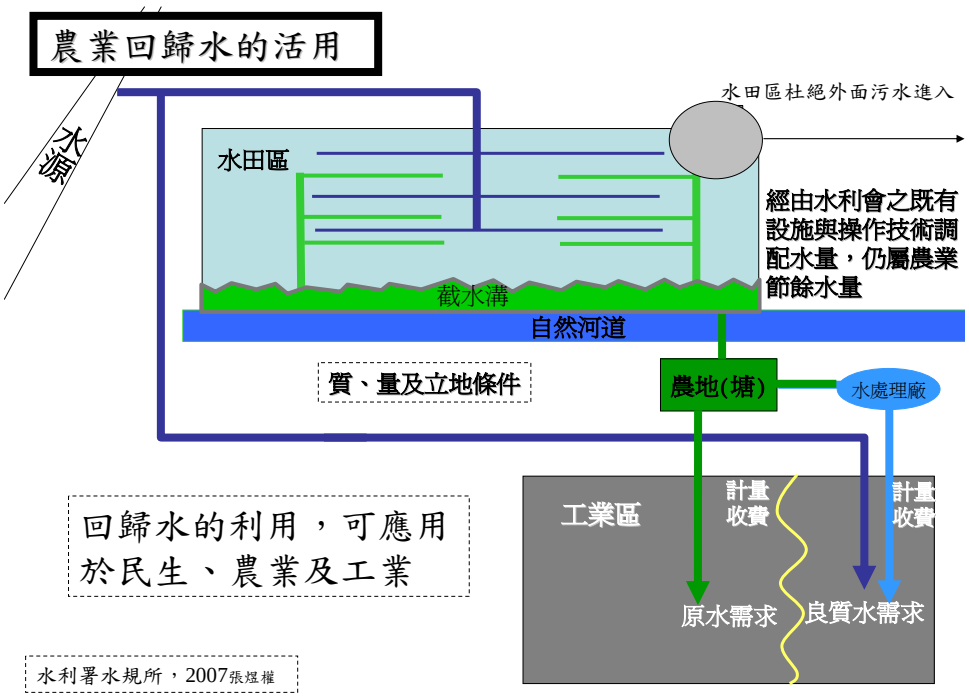


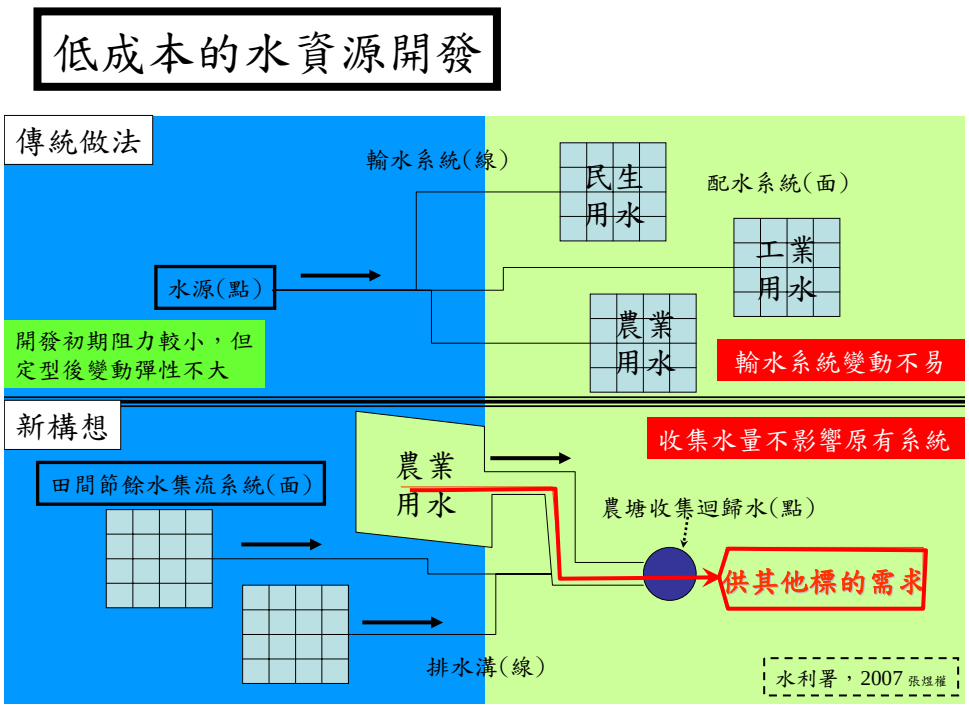
2. 不可忽略的農業回歸水

a. 台灣水資源的用水分布
b. 農業回歸水的活用
c. 低成本的水資源開發

台灣水資源的用水分布




農業回歸水的活用
水源
水田區
水田區杜絕外面污水進入
經由水利會之既有設施與操作技術調配水量，仍屬農業節餘水量
截水溝
自然河道
質、量及立地條件
農地(塘)
水處理廠
工業區
計量收費
計量收費
原水需求
良質水需求
回歸水的利用，可應用於民生、農業及工業
水利署水規所，2007張煜權


低成本的水資源開發
傳統做法
輸水系統(線)
民生用水
配水系統(面)
工業用水
水源(點)
農業用水
開發初期阻力較小，但定型後變動彈性不大
輸水系統變動不易
新構想
收集水量不影響原有系統
田間節餘水集流系統(面)
農業用水
農塘收集迴歸水(點)
供其他標的需求
排水溝(線)
水利署，2007 張煜權

水資源供需之間的新概念

1. 水田有淨化水質功能，水質較佳。

2. 以標的用水量的需求，彈性劃定上游鄰近水田的集水範圍。

3. 供需之間距離短，輸水設施規模較小，工程成本較低。

4. 因屬農業餘水移用，較無標的用水間的紛爭。

5. 水田回歸水的變化較為穩定，有利用水調配的對應。

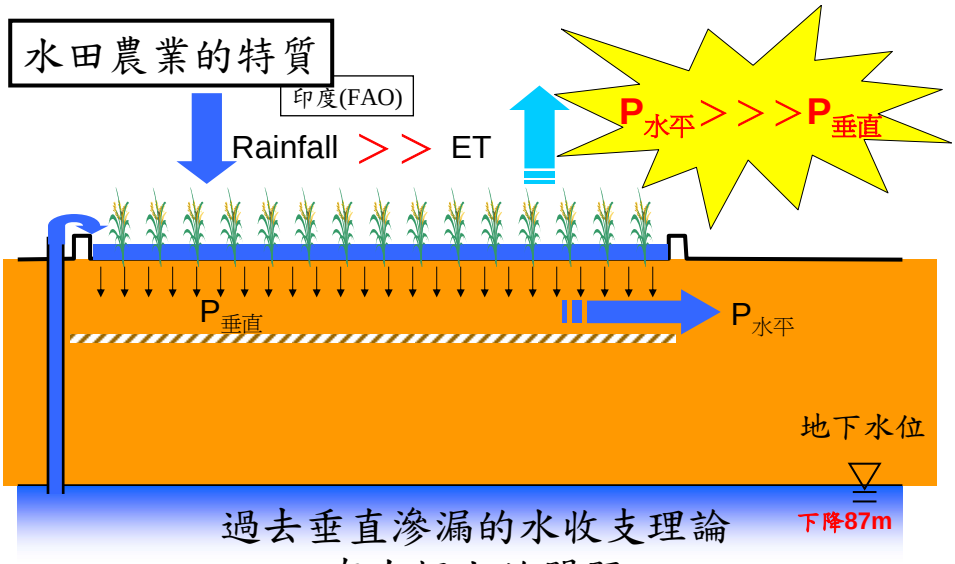
6. 非灌溉期間，原用灌溉水可直接支應下游之需。

7. 本技術在日本之「水土里」已有成功的應用例。

3. 沿海砂丘地的植生可行性

a. 水田農業的特質
b. 築壩原理(烏山頭)及伏流截水(屏東)之啟示
c. 活用在砂丘地的綠化工程

水田農業的特質



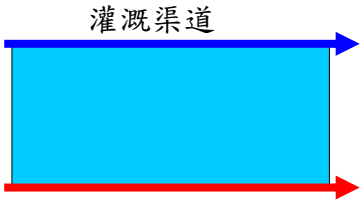
過去垂直滲漏的水收支理論
存在極大的問題

雲林水利會利用水田水收支原理創造新水資源的新策略

築壩原理(烏山頭)及伏流截水(屏東)之啟示

理論

日本東京大學（台灣大學客座教授）
白井清恆教授之「溝紋補注工法」



排水溝挖深，增加溝底滲漏

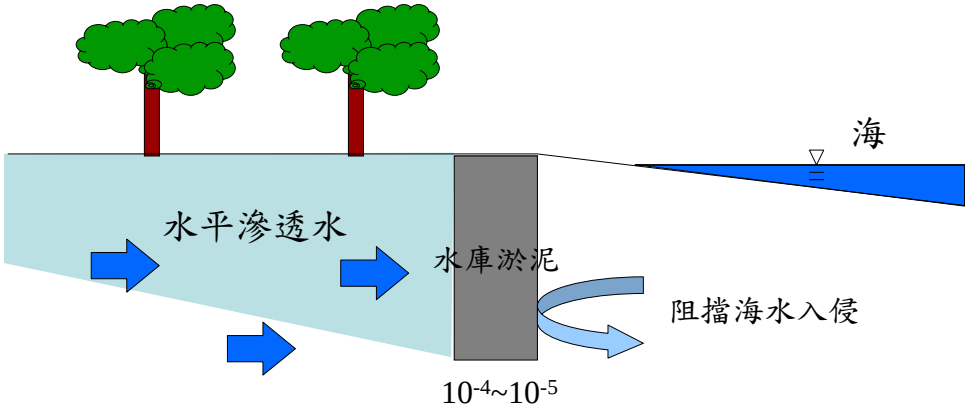
實證

1、屏東地下伏流水之應用，傳承80年前鳥居新平先生的取水構想。

2、台灣嘉南地區之「三年輪作制度」實施80年，使沙漠地變成綠地及水庫的築壩原理。

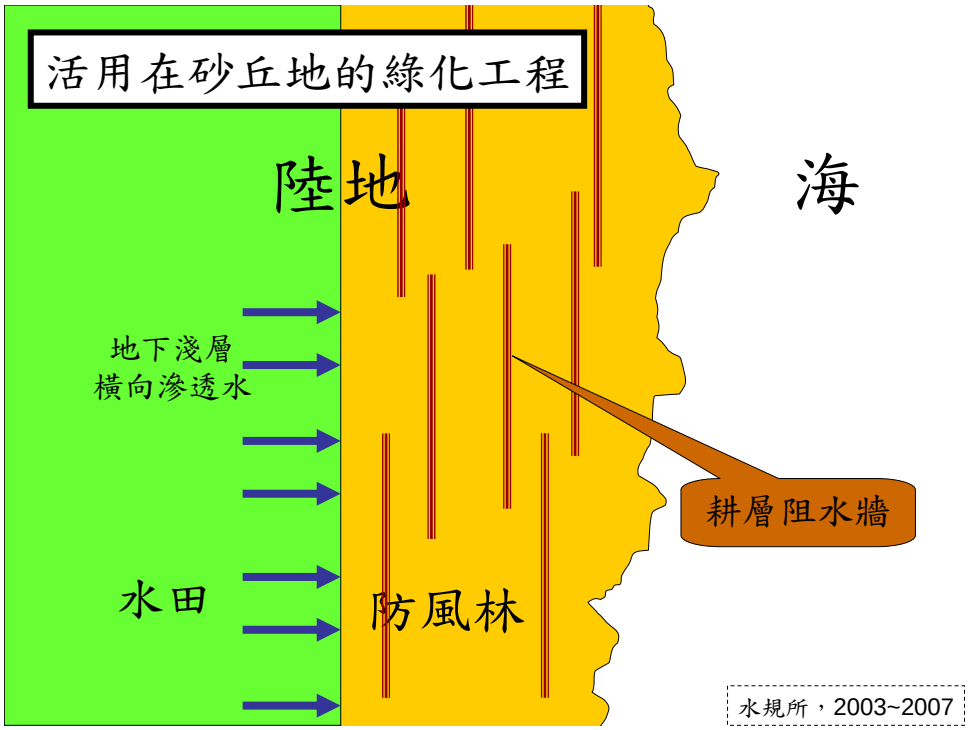
活用在砂丘地的綠化工程

無灌溉設施領域



水規所，2003~2007

活用在砂丘地的綠化工程



水規所，2003~2007

活用在砂丘地的綠化工程(台灣 2008)

無灌溉




活用在砂丘地的綠化工程

1. 收集水田地區外排入海的水平滲漏水。
2. 阻擋沿海地區海水的入侵。
3. 利用水庫肥沃的底泥作為擋水層，經水量及肥分促進防風林的成長。
4. 改善沿海沙丘地的土壤質地。
5. 解決水庫淤泥的去處及有效利用。
6. 防治沿海地區風沙的吹襲。

水規所，2003~2007

第五屆世界水論壇大會

- 時間：2009/3/16-3/22
- 地點：土耳其伊斯坦堡
- 台灣的水資源技術對世界的貢獻

1. **Potential Benefits of Extra-application of Water to Paddy Fields**
2. **Pond Irrigation System of Taoyuan Area in Taiwan**
3. **Ideas of Field Application from Sand Dune Conservation Experience**

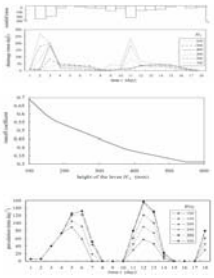
Topic 1.1- Adopting to Climate Change

Potential Benefits of Extra-application of Water to 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 water demands by the domestic and industrial water users. This imposes an additional pressure to the agricultural sector, presently using about 80% of available water resources in Taiwan, to sharply curtail the water use. Furthermore, under the current prospect of Taiwan becoming a member of the World Trade Organization (WTO) that will surely allow foreign countries to increase importing rice of lower cost or higher quality, a substantial reduction in paddy field acreage in Taiwan is imminent. Under such an environment, some of the concepts that were unconceivable before begin to appear logical and worth exploring.



Potential benefits of extra-application of water to paddy fields

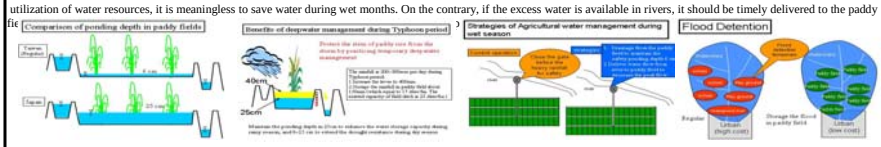
A concept that now seems logical is to apply some of the excess water, which will become available owing to the reduced rice field acreage, to some of the remaining paddy fields (Lee et al., 1995), under the following hypotheses:

1. The increased application of water to the rice plants may improve the productivity and rice quality. For instance, the required average depth in paddy field in Taiwan is 6 cm 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 apply more water, the height of the levees around the paddy fields must be raised, which in turn will make the paddy fields become effective rainwater cistern systems during wet months (Hayase, 1994).
3. The increased water depth in paddy fields will increase percolation of water through soil and hence increase the recharging of ground water aquifers (Wen, 1995).
4. The elevated groundwater table and increased runoff from paddy fields that will result from the increased application of water will benefit the plant growth and the overall ecological system of the adjacent areas (Sekiya, 1992).

Under the above backgrounds, the purpose of this paper is to present results from a project to investigate the potential benefits of an extra-application of water to paddy fields.

Practical applications

Irrigation water differs substantially from the water used in industrial or domestic consumption. Its purpose is to satisfy the evapotranspiration needs for maintaining the crop's normal growth. Thus, from the viewpoint of effective utilization of water resources, it is meaningless to save water during wet months. On the contrary, if the excess water is available in rivers, it should be timely delivered to the paddy fie



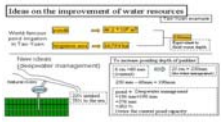
Topic 1.1- Adopting to Climate Change

Pond Irrigation System of Taoyuan Area in Taiwan

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

Introduction

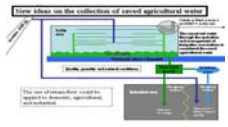
Net water consumption in wetland paddy irrigation takes place in evapotranspiration ETcrop(t) and the growth of plant bodies (Brouwer and Heibloem, 1986). The other part of the irrigated water moves downstream after infiltrating into the soil or flowing directly into the adjacent drain (Masayoshi and Akira, 1999). The wetland paddy has a buffer function for water quality (Sekiya, 1992), \and higher water reuse ratio in wetland paddy can reduce the net runoff load to zero (National Institute for Rural Engineering, 2004). Therefore, the water users in downstream areas have the opportunity to reuse the water.

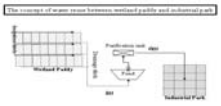


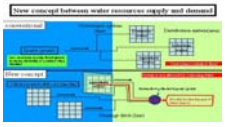
Optimal water allocation correspond with pond irrigation system

Limited land resources force the industrial development has to compete with the agricultural land use in Taiwan. In the wake of the large-scale industrial park developed, the water shortage is critical in local area. The wetland paddy has a buffer function for water quality and quantity is like an effective rainwater cistern system. Linking up a water reuse system in wetland paddy can supplement the industrial water needs. Since the water need in urban and industrial water use is growing, the reuse of return flow from wetland paddy to supplement the dramatic increasing water needs is critical.

The concept of water reuse between wetland paddy and industrial park is showed as Figure, in which I(t) is the return flow rate from wetland paddy at time t (m3 10-days-1); O(t) is the reuse wate collecting return flow(m3 10-days-1), DPmax is the maximum water storage of pond (m3) and DPmin is the minimum water storage of pond (m3). Through the simulation of the reuse of return flow, the potential benefits of the reuse system is reasonable estimated.

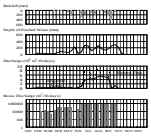




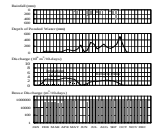


Conclusions

Apart form meeting the water needs at peak demand periods, the reuse of return flow is a quick-response water supply solution. Accompany with the serious of water management strategies, the water reliability and crop security can be achieved in the same time through the reuse of return from wetland paddy. The effects of practicing the deepwater management, enlarging the capacity of regulated pond in the downstream and probing a suitable cultivated paddy scale are respectively presented as follow figures (Chang et al., 2009). In general, the return flow and the effective rainfall increase as the maximum ponding depth of deepwater management increases. As the capacity of pond in downstream increase, the reuse of return flow increase and the local water need can be alleviated. The supply-and-demand gap between seasons become harmonized when the area ratio of the first crop season increase, which results in the decrease of the drought frequency.



Without reusing the return flow



With reusing the return flow

Topic 1.1- Adopting to Climate Change

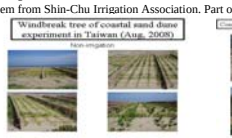
Ideas of Field Application from Coastal Area Conservation Experience

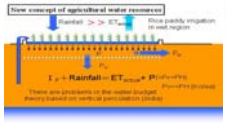
The International Society of Paddy and Water Environment Engineering (PAWEES)

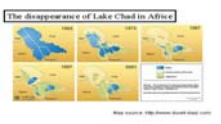
Introduction

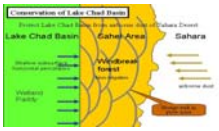
Sand dune of Chiting Coast are sand and gravel deposits within a marine beach system, including beach berms, frontal dunes, back dunes and other sand and gravel areas deposited by wave or wind action. The coastal sand dunes extend into the paddy fields with irrigation system from Shin-Chu Irrigation Association. Part of the sand dune includes areas which have been covered by artificial windbreak tree and lawns. Sand dune systems also include all vegetation which is nativeto and occurring in the area.

In order to improve the soil texture and conserve the land resource, plenty of field experiments were conducted by the Water Resources Agency (WRA) in Chiting Working Station from 2003 to 2008. Those experiments integrate the experiences of the groundwater recharge movement in the Indus basin, the “Creek Irrigation” technology of paddy fields develop from the coastal area in Kiu-Shiu area for 300 years and the “3-year crop rotation system” contribute from Chia-Nan Irrigation Association for 80 years, which are showed as Figures.



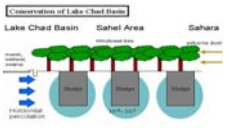


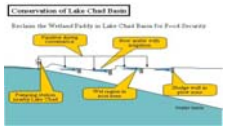




Explore ideas from the coastal sand dune conservation

With the consultation of experts and professionals from Taiwan and Chad, several ideas of field application are explore from those experiments which may be able to apply on the land conservation in Lake Chad Basin. In the past 50 years, West Africa has experienced large land-use changes including deforestation, overgrazing and reclamation and a persistent drought since the 1960s. In the short-term, destructive land use change may results in the dramatically change in water flow, or even eliminating the low flow in some area. In the long-term, the reductions in evapotranspiration and water recycling arising from land-use changes may initiate a feedback mechanism that results in reduced rainfall. In countries of the Sahel, the aforementioned persistent drought has reduced the area of Lake Chad from 23,500 km^2 to about 1,500 km^2.

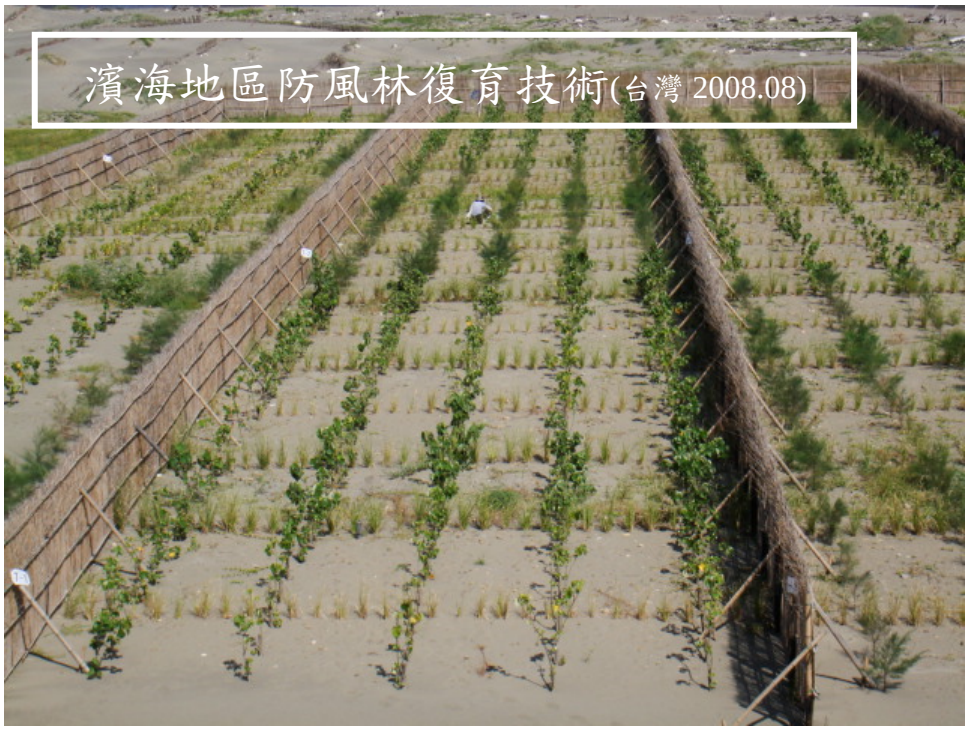


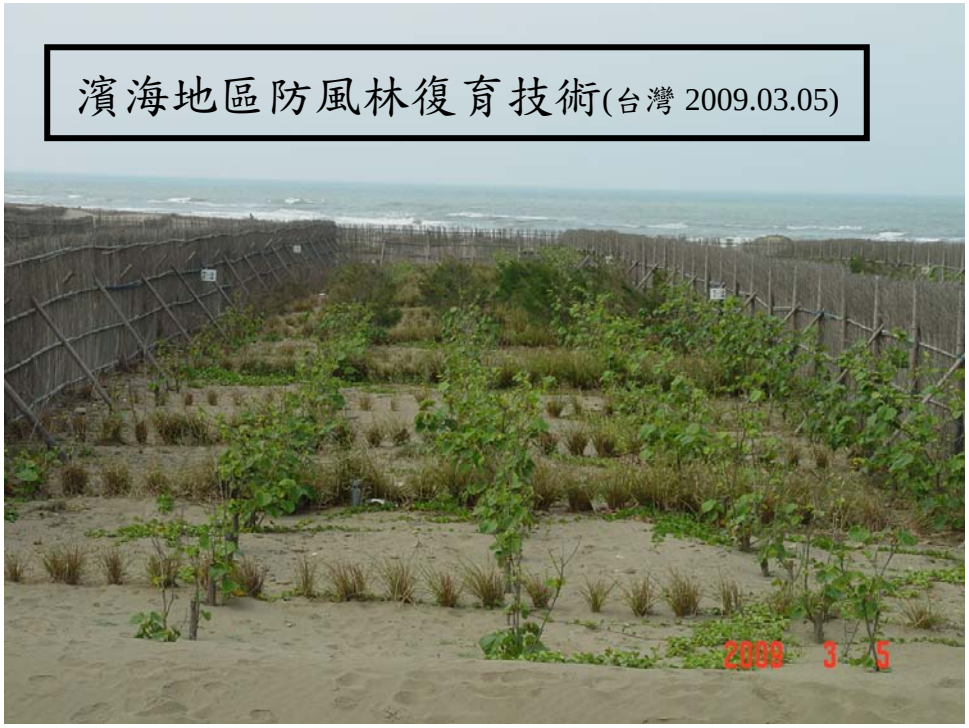


Application Strategies

The ideas of land conservation strategies developed from the experiences of Chiting Working Station are show as Figures, which can be concluded as follow.

1. The horizontal seepage from paddy area is collected to avoid discharging to the desert.
2. The blocking wall, which is formed by fertile sludge, would be good for the growth of windbreak forests.


濱海地區防風林復育技術(台灣 2008.08)


濱海地區防風林復育技術(台灣 2009.03.05)
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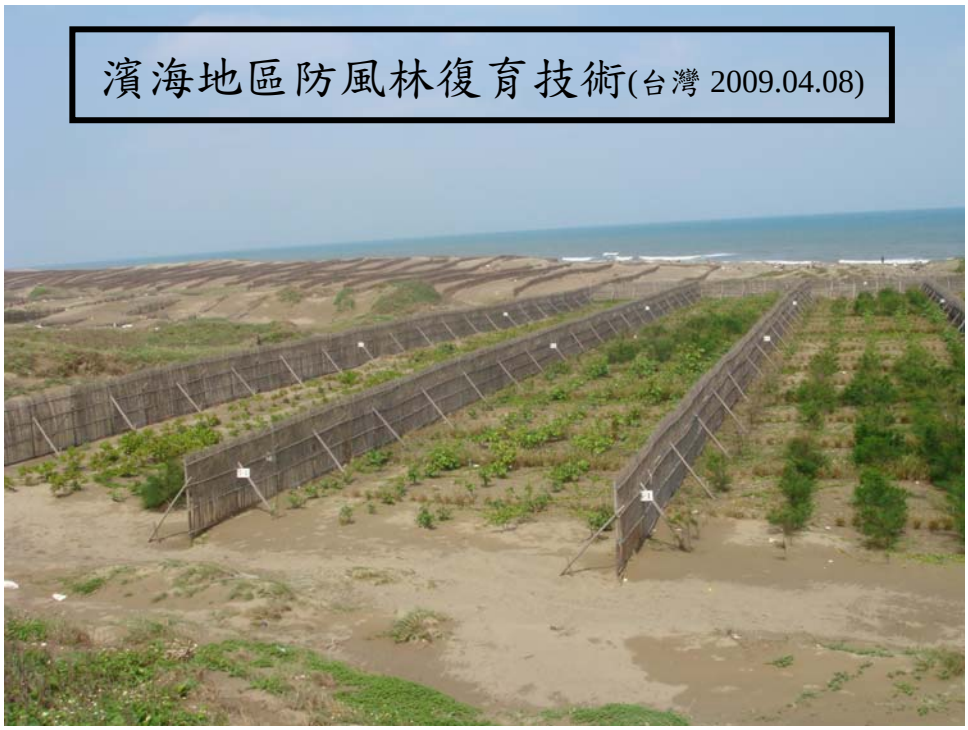
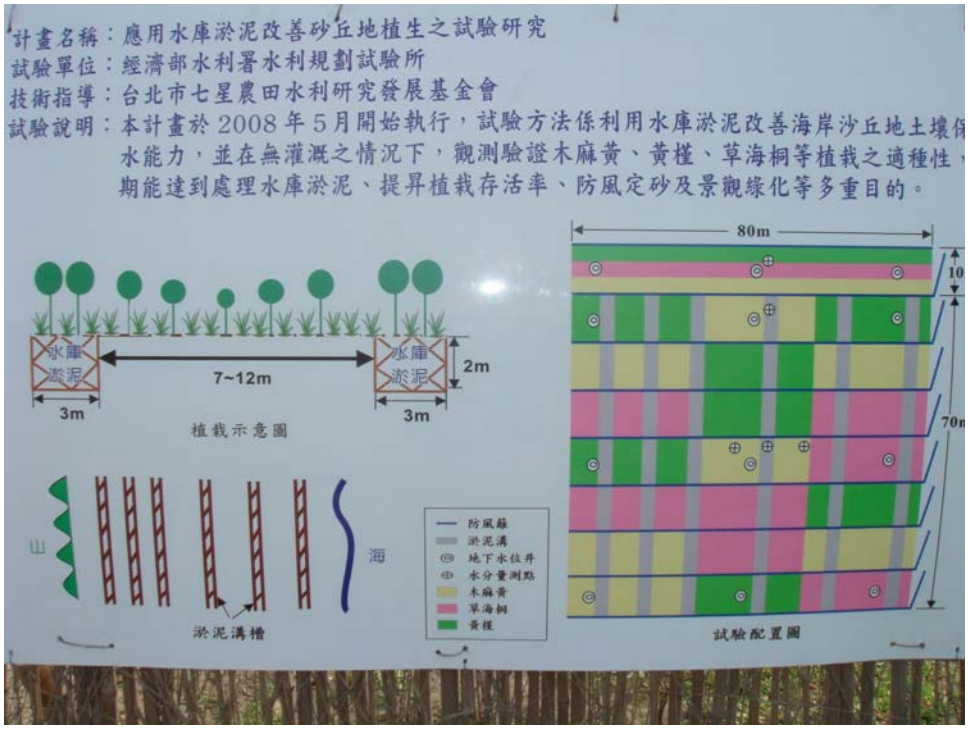
濱海地區防風林復育技術(台灣 2009.04.08)



濱海地區防風林復育技術(台灣 2009.04.08)


濱海地區防風林復育技術(台灣 2009.04.08)


計畫名稱：應用水庫淤泥改善砂丘地植生之試驗研究
試驗單位：經濟部水利署水利規劃試驗所
技術指導：台北市七星農田水利研究發展基金會
試驗說明：本計畫於 2008 年 5 月開始執行，試驗方法係利用水庫淤泥改善海岸沙丘地土壤保
水能力，並在無灌溉之情況下，觀測驗證木麻黃、黃槿、草海桐等植栽之適種性，
期能達到處理水庫淤泥、提昇植栽存活率、防風定砂及景觀綠化等多重目的。
水庫淤泥
7~12m
2m
3m
3m
植栽示意圖
山
海
淤泥溝槽
防風籬
淤泥溝
地下水位井
水分量測點
木麻黃
草海桐
黃槿
80m
10
70m
試驗配置圖

敬請指正