出國報告（出國類別：出席國際會議）

赴澳洲參加
國際灌溉排水協會第 **63** 屆國際執行委員會議
第 **7** 屆亞洲區域研討會議

服務機關：國際灌溉排水協會中華民國國家委員會等
派赴國家：澳大利亞
出國期間：中華民國 101 年 6 月 22 日至 6 月 30 日
報告日期：中華民國 101 年 8 月 30 日

摘 要

國際灌溉排水協會國際灌溉排水協會第63屆國際執行委員會議及第7屆亞洲區域研討會活動，2012年6月23日至6月28日計6天在澳洲阿得雷德舉行，此次由國際灌溉排水協會中華民國國家委員會莊光明主席為團長率領國內各單位專家，組成23人之代表團赴澳洲參加此次大會，成員包括行政院農業委員會、經濟部水利署、台東、宜蘭、石門、新竹、桃園、台中、雲林、南投、嘉南等農田水利會、國立成功大學、國立中央大學、清雲科技大學、康寧大學、義守大學、醒吾技術學院、農業工程研究中心等專家代表。會議期間由莊主席出席國際灌溉排水協會第63屆國際執行委員會，行使本屆ICID主席及三位副主席任期屆滿改選之權益。

台灣代表分別參與11場技術委員會工作小組會議，其議程分組則包括【亞洲區域工作小組 ASRWG】、【知識類組 Knowledge】-灌溉排水及防洪史工作小組、【流域類組 Basin】-環境工作小組、乾旱工作小組、感潮區域永續發展工作小組、全球氣候變遷與灌溉工作小組、【系統類組 System】-排水工作小組、現代化灌溉服務工作小組、消弭貧窮工作小組、【農田類組 On-Farm】-田間灌溉系統工作小組、【專案小組 Task Force】-水庫淤積工作小組等。

本年度第7屆灌溉排水研討會主旨為「提升區域合作以確保水資源及糧食安全」，其中台灣參與論文發表共2篇。本次大會共有來自56國、多達500人以上的各國代表共襄盛舉，會中發表逾200份研究報告，會議議題則涵蓋「整體水資源管理」、「都會區綠地灌溉」、「現代化灌排系統」、「保育用途之水資源」、「農耕技術」、「排水與防洪」、「氣候變遷」、「區域合作」及「濕地管理與環境用水」等廣泛範圍。

此次國際會議在澳大利亞召開，澳大利亞為典型的海島型國家，位於印度洋和太平洋之間，面積約為 768 萬平方公里(約為台灣 214 大)，是世界上第六大國家，也是世界上最乾旱的陸居地，降雨變化極劇，經常發生不同規模的乾旱及洪澇事件。根據 1820 年起之氣象紀錄統計，澳大利亞全國各地共發生 10 次重大乾旱及 11 次水災，造成嚴重的環境破壞及農業損失。澳洲目前人口約 2,280 萬人，年平均可用水資源估計有 3,360 億立方公尺，水庫之儲水容量約 840 億立方公尺。農業用水佔澳洲水資源總消耗量之 65%(73 億 5,900 萬立方公尺)。2009 年~2010 年，184 公頃灌溉農地之灌溉水量達 65 億 9,600 萬立方公尺，其中，已實施噴灌及微灌之農地約佔 38%灌溉地面積；排水面積約 220 萬公頃，牧場總面積達 542,000 公頃佔灌溉地面積之最大比例，灌溉用水佔總灌溉水量之 26%。本次會議召開地點在澳大利亞南方的阿德雷德(Adelaide)，其為南澳第一大城，澳大利亞第五大城，主要的經濟來源是農業收入和觀光資源。

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附錄二 台灣論文發表–台灣大型灌溉排水計畫之發展概況

History of Large Scale Irrigation and Drainage Projects in Taiwan

(張煜權、陳清田、林國華、甘俊二、謝勝賢、楊明風)

附錄三 台灣論文發表–嘉南灌溉系統模式之更新改善

Experiences on innovative irrigation facilities - remodelling Chia-nan irrigation system at southern Taiwan

(楊明風、詹明勇、鄭昌奇、謝勝賢)

壹、目的

國際灌溉排水協會(International Commission on Irrigation and Drainage, ICID)成立於 1950 年 6 月 24 日，迄今計有 110 個會員國，其中包括 28 個非洲國家委員會、18 個美洲國家委員會、35 個亞太地區國家委員會以及 29 個歐洲國家委員會。ICID 爲一科學、技術和非營利爲目的之非政府國際組織(NGO)，致力於灌溉排水、防洪及環境管理等技術研討以提高世界糧食之需求；其主旨以工程、農糧、經濟、生態及社會等不同專業領域應用於水土資源管理，以達到永續灌溉農業環境的維護。目前 ICID 於水管理技術和處理相關問題已累積 60 年以上豐富經驗，每一年定期舉行國際執行委員會議及學術研討會。

我國於 1969 年由農復會申請加入國際灌溉排水協會，至 1995 年由有關機關及團體組成國家委員會，℃爲展現我國在灌溉排水領域之優勢實力及水利科技實務之成果，我國代表團積極投入參與大會國際執行會議及技術委員會之工作小組會議，期與各國代表相互交流經驗與研究成果，俾推展國際事務連繫及技術交流，以擴展我國在國際組織之活動空間，同時，增加我國對於世界各國在水資源管理、農業發展、環境與生態保護等方面發展之瞭解。

本次組團出國之目的，爲參加第 63 屆國際灌排協會執行委員會之技術委員會工作小組會議暨第 7 屆亞洲區域研討會議，除由專家學者做論文發表外，亦另外安排技術考察澳洲之農田水利及灌溉農業情形。

貳、過程

一、考察團員

序號	姓 名	機關名稱 /職稱
1	莊光明	國際灌排協會中華民國國家委員會 主席
2	田巧玲	經濟部水利署 主任秘書
3	李允中	行政院農委會農田水利處 灌溉管理科科長
4	吳瑞賢	國際灌排協會中華民國國家委員會 副祕書長 ICID 氣候變遷工作小組 秘書/中央大學土木工程系 教授
5	郭勝豐	ICID 亞洲區域工作小組 委員 康寧大學休閒資源暨綠色產業學系 教授
6	高瑞棋	ICID 感潮區域工作小組 主任委員 成功大學水工試驗所 副所長
7	王筱雯	ICID 感潮區域工作小組 委員 成功大學水利及海洋工程學系 助理教授
8	鄭昌奇	ICID 乾旱工作小組 委員 清雲科技大學工業工程與管理系 副教授
7	詹明勇	ICID 現代化灌溉工作小組 委員 義守大學土木與生態工程學系 副教授
9	張煜權	ICID 消弭貧窮工作小組 委員 醒吾技術學院 副教授
10	陳清田	ICID 田間灌溉工作小組 委員 嘉義大學土木與水資源工程學系 副教授
11	譚智宏	國際灌排協會中華民國國家委員會技術合作與人才培育委員會 執行祕書/ 農業工程研究中心資源組 組長
13	羅應鑑	台東農田水利會 會長
14	林寬沛	宜蘭農田水利會 機要秘書
15	呂芳堅	石門農田水利會 總幹事
16	陳美嫦	新竹農田水利會 管理組長

序號	姓 名	機關名稱 /職稱
17	陳清峯	台中農田水利會 灌溉股長
18	林志敏	南投農田水利會 灌溉股長
19	王培展	桃園農田水利會 工程師
20	陳紫品	雲林農田水利會 副工程師
21	蔡勝炫	嘉南農田水利會 副管理師
22	劉珺貽	成功大學水工試驗所 行政助理
23	倪佩君	國際灌排協會中華民國國家委員會 秘書

二、會議行程表

(一) 出國時間自 101 年 6 月 22 日至 6 月 30 日。

(二) 會議時間自 101 年 6 月 23 日至 6 月 28 日，行程如下：

日期（星期）	行程內容	地點
6 月 22 日 (五)	● 去程-台北出發前往澳洲 (下午 3:25)	台北✈香港 香港✈墨爾本 墨爾本✈阿得雷德
6 月 23 日 (六)	● 抵達澳洲阿得雷德 (上午 10:00)	
6 月 24 日 （日）	● 技術委員會工作小組會議	阿得雷德 (Adelaide)
6 月 25 日 （一）	● 技術委員會工作小組會議	阿得雷德 (Adelaide)
6 月 26 日 （二）	● 第 7 屆亞洲區域研討會(開幕典禮)	阿得雷德 (Adelaide)
6 月 27 日 （三）	● 技術參訪-藍湖(Blue Lake)	甘比爾 (Mt. Gambier)
6 月 28 日 （四）	● 第 62 屆國際執行委員會議	阿得雷德 (Adelaide)
6 月 29 日 （五）	● 回程-澳洲阿得雷德出發 (上午 06:45)	阿得雷德✈柏斯 柏斯✈香港 香港✈台北
6 月 30 日 （六）	● 抵達台灣 (上午 00:20)	

三、參加會議議程

日期 (星期)	時間	大會議程	委員代表	列席人員
6/23 (六)	11:00-17:30	註　冊	全體人員	
6/24 (日)	08:30-10:30	【WG-DRG】 「排水」	陳弘凷* (譚智宏代)	
		【WG-ENV】 「灌溉排水與防洪對環境衝擊」	譚義績* (吳瑞賢代)	林寬沛、林志敏
	11:00-15:00	【WS-SDTA】 「感潮區永續發展」	高瑞棋 王筱雯	劉珺貽、林寬沛
		【ASRWG】 「亞洲區域」工作小組會議	郭勝豐	莊光明、譚智宏
		【WG-CLIMATE】 「全球變遷與灌溉」	吳瑞賢	陳清田、田巧玲
	15:30-17:30	【WG-HIST】 「灌溉、排水及防洪史」	舒文斌* (譚智宏代)	倪佩君
		【WG-DROUGHT】 「水源緊張區域之水管理」	鄭昌奇	詹明勇、田巧玲
		【WG-ON-FARM】 「田間灌溉系統」	陳清田	呂芳堅、陳清峯 蔡勝炫、王培展
6/25 (一)	15:30-17:30	【WG-MIS】 「現代化灌溉服務」	詹明勇	鄭昌奇、李允中 羅應鑑、陳美嫦
		【WG-POVERTY】 「消弭貧窮」	張煜權	陳清田、陳紫品

日期 (星期)	時間	大會議程	委員代表/論文發表作者
6/26 (二)	08:30-17:20	第 7 屆亞洲區域研討會 (論文發表)	詹明勇、鄭昌奇
	08:30-15:00	【PCTA】 「技術活動委員會」	高瑞棋
	11:00~12:30	【TF-SEDIMENTATION】 「水庫淤積」	游保杉* (王筱雯代)
	09:30-18:00	技術參訪－【Blue Lake】	全員參加
6/27 (三)	09:30-18:00		
	09:00-17:20	第 7 屆亞洲區域研討會 (論文發表)	張煜權、陳清田
6/28 (四)	08:30-17:30	第 63 屆國際執行委員會議	莊光明主席 吳瑞賢副秘書長
	19:00-22:00	歡送晚宴	主席及部分代表人員

註*：原台灣委員代表無法參與本次會議，由代理人出席。

參、心得

一、參加會議

國際灌漑排水協會(簡稱 ICID)

(一) 第 63 屆國際執行委員會會議(International Executive Council, IEC)

本次進行 15 項議程討論，台灣由莊光明主席代表出席參加本次會議，與會各國國家委員會主席表決各項議案，並投票改選 ICID 3 位副主席(任期：2012~2015 年)。茲將本次議程決議重點整理如下，以了解 ICID 之會務運作，並供我國代表未來參與 ICID 相關活動及會議之參考。

1.拓展國際灌排協會會員

依照拓展國際灌排協會會員評估小組的提議，執行委員會於第 62 屆執行委員會議中決議新增個人、機關和公司行號會員類別。對於相關大會章程所需修訂，國際執行委員會並成立特別小組進行評估。

特別小組所提議對 ICID 章程當中第 3、4、5 章和其他相關章節進行相關調整。有關新增「直屬會員(Direct Membership, DMs)」之規範原則如下：

(1)通則

- 直屬會員可參與技術工作小組。
- 直屬會員可列席 IEC 會議，但不具表決權。
- 會員申請之審核作業應有效率。
- 宜簡化行政作業程序。
- 應遵守章程規定。

(2)直屬會員類別

- 公司(Company)

  A 型－平均年營業額達 100 萬美元。

  B 型－平均年營業額 100 萬~1,000 萬美元之間。

  C 型－平均年營業額 1,000 萬美元以上。

- 機構(Institutation)

  a 型－職員人數 1-50 人。

  b 型－職員人數 50 人以上。

- 個人(Individuals)

  青年專家－40 歲以下。

  退休人員－65 歲以上。

  一般會員(其他)。

2.總會各會員國(NCs)之會籍現況

國際灌排協會網絡遍及 110 國，其中包括 28 個非洲國家委員會、18 個美洲國家委員會、35 個亞太地區國家委員會以及 29 個歐洲國家委員會。目前各會員國之會籍概況如下：

區域	積極 會員	準停權 會員	申請通過 但未繳費	退會	合計
非洲	06	17	05	-	28
美洲	05	11	01	01	18
亞洲及 大洋洲	22	08	04	01	35
歐洲	22	06	-	01	29
合計	55	42	10	03	110

3.籌辦「世界灌溉論壇-World Irrigation Forum」

ICID 每年定期召開 IEC 會議，同時以三年為 1 週期之重要會議規劃，各年度會議重點如下：

- 第 1 年：辦理世界灌溉論壇-World Irrigation Forum
- 第 2 年：辦理 ICID 灌排研討大會-Congress
- 第 3 年：技術研習議題-Technical issues

其中，第 1 屆世界灌溉論壇(WIF)暨第 64 屆 IEC 會議將於 2013 年土耳其·Mardin 舉行，預估與會代表至少 800 位。

4.總會章程修訂

國際執行委員會於第62屆國際執行委員會議中成立特別小組評估ICID章程及附例的修訂，以因應總會辦公室會務作業及新會員入會制度之建立。特別

小組成員包括：

- 主任委員：榮譽主席 Chandra A. Madramootoo
- 委員：榮譽副主席 Larry D. Stephens
- 委員：副主席 A.K. Bajaj
- 資源人員： Avinash C. Tyagi (Resource person)

(1)有關直屬會員(Direct Membership)入會制度如下：

凡尚未申請入會 ICID 之國家，或已屬 ICID 會員國但並無個人或團體會員者，該國家所屬之公司、機關及個人有意願申請加入 ICID 者，必需經由 IEC 會議審核通過，始成為 ICID 之直屬會員。直屬會員得參與 ICID 技術活動委員會之各工作小組，但必須遵守章程規定。

(2)準停權會員國家之會籍：

為鼓勵準停權會員國家踴躍參與 ICID 會務活動，有關追繳常年會費事宜如下，如該會員國家已繳交當年會費，且同意繳還自停繳日起之前 3 年會費，並自當年度起算於 5 年內償還者，即可於當年恢復會籍；但對於低開發國家則不受上限。

5.節水（WatSave）獎

擔任評審團召集人的前主席 Chandra Madramootoo，宣布得獎名單，獎項及得獎人員如下：

(1) 節水技術獎

「Theory and technology of controlled irrigation of rice in China」

Prof. Peng Shizhang (中國)

(2) 節水創新水資源管理獎

「Integrated water recovery-providing regional growth for northern Victoria, Australia」

Mr. Peter McCamish (澳大利亞)

6.國際灌排協會期刊《灌溉與排水》之最佳論文獎

最佳論文獎選自 2010~2011 年間投稿至本會期刊的文章，由國際灌排協會編輯委員會(EB-JOUR)主席暨本會前主席 Bart Schultz 宣布 2012 年最佳論文：

- 得獎者：

  Zahra Paydar, Freeman Cook, Emmanuel Xevi, and Keith Bristow (澳大利亞)

- 論文名稱：

  「An Overview of Irrigation Mosaics」，刊登期數：Volume 60, No. 4.。

7.三位副主席任期屆滿之改選

- 副主席選舉

  根據國際灌排協會組織章程(1996 年)第 6.2.4 條的規定，下列三名副主席的三年任期(2009-2012)，將於阿得雷德舉行之國際執行委員會議結束後任職期滿。

Dr. Willem F. Vlotman	澳大利亞
Dr. Laszlo G. Hayde	匈牙利
Mr. A.K. Bajaj	印度

新任 ICID 副主席：

- Mr. Laurie C. Tollefson (加拿大)
- Dr. Hüseyin GŰNDOĞDU (土耳其)
- Mr. François BRELLE (法國)


(加拿大)


(土耳其)


(法國)

8. 會議預告

- 2013 年

(1) 土耳其馬爾丁(Mardin)・10 月

第 64 屆國際執行委員會暨第 8 屆亞洲區域研討會

- 2014 年

  (2) 俄羅斯・聖彼得堡(St. Petersburg)－ 6 月

  第 12 屆國際排水研討會

  (3) 韓國・首爾(Seoul)－9 月 14-20 日

  第 65 屆國際執行委員會暨第 22 屆國際灌溉排水研討大會

- 2015 年

  (4) 法國・蒙彼利埃(Montpellier)－ 10 月

  第 66 屆國際執行委員會會議暨第 26 屆歐洲區域研討會議

- 2016 年

  (5) 泰國・清邁(Chiang Mai)

  第 67 屆國際執行委員會會議暨第 9 屆亞洲區域研討會議

(二) 技術活動委員會工作小組會議

目前 ICID 技術委員會各類別工作小組中台灣所屬之正式委員共有 10 位，本年度亦分別於「田間灌溉系統」及「消弭貧窮」工作小組提名 2 位新委員，經審核通過，茲將各工作小組會議內容重點摘要如下：

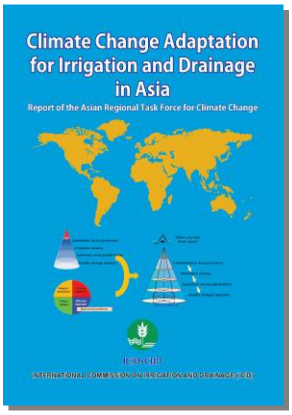
區域工作小組

1.亞洲區域工作小組會議【ASRWG】

出席委員：郭勝豐 教授

(1)本工作小組正致力於亞洲區域氣候變遷專案小組(ARTC-CC)的工作，相關工作已於 2012 年完成，副主任委員 Tai Cheol Kim 正草擬新的專案小組議題，新專案工作小組成員七個國家如下：馬來西亞，泰國，土耳其，伊朗，日本，台灣，韓國。

(2)前副主席 Shinsuke Ota(日本)報告 ARTC-CC 工作成果"Climate Change Adaptation for Irrigation and Drainage in Asia"，本研究報告分析重點如下：



- 各國氣候及灌排系統之狀況。
- 除科學和技術之外，研究範圍廣泛包括治理、人文、社會運動、地方作法等相關議題。
- 各案例依其地理位置分區歸類。
- 擷取因應氣候變遷成功策略之要素。

台灣委員代表郭勝豐教授提出之案例為「Study on Paddy Fields Multi-Functionality for Sustainable Environment and Climate Change in Taiwan」，亦列入該報告書。

(3)第 8 屆亞洲區域研討會議將於 2013 年 9 月 29 日至 10 月 5 日於土耳其舉辦，大會主題為「缺水情形下之灌溉管理」，子議題包括：氣候變遷與乾旱，缺水下之節水灌溉，乾旱抵抗之變化性，先進農業科技，灌溉系統之重建，農田水利管理，灌溉管理之財務機制，環境對灌溉計畫之影響，地下水灌溉等。

知識類組

2.灌溉、排水及防洪史工作小組會議【WG-HIST】

出席委員：譚智宏 組長(代)

(1)印尼國家灌溉排水委員會出版「印尼古灌溉渠道(Irrigation Tunnelling in Ancient Indonesia)」，該報告書於會場中傳閱。

(2)灌溉、排水及防洪史工作小組之網頁 http://wg-hist.icidonline.org/已開始運作，並希望增加灌溉渠道相關影片。

(3)本年度大會同時舉辦”Historical Water Sustainability: Lessons to Learn”研習會，相關論文會在下年度彙整出版。

流域類組

3.乾旱工作小組會議【WG-DROUGHT】

出席委員：鄭昌奇 教授

(1)依工作計畫探討「乾旱管理對策」、「面對水源稀少性」及「永續農業之降雨管理」等議題，台灣委員代表鄭昌奇教授負責「Drought Management Strategies」之議題，各議題主持人於本次工作會議中提出報告。

(2)鄭昌奇教授在乾旱缺水工作小組提出子題一『水資源緊張地區的乾旱管理策略』手冊撰寫大綱，乾旱工作小組成員對於大綱均給予正面的肯定，但在短時間內要詳細檢討可能不容易，在加上乾旱小組三個主題有明顯重疊或定義上混淆的情況。所以，召集人最後裁定在明年土耳其年會暨乾旱小組工作研習會舉行之前，必須提出確定完整且顧及不同層面的大綱定稿本，該大綱定稿之前須在各委員間流通討論。俟定稿綱樣確認之後，希望各子題負責人能協調相關人員整理出三篇左右的文章，在明年乾旱工作研習會中報告，藉之完成報告的雛形，並於最短時間內完成前述的手冊，向大會提出成果說明。

4.全球變遷及農業水管理工作小組會議【WG-CLIMATE】

出席委員：吳瑞賢 教授 (擔任本工作小組秘書)

(1)工作小組提議研擬有關「氣候變遷之影響下灌溉與排水之調適方法」。

(2)ICID 將持續與世界氣象組織共同合作有關氣候之資訊及其運用。

5.感潮區永續發展工作小組會議【WG-SDTA】

出席委員：高瑞棋 副所長(擔任本工作小組主任委員)

出席委員：王筱雯 教授(青年專家代表)

(1)籌備發行 ICID 期刊之 SDTA 特刊，費用共計 15,000 美元，由韓國、日本及台灣共同分攤。

(2)預計於韓國辦理 ICID 大會期間召開一場研習會。

6.灌溉排水與防洪對環境衝擊工作小組會議【WG-ENV】

出席委員：吳瑞賢 教授(代)

(1)本工作小組將探討 3 個議題，包括「農業回歸水」、「永續環境管理」及「灌溉與排水對人體健康之影響」。

(2)將於 2013 年土耳其辦理 ICID 年會期間，召開工作小組研習會議。

7.排水工作小組會議【WG-DRG】

出席委員：譚智宏 組長(代)

(1)國際灌溉排水協會排水工作小組將建置世界排水區域"Drained area in the world"資料庫，並推舉各區域自願負責人。

負責人	涵蓋的區域或國家
Jakko Sierla/ Helena Aijo	斯堪的納維亞國家(Scandinavian countries)
Mati Tonismae	波羅的海國家(Baltic counties)
Irena Bondarik/ YuriiYanko	俄國(Russia)
Bernard Vincent	南歐和東歐;馬格里布 (South Europe and East Europe ; Maghreb)
Victor Dukhovny	蘇聯解體後的前蘇聯加盟共和國(NIS)
Ardavan Azari	中東國家(Middle East)
Loh Kim Mon	亞洲國家(Asia)
Gerhard Backeberg / AT van Coller	南非和鄰近國家 (South Africa and neighbors)
James Ayars	北美國家(North America)

(2)排水工作小組之網頁 "DRAINLINE" http://wg-drg.icidonline.org/已正常運作，小組成員應檢視並提供相關資料、連結與文獻給本工作小組。

(3)去年德黑蘭會議後，印度國家委員會提案編撰「生物排水(bio-drainage)植物經驗分享」。

系統類組

8.現代化灌溉服務工作小組會議【WG-MIS】

出席委員：詹明勇 教授(代)

(1)工作小組成立於 2007 年，迄今恰好六年一個循環。因為加拿大專家擔任召集人期間無法適時掌控各國委員的參與程度，以致於沒有確切的成果或相關該呈現給大會討論的文件。召集人建議先解散該工作小組，所以沒有討論申請加入委員會的名單。

(2)伊朗代表宣讀其編撰中的書刊—渠道工程-限制與發展，內容堪稱豐富完整，但美國、日本、FAO 代表咸認為渠道工程設計因地制宜的成分太多，由 ICID 出版類似的書籍是否合宜？同時該書也沒有考量灌溉系統的管理與成本，對於耕作方式也欠缺章節論述。

(3)主任委員徵詢意見，包括：現代化議題如何繼續下去、是否成立新的工作小組及新的任務、「現代化」議題可否被「灌溉管理永續改進」議題所取代等。經過 100 分鐘熱烈討論，召集人還是裁示先行撤銷灌溉現代化工作小組，明年先以任務編組暫代工作小組的事務性工作，俟年會檢討工作小組與推薦召集人之後再研擬主題，推動下階段工作。

(4)本工作小組在建議為延續本工作小組任務以新的形式成立新工作小組前提下，將提送一備忘錄(note)，清楚敘述未來工作計畫。

其實，灌溉現代化技術在台灣正在有系統的推動，例如地理資訊系統、節水灌溉、農業用水多目標利用等，農委會都有完整的成果，只是我方欠缺資料的整合與提供，造成灌溉排水發達的國家不理我們，技術落後的國家找不到奧援的機會。若中華民國農業相關部會(不僅僅農水處)能整合資料完成中華民國灌溉排水年報(Annual Book of Irrigation and Drainage of Taiwan)，將有助於國力的行銷，更可善盡國際共助的公益力量。

9.消弭貧窮工作小組會議【WG-POVERTY】

出席委員：張煜權 教授

(1)工作小組正籌備有關“Role of Irrigation in Poverty Alleviation and Ehance Livelyhood”之 ICID 聲明報告。預計於 2013 年完成並提報至 IEC 會議。

農田類組

10.田間灌溉系統工作小組會議【WG-ON-FARM】

出席委員：陳清田 教授

(1)全球使用微灌與噴灌之現況調查：

副主席 Prof. Peter Kovalenko 於 2012 年 3 月 30 日烏克蘭舉行國際科學會議，提供有關烏克蘭、俄羅斯、哈薩克、亞塞拜然、烏茲別克斯坦、摩爾多瓦等國最新微灌與噴灌資料。工作小組亦已將資料予以更新，根據最新資料顯示：世界上噴灌面積目前大約 4 千 289 萬公頃，微灌面積約 1 千 33 萬公頃，日候仍請各委員及會員能再檢視各國資料，俾以維持此資料之更新。

(2)通過 2012~2014 年之工作計畫書：

- 持續更新 ICID 會員國噴灌和微灌面積數據。
- 將第 8 屆德黑蘭國際微灌會議提交的文件上傳於(WB)網站。
- 第 9 屆國際微灌大會的主辦單位計劃和協調。
- 發表“小農夫和溫室的微灌”論文。
- 發表“連續灌溉對田間用水管理和土壤水源涵養”論文。
- 完成修訂“調查世界上廣泛使用噴灌和微灌”問卷，並分發給非華語國家。
- 彙編已填寫完成之“調查世界上廣泛使用噴灌和微灌”問卷收到的資料。
- 準備編製國家委員會運行草案

專案小組

11.水庫淤積專案小組【TF-SEDIMENTATION】

(1)工作小組之活動計畫必須配合國際大壩委員會(ICOLD)。

(2)技術活動委員會建議先撤除本工作小組，並請中華台北委員會(Chinese Taipei Committee)與土耳其委員會(Turkey National Committee)共同研商於 2013 年 IEC 大會期間籌辦一場研習會。

(三) 第 7 屆亞洲區域研討會-台灣論文發表

Regional Co-operation for Water & Food Security

【提升區域合作以確保水資源及糧食安全】

論文題目	共同作者	附件
議題 1、整體水資源管理		
1. History of Large Scale Irrigation and Drainage Projects in Taiwan 台灣大型灌溉排水計畫之發展概況	張煜權、陳清田 林國華、甘俊二 謝勝賢、楊明風	附錄二
議題 3、現代化灌溉及排水系統		
2. Experiences on innovative irrigation facilities - remodelling Chia-nan irrigation system at southern Taiwan 嘉南灌溉系統模式之更新改善	楊明風、詹明勇 鄭昌奇、謝勝賢	附錄三

二、技術考察

(一) 澳大利亞水資源利用概況

1. 地理環境及氣候變化

澳洲四面環海，國土總面積約 768 萬平方千公尺，由六個州、北領地和首都直轄區組成。澳大利亞地勢低平，是世界上地表起伏最緩的大陸，全境平均海拔 350 公尺，87%的地區海拔低於 500 公尺，海拔不到 100 公尺以上的山地不到 1%，河流稀疏，且無流區面積較大，共有大小河流 240 條，多爲季節性河流，四季不斷的河流只限於北部和南部海岸一帶，位於澳洲中部大自流盆地含有豐富的地下水資源，是世界上最大的地下水源地。

澳洲目前人口約 2,280 萬人，年平均可用水資源估計有 3,360 億立方公尺，國內建有水庫進 400 座，總蓄水容量約 840 億立方公尺。

沙漠和半沙漠地區占全國土地總面積的 35%，年平均降雨量小，蒸發量大，是世界上最乾旱的陸居地，降雨變化極劇，經常發生不同規模的乾旱及洪澇事件(如圖 1)。根據 1820 年起之氣象紀錄統計，澳洲全國各地共發生 10 次重大乾旱及 11 次水災，造成嚴重的環境破壞及農業損失。

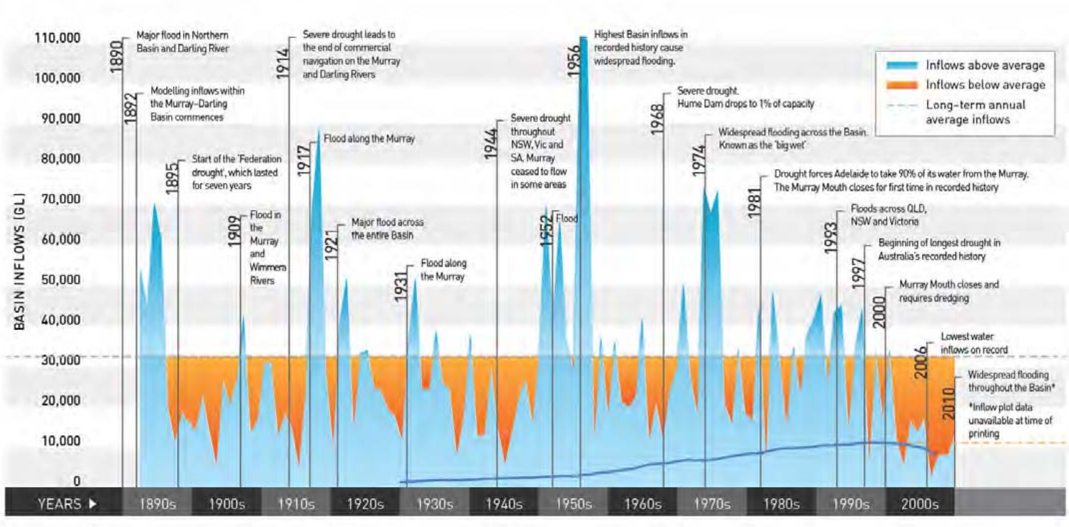


圖 1. 澳大利亞-墨累達令流域發生乾旱及洪澇時間圖

在 20 世紀時期，對於氣候變異之因應作爲，主要強調建造水庫以解決乾

旱時期之缺水危機，而較少關注於防洪之相關措施。1930 年~1990 年期間，當墨累達令流域(Murray Darling Basin)上的取水堰完成後，農業灌溉面積明顯增加，並開始管理許多分佈在澳大利亞各地區之灌排系統調節設施。

2. 水資源及水價

澳大利亞的水資源主要來源於地表水、地下水及淡化水。其中，近一半的水資源來源於西澳，其地下水源在 2008 年到 2009 年間，提供澳洲總水量近 30%之比例。2008~2009 年間，澳洲共回收約 3.48 億立方公尺的水，其中回收農業用水佔 30%(1.02 億立方公尺)。水資源持續短缺和水資源管理設施之投資，影響了使用水的平均價格，2008-2009 年，澳洲每戶年平均飲用水費一度爲新台幣 56.9 元，農業用水爲一度新台幣 3.54 元。

3. 農業灌溉與節水技術

農業用水佔澳洲水資源總消耗量之 65%(73 億 5,900 萬立方公尺)。2009 年~2010 年，184 公頃灌溉農地之灌溉水量達 65 億 9,600 萬立方公尺，其中，已實施噴灌及微灌之農地約佔 38%灌溉地面積；排水面積約 220 萬公頃，牧場總面積達 542,000 公頃佔灌溉地面積之最大比例，灌溉用水佔總灌溉水量 26%；畜牧用水佔農業用水 10%，其中包含牲畜飲水、乳品業及牲圈清潔等。

灌溉農業產值每年估計約 90~110 億元澳幣，其集中在 30%之農產品及澳洲 5%之農地。澳洲全國約有 41,000 個使用灌溉施作方式的農民，這些農民都獲有專業灌溉技術服務，如工程師、農村供水、灌溉農業經營諮詢、灌溉設計、設備安裝及訓練服務等。

近年來聯邦政府從多方面扶持節水灌溉之發展，並出資鼓勵科研機構進行節水技術研究，如鼓勵農場改造灌溉系統，可向州政府申請 1.2 萬澳元補助。另，推廣應用先進的微、噴、滴灌節水技術，以改變傳統的地面溝、畦灌及大水漫灌。澳洲灌溉工程斗渠以上的部份由政府投資興建，並成立專門機構管理，農場內部設施則由農場主自己負責。各個農場的邊界接水口多裝又自動量水計，按照預先分配的水量用水。農民興建節水灌溉工程可向政府的專門機構申請到普通商業貸款利率低 7%的優惠貸款。

4. 2007 水利法

爲因應全國各地可能遭受長期且嚴重之乾旱，氣候變遷模式預測未來在人口稠密區域及南澳農業地區將面臨降雨量減少之危機，2007 年澳洲政府在水利法中頒布將過去由各州政府負責之水資源管理，提升至國家層級，並建立長期的水資源管理改善措施。水利法首要之務，強調各河流之整復以利永續。澳洲許多河川因歷經各次乾旱、水量超抽、農業不當取水等因素，其生態環境已被破壞，澳洲當局在極端氣候之威脅下，已藉由墨累達令流域(Murray Darling Basin)之計畫啓動，將展開一連串水資源相關政策之變革。

5. 現代化灌溉

維多利亞州政府於 2002~03 年實施一項大規模計畫－總渠道控制(Total Channel Control)，這是一種新的灌溉管理技術，包括渠道內面工(Channel lining)、電腦控制操作、提升量測精準度及最佳化渠道管線佈置-連結 6,500 公里長的 GMW 管路系統。維多利亞州政府分別於 2006 年、2007 年及 2008 年再公佈實施現代化計畫，節省水量共達 5 億立方公尺。這些投資之前提是將輸水效益由 70%提升至 85%。

澳洲大規模灌溉計畫之農地外(off-farm 從蓄水設施至農地)及系統(system 從儲水槽至陸地)之平均輸水效益分別爲 70%與 50%。政府投入 120 億澳幣執行全國各項水資源計畫與策略方案，包括投資基礎建設以協助各標的用水者在未來能減少用水量、購買環境用水、並承諾讓國人享有更健康的環境。

澳洲是屬於缺水型的國家，其建立水交易市場之結構，取決於水資源買賣雙方可取得之權益，包括永久性及短期交易型態。自實施此項變革後，墨累達令流域內外之水資源交易量大增，此項水交易政策是國家水資源改革之重大施政項目。但無法避免的是，未來可供應澳洲農業灌溉用水量勢必會大量減少。

6 墨累達令流域計畫

澳洲約有四分之一的農地位於墨累達令流域(MDB)之內，2009 年~2010 年間，MDB 擁有澳洲 37%農業灌溉事業，53%灌溉農地及 54%灌溉用水量。

2011 年 12 月，政府公佈該流域計畫草案，並徵詢民意。此流域計畫之主要目的在於除考量社會經濟之發展，應限定取水量以共同維護流域資源之永續性及環境保育。可持續性的取水量上限(Sustainable Diversion Limits)規定，將成為各流域之新取水規範限定。各流域之低流量預測值，是執行配水規劃及各季節可取水量之主要考量因素。

未來可取得之水資源將逐漸減少，面對此項挑戰，澳洲政府目前已承諾投入 40 億元澳幣，用來提升墨累達令流域內的現代化灌溉設施。同時，政府另投入超過 460 萬元澳幣，協助 18 個供水單位在墨累達令流域各灌區內實施現代化計畫，這些供水單位佔該流域 75%的灌溉水權。

墨累河系統操作(River Murray System Operators)必須與緊急行動計畫(Emergency Action Plan, EAP)相互配合，包含年度防洪演習。EAP 會定期觀察及掌握流量情況，MDBA 應用洪水軟體(MIKE)建立各觀測點(icon sites)之水力模式，並訂定災害應變計畫以因應洪災後河水鹽度之突發性變化。溪流及河水流域之洪水平原管理計畫主要由各州政府結合社區建立洪水風險管理策略，共同維護洪水平原環境。洪水平原管理之主要理念在於應同時兼顧各社區之社會經濟發展與洪水平原生態環境系統之永續維護。

在澳洲其他地區亦遭遇如墨累達令流域相同的經歷，如昆士蘭洲，70%地區已發生連續 6 年乾旱，在 2010~11 年間又有部分地區遭受洪水及颶風侵襲。在乾旱期間，昆士蘭東南地區已採取一套用水管理策略，即減供超過 1/2 的住戶用水量。昆士蘭政府啓動聯合國國際空間和重大災害憲章(International Charter on Space and Major Disasters)，以取得大量災害相關的空間數據。

澳洲政府已啓動如何管理未來水資源之藍圖，並由國家水資源委員會負責執行國家水資源改革計畫。

(二)南澳洲甘比爾山－藍湖

藍湖(Blue Lake)是於數千年前甘比爾(Mount Gambier)火山爆發後，累積雨水與鄰近地下水流入所形成的火口湖，也是城市的供水區，面積約 69 公頃，平均水深 76 公尺，寬 657 公尺，長 1,087 公尺，蓄水量 3600 萬噸(360,000million liter)，主要以重力流方式供應都市用水，抽水站具有用來確保湖水的水位始終低於城鎮街道水平線的調節功能，每年爲附近的居民提供 35 億升的飲用水。

甘比爾山擁有豐沛的降雨量、充足的地下水源以及溫和的天氣等優異的天然地理環境，其平均年降雨量可達到 450 毫米至 820 毫米。環湖步道總長 3.6 公里，可眺望藍湖及週邊壯麗景觀，從步道的岩層可看出多孔的火山石夾雜碳酸鈣及海洋沉積貝殼，在 1500 萬年至 4000 萬年間，澳洲大陸升起及火山爆發，所造成目前的景觀，藍湖湖水清澈，水溫經常保持在 10 度 C 上下，而且不必設自來水廠，可由湖水直接抽用，實一奇蹟。

此行參觀了藍湖抽水站，站內利用白雲石開挖豎井改裝而成玻璃升降梯直下 30 公尺，進行地底下 45 分鐘的體驗。經過橫坑到達湖邊，有三條約 36 公分的抽水管線，其中有一條加氯直接供應城市用水，每天約 1 萬噸，這是上帝的恩賜給這個城市的居民。藍湖供水系統包含一三機組抽水站、控制中心、上層與中層蓄水塔與管路供水設備等，經由抽水設備提供附近甘比爾山市約 25,000 人之農業與民生用水。

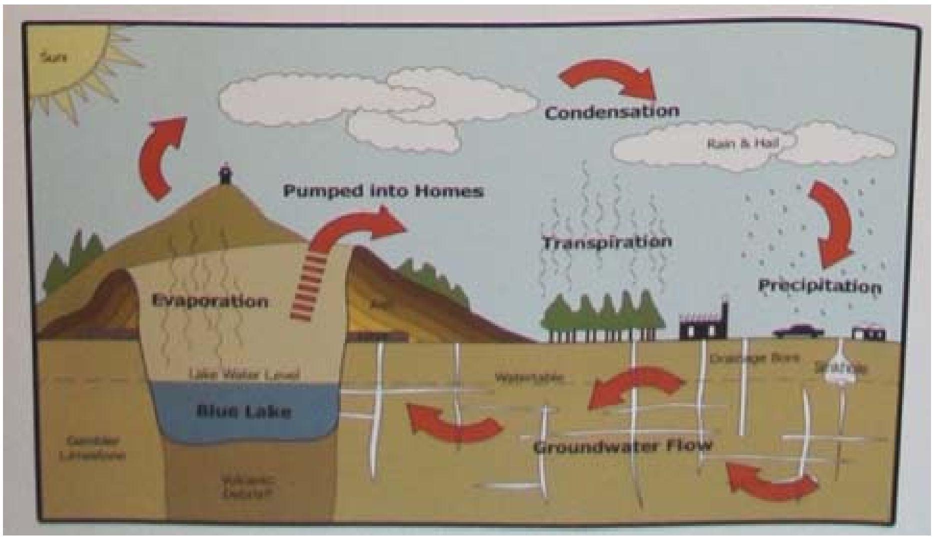


圖 2. 藍湖水文循環包含地下水流補注、降雨、蒸發與湖水儲蓄等。

藍湖火口湖的特色爲一石灰岩所形成的克斯特地形，地下水流扮演重要的角色，藍湖地下集水區的水，主要來自二區地下水的流動：第一區稱爲集水區(The capture zone)，大約分佈在湖的北方延伸 19 公里的範圍，第二區稱爲保護區(The protection zone)約位於湖的南方約 7 公里的範圍（如圖 3）。地下水經過石灰岩層多孔隙過濾水流，再流入藍湖儲存，水質清澈，也由於水質的潔淨，有機質與泥沙的含量也遠低於一般內陸湖泊。

圖 3. 藍湖地下集水區水流補注圖

藍湖有隨季節變換顏色的特性，因此每年吸引許多觀光客的造訪。澳大利亞海洋地質系教授克里斯馮德博奇從 75 米深的湖底面泥沙分析，發現它幾乎完全由碳酸鈣或石灰石晶體組成，由於地表水進入湖週圍的多孔岩石向海的方向流，它是超飽和碳酸鈣，在夏天呈現耀眼的藍色，主要由於夏天湖水較溫暖，溶解出更多石灰岩，石灰岩中的方解石結晶(Calcite crystals)會與水中腐植質相鍵結並沉入湖底，清澈的水質容易吸收光譜中較靠近紅色的區段，而反射更多的藍光，形成湛藍的湖面。反之，在冬季由於腐植質與藻類在湖面生長，影響光線的散射形成灰色的水體。

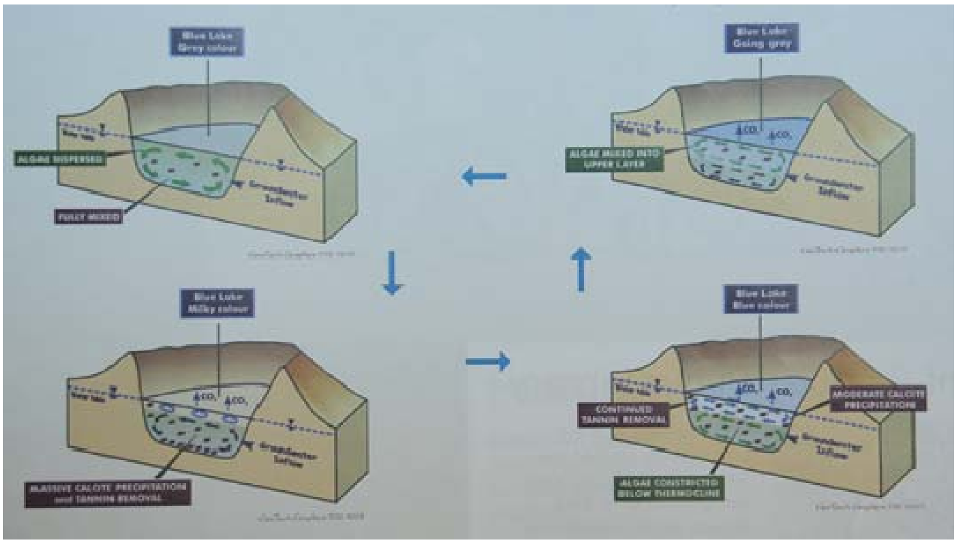
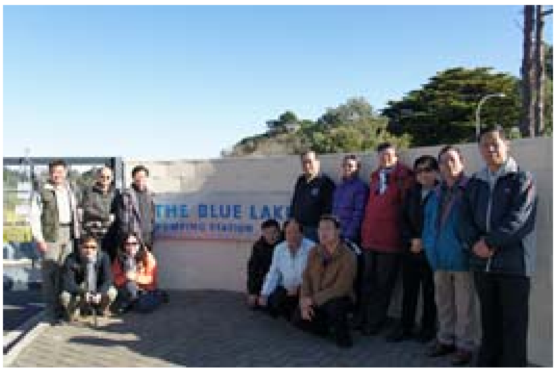


圖 4. 藍湖湖水四季變動情形，左上、左下、右下至右上依序爲冬季、春季、夏季以及秋季

藍湖抽水站全景，包含控制中心（上方房舍）與抽水機組

藍湖抽水站三座抽水機組



藍湖火口湖抽水站前合影

抽水站內保存良好的傳統指針記錄紙式類比流量計

圖 5. 藍湖火口湖抽水站技術參訪

南澳水務局(SA Water)定期對藍湖何其附近峽谷湖(Vally Lake)的水位座高程基準測量以及交叉對比藍湖抽水站的抽水量和使用量發現：近 50 年的抽水量已經導致藍湖水位明顯下降。從 1950 年的平均水平面 16.4 公尺下降至 2010 年的 11.4 公尺，下降比例達 30%，此意味地下水資源的減少(如圖 6)

圖 6 藍湖年平均水位及抽水量

為此，南澳水務局已經開始著手實施藍湖保護計畫，並重新制定工業污染源和化學用品使用及回收的規範，並規定要依照環保會的標準避免有害物質經雨水而滲透到地下水層造成地下水污染。同時，南澳水務局也積極宣導個人保育意識，減少道路清潔用水，禁止將垃圾等有害物質傾倒近排水系統，及禁止對雨水資源造成污染等措施，期藉由廣大民眾的力量做到全民愛水、節水及護水。

(三) 阿得雷德－灌溉設施展覽會

今年度現場廠商展出的農業相關器材或設備與往年在中亞國家絕然不同，中亞國家多以工程兼具顧問公司、灌溉設施規劃、農業水資源規劃管理等方向較多，澳洲參展的廠商則以農業機械(耕耘機、挖溝機、可移動式電力設備與單給水系統)、農場規劃、量測儀器(微氣候儀、土壤濕度、水利設施水位流量觀測)與及農具設施等。因為澳洲地廣人稀，所有農業設施使用的方向與習慣當然和小規模作業的農業管理有明顯的不同。但展場中也有部分的精密設施(微氣候觀測、土壤濕度、遙測水位)值得國內具高經濟作物引進，提升灌溉管理與水資源管理的效率。

圖 7 農業灌溉設施－阿得雷德展覽會場

其次有關農業現代化管理或技術的部分，因爲跨國性的技術交流越來越爲普遍，部分東南亞國家(印尼、馬來西亞)都會擺設展場，一方面呈現他們在灌溉排水上的發展情形，另一方面也爲其顧問公司尋找跨國服務的機會。如果台灣政府部門(農業委員會或水利署)透過每年 ICID 的年會，租用一到二個展櫃也可以有效的宣傳國內灌溉排水工程、水資源規劃、農業水資源的氣候變遷對策、感潮帶的營運管理等豐碩成果，並推薦績優顧問公司和施工廠商，開設看板和整合性的文宣傳單在 ICID 年會展出，讓服務績優的顧問公司在國際舞台曝光爭取國際競標機會。

在此次研討會中參觀各大廠商參展之各項先進灌溉設備及技術，其中亦是以管路灌溉爲主要項目，不論在硬體材質或是在軟體技術應用上相對於台灣都大有成長，回顧台灣(如嘉南平原等)亦是一個缺水地區，如何將最先進之節水灌溉設備及技術應用於田間是目前一大課題，如何能降低成本及延長使用年限方能達到普遍化亦是必需突破之瓶頸。

三、參加會議及技術考察心得

本屆研討會議會議所關注的議題仍是國際水資源環境及糧食安全、氣候變遷對自然生態、農業、水資源及糧食安全等，如:「乾旱管理策略」、「缺水危機」、「永續農業之降雨管理」、「灌溉在消彌貧窮所扮演之角色」等，都是值得認真探討的。

尤其是有關「灌溉在消彌貧窮所扮演之角色」是一個特殊的議題，現今多數開發中國家經濟的最大風險，源於國民之間存在嚴重的貧富差距。農村裡生活難以為繼的貧苦農民，紛紛抱著夢想湧入城市，追尋較好的生活機會。認為都市不僅可以賺到比較多的錢，並且可能獲得醫療保健，子女受教育的機會也比較大。然而，等農民到了城市才發現，事情根本不是自己所預期的那樣。他們除了務農之外，絕大多數沒有可在都市謀生的技能，因此只能靠打工糊口，最後會流落到在都市邊陲居住，造成社會與環境問題。

會場位處的阿得雷德是一個有遠見的城市，其呈棋盤狀的城市規劃如：建築區之間有寬敞整齊的街道及公共廣場、城市周圍有綠意盎然的公園環繞、到處可見的裝置藝術、美術館、博物館等。在居民以生活品質要求觀念下，政府提供悠閒安適的生活環境空間，實值得台灣城市規劃者借鏡與省思。

本次除了既定的會議行程，還特別安排參觀阿得雷德城市及其附近地區農牧及水源設施，此地區實為缺水地區，在市區內之綠地幾乎都是以管路灌溉為主，而市區外大多為草原，以畜養綿羊、牛為主，其灌溉亦多是以節水灌溉為主，其主要經濟作物為葡萄。

1. 墨累河(Murray River)：

墨累河是澳洲大陸的第一大河，發源於新南威爾斯州東南部的派勒特山，經亞歷珊德拉湖（Lake Alexandrina）匯入大海，主要支流有大令河、拉格蘭河、馬蘭比吉河等，流域面積即達台灣面積將近 30 倍的 107 萬多平方公里。墨累河最主要流域在新南威爾斯和維多利亞兩州境內，出海口卻在南澳大利亞首府阿得雷德附近。河域有休姆湖和維多利亞湖二個大型水庫，水源供給阿得雷德全城使用。整個流域也是澳洲最重要的畜牧、農糧和水果的產地，是澳洲除了分水嶺東側之外農業最發達的地區。

2. 布羅莎峽谷(Barossa Val-ley）：

布羅莎山谷位於阿得雷德市區北方 65 公里，藍嶺山脈西側谷地的氣候和地形都適合種植釀酒葡萄，澳洲的釀酒葡萄品種不下 50 種，布羅莎最出名最古老的酒莊，已愈 150 年歷史。當地大面積種植葡萄，農民採用微型滴灌方式給水灌溉，而為保護葡萄園區不受污染，每個人還需將鞋底經過消毒才准許進入，是一特殊難得的經驗。布羅莎山谷擁有乾淨純化的水質，也是釀造葡萄酒最好的地利條件。

圖 8. 布羅莎峽谷-葡萄園種植區

3. 下沉式的天坑花園

天坑是溶解的石灰岩，頂部倒塌時創造向下，洞穴的地板表土形成「沉沒的花園」，有時也被稱為完美的環境。新的植栽為本地和外來物種的混合，包括棕櫚樹、松樹、 葉喬本、阿坎瑟斯、仙人掌、繡球花和桉樹金合歡等。

圖 9. 天坑花園一景

4. 南澳大草原區灌溉

澳洲灌溉系統包括地表徑流，微滴灌噴頭或各種形式噴灌，沿公路見到一處大草原，灌溉以大型四節輪支架噴灌，它由水源區(集水井或地下水井)壓送水管在四節輪支架上一處長約 40~50 公尺範圍內噴灌，另有微灌系統包括微型噴頭、滴灌或滴入和亞表面灌溉，非常精確的將水送到植物根部，在各種條件下，可以在各種土壤保持高價作物的灌溉，且只需要高壓供水，但安裝費較貴，但也提高水分利用效率更高的技術系統和加壓輸水。

圖 10. 南澳大草原區灌溉區

透過本次參與國際灌溉排水研討會議及澳洲水資源管理及農田水利技術發展之經驗，團員代表體驗如下：

(1) 水利事業需與社會大眾緊密結合：讓社會大眾實際體驗各項農業與水資源相關活動，希望藉由這些體驗活動，讓社會大眾更能珍惜水資源的重要與了解農業經營的現況，這種教育往下扎根的觀念，對日後農業推廣有莫大助益。

(2) 推廣生態保育與環境保護：讓民眾了解生態保育與環境保護之重要，教育社會大眾對於生態保育與環境保護之認識及關心，這種教育要由家庭、學校、社區做起，對生態保育及環境保護方能落實。

(3) 水利事業與國際接軌：各項農業與水資源措施應透過產、官、學界共同努力營造最有利及最理想之措施，使我國之水利事業及農業經營達到最有效之利用與平衡，並了解國際現況與趨勢，並與之接軌，以達成永續農業灌溉環境。

肆、建議事項

1.國際灌溉排水協會(ICID)基本上是各國自發性的技術與學術交流的場域，但在會籍檢討與各工作小組活動的過程又充滿政治性格的特質。台灣(CTCID)多年來參與 ICID 年會或區域會議，多由水利會推薦參加與部分熱心的學界教授先生與會。前者可以表現出台灣對於 ICID 會議的支持與贊助性質(註冊會費是主辦國的經費來源)，後者爲熱心教授委員投稿論文與積極參加各工作小組的討論或擔任更重要的職務。對於台灣各團員代表，宜事前宣導 ICID 的性質並賦予相當程度的任務(如參與工作小組活動、由廠商參展設施的資料收集整理等)。

2.參與工作小組會議過程中，各國委員間均交換彼此的訊息，審諸過去多年的經驗，台灣的資料都欠缺完整性。其實，國內資料尚有待系統化的整理(格式、單位、表現年度等)，並給予精準的英文化。建議透過農委會相關單位(農水處、農糧處等)提供完整資料，做成台灣地區灌溉排水現況(Irrigation and drainage fact sheet of Taiwan)單張，透過網頁與紙本提供 ICID 會員國參酌引用。

3.各參與工作小組的委員於會後可撰寫單張會議記錄(必要時中英文並呈)，內容包括(1)工作小組任務(mandate)的重點；(2)親自參與會議的會員國委員；(3)工作小組的會議結論及(4)下年度我方(台灣)可以扮演的角色與思考方向。除參與 10 個工作小組會議紀錄之外，由 CTCID 秘書處整理大會與 IEC 會議的結論，讓每年與會的記錄會更爲務實精進，將這些經驗可以傳承，不至於年年變動委員而難以務實與會。

4.有關 IEC 會議之各會員國國旗擺設問題，今年仍然發生獨缺中華民國國旗，雖經協調結果 ICID 秘書處同意將各國國旗全數撤除，合乎我方預期，但實難保證未來不再發生，是否應主動出擊，建議做法如下：

(1) 由台灣代表於 IEC 會議前先行拜會 ICID 秘書處，溝通我方可接受之做法，亦可考慮提大會列入議程討論。

(2) 於會前拜會各會員國主席或代表，說明或透過說帖，闡明我方立場與建議合適做法，請其同意配合。說帖內容基本上可自我國爲創始會員國之一，至今均按期繳費，且登記會旗爲我國國旗，復說明我國近年來在參與人數、

發表論文、參與工作會議、以及提供相關成果等之實質貢獻，故按理我方可要求擺設登記之國旗會旗等，提出我方建議做法等。說帖可請外交單位使用精確之語言文字。

參考資料

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(2)「ICID 2012 年 IEC 會議簡報」。

(3)「澳洲水資源現狀及發展報告」經濟部水利署田巧玲主任秘書。

(4)「亞洲區域工作小組會議紀錄」，康寧大學郭勝豐教授。

(5)「2012 ICID 年會出國心得」，清雲科技大學鄭昌奇教授及義守大學詹明勇教授。

(6)「田間灌溉工作小組會議紀錄」，嘉義大學陳清田教授。

(7)「灌溉、排水及防洪史工作小組會議紀錄」暨「排水工作小組會議紀錄」，農業工程研究中心譚智宏組長。

(8)「藍湖火口湖供水計畫」，農業工程研究中心譚智宏組長。

(9) 2012 年赴澳洲、阿德雷德參加「國際灌排協會第 63 屆國際執行委員會議暨第 7 屆亞洲區域研討會」出國報告，石門農田水利會呂芳堅總幹事。

(10)「2012 年 ICID 澳洲會議心得報告」，宜蘭農田水利會林寬沛機要秘書。

(11) 參加「國際灌溉排水協會第 63 屆國際執行委員會議」暨「第 7 屆亞洲區域研討會」心得報告，新竹農田水利會陳美嫦管理組長。

(12)「ICID-2012 澳洲技術參觀行程」，嘉南農田水利會蔡勝炫副管理師。

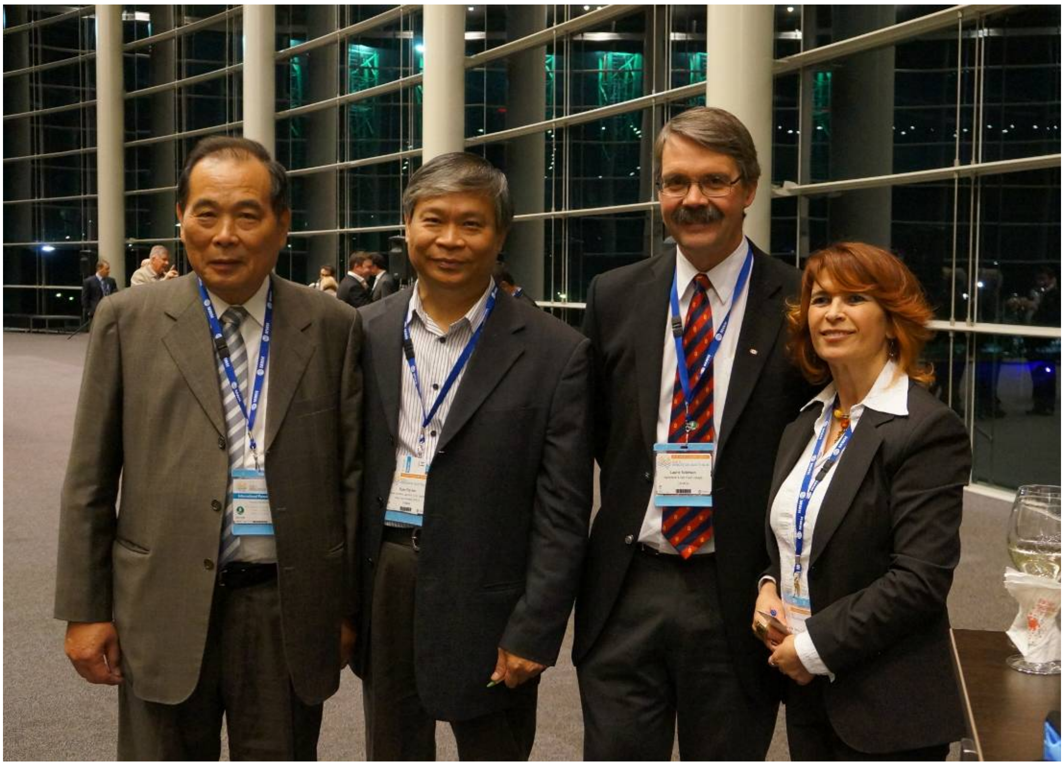
附　錄　一

參加會議活動照片

第 63 屆國際執行委員會議會場-白色圓弧頂建築

第 63 屆國際執行委員會議會場-IAL Conference Center 入口處

全體團員於伊朗德黑蘭會議中心合影

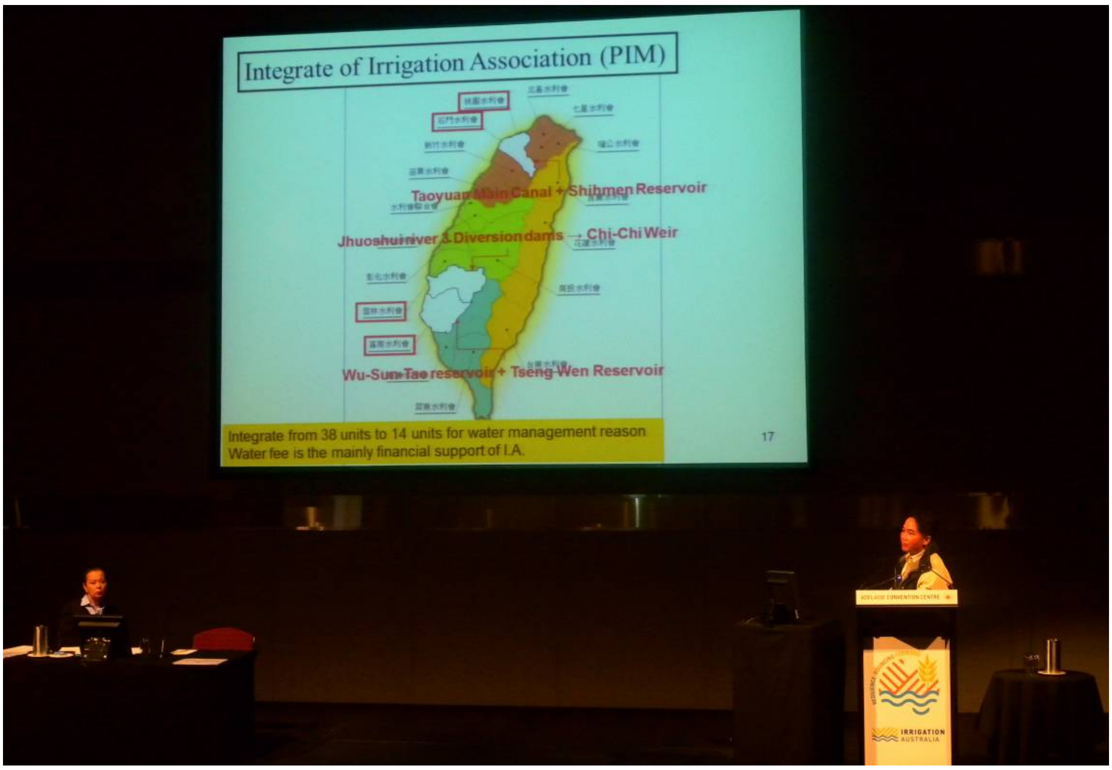


莊光明主席、高瑞棋副所長與 **ICID** 新任副主席 **Mr. Laurie C. Tollefson(**右 **2)**合影

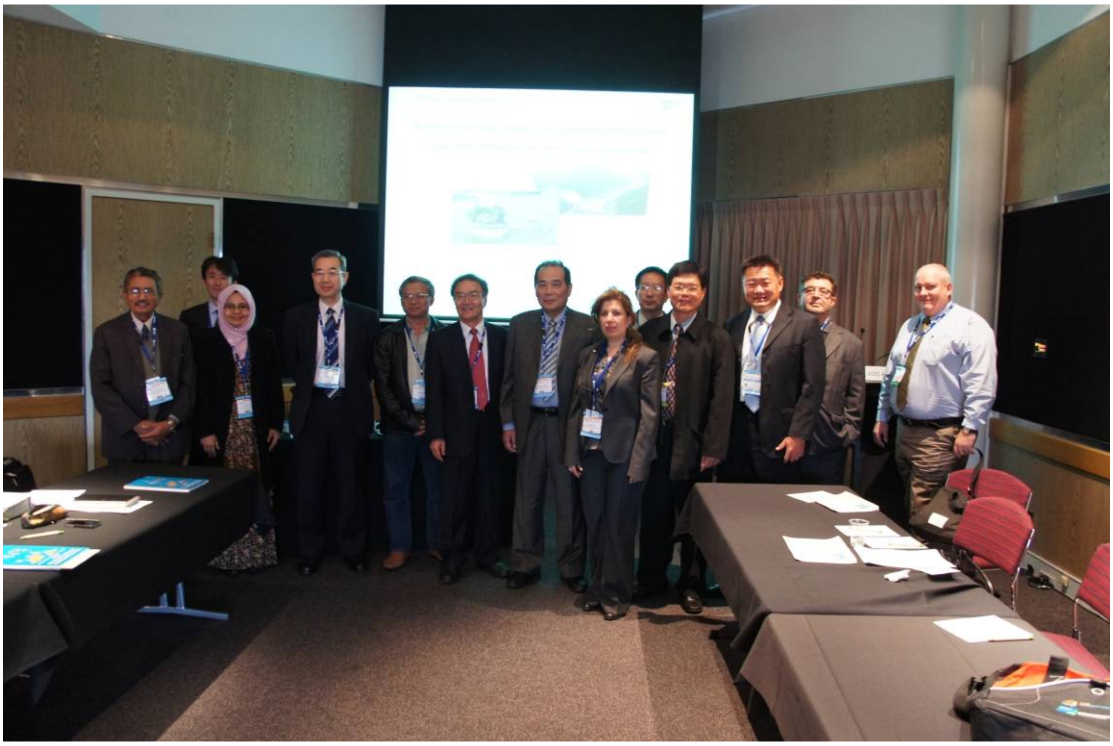
第 63 屆國際執行委員會議－出席代表莊光明主席(右 1)、吳瑞賢副秘書長(右 2)

第 63 屆國際執行委員會議－莊光明主席行使投票權選舉 ICID 副主席

第 **7** 屆亞洲區域研討會-詹明勇教授發表論文



第 **7** 屆亞洲區域研討會-張煜權教授發表論文

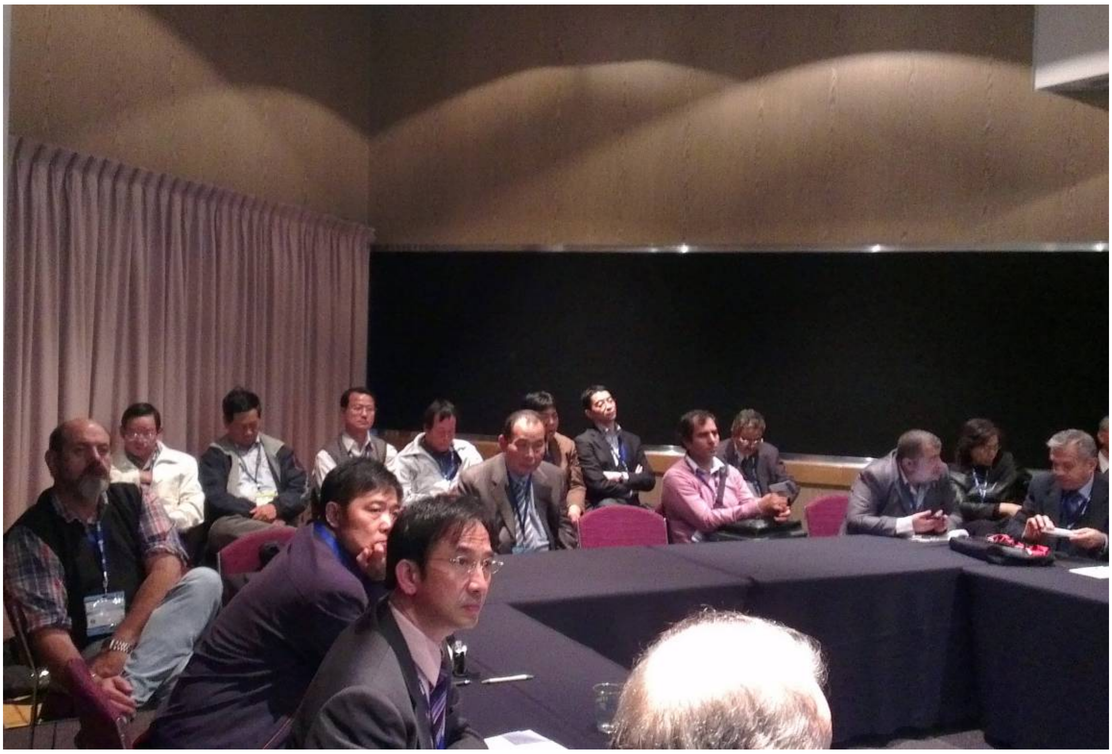


亞洲區域工作小組會議－郭勝豐委員提案例報告

全球氣候變遷與灌溉工作小組會議　－吳瑞賢委員共同主持

感潮區域永續發展工作小組－高瑞棋主任委員主持

乾旱工作小組－鄭昌奇委員專題簡報



田間工作小組－陳清田委員出席

消弭貧窮工作小組－張煜權委員出席

現代化水資源灌溉系統工作小組－詹明勇教授代理出席

灌溉史工作小組－譚智宏組長代理出席

水庫淤積工作小組－王筱雯教授代理出席

台灣代表參加韓國國家委員會之晚宴

技術參訪－藍湖

技術參訪－藍湖

附　錄　二

第 7 屆亞洲區域研討會議論文發表

台灣大型灌溉排水計畫之發展概況

History of Large Scale Irrigation and Drainage Projects in Taiwan

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Chun-E Kan, Sheng-Hsien Hsieh, Ming-Feng Yang
（張煜權、陳清田、林國華、甘俊二、謝勝賢、楊明風）

History of Large Scale Irrigation and Drainage Projects and the Growth of Regional Societies in Taiwan

Abstract: Taiwan and Japan have been facing double exposure on agriculture as developed countries in the Eastern Asia in these days. The performance of large-scale irrigation projects deeply affects the vulnerability and the adapting capacity for local food security. This paper demonstrates the development of irrigated agriculture in Taiwan, and focuses especially on the history of large scale irrigation and drainage projects, critical agricultural issues to which Taiwan has been facing, and challenging cases of cooperation between agricultural sector and industrial sector based on literature review and field survey.

Key words: Taiwan, Irrigation and Drainage, Water management, Agricultural development projects, Infrastructures

1. INTRODUCTION

The coming global food crisis is not only a result from the increasing world population, but also from the climate change and economic growth. That means the vulnerability of agriculture should be examined, the adapting capacity to climate change will decline and the competition for water, labor and land resources between sectors will become keener due to the economic globalization. In the case of irrigated agriculture, sustainable development strategies must be taken up as well as environmental changes.

The introduction of modern agricultural technologies and policies from Japan is said to have a profound impact on the modernization and development in Taiwan. Especially, the large scale irrigation and drainage projects which had been accomplished since pre-war have contributed not only to improve regional agricultural productivity but also to be the initial bases for regional socio-economic growth.

However, both Taiwan and Japan have been facing double exposure on agriculture as developed countries in the Eastern Asia in these days. The performance of large-scale irrigation project deeply affects the vulnerability and the adapting capacity for local food security.

This paper demonstrates the development of large scale irrigation and drainage projects, critical agricultural issues to which Taiwan has been facing, and challenging cases of cooperation between agricultural sector and industrial sector based on literature review and field survey.

2. IRRIGATION DEVELOPMENT

Being situated in both of the tropical and subtropical oceanic zones and also in the Asian monsoon region, and with a large ratio of mountainous lands on the island (Fig. 1), the climates in Taiwan are greatly influenced by the monsoons as well as the land forms.

The average annual rainfall in Taiwan is 2,610 mm, which far exceeds the world average of 650 mm/year. Although the amount of rainfall sounds plenty, the water resources management is tough as the annual allocated water per capita is only around 1/8 of the world average due to the uneven distribution both temporally as well as spatially. The rainfall pattern in Taiwan is mostly concentrated torrential with short duration, and the sediment yield per unit area of the rivers is about 64 times of the world average (COA, 2001). Those features induce the damage of flood and drought is very frequently in Taiwan. The development of agriculture is highly depended on the large scale irrigation and drainage projects.

Figure.1 Map of Taiwan Island

The course of irrigation development in Taiwan that has lasted for over 400 years since its inception can be divided into several stages as indicated in Fig. 2 (COA, 2009), which can be summarized below.

2.1 Free development period (before 1895)

The term of "irrigation facilities" was first introduced in Taiwan later during the Dutch colonization of Taiwan (1622 ~ 1661). During the administration period of General Zheng who recovered Taiwan Island from the Dutch hands (1662~1683), several irrigation projects had been developed including diversion works, ponds and canals for farmland irrigation to enhance agricultural produces especially rice and sugar for the purpose of politically and militarily motivated. However, because of severe financial constraint, few significant irrigation works were developed in this period.

As the immigrants from the China mainland to Taiwan increased in 1680s, the private sector began participation in development of irrigation projects, invested by either the singles or the partnerships. By the year of 1895 when the Qing Dynasty handed over the island to the Japanese Government due to loss of war, the total area of paddy fields in Taiwan exceeded about 200,000 ha, of which around 110,000 ha were irrigated by the canal water which sources included stream flows, rainwater stored in ponds and groundwater abstracted from wells. These irrigated areas were ever supplied water from several canals, which were then expanded and upgraded afterwards till nowadays and hence still exist presently. These canals are among others the Liugong Canal at Taipei area in the north, Babao Canal at Changhua area in the central and Caogong Canal at Kaohsiung area in the south of Taiwan.

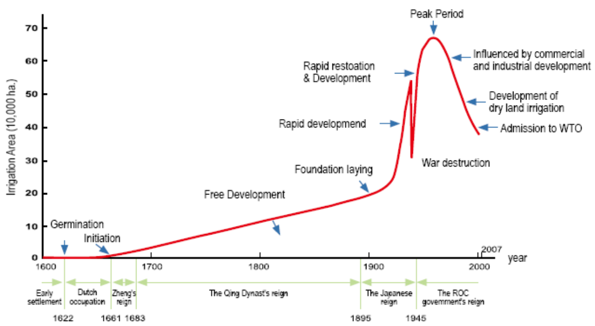

Figure 2. The irrigation development stages in Taiwan

2.2 Foundation lying period (1896 ~ 1945)

To fulfil the development goal of the policy of "Agricultural Taiwan" set forth by the Japanese Government during these years, the public funds were allocated to invest a great deal in the irrigation projects in Taiwan. As long as the colonial administration period a total of 18 reservoirs and regulating storages were constructed, of which the Sun-Moon Lake and Wusantou Reservoir were the largest which design by Japanese engineer Mr. Yoichi HATTA. These two have been among the most famous water resources works even up to date. Both of them are of the off-stream dams storing transbasin flows. The achievements in these construction works showed the practices of sophisticated and comprehensive engineering planning procedures and advanced construction techniques.

Regarding the irrigation projects newly developed by the colonial administration, those of outstanding included the irrigation systems of Liugong and Taoyuan in the north; Houli, Chizipi and Babao in the middle; Chianan, Shizitou and Caogong in the south; and Jiyeh and Beinan in the east of Taiwan. The largest two irrigation systems then were Chianan Irrigation System in Chianan plain area in the south and Taoyuan Irrigation System in the Taoyuan terrace in the north of Taiwan.

Each of the systems served over tens of thousands hectares of farmlands. Additionally, the sugar mills then constructed their own small to medium scale irrigation systems including reservoirs and ponds, by means of their own capitals to irrigate about 30,000 ha of farms at their plantations located in various districts of the island. In 1937, the paddy area in Taiwan reached around 544,000 ha, and produced rice grains of about 1.77 million m. tons, which both were the highest during the Japanese colonization era.

On the other hand, based on the fundamental survey conducted in 1934 the Japanese colonial administration of Taiwan ever formulated an island-wide farmland improvement plan in 1938, which included development of 66 irrigation projects to benefit a total agricultural area of about 506,100 ha. The plan was scheduled to firstly complete 39 significant projects within 11 years. However, due to the outbreak of the 2nd World War (WWII) in the Pacific region in early 1940s, the implementation progresses of these were very slow owing to severe lack of construction materials, machineries and labor. Eventually only three of them were duly completed.

During the colonial period Taiwan's irrigation system management of centralized approach adopted by the government attributed to the successful implementation of irrigation projects in renewal, improvement and new development. Therefore, with the strong policy support of the government, and applying the modern engineering technologies including application of reinforced concrete in design and construction of irrigation and drainage works, the irrigation project development progressed rapidly and several of large scale modern civil works were completed as mentioned previously. By the end of this era in 1945, due to the Pacific War devastation on the island of Taiwan, the irrigation area reduced to about 486,300 ha, and produced rice grains of about 0.75 million m. tons.

2.3 Mature/ Degradation period (from 1946)

At the beginning of Post-War era, in order to restore the island's staple food production to its pre-war level, the ROC Government in its great efforts of reconstruction of Taiwan's major infrastructures including irrigation facilities, during the initial stage of about 10 years following recovery of Taiwan, concentrated on among others the major repairs or rehabilitation of the existing irrigation facilities and continuation of the unfinished previous projects suspended due to war affairs. Besides, the Government also implemented in parallel with drastic land reform program based on the ″tenants-are-landowners″ policy.

From late 1950s till 1960s when the national socioeconomic situations were improved, the Government then initiated implementation of new irrigation projects such as the Douliu Irrigation System at the plain of south of the Jhuoshui River in central Taiwan, and the Shimen and Zenwen Reservoirs respectively in the northern plateau and in the southern plain. The two reservoirs aimed to stabilize the irrigation water supply to the existing Taoyuan and Chianan Irrigation Systems, respectively; and the Shimen reservoir also supplies water to the new Guangfu Irrigation System. While both reservoirs provide with water for the increasing demands of domestic and industrial uses, they also support other purposes such as power generation, flood control and tourism. These new irrigation infrastructures developed then expanded the irrigation area in Taiwan to about 490,000 ha in 1960s.

In addition, the farmland consolidation projects has been implemented by the Government to better the mostly small-sized and or irregularly shaped farm plots for raising framing efficiencies and directly drawing irrigation water from sub-tertiary or quaternary canals, as well as to drain excess water directly to tertiary drains since 1960.

The farmland consolidation was a process to consolidate the excessively small and fragment farm parcels mostly less than 1 ha each in adjacent, through exchanges of ownerships and ensuing plot-annexations; and meanwhile irrigation canals, drainage ditches and farm roads were provided altogether in the tertiary units(each size typically about 50 ha) of irrigation systems. The consolidated farm plots each thus would be able to directly draw irrigation water from the adjacent canals and discharge excess water into the bordered drains, while the farming inputs, implements, and outputs or produces would be conveniently accessible.

As new water sources for irrigation as well as other purposes have become increasingly difficult to exploitation or development in the island since 1980s due to constraints of geological and hydrological appropriateness and environmental conservation concerns, there have been little significant irrigation development projects.

To expand irrigation area with water-save methods to the upland farms for increasing local farm produces and ensuring the product quality and hence to improve the farmers' incomes from farming, since 1983 the government has been providing financial and technical assistance to the farmers who are the owners and cultivators of their upland crop farmlands. Water-save irrigation facilities have been designed and built to best suit to their farmland forms and the crops grown. The facilities included water pipes and pumps as well as appurtenant devices for sprinkling, dripping and micro irrigation systems. As of 2007, a total of 38,420 farm-holders have installed the aforementioned facilities to benefit about 29,247 ha of upland crop farms producing mainly vegetables, tea, grape, pear and tangerine, among others. The benefits achievements included more economic water uses; higher crop yields and greater net returns.

As a result of rapid industrial development and fast urbanization in Taiwan since 1970s, the arable lands including irrigation lands have been converted to non-agricultural purposed lands. Up to the year of 2007, the irrigation area of Taiwan reduced to around 422,168 ha, of which about 382,229 ha were serviced by the existing 17 irrigation associations in all. According to the inventories of the irrigation systems in the year of 2007 compiled by the Joint Irrigation Association of Taiwan, an organization with its members being all the existing irrigation associations, quantities of the main items of facilities, with an overall length of about 46,429 km of irrigation canals and 23,481 km of drainage ditches.

3. DOUBLE EXPOSURE CHALLENGE

The "double exposure" refer to the fact that regions, sectors, ecosystems and social groups will be confronted both by the impacts of climate change and by the consequences of globalization (O'Brien et al. 2004). Climate change and economic globalization, occurring simultaneously, will result in new or modified sets of winners and losers. In order to find out the vulnerability of irrigation agriculture under double exposure in Taiwan, the definition of vulnerability is discussed as a function of adaptive capacity, sensitivity, and exposure (McCarthy et al., 2001).

3.1 Adaptive capacity of climate change

Rice is the staple crop in Taiwan, and until recently, rice cultivation has been central to the agriculture economy and culture. The history of irrigation agriculture almost regards in paddy rice system. Although the irrigated paddy rice possessed a well-infrastructure base and management experience in Taiwan, but the overproduction in rice resulted in abandoned field and transferred crop after 1970s. The development of large scale irrigated project was fallen in a rut. Until 2007, the irrigation area only occupies 40% of paddy field and about 60% of paddy field is still rain-fed paddy and most of the irrigation lands are irrigated mainly under large-scale irrigation and drainage projects (TJIA 2007), where timely and equal distribution of water against the whole command area is prerequisite. Therefore, quality of irrigation and drainage facility is an important measure of relative adaptive capacity of agriculture land, and districts with better facilities are presumed to be better able to adapt to climatic stresses.

In the early stages of irrigation development in Taiwan, the related facilities were constructed by privates, as mentioned before. It was during the Japanese colonial era that its administrative authorities granted the irrigation organizations in Taiwan the status of public juridical persons so as to delegate them more authority and responsibility, and meanwhile to strengthen their organizational structures and promote their capabilities to carry out the operation and management of increasing irrigation facilities in numbers, scales and technical sophistications as well.

In Taiwan, the collection of water fees is always the major income of Irrigation Associations to provide the service. From the economic viewpoint farmers may not have any incentives to organize an irrigation association under tenant farming or poor marketing condition, so it became difficult as farmers only receive the benefit of crop yield after overproduction in paddy rice. Especially the urbanization after 1970s, the operation of Irrigation Associations in Taiwan has been challenged by the sole purpose of irrigation as the service is provided beforehand.

3.2 The sensitivity of climate change

Taiwan locate in Asia-Pacific monsoon region, the precipitation received in monsoon season is very important for farmers, and the irrigation plans are often promoted in a supply-oriented fashion. If the monsoon arrives too early, too

late or is erratic in its intensity, farmers will be adversely affected. Water scarcity becomes the main productivity constraint for Taiwan agriculture. Many case studies show that assured irrigation reduces farmers' vulnerability to low and erratic rainfall. According to the climate pattern analysis of the 40years (COA, 2008), the rainfall and the length of dry period are dramatically polarizing. Those means the cropping pattern is changing in Taiwan.
Besides, substantial siltation in Taiwanese reservoirs generally results from natural collapse and anthropogenic activities. In addition, with its steep terrain and torrential rains leading to intense transient flows, Taiwan can experience severe sediment problems. Faced with both the increasing difficulty of developing new water resources, and the potential consequence of severe water shortages, it is essential for Taiwan to prolong the utility of existing reservoirs, and to protect the quality of the water supply. On the other hand, due to the global climate warming effect, occurrences of unusual intensity storms or torrential rains have become more evident in recent years, and hence the scales of flooding of farmlands, in addition to urban areas, have become more severe.

3.3 The sensitivity of globalization on rice system

The past three decades have seen a decline in the domestic consumption of rice. Many Taiwanese rice producers have been forced into a practice of crop diversification to boost their income, and to save on the costs required to produce rice at a competitive price, and regional sufficiency or deficiency in rice production has become a serious issue. After the opening up of international markets, local rice producers are in competition with other producers on the international market, and have been required to perform cost saving measures. But it is hard for the small farm.
In 2010, the average farm size in Taiwan was 1.09 ha per household (COA, 2008). By this standard, the Taiwanese farmer would originally be categorized as a ″peasant″. In the past three decades, however, changes in the nature of ″peasants″ have been accelerated along with commercialization of rice, and through urbanization. Moreover, young adults migrate from rural to urban contributing to the rapid depopulation and ageing in rural area and leave a landscape of deserted villages and abandoned fields.
Until 2008, the harvested area occupies only about 60% of paddy field and about 40% of paddy field is abandoned. Since the abandoned fields always generate at random location, they not only result in fragment landscape but also in low water productivity. Some of irrigation water is drained directly to the downstream without use. The low irrigation water efficiency is always debate by other water sectors, and asks to transfer the irrigation water right to others. The relationship between the abandoned paddy field and the water competition resembles "a vicious circle", which accelerates the collapse of rice system and results in high rate of food imports from international markets. In 2010, Taiwan's food self-sufficiency rate is only 32%. For food security reason, it is not a good trade in long term.

4. SUSTAINABLE DEVELOPMENT

The worsening of climate change in recent years has brought the hydrological conditions into more extremes, and threatens the water sectors. Especially for irrigated agriculture, the irrigation land is always forced to conduct fallow in order to transfer the water to other sectors, which may introduce the deficit risk shift to irrigation sector and food security problem (Y.C. Chang 2007). That is, traditional irrigation practices are no longer capable for the normal operation of water resources distribution, and hence new ideas are needed.

4-1 Diversification of Irrigation Association

In addition to find the sustainable development of Irrigation Associations, the Irrigation Associations should not confine themselves on the single service of irrigation. Instead, through diversification of the businesses by making better use of the facilities, land assets, and human resources, the financial situation of the Irrigation Associations should be significantly improved. The example of Chia-Nan Irrigation Association in southern Taiwan is a successful case. Besides traditional irrigation and drainage, Chia-Nan Irrigation Association also engages in: 1.power generation by setting up a power plant, yet under the condition that water conveyance is not affected, 2. renting the canal network to other sectors for water conveyance, 3. constructing business buildings for commercial use, and 4. establishing water-friendly parks or entertainment parks beside the waterways. The management of sustainable diversification without selling properties by the Chia-Nan Irrigation Association is definitely a model example in Taiwan.

4-2 Enlargement of Irrigation Unit

The plot with the area of about 0.25 hectare has been the operation unit for water distribution in Taiwan, and the principle of rotational irrigation by distributing water to each plot stepwise is adopted (TJIA 2007). However, instead of the continuous uniform rainfall with long durations, current rainfall occurrences are mostly concentrated torrential rain. Without the regulation from reservoirs, it is difficult to maintain a constant irrigation flow.

As a result, it is suggested in this article that the "irrigation group", which is consisted by a collection of plots with the total area of 6 hectares (Fig. 3), be considered as the operation unit of irrigation. By keeping the ridges of adjacent plots in the irrigation group connected in a state of continuous irrigation, the operation cost of irrigation management will be significantly reduced.

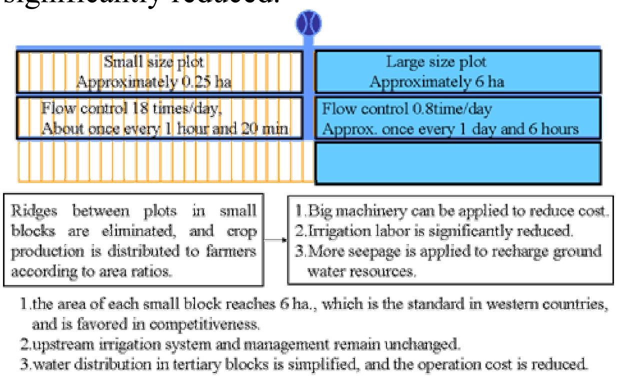

Figure 3. Water storage capacity of deep ponding water management

4-3 Deep Ponding Irrigation

The water depth in rice-paddy fields has been 60 mm. Under the concept of “paddy fields are reservoirs”, this depth is strongly suggested to be raised with many benefits. In specific, the water depth is suggested to be increased to 250 mm by raising the ridges, and the irrigation practice is regarded as deep-ponding (Fig. 4) (Y.C. Chang *et. al.*, 2007). With the deep-ponding, the ability to withstand water-shortage is increased more than four times as compared with the conventional irrigation.

In addition, when the idea of deep-ponding is associated with the augmentation of irrigation units, then under the safety range of tolerable flooding, these irrigation units also provide a storage space for the excessive runoff, especially when it is brought in by the concentrated torrential rain. That is, if the ridges were to be raised so that water depth was increased from 60 mm to 250 mm, an equivalent space of 190 mm is ready for water storage.

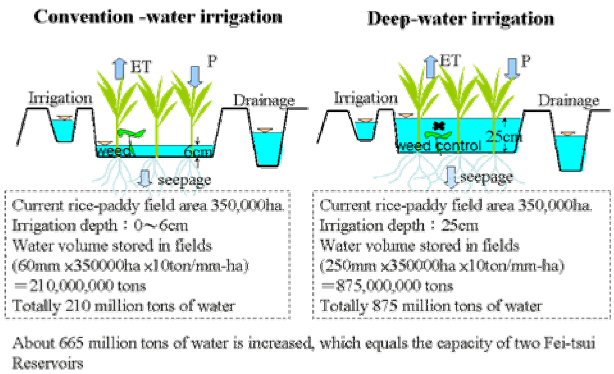

Figure 4. Deep-ponding water management

4-4 System of Rice Intensification (SRI)

In order to meet the growing demand of food, the idea of breeding new species of rice with super-high yield has been started since late 1980’s in many countries of the world. According to the studies in Japan, it was found that high productivity could be achieved by associating species improvement with deep-ponding irrigation management. And a methodology for increasing the productivity of irrigated rice by changing the management of plants, soil, water and nutrients, known as the System of Rice Intensification (SRI), was proposed later in 1983 by Henride Laulanie, based on his experiences in Madagascar. The experimental records of SRI from 36 locations of the world indicate that when compared with conventional irrigation, the application of SRI may result in advantages such as more

productivity, less irrigation water consumption, lower production cost, less fertilizers, and better root growth, etc.,. However, a great deal of labor is needed for running SRI in terms of transplanting, weeding, and water management.
In fact, the practice of SRI is very similar to the field management of Taiwan in the 1970's. Major activities in Taiwan included reducing rice planting density, alternate irrigation between wet and dry conditions, weeding by plowing, and increasing soil aerations, etc. A study was conducted in the years from 2009 to 2011 regarding the comparison of dense cultivation with deep-ponding and SRI. And the preliminary conclusion was that both techniques were helpful to the increase of rice production, but different in the process. The dense cultivation with deep-ponding has the function of flood detention, and is suitable for larger irrigation scale. SRI, instead, is applied by using the capability of drought endurance, and is suitable for small farm holders.

4-5 Reuse of the Return Flow
Taiwan has transformed from agricultural society into a hi-tech along with diversified agriculture in recent years, and the demand for industry water resources has dramatically increased up to 10% of the total developed water resources. Hence, return flow has been considered as one of the water resources for local industrials.
Agriculture in Taiwan accounts for 70% of the total water resources with 12.24 billion tons, and irrigation for rice paddy takes 10.55 billion tons. However, the actual amount of evapotranspiration is under 50% (Y.C. Chang et.al., 2001). Most irrigated water becomes return flow in the form of surface runoff or subsurface percolation, and is often reused downstream as one major source of irrigation water. As a result, how to make better use of the return flow has become a challenge for the water resources engineers in Taiwan (Y.C. Chang et.al., 2010).

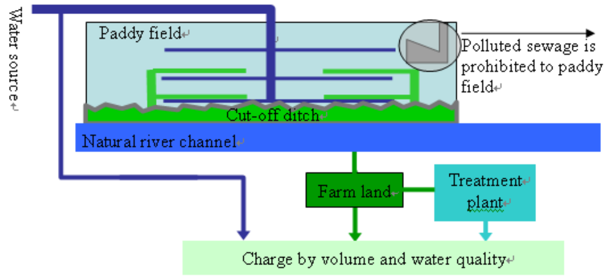

Figure 5. Return flow recovery system

4-6 Forestation in Coastal Sandy Soils
In paddy fields, there is significant amount of horizontal percolation moving downward, meanwhile, there are sandy soils in the north-western coastal area. By making use of the sludge from reservoir sedimentation, if a shallow cut-off wall is to be installed along the coasts in an attempt to intercept as well as retain the horizontal percolation from upstream, then the planting of crops or trees would be possible. A series of experiments concerning forestation along the coast have been conducted in MialLi, and the result was quite successful and promising.

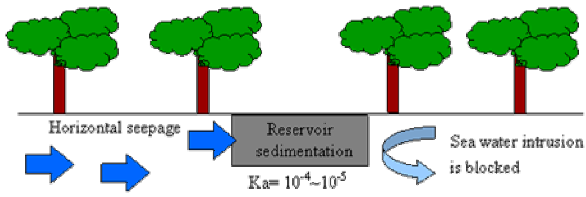

Figure 6. Cut-off wall in Non-irrigated Area

5. CONCLUSIONS
The process of people struggle with water and food could be taken as the epitome of the human history. During those years of adapting clime change, we experience the nature that seems to be readable but hard to be predictable. The study is not going to present an innovation of water management, but try to find water-wise strategies through the review of the irrigation agriculture in Taiwan which is affected by China, Dutch, Japan and USA in her long term development. As a result of this study, following findings are concluded. 1) Modern technologies have been introduced to Taiwan by many Japanese engineers under huge capital investments from Japan, and many of those technologies and infrastructures have been still used effectively. 2) Some of irrigation water and return water are used as industrial

water. 3) Taiwan agriculture has been claimed to considerably reform itself since Taiwan was admitted to WTO. In addition to these, some of problems are clarified, such that the irrigation area decreases annually result in the food policy, and the irrigation water has been polluted during urbanization.

During the past 400 years, irrigated paddy always plays an important role in the area, as the cultivation reserve the water cycle environment by managing floods in occasion of storm rainfall, recharging ground water, and keeping water in farmlands. It is critical to find a wise balance between food crisis and rural urbanization in the region.

ACKNOWLEDGE

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附　錄　三

第 7 屆亞洲區域研討會議論文發表

嘉南灌溉系統模式之更新改善

Experiences on innovative irrigation facilities

- remodelling Chia-nan irrigation system at southern Taiwan

Ming-Feng Yang, Ming-Young Jan,

Chang-Chi Cheng, Sheng-Hsien Hsieh

（楊明風、詹明勇、鄭昌奇、謝勝賢）

Experiences on innovative irrigation facilities - remodelling Chia-nan irrigation system at southern Taiwan

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Summary

Chia-nan irrigation association (CNIA) faces the shortage of water supplying for current irrigation area due to climate change and increasing water demand by domestic or industrial sectors. This paper explains the experiences of CNIA that remodelled the water supplying scheduling and carried out some innovative water allocation modules to ease the problem of water shortage with less financial input and maximize the irrigated paddy area.

Story behind

In 1965, the Taiwan government promulgated the General Rules Governing the Organization of Irrigation Associations as the guiding principle for the organization, operation and management, and supervision of irrigation associations at the central government level. Irrigation Associations have then undergone a series of consolidation and re-organization into 17 Irrigation Associations, of which 15 are scattered around the Province of Taiwan and two in the city of Taipei. Due to socio-economic change, the General Rules that promulgated in 1965 was revised in 1993 for the purpose of promoting irrigation efficiency and improving farmer service. The chairman was government appointee. However, this General Rules was revised again by the congress in 2001, with both chairman and association committees been elected by the members.

Chia-nan irrigation system is the largest irrigation association with 71km width and 86 km long system that covers a total irrigated area about 75,000 hectares. The main crops are rice, sugar cane, beans, peanuts and corns. There are some cropping patterns for irrigation at CNIA such as the upland cropping area, single rice cropping, double rice cropping, rotational cropping area and other cropping combinations (Fig. 1). The drought event occurs frequently since the first severe water shortage came at mid 1980. Uneven rainfall distribution makes the operation experience of water supplying became invalid. CNIA has to take new challenge to solve the problem of valid water supply for its members (farmer) and also save more water for others purposes use.

Problem

Besides the water required from farmers or irrigated area, CNIA is expected to share more water for newly developed scientific and industrial base near Tainan. Due to limited available rainfall and water supplying systems, agricultural sector from central government pushes CNIA to a stage to change the existed water supplying management rules. Activation of the hydraulic facilities is the other alternative to be adopted to meet the water problems.

Water supply and demand

Based on the registered water right, CNIA can take 9000 million cubic meters water from stream or reservoirs, but the actual water taken was 6300 million cubic meters at 2009. Only

70% of scheduled water can be used for the irrigated area, some of the projected area must be assigned as fallow or set aside. While the decrease allocated water for irrigation, domestic and industrial sectors take almost 3000 million cubic meters of water. This is a lowest record of water allocation ratio for agricultural use and highest value for domestic use. CNIA needs more water management skill through innovative concepts and facilities activation.

Result and Discussion

CNIA studied the paddy irrigation habits from farmers and introduced the "shifted program" to low down water supplying peak. Shifted program can ease the high required water flow rate at the same time and the leakage through canal is decreased due to lower water depth. At the first rice season (from spring to summer), CNIA save more than 40 million cubic meters of water without any fallow block. Saved water offers domestic usage and make more money for CNIA. At the second stage of rice season (from summer to autumn), CNIA enhances more paddy management and sets aside few paddy blocks to save 18 million cubic meters of water for industrial use. Details of shifted program and rotated management will be presented at the full paper.

Irrigation facilities activation is the second step to manipulate the water allocation. Tseng-Wen reservoir and Pai-Ho reservoir are the main storage system for CNIA. Tseng-wen was suffered more than 1000 million of debris during Morakot typhoon at 2009. Pai-ho was deposited almost to the state of malfunction. CNIA intends to active Pai-ho at first, dredging and sand flushing will be considered to move out the deposited sands within reservoir. More than the reservoir activation, CNIA invested a pump system through main channel to Pai-ho that offers 0.1 million cubic meters of water per day for over-basin irrigation. Full paper will draw the detail of the over-basin irrigation system operation.

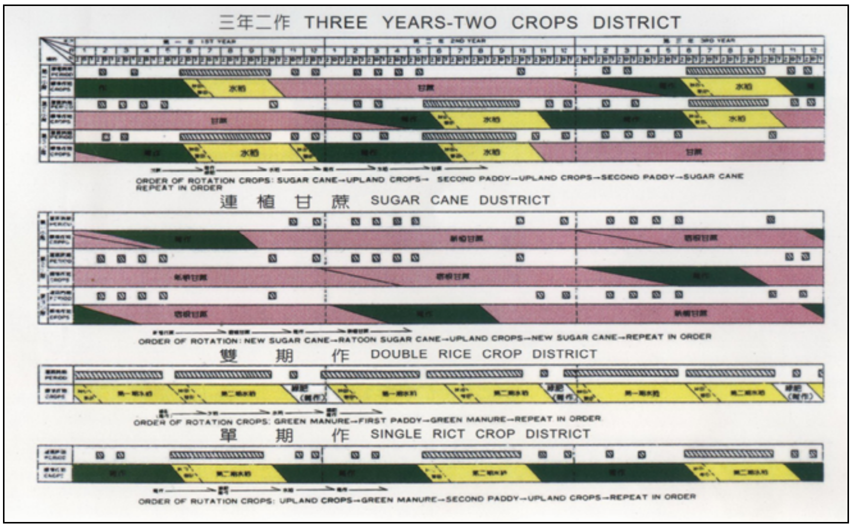

Figure 1 Typical cropping pattern at CNIA

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