出國報告（出國類別：出席國際會議）

赴泰國參加
水田與水環境 2012 國際研討會
Paddy and Water Environment Engineering 2012 International

服務機關：經濟部水利署
姓名職稱：楊署長偉甫、簡副組長俊傑等
派赴國家：泰國
出國期間：中華民國 101 年 11 月 26 日至 11 月 30 日
報告日期：中華民國 102 年 2 月 26 日

摘 要

國際水田與水環境學會 (簡稱 PAWEES) 2012 國際研討會於 11 月 27 日至 29 日假泰國曼谷皇家灌溉部〈Royal Irrigation Department〉舉行，本次研討會主題為「在亞洲季風水與環境管理之挑戰〈Challenges of water & environmental management in monsoon Asia〉」，議程共包括四項議題：「氣候變遷與不確定性」、「灌溉計畫之參與管理」、「水資源管理新技術」及「水田灌溉排水之環境永續」。四項議題都是現今對於水田與水環境發展或管理十分重要，各領域之專家學者齊聚於此研討會場所，進行全方位之科學研討及學術、經驗交流，以促進國際科學技術之發展。此外，此次年會亦舉行對水田與水環境具重大貢獻者及評論人之頒獎典禮、PAWEES 未來方向與合作提案等會議，並針對去〈2011〉年水患概況，安排之實地技術考察活動。此次研討會包含水利署楊署長偉甫及台灣大學生物環境系統工程學系張教授斐章之專題演講，及７０餘篇研究發表，相當多專家學者與會分享研究成果，及進行熱烈討論。

目 錄

壹、目的

國際水田與水環境學會（International Paddy and Water Environment Engineering 簡稱 PAWEES）是由日本農業土木學會、南韓農業工程學會及台灣農業工程學會所組成之國際性學術組織，透過定期舉辦學術研討會及共同發行期刊，提供日本、南韓、台灣及亞洲其他國家與農田水利、農業環境、水資源等相關領域之政府部門、專家學者研究成果之發表平台與經驗分享。

經濟部水利署為我國水利主管機關，肩負政策研擬、建設執行、水資源統籌調配等主要任務。基於積極參與相關國際活動，汲取日本、南韓等國家有關農田水利及水資源等前瞻性思維、先進技術與維護管理經驗，並建立更活絡之溝通管道，乃由社團法人台灣農業工程學會邀請經濟部水利署、行政院農業委員會、台灣大學生物環境系統工程學系及財團法人農業工程研究中心等相關單位共同派員組團參加國際水田與水環境學會所舉辦之 2012 PAWEES 年會暨研討會，並由水利署楊署長（兼台灣農業工程學會理事長）擔任團長。

貳、過程

一、考察團員

序號	姓 名	機關名稱 /職稱
1	楊偉甫	經濟部水利署署長（兼台灣農業工程學會理事長）
2	簡俊傑	經濟部水利署副組長
3	洪銘德	行政院農委會農田水利處技正
4	張斐章	台灣大學生物環境系統工程學系教授
5	鄭克聲	台灣大學生物環境系統工程學系教授
6	余化龍	台灣大學生物環境系統工程學系教授
7	胡明哲	台灣大學生物環境系統工程學系教授
8	陳品安	台灣大學生物環境系統工程學系博士班研究生
9	蔡宇軒	台灣大學生物環境系統工程學系碩士班研究生
10	譚智宏	財團法人農業工程研究中心組長

二、會議行程表

(一) 出國時間自 101 年 11 月 26 日至 11 月 30 日。

(二) 會議時間自 101 年 11 月 27 日至 11 月 29 日，行程如下：

日期（星期）	行程內容	地點
11 月 26 日（一）	● 去程一桃園至曼谷	曼谷 (Pakkred)
11 月 27 日（二）	● 國際研討會	曼谷 (Pakkred)
11 月 28 日（三）	● 國際研討會暨年會	曼谷 (Pakkred)
11 月 29 日（四）	● 技術參訪	Saraburi 省
11 月 30 日（五）	● 返程一曼谷至桃園	

三、參加會議議程

日期 (星期)	時間	大會議程	備註
11/27 (二)	08:30-09:00	註冊	
	09:00-11:50	開幕及專題演講	楊署長偉甫及張教授斐章報告
	13:00-18:00	分組研討	鄭教授克聲及張教授斐章報告
11/28 (三)	09:00-11:00	分組研討	陳研究生品安報告
	11:00-12:00	頒獎	
	13:15~15:15	年會分組報告	
	16:00-17:30	泰國宣言及閉幕	
11/29 (四)	08:30-16:30	技術參訪	Bang Pa-In 工業區防洪計畫及 Rengrang 操作維護計畫現勘

參、心得

一、參加會議

(一) 本次國際研討會開幕首先由主辦單位之一泰國 Chulalongkorn University〈簡稱 CU〉工學院院長就主辦本次研討會之目的及相關內容作一簡要說明，接著由 CU 校長 Dr.pirom Kamol-ratanakul 及另一共同主辦單位泰國 Kasetsart University 副校長 Dr.Siree Chaiseri 與 PAWEES 輪值主席韓國 Dr.Tai-cheol Kim 致詞。

(二)研討會主辦單位特別邀請泰國皇家灌溉局局長 Mr.Lertviroj Kowattana 就「泰國洪水管理」作專題演講，提及泰國平均每年有 3.05 場暴雨，尤其集中於 9 至 11 月。2012 年 10 月水患重創泰國經濟甚鉅後，重新思考洪水治理策略，包含洪水滯留、疏導、保護經濟重點區域等，並輔以水庫管理、預警系統、河道疏濬、設施結構補強等工程及非工程措施。

(三)研討會主辦單位亦邀請日本 Mr.Hiroyuki Koruma 先生(FAO 聯合國糧食暨農業組織助理署長)就「全球及區域性糧食安全—須特別關注稻米水與環境」提出報告。他指出開發中國家普遍營養不足，亞洲及太平洋國家普遍營養不足人數中，百分之 88%只分布在 6 個國家，其中巴基斯坦占 35.7%、孟加拉 25.5%。雖然在 1990 年到 2009 年，亞洲貧窮人數與全球人口比(每天仰賴 1.25 美金以下生存者)從 50%降到 22% ，但開發中國家最弱與中收入國家已觀察到惡化之收入兩極化及不平等，尤其食物價格高漲及波動性影響，貧窮之消費者需付 70-80%收入來支付食物費用。資料顯示目前看來不會有糧食危機，但他也提出警告至 2050 年當穀物需求多 10 億噸(成長 45%)、肉類需求多 196 百萬噸(成長 76%)等之

情況下，我們卻受限於可耕地面積擴張停滯及水資源稀少性增加，且近數十年來過少農業投資導致生產力成長下降及其他不確定性包括原油價格、食物價格、氣候變遷之負面影響和自然災害，我們能否生產足夠食物來滿足未來持續成長人口之需求？FAO 目前提出一些解決方案，包含強化農業更高之生產力和降低使用有害農業化學、跨流域和區域自然資源管理、大量投入可增加生產力之農業研究並投資必要之基礎設施等。

(四)本次研討會有四大議題，包含「氣候變遷與不確定性」、「灌溉計畫之參與管理」、「水資源管理新技術」與「水田灌溉排水之環境永續」，「水資源管理新技術」由水利署楊署長偉甫主講「台灣水資源之挑戰與因應」。楊署長首先說明台灣由於先天條件不佳，河川地形地勢險峻，3/4 以上雨量直接入海或蒸發損失，地質條件不佳沖蝕量大，可建壩之地點與庫容均受限；且降雨量時空分布不均，豐枯水年差異大於 2000 毫米，每人每年分配水量僅 3916 立方公尺，不及世界平均值 1/5。尤其近年來大雨次數越來越多，日雨量大/等於 200 毫米以上自 2000~2010 年平均高達 200 次（1980~1989 年平均 115 次、1990~1999 年平均 118 次）。復以人為破壞水土保持、人為水質汙染、地下水嚴重超抽導致地層下陷、國土利用欠缺整體規劃、蓄水容量不足等後天條件影響，造成台灣特殊之水環境。為因應社經發展及氣候變遷，楊署長指出政府將以「追求水資源永續利用」、「提供安全之基礎用水」與「建立政府民間溝通平台」，為台灣水資源之三大施政目標；並以「建立水源以供定需機制」、「極端異常氣候因應調適」、「落實推動三全節水運動」、「提升既有水利設施效能」、「推動多元化水資源開發」、「適時合理調整水價」、「建立政府民間溝通平台」為推動策

略。最後楊署長強調“水”是有限資源，非取之不盡、用之不竭，因此天然水資源必須總量管制；尤其氣候變遷與水庫淤積均將影響未來地面水可供水潛能。如未能事先調整用水需求，將迫使農業部門增加抽取地下水，並使地層下陷情勢擴大。故調整農產業結構與推動節水措施為必須積極研究與推動之工作。期待未來能與各國專家共同攜手合作，提昇灌溉水質與水量管理技術，期能透過安全穩定之灌溉水源，確保糧食安全、水資源保育與國土保安。

（五）水資源管理新技術另由台灣大學生物系統工程學系張教授斐章主講「濁水溪水系地面水與地下水交互變動機制之研究」。張教授指出，台灣由於地下水成本低廉且具有穩定出水量及良好水質，在現今台灣成為枯水期或缺乏儲水設施地區之重要水源；惟因過度抽取地下水而引發劇烈地下水位下降及嚴重地層下陷，導致海水倒灌與土地鹽鹼化之災害發生，並伴隨環境及經濟上之損失。以台灣濁水溪流域上游山區為研究案例，透過建立地下水位變動量推估模式，來探討山區地下水補注及交互機制，以達到有效運用水資源管理之策略。透過地下水位變動量進行雨量及流量相關性分析，來確認受雨量及流量之地下水補注因素，且訂定地下水位變動量推估之有效降雨量門檻值。研究結果顯示當日地下水位變動量與前一日雨量和當日流量相關性最高，表示藉由訂定有效雨量之門檻值及各監測井之地下水位變動趨勢，所建構之類

神經網路可良好推估當日地下水位變動量。

（六）在氣候變遷與不確定性之分組研討中，台灣大學生物環境系統工程學系鄭教授克聲發表「以序率暴雨模擬處理氣候變遷之不確定性」。鄭教授指出，不管規模大小，全球暖化對氣候及天氣有深遠之影響・為了處理如此之改變，目前正尋找調適策略；惟規劃調適策略需改進觀念及氣候變遷不確定性之量化分析，因此研究中用 MRI 高解析輸出評估氣候變遷對台灣暴雨特性之影響・也對不同暴雨特性變化做量化分析・建立能考慮實際暴雨特性之序率暴雨模型(SSRSM)・SSRSM 由暴雨發生率模擬、延時與整場事件降雨量聯合模擬和雨量分布圖模擬等三個要素組成・如設定好預測期間裡之暴雨代表特性，SSRSM 可產生大量之模擬輸出，每一個輸出產生年時雨量序列・從 SSRSM 之產出，用頻率分析可得到一系列設計延時之最大年雨量及各種重現期與延時之設計暴雨深度，並成功應用在台灣許多區域・

另於水田灌溉排水之環境永續分組研討中，台灣大學生物環境系統工程學系陳品安博士生亦發表「運用 NARX 類神經網路推估河川流域之區域總磷濃度」。由於磷為動植物必需的礦物質營養素，惟過高濃度脂磷會導致河川優養化，造成水質惡化。河川水質常以總磷(total phosphate)之含量做為評估指標，其組成物包含正

磷酸鹽、縮合磷酸鹽及有機磷酸鹽。如有效推估總磷含量，對於河川水質研究將有很大助益。陳博士生指出，由於新北市、桃園縣都市迅速發展，導致大量污染物流入大漢溪，造成河川水質急速惡化。故其以位於石門水庫下游之大漢溪做為研究區域，並以動態類神經網路 NARX(Nonlinear AutoRegressive with eXogenous input) network 建置總磷推估模式及資料補遺，配合交叉驗證、Gamma Test 和 Bayesian regularization method，找出顯著因子與較佳之模式架構。研究結果顯示 NARX 能準確推估區域之總磷濃度且有效補遺缺失之資料，並可對於河川水資源問題之決策及管理提供有效資訊及參考依據。

（七）PAWEES 2012 國際水田及水環境學會年會今年亦頒發國際水田與水環境學會之國際獎項，台灣方面有楊署長偉甫、臺灣大學生物環境系統工程學系余教授化龍獲頒最佳評論人獎項，感謝對於國際水田及水環境學會之貢獻。

（八）大會會後依往例發表 PAWEES 2012 泰國宣言(THAILAND STATEMENTS)，作為未來 PAWEES 成員國共同努力方向。

1. PAWEES國際期刊（PWE）在農業科學、工程及環境科學裡享有盛名．從2003年初刊以來，PWE已出版超過400篇文章．從2009年 12月就被登記於SCIE理工類期刊，2011 12月發布衡

擊要素(impact factor)達0.99·

2. 因PWE受到國際認同，期刊內容顯著增加·PAWEES同意持續支持PWE之出版及品質維護·PAWEES彼此了解為滿足工作量增加而強化PAWEES管理能力和編輯能力之必要性·
3. PAWEES之各項活動，包含PWE之編輯委員會將擴展與稻田農作地區或國家的合作關係，並持續努力處理各項水稻田和水環境領域相關課題·
4. PAWEES會員已討論學生及教授於亞洲國家之交換方案，也包含與其會員國合作研究計畫·PAWEES同意成立一個工作小組來討論，期待更具體、更實質的內涵，能在下次年會討論。
5. PAWEES 2013國際研討會將在南韓國舉行·這次研討會仍討論水田和水環境相關之議題，具體會議主題稍後發布·PAWEES希望在2013年可提供一個參與者間提升知識及經驗交換之機會·

二、技術考察

(一) Bang Pa-in 工業區防洪計畫

1. 背景說明

Bang Pa-in 工業區位於曼谷北方 Chao Phraya 河集水區內，2011 年 6 至 10 月間計有 5 次颱風侵襲。泰國年降雨量高達 1286 毫米(過去 30 年年平均雨量 976 毫米)，尤其 10 月 1 日及 10 月 5 日兩次颱風造成曼谷地區嚴重水患。

在 Chao Phraya 河低窪地區造成淹水過去並不常見，惟由於經濟發展，在洪水平原開發逐漸增加但卻未有充份保護及缺少風險意識，高洪水位越堤致使許多堤防潰決造成重大損失。

2. 工業區防洪工程規劃

泰國政府為保護工業區免於水患，初步就考慮氣候變遷及不考慮氣候變遷下模擬 100 年重現期河川最高水位分別為標高 4.89 公尺及 4.45 公尺，1000 年重現期河川最高水位分別為標高 5.82 公尺及 5.53 公尺因此設計堤防高度為標高 6 公尺。另考量工業區內空間大小及工程費用，於周圍堤防上設計 I 型及 T 型兩種防洪牆，廠區出入口處於颱洪期則採人工架設檔板(10 人操作 30 分內可完成)。該工程正施工中，預計 2012 年年底完工後，交由泰國最大之顧問公司負責維護管理

（二）Rengrang 操作維護計畫

該計畫係屬泰國皇家灌溉局所監管 10 項操作維護計畫之一，主要任務為提供農業用水、市政用水及灌溉轄區內水利構造物維

護。本計畫於 1952 年開始，1964 年建造完成。

三、參加會議及技術考察心得

本次研討會之議題均是目前國際所關注如水資源環境、糧食安全、氣候變遷對環境生態、農業、水資源等之影響，值得深入探討研究。台灣、日本、南韓與泰國、菲律賓、馬來西亞等國於本次研討會中，針對議題提出相關之研究報告，各研究成果內容相當豐碩，且能確實應用於實務上之問題。

例如議題一「氣候變遷與不確定性」部分，諸如土地利用改變策略之評析、農民對於灌溉計畫之調適因應、以序率暴雨模擬處理不確定性、農業用水供應能力評估、水資源政策之決策架構分析等；議題二「灌溉計畫之參與管理」部分，包含農民參與灌溉管理之評估、參與公共灌溉系統灌溉開發管理之影響、以需求導向灌溉供應下農民於水田灌溉行為調查等；議題三「水資源管理新技術」部分，諸如衛星資料應用於洪水模擬、應用衛星影像評估稻米淹沒損失、地表水及地下水間相互補助機制調查、糧食生產地自動灌溉系統開發、居民水資源意識於地區性之差異、生產生質酒精之水足跡等；議題四「水田灌溉排水之環境永續」部分，如亞洲經驗可否轉移至非洲—草擬非洲稻米生產手冊之學習教訓、以類神經網路估算河川集水區總磷濃度、水田循環灌溉下排水水質與負荷特性、水田區三種蛙類棲息潛能圖、溫室與傳統農作淺層地下水入滲汙染物負荷監測、福岡放射性銫去除之

挑戰—從農村規劃觀點等，均具有前瞻性之構思及提供解決現況問題之策略或方法。從研討會各專家學者之相互討論分享研究成果中，皆能感受到國際間各學者對4相關議題之重視。

本次大會安排參訪Bang Pa-in工業區防洪計畫及Rengrang 操作維護計畫除安排專人做詳盡之簡報、對參加人員提出之疑問耐心回答外，參訪現場亦安排專人詳細解說，參加人員均可瞭解問題發生原由及泰國當局對解決問題之想法與作為。

本次研討會無論是議程安排與技術參訪規劃、中場休息餐點及午晚餐之提供，均可感受大會之用心；對於住宿較遠之各國參加人員，還提供小巴接送服務，十分貼心，由衷感謝主辦單位與工作人員之付出與辛勞。

肆、建議事項

一、由台灣、日本及南韓所成立之國際水田與水環境學會從 2002 年在日本京都舉辦第一屆國際研討會至今已行之有年，每一屆針對與水田及水環境相關議題邀請專家學者作專題演講及研究發表，使亞洲各國對於灌溉管理、水環境維護、應用科技等之提升頗多助益。以本屆研討會觀之，日本與南韓代表團至少都有 30 人以上參加，其中亦不乏在校學生，顯見其對研討會之重視。反觀台灣代表團在報到時相形失色，主要係各單位由於近年來出國經費有限；惟考量台灣參與國際社會不易，又是本學會發起國之一，建議仍應積極參與，並廣邀農業及水利界先進、農田水利會、農田水利聯合會、顧問公司等共同參加，除可將台灣各界研究與經驗輸出，及汲取他國長處外，並可促進國際間之交流與合作。

二、國際水田與水環境學會主席係由台灣、日本及南韓三國農業工程學會理事長輪流擔任，2013 至 2014 年將輪由台灣農業工程學會楊理事長偉甫擔任。尤其 2013 年年會及國際研討會將於南韓舉行，2014 年將於台灣舉行，台灣過去雖有承辦三次經驗，建議仍應與相關單位儘早規劃，水利署及農委會亦應配合協助，做好最佳之安排與準備。

三、台灣大學生物系統工程學系張教授斐章於本次年會中曾提出建議，希望成立一研究計畫，由三個會員國共同合作，獲得極大迴響。未來研究計畫之執行，建議可由台灣農業工程學會結合台灣大學生物系統工程學系、農業工程研究中心及相關水利會共同組成研究團隊，藉由計畫之執行來加強會員國間之聯繫與交流。

附錄

附錄一　活動照片

附錄二　專題演講－台灣水資源之挑戰與因應

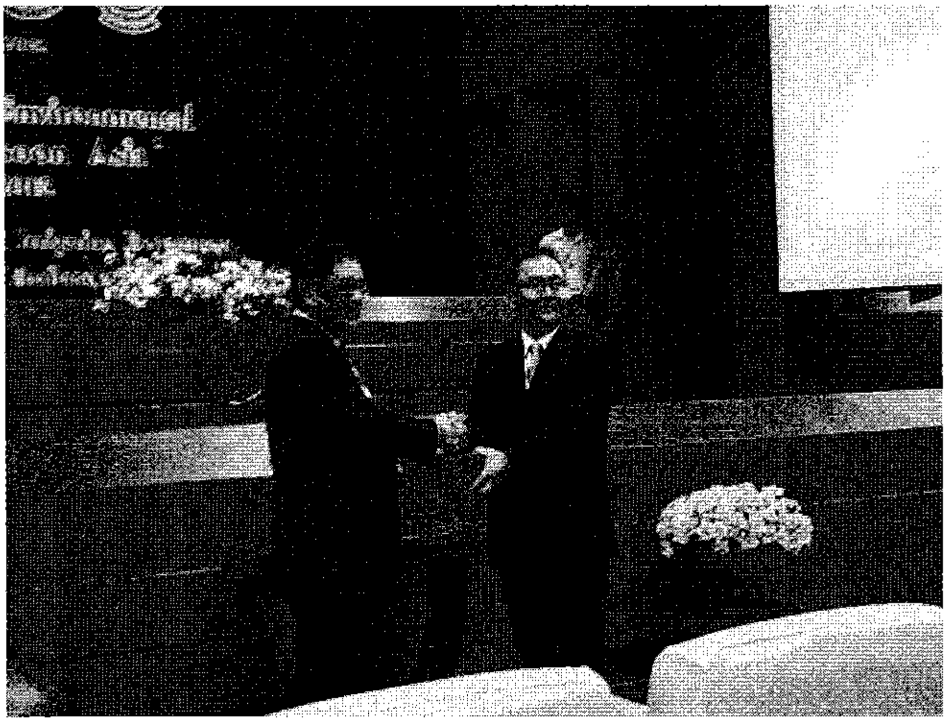
附錄三　專題演講－濁水溪水系地面水與地下水交互變動機制之研究

附錄一

照片 1 泰國皇家灌溉局國際國際會議廳報到入口處

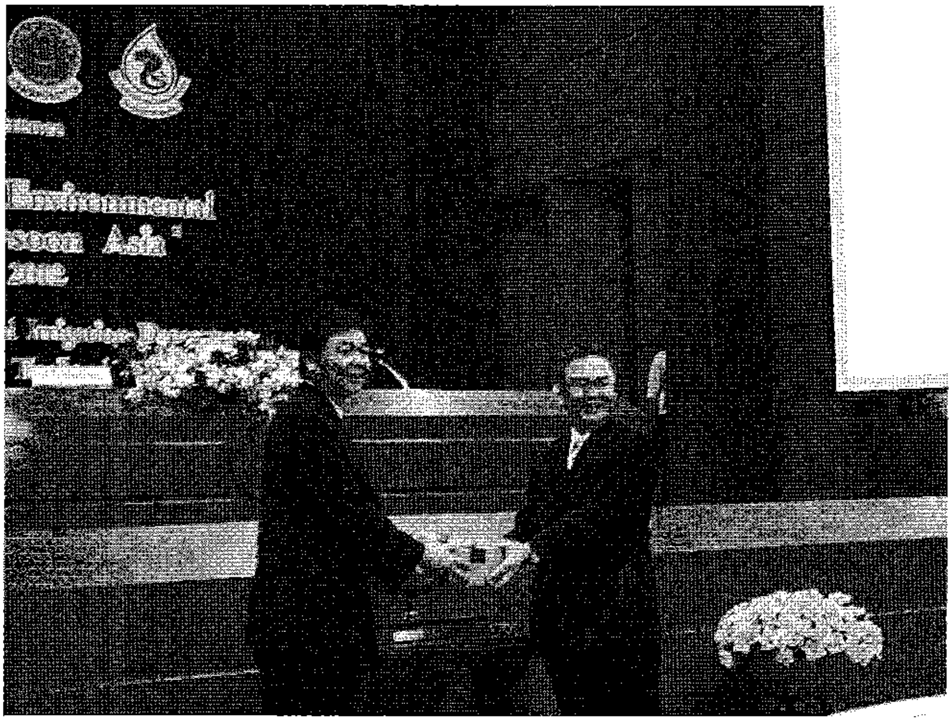
照片 2 台灣代表團於泰國皇家灌溉局國際國際會議廳前合影

照片 3 楊署長專題演講



照片 4 楊署長偉甫演講後接受大會主席頒獎

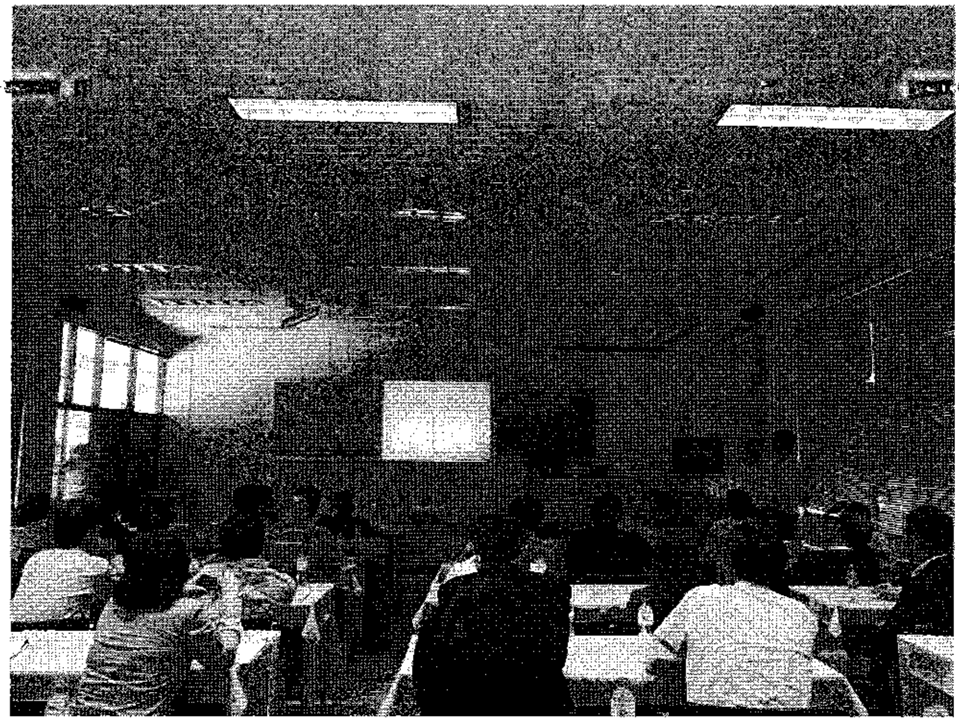
照片 5 張教授斐章專題演講



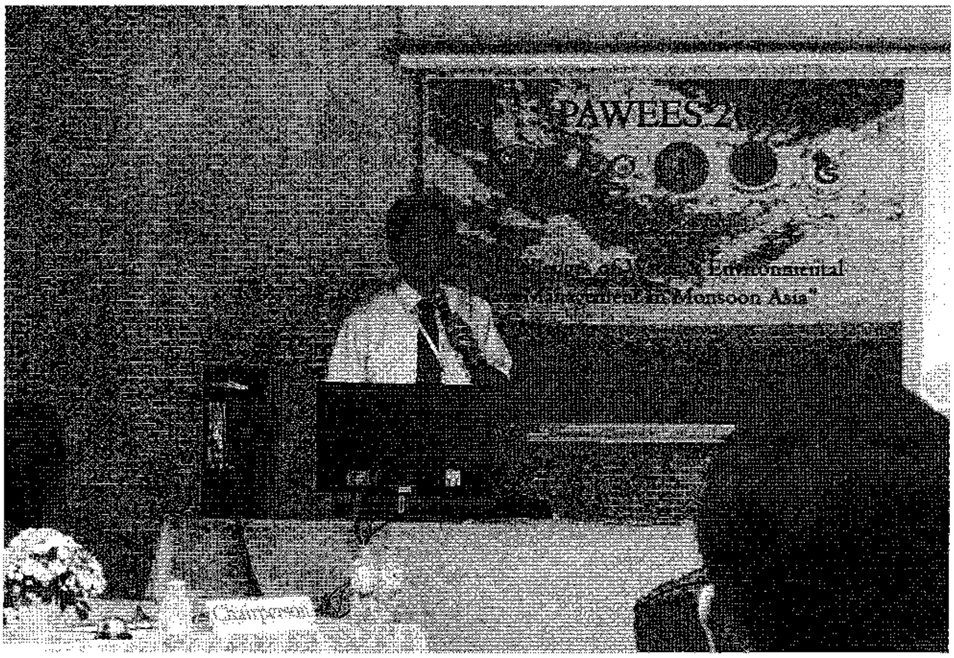
照片 6 張教授斐章演講後接受大會主席頒獎

照片 7 專題演講者全體合影

照片 8 台灣代表團於研討會場與大會主席合影

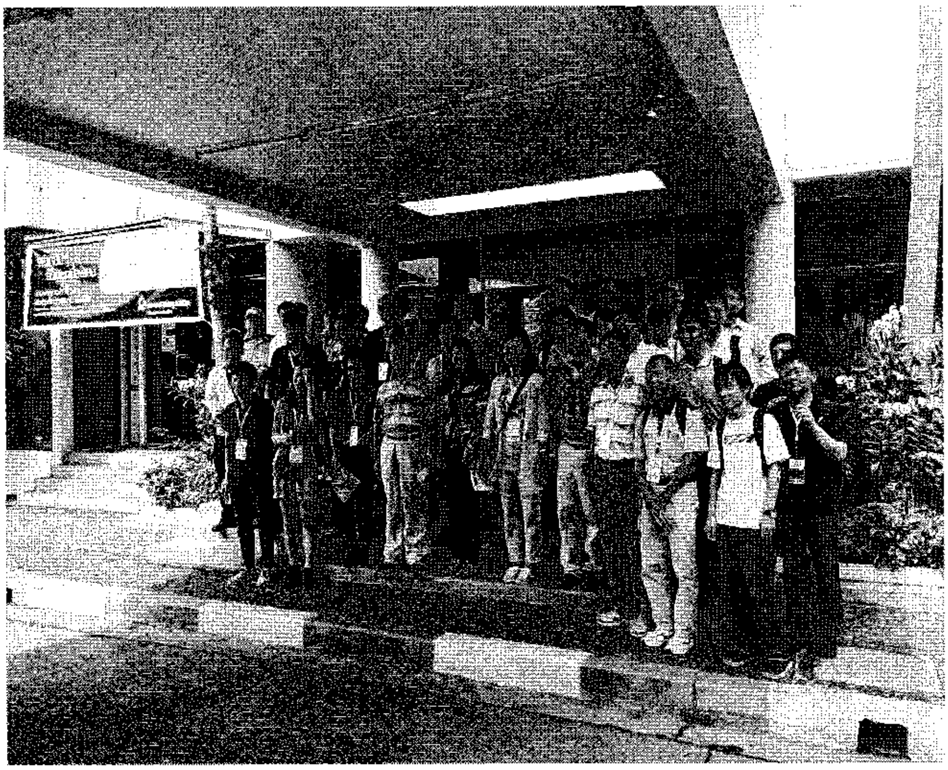


照片 9 分組研討

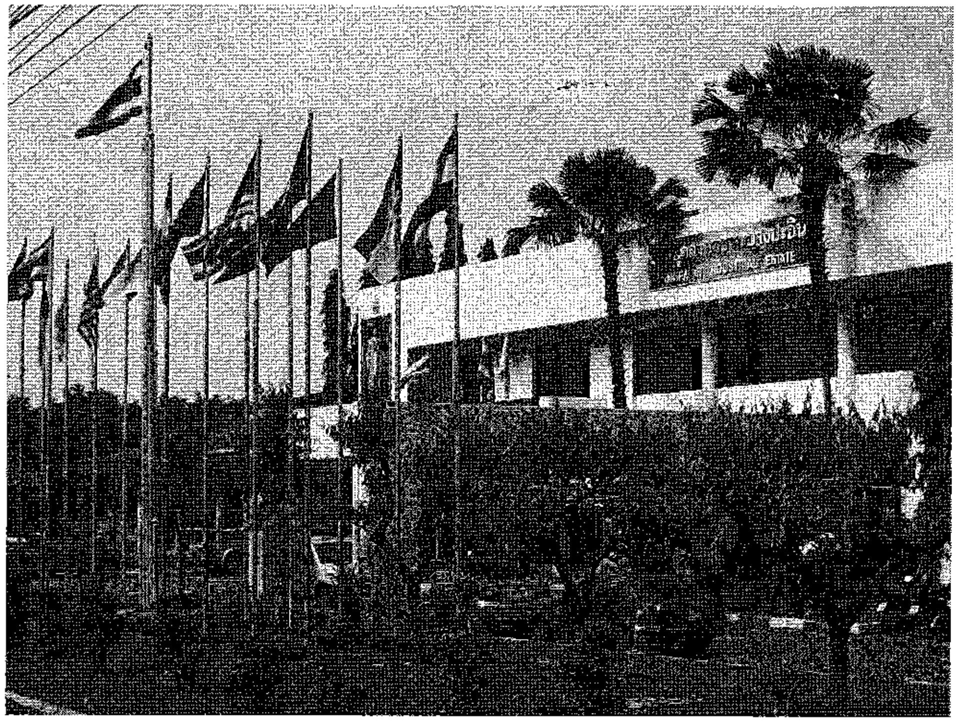


照片 10 鄭教授克聲論文發表

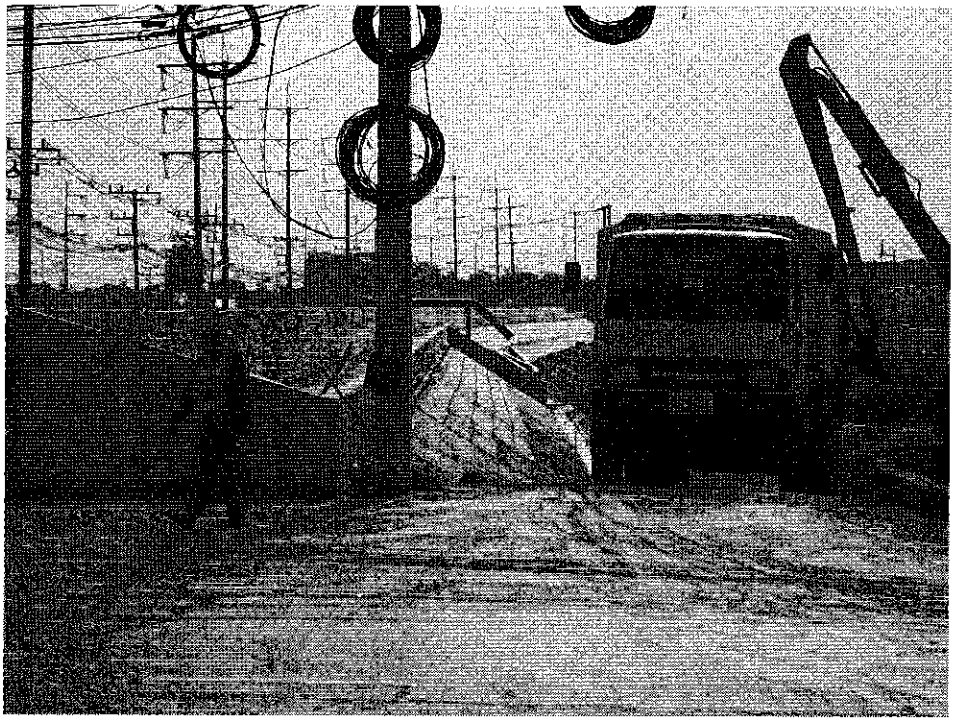
照片 11 聽取 Bang Pa-in 工業區防洪計畫簡報



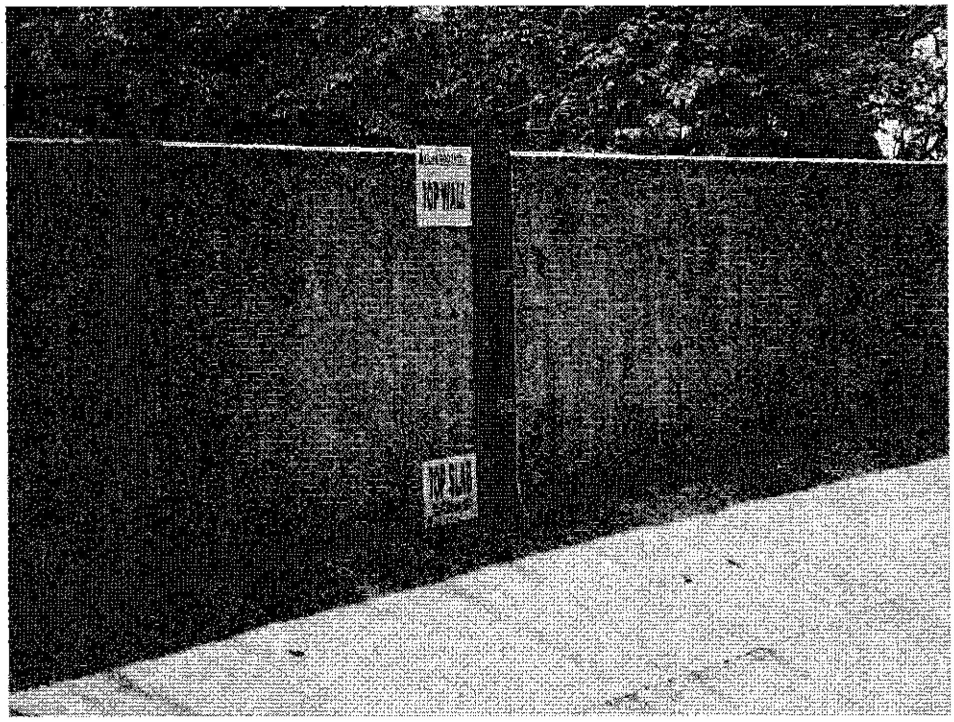
照片 12 全體人員於 Bang Pa-in 工業區管理處前合影



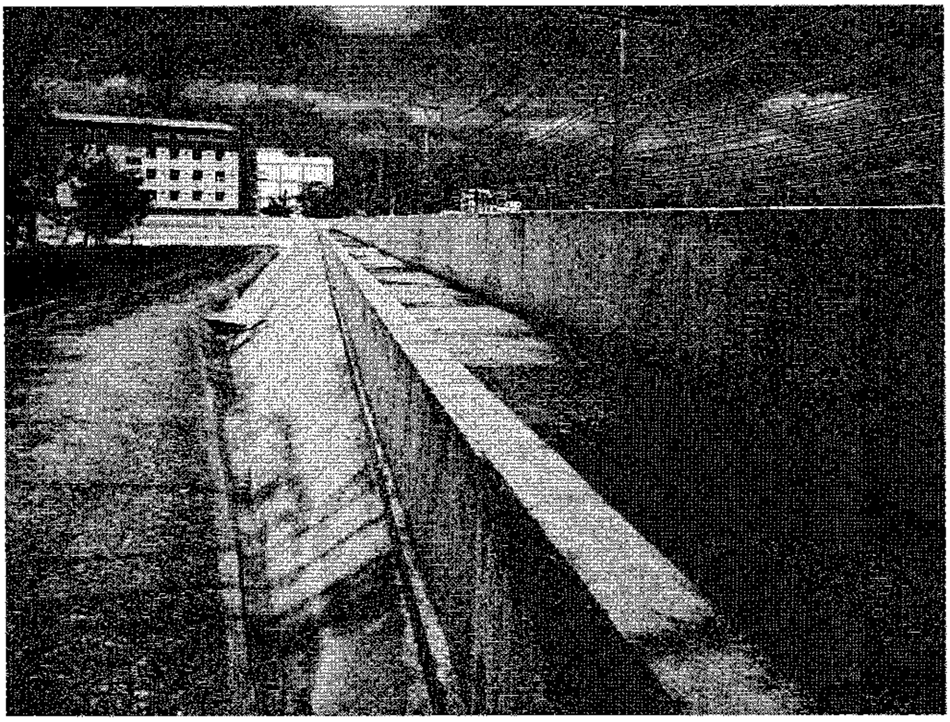
照片 13 進駐 Bang Pa-in 工業區之廠商代表國（含台灣）



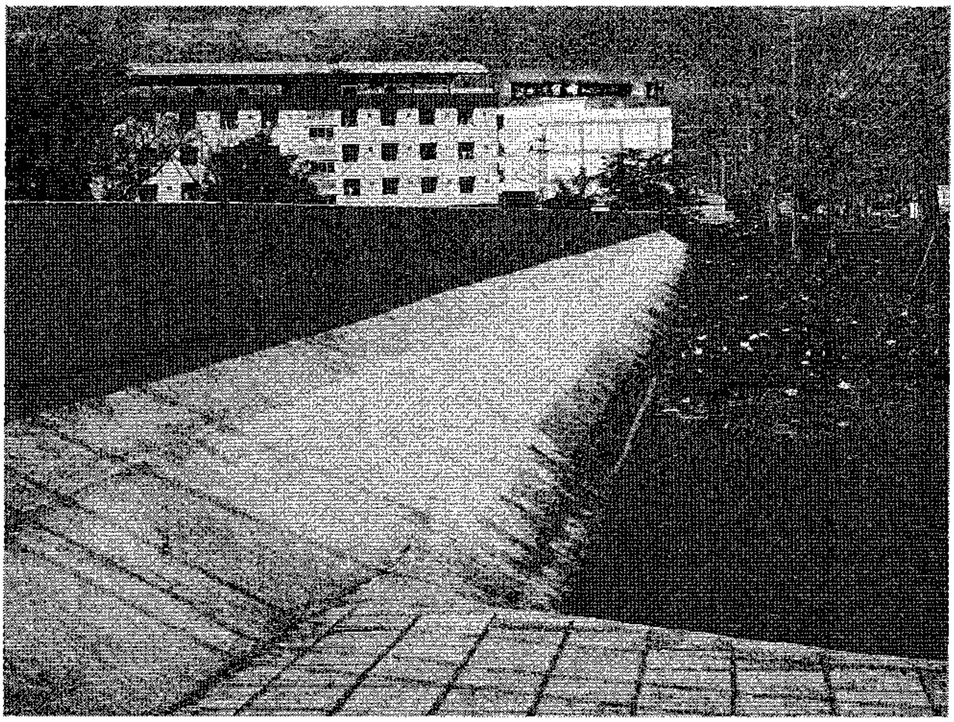
照片 14 Bang Pa-in 工業區施工中防洪牆



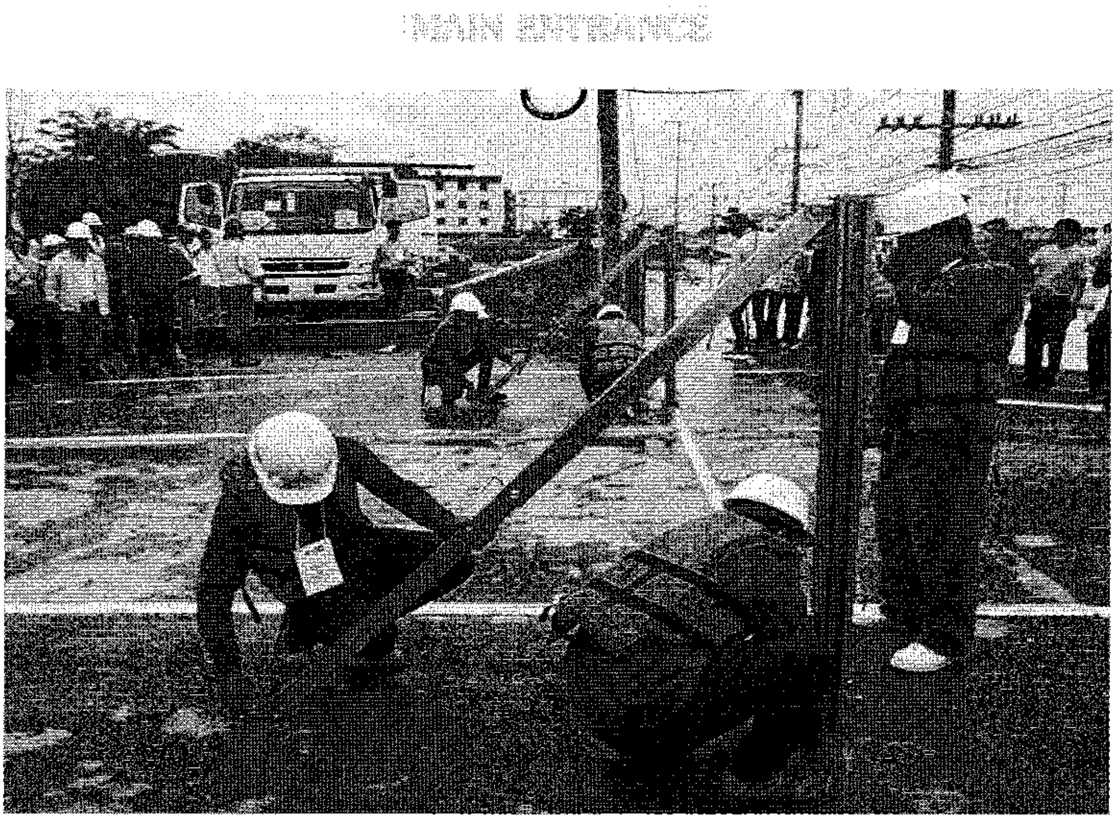
照片 15 Bang Pa-in 工業區已完工防洪牆（內側）



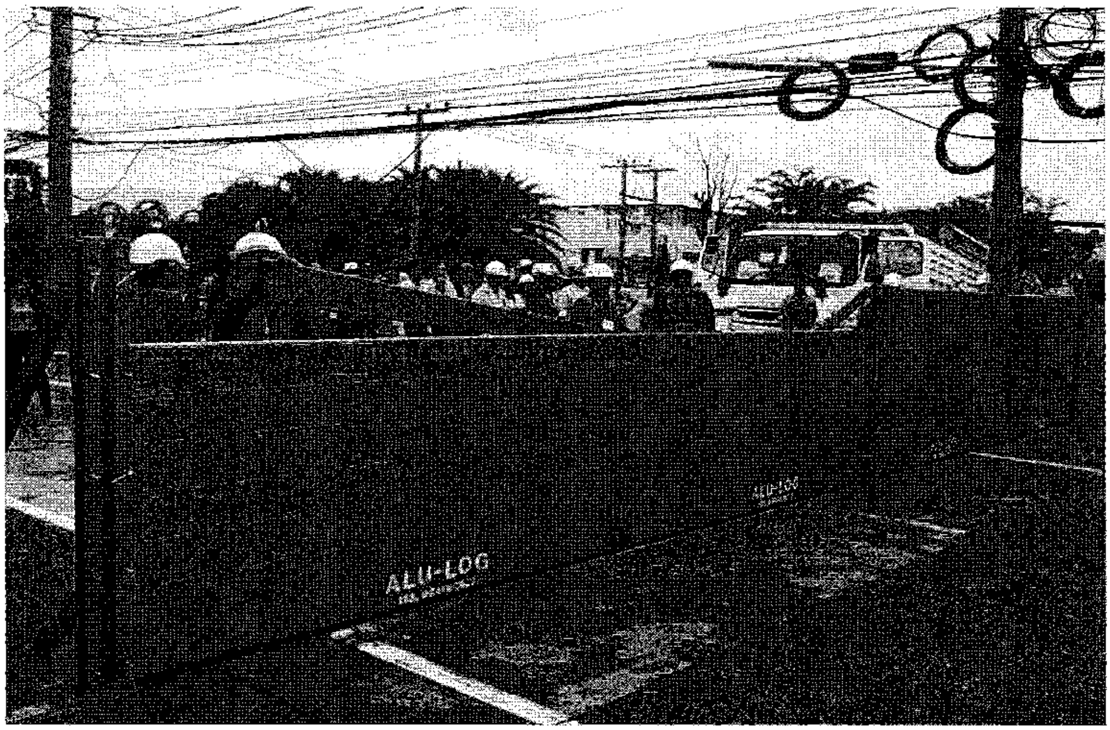
照片 16 Bang Pa-in 工業區已完工防洪牆（內側）



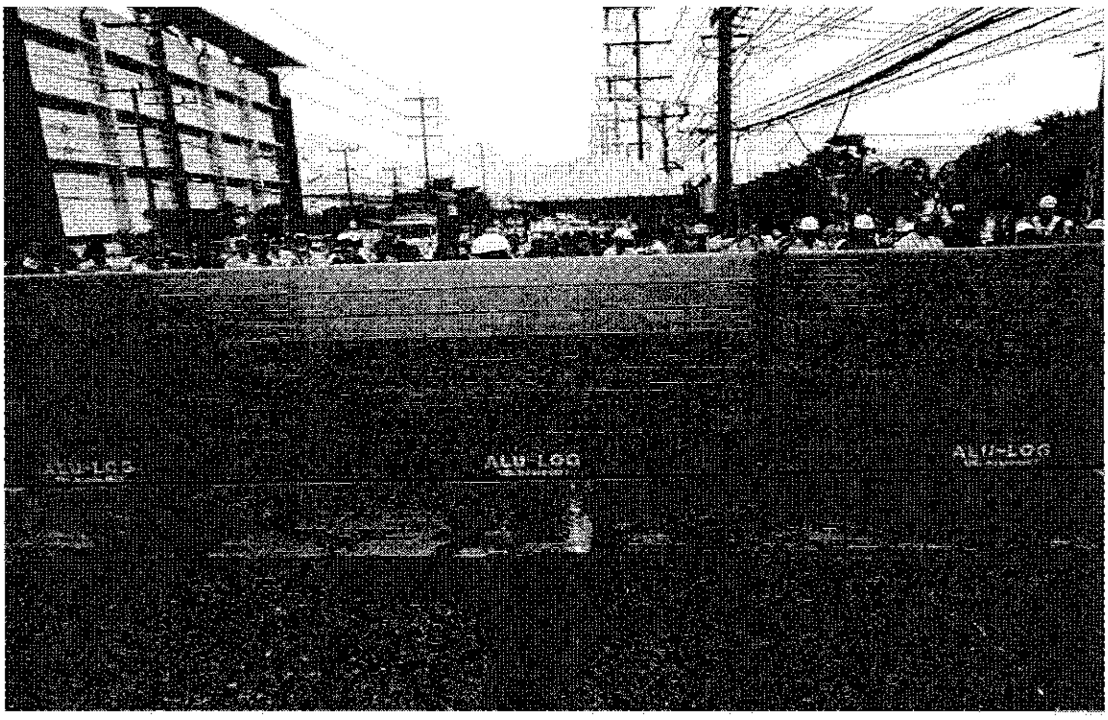
照片 17 Bang Pa-in 工業區已完工防洪牆（外側）



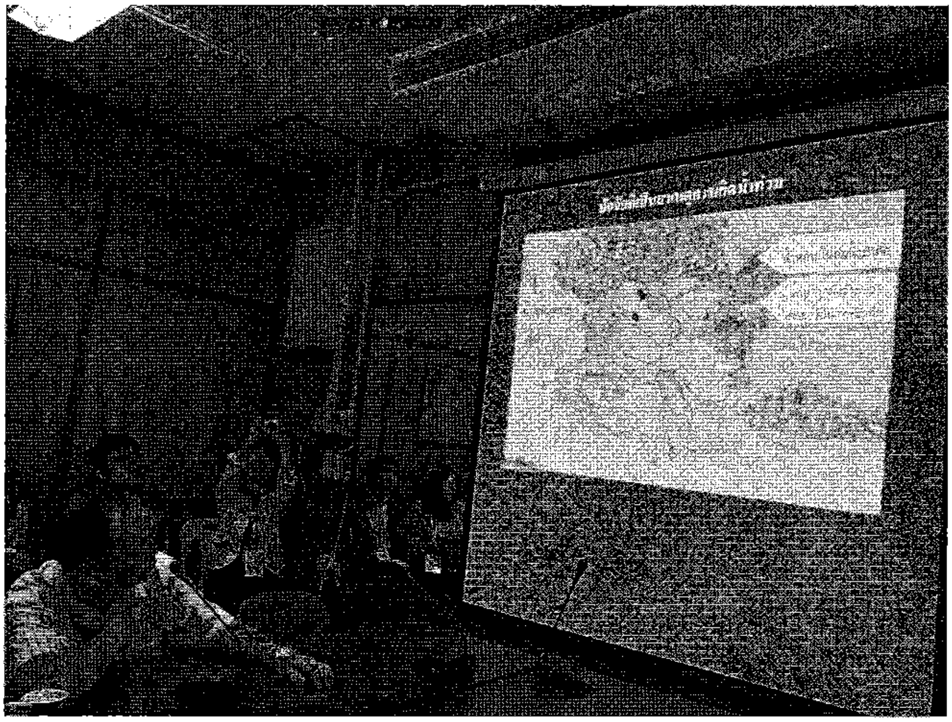
照片 18 Bang Pa-in 工業區出入口防洪牆閘板組裝演練（摘錄自簡報）



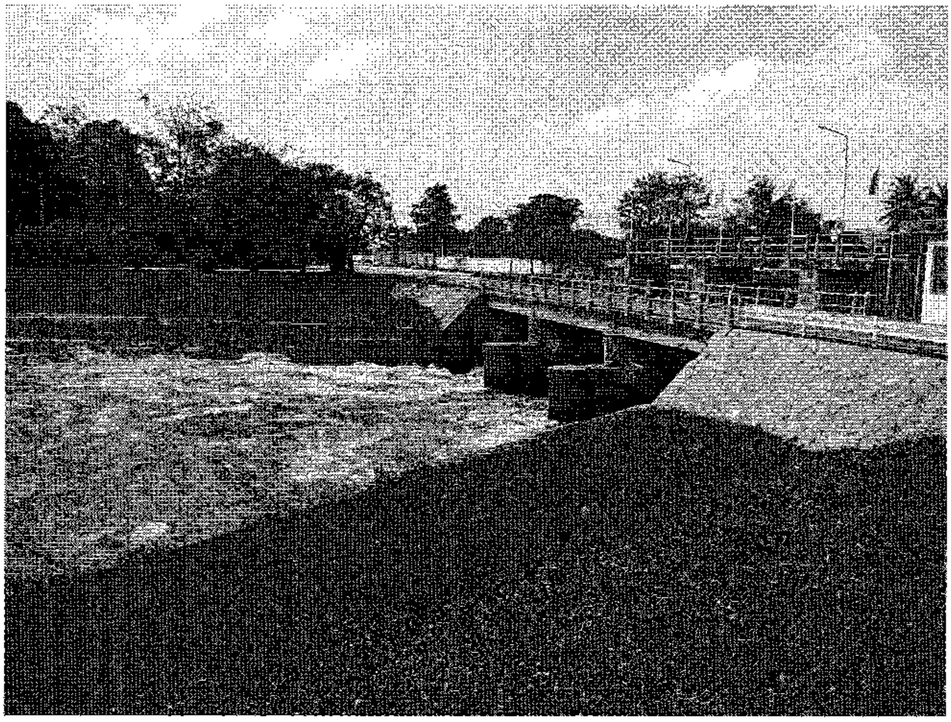
照片 19 Bang Pa-in 工業區出入口防洪牆閘板組裝演練（摘錄自簡報）



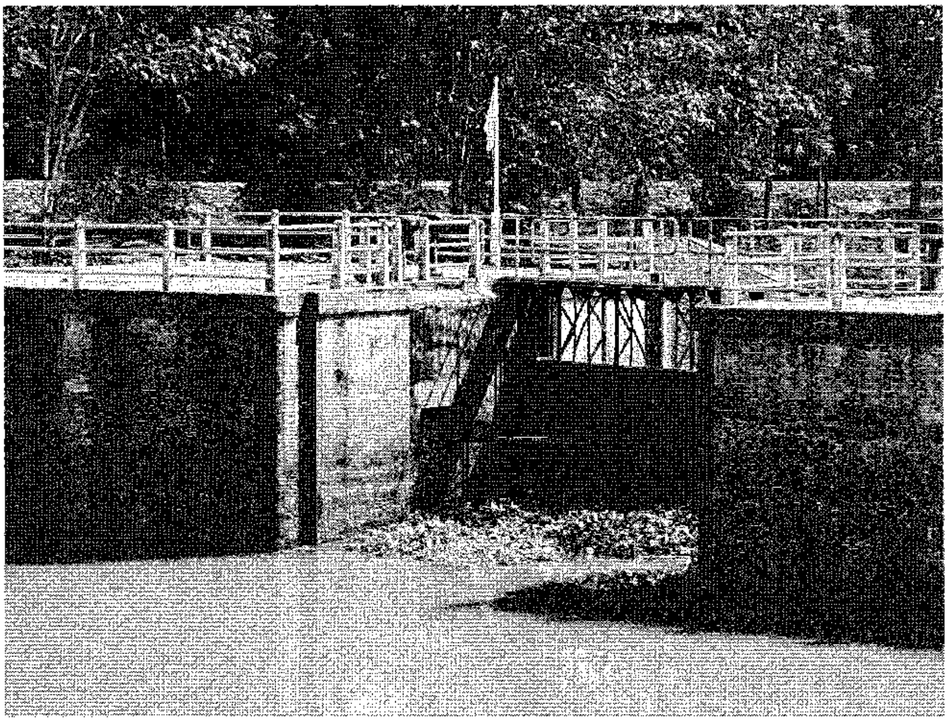
照片 20 Bang Pa-in 工業區出入口防洪牆閘板組裝演練（摘錄自簡報）



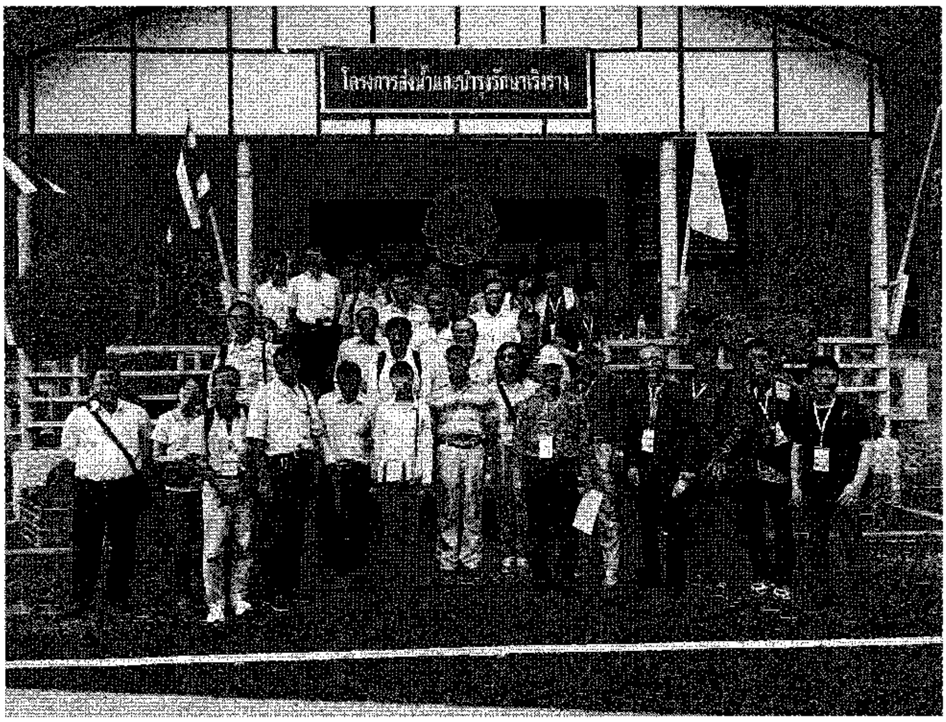
照片 21 聽取 Rengrang 水資源操作管理計畫簡報



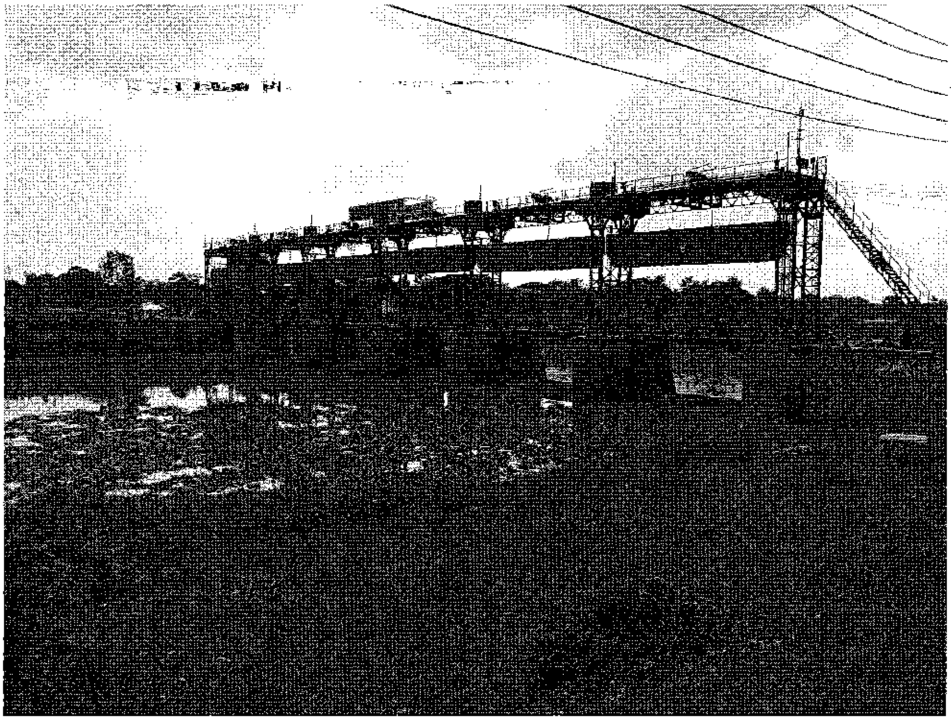
照片 22 Rengrang 水資源操作管理計畫渠首工



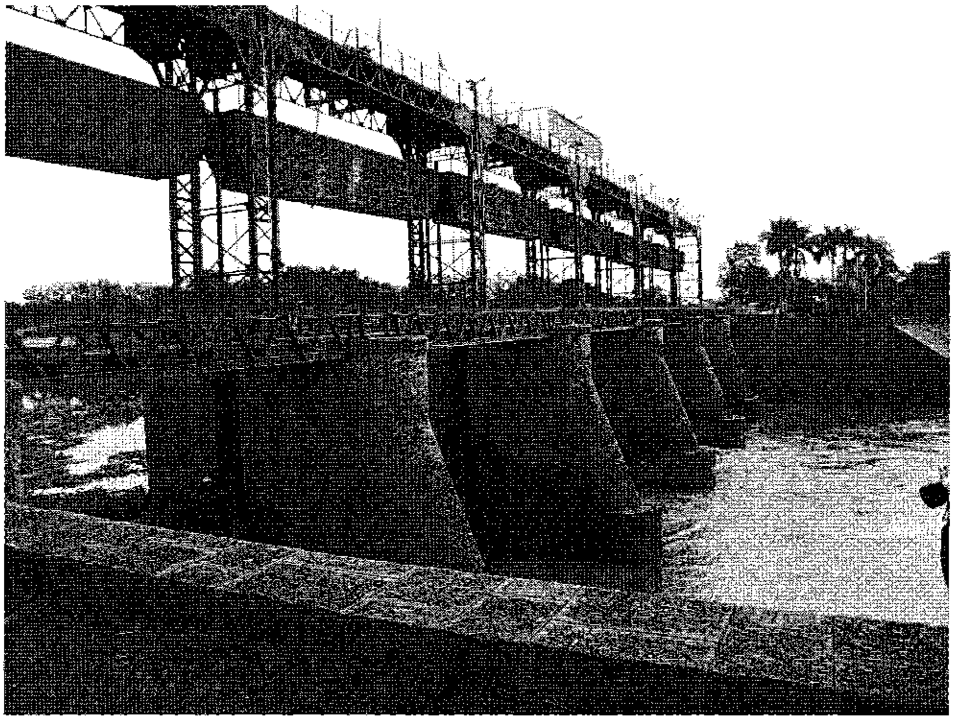
照片 23 Rengrang 水資源操作管理計畫分水閘



照片 24 全體人員於 Rengrang 水資源操作管理計畫管理處前合影



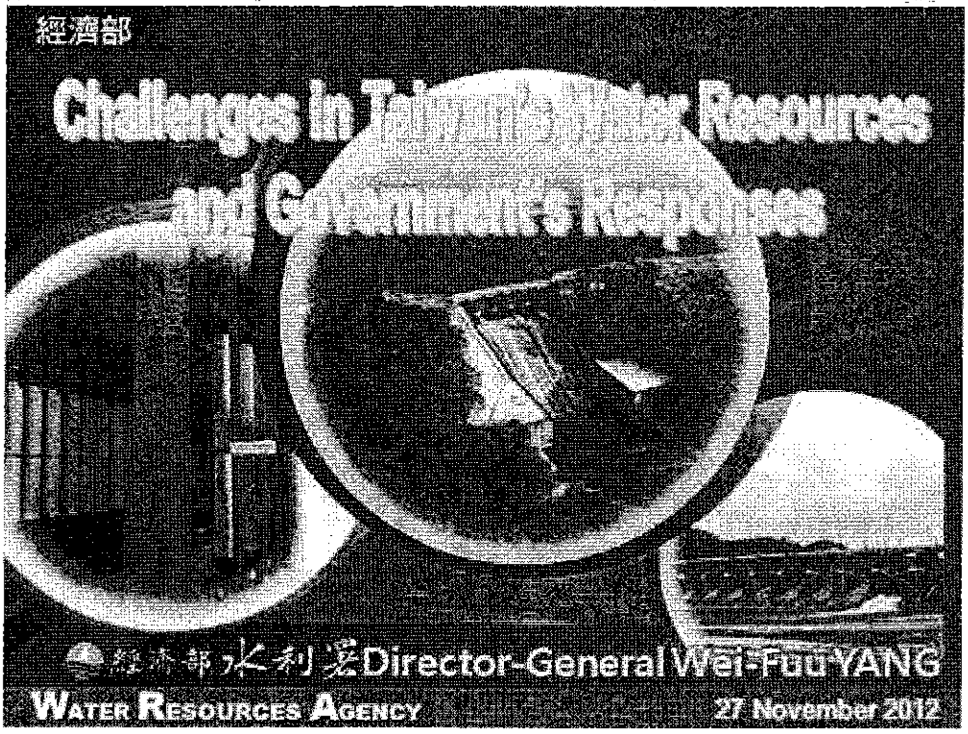
照片 25 Rengrang 水資源操作管理計畫渠首工（上游面）

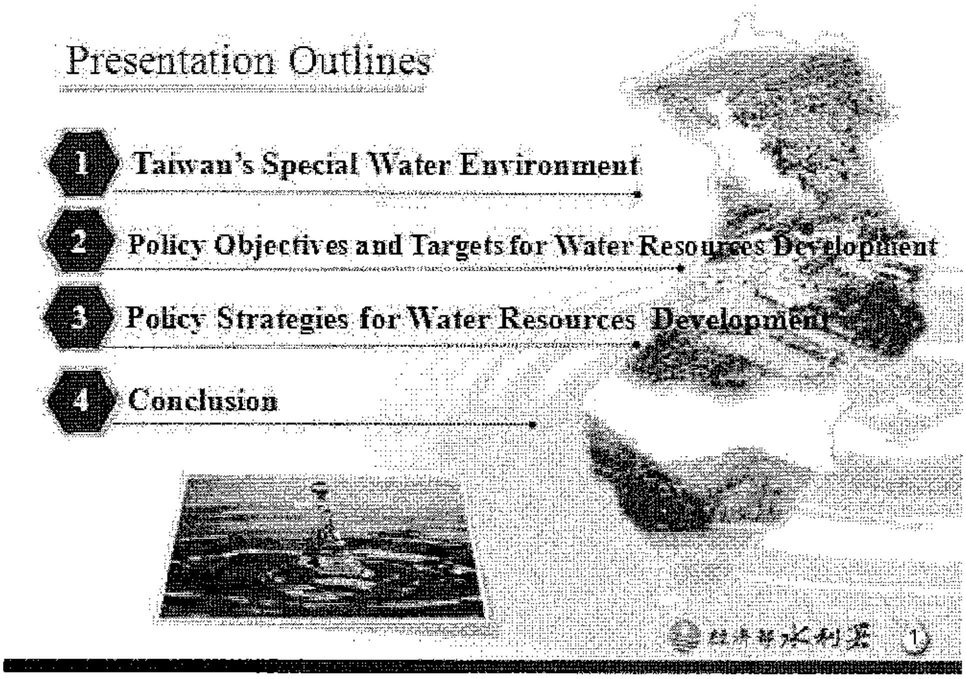


照片 25 Rengrang 水資源操作管理計畫渠首工（下游面）

照片 27 Rengrang 水資源操作管理計畫渠首工紀念碑

附錄二

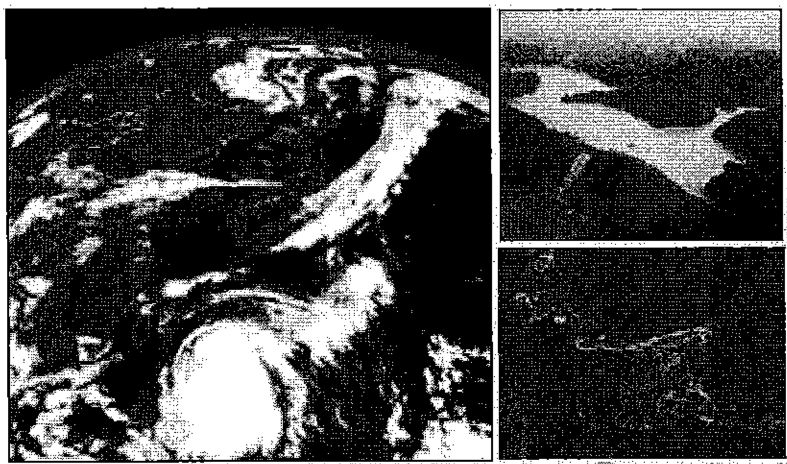

經濟部
Challenges in Taiwan's Water Resources and Government's Responses
經濟部水利署 Director-General Wei-Fuu YANG
WATER RESOURCES AGENCY
27 November 2012


Presentation Outlines
1 Taiwan's Special Water Environment
2 Policy Objectives and Targets for Water Resources Development
3 Policy Strategies for Water Resources Development
4 Conclusion
經濟部水利署
1

1 Taiwan's Special Water Environment

◆Geographical Factors

◆Human Interference



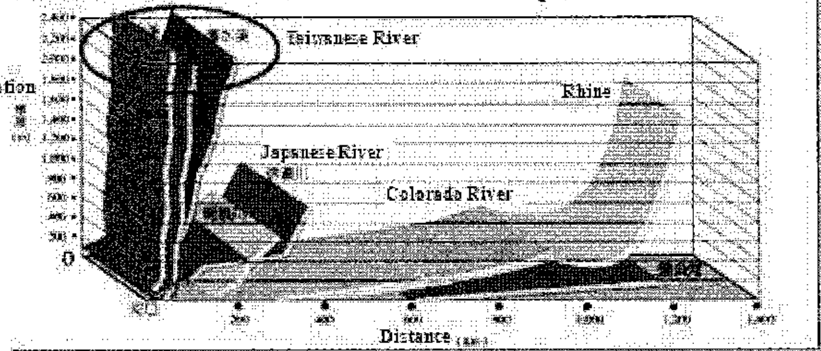
1 Taiwan's Special Water Environment-Geographical Factors

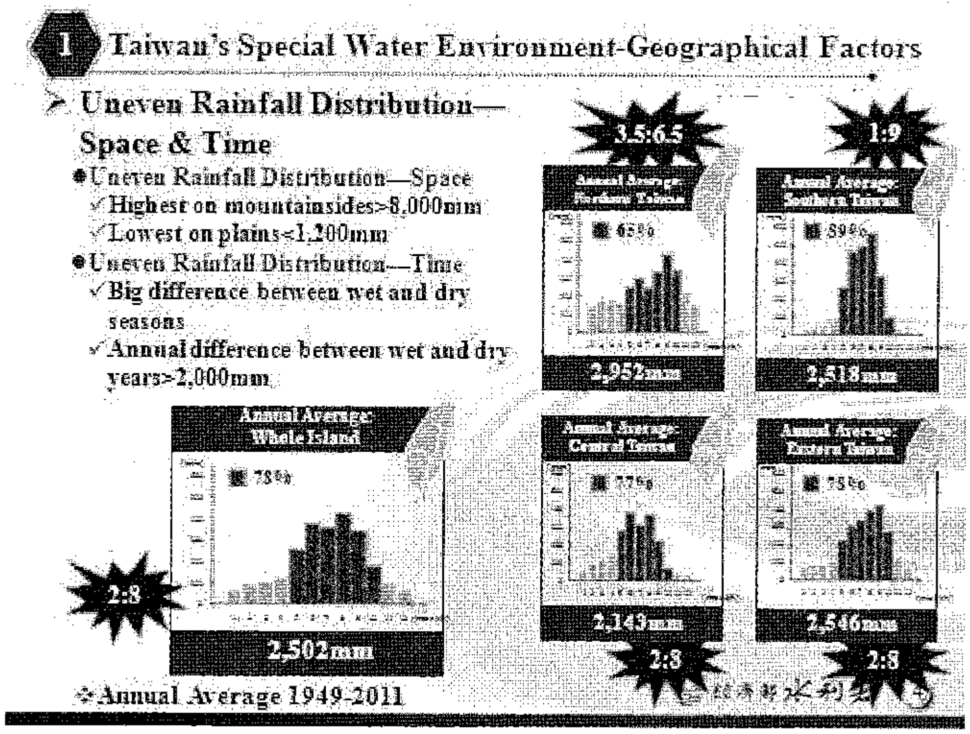
➢ **Unfavorable River Topological Conditions**

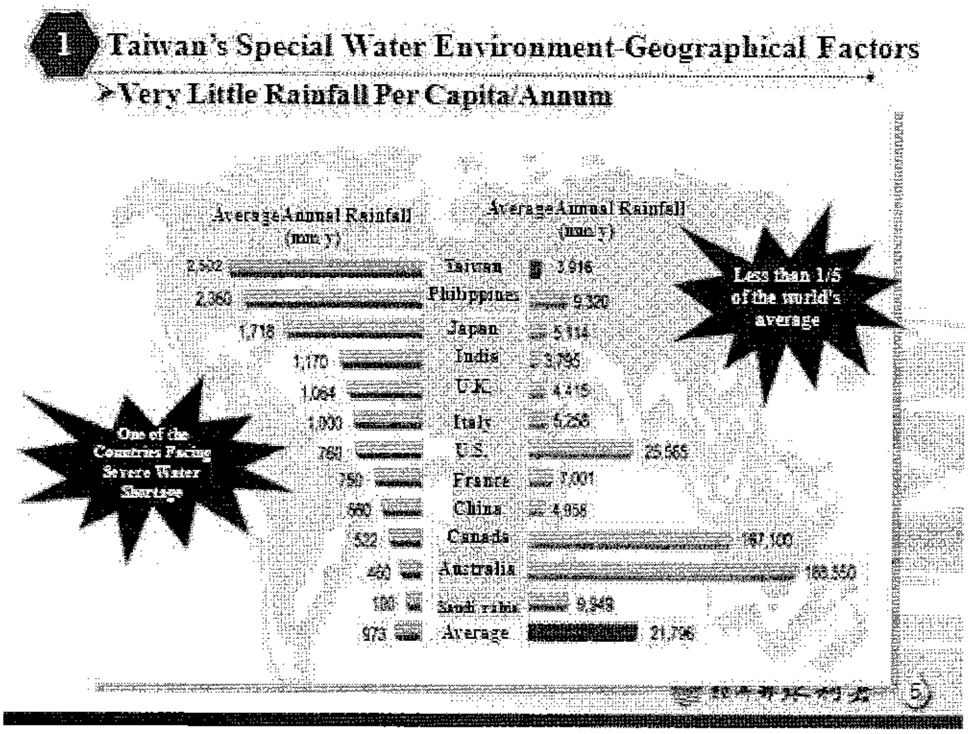
- Steep Terrain: More than 3/4 of rainfall flows directly into the sea or evaporates, with a high sediment transport rate
- Narrow River Valleys: Limited dam/reservoir capacity
- Young and Weak soil: Limited sites for dams and reservoirs

River Slope Comparison

✧Upstream Gradient>1/100



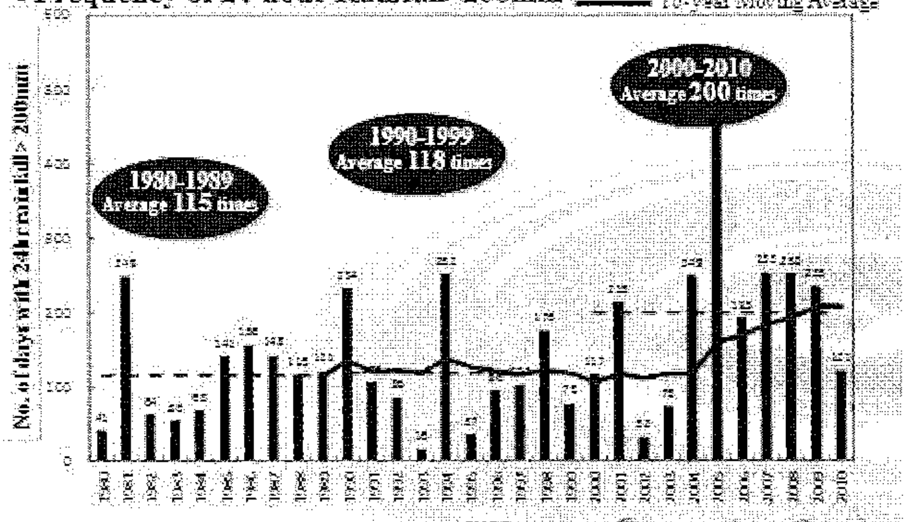

1
Taiwan's Special Water Environment-Geographical Factors
Uneven Rainfall Distribution—Space & Time
Uneven Rainfall Distribution—Space
Highest on mountainsides>8,000mm
Lowest on plains<1,200mm
Uneven Rainfall Distribution—Time
Big difference between wet and dry seasons
Annual difference between wet and dry years>2,000mm
3.5:6.5
1:9
2,952mm
2,518mm
Annual Average: Whole Island
78%
2:8
2,502mm
2,143mm
2,546mm
2:8
2:8
Annual Average 1949-2011


1
Taiwan's Special Water Environment-Geographical Factors
Very Little Rainfall Per Capita/Annum
Average Annual Rainfall (mm/y)
Average Annual Rainfall (mm/y)
2,502 Taiwan 3,916
2,360 Philippines 6,320
1,718 Japan 5,114
1,170 India 3,795
1,064 U.K. 4,415
1,000 Italy 5,258
760 U.S. 25,565
750 France 7,001
660 China 4,958
522 Canada 167,100
460 Australia 183,550
100 Saudi rabia 9,949
973 Average 21,796
Less than 1/5 of the world's average
One of the Countries Facing Severe Water Shortage
5

1 Taiwan's Special Water Environment-Geographical Factors

➢Increasing Torrential Rain Frequency

● Frequency of 24-hour Rainfall>200mm

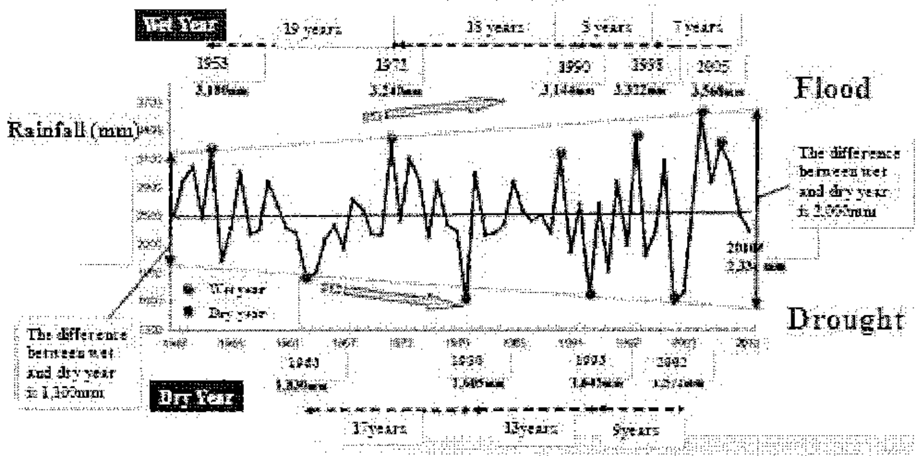


✧Based on the statistics of the 148 WRA and CWB stations.

1 Taiwan's Special Water Environment-Geographical Factors

➢Significant Impact from Closely Distributed Flood-Drought Frequencies

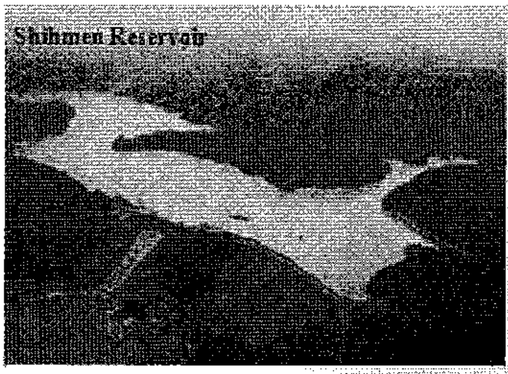
Annual Rainfall (1949-2010)



1 Taiwan's Special Water Environment-Geographical Factors

➢ Poor Geological Conditions with Large Erosion at Watersheds

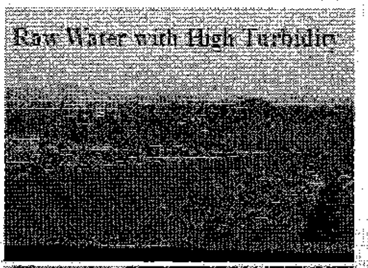
- Young and Weak soil: Limited sites for dams/reservoirs.
- Fragmented Geological Structure: Prone to washing
- Jiji Earthquake: soil loosened

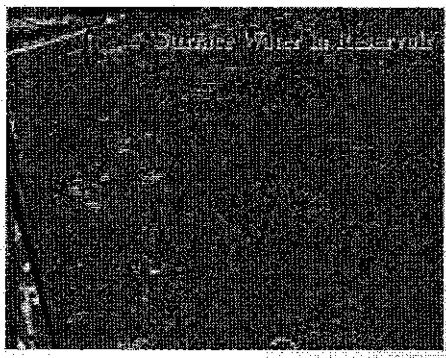


1 Taiwan's Special Water Environment-Geographical Factors

➢ Poor Water Body Quality

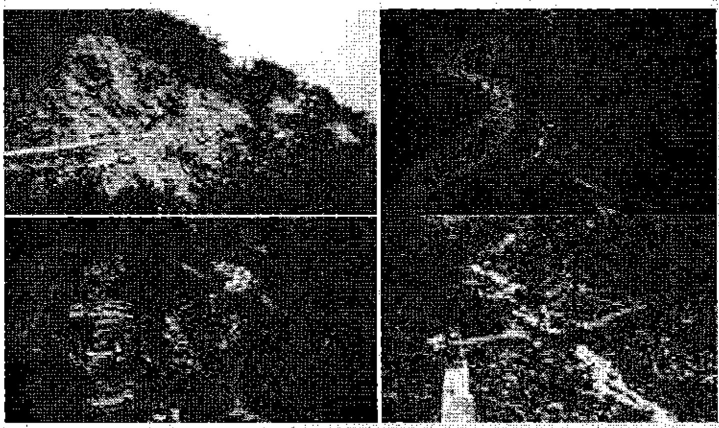
- Hot Summer: Algae grow rapidly over water body, severely affecting water quality
- Washing by Heavy Rainfall: Turbidity increases, affecting water use





1 Taiwan's Special Water Environment-Human Interference

- Human Damage on Water Conservancy
  - Cultivation and logging abuse at watersheds
  - Excessive infrastructure expansion and improper maintenance



1 Taiwan's Special Water Environment-Human Interference

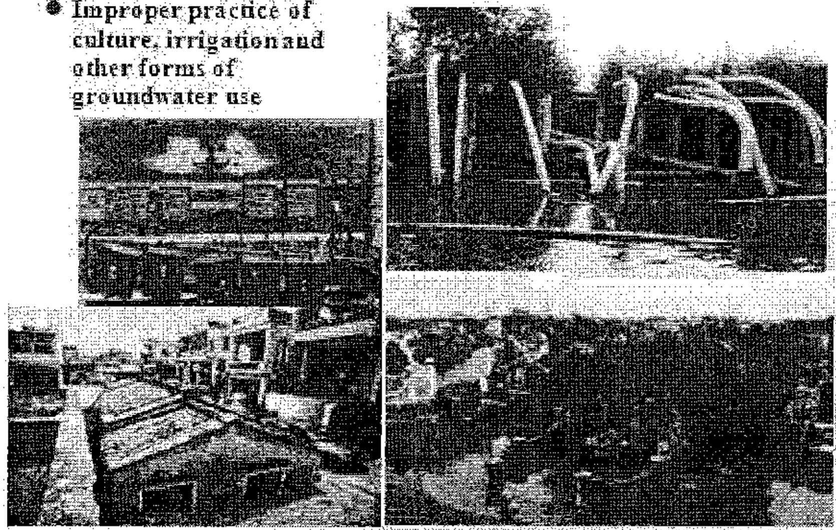
- Man-induced Water Pollution
  - Dumping garbage at watersheds
  - Using pesticides and chemical fertilizers in high mountain areas
  - Discharging domestic and industrial wastewater
  - Discharging animal-rearing wastewater

✧Photos from the Internet

1 Taiwan's Special Water Environment-Human Interference

➢ Severe Groundwater Overuse

- Improper practice of culture, irrigation and other forms of groundwater use

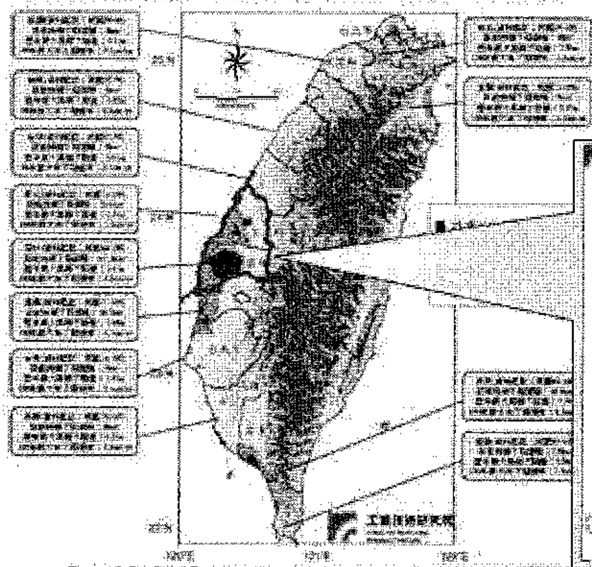


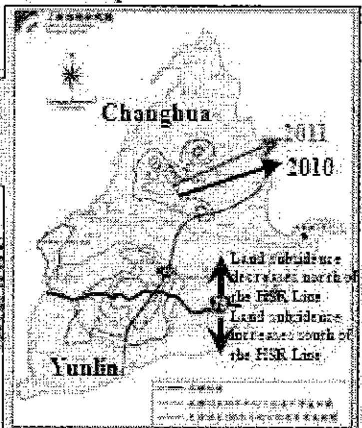
12

1 Taiwan's Special Water Environment-Human Interference

➢ Excessive Groundwater Overuse—Land Subsidence

- Continuously subsiding area across Taiwan: 5344(km²)
- Significant land subsidence in Changhua and Yunlin due to change in the agricultural system which results in increasing water consumption.





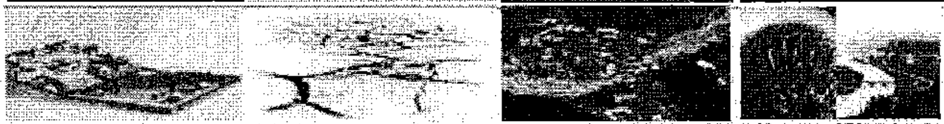
Land Subsidence Conditions in Taiwan 2011

13

1 Taiwan's Special Water Environment-Human Interference

➢Absence of Overall Planning for Homeland Uses

Over-Development and Overuse of Urban Areas	[illegible]	Improper Land Use of High-Sensitive and Vulnerable Areas	Absence of Planning for Sustainable Use of Urban and Rural Areas

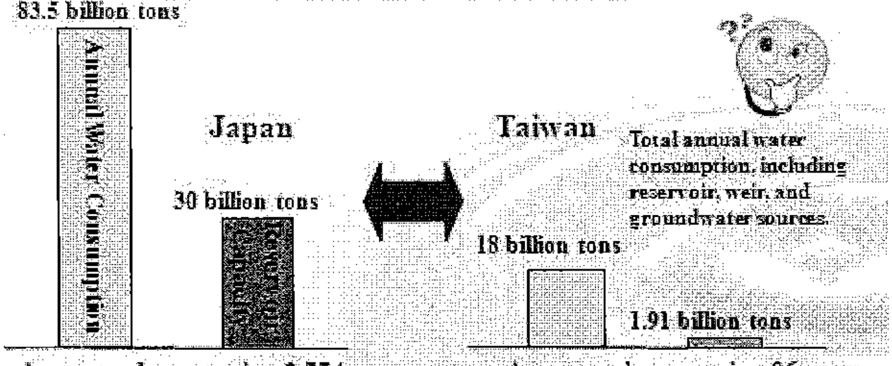


●Expansion of Impervious Area →Reduction of groundwater infiltration and increase of surface water runoff ●Population Growth and Centralization → Increase of water demand and wastewater output	●Misplacement of High-Water-Consuming Industries → Areas with high water shortage urge investment in high-water-consuming industries, thus affecting future industrial development and impacting sustainable operations of original industries.	● Continuous hazards from improved land use in highly sensitive areas → A waste of social cost in hazard mitigation and impacts soil conservation and water conservancy.	● Absence of Planning for Sustainable Development and Growth Management of Urban and Rural Areas →Unsustainable use of farmland in agricultural areas; impacts agricultural production and water storage function of farmlands.

1 Taiwan's Special Water Environment-Human Interference

➢Insufficient Water Storage Capacity

- The annual reservoir water supply is 4.33 billion tons, and the effective reservoir capacity is only about 1.91 billion tons. The average utilization rate is 2.3 times. (4-5 times for Shihmen Reservoir)



Announced reservoirs: 2,774
Effective reservoir capacity in total annual consumption: 36%

Announced reservoirs: 96
Effective reservoir capacity in total annual consumption: 10.6%

2 Policy Objectives and Targets of Water Resources Development

Objectives

Pursuit of Sustainable Use of Water Resources

- ☐ Equal emphasis on environmental protection, economic development, and social justice
- ☐ Total volume control of the development and use of natural water resources (20 bn tons/year)
- ☐ Zero yield growth of natural water resources in dry seasons (standard in 2001)
- ☐ Enhance water use efficiency of all targets

Provision of Safe Basic Water Supply

- ☐ Diversification of water resources development
- ☐ Promotion and education of water conservation
- ☐ Enhancement of efficiency of agricultural water management

Establishment of a government-public communication platform

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2 Policy Objectives and Targets of Water Resources Development

	Quantified Targets for 2031
Emerging Water Sources	• Seawater desalination consumption: 500,000 tons/day • Reclaimed water consumption: 1,200,000 tons/day
Water Consumption Per Capita	• Reduction from 271 Liters/day to 240 Liters/day
Running Water Leakage	• Reduction from 21% to 15%
Land Subsidence	• Continuously subsiding area: Reduction from 633km^2 to less than 100km^2

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3 Policy Strategies for Water Resources Development

Policy Objectives

- Pursuit of the sustainable use of water resources
- Provision of safe basic water supply
- Establishment of a government-public communication platform

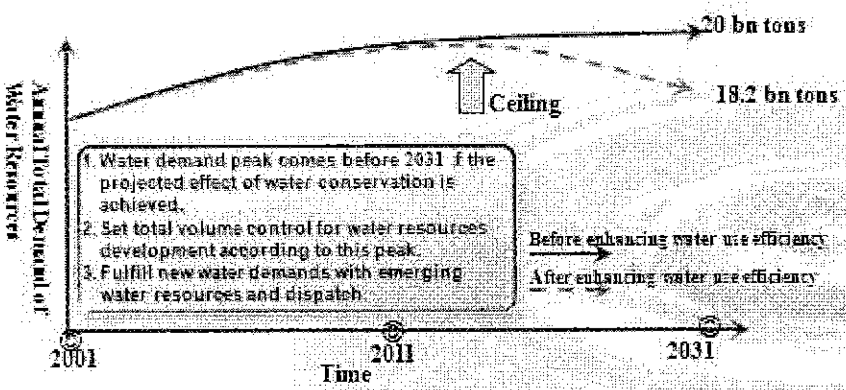
Promotional Strategies

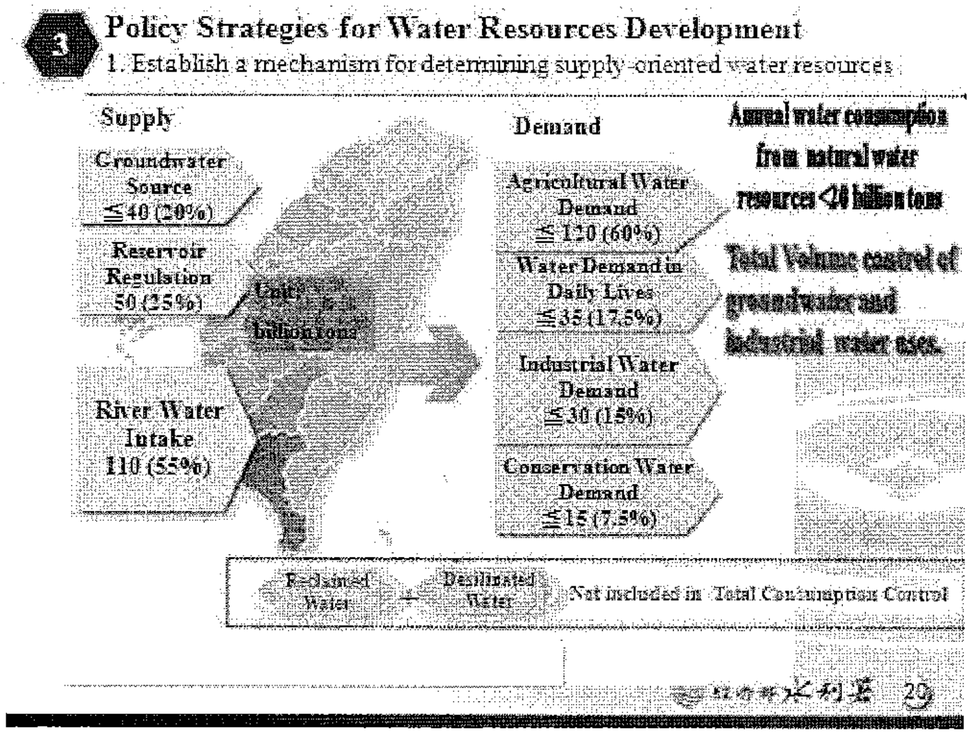
1. Establish a mechanism for determining supply-oriented water resources
2. Respond and adapt to extreme climate
3. Enforce the Holistic Water Saving Movement
4. Enhance the efficiency of existing water resources facilities
5. Diversify water resources development
6. Adjust water price at appropriate times
7. Establish a friendly government-public communication platform

3 Policy Strategies for Water Resources Development

1. Establish a mechanism for determining supply-oriented water resources

A Reasonable Ceiling for the Total Volume for Natural Water Resources Development





3
Policy Strategies for Water Resources Development
1. Establish a mechanism for determining supply-oriented water resources
Supply
Groundwater Source ≦40 (20%)
Reservoir Regulation 50 (25%)
River Water Intake 110 (55%)
Demand
Agricultural Water Demand ≦120 (60%)
Water Demand in Daily Lives ≦35 (17.5%)
Industrial Water Demand ≦30 (15%)
Conservation Water Demand ≦15 (7.5%)
Annual water consumption from natural water resources <20 billion tons
Total Volume control of groundwater and industrial water uses.
Reclaimed Water
Desalinated Water
Not included in Total Consumption Control
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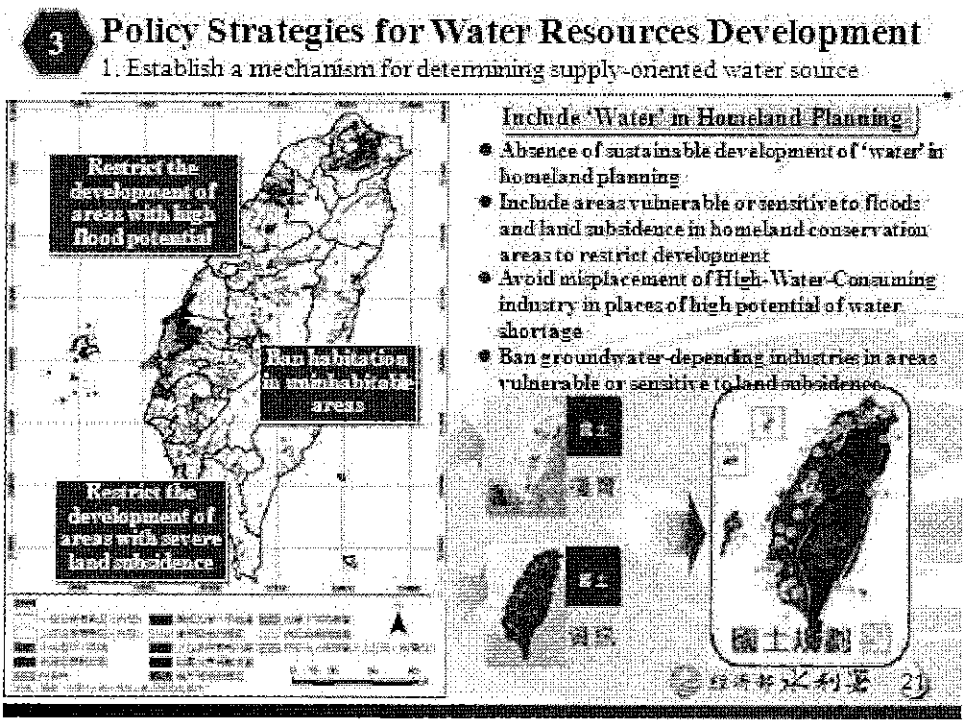

3
Policy Strategies for Water Resources Development
1. Establish a mechanism for determining supply-oriented water source
Restrict the development of areas with high flood potential
Ban habitation in uninhabitable areas
Restrict the development of areas with severe land subsidence
Include 'Water' in Homeland Planning
Absence of sustainable development of 'water' in homeland planning
Include areas vulnerable or sensitive to floods and land subsidence in homeland conservation areas to restrict development
Avoid misplacement of High-Water-Consuming industry in places of high potential of water shortage
Ban groundwater-depending industries in areas vulnerable or sensitive to land subsidence.
國土規劃
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3 Policy Strategies for Water Resources Development

1. Establish a mechanism for determining supply-oriented water source

Strengthen Water Use Plan Review & Audit System

Review

- Review and approve water use and water supply subject to the Regional Plan Act, Guidelines for Conducting Environmental Impact Assessment of Development Activities, and Directions for municipal or County (City) Government Applying for Newly Constituted or Extended Urban Plans .
- Review the planned water consumption, water conservation plan, and water source supply plan according to the availability of regional water resources.

Audit

- Audit actual water consumption records, consumption difference explanation, the status of implementation of the water conservation plan, water recycling measures, and water consumption reduction measures.
- Audit, cancel, withdraw or change the water consumption plan according to the results of consumption difference analysis when water consumption is below planned consumption.
- Establish an electronic on-line reporting system.

3 Policy Strategies for Water Resources Development

1. Establish a mechanism for determining supply-oriented water source

Strengthening the Review of Water Right Registration

Water Demand Check

- According to Article 17 of the Water Act, "an entity, a corporation or a citizen may apply for water rights for each specific purpose, provided water consumption of such purpose is required by the business operated.
- According to Item 1, Point 4, of the Directions for Application Review on Water Right Registration, Competent authorities shall, during review of the yield of water rights, consider the monthly hydrological conditions at the point of intake, the approved upstream and downstream water rights, the base discharge for environmental protection purpose, and the yield demanded of [illegible]

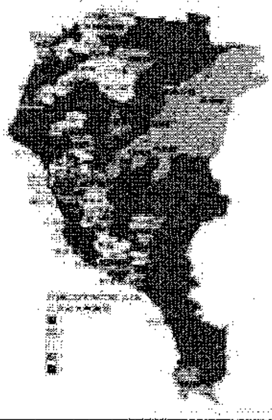
Water Supply Check

- According to Article 15 of the Water Act Enforcement Rules enacted on 17 November 2004, the total rights of surface water approved shall be the yield of surface water with flow exceedance probability of 85% or higher.
- Process of water right registration:
  - Audit applications according to the scope of water consumption proposed by applicants
  - Calculate the reasonable water consumption of business
  - Calculate the potential yield of surface water
  - Approve water rights as required according to the Directions for Application Review on Water Right Registration

3 Policy Strategies for Water Resources Development

2. Respond and adapt to extreme climate

- ✓ Analyze the future shortage potential, risk and recovery ability of water resources; analyze the impact of climate change on surface water resources; draw the water resources risk map; and establish the adaptation route map.
- ✓ Review the necessity and suitably develop traditional water resources; aggressively develop such climate-unaffected emerging water resources as seawater desalination and water renewal; and enhance the reliability and redundancy of overall water resources.



Water Supply Risk Map in Scenario A1B of NCDR

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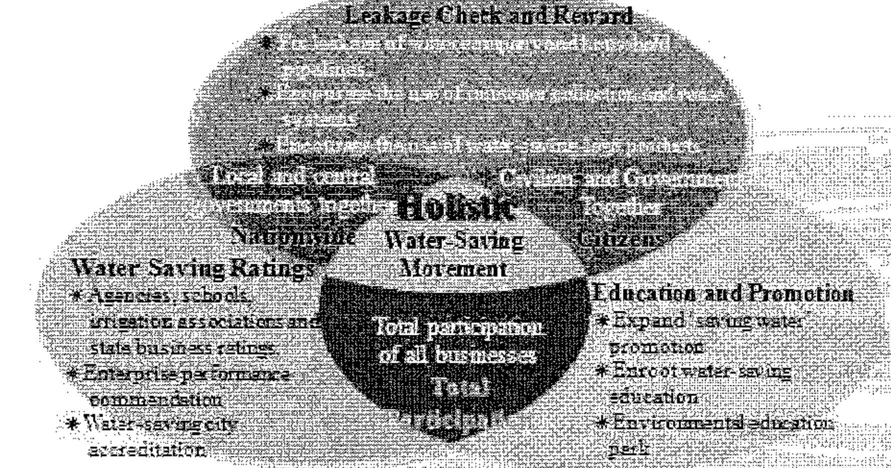
3 Policy Strategies for Water Resources Development

3. Enforce the Holistic Water Saving Movement



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3 Policy Strategies for Water Resources Development

3. Enforce the Holistic Water Saving Movement

Reduce Daily Life Water Consumption | **Enhance Agricultural Water Efficiency** | **Enhance Industrial Water Efficiency**

Effective Use of Irrigation Water

- **Enhance the efficiency of agricultural water use**
  - Review the rights of reasonable agricultural water use and the present status of irrigation water consumption.
- **Reinforce irrigation management**
  - Reinforce irrigation water management, increase ponds to collect rainwater and return water.
- **Promote saving agricultural water technologies**
  - Implement auto-irrigation management demo plans and promote water-saving spray irrigation facilities.

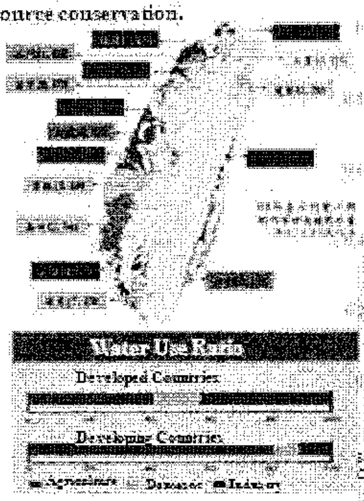
Support of Daily Life and Industrial Water Consumption with Agricultural Water

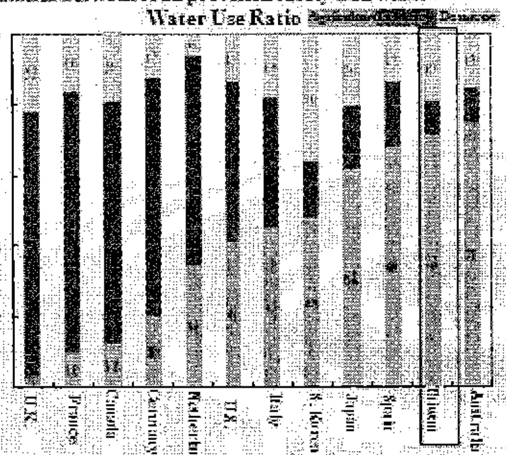
- **Amend the Organic Statute for Irrigation Associations**
  - Allow irrigation associations to support daily life and industrial water consumption with agricultural water.
  - Diversify the operation irrigation associations

3 Policy Strategies for Water Resources Development

3. Enforce the Holistic Water Saving Movement-**Enhance the Efficiency of Agricultural Water Use**

- **In Taiwan, agricultural water consumption commands 70% of total water consumption.** The structure of agriculture and irrigation systems will be reviewed, and farming management technology will be improved to maintain a **balance between food provision safety and water resource conservation.**





Source:

Policy Strategies for Water Resources Development

3. Enforce the Holistic Water Saving Movement-Food Security Conference 2011 in Taiwan

Conclusion ➡ **Issue 5: Reinforce the quality and quantity management of agricultural water to provide safe and steady irrigation water sources.**

Agendum (1): Reinforce the effective management of irrigation water to enhance the efficiency of agricultural water use

Strategy

Continuously invest in modern irrigation management systems and technology, and adjust agricultural structure and promote water-saving measures to enhance the **efficiency of agricultural water use and ensure food provision safety.**

Measures

1. Rehabilitate fallow according to local water resource conditions after reviewing the farming system. Assist farmers in adjusting the agricultural system and encourage group operations to enhance food self-sufficiency.
2. Maintain reasonable irrigation consumption of irrigation associations; establish a reasonable compensation mechanism for water resource dispatch; encourage irrigation associations to reinforce water-saving measures; and prioritize surplus agricultural water reuse to enhance the efficiency of water resources.
3. Continuously invest in irrigation distribution systems and water dispatch and storage facilities, and construct location-specific water-saving and energy-saving modern management systems to ensure water resources are supplied in the best interest of the country.
4. Expand the scope of farmer consultation on modern water-saving spray irrigation facilities to enhance the efficiency of agricultural water use and improve crop quality.

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Policy Strategies for Water Resources Development

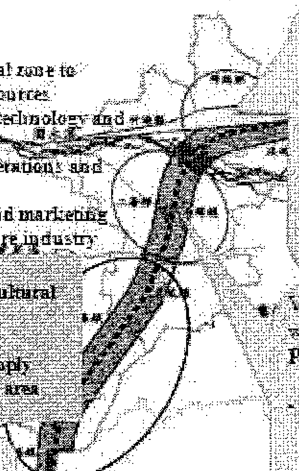
3. Enforce the Holistic Water Saving Movement- **Goden Corridor Project: A Solution for Taiwan High Speed Rail Safety in Areas with Land Subsidence**

General Planning

- Establish a water-saving agricultural zone to revitalize the use of agricultural resources
- Improve water-saving agricultural technology and IT use
- Expand the scale of agricultural operations and introduce new-generation farmers
- Promote postmodern agriculture and marketing diversification and develop the leisure industry

Projected Goals

- **Develop low water-consuming agricultural clusters**
- **Increase the income of farmers**
- **Enhance self-sufficiency of food supply**
- **Establish LHOAS agriculture demo area**



Wet paddies are grown in areas with relatively stable water supply.
Promote modern irrigation technology and water-saving farming techniques.
- Use of automatic monitoring and recording system to enhance irrigation efficiency
- Promote the system of rice intensification (SRI)
- Reinforce irrigation management
- High-tech cooperative demo greenhouse

Vegetables are grown in areas with relatively stable water supply.
Promote modern water-saving vegetable growing sites.
- Develop and promote pipeline irrigation and water monitoring systems
- Promote irrigation water supply grading and management and monitoring systems
- High-efficiency agricultural water use demo greenhouse

Not suitable for water-consuming crops when water supply is relatively insufficient.
Promote water-saving and energy-saving arid crop areas

Policy Strategies for Water Resources Development

3. Enforce the Holistic Water Saving Movement

Reduce Daily Life Water Consumption | Enhance Agricultural Water Efficiency | **Enhance Industrial Water Efficiency**

Technical Guidance for Factory Water-Saving

- Continuously provide factories with water-saving consultation
- Establish a water-saving technology database
- Organize industrial water saving technology seminars

Enforcement of Industrial Water Conservation

- Promote the reward system for water conservation achievement to profit businesses
- Strengthen industrial water consumption review

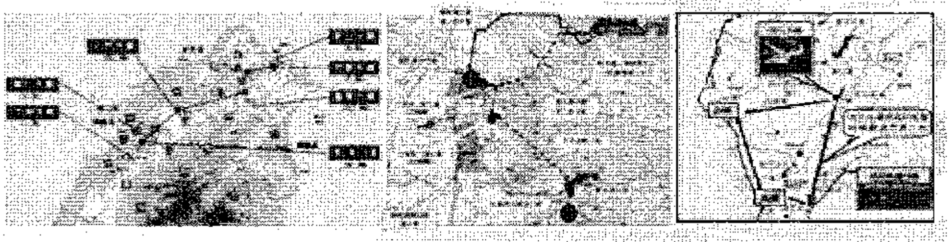
Promotion of the Product Water Footprint Label

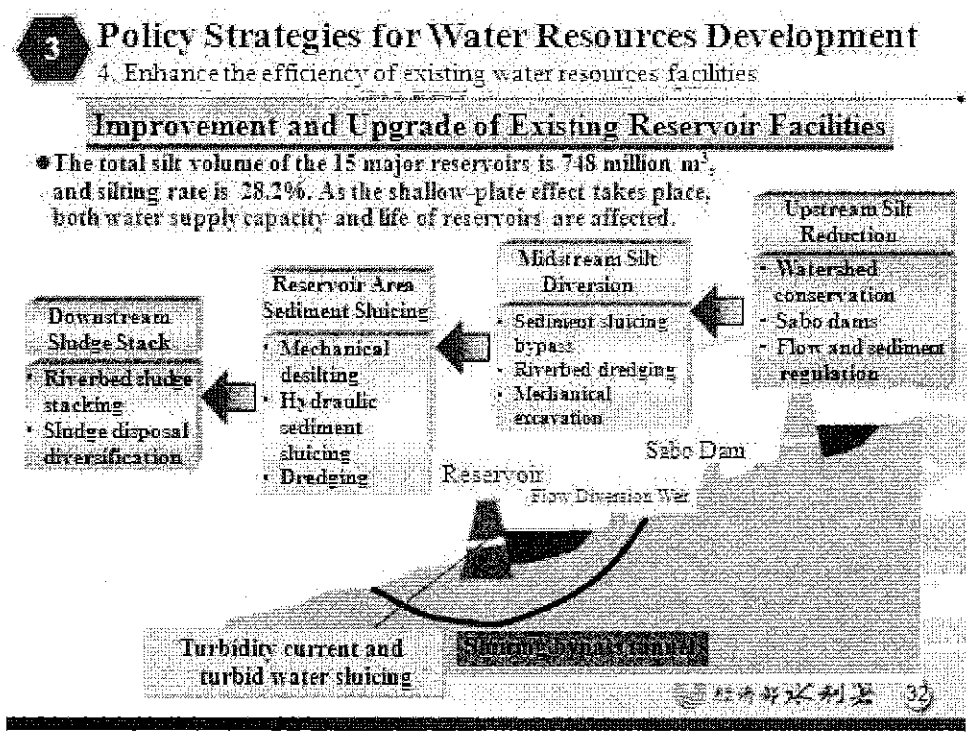
Policy Strategies for Water Resources Development

4. Enhance the efficiency of existing water resources facilities

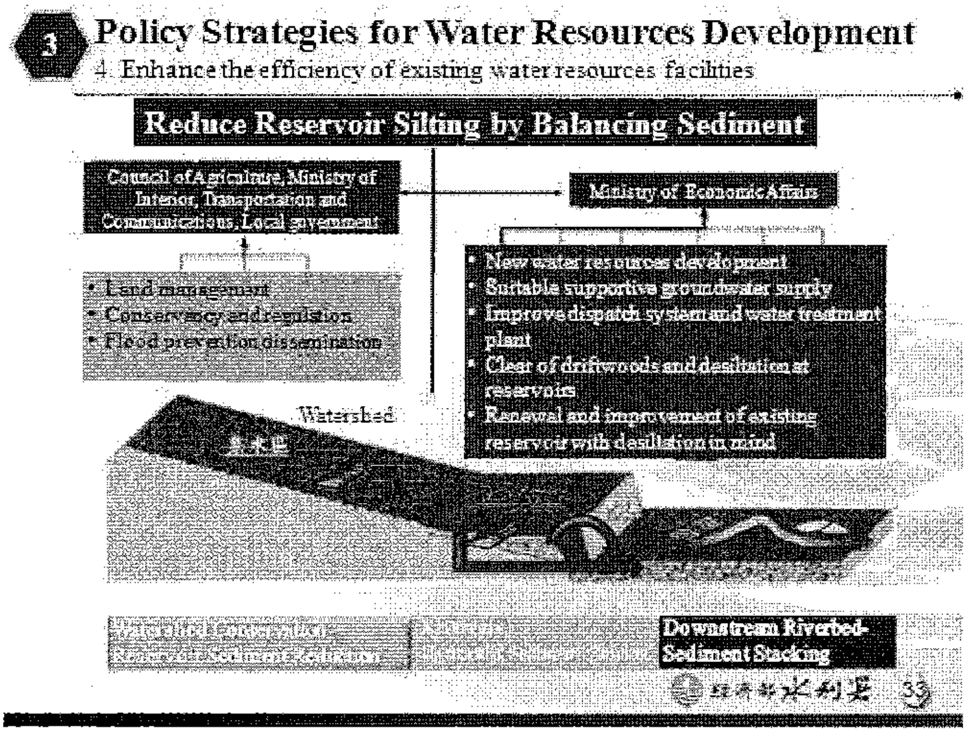
Enhance water resources supply capacity by promoting joint dispatch and use of regional water sources

	Northern Region	Central Region	Southern Region
Reservoir incorporation and dispatch	Shimen Reservoir and Feitsui Reservoir	Liyutan Reservoir and Shigang Dam	Zhengwen Reservoir, Nanhua Reservoir, and Gaoping Weir
Joint use of water sources	Xindian River and Dahan River	Daan River and Dajia River	Zhengwen River and Gaoping River

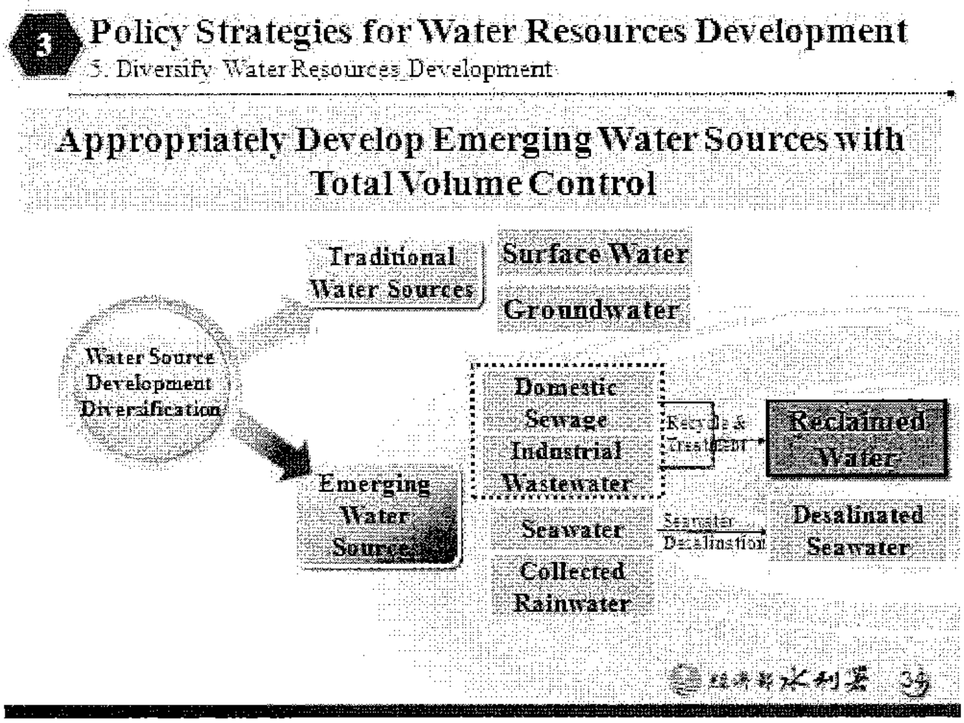




Policy Strategies for Water Resources Development
4. Enhance the efficiency of existing water resources facilities
Improvement and Upgrade of Existing Reservoir Facilities
● The total silt volume of the 15 major reservoirs is 748 million m3, and silting rate is 28.2%. As the shallow-plate effect takes place, both water supply capacity and life of reservoirs are affected.
Upstream Silt Reduction
• Watershed conservation
• Sabo dams
• Flow and sediment regulation
Midstream Silt Diversion
• Sediment sluicing bypass
• Riverbed dredging
• Mechanical excavation
Reservoir Area Sediment Sluicing
• Mechanical desilting
• Hydraulic sediment sluicing
• Dredging
Downstream Sludge Stack
• Riverbed sludge stacking
• Sludge disposal diversification
Sabo Dam
Reservoir
Flow Diversion Weir
Turbidity current and turbid water sluicing
Sluicing bypass tunnel
32



Policy Strategies for Water Resources Development
4. Enhance the efficiency of existing water resources facilities
Reduce Reservoir Silting by Balancing Sediment
Council of Agriculture, Ministry of Interior, Transportation and Communications, Local government
• Land management
• Conservancy and regulation
• Flood prevention dissemination
Ministry of Economic Affairs
• New water resources development
• Suitable supportive groundwater supply
• Improve dispatch system and water treatment plant
• Clear of driftwoods and desiltation at reservoirs
• Renewal and improvement of existing reservoir with desiltation in mind
Watershed
Downstream Riverbed-Sediment Stacking
33



3
Policy Strategies for Water Resources Development
5. Diversify Water Resources Development
Appropriately Develop Emerging Water Sources with Total Volume Control
Traditional Water Sources
Surface Water
Groundwater
Water Source Development Diversification
Domestic Sewage
Industrial Wastewater
Reclaimed Water
Emerging Water Sources
Seawater
Seawater Desalination
Desalinated Seawater
Collected Rainwater
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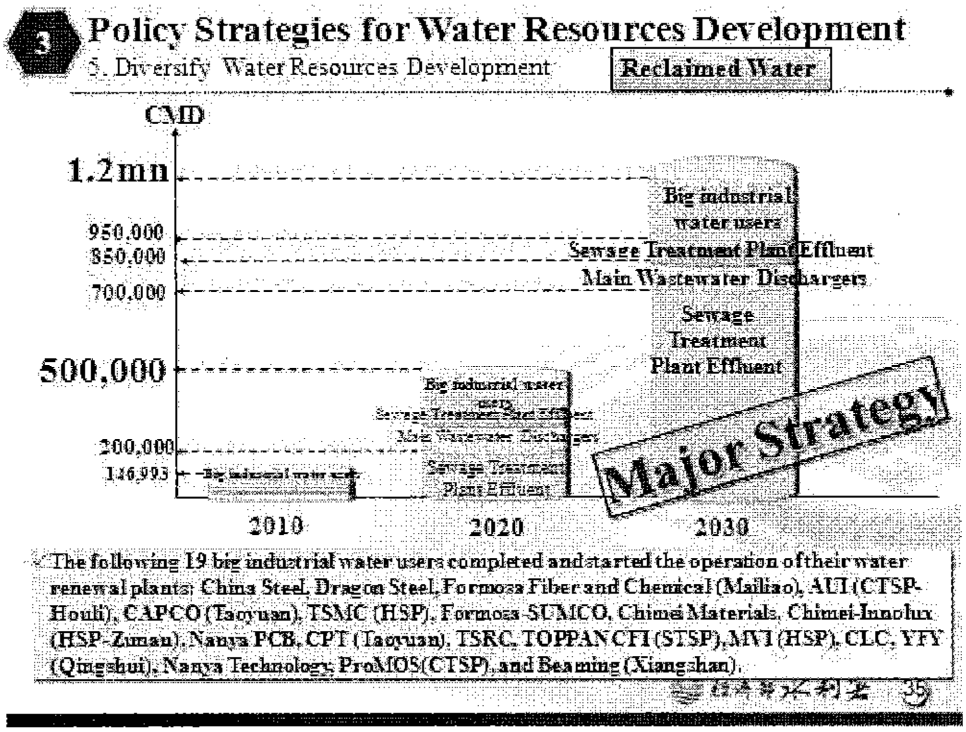

3
Policy Strategies for Water Resources Development
5. Diversify Water Resources Development
Reclaimed Water
CMD
1.2mn
950,000
850,000
700,000
500,000
200,000
146,993
Big industrial water users
Sewage Treatment Plant Effluent
Main Wastewater Dischargers
Sewage Treatment Plant Effluent
Major Strategy
2010
2020
2030
The following 19 big industrial water users completed and started the operation of their water renewal plants: China Steel, Dragon Steel, Formosa Fiber and Chemical (Mailiao), AUI (CTSP-Houli), CAPCO (Taoyuan), TSMC (HSP), Formosa-SUMCO, Chimei Materials, Chimei-Innolux (HSP-Zuman), Nanya PCB, CPT (Taoyuan), TSRC, TOPPAN CFI (STSP), MVI (HSP), CLC, YFY (Qingshui), Nanya Technology, ProMOS(CTSP), and Beaming (Xiangshan).
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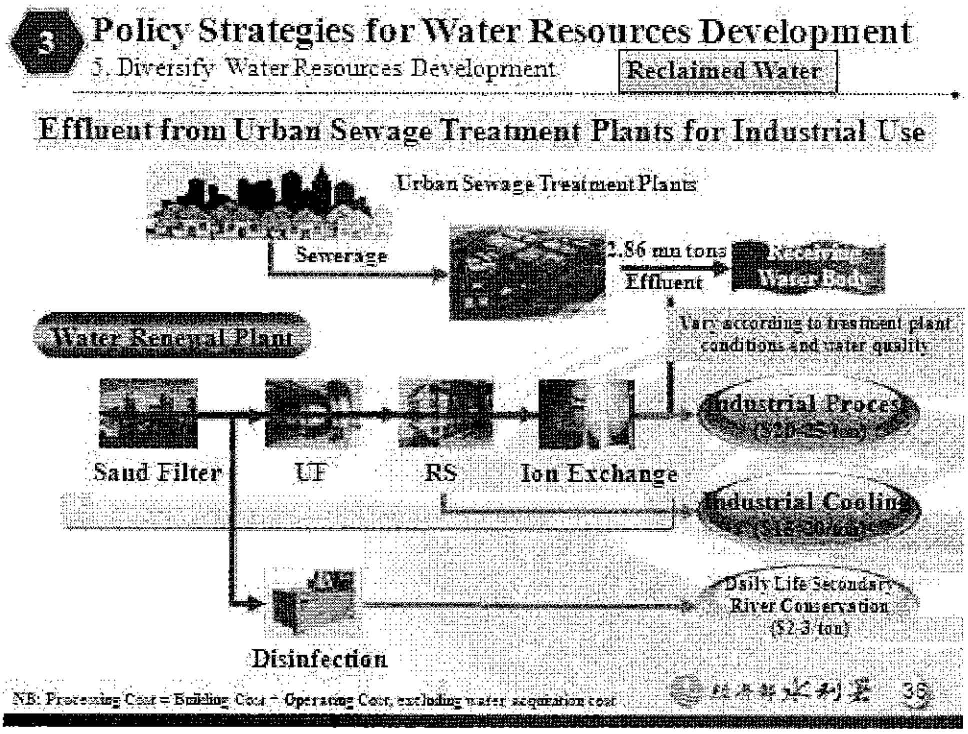
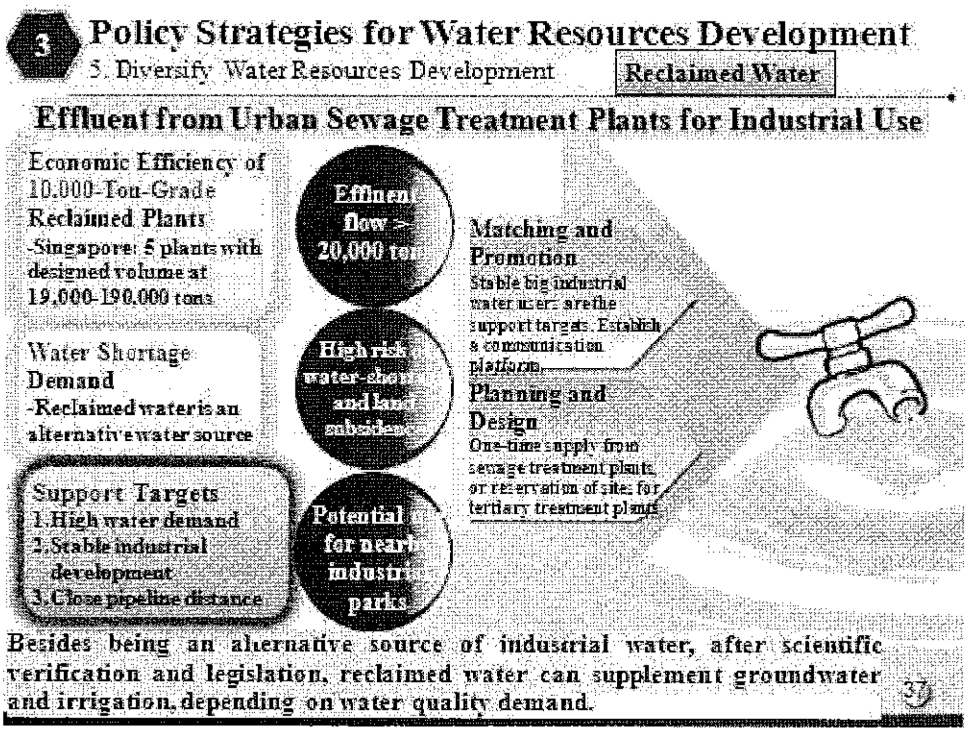

Policy Strategies for Water Resources Development
5. Diversify Water Resources Development
Reclaimed Water
Effluent from Urban Sewage Treatment Plants for Industrial Use
Urban Sewage Treatment Plants
Sewerage
2.86 mn tons
Effluent
Vary according to treatment plant conditions and water quality
Water Renewal Plant
Sand Filter
UF
RS
Ion Exchange
Industrial Process
Industrial Cooling
Daily Life Secondary River Conservation ($2-3/ton)
Disinfection
NB: Processing Cost = Building Cost + Operating Cost, excluding water acquisition cost
36


Policy Strategies for Water Resources Development
5. Diversify Water Resources Development
Reclaimed Water
Effluent from Urban Sewage Treatment Plants for Industrial Use
Economic Efficiency of 10,000-Ton-Grade Reclaimed Plants
-Singapore: 5 plants with designed volume at 19,000-190,000 tons
Water Shortage Demand
-Reclaimed water is an alternative water source
Support Targets
1.High water demand
2.Stable industrial development
3.Close pipeline distance
Effluent flow > 20,000 ton
Potential for nearby industrial parks
Matching and Promotion
Stable big industrial water users are the support targets. Establish a communication platform.
Planning and Design
One-time supply from sewage treatment plants, or reservation of sites for tertiary treatment plants
Besides being an alternative source of industrial water, after scientific verification and legislation, reclaimed water can supplement groundwater and irrigation, depending on water quality demand.
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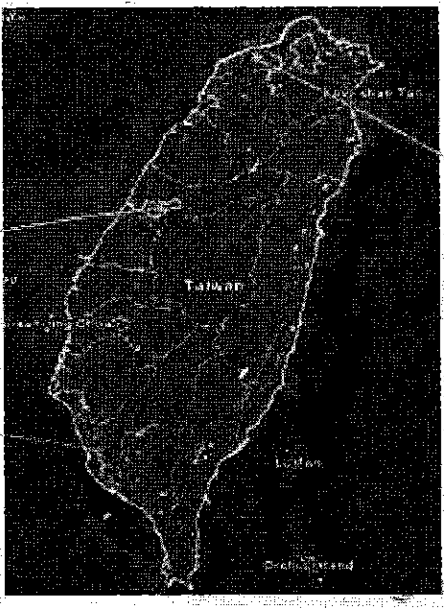
Policy Strategies for Water Resources Development

5. Diversify Water Resources Development **Reclaimed Water**

- Case of Existing Sewage Treatment Plants
- 3 demo plants
- Output: approx 240,000 tons



Taichung Futian Water Recycling Center
55,000/100,000/297,000 CMD for Taichung Harbor Special Industrial Park. 118,500 tons CMD for Dragon Steel through environmental impact assessment. CPDC and CMFC also express intention to use.

Present Effluent Flow/Present Designed Flow/Period-End Designed Flow

Fengshan River Water Treatment Plant
17,000/50,000/110,000 tons CMD for Linhai Industrial Park. China Steel develops a water renewal plant in BOO. It will process 90,000 tons of effluent to output 45,000 tons of water in 2015.

Present Effluent Flow/Present Designed Flow/Period-End Designed Flow

Zhongli Water Recycling Center
0/39,000/157,000 tons CMD for Dayuan and Guanyin industrial parks. Request of Oriental Petrochemical to consume 28,000 tons CDM through environmental impact assessment.

Present Effluent Flow/Present Designed Flow/Period-End Designed Flow

Planning Planed Pilot Plant

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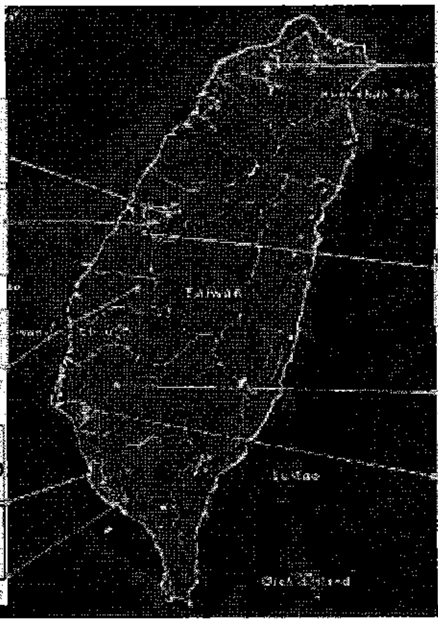
Policy Strategies for Water Resources Development

5. Diversify Water Resources Development **Reclaimed Water**

- Projects with Promotional Potential



Taichung Fengyuan Water Recycling Center
0/30,000/90,000 tons CMD for CTSP-Taichung.

Taichung Dali Water Recycling Center
0/35,000/70,000 CMD for Wuxi River restoration.

Touliu Water Recycling Center
10,000/15,000/20,000 CMD for Yunlin Technology Park

Present Effluent Flow/Projected Flow in 2021/Period-End Designed Flow

Kaohsiung Nanzi Water Recycling Center
40,000/63,000/125,000 tons CMD for Dafen Industrial Park

Kaohsiung Linhai Water Recycling Center
0/20,000/80,000 tons CMD for Linhai Industrial Park

Present Effluent Flow/Projected Flow

Taoyuan Guishan Water Recycling Center
14,000/20,000/35,000 tons CMD for Huaya Industrial Park

Taoyuan Water Recycling Center in Taoyuan
0/50,000/20,000 tons CMD for Dayuan and Guayin industrial parks or Nankang River restoration.

Present Effluent Flow/Projected Flow in 2021/Period-End Designed Flow

Changhua City Water Recycling Center in Changhua
0/15,000/65,000 tons CMD for Changbin Industrial Park

Tainan Yongkang Water Recycling Center
0/29,000/87,000 tons CMD for STSP and Tree Valley Industrial Park

Tainan City Water Recycling Center in Tainan
0/23,000/93,000 tons CMD for STSP-Kaohsiung

Present Effluent Flow/Projected Flow in 2021/Period-End Designed Flow

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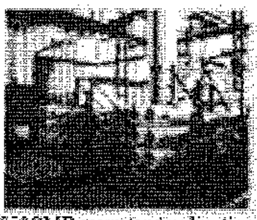
Policy Strategies for Water Resources Development

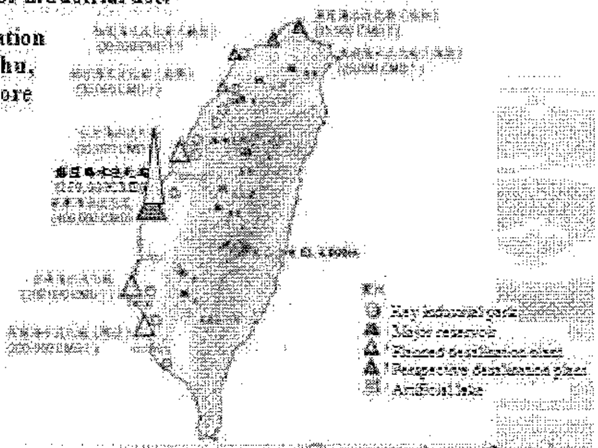
5. Diversify Water Resources Development **Seawater Desalination**

Future Promotion Planning and Targets

- Seawater desalination is a stable water source and mature technology that should be further promoted. In Taiwan, the production cost is $NT30-50/ton, which can be prioritized as backup water for industrial use.
- At present, seawater desalination is planned in Taoyuan, Hsinchu, Tainan, Changbin, and offshore islands.



A 950CMD seawater desalination set in Nangang, Mazu.

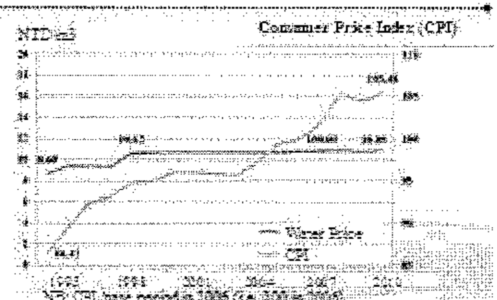


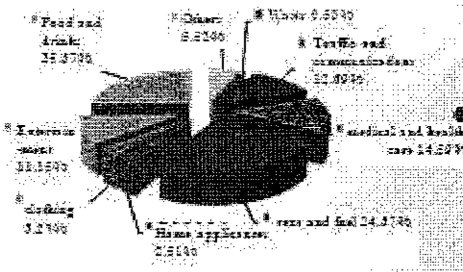
Policy Strategies for Water Resources Development

6. Adjust water price at appropriate times

Present Water Price

- In Taiwan, water bills account for only 0.53% of the family expenses, which is far lower than the 2-4% determined by WHO.



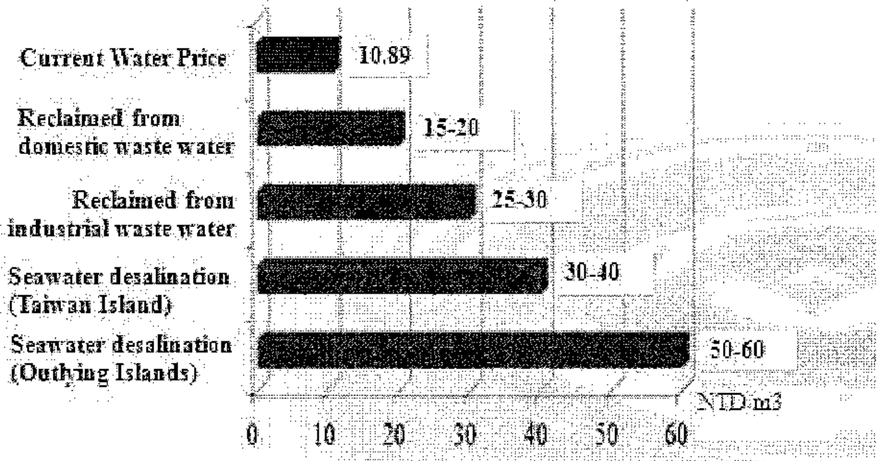


- Water price in Taiwan has not been adjusted according to commodity price fluctuation for 18 years.

Policy Strategies for Water Resources Development

6. Adjust water price at appropriate times

- **Absence of Investment Incentives for Water Businesses and Users**

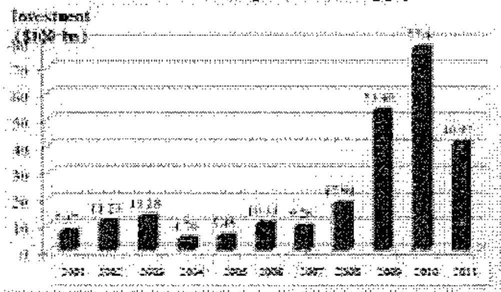


Policy Strategies for Water Resources Development

6. Adjust water price at appropriate times

- **Taiwan Water Corporation is unable to balance its finances and has needed government subsidies for a long time. As a result, it has no funds for equipment upgrade.**

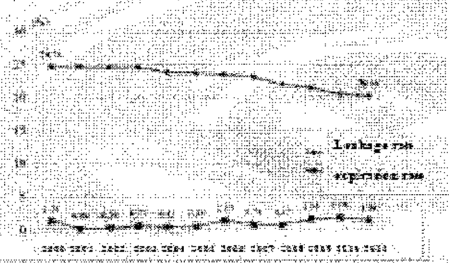
✓ The government must continuously supply the water corporation with funds to maintain uninterrupted water supply.



Government subsidization from 2001-2011: $25,135 billion

✓ Insufficient income from water bills, thus unable to invest in replacement of old pipelines.

Annual Water Leakage Rate and Pipeline Replacement Rate of Taiwan Water Corporation



3 Policy Strategies for Water Resources Development

7. Establish a friendly government-public communication platform

Public Hearing for EIA of Dadu Weir Project Was Suspended- Jan. 26, 2011

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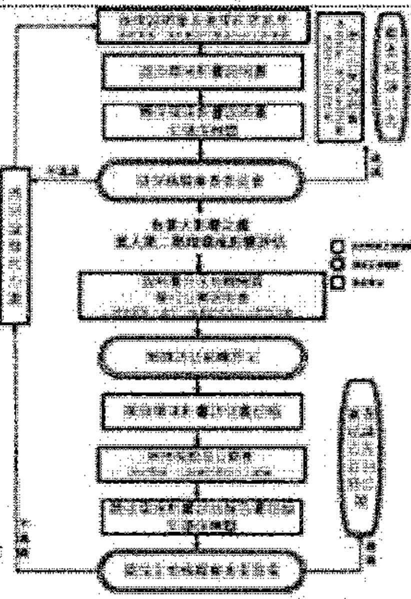
3 Policy Strategies for Water Resources Development

7. Establish a friendly government-public communication platform

➢Establish SOPs

- According to the "SOP of Holding Public Hearing for the Environmental Impact Assessment of Water Resources Project Planning", WRA should invite related agencies, citizen representatives, interested parties, opinion leaders and citizens to participate in and enable public understanding and opinion exchange.



SOP of Holding Public Hearing for the Environmental Impact Assessment

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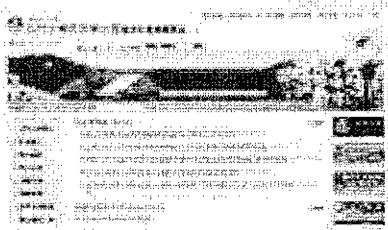
3 Policy Strategies for Water Resources Development

7. Establish a friendly government-public communication platform

➢Real Actions

●Face-to-face communication

●Provide transparent information over a network platform



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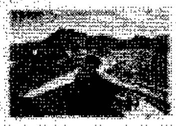
4 Conclusion

- Taiwan receives abundant but spatially and temporally uneven rainfall distribution due to special water environment. It is necessary to make long-term water resources policies and develop strategies in adaptation to the impacts of climate change and extreme weather events.
- Water is a limited resource and subject to depletion. Therefore, the total natural water consumption control should be implemented by means of restricting water demand to maximum possible water supply, especially when climate change and reservoir sedimentation influence the future surface water supply potential. To prevent from groundwater overpumping for agriculture and the resulting land subsidence, the adjustment of agricultural industry structure and promotion of water saving are necessary and urgent.
- Through international cooperation, it's expected the technology to manage irrigation water quality and quantity can be enhanced, and thus the food security and water resources conservation could be achieved.



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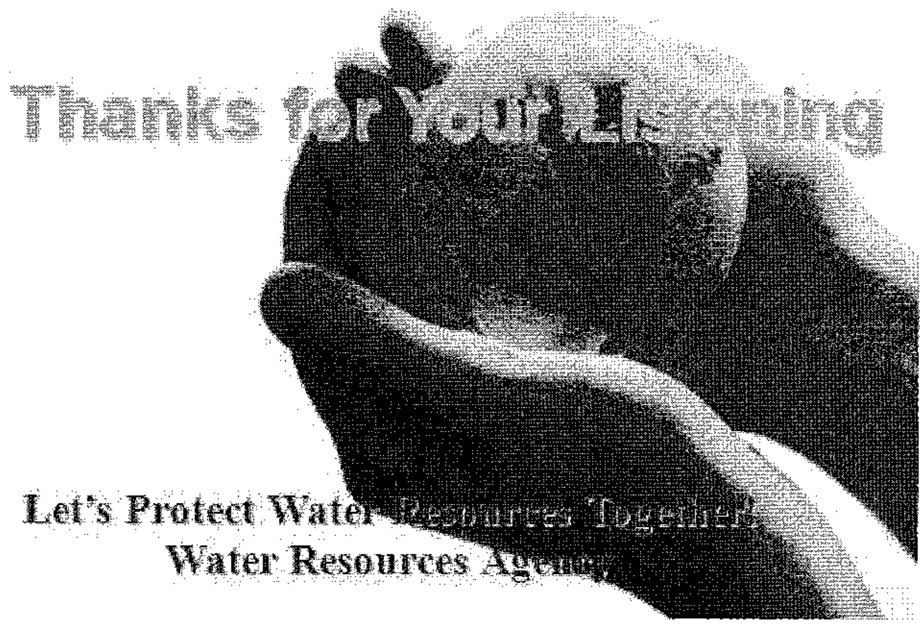
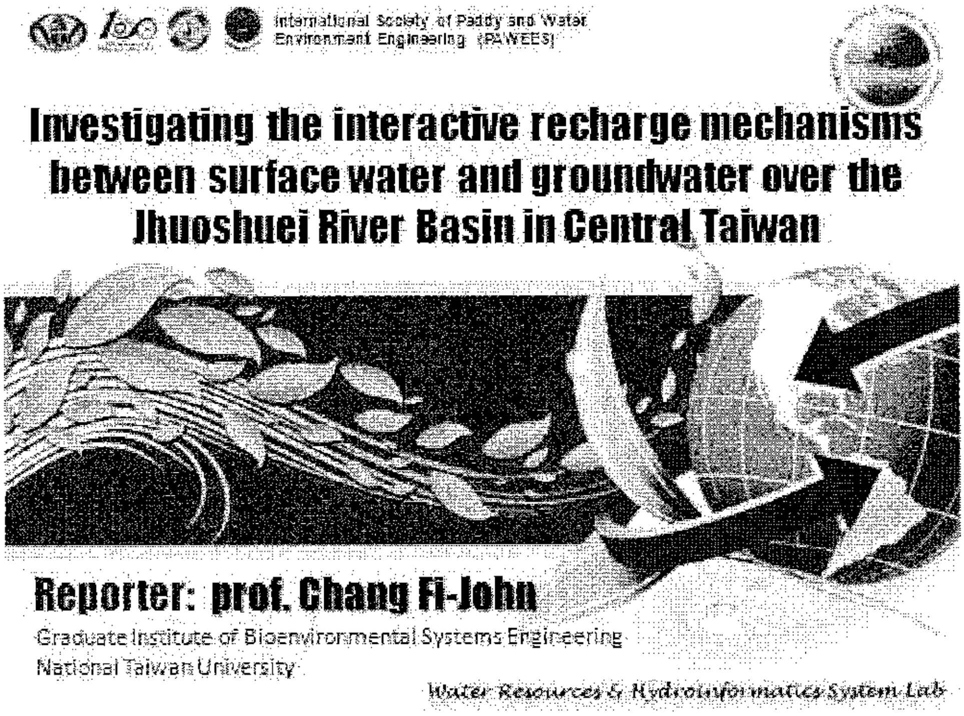
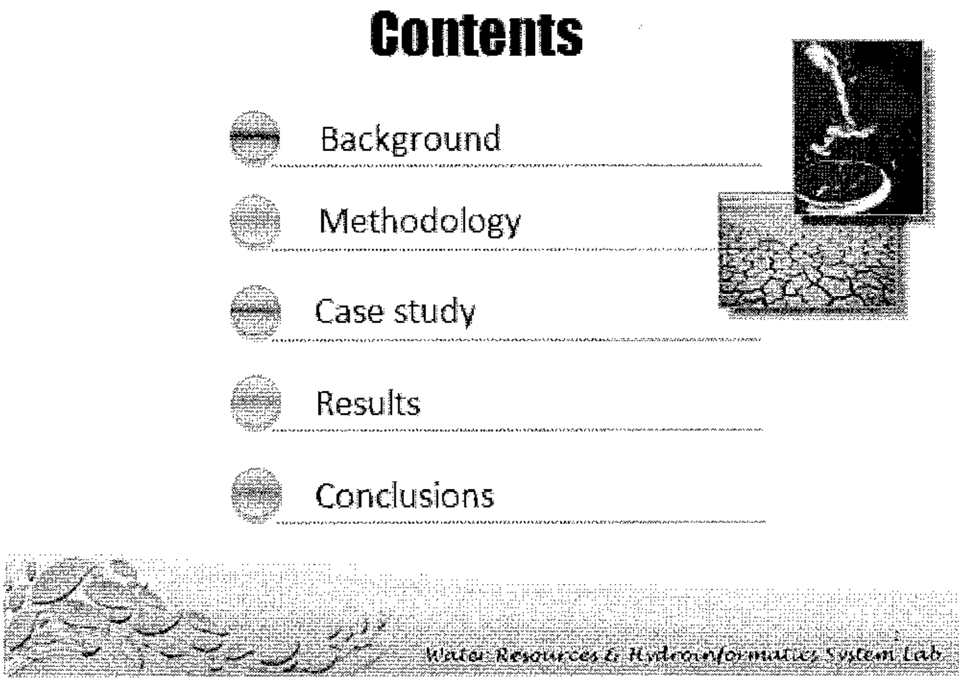

Thanks for Your
Let's Protect Water
Water Resources

附錄三

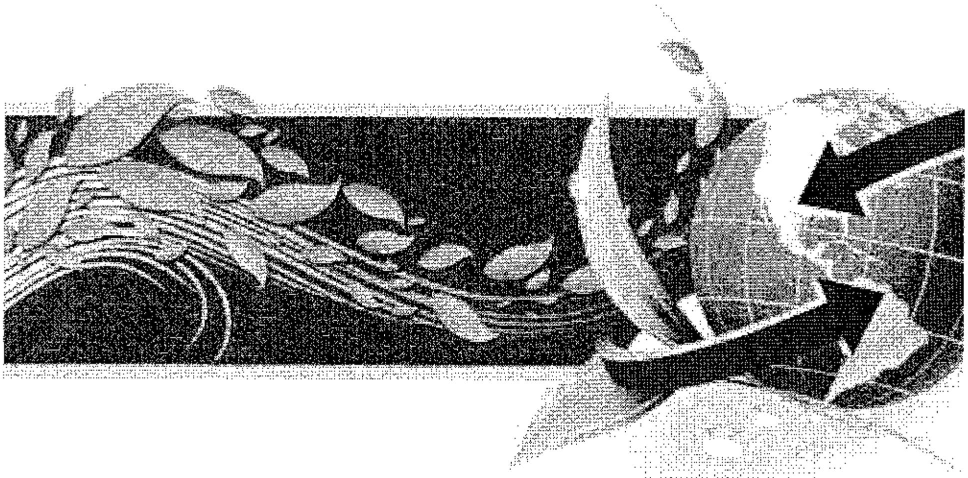


International Society of Paddy and Water Environment Engineering (PAWEES)
Investigating the interactive recharge mechanisms between surface water and groundwater over the Jhuoshuei River Basin in Central Taiwan
Reporter: prof. Chang Fi-John
Graduate Institute of Bioenvironmental Systems Engineering
National Taiwan University
Water Resources & Hydroinformatics System Lab



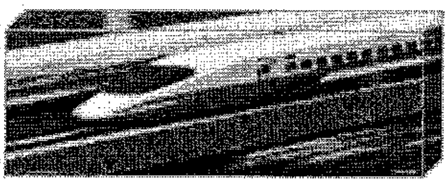
Contents
Background
Methodology
Case study
Results
Conclusions
Water Resources & Hydroinformatics System Lab

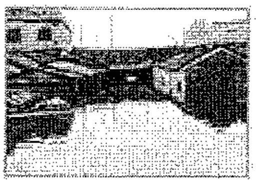
Background



Water Resources & Hydroinformatics System Lab

Background





- Uneven spatial and temporal distribution of rainfall and insufficient water storage facilities in Taiwan
- Due to inappropriate industrial and/or environmental development, **groundwater levels drop seriously** at some coastal areas in Taiwan
- Subsidence phenomenon, seawater intrusion, soil salinization and seawater intrusion results in disasters that cause a dual loss in environment and economy

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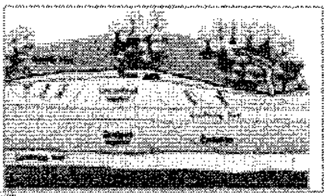
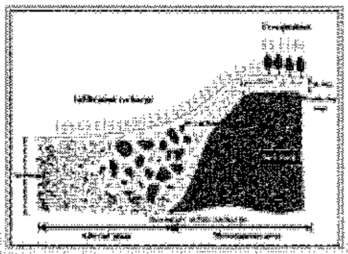
Background

- Groundwater has become an important water source for agricultural, industrial and domestic water users during drought periods and/or at the areas short of water storage facilities

- Groundwater is considered for several features such as low-cost, stable water temperature, constant water quantity, good water quality and easy accessibility





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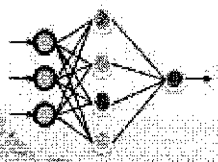
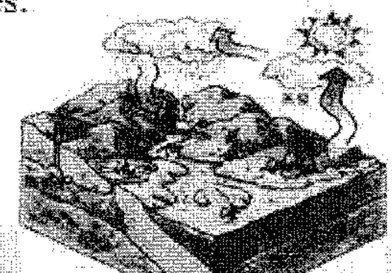
Objective

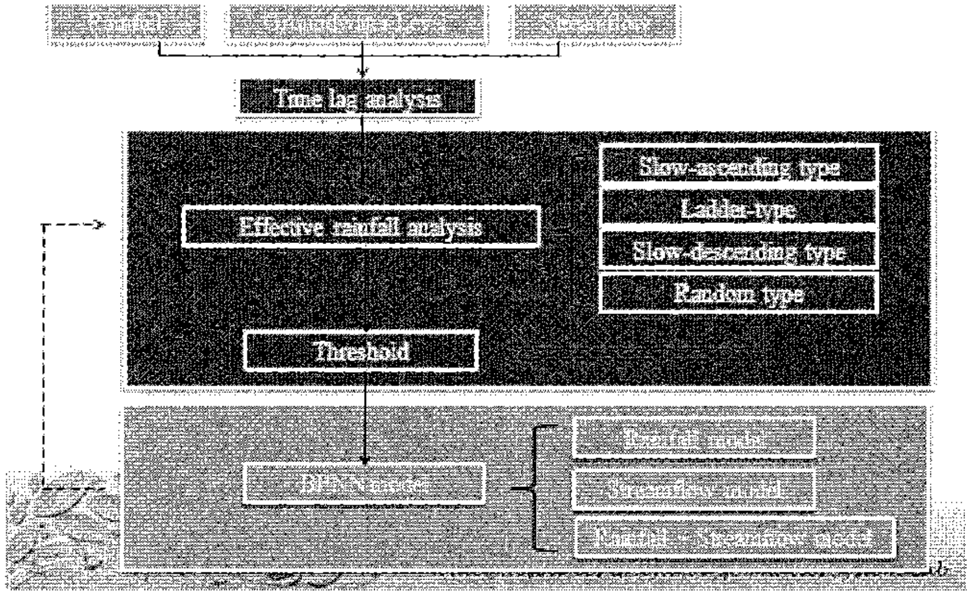
- Understand and investigate the interactive recharge mechanisms between surface water and groundwater over the Jhuoshuei River basin in Central Taiwan by using an artificial neural network coupled with statistical analyses.



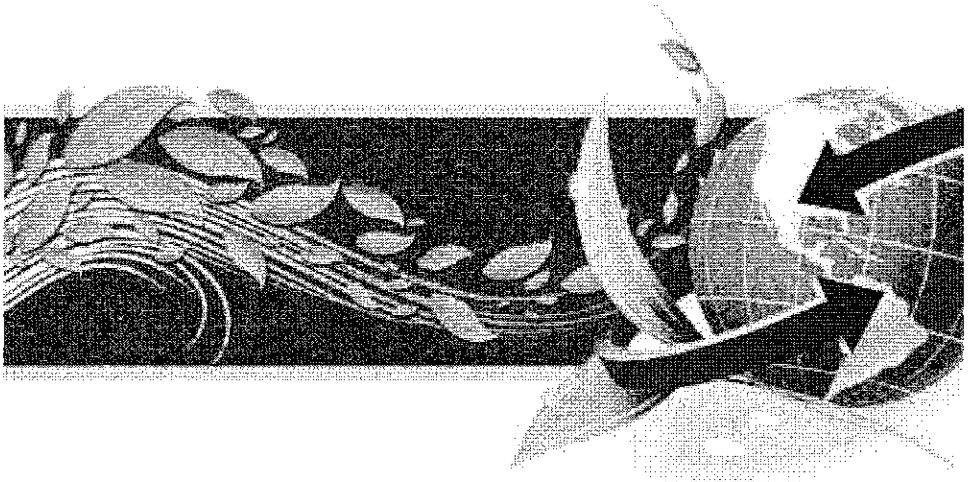


Water Resour

Flow chart of groundwater recharge mechanism



Methodology



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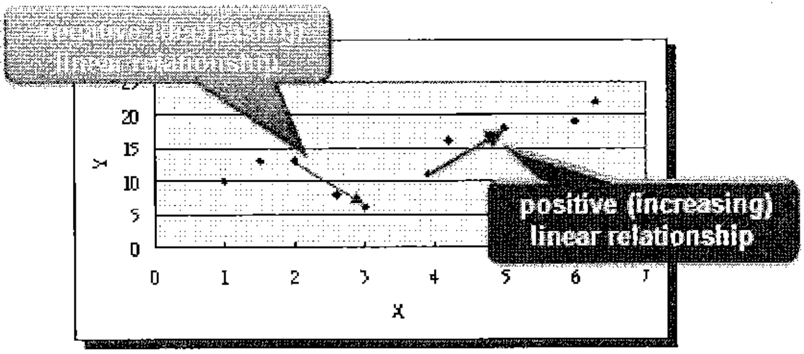
Pearson Correlation Coefficient



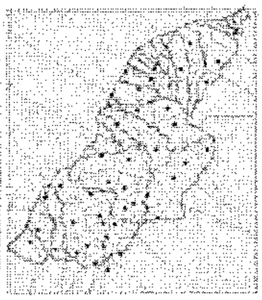
- Measures dependence between two quantities
- Identify time lags between groundwater level variations and rainfall as well as streamflow

Thiessen Polygon Method

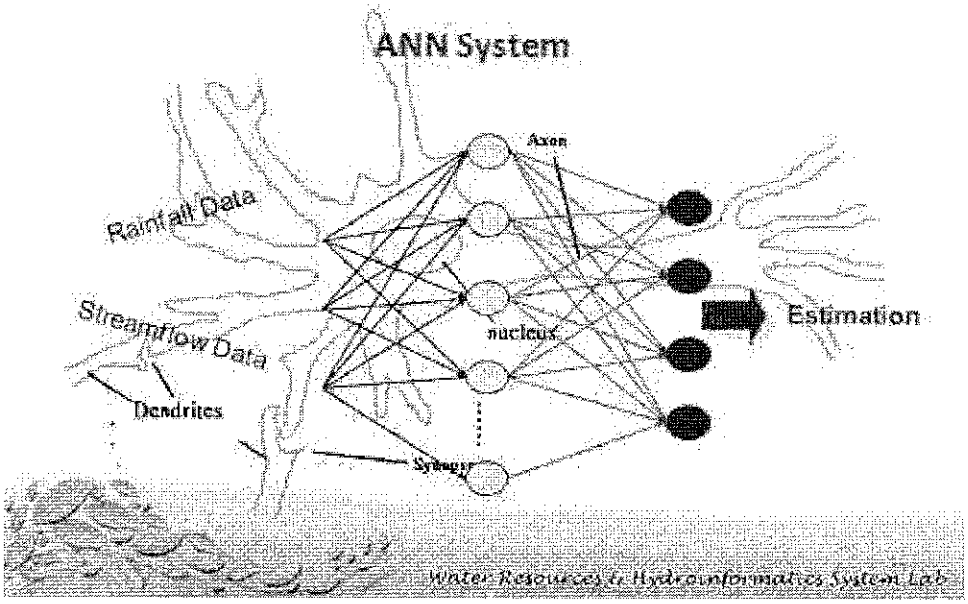
$$\overline{P} = (\sum_{i=1}^{N} P_i A_i)/(\sum_{i=1}^{N} A_i)$$

P ：average rainfall of the area (mm)
N ：the number of rainfall gauging stations of the area
P_i ：rainfall of the i^{th} rainfall gauging station of the area (mm)
A_i ：controlling area (m^2)

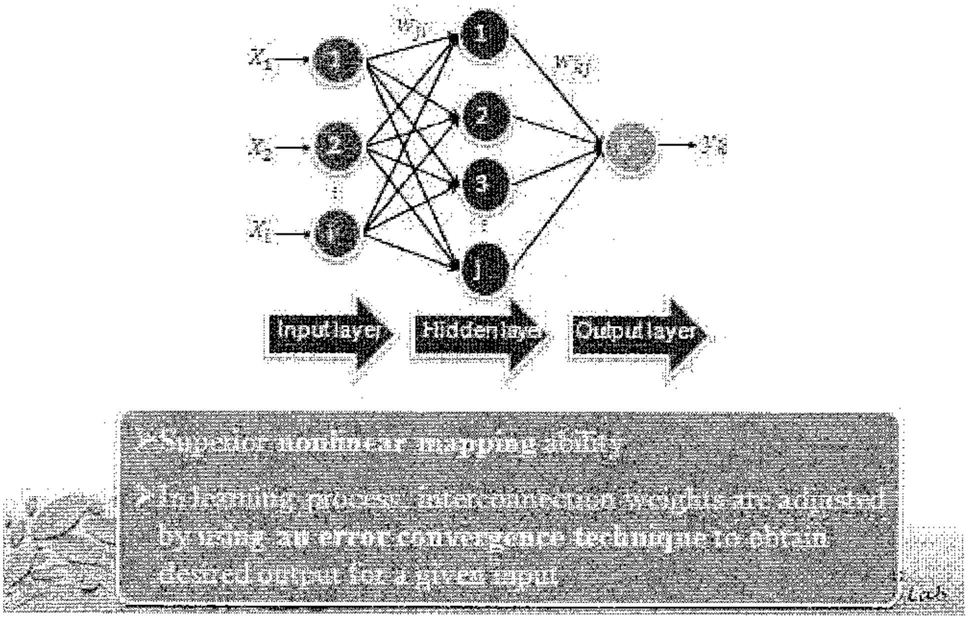
- ➢ Concept of weighting
- ➢ Approximate relative significance of data from points scattered arbitrarily across an area
- ➢ Easier to calculate than Isohyetal method



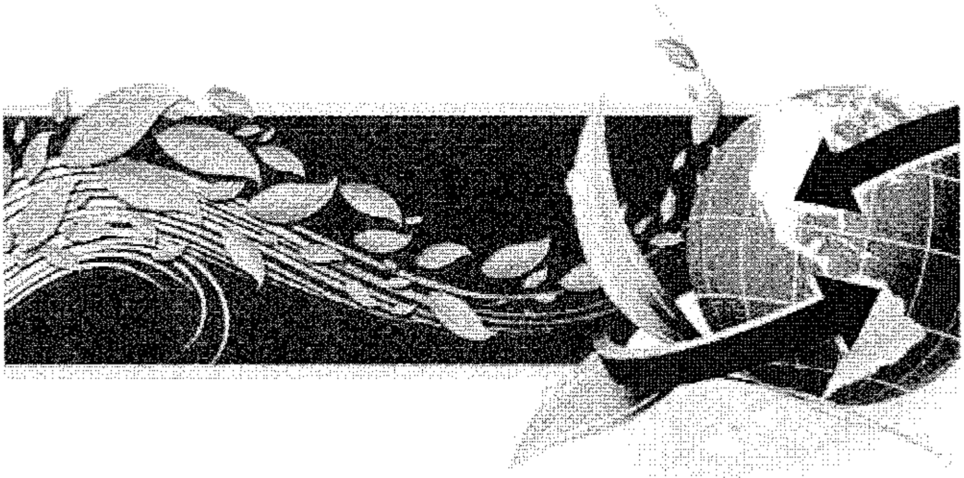
Artificial Neural Network



Back-Propagation Neural Network (BPNN)

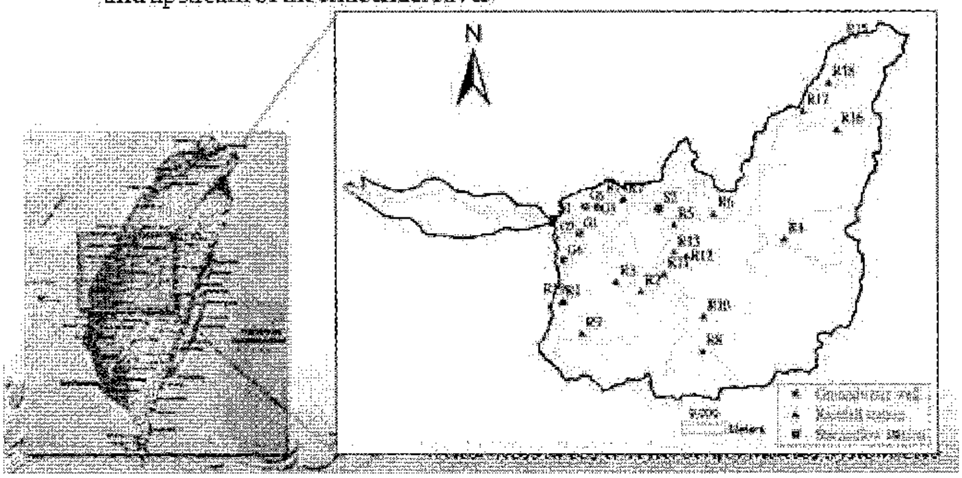


Case study



Jhuoshuei River basin in Central Taiwan

- Groundwater level monitoring wells were built over the pass
- Streamflow and rainfall gauging stations are located at the midstream and upstream of the Jhuoshuei River



Data collection

- Collection period of daily data ranged from 2001 to 2010 over a total of 8 rainfall gauging stations, 4 streamflow gauging stations and 8 groundwater level monitoring wells
- Missing data were infilled by using linear regression techniques based on the data of surrounding gauging stations

statistics of eight groundwater level monitoring wells

Monitoring well	Well depth (m)	Groundwater level (m)				
		Max	Min	Average	SD[1]	Variance
G1(1)	102.6	146.6	138.5	141.8	1.91	3.65
G1(2)	199.3	145.4	136.3	142.7	1.53	2.33
G2(1)	204.5	202.2	189.9	196.0	2.69	7.25
G3(1)	24.1	176.0	167.5	169.2	1.06	1.12
G4(1)	52.0	169.1	161.5	166.5	0.75	0.56
G4(2)	102.0	170.4	164.4	167.5	0.89	0.79
G5(1)	78.2	145.2	133.0	137.7	2.24	5.00
G5(2)	193.2	139.5	132.2	135.6	1.50	2.24

Result and Discussion

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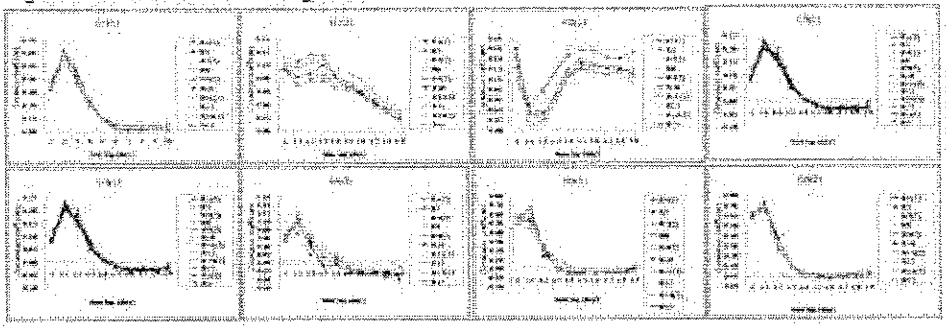
Time delay analysis - rainfall

Correlation between groundwater level variation and rainfall of different time lags at groundwater level monitoring wells



Rainfall on the previous day prior to current day 【R(t-1)】 is determined as an input to the BPNN model for estimating groundwater level variations

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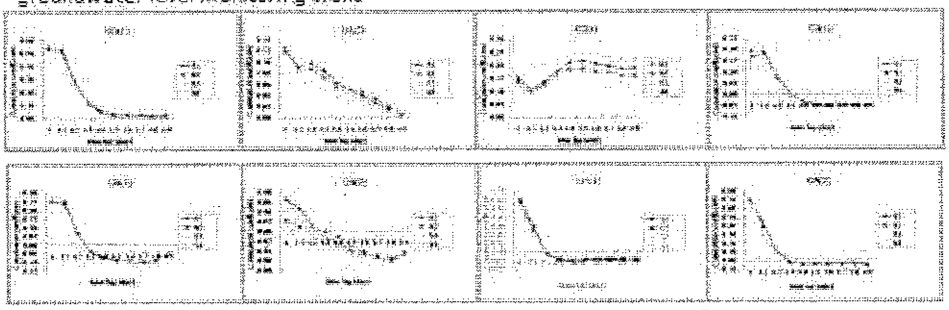
Time delay analysis - streamflow

Correlation between groundwater level variation and streamflow of different time lags at groundwater level monitoring wells



Streamflow on the 【current day】 is determined as an input to the BPNN model for estimating groundwater level variations

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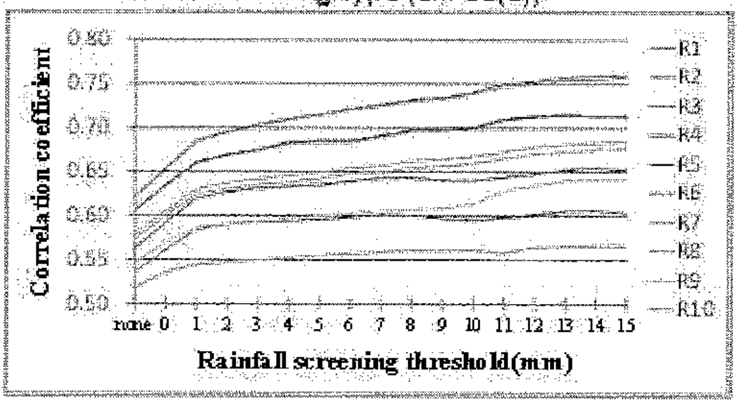
Effective rainfall threshold analysis

Slow-ascending type (ex: G1(1))



After filtering out rainfall data below threshold of 2 mm, correlation between groundwater level variations and rainfall significantly improves and shows an ascending trend.

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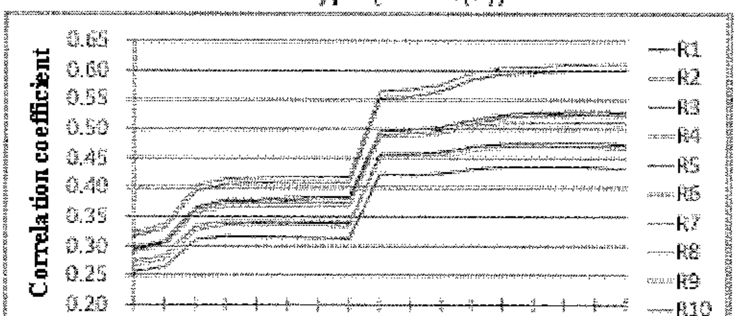
Effective rainfall threshold analysis

Ladder-type (ex: G4(1))



Sudden increases in the correlation coefficients occur at rainfall screening thresholds of 1 mm and 7 mm

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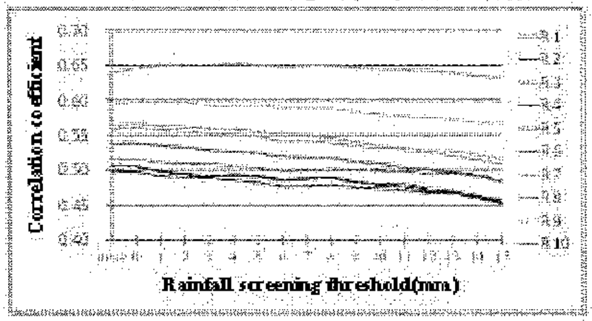
Effective rainfall threshold analysis

Slow-descending type (ex: G5(1))



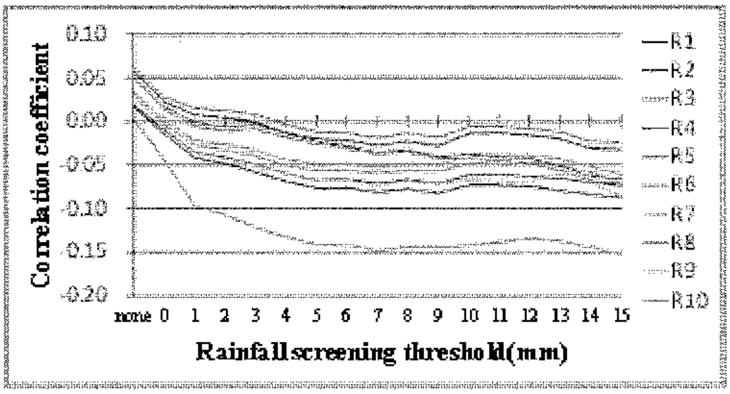
Correlation between groundwater level variations and rainfall decreases and shows a descending trend

[illegible] matter how high the rainfall intensity is

The use of rainfall thresholds would reduce correlation between groundwater level variations and rainfall

Effective rainfall threshold analysis

Random type (ex: G2(1))



Impact of recharge from rainfall to groundwater is comparatively small for deep-depth wells

Estimation model of groundwater level variations

*Model with threshold

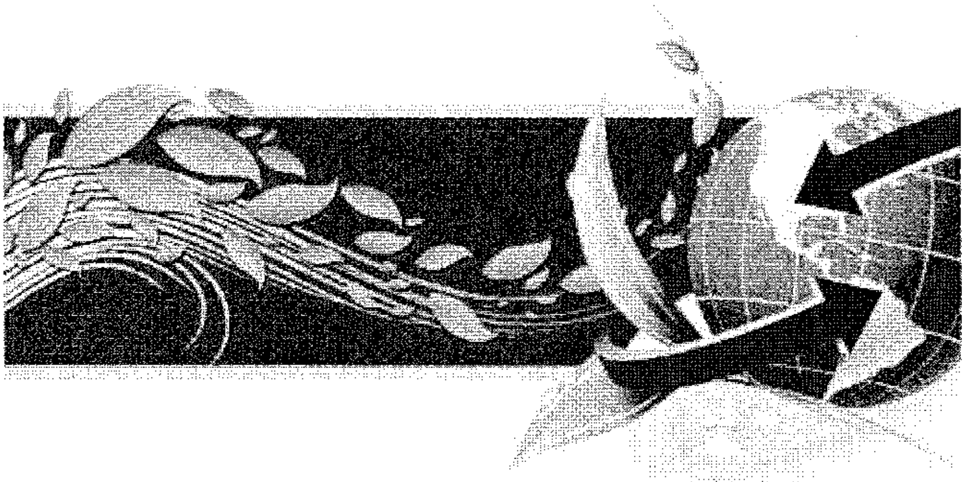
Well	Input combination	Correlation coefficient			RMSE (m)		
		training	validation	testing	training	validation	testing
G1(1) [threshold: 1 mm, well depth: 102.6 m]							
	Streamflow	0.67	0.66	0.66	0.08	0.07	0.10
	Rainfall	0.77	0.76	0.75 8%	0.06	0.08	0.07
	Streamflow*	0.75	0.74	7% 0.71	0.09	0.09	0.11
	Rainfall*	0.81	0.81	0.80	0.08	0.08	0.08
	Rainfall+Streamflow*	0.84	0.83	0.91	0.07	0.07	0.07
G2(1) [threshold: 6 mm, well depth: 78.2 m]							
	Streamflow	0.83	0.83	0.86	0.17	0.15	0.13
	Rainfall	0.81	0.82	0.77	0.16	0.18	0.19
	Streamflow*	0.83	0.84	0.87	0.15	0.19	0.22
	Rainfall*	0.83	0.83	0.81	0.17	0.20	0.17
	Rainfall+Streamflow*	0.88	0.90	0.89	0.15	0.15	0.15

Estimation model of groundwater level variations

*Model with threshold

Well	Input combination	Correlation coefficient			RMSE (m)		
		training	validation	testing	training	validation	testing
G3(1) [threshold: 5 mm, well depth: 24.1 m]							
	Streamflow	0.38	0.31	0.25	0.12	0.15	0.42
	Rainfall	0.63	0.49	0.43 148%	0.15	0.14	0.22
	Streamflow*	0.59	0.61	91% 0.62	0.13	0.12	0.23
	Rainfall*	0.78	0.78	0.82	0.11	0.18	0.10
	Rainfall+Streamflow*	0.87	0.85	0.82	0.10	0.09	0.12
G4(1) [threshold: 7 mm, well depth: 52 m]							
	Streamflow	0.41	0.31	0.37	0.17	0.30	0.12
	Rainfall	0.44	0.40	0.43 70%	0.19	0.24	0.12
	Streamflow*	0.69	0.65	91% 0.63	0.16	0.13	0.14
	Rainfall*	0.82	0.85	0.82	0.11	0.12	0.12
	Rainfall+Streamflow*	0.89	0.93	0.82	0.08	0.11	0.15

Conclusion



- Current groundwater level variation (t) is related to rainfall of previous day (t-1)
- Current groundwater level variation (t) is related to current streamflow (t)

- Clay layers in aquifers can well separate shallow and deep wells
- Gravel layers in aquifers make the shallow and deep wells have similar groundwater level variation trends

- The correlations between groundwater level variations and rainfall with threshold show four types of patterns: slow-ascending type; ladder-type; slow-descending type; and random type

- Investigates groundwater recharge mechanism at mountainous areas by BPNN
- BPNN models perform rather well because observations and estimations have high correlations and small RMSE values
- Estimation models with both rainfall and streamflow as inputs perform the best

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- Groundwater level variations of groundwater level monitoring well right next to the Jhuoshui River are significantly influenced by the lateral recharge from the river
  - Streamflow model can better estimate than rainfall model
- Groundwater level variations of groundwater level monitoring wells far from the Zhuoshui River are less influenced by the lateral recharge from the river
  - Rainfall models can outperform the streamflow models

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- More understanding about the **interactive recharge mechanism** between mountainous water resources and groundwater

- **Facilitate**
  - discussion on mountainous water resource conservation strategy for alleviating land subsidence in downstream areas
  - influence of hydraulic structures on infiltration during rainfall events
  - soil erosion reduction

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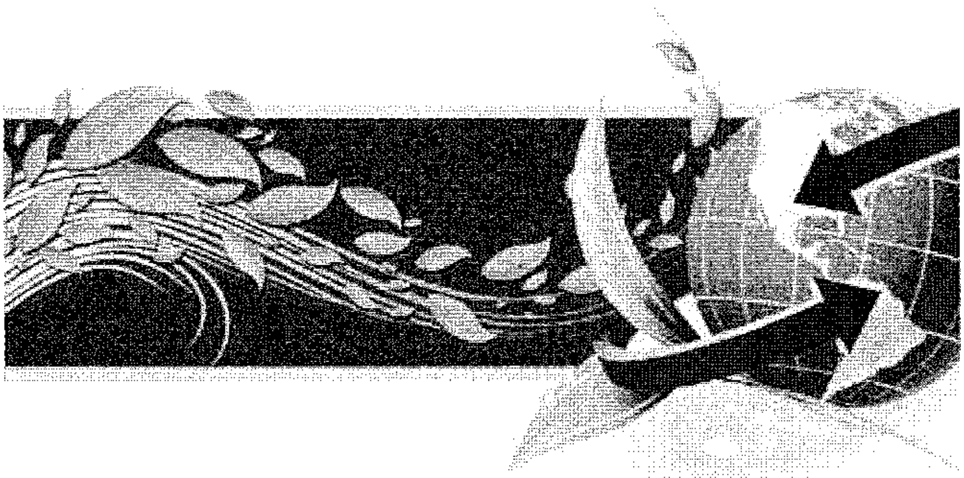
Thanks for your attention



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附錄四

PROGRAMME (Day 1)
PAWEES 2012 International Conference

DAY 1: 27 November 2012 (Tuesday) Venue: XujatKambhu Convention Hall

08.30	**Registration**	
[illegible]		
09.00	**Conference Report**	**Dr. Boonsom Lerdhirunwong** Dean of Faculty of Engineering, CU
09.05	**Opening Speech**	**Dr. Pirom Kamol-ratanakul** President of Chulalongkorn University
09.10	**Opening Speech**	**Dr. Siree Chaiseri** Vice President of Kasetsart University
09.15	**Opening Remarks**	**Dr. Tai-cheol Kim** President of PAWEES
09.20	**Keynote Speech**	**Mr. Lertviroj Kowattana** Director General of RID
09.45	**Global and regional food security with special attention on rice,water and environment**	**Mr. Hiroyuki Konuma** Assistant Director General of FAO
10.10	**Coffee break**	
[illegible]		
10.30	**Session A** Climate Change and Uncertainty	**Dr. Jin Soo Kim** President-elect of KSAE
10.50	**Session B** Participatory Management for Irrigation Projects	**Mr.Va-Son Boonkird** Royal Irrigation Department
11.10	**Session C** Emerging Technologies in Water Management	**Mr. Wei-Fuu Yang** President of TAES, Taiwan
11.30	**Session C** Emerging Technologies in Water Management	**Prof. Fi-John Chang** National Taiwan University
11.50	**Radioactive contamination of paddy soil and its transfer to rice in Fukushima**	**Dr. Sho Shiozawa** President of JSIDE
12.10	**Lunch break**	
[illegible]		
14.40	**Coffee break**	
[illegible]		
18.00	**Reception Dinner**(For registration participants)	

DAY 1 (November 27, 2012) Plenary session presentation Venue: Learning Building 2

	ID	[illegible]	ID	Session B Participatory Management for Irrigation Projects Venue: 1st fl Lecture Room C12	ID	[illegible]
	ID	Chair: Assoc. Prof. Dr. Nuchanart Sriwongsitanon, KU	ID	Chair: Prof. Joongdae Choi , Korea	ID	Chair: Dr. Aksara Putthividhya, CU
13:00	-	Invited paper: Farmers' responses to climate change adaptation in irrigation project (Thailand Case Study) Assoc. Prof. Chaiyuth Sukhsri, Chulalongkorn University, Thailand	033	Paper B1: Irrigation Vulnerable Duration Assessment using Distribution of Agricultural Water Supply and Demand Nam, W.-H.*, T. Kim, J.-Y. Choi, J.J. Lee	012	Paper C1: Assessing Flood Damages of Rice in the Chao Phraya Delta, Using MODIS Satellite Imageries Kotera, A.*, T. Nagano
13:20	008	Paper A1: Simulation of GHG emission from paddy by DNDC model for climate change impact in Korea Shin, M., J. Jang, Y. Sung, J. Choi	044	Paper B2: Assessment of Farmer Participation in Irrigation Management for Paddy Irrigation Development in Myanmar Naing, M.M.*, Z.-M. Htut	015	Paper C2: Optimizing Non-Flooded Irrigation under System of Rice Intensification Crop Management using Genetic Algorithms Arif, C.*, M. Mizoguchi, B.I. Setiawan, R. Doi
13:40	025	Paper A2: Coping with uncertainties in climate change by stochastic storm rainfall simulation Cheng, K.-S.*, Y.-C. Wu, Y.-F. Su, J.-J. Liou	045	Paper B3: Impact of Participatory Approaches on Irrigation Development and Management for Communal Irrigation System (CIS): Case Studies in three provinces of North Philippines Balderama, Orlando F.	018	Paper C3: Investigating the interactive recharge mechanisms between surface water and groundwater over the Jhuoshuei River Basin in Central Taiwan Chang, Fi-John et al.
14:00	032	Paper A3: The study to parameter sensitivity analysis of the Denitrification-Decomposition (DNDC) model Vanichsan, D.*, and B. Kaonyuen	071	Paper B4: Investigation of paddy field irrigation activities by farmers aiming for demand-oriented irrigation service Iida, T.*, M. Kimura, K. Yoshida, N. Kubo, T. Yokoi	023	Paper C4: A Bayesian Uncertainty Analysis of the Modeled Surface- and Ground-Water Flows in an Agricultural Watershed Imagawa, C.*, J. Hendon
14:20	046	Paper A4: Climate Change Impact Assessment in Sukhothai Province: Intercomparison between Three Global Climate Models Hanittinan, P.*, S. Koontanakulvong			024	Paper C5: A Study on Drainage Efficiency of Shortcut Canal Project in the Lower Thachin River Intaboot, N.*, W. Taesombat
14:40				Coffee break		
		[illegible]		[illegible]		[illegible]
	ID	Chair: Prof. Chaiyuth Sukhsri, CU	ID	Chair: Mr. Boonyong Phyasitrinon , RID	ID	Chair: Assoc. Prof. Dr. Suwattana Jidaladakorn, KU
15:00	049	Paper A5: Probability based assessment of Climate Change Impact on Irrigation Systems in Upper Chao Phraya Basin Koontanakulvong, S.*, C. Suthidhummajit	031	Paper C6: Drought response mode by farmers after decreasing water supply Tanji, H.*, H. Kiri and T. Nakaya	061	Paper C12: System of Environment-Economic Accounting for Water in case of Thailand Suttinon, P.*, and S. Nasu
15:20	051	Paper A6: Assessment of Climate Change Impact on Agricultural Water Supply Capacity Using SWAT and MODSIM models Ahn, S.R.*, R. Ha, and S.J. Kim	036	Paper C7: Development of Automated Irrigation System for Food Production Land Saptomo, S.K.*, B.I. Setiawan	062	Paper C13: Application of Input-Output Table for future water resources management under policy and climate change in Thailand: Rayong Province Case study Jamparti, D.*, P. Suttinon, S. Nasu and S. Koontanakulvong
15:40	052	Paper A7: Assessment of Climate Change Impact on Multi-purpose Dam based on RCP emission scenarios Using SLURP model Ha, R.*, S.R. Ahn, and S.-J. Kim	047	Paper C8: Satellite Data Application for food simulation Pakdeesung, K.*, S. Koontanakulvong, A. Srisaywat	053	Paper C14: Water Footprint of Bioethanol Production in Thailand Sukumalchart, T.*, A. Pornprommin, S. Lipiwattanakarn
16:00	057	Paper A8: Mitigation Method of Irrigation Systems against Climate Change in the Chao Phraya Basin, Thailand Miyazato, T., K. Higuchi*, and H. Watanabe	048	Paper C9: Statistical Forecasting of Rainfall and Runoff by ENSO index in Chao Phraya River Basin in Thailand Chaowiwat, W.*, S. Koontanakulvong	055	Paper C15: Development of a Float Type Optical Water Level Measurement by Image Processing Technique: Field Experiment Binvimone, C.*, V. Vudhivanich, P. Chuaiguk
16:20	075	Paper A9: Analysis Framework for Water Resource Policy Decision-Making under Effects of Climate Change N. Bongochgetsakul, P. Suttinon, K. Uemoto, S. Nasu	056	Paper C10: Estimation of Streamflow by SWAT Model in Sedone River Basin, LAO P.D.R Kimala, V.* and E. Koutsakucha	073	Paper C16: Estimation of Optimum Planting Date of Cassava after Rice based on Real-time monitoring data using Field Monitoring System in Rain-fed upper paddy field in Northeast Thailand Srisutham, M., M. Mizoguchi, A. Polthanee, R. Doi
16:40			059	Paper C11: Yoshino and Han River Basins Development and Management Comparative Study Putthividhya, A.*, S. Koontanakulvong, and F. Hokungwan	077	Paper C17: Regional difference in the citizen's consciousness of water resources Uemoto, K.*, P. Suttinon, N. Bongochgetsakul, S. Nasu

DAY 2 (November 28, 2012) Plenary session presentation Venue: Learning Building 2

	ID	Session D Environmental Sustainability in Paddy Irrigation and Drainage Venue: 1st fl Lecture Room C11	ID	Session D Environmental Sustainability in Paddy Irrigation and Drainage Venue: 1st fl Lecture Room C12	ID	Session D Environmental Sustainability in Paddy Irrigation and Drainage Venue: 2nd fl Lecture Room C14
	ID	Chair: Assoc. Prof. Dr. Kobkiat Pongput, KU	ID	Chair: Prof. Seong-Joon Kim, Korea	ID	Chair: Prof. Nobumasa Hatcho, Japan
09:00	001	Paper D1: Can Asian Experience be transferred to Africa? -Lessons Learned from Drafting a Rice Production Manual in Africa Fujimoto, N.*, K. Osuga and C. Hirose	013	Paper D6: Genetic diversities and population structures of small freshwater fishes in Mekong River basin Koizumi, N.*, S. Morioka, A. Mori, B. Vongvichith, K. Nishida, K. Watabe and T. Takemura	027	Paper D11: Habitat potential maps of three frog species for paddy field areas of the middle Sakura River basin, Japan Watabe, K.*, A. Mori, N. Koizumi, T. Takemura and K. Nishida
09:20	002	Paper D2: Water Quality Constituents Export from Paddy Field in Southern Korea Yoon, K.-S.*, D.H. Choi, J.W. Jung, W.J Choi, K.S. Lee, S.J. Lim	014	Paper D7: Characteristics of Drainage Water Quality and Loading from Paddy Field under Cyclic Irrigation and its Management Options Kunihara, K.*, Y. Matsuno, and N. Hatcho	040	Paper D12: Challenges in the decontamination of radioactive cesium of Fukushima: a rural planning perspective Hashimoto, S.*, H. Arita, T. Yasutaka and Y. Iwasaki
09:40	006	Paper D3: Evaluation of field Measurements and Estimated Rice Crop Water Requirement Maina M. M.*, M. S. M. Amin, W. Aimrun, A. Samsuzana	017	Paper D8: Estimating Regional Total Phosphate Concentration in a River Basin through the NARX network Chang, Fi-John et al.	058	Paper D13: Soil Macro Nutrient (N, P, K) during Growth Stages under Conventional and SRI (System of Rice Intensification) Practices in Tropical Soil Ardiansyah*, Masrushi, C. Arif, S.K. Saptomo, B.I. Setiawan
10:00	007	Paper D4: Effect of Rice Straw (Rs) Mulch and Soil Amendments on Runoff under Laboratory Rainfall Conditions Won, C., M. Shin, Y. Choi, J. Shin, W. Park, J. Choi*	021	Paper D9: Development of the World Atlas of Irrigated Agriculture for Sustainability Science Nagano, T.*, A. Kotera	069	Paper D14: A study of the reason why the reported yields of the System of Rice Intensification (SRI) are so widespread Wakimoto, Y.*, E. Yamaji and S. Sato
10:20	009	Paper D5: Runoff and NPS Pollution Discharge Characteristics from Sloping Upland Fields in Korea Shin, J.Y., M. Shin, H. Yang, J. Choi	022	Paper D10: Influential factors in determining the timing of transplanting lowland rice: case study in Lao PDR Ikeura, H.*, S. Inkhamseng, S. Vongphachanh, P. Xayyanya	072	Paper D15: Monitoring of Shallow Groundwater Infiltration of Pollutant Loads in Greenhouse and Conventional Farming Practices Hong, E.M.*, J.-Y. Choi, M. S. Kang, S.-H. Yoo, J.-R. Jang
10:40				Coffee break		

PROGRAMME (Day 2)
PAWEES 2012 International Conference and PAWEES Award ceremony & Annual meeting

DAY 2: 28 November 2012 (Wednesday) Venue: XujatiKambhu Convention Hall

08.30	**Registration**	
[illegible]		
10.40	**Coffee break**	
[illegible]		
11.00	**International Award** **Paper and Reviewer Award**	
12.00	**Lunch break**	
[illegible]		
	PWE publication	
13.15	Commentator: Korea	**Prof. Seong Joon Kim**
13.20	Commentator: Taiwan	**Prof. Ming-Che Hu**
13.25	Commentator: Japan	**Dr. Yoshiyuki Shinogi**
13.35	Commentator: Thailand	**Dr. Varawoot Vudhivanich**
[illegible]		
14.40	**Management of PAWEES**	
	Commentator: Korea	**Prof. Jin-Yong Choi**
	Commentator: Taiwan	**Prof. Hwa-Lung Yu**
	Commentator: Japan	**Dr. Masaru Mizoguchi**
	Commentator: Thailand	**Dr. Suchart Koontanakulvong**
14.45	**Coffee break**	
[illegible]		
15.15	**International cooperation opportunities among member countries**	
	Commentator: Korea	
	Commentator: Taiwan	**Prof. Joongdae Choi**
	Commentator: Japan	**Dr. Chih-Hung Tan**
	Commentator: Thailand	**Dr. Nobumasa Hatcho**
		Mr. Va-son Boonkird
[illegible]		
16.00	**PAWEES-ICID Collaboration Presentation**	**Dr. Tai-cheol Kim**
[illegible]		
16.35	**Closing Remarks**	**Dr. Suchart Koontanakulvong**
17.30	**Dinner with cultural events**: Loy Krathong (For foreign and invited guests)	

附錄五

PAWEES 2012 International Conference & PAWEES Annual Meeting PAWEES 2012 THAILAND STATEMENTS

Nov. 27-28, 2012

PAWEES 2012 International Conference and annual meeting were held on November 27-28, 2012 in the Royal Irrigation Department complex in Pakkred, Thailand.

The main theme was "Challenges ofWater &Environmental Management in Monsoon Asia." Over 40 research papers were presented and discussed in the conference. In the annual meeting, four agenda items were discussed to strengthen future cooperation on research and education among the parties.

PAWEES has mutually agreed to the following statements:

1. The international journal of PAWEES, Paddy and Water Environment (PWE) is well recognized in the disciplines of agricultural science, engineering, and environmental science. PWE has published more than 400 manuscripts since its first issue in 2003. It has been listed in the SCIE since December

2009, and its first Impact Factor (IF) of 0.99 was released in December 2011.

2. As a consequence of accelerated world recognition of PWE, the number of submissions to the journal has dramatically increased. PAWEES agrees to continuously support the publication of PWE and the maintenance of its quality. PAWEES mutually understands the necessities to strengthen the management capacity of PAWEES and the editorial capacity of PWE for meeting increasing workloads.
3. The activities of PAWEES, including PWE editorial, shall expand in cooperation with national and international institutions as well as individual experts from other paddy cultivation regions or societies of the world. The PAWEES continues to vigorously tackle various practical problems while guarding its original philosophy to pursue the understanding of the paddy and water environment.
4. PAWEES members have discussed the student and professor exchange program with institutes in Asian countries. AWEES has also discussed opportunities of research collaboration

withits member countries. The PAWEES agrees to form a working group to discuss an action plan for the development of collaborative research projects of mutual interest and discuss proposals in the next PAWEES annual meeting.

5. PAWEES 2013 International Conference will be hosted by KSAE and will be held in Korea. The purpose of this Conference is to discuss issues related to the paddy and water environment. The specific theme of the conference will be announced later. PAWEES hopes that PAWEES 2013 will provide an pportunity to enhance the exchange of our knowledge and experience among participants.