行政院所屬各機關因公出國人員報告書

（出國類別：出席國際會議）

出席ＡＰＥＣ

永續農業發展與技術研討會

行政院研考會/省(市) 研考會 編 號 欄

出 國 人：

服務機關：行政院農業委員會農業試驗研究所

職　　稱： 組長

姓　　名： 安寶貞

服務機關：行政院農業委員會水土保持局

職　　稱： 科長

姓　　名： 徐森彥

出國地點：中國北京

出國時間：九十一年十一月十八日至二十七日

報告日期：九十二年一月三十日

系統識別號:C09200782

公 務 出 國 報 告 提 要

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報告名稱:

出席ＡＰＥＣ永續農業發展及技術訓練研討會

主辦機關:

行政院農業委員會水土保持局

聯絡人／電話:

／

出國人員:

徐森彥　行政院農業委員會水土保持局　企劃組　科長
安寶貞　行政院農業委員會農業試驗所　技術組　組長

出國類別: 其他

出國地區: 中國大陸

出國期間: 民國 91 年 11 月 18 日 -民國 91 年 11 月 27 日

報告日期: 民國 92 年 01 月 30 日

分類號/目: F11／山坡地問題　／

關鍵詞:　ＡＰＥＣ，農業資源，永續農業

內容摘要: 本次「永續農業發展及技術訓練研討會」主題包括：（一）永續農業發展政策（二）永續農業技術之篩選、模式及移轉（三）農業資源（水、土、氣候及生態）保育及利用（四）永續農業發展之資訊科技（五）農業環境污染與保護（六）消弭鄉村與貧窮（七）永續農業發展之生態工法及建築（八）在生態安全下之農業永續姓評估（九）民眾參與及教育等，由於本次會議議題較爲廣泛，爲使我代表團能充分掌握議題之進展及達到訓練研討之目的，我國立即爭取二員參加名額， 台灣永續發展的願景面對全球「永續發展」的綠色潮流，台灣應該根據「永續發展」的理念，來定位二十一世紀台灣的發展願景，則台灣首要調整過去只重開發、追求快速高度經紀籌漲的心態，扭轉成長與所得的觀念，已追求質的提昇，來取代量的擴增。

本文電子檔已上傳至出國報告資訊網

目　　錄

出席 APEC 永續農業發展及技術訓練研討會報告

安寶貞[1]　徐森彥[2]

摘要

APEC 部長級年會約於每年九月至十一月間舉行，主要任務為決定 APEC 活動的大政方針，並討論區域內的重要經貿問題。部長級年會之下設有資深官員會議（Senior Officials Meeting, SOM），為 APEC 運作的核心機制，出席該會議之代表為各會員體主管部會的次長級或司長級官員，主要任務在執行部長級會議的決議，並建立工作程序及監督協調 APEC 各級論壇之工作。本次「永續農業發展與技術訓練研討會」主題包括：（一）永續農業發展政策（二）永續農業技術之篩選、模式及移轉（三）農業資源（水、土、氣候及生態）保育及利用（四）永續農業發展之資訊科技（五）農業環境污染與保護（六）消弭鄉村與貧窮（七）永續農業發展之生態工法及建築（八）在生態安全下之農業永續姓評估（九）民眾參與及教育等，由於本次會議議題較為廣泛，為使我代表團能充分掌握議題之進展及達到訓練研討之目的，我國立即爭取二員參加名額。

筆者等承行政院農業委員會之推薦，代表我國出席原訂於二〇〇二年九月十六日至二十四日在中國北京舉行之亞太經濟合作（簡稱 APEC）農業技術合作工作小組（簡稱 ATCWG）「永續體農業發展與技術訓練研討會」，因故延期於同年十一月十八日至二十七日舉開，並要求在會中發表論文每人各一篇共二篇，分別介紹我國作物病害之非農藥防治技術及水土保持工作之永續發展，獲與會各國之重視及廣大迴響，會議順利圓滿完成。

台灣永續發展的願景面對全球「永續發展」的綠色潮流，台灣應該根據「永續發展」的理念，來定位二十一世紀台灣的發展願景，則台灣首要調整過去只重開發、追求快速高度經紀籌漲的心態，扭轉成長與所得的觀念，已追求質的提昇，來取代量的擴增。

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[1] 行政院農業委員會農業試驗所組長

[2] 行政院農業委員會水土保持局科長

壹、緣由

永續農業（Sustainable Agri-culture）之定義，先就所發表論文及有關文獻所做定義整理討論，最後以美國 1990 年農場法案（1990 Farm Bill, USA）之定義作修正，作成一般人能了解的（Common understanding）定義如下：「永續農業是動植物生產的綜合體系，基於良好和適當的應用技術以及最佳農耕方法與作業技術之採用，使農地永續利用，以達（一）滿足人類食物、纖維及其他需求（二）強化農業經濟所依賴之環境品質與天然資源（三）最有效利用不可再生資源和農場內資源（四）維持農場作業之經濟多樣性（五）強化農民和社會總體之生活品質。」

「亞太經濟合作」（Asia-Pacific Economic Cooperation，簡稱 APEC）是在一九八九年由澳大利亞前總理霍克（Robert Hawke）所倡議成立的亞太區域各經濟體高階代表間之非正式經濟諮商論壇，希望藉由亞太地區各經濟體政府相關部門官員的對話與協商，帶動該區域經濟成長與發展，成立時共有十二個創始成員。

APEC 是亞太地區最重要的多邊官方經濟合作論壇之一，以其成員涵蓋之地理區域（包括東北亞、東亞、東南亞、大洋洲、北美及中南美地區共廿一個全球重要經濟體）、整體經濟力量（總人口約廿五億人，貿易總額佔全球近五成）及組織活動（最高決策層級達各經濟體元首層級，所涉議題幾涵蓋各會員體大部分行政部門之業務）而言，APEC 均可謂是我國目前實際參與之最重要國際多邊機制之一，APEC 所形成的共識對全球經貿政策及規範具有極大影響力，故我國在 APEC 倡議之初即積極爭取加入，以加強與亞太各國的經濟合作關係，擴大國際活動空間及增進我經貿利益。經一九九一年 APEC 主辦會員體韓國居間協調，我勉予同意以"Chinese Taipei"名稱與中共及香港在一九九一年同時加入 APEC 為成員。

APEC 目前成員除我國外，尚有澳大利亞、汶萊、加拿大、智利、中共、香港、印尼、日本、韓國、馬來西亞、墨西哥、紐西蘭、巴布亞紐幾內亞、秘魯、菲律賓、俄羅斯、新加坡、泰國、美國及越南，總計廿一個成員均係以「經濟體」（Economy）身分參與，此為 APEC 之特殊設計。另尚有「東南亞國家協會（ASEAN）」、「太平洋經濟合作理事會（PECC）」及「太平洋島嶼論壇（PIF）」三個國際組織為其觀察員。

APEC 體制屬「論壇」性質，其日常運作係以「共識決」（Consensus）及「自

願性」(Voluntary)為基礎，經由各成員間相互尊重及開放性的政策對話達成尋求區域內共享經濟繁榮之目標；近年來 APEC 並強調「經濟技術合作」（Ecotech）議題，成為 APEC 除貿易暨投資「自由化」及「便捷化」任務以外的三大支柱工作之一，盼透過具體之經濟技術合作計畫縮短已開發及開發中經濟體間的發展差距。

APEC 部長級年會約於每年九月至十一月間舉行，主要任務為決定 APEC 活動的大政方針，並討論區域內的重要經貿問題。部長級年會之下設有資深官員會議（Senior Officials Meeting, SOM），為 APEC 運作的核心機制，出席該會議之代表為各會員體主管部會的次長級或司長級官員，主要任務在執行部長級會議的決議，並建立工作程序及監督協調 APEC 各級論壇之工作。資深官員會議之下設有十一個工作小組（Working Group）、三個委員會（Committee）、一個次級委員會（Sub-committee）及兩個特別任務小組（Task Force），負責推動貿易暨投資自由化與便捷化、經濟技術合作、性別整合、電子商務、人力資源發展、能源、工業科技、運輸、海洋資源保育、電信暨資訊、觀光、漁業、農業及中小企業等領域的合作。此外，倘各工作小組在推動實務工作上認為有提高協調層次之必要，亦可召開專業部長會議。另自一九九三年起，APEC 主辦成員皆在部長級年會之後召開非正式經濟領袖會議，會中例均採納部長級年會通過的重大決議，經由發佈領袖宣言的方式，揭示 APEC 未來發展的政策方向。自一九九五年起，APEC 亦設立企業諮詢委員會(簡稱 APEC)，由各會員體遴派大、中、小型企業代表組成，直接將民間部門的意見提交 APEC 成員之領袖們參考。

APEC 主要架構自下而上分別為工作小組與次級論壇、資深官員會議、部長級年會及非正式經濟領袖會議(APEC 組織圖如附件一)，外交部國際組織司負責研議規劃我政府處理 APEC 事務之部會協調工作，並聯繫協調國內各專業部會處理參與 APEC 事宜。例如在參加資深官員會議及部長級會議方面，外交部均與各專業部會保持密切協調，並於會前召開行前會議，就整體參與立場及策略進行研商；另在領袖會議方面，外交部均將相關研議及規畫呈報府院，奉核示後由外交部負責執行。

筆者等承行政院農業委員會之推薦，代表我國出席原訂於二〇〇二年九月十六日至二十四日在中國北京舉行之亞太經濟合作（簡稱 APEC）農業技術合作工作小組（簡稱 ATCWG)「永續體農業發展與技術訓練研討會」，因故延期於同年

十一月十八日至二十七日舉開，並要求在會中發表論文每人各一篇共二篇，分別介紹我國作物病害之非農藥防治技術及水土保持工作之永續發展，獲與會各國之重視及廣大迴響，會議順利圓滿完成，獲致具體結論，將於日後再由其他會員體舉辦後續研討會，以推動相關合作事宜。

本次「永續農業發展與技術訓練研討會」主題包括：(一）永續農業發展政策（二）永續農業技術之篩選、模式及移轉（三）農業資源（水、土、氣候及生態）保育及利用（四）永續農業發展之資訊科技（五）農業環境污染與保護（六）消弭鄉村與貧窮（七）永續農業發展之生態工法及建築（八）在生態安全下之農業永續姓評估（九）民眾參與及教育等，由於本次會議議題較為廣泛，為使我代表團能充分掌握議題之進展及達到訓練研討之目的，我國立即爭取二員參加名額，由外交部同意補助本會出席專家及人員一名之相關經費，本會補助一名。會中就各 APEC 會員體之永續農業技術發展現況交換資訊，並討論未來具體合作行動計畫，提報次級論壇、資深官員會議討論。謹將本次研會情形及結論報告於后：

貳、行程（APEC 行程表）

時　　間	地　　點	內　　容
十一月十八日(星期一)		
一〇：〇〇-一一：四五	台北—香港	搭中華航空 CI605 班機
一三：四五-一六：四五	香港—北京	搭港龍航空 KA992 班機
一九：〇〇	友誼賓館 The Friendship Hotel	報到、住宿
十一月十九日(星期二)		
〇九：〇〇-〇九：三〇	友誼賓館貴賓樓翠竹軒	開幕式致歡迎詞
〇九：三〇-一一：一〇	友誼賓館貴賓樓翠竹軒會議室 主席：Mr. Li Zhengdong 副司長（國際合作司）	發表論文： 陳章良教授（中國農業大學）發表： Public Participation and Education in Biotechnology and Sustainable Agriculture. Zhai Huqu 教授（中國農業科學院）發表： Sustainable Agriculture Development in China.
一一：一〇-一一：五〇	友誼賓館貴賓樓翠竹軒 主席：唐華俊所長（中國農業科學院農業自然資源和農業區劃研究所）	發表論文： （日本）發表： Mr. Yokoi Yukio Japanese Policies For Promoting Sustainable Agriculture.
一三：三〇-一四：一〇	友誼賓館貴賓樓翠竹軒 主席：Prof.Mei Fangquan (InformationCanter,CAAS , P.R.China) 協同主席：Mr. Cho yaung-sook (National rural Living ScienceInstitute,NIAST, Rural Development Administration,Korea)	發表論文： Prof.Yan Ruizhen（中國人民大學）發表： Rural Poverty Alleviation and Human Sustainable Development.
一四：一〇-一四：五〇	友誼賓館貴賓樓翠竹軒 主席：Prof.Mei Fangquan (InformationCanter,CAAS, P.R.China) 協同主席：Mr. Cho yaung-sook (National rural Living ScienceInstitute,NIAST, Rural Development Administration,Korea)	發表論文： Mr.Lim Jit sai（馬來西亞）發表： Policies and Guidelines for Sustainable Agriculture Development In Malaysia
一五：一〇-一五：五〇	友誼賓館貴賓樓翠竹軒 主席：Mr. Yokoi Yukio 協同主席：Prof.Yan Ruizhen	發表論文： Prof.Mei Fangquan（中國）發表： Food Security And Sustainable Agricultural Development
一五：五〇-一六：三〇	友誼賓館貴賓樓翠竹軒 主席：Mr. Yokoi Yukio 協同主席：Prof.Yan Ruizhen	發表論文： Mr. Cho yaung-sook（韓國國家農村生活科學院）發表：

		Programs on Rural Viability For Sustainable Agricultural Development in Korea-Focused on the Rural Living Improvement
一六：三〇-一七：一〇	友誼賓館貴賓樓翠竹軒 主席：Mr. Yokoi Yukio 協同主席：Prof.Yan Ruizhen	發表論文： Dr. Shu Geng（中國農業科學院）發表： Management of Crop Water Demand: a Key and Sustainable Agriculture
一八：〇〇	迎新餐會（友誼賓館聚秀園）	中華人民共和國農業部發展計畫處及國際合作處合邀
十一月二十日(星期三)		
〇九：〇〇-〇九：四〇	友誼賓館會議樓 主席：Ms.So Nellie Ngar Chung (Agriculture,Fisheries and ConservationDepartment, Hong Kong,P.R.China) 協同主席：Dr.Chen Youqi (Professor,Institute of Natural Resources and RagionalPlanning,CAAS, P.R.China)	發表論文： Mr.Wang Zhaoqian（中國浙江大學）發表： Ago-Ecological Engineering Construction For Sustainable Agriculture
〇九：四〇-一〇：二〇	友誼賓館會議樓 主席：Ms.So Nellie Ngar Chung (Agriculture,Fisheries and ConservationDepartment, Hong Kong,P.R.China) 協同主席：Dr.Chen Youqi (Professor,Institute of Natural Resources and Ragional Planning , CAAS,P.R.China)	發表論文： Mr.Hsu Sen-Yen（中華台北農委會水土保持局）發表： Soil and Water Conservation in Chinese Taipei
一〇：四〇-一一：二〇	友誼賓館會議樓 主席：Mr.Lim Jit sai 協同主席：Dr.Ren Tianzhi (Professor,Institute of Natural Resources and RegionalPlanning,CAAS, P.R.China)	發表論文： （中國）發表： Dr.Zhang Weili Information Technologies for Sustainable Agriculture
一一：二〇-一二：〇〇	友誼賓館會議樓 主席：Mr.Lim Jit sai 協同主席：Dr.Ren Tianzhi (Professor,Institute of Natural Resources and Regional Planning,CAAS,P.R.China)	發表論文： Eguillor Pilar(智利農業部農業研究政策局）發表： Policies for Sustainable Agriculture Development
一三：三〇-一四：一〇	友誼賓館會議樓 主席：Dr. Shu Geng 協同主席：Eguillor Pilar	發表論文： Dr.Tang Huajun（中國）發表： Integrated Management of Natural

	協同主席：Eguillor Pilar (智利農業部農業研究政策局)	Integrated Management of Natural Disastets for Sustainable Agricultural Development
一四：一〇-一四：五〇	友誼賓館會議樓 主席：Dr. Shu Geng 協同主席：Eguillor Pilar (智利農業部農業研究政策局)	發表論文： Ms.Ann Pao-jen（中華台北農委會農業試驗所）發表： Current Status of Non-chemical Techniques used in Plant Disease Control in Chinese Taipei
一五：一〇-一五：五〇	友誼賓館會議樓 主席：Dr. Zhang Weili (Institute of Soil Sciences,CAAS,P.R.China) 協同主席：Nguyen Thanh Xuan (National Institute Of Agricultural Planning And Projection	發表論文： Zhoo Jingyin（越南）發表： Study on the Developing Model Of Urbanized Agriculture
一五：五〇-一六：三〇	友誼賓館會議樓 主席：Dr. Zhang Weili (Institute of Soil Sciences,CAAS,P.R.China) 協同主席：Nguyen Thanh Xuan (National Institute Of Agricultural Planning And Projection	發表論文： Kimi sani（馬來西亞）發表： Drainage Water Recyling:Sustaining Productive Rice Environment
一六：三〇-一七：一〇	友誼賓館會議樓 主席：Dr. Zhang Weili (Institute of Soil Sciences,CAAS,P.R.China) 協同主席：Nguyen Thanh Xuan (National Institute Of Agricultural Planning And Projection	發表論文： Prof.Bai Qingyun（中國）發表： Agricultural Environment Pollution and Protectoin
十一月二十一日(星期四)		
〇九：〇〇-〇九：四〇	友誼賓館會議樓 主席：Mr.Hsu Sen-Yen 協同主席：Dr.Qiu Jianjun (Professor,Institute of Natural Resources and Regional Planning,CAAS,P.R.China)	發表論文： Prof.Cheng Xu（中國）發表： Promotion of Public Participation in Sustainable Agricultural Development
〇九：四〇-一〇：二〇	友誼賓館會議樓 主席：Mr.Hsu Sen-Yen 協同主席：Dr.Qiu Jianjun (Professor,Institute of Natural Resources and Regional Planning,CAAS,P.R.China)	發表論文： Nguyen thanh xuan（越南）發表： Land resources Assessment Using GIS for sustainable Agriculture in Vietnam

一〇：四〇-一一：一〇	友誼賓館會議樓 主席：Tang Huajun	發表論文： Li Bingbo（中國）發表： The Research on Development Models of Sustainable and High Efficiency Agriculture in Tai Lake Region
一一：一〇-一一：四〇	友誼賓館會議樓 主席：Tang Huajun	發表論文： Lu Weiguang（中國）發表： Study on the Criteria for Ecological Evaluation of Sustainable Agriculture
一一：四〇-一二：〇〇	友誼賓館會議樓 主席：Tang Huajun	發表論文： Dr.Tang Huajun（中國）發表： Conclusion Speech
十一月二十二日(星期五)		
〇九：〇〇-一〇：二〇	友誼賓館會議樓 主席：Tang Huajun	發表論文： Dr.Chen Youqi（中國）發表： GIS Technology and its application for the Management Resources
一〇：四〇-一二：〇〇	友誼賓館會議樓 主席：Tang Huajun	發表論文： Kang Yaohu（中國）發表： Irrigation and Water-saving Technologies for Sustainable Agricultural Development
一三：三〇-一四：五〇	友誼賓館會議樓 主席：Ms.Ann Pao-jen	發表論文： 劉莊博士（中國南京農業大學地理資源系）發表： 農業資訊之收集：遙測技術之發展及其於永續農業發展之應用
一五：一〇-一六：三〇	友誼賓館會議樓 主席：Ms.Ann Pao-jen	發表論文： 楊永崗博士（中國國家環保總局有機食品發展中心合作部主任）發表：有機農業
十一月二十三日(星期六)		
〇九：〇〇-一〇：二〇	友誼賓館會議樓 主席：Dr.Chen Youqi	發表論文： （中國）發表： Wang Xu Precision Agricultural Technology and its application for Sustainable Agricultural Development
一〇：四〇-一二：〇〇	友誼賓館會議樓 主席：Dr.Chen Youqi	發表論文： （中國）發表： Duan Xiayu Precision Agricultural Technology and its application for Sustainable Agricultural Development
一三：三〇-一四：五〇	友誼賓館會議樓 主席：Wang xiu	發表論文： （中國）發表： Wang Jianwu Traditional Agricultural Techologies of China

一五：一〇-一六：三〇	友誼賓館會議樓 主席：Wang xiu	發表論文： （中國）發表： Dr.Ren Tianzhi Farming System in China
十一月二十四日(星期日)		
〇八：〇〇-一六：三〇	技術訓練及現場觀摩	Bus in front of Building 4 Developmental Plot of Precision Agriculture in Xiao Tangshan Expreimental Site for High-tech Agriculture in Shunyi County of Beijing
十一月二十五日(星期一)		
〇八：〇〇-一六：三〇	技術訓練及現場觀摩	Bus in front of Building 4 Ecological Agricultural Development in Yanqing County of Beijing
十一月二十六日(星期二)		
〇八：〇〇-一六：三〇	技術訓練及現場觀摩	Bus in front of Building 4 Watershed Integrated management Resources Development and Township Construction Modernized Rural Economic Development
一九：〇〇	友誼賓館貴賓樓翠竹軒歡送	Conclusion Banquet Invitd by the Institute of Natural Resources and Regional Planning,CAAS,P.R.China Enter with the delegate badge
十一月二十七日(星期三)		
〇八：一五-一一：五〇	北京—香港	搭港龍航空 KA905 班機
一二：五〇-一四：二〇	香港—台北	搭中華航空 CI606 班機

參、會議經過

本次研討會係專家小組之中型討論會，在中國北京友誼賓館展開為期八天大會報告、各國報告及技術訓練。主題包括：(一）永續農業發展政策（二）永續農業技術之篩選、模式及移轉（三）農業資源（水、土、氣候及生態）保育及利用（四）永續農業發展之資訊科技（五）農業環境污染與保護（六）消弭鄉村與貧窮（七）永續農業發展之生態工法及建築（八）在生態安全下之農業永續姓評估（九）民眾參與及教育等，由於本次會議議題較廣泛，為使各國代表團能充分掌握議題之進展及達到訓練研討之目的，主辦國依參加國別，安排以長方形之會議室自由排開，共有八個國家、九個 APEC 成員，共五十餘位專家參加，包括我國二人、日本一人、美國一人、智利一人、韓國三人、馬來西亞二人、越南一人、香港一人及中國四十餘人。

(一)開幕式：

開幕式由中國農業部計畫發展司司長 Mr. Xue Liang,及國際合作司副司長 Mr. Li Zhengdong 擔任主席，並邀請中國農業科學院農業自然資源和農業區劃研究所所長共同主持。Mr. Xue Lian 主席致歡迎詞後，即展開為期八天之大會報告、各國報告及技術訓練等相關課程，會中採取由各國代表輪流擔任主持人、協同主持人及報告人，報告結束後，立即進行討論，藉由充分討論及溝通，參加人員無不就所學專長及其領域發揮，並一窺他國所長，盡情吸收。

(二)論文發表：

開幕式後即開始論文發表會，此次會議安排論文發表共二十三篇，依序為我國代表二篇、日本代表一篇、馬來西亞代表二篇、韓國代表一篇、美國代表一篇、越南代表一篇、智利代表一篇及中國代表十四篇。論文發表大要如下：

1.我國代表安寶貞組長（行政院農業委員會農業試驗所）發表：「作物病害之非農藥防治技術」

我國代表安寶貞組長以投影片介紹台灣地區作物病害之非農藥防治技術，報告近年來台灣作物病害之非農藥防治成果，甚受與會者肯定台灣的成就，希望獲得更詳細的資料與將來有機會來台灣參觀與學習。其中包括：馬來西亞詢問利用網室栽培防治木瓜輪點病的技術；中國詢問健康種苗、各種非農藥製劑的使用、及許多病害診斷鑑定與防治的問題；韓國詢問柑橘疫病問題。而智利、越南、中

國、馬來西亞、韓國均希望獲得更多的資訊。報告內容敘述臺灣地處熱帶與亞熱帶，氣候高溫多濕，適合多種病害的發生與傳播，嚴重影響農產品之產量與品質。然而自從農藥問世後，基於經濟與速效之考量，農民多以化學方法來防治病害，而忽略其他的防治手段。但農藥的使用有太多的負面影響。如(1) 農藥中毒與殘毒：有礙農民與消費者的健康 (2)藥害：使用不當時有害植物 (3)抗藥性：經常使用農藥易導致病原產生抗藥性 (4)危害非目標生物 (5)環境污染：許多農藥在自然界中代謝緩慢，造成水源與土壤污染，嚴重破壞生態體系。尤其環保意識抬頭後，農藥更是受人詬病。近年來，政府極力提倡與發展『有機農業』與『永續農業』，在病蟲害管裡方面多獎勵研發安全且有效的非農藥防治方法，為的就是逐漸降低對化學農藥之依賴，以保障蒼生的健康、生態的平衡、及農業的永續經營。今將經常使兒用之非農藥防治手段說明如下：包括健康種苗、抗病育種、誘導性抗病、交互保護、拮抗微生物、非農藥殺菌物質與營養液、抗蒸散劑、土壤添加物、栽培管理如網室栽培、套袋、地面覆蓋等、物理防治法如太陽能滅菌、土壤蒸汽消毒等。這些非農藥防治法使用得當時，不但可以減少農藥的使用，且對病害防治可達事半工倍之效果。

2.我國代表徐森彥科長（行政院農業委員會水土保持局）發表：「中華台北水土保持」

我國代表徐森彥科長以豐富投影片介紹台灣的水土保持，各國代表對台灣水土保持認識與宣導成功，給予甚高評價，報告後獲得很大迴響，各國代表提出不少問題，均一一詳加解答，深獲很高評價；期間，浙江大學農業生態研究所暨浙江省生態學會理事長王兆騫教授亦曾數次表達與我交流之意願及對水土保持之興趣。本次發表之論文摘要敘述地球只有一個，大地是人類生活的搖籃，推動自然農法的原則是與生態共生、並與自然界取得平衡發展。所以，為順應台灣頻繁之天災地變與崩塌，大地早已建立一套繁複之自我復育機制運作。

水土保持是國家永續發展不可或缺之一部分，亦為政府施政重點。台灣水土保持事業早在 1951 年由農復會(農委會前身)創辦以來，經過 50 年長期的發展，已由早期實施農地水土保持，減少土壤沖蝕，增加農地生產力，逐漸擴展到山坡地保育利用、坡地綠美化、集水區保育、治山防災、土石流防治、教育宣導等多功能標的。1994 年水土保持法公佈後，更依據其立法宗旨：「保育水土資源，涵養水源，減免災害，促進土地合理利用，增進國民福祉」，奠定水土資源永續發

展之法律制度。

3.中國代表 ZHAI HUQU(Chinese Academy of Agricultural Sciences)發表:「永續農業在中國的發展」

本報告主題指出農業是人民經濟的基礎，永續農業是世界農業的主要傾向和對於中國的農業的一個緊急和長期的任務。作為一個大農業國家，中國的社會和經濟的發展取決於農業發展大規模提昇的結果。然而，例如人口，資源，環境，社會和經濟的一系列問題在鄉村地區發生和將限制農業生產。因此，鄉村社會和經濟的永續農業和永續發展應該是在21世紀。

4.韓國代表 Cho,Young Sook(Rural Living Science Institute,RDA,Republic of KOREA) 發表：「對於朝鮮永續農業發展鄉村生存能力上的程式」

報告中指出永續發展的概念超出環境的狹窄意思，使鄉村生活合格和使人們保持鄉村團契是維持團契的重要原素。因為如此，對於永續發展，為支援鄉村活著的指數的發展鄉村人、教育和擴展在鄉村女人和年長的、農民的健康及鄉村生存能力上的程式，更好的利用傳統和本土的知識需要在南朝鮮推進。

5.中國代表 Tang Huajun(Institute of Natural Resources and Regional Planning，Chinese Academy of Agricultural Sciences）發表：「為永續農業發展綜合了自然災禍管理」

中國是有 7000 - 8000 年歷史的一個大農業國家。然而它的農業遭受了不同種類的無數自然災難和災禍。例如水災，乾旱和森林的火等自然災禍上的資訊對必要預防性測量很重要。然而，沈重地與東方亞洲季風氣候和球體的頂點變化聯繫的不確切原素影響降雨量模式，導引水災的情況的形成，中期和可變性水圍木和乾旱在不同地區交替著發生。指導經濟損失 RMB/年是多於 100 十億元，大約 4% 到瓷器的國民生產毛額中 8%個。在平均值方面，大約 9 百萬平方公頃耕地由乾旱和水災過去每年影響了五十年。中國政府特別注意利用空間技術以抗擊自然災禍，例如，不同站臺已經用擺渡，NOAA，陸地衛星，ERS 和 RADARSAT 來監控自然災禍已經制定，同時，飛機衛星地面監控系統。本文在中國中為自然災禍管理提供這個一般情況和綜合的方法。提出了對於抗擊自然災禍的一些策略選擇。

6.中國代表 Shu Geng, Tianzhi Ren and Richard L. Snyder 發表:「大量水需求的管理：永續農業的一個關鍵」

足夠水供應是收成不可沒有生產的十分重要輸入之一。如果水是豐富的，水

對於農業的應用不是限制的一個關係。然而，這大多數不是世界的一部分的情況，對於世界許多部分中的增加的人口和經濟，使水需求和不充分也相稱的惡化。如果食品安全是居住的國家中的一個有關關係，水很有可能是關係的底部線。水資源的這樣聰明的管理對農業堅持能力至關重要。在本文中，我們將介紹一個 evapotranspirat 基礎的電腦台仿真模型，SIMETAW，這能夠用來計算和在位置為一個給定的收成類比收成 evapotranspirat。能夠對在農業方面水應用作為強大管理工具控告這個模型並且如果正確地應用了，能在北方中國中充分地改進農業堅持能力。

7. 中國代表 Bai Qingyun, Shen Yue and Wang Nong(Agro-Environment Protection Institute) 發表：「在國家的水準和農業的永續發展連接 Agroecosystem 的品性」

增進與生長人口聯繫的農業產品的需求和生活條件的增強二者，agroecosystem 品性的減少，淡水的缺乏今天都是對於中國農業發展的大挑戰。WTO 的入口，農業基礎調整的主要需要，將穩定改變中國的農業的特性，但是更多很可能的製造食品安全另外的問題，例如特點為混合種子，水利，機械化，化肥和殺蟲劑的用處在最後的二十年強烈農業已經被支配了和已經引起中國農業可維持的發展的一個大柵欄的許多社會的，經濟的，環境和生態問題。農業的可維持的發展必須滿足幾個需要：即社會的，經濟的，環境和生態需要，有利於更多生存能力和競爭和友好的環境。是否農業能夠制定可維持的發展，這作為整個以國家水準大地依靠 agroecosystem 的品性，由對收成播種的多文化和種田得像土壤品性那樣好的家畜組成。或者深深地講，各種水準的生物多樣性是這些生態系統的一個核心部分。中國農業的期望，到使它富，agroecosystem 生物多樣性的增強為了使它成為高品性，農場化學制品的小心利用，完整有害物管理(IPM)的擴展和綜合了收成管理(ICM)，的土壤裡，有組織物質的增加並且把淡水在水利上的明智用於增進它的生態效率被認為是切實可行策略，以國家水準，對於在中國進步中農業的永續發展。

8. 中國代表 K. Sani, M. Mashhor, M. Uyub and N.A. Puat 發表：「排水再循環：維持生產米的環境」

透過在使用期望意思廣場模型的位置和季節上，系統的斯堪的 SAS 結合的統計分析決定了在這個 Muda 地區對於米水利使排水水再循環的優點。地區再循

環，以黏土土壤陽離子交流容量 15 到 20 cmol(+)kg^{-1}，沒有這樣的實踐在水下獲得了比地區 26%更高產量。然而，在 Seberang Perai 中再循環的排水水的類似實踐，以土壤陽離子交流容量 7 到 10 cmol(+)kg^{-1}，記錄了大約唯一的產量 12%增量。

9.中國代表 Mei Fangquan 發表：「早在 21 世紀之前在中國的食品安全和維持食品生產」

中國的食品安全的發展是引起世界範圍注意的一個關鍵性問題。對於認識到食品安全的基礎是確保總的數量平衡和在食品供求之間架構的可維持的發展。因此，認識到食品安全的雙重目標和資源和環境的改進，這對於中國必不可少。

10.馬來西亞代表 Lim Jit Sai（Director， Soil Management Division，Department of Agriculture, Kuala Lumpur,Malaysia.）發表：「馬來西亞中的永續農業發展時的策略和方針」

馬來西亞是永續發展的強壯擁護者。在農業部分中，這導入和執行了指導和確保明智土地用作農業生產，相反影響環境的幾測量。測量採取的包括闡明和執行策略，技術方針和立法，並且增進例如土壤的環境友好的實踐保護測量，慢慢虛弱的再循環和恰當的處置。

確保把土地和林業的發展永續用作農業的兩個主要策略是國家農業策略和國家林業策略。國家農業策略透過資源的有效使用強調增加生產力和使為農業生產為土地新的開口意志受挫。這個目標要由介紹 agro-forestry 在堅持能力的基礎方面完成；用橡皮和油的手掌 holdings 高聳的牛和羊的綜合；懶惰土地的修復；小土地的合併到更大和更經濟的單位裡部分土地；把湖、池塘和礦物的水池更有效的用作溶液培養；按使用新提升現存或者拒絕的土地區的生產力和環境友好的技術；高價值的 raiplanting 收成；和改進問題土壤的生產力如此沙質近海岸的土壤，酸性物質硫酸鹽，礦物的土地和泥炭 (BRIS)。

11.中國代表 Li Bingbai Huang Xiaojun and Zhang Yunbai 發表：「在台湖地區，永續和高的效率農業發展模型方面的研究」

報告人為江蘇省海岸經濟發展的地區和 Tailake 的地區的代表，countywide 的一個發展模型和工具的方法永續超高的效率，農業在 Changshu 城市被研究了。評價了縣(郡)的外部環境，countywide 農業架構的調整，分析了鄉村工業架構。它為在發展的地區，可維持超高的效率農業的發展考察了。根據對於外部環境的

分析結果和根據對於 countywide 農業 Eco-economy 系統的評價結果，作為提出了對於 Changshu 城市永續和高的效率農業的發展模型他輸出向東的發展模型綜合安裝的農業和綠色的農業。對準增進輸出與農業的輸入的比，對國際市場而不國內的將銷售農業產品，地方性的市場，生長主要成份收成的地區將大大地減少，如同糧食，棉花，oilseed，等等

12. 中國代表 Wu Yongchang, Yan Caihong Hu Zhiquan 發表：「農業永續和鄉村的發展(SARD)時的最好的實踐在中國」

自從 1994 年，隨著中國的議程 21 的出現和永續發展策略的建立，中國政府加快提升努力執行永續發展的程式。在 1997 年，給 25 個實驗地區再定義以導航可維持的發展，在大城市、在城市，城鎮和地區包括。作為一個重要原素，永續農業和鄉村的發展 (SARD) 被決定用某種飛行員縣或者城鎮實驗在本地水準中。許多縣尋找適應本地條件的路徑執行程式。尤其，關於永續農業的三個情況和鄉村的發展建立了一些例子。在這些情況中，Zhuang 自治地區廣西的 Gongcheng Yao 自治縣表示了西方地區的多山地區，安徽省中的 Maoji 永續團契用鄉村的表示了很少城鎮的建設，並且省中河北的 Zhengding 縣在中央地區表示了這個傳統農業團契。

13. 中國代表 Li Zhemin 發表：「對於在中國農業 Transgenic 有機體安全發展的現行狀況和對策」

基於對於在中國，某種干擾中，農業 transgenic 有機體安全發展情況上的細節的回顧例如完全安全管理系統，提升進退場門的管理，和把公眾安全意識提升到 transgenic 食品，提出以提升這些農業 transgenic 有機體的安全。

14. 中國代表 Qiu Jianjun　Wang Ligang 發表：「關於 Agro-ecosystem 持續性評價的討論」

基於 agro-ecosystem 堅持能力和它的評價的重要概念的細節分析重要評價指標--提出了 agro-ecosystem 的碳和氮(C&N)平衡，並且也導入了對某種評價 biogeochemical 模型的方法，最後，把 agro-ecosystem 中 C&N 的平衡上評價的優先列成表了。

15. 中國代表 Yaohu Kang 發表：「永續農業的最先進的水利技術之一」

水資源平衡和環境的品性是可維持的農業的兩個重要索引指標。超限使用水資源是水缺乏是主要原因。對環境退化的原因應包括土壤污染由於化學制品和污

染的深滲透化學制品，地下水污染超使用，由於廢物和縫合的水利的土壤污染使用傳統表面水利，等等。因此，為了保持永續農業的發展，主要努力必須致力於發展增進水使用效率的現代化的水拯救的水利技術，施肥給低品性水的使用效率，安全使用，和保存的土壤和地下水的環境。微水利有水拯救，高潮使用效率，高化肥應用和使用的效率的優勢，透過減少化學制品的深滲透，使用鹽水的可能性和縫合的水防止的地下水品性。因此，廣泛微水利的使用對可維持的農業吉利。

16.中國代表 lÜ Weiguang Zhao, Jingyin Zhang, Zhangeng,發表:「在對大城市特性合適的生態農業模型方面研究」

國內和國際的生態農業模型的種種介紹了，培養了大城市生態農業的重要性，並且最後在本文中闡明了模型的大城市生態農業的特性和發展的策略。

17.越南代表 Nguyen Thanh Xuan 發表：「在越南中為永續農業把資源估價使用地理資訊系統送到」

廣泛農業活動在引起強烈影響農業資源的越南中已經發生了。每 capita 的自然土地和培養的土地是低的和由於高人口成長比率傾向於對還原。土地資源使用發現不合理和低效能。評價這些資源的土地資源和雇用的條件成為緊急和現實的需要。

向地理資訊系統在越南中已經介紹了和作為對於越南的一個永續農業支援恰當國家資源利用的土地資源估價的有效工具迅速改進。為了為土地資源估價地理資訊系統是可適用的執行了兩個方法，即 agro-ecological 地區和土地的評價。每一個方法的優勢和劣勢是在本文中檢查的。介紹了為 Dak Lak 省中的主要收成，土地適宜性估價的一些模型。模型有前途以在越南中在其他地區申請所有土地使用類型。

18.中國代表 Zhao Jingyin lÜ Weiguang[1] Zhang Zhangeng[2] 發表:「在生態農業的評價索引系統方面研究」

在中國生態農業的系統導入了評價索引的一般情況，和設計原理設計，評價反對，實踐，量標準，索引系統的計算，並且對使用合適的索引系統計算模型在本文中討論。

19.智利代表 Eguillor Pilar 發表：「對於一個永續農業的策略：智利的情況」

智利地理學有這樣的廣寬的和氣候上的多樣性。因此，它的農業和林業的工

業的提供產品的不尋常廣寬的範圍。這都是一個優勢和一個挑戰。智利的南方半球的位置，它的高 phytosanitary 和動物園清潔衛生的條件和人類資源的品性部分放入把智利農業一個特權位置以碰到新國際挑戰。

智利對世界的主要商業塊透過綜合和透過大量自由貿易同意的簽名是公開的它商業過程。因此，把與能夠適應這個公開過程和能夠的一個競爭農業的發展聯繫農業部分面的挑戰已經插入國際經濟。

經濟效率的水準，透過生產費用還原和或者國家農業生產力的增加，對它的極限在許多項中到達。農業產品的國際價格，由補助金的高水準經常變形，對競賽的可能性構成房頂。這創造需要產生新選擇，使這個農業發展可能。

將來，期望食品需求將為品性和無毒性的食品以及為生產這些產品的環境條件把優先選擇強烈連接在消費者上。因此，對例如自然資源和它的農業發展的一個好基礎基於生態環境的保護和它的資源合理地使用的智利，國家那些農村的一般傾向最喜歡。為了執行如上所述的戰略選擇，需要一個農業策略，指公眾當局的一套決定和行動需要。因為在民主狀態若干男演員方面，從私人和公眾部分，參與農業過程，公開策略在談判的一個過程方面是基本的，這很重要。因此，為了成功面對這個挑戰，十分重要條件是對於狹窄公眾和這個私人部分之間的合作。這個聯盟有一個戰略價值定義長久術語目標和執行對這些目標聯繫的多樣化主動。

20. 中國代表 Duan Xiayu 發表：「中國中的 IPM 和它的實踐」

完整有害物管理(IPM)成為了今天廣泛使用和理解的術語。在 IPM 定義(Bajwa and Kogan, 2002)的一個概要中完整控制，有害物管理或者綜合的有害物管理的多於 60 個定義，1959 到 2000 始於，已經被編輯了。這些定義表達了的不同 understandings 和概念方面的強調。

21. 中國代表 Ren Tianzhi 發表：「中國耕種系統」

22. 中國代表 Chen Youqi 發表：「農業資源管理的地理資訊系統和它的應(運)用」

地理資訊系統技術提供工具的一個靈活裝置以完成由政府代辦處處理的功能的多樣化排列成陣式。更重要，地理資訊系統技術在部門中間使分享的資料更容易，政府才能夠作為一個單一企業工作。

由於商業和經濟的 globalization 帶來我們的世界帶來得更近，問題用普遍含義越來越多地穿過國際邊界。地理資訊系統幫助民族(國家)政府比較和分析需要提出這些問題的資料的量。

地理資訊系統越過幾乎所有訓練，為論述提供一種共有語言，和充當工具，可帶來政府、各機關資訊。

地理資訊系統的很大呼籲產生於他們的綜合關於環境的大量的資訊和提供分析工具的強大指令表以考察這個資料的能力。上面的例子顯示了屬於城市運輸計畫的唯一的一些地圖層。假如運用涉及仿製一個危害的種類的產地或者從一個冒險材料地點，滲漏的環境結果，包括的層就會很不同。

想像成數百或者成千的地圖排列成陣式，以顯示關於運輸網路，水文學，人口特性，經濟活動，政治權限，和自然和社會的環境的其他的特性的資訊系統的潛力。這樣的一個系統處於各式各樣的情況下，可作為城市的危險管理，緊急事件預報，或者，依此類推至運輸之疏通與活絡。在層次資訊分離的能力，其最大的潛力的原因，為其資訊與其他層結合為地理資訊系統，以作為研究和決定的工具。

肆、技術訓練及現場觀摩

一、11 月 24 日，田間實習

上午參觀小唐山精準農業，利用衛星遙測技術輔助大型機具採收，因時值隆冬，田間未見任何工人及作物，可惜無法實際操作。大型機具採收用於較粗放耕作經營，與我國集約式精緻耕作經營不同，無法適用。

下午參觀北京近郊 Shunyi 縣高科技農業實驗地，該地係由台商投資經營，繁殖及改良各種蘭花及植物，作物改良後，根莖粗壯可食用，蘭花署台灣常見種，有石斛蘭、文星蘭、蝴蝶蘭等等，並未見新品種。台灣商人開設的蘭園與水耕蔬菜園，規模比台灣小。北京市區的消費水準與台灣差異不大，台灣蝴蝶蘭在此甚受歡迎，價格每株約 100 元台幣，與台灣地區相當，可開拓外銷市場。

二、11 月 25 日，田間實習

上午參觀延慶縣果樹生態科技生態示範園區，園區位於縣城東北七公里，佔地面積 1100 畝，栽種優良葡萄（350）、梨（200）、李子（150）、桃（100）、杏（100）五個樹種，建設成三高，高生產、高科技、高質量的果品生態生產基地和特優新

苗木繁殖基地，2002年獲得中國農業會頒發的全國農業科普示範基地證書。園區沼氣為鈕帶連接生產環帶，實現生產生態達到生態平衡，蟲害防治以物理防治為主，安裝高壓殺蟲燈，效果顯著，大大減少了農藥的使用量。延慶並推廣環保熱能氣化爐，以山裡農家燒飯不冒煙為號召，作為延慶生態示範縣建設的一個項目開始在山區推行。

下午參觀北京近郊延慶縣生態農場發展，延慶縣果品服務中心成立於1985年，員工110人，以縣委制定的『旅遊牽動、城鎮帶動、科技推動』為指導方針。延慶縣位於北京的西北71公里處，萬里長城八達嶺腳下，全縣現有土地面積2000平方公里，人口27萬人其中農業人口23萬人，，平均海拔高平均海拔高500米左右，光照充足，晝夜溫差大，水源、空氣沒有任何污染，具有發展優質果品生產的獨特自然條件優勢。引進新葡萄品種17個，鮮食杏品種5個，李子品種9個，板栗品種5個，梨品種5個，初步建成1萬畝優質鮮食葡萄基地，5萬畝優質規模蘋果基地，6萬畝規模仁用杏基地，3萬畝規模板栗基地，1萬畝規模優質李子基地和1萬畝規模優質鮮食杏基地。年產優質果品一億斤。行程中曾就教是否建立評鑑基準或評估模式，惟現仍以評鑑小組成員評分模式進行，並無一套評鑑機制。

三、11月26日，田間實習

(一)參觀長溝鎮三座庵小流域集與節灌千畝柿子園區建設工程

由於中國北方降雨少，年雨量在400mm以下，作物缺水嚴重，水資源為影響耕作第一重要因子。因此中國在北京長溝鎮進行集雨工程，收集雨水節灌供柿子元使用。共有工程45處，據稱集雨面積約1萬平方公尺，可以集雨4萬平方公尺，可供灌溉三萬三千株柿子樹。目前工程費用150萬人民幣，五年後可以收柿子五百萬斤，收入四百萬元，每人每年平均收入約6千人民幣元。

(二)參觀青龍湖北西水利富民綜合發展工程。

為因應2008北京奧運，中國政府在奧運地點(北京)積極開發各項工程，以給外賓較好的印象。青龍湖水利富民工程包括節雨灌溉、修路、建立精品果園四千畝地，植觀賞樹與果樹(約20萬株)，目前投入資金850萬人民幣，工程進行至第四期，以發展觀光果園為目的，受益農戶1500戶，每年收入可達萬元。

(三)參觀長溝鎮兩處社區，為當地較有規模的建築，面積寬敞，可供為民宿，只是式樣較呆板。

(四)參觀北京古石器時代遺址。

伍、心得與建議

台灣永續發展的願景面對全球「永續發展」的綠色潮流，台灣應該根據「永續發展」的理念，來定位二十一世紀台灣的發展願景，則台灣首要調整過去只重開發、追求快速高度經紀籌漲的心態，扭轉成長與所得的觀念，已追求質的提昇，來取代量的擴增。

一、 檢討並改變過去產業發展的方向與型態，過去台灣著重於高耗能、高耗水、高污染產業的發展，導致自然生態的破壞與環境品質的惡化。因此，台灣應致力於發展低耗能、低污染、高知識、高技術密集的產業，以建造一個「綠色矽島」為目標。

二、 順應世界潮流維持國際競爭力，台灣是一個開放型海島經濟，對外貿易依賴度非常高，國際貿易的勝衰是影響台灣經濟發展的重要因素，因此，迎合世界的潮流，台灣必須遵守各種國際公約的規範，致力產業永續發展，生產符合綠色觀念的產品。

三、 台灣目前的再生能源所佔的比率還不到 1% ，與先進國家相去甚遠，永續發展的能源政策與經濟發展和環境保護息息相關的能源政策，必須由「開源」轉為以「節流」為主，導正過去「開源重於節流」的觀念，建立一個「高效率、低污染」永續發展的能源政策

四、 永續發展的國土總體規劃策略，國土的總體再造應以「環境生態、綠色優先」的思考重新調整，將過去以發展、開發為目的國土規劃方向，扭轉為福祉為目的導向，以生態間的平衡、世代間的公平、區域間的均衡、以及族群間的和諧等原則來考量，確保國土的永續經營。

五、 永續發展的水資源政策，我悶必須認清「世界必然走向匱乏」，已少開源、多節流的原則，進行所有資源政策的檢討，水權是實現人類尊嚴與生命健康不可或缺的一項權利。台灣水資源的問題在本世紀出已浮現，未來可能成為政府必須面對的重要課題。

本次會議，出席經濟體成員只有九個，包括智利、日本、韓國、馬來西亞、越南、美國、中國、香港與我國，感覺其他十二會員國成員不是很重視，共襄盛舉氣份

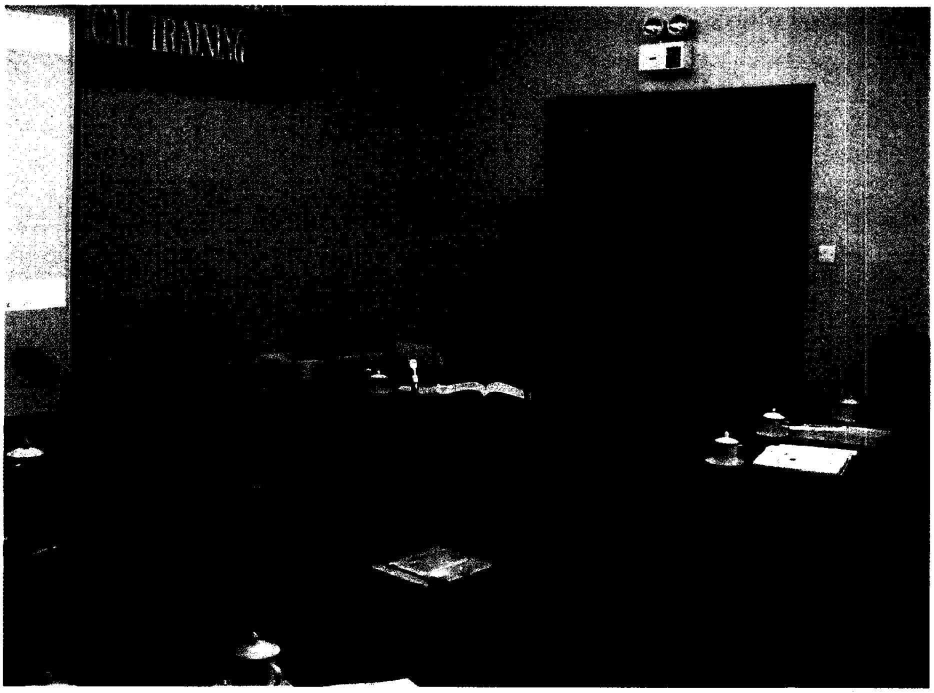
不足。會議正式議程共有八天，包括星期假日，十分密集，課程多，惟 2/3 時間似在報告中國各省的個案，缺乏國際會議的交流意義，反而變成是中國永續農業會議探討。經由實際參與國際會議，深覺日後我國在舉辦類似國際會議時，宜多加強注意，包括選擇議題、與會經濟體報告次數的均衡、訓練課程與田間實習的適當性，以增加外國人對台灣的好感。中國北京在十一月即已地凍天寒，大部分與會代表都感染感冒。我國以後在舉辦類似會議時，宜選擇合適的季節舉開。

參加 APEC 會議獲得不少不同領域知識，他山之石，可以攻錯，廣開門戶，增廣見聞，尤其與與會代表相處融洽，更是一大收獲，大部分經濟體成員對台灣經濟發展均給予相當肯定，羨慕我國的富裕繁榮與進步，希望有機會來台灣學習或參觀在會議中報告的各項成果。

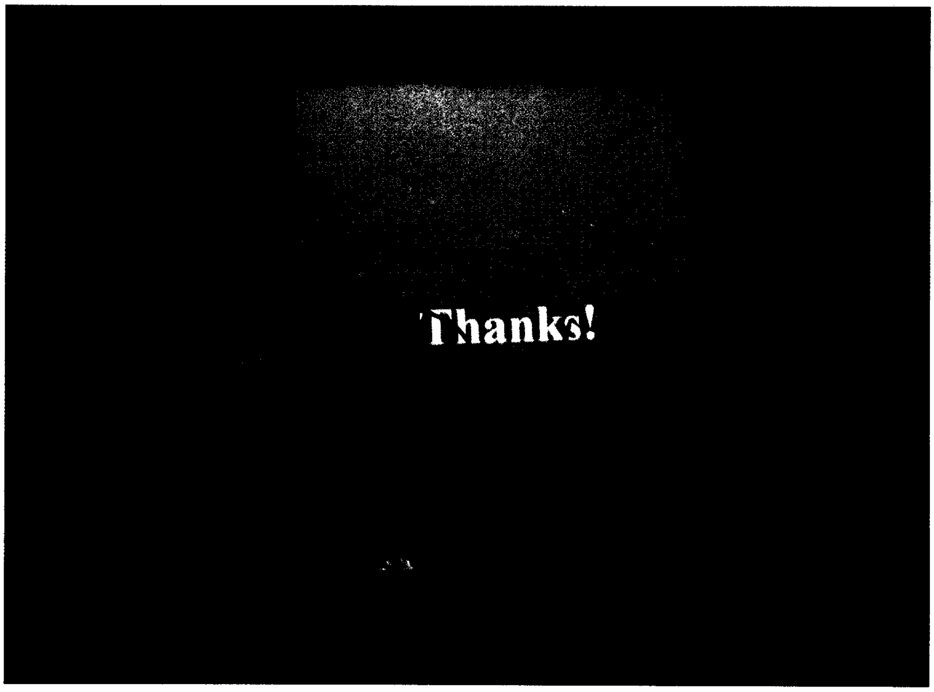
最後，仍深深感謝中國農業部計畫發展司對外經貿處王占祿處長、中國農業科學院農業自然資源和農業區劃研究所唐華俊所長、陳佑啟博士及科研處副處長、孟秀華小姐、何英彬先生等工作同仁，由於他們的發自內心的關懷與照顧，讓冷冷十一月底的北京，升起陣陣的熱意，雖身處他鄉，卻令人感受滿懷溫暖，讓人懷念不已。

91.11.24. 拜會中國農業科學院意見交流情形

91.11.24. 參觀中國國家精準農業研究示範基地



91.11.21. 本會水土保持局徐森彥科長擔任研討會主席討論情形



91.11.22. 本會農業試驗所安寶貞組長擔任研討會報告人討論情形

附件

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CONTENTS

Sustainable Agriculture Development in China

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Agriculture is the foundation of national economy. Sustainable agriculture is the main trend of the world agriculture and an urgent and long-term task for China's agriculture. As a large agricultural country, China's social and economic development depends on the "relevant effect" of agricultural development on a large scale. At the same time, a series of problems such as population, resources, environment, society and economy is occurring in the rural areas and will restrict the agricultural production. Therefore, sustainable agriculture and sustainable development of rural society and economy should be the main part of the general strategy of sustainable development of China in the 21st century.

1. Achievements of Chinese Agriculture Development

1.1 Review of Traditional and Modern Agriculture in China

China is a large agricultural country with the longest history in the world and one of the main original places of world agriculture. In its long history of more than 4000 years, China's agriculture follows the simple and old systematic ecological viewpoint of the circulation and regeneration of matter and the harmonious development of society and nature, which guaranteed the development of China's agriculture in a long flourishing way and supported the sustainable development of Chinese nation successfully. An agro-technical system suitable for China's traditional agriculture has formed gradually. For instance, in order to produce enough agricultural products and make the agricultural resources into full play, farmers in China have gradually found out the intensive and meticulous cultural techniques of continuous cropping, rotation and multiple cropping, intercropping and relay intercropping, complex production system of agriculture and forestry, fallow, etc. Farmers adopt the suitable cropping system according to the local conditions in order to increase the utilization efficiency of unit land and bring the yield potential of land into full play; adopt the comprehensive measures of planting legume crops or green manure crops and fertilize soil with manure and application of organic manure, which promoted the combination of land utilization and land nourishment and kept the soil fertility at higher level; through the construction of terrace lands, pay attention to irrigation and drainage, soil and water conservation, improving the conditions of agricultural production, etc. The idea of sustainable agriculture is emerged from these traditional agricultural techniques. So, China's traditional agriculture has made a significant contribution to the development of sustainable agriculture in the world.

Since the founding of the People's Republic of China, especially since the eighties of the 20^{th} century, with the changes of productive relations and the improvement of productive conditions, China's traditional self-sufficient agriculture has been gradually transformed to modern commercial agriculture and its productivity increased. Tremendous changes have taken place in China's agriculture. The significant manifestations are as follows:

1.1.1 Farmers' Income Increased Steadily

Since the eighties of the 20^{th} century, the rural productivity in China has released greatly through a series of economic reform. The food crops and other agricultural products increased rapidly and China has become a country from the shortage of food for a long period of time to a general balance in total and has surplus in a bumper harvest year, which has basically solved the people's problems of simply having enough to eat. So China has created a magnificent feat in feeding her people occupying 22% of that in the world with only 10% of the cultivated lands in the world. In the 80's, the grain per capita in China surpassed 350kg, and it was about 400kg in the 90's. The per capita consumption level of grain at present is about 260kg. Along with the continuous development of food production, the animal husbandry and aquiculture in China have developed rapidly and the dietary structure has been improved. The quantity of per capita consumption of meat, egg, milk and other non-staple food increased while that of the food decreased. The per capita income of the farmers in China has reached 2366 Yuan RMB in 2001.

1.1.2 Production Conditions Improved and Agriculture develops sustainably.

Since the founding of the People's Republic of China, total machine power of the whole nation, electric energy used in rural areas, the mechanized farming area, the amount of chemical fertilizer use, the irrigated lands, etc. increased significantly. In the past 50 years, both the central and local governments, the collective organs and farmers have been investing actively for strengthening the construction of agricultural infrastructure, undertaking water conservancy projects, promoting the improvement of medium- and low-yield lands as well as the improvement of saline and alkaline lands, which makes the productive conditions of agriculture in China be improved greatly and the sustainable development ability of agriculture be risen to a certain extend. According to the agricultural production index from FAO, taking that in the period of 1961-1965 as 100%, the agricultural production index of the world average, the developed countries' average, and the developing countries' average were 188, 158, and 238 respectively, while that of China was 268. The agricultural production index of China in 1999 was still occupied the first place in the world.

1.1.3 Comprehensive Development of Agriculture is Strengthened, the Pattern of Natural Economy is Broken Through and the Structure is Becoming Rational

Since the 80's, the state has raised a great quantity of money for carrying out comprehensive development of agriculture with the emphasis on increase the output of main agricultural products of grain, cotton, oil, meat, sugar, and others. According to the principle of comprehensive management of mountain, water, forest, field, and road, and the principle of comprehensive utilization of agricultural resources, agricultural resource investigation and agricultural regional planning have been conducted. More than 40 agricultural development areas have been set up in the whole country to carry out regional comprehensive management taking sustainable development as the key. Especially owing to the strategy of "western development" and "structural readjustment" implemented in China at present, the regional distribution of agricultural production in China is becoming reasonable. The natural economic structure existed for a long time in agricultural has been broken and the levels of agricultural commercialization and specialization have been improved significantly.

1.1.4 Agricultural Sciences and Education is Developed Greatly

In the last 50 years or more, great achievement has been obtained in China's agricultural sciences and education. At present, there are 1142 agricultural scientific research organizations containing more than 120000 staffs, among them 60000 are scientific researchers, at or higher than the prefectural level in the whole country. There are more than 220000 agro-technical extension stations, soil and fertilizer stations, seed propagation stations and animal husbandry and veterinary stations containing more than 900000 staffs at various levels of the country. The country has 58 agricultural universities and colleges. The development of agricultural science and technology and education has played a great driving effect on the increase of scientific and technological contents of China's agricultural production, accelerated the transformation of scientific and technological achievements and promoted the sustainable development of agriculture.

1.2 Challenges of China's Sustainable Development in Agriculture

China has won tremendous successes in agriculture in the last 50 years or more. Especially through reform and development in recent 20 years, China's rural areas have entered a new era. Under the new situation of implementing socialist market economy, agriculture and rural economy faces many new contradictions and new problems. There are still some non-sustainable factors as follows in the process of sustainable and stable development of China's agriculture:

1.2.1 Over Population is the Largest Obstacle for Sustainable Development

The base number of China's population is big and the population growth rate is rapid. According to the 5th national population census statistics, the current total population of China is 1.295 billion. The large number and rapidly growth of population result in the reverse development between China's population and cultivated land, the synchronous growth and synchronous counteraction of population and food, the increasingly contradictions between population and environment and resources day by day and other harmful situation. So, the large number and rapidly growth of population aggravate the pressure in employment of China's agricultural manpower, the improvement of living standard, and the increase of agricultural product requirement, and thus leading to the occurrence of non-sustainable development in the process of agricultural production in some areas of China.

1.2.2 Amount of Natural Resource Per Capita is Small and Over Utilized

Cultivated land is the base of agriculture. China's cultivated area is less than 130 million ha, per capita cultivated area is less than 0.1ha, which is only 1/3 of that of the world. Owing to the development and construction of cities, traffic and other public installations, the decreasing trend of cultivated land has not be controlled effectively, but the decreasing speed is accelerated in recent years. With the decreasing of cultivated land, the quality is also deteriorated obviously. The average content of organic matter of the national cultivated land is less than 1.5%, which is obviously lower than the level of 2.5%-4% of the European and American countries. The ratio of medium- and low yield land increased from the original 2/3 to the present 4/5. The total amount of China's water resource is 280 million m^3, which occupies the 6th place in the world. However, the per capita water resource in China is only 1/4 of the world. China is one of the 13 countries in shortage of water in the world. Drought and shortage of water have become the main obstacle to sustainable development of China's agriculture. China has nearly 400 million ha of grassland, in which 330 million ha can be utilized, which is only next to Australia and Russia and occupies the 3rd place in the world. However, the per capita area of grassland is 0.3ha, which is only 1/3 of that of the world. At the same time, the grassland is deteriorated and the productivity is declined in large areas owing to the predatory utilization. In the 70's, the deterioration rate of grassland in China was 15%, which rose to 21% in the 80's. At present, the yield of grassland in China decreased by 30%-50% as compared with that in 50's and the reduction of yield is even larger in some other areas.

1.2.3 Deterioration of Ecological Environment is not Controlled Effectively; Ecological Destruction and Environmental Pollution become a Real and Potential Threat to

Sustainable Development of Agriculture

China faces an increasingly severe problem of soil and water loss at present. The area of soil and water loss in China is large and extensive. The current area of soil and water loss is 3.67 million km^2, which is 38% of the total area of national land. Among the area of soil and water loss, the water erosion area is about 1.79 million km^2, and the wind erosion area is 1.8 million km^2. The direct economic loss caused by soil and water loss is more than 10 billion yuan RMB and the amount of lost soil is 5 billion tons each year. In recent 40 years, 610000 km^2 of the soil and water loss area has been comprehensively harnessed in the whole nation, 30 million ha of forest for conservation of soil and water are planted which have played a positive role in suppression of soil and water loss. However, the general trend has not been changed and the development of soil and water loss is aggravating.

The area of desert in China is 2.622 million km^2, which is 27.3% of the nation's terrestrial area and 79% of the nation's dry land area. Owing to the damage of desertification, the area of deteriorated grassland reaches 128 million ha, and what is worse is that there are large quantities of farmland being declining in yield rapidly or with productivity lost. Desertification not only causes severe deterioration of land productivity, but also threatens the existence of human being and living environment. Since 90's, there are 23 extraordinary serious windstorms occurred in China, which is only 8 in 60's, 13 in 70's and 14 in 80's.

Agricultural pollution is relatively serious. Water pollution has become an obstacle in inhibition and disturbance of sustainable development of agricultural in China. The degree of pollution is aggravating continuously and the extent is expanding. According to the statistics of the State Bureau of Environmental Protection, more than half of the seven water systems in the whole country are polluted seriously and most of the rivers adjacent to cities are polluted to different extents. There are many ways that cause field pollution and the major ones are sewage water irrigation and the excessive use of pesticides, agricultural plastic sheeting, chemical fertilizers, etc. Yield reduction or even total crop failure caused by sewage water irrigation occurred every year in some districts in China and the hazardous effects could last for several years.

The reduction of biodiversity is also serious. China is one of the countries with most abundant biodiversity in the world and occupies the 9th place in the world. Owing to the damage of the ecological system of natural forest, the habitat of wild animals is reduced dramatically. And the more serious is the illegal abuse hunting, which caused the number of species reduced and on the brink of extinction. According to the relevant data, there are 15%-20% of the species in China including 4600 species of higher plants and 400 species of wild animals are on the brink of extinction or in a threatened situation. More than 200 species of higher plants and more than 10 species of wild animals have been stamped out in recent dozens of years and another 20 species of wild animals are close to the extinction.

1.2.4Shortage of Agricultural Investment Limits the Ability of Sustainable Development of Agriculture in China

For a long period of time in the past, affected by the low comparative interest of agriculture, the priority of input of funds and materials in China is non-agricultural industry, the increase of agricultural input has been fallen behind and the percentage of agricultural input declined. So the basic conditions of agriculture in China have not been much changed and are relatively frangible. Farmland capital construction investment reduced from average 11% of 30 years since the founding of the Republic to the present 3%-4%. For lack of agricultural infrastructures, some of them have long been out of repair, so the ability to fight natural calamities is weak. As the prices of the means of agricultural production hike, farmers are not enthusiastic in input, and the supply of the means of agricultural production (including chemical fertilizer, electric power, agricultural machine, fuel oil pesticides etc.) is short. The shortage of input in agricultural production results in the occurrence of the negative aspect of lacking plenty stamina in current agricultural production.

2. Sustainable Agriculture Development: the Chinese Perspective

2.1 The Basic Connotation of China's Sustainable Development of Agriculture

Sustainable agriculture represents a whole new viewpoint of agricultural development and is an important component of sustainable development strategy, which has drawn more and more attention in China. The ultimate tenet and first task of sustainable agriculture is to deal with the relations between agricultural development and resources, environment and society, especially the relation between nature and human beings.

The proposal of concept of sustainable agriculture is a strong re-think as well as criticism to traditional or modern economic development forms (such as high input, high output, pursuing maximum interest of current generation but neglecting the conservation of the bases like resources, environment, etc.). Sustainable agriculture is generated on the extension of the definition of sustainable development to the field of agriculture and rural economic development. The developing progress of the definition experienced over ten years' arguments, which led to no uniform definition until today. However, people has reached agreements on the following aspects: firstly, putting stress on do not sacrifice progeny's living and developing interest just for current development; secondly, sustainable agriculture is a process, not a purpose or form; thirdly, economic, social and ecological efficiency should all be considered in development.

Compared with traditional agriculture, sustainable agriculture takes scientific technology and knowledgeable labor as main inputs, and material resource as assistant input. At the same time it can take into consideration of economic, social and ecological efficiency, which led to the harmony-sustained development of economy, society and ecology. The fundamental characters of it reflect in the following three aspects. First, reasonability of input, which means to take scientific technology and knowledgeable labor as main inputs, and increase utilization efficiency and output efficiency of resources through increasing scientific technology and high quality live labor input as well as decreasing material resource input. Second, harmony of system, which means to accelerate the all sided and sustainable development of society, economy and resources through harmony of system, and at the same time promote the sustainable development of production, economy and ecology through mutual harmony between man and nature, production and resources, society and economy and economy and environment. Third, comprehension and sustainability of development, which means to ensure the sustainability of economic development, everlasting utility of resources and sustained fine environment through reasonable input and harmony of system function. Reasonable input is the condition of system harmony. Only on the base of reasonable input and harmony of system function can the all-sided sustainable development be realized.

China's sustainable agriculture ought to come along with China's situation and combined with the international sustainable development. And the sustainable agriculture should adjust and optimize agricultural industry and product structure on the basis of insisting on household contract and double-level management during the course of realizing socialist market economy and agricultural modernization process. Meanwhile, China should increase input to enhance the comprehensive productivity of agriculture, prevent and control pollution to keep the balance of agricultural ecology, as well as increase the output rate of resources to promote the increase of farmers' income. Through these measures China can build her agriculture into a modern one with reasonable utilization of resources, intensive management and commercialized production.

2.2 Tasks and Objectives of Sustainable Agriculture Development

Based on modern industry and scientific technology, the object of China's sustainable development of agriculture is to take full use of the technological core of China's traditional agriculture to realize the sustainable increase of productivity, sustainable improvement of soil fertility, sustainable harmonic rural ecological environment as well as high yield, high quality, high efficiency, and low consumption and sustainable utilization of the protected agricultural natural resources to guarantee the balance of resource utilization between generations. On the basis of the above measures a comprehensive agricultural system using modern scientific technology, modern industrial equipment and modern management model will be set up step by step. The construction of sustainable agriculture should be based intimately on the "three objects" of sustainable agriculture and rural development. The contents of them put stress on three aspects. Firstly, two increases in economic system, one is increasing yield of food; the other is increasing income of farmers. Secondly, two controls in social system, one is the control of rapidly increase of population, and the other is the control of abusive use of natural resources. Thirdly, two treatments in ecological system, one is the treatment of water and soil loss, the other is treatment of environment pollution. Meanwhile, China should adopt engineering, technological and biological and other measures, and hurdle all sorts of unsustainable factors to explore different models for sustainable development of agriculture. The object of China's sustainable development of agriculture and ecological construction can be split as follows in a more detailed way:

2.2.1 Objectives in the Near Future

From now on to the year 2010, to further extend the coverage of ecological agriculture, and improve the conditions of agricultural production in water and soil loss areas. Primarily turn the deteriorating trend of ecological environment of grassland, and alleviate the tense situation of energy source in rural areas. Meanwhile protect agricultural resources and accelerate a virtuous cycle of ecological environment.

To guarantee the realization of the above-mentioned object, the following key construction tasks should be accomplished in the near future. The first task is to improve the conditions of agricultural production, which means return some land for farming to forest and grassland, make comprehensive management on the sloping land with the slope gradient lower than 25 degrees as well as practicing precise seeding and high yielding. In the districts with sloping land, try to increase per capita 0.5mu (1ha=15mu) of farmland with the capacity of "holding water, soil and fertility", and the per capita area of fundamental farmland reaching 1.5mu in the north and 0.6mu in the south. Increase the coefficient of precipitation and grain production from the present 0.35 kg/mm to 0.5 kg/mm. The second is the ecological construction of grassland through construction of new artificial grassland, improving natural grassland and deteriorated, desert and alkaline-affected grassland. The third is to accelerate the energy projects construction in rural areas, and prohibit the excessive consumption of biological energy source. At the same time, promote the percentage of popularizing firewood- or coal-saving stoves over 85%, extend solar water-heater, and vigorously extend the 'quaternity' model of greenhouse, livestock shed, toilet and firedamp in the north and 'pig-firedamp-fruit' ecological model in the south.

2.2.2 Medium-term Objective

From 2011 to 2030, strengthen the construction achievements on ecological agriculture, dry land farming and energy ecological engineering. The deteriorated, desert and alkaline-affected grassland all over the country will be harnessed in different extents. Obvious improvement will be realized in the conditions of agricultural production and ecological environment in areas with fragile ecology and the ecological system will step into a virtuous circle in part of the areas. There will be magnificent improvement on the comprehensive productivity of agriculture. The consumption of biological energy in project constructing areas will be obviously lower than the rational supplied amount of biological energy and taking on the virtuous circle road of "energy source-ecological environment".

The concrete objects are: The transfer and application percentage of the comprehensive agricultural scien-tech achievements, plant recovery of fertilizer nutrient, field water-use efficiency will reach 50% or more. The percentage of agro-technical popularization of dry farming will reach 90% or more. The coefficient of grain production of rain-fed field will be stable at 0.8-1kg/mm, the security coefficient will keep at 90% or more, and farmers' annual per capita grain production will reach more than 500kg. Diversified economic system will be further strengthened and will become the main source of farmers' income. The deteriorated, deserted, and alkaline-affected grassland will be harnessed continuously and China will work hard for the recovery of about half of these grassland. At the same time, new artificial grassland and improved grassland must be increased so as to keep the area of accumulated artificial grassland to 2000 million mu(133.3 million ha), which will occupy 33% of the total area of grassland in the whole country. The productivity of the artificial grassland will reach 7 sheep unit per hectare. Land for rotation of crop and grass should be constructed in areas with favorable conditions, while the areas where the ecological environment is foul, abusive reclamation, or overgrazing, must be firmly prohibited and carried out the practice of returning land from farming to grass.

2.2.3 Long-term Objectives:

From 2031 to 2050, the work of popularization of ecological agricultural techniques will be carried out in the whole country so as to improve the agro-ecological environment completely. The sloping land will be changed into terrace land, the deteriorated, deserted, and alkaline-affected grassland will be recovered completely. The structure and combination of the factors of agricultural production will be more rational and the agricultural natural resources will get effectively protected. High efficiency, high quality and clean energy will be used in rural areas and a virtuous circle in ecological economy of rural energy source will be accomplished in the whole country. Till the middle period of this century, a virtuous ecological environmental system suitable for the sustainable development of national economy will be established.

2.3 The Acting Plan of China's Sustainable Agriculture

Sustainable development is the inevitable demand of the social development of human beings. As a less developed country in economy and with more population and few lands, China must take the sustainable development road with the coordination of population, economy, resources, and environment if she wants to realize the historical change from traditional agriculture to modern agriculture. Sustainable development is the general trend of the current world agriculture as well as the road China must take in future. Although the history of research and development of sustainable agriculture in China is not long, but the developmental potential and prospects have already been manifested.

2.3.1 Main Action on Sustainable Agriculture in China

In June 1992, the United Nations Conference on Environment and Development (UNCED) was held in Rio de Janeiro of Brazil, at which, Rio de Manifesto of Environment and Development and UNCED Agenda 21 were adopted. It has fully reflected the new considerations of today's human society for sustainable development and the global common knowledge for cooperation on the field of environment and development as well as the supreme promise of politics. A Chinese delegation, headed by China Premier Li Peng, attended the conference and promised to implement all documents adopted at the meeting. Soon after the conference, Chinese government had put forward Ten Major Countermeasures. In 1994, the state council worked out China Agenda 21, defining the basic strategy for sustainable development. According to China Agenda 21, Chinese ministry of agriculture drew up "China Agenda 21---Thc Plan for the Action of Agriculture" in 1998. At present, sustainable agriculture has been accepted broadly both in concept and action. There are more than 2000 counties, township, or village engaging eco-agriculture, about 9.33 million hectares in total, and by the end of 2000, the areas of no-pollution production is 932,000 hectares. This shows that China's sustainable agriculture has got into a new developing stage. At the World Summit on Sustainable Development (WSSD) in Johannesburg in the past two months, Premier Zhu Rongji told the world that, China has, and will take more actions to promote the sustainable development of China, and make great contribution to the world.

2.3.2 Research on Sustainable Agriculture

Since the 90's of the 20^{th} century, China has made a splendid progress in sustainable development of agriculture. In 1994, China successfully organized "The International Symposium on Sustainable Agriculture and Rural Development" in Beijing, at which, China had put forward that China would take "the Road of Modern, Intensive and Sustainable Agriculture", which drawn a close attention in academic fields. In 1997, China again successfully sponsored "97 International Symposium on Sustainable Technology of Agriculture" in Beijing, exerting a tremendous influence at home and abroad, which vigorously pushed forward the research work on sustainable development in China.

In the periods of " the Eighth Five-year Plan" and " the Ninth Five-year Plan" the State Ministry of Science and Technology had completed the researches of "the Road and model for Sustainable Agriculture and Rural Development in China"; "Research and Construction on Sustainable Agriculture and Rural Development in China"; "the Technology and Application of Sustainable Agriculture and Rural Development". The ministry had preliminarily pointed out the intention and goal of sustainable development and rural development (SARD) and the road for the development of sustainable development in China. This had formed political frame of SARD. After that, China had established more than 30 kinds of developmental model of SARD and perfected the index evaluation system. The regional research, with the goal of sustainable and high efficient use of water and soil resources, had also gained remarkable results.

2.3.3 Construction and Development of Experimental Zone of Sustainable Agriculture

In 1992, the national office of agricultural regional planning organized and carried out the construction on research and demonstration counties for SARD in China, under the support of National Committee of Science and Technology. They constructed 20 experimental regions, including different areas and production models of plains, hills, mountain areas, irrigation, drought, water and soil loss, karst, desertification, water network and wetland, sea sands, grassland and suburbs, which was distributed over 8 national zones of agriculture in China. By the year of 1995, the experimental regions and counties had been increased to 30, gained a marked success.

During the period of "the Ninth Five-year Plan", the national sectors of agricultural resource regionalization and Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences (CAAS) had constructed a batch of demonstration zones of sustainable agriculture and sustainable and high efficient use of agricultural resource, and experimental bases with different climate and soil resources in 26 provinces, cities and prefectures. Of them, there were 39 zones at national level. According to the statistical analysis in 31 demonstration zones, 136 million yuan had been input during the 3 years from 1995 to 1997, of which, 3% was national, 24% was regional and 73% was from households in these demonstration zones. The areas of these zones increased from 5000 ha to 20000 ha; the households involved increased from 3700 to 50000; the areas covered reached 170000 ha, which increased almost 10 times and the households benefited reached 650000, which increased 20 times. These achievements promoted the development of sustainable and high efficient use of resources, and agricultural economy at regional level basically achieved integration of society, ecology and economic benefit and formed the model of sustainable and high efficient use of multi-resources of agriculture.

2.3.4 Formulation and Perfecting of Policies, Law and Regulations Related

In order to implement the strategy for sustainable development, China has formulated a series of general and specific policies that suit to Chinese conditions, which maintained and coordinated a proper relationship between environment and development and done a good job to constrain worsening of environment and promote ecological improvement. (a) Sustainable development of agriculture has been fixed by the "Decision" of the Third Plenary Session of the Fifth Central Committee as one of the fundamental policies to realize the goal of getting into new century of agriculture and rural development. (b) In 1998, the state council released "State Program of Construction on Ecological Environment", in which, the general goal for the construction of ecological environment was put forward: Within 50 years, the people of the whole country will have been organized to strengthen the protection of resources of natural forests and wild life existed and to plant trees and grass to prevent desertification; to construct ecological agriculture and improve the conditions for living and production; strengthen the comprehensive treatment and complete a batch of engineering to improve state ecological environment.

China has formulated a series of laws and regulations to protect environment and control pollution and rationally utilize resources, including 6 laws of environmental protection; 9 laws and regulations related to resources; more than 30 laws and regulations of environment; more than 70 regulations on environment; more than 900 local laws and regulation on environment and over 90 mandatory standard on pollution discharge and environment quality, according to incomplete statistics. It can be said that a system of laws and regulations on environment that suit to the conditions of China has preliminarily been formed. The state released "Criminal Law" for the first time setting the actions that seriously destroy environment and resource as crime. By the end of last year, China had banned and closed more than 6500 small enterprises, according to these laws and regulations.

2.3.5 Education and Training of People with the Thought of Sustainable Development

The key for economic development relies on advanced science and technology to improve the quality of laborers, of which, people are the most active factor in productivity and farmers are the main body in the course of agricultural production. The national principles and policies on agriculture are realized also through farmers and sustainable development of agriculture and of rural areas will depend on, in a final analysis, farmers' quality. The proportion of agricultural population is bigger in China and farmer's quality is still low. It is especially important to improve farmer's education level. The population in China in 2000 was 1295 million, accounting for 1/5 of the world population. The agricultural population, who live in rural areas, made up 63.91% of the whole population in China and illiterate & semi-illiterate in laborers account for about 20%, which is the main reason for low productivity in China.

The state will increase input and speed up elimination of illiterate while popularize 9 years compulsory education and widespread professional education, continue to extend broadcasting and TV networks on agriculture and maintain the engineering of "Green Certificate". The content of sustainable development of agriculture and ecological agriculture should be added to the course of middle school and agricultural practice in rural areas. China will also develop vigorously education of rural grass-roots cadres and technical people on sustainable development, who will play a leading role in the practice of sustainable development of agriculture.

3. Promotion of Sustainable Agriculture Development and Environment Protection in the New Century

Sustainable development is the only way to the development of agriculture in China. In the new century, we must handle correctly "Two Major Relationships" and establish "Two Systems" while increase disposal efficiency of agricultural resources and decrease destruction of ecological environment in order to push on sustainable agriculture in China.

3.1 Handle Correctly the Relationships among Food Security, Resource and Ecology

Under certain level of economy, food security, resources and ecology are a group of goal system that condition each other and promote each other. There will be no increase of food and economy without development and application of resources but excessive development of resources will decrease the quantity of resource, which will inevitably restrict the increase of food and economy. But when the economic level reach a certain height and the input for improving environment and increasing the storage of resources has been increased, the development of food and economy will be promoted further. In the long period of time in the future, China will put forth effort on the following:

3.1.1 Construction of Resources and Ecology

The agriculture and rural economy in China is getting into a new stage of development with the remarkable increase of overall productivity on agriculture, especially food and other agricultural products. The demand and supply reached basic balance and there would be some surplus in bumper harvest year. The security consciousness of resource and ecology will be further strengthened and the strength of input for the treatment of environment will be increased to ease the tendency of environmental worsening and guarantee the quantity and quality of existing resources in order to meet the demand of high-speed development of economy.

3.1.2 Control the Increase of Population

The main aspect of the contradiction among population, food, resource and environment is population. Therefore, we should decrease the growth rate of population, especially the population in rural areas to alleviate the population pressure of agricultural resources and environment.

3.1.3 Moderate the Amount of Living Consumption

Over consumption is the waste of resource and space. On one hand, we should establish the food consuming structure that suits to the state condition; On the other hand, the reasonable consumption between generations should be considered to lead people for "plain living" while avoiding over seeking "luxury living", pollution of environment and the waste of resources. We should leave our younger generations the same or even better basis for living and development — resources and environment.

3.2 Coordinate the Relationship between High Input and Sustainability

The pressure is getting more serious with the increase of population and the demand for agricultural product due to the rise of income, which requires even more input on agriculture to guarantee the high output for agriculture. On the other hand, with the development of economy, unreasonable development and application of resources and substance input, have done the great damage to resource and environment, and the declined resource storage and quality have become the main factor to hinder the sustainable development of agriculture in China. Therefore, to guarantee the demand of agricultural products while protecting the resource environment is a difficult problem that must be solved in china in the future. (a) Increase the input level of agricultural substance and guarantee the increase of agricultural products to meet the increasing demands of national economy and people's living standard, which is the firstly important goal. But the increase of substance input should not seek quantity as did in the past, the quality of the inputs should be underlined. For example, compound fertilizer, which has high efficiency and low residue, should be used as main fertilizer. (b) Improve the utilization efficiency of resources. Increasing 10 percent points of utilization rate of water, fertilizer and chemical equals to the rise of 10% exotic substance input, which can improve agricultural output without increasing substance input. (c) Take various methods to improve the conditions of resource environment, decrease environmental pollution and protect against decline of storage and quality of resources. The Chinese government should take economic measures to support farmers' productive activity, including the improvement of arable land and ecological environment as well as planting trees. For those productive activities that could destroy ecological environment and arable land should be banned by the government.

3.3 Establish Technical System of Sustainable Agriculture

The technical system of sustainable agriculture in China is comprised by three parts: (1) Conventional technology, which combined mainly organic agriculture with ecological agriculture; (2) High efficiency utilization technology, which takes the potential utilization of resource as the key; (3) Higher-new technology of agriculture, with tagging the latent power of biology as the core goal. The technologies in conventionally organic agriculture are the essence that evolved from several thousand years and the basis for sustainable development of agriculture. The intensive cultivation of conventional agriculture mainly utilize organic manure to realize the goal of improvement of soil environment and balance of nutrients, and increase the production and benefit from land through rotation and inter-cropping. They all are the practices that we should inherit and continue to use. Low efficiency, waste of resource and pollution of environment are the main obstacles for sustainable development of agriculture in China in the future. Therefore, It is the key for sustainable development of agriculture in China to apply technological achievements of modern agriculture and to increase efficiency of resource utilization. This mainly includes some technologies of intensive management for arable land, water saving irrigation and formulation fertilizer application, etc. Higher-new technologies are the hope of sustainable development of agriculture in the future in China, which include new variety breeding for plant and livestock; new variety of high production, better quality with disease and stress resistance; application of high & new technology in animal breeding and crop planting, such as utilization of germ-free seedling and the application of computer in agriculture, etc. The rise of facility agriculture, such as microorganism technology, which can produce protein, fat and sugar by industrialization, has made agriculture step towards industrialized production of agriculture. It has short productive circle but with high production and no waste drainage, and can fully utilizes space, material and resources and extend space for human living.

3.4 Establish the Management System of Sustainable Agriculture

Resource disposition through market will certainly lead to less protection and over utilization of resources, which is not compatible with sustainable development. This needs Government's intervention to remedy the defect of market and protect resource and environment to achieve the goal of sustainable development. The government should also complete the management policy, law and regulation system for sustainable agriculture under market mechanism to widely implement paid-system for water and land resources to realize overall and efficient management of agriculture and its resources.

3.4.1 New Ideas on Property Right System

The forms of property right have different influence on the utilization efficiency of resources and their sustainable development. Generally speaking, under the system of private right of property, it is easy to form the market of natural resources and the resources can be effectively disposed without intervention of government but their sustainable use will be ignored, leading to the short-term action. While under the system of public right of property, it is easy to achieve the sustainable goal but resources cannot be effectively used without intervention of government because the resource market cannot be easily formed and operated. There will be a process to form different rights of property, which related to the particularity of different resources. We should readjust the system of property right and strengthen out the ownership of basic resources, such as water and land, to avoid the vacancy of main body of resource ownership and control short-term action and low efficiency on resource disposition.

3.4.2 Internalization of Outside Cost

The outside cost is one of the important origins of attenuation of agricultural resources and deterioration of environment. Establishing the rules on internalization of outside cost that suits to market mechanism is an important part of policy system of sustainable agriculture. The purpose is to force internalization of outside cost from responsible person's production through the methods of price, credit and tax, etc and let the producer himself pay the price of resource & environment. It is, on one hand, to stimulate responsible person to avoid waste and damage of resources as possible as he can or take some measures to prevent additional cost to get best benefit. On the other hand, the government will raise funds through internalization of cost to protect resources and environment.

3.4.3 Price Control of Resources

Price of resources is the basis and prerequisite of marketing for resource disposition and the economic lever for management of agricultural resources. We should establish a rational price system of agri-resources and breed the market for water and land resources to promote paid system of their utilization and disposition.

3.4.4 Monitoring Evaluation System

According to the three major goals of food security, resource and ecology, the index system of monitoring evaluation for sustainable agriculture will be designed to gradually establish the information system of sustainable agriculture management and master the dynamic changes of basic resources, such as water and arable land, to optimize on time the model for agricultural development and to realize the modernization of sustainable agricultural management.

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Programs on Rural Viability for Sustainable Agricultural Development in Korea

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The concept of sustainable development is beyond narrow meaning of environment. To qualify rural life and to keep people in rural community are important factor to sustain community. For such, programs on rural viability for sustainable development, such as development of the rural living indicators for supporting rural people, education and extension on rural women and elderly, farmer's health, making better use of traditional and indigenous knowledge need to be propelled in South Korea.

Key words: rural viability, quality of rural life, rural women, sustainable rural development.

Integrated Natural Disaster Management for Sustainable Agricultural Development

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Abstract

Sustainable agricultural development must first of all address food adequacy and, at the same time, maximize the efficiency of input, profitability and friendliness to the environment. China is a big agricultural country with a history of 7000-8000 years. However its agriculture suffered countless natural calamities and disasters of different kinds. Information on natural disasters such as floods, drought and forest fire is very important for necessary preventive measures. However, uncertain factors related to Eastern Asia monsoon climate and globe climatic change heavily affect the rainfall pattern and period and variability in China, leading to the formation of a situation in which floods, water logging and drought occur in different regions alternatively. Direct economic loss is more than 100 billion yuan RMB/year, about 4% to 8% of china's GNP. On the average, about 9 million hectares of farmland are affected annually by drought and floods in the past five decades. The Chinese government pays special attention to utilizing space technology to combat natural disasters, for example, different platforms such as FY, NOAA, LANDSAT, ERS and RADARSAT have been used to monitor natural disasters, at the same time, the Airplane-Satellite-Ground Monitoring System has been established. This paper gives the general situation and integrated methodologies for natural disasters management in China. Some policy options for combating natural disaster are proposed.

Key Words: Natural Disaster, Drought, Flood, Sustainable Agriculture Development

Management of Crop Water Demand: A Key to Sustainable Agriculture

Shu Geng, Tianzhi Ren and Richard L. Snyder

ABSTRACT

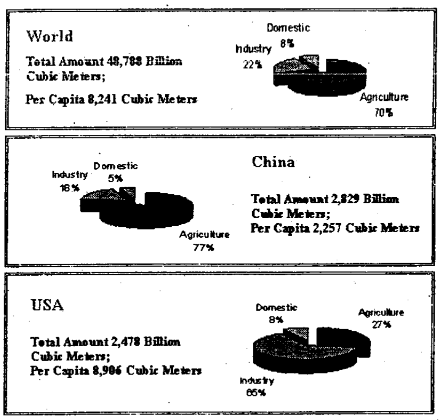
Sufficient water supply is one of the essential inputs that crop can't be productive without. If water is abundant, water application for agriculture is not limiting then it is not a concern. However, this is not the case in most part of the world. With an ever-increasing population and economy in many parts of the world, water demand and inadequacy are also proportionally exacerbated. If food security is a relevant concern in populated countries, water is most likely the bottom line of the concern. Thus intelligent management of water resources is critical to agricultural sustainability. In this paper, we will introduce an evapotranspiration-based computer simulation model, SIMETAW, which can be used to calculate and to simulate crop evapotranspiration for a given crop at a location. This model can be sued as a powerful management tool for water applications in agriculture and if applied correctly, could substantially improve agricultural sustainability in northern China.

Key Words: Sustainable agriculture, water availability, Simulation model, Crop evapotranspiration.

INTRODUCTION

Fresh water is limited in the world and particularly in China. Figure 1 shows the fresh water resources and uses in 1999. Though China has slightly more water than the US but has only 1/4 of that of the US on the per capita basis. The average of 2,829 cubic meters per person means half of the population is in a status of seriously water shortage, i.e., below 2,400 cubic meters.

Fresh water resources and uses in 1999



Water shortage in China is widely spread, through out the entire northern and western regions. For example, Huabei Plain, which is one of the most productive agriculture areas: produces 52% of the wheat and 33% of the maize but only has less than 5% China's water resources. Intelligent management of water resources is clearly critical to China's agricultural and economic development. Huabei likes China on the average uses 78% water resources for irrigation and 81% irrigation water is used singly for winter wheat. This disproportional application of water is obviously a problem.

How much water should be used for agriculture is an economic question, in some cases, is also a political decision. To address the question scientifically, we should know accurately the water demands for varies crops that may grown in a region. Once the demand is understood, the planning questions can be addressed scientifically. This paper shows a methodology, which uses crop evapotranspiration as a tool for crop management based on the available amount of water for crop growth. Specifically, we will introduce a computer simulation model or the 'Simulation of Evapotranspiration of Applied Water' program (SIMETAW), which originally was developed to help the State of California to plan for future water demand by agriculture and landscape irrigation. SIMETAW though empirical, accounts for many factors affecting crop evapotranspiratin that are generally ignored in other programs. Rainfall, soil water-holding characteristics, effective rooting depths, and ET_c are included to determine effective rainfall. Combining crop evapotranspiration (ET_c) with effective rainfall estimates provides net water application requirements for various crops. When divided by the weighted mean application efficiency, the result is a site-specific total irrigation requirement to produce a crop. In addition, a rice example is provided to show crop evapotranspiration can be used to construct phenology models.

CROP EVAPOTRANSPIRATION

Crop evapotranspiration (ET_C) depends on many factors: crop characteristics, soil properties, and weather conditions. The reference evapotranspiration ET_0 represents the evapotranspiration of a standard crop such as grass or alfalfa. This amount can be approximated by weather variables. The ratio of the transpirations of a specific crop to this standard crop is called crop coefficient. The crop coefficient can be estimated from the crop growth and developmental data, which can then be used to convert the reference evapotranspiration to the specific crop evapotranspiration. Below we describe the procedure of calculating reference evapotranspiration and the crop coefficient.

Reference Evapotranspiration: reference evapotranspiration is estimated from daily weather data using a modified version of the penman-monteith equation (allen et al., 1999, walter et al., 2000, and itenfisu et al., 2000.). The equation is:

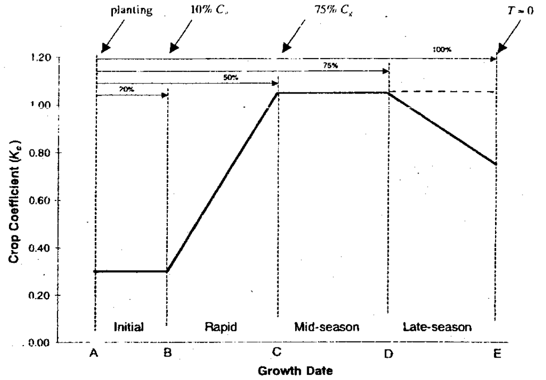
$$ET_o = \frac{0.408\ \Delta\ (R_n - G) + \gamma \frac{900}{T + 273} u_2\ (e_s - e_a)}{\Delta + \gamma\ (1 + 0.34\ u_2)} \qquad (1)$$

where Δ is the slope of the saturation vapor pressure at mean air temperature curve (kPa $^oC^{-1}$), R_n and G are the net radiation and soil heat flux density in MJ $m^{-2}d^{-1}$, γ is the psychrometric constant (kPa $^oC^{-1}$), T is the daily mean temperature (^oC), u_2 is the mean wind speed in m s^{-1}, e_s is the saturation vapor pressure (kPa) calculated from the mean air temperature (^oC) for the day, and e_a is the actual vapor pressure (kPa) calculated from the mean dew point temperature (^oC) for the day. The coefficient 0.408 converts the $R_n - G$ term from MJ $m^{-2}d^{-1}$ to mm d^{-1} and the coefficient 900 combines together several constants and coverts units of the aerodynamic component to mm d^{-1}. The product 0.34 u_2, in the denominator, is an estimate of the ratio of the 0.12-m tall canopy surface resistance (r_c=70 s m^{-1}) to the aerodynamic resistance (r_a=205/u^2 s m^{-1}). It is assumed that the temperature, humidity and wind speed are measured between 1.5 m (5 ft) and 2.0 m (6.6 ft) above the grass-covered soil surface. For a complete explanation of the equation, see Allen et al. (1999).

Crop Coefficients: While reference crop evapotranspiration accounts for variations in weather and offers a measure of the 'evaporative demand' of the atmosphere, crop coefficients account for the difference between the crop evapotranspiration and ET_o. The main factors affecting the difference are (1) light absorption by the canopy, (2) canopy roughness, which affects turbulence, (3) crop physiology, (4) leaf age, and (5) surface wetness. Because evapotranspiration (*ET*) is the sum of evaporation (*E*) from soil and plant surfaces and transpiration (*T*), which is vaporization that occurs inside of the plant leaves, it is often best to consider the two components separately. When not limited by water availability, both transpiration and evaporation are limited by the availability of energy to vaporize water. During early growth of crops, when considerable soil is exposed to solar radiation, ET_c is dominated by soil evaporation and the rate depends on whether or not the soil surface is wet. If a nearly bare-soil surface is wet, the ET_c rate is slightly higher than ET_o, when evaporative demand is low, but it will fall to about 80% of ET_o under high evaporation conditions. However, as a soil surface dries off, the evaporation rate decreases considerably. As a canopy develops, solar radiation (or light) interception by the foliage increases and transpiration rather than soil evaporation dominates ET_c. Assuming there is no transpiration-reducing water stress, light interception by the crop canopy is the main factor determining the ET_c rate. Therefore, crop coefficients for field and row crops generally increase until the canopy ground cover reaches about 75%. For tree and vine crops the peak K_c is reached when the canopy has reached about 70% ground cover. The difference between the crop types results because the light interception is somewhat higher for the taller crops.

Crop Coefficient of Field And Row Crops: Crop coefficients are calculated using a modified Doorenbos and Pruitt (1977) method. The season is separated into initial (date A-B), rapid (date B-C), midseason (date C-D), and late season (date D-E) growth periods. Figure 2 shows a hypothetical crop coefficient (K_c) curve for typical field and row crops showing the growth stages and percentages of the season from planting to critical growth dates. Fixed annual K_c values are possible for some crops with little loss in accuracy. These crops include pasture, warm-season and cool-season turfgrass, and alfalfa averaged over a season.

Figure 2 shows The K_c values for a hypothetical crop, which are based on the ET_o data and crop, soil, and management specific parameters. During the off-season, crop coefficient values are estimated from bare soil evaporation.



RICE EVAPOTRANSPIRATION

The above method was used to calculate the rice evapotranspiration in Taitung, Taiwan for 1997 to 1998, which covered three growth seasons. Figure 3 illustrates that cumulative crop evapotranspiration is relatively consistent for the development of the rice crops that are grown under different environments: between seasons and years. It is less reliable as a predictor for crop growth or biomass accumulation (Figure 4).

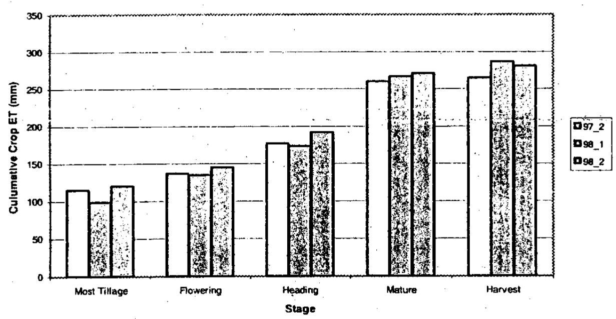


Figure 3. Cumulative Crop Evapotranspiration as a predictor for the development stages of rice plants.

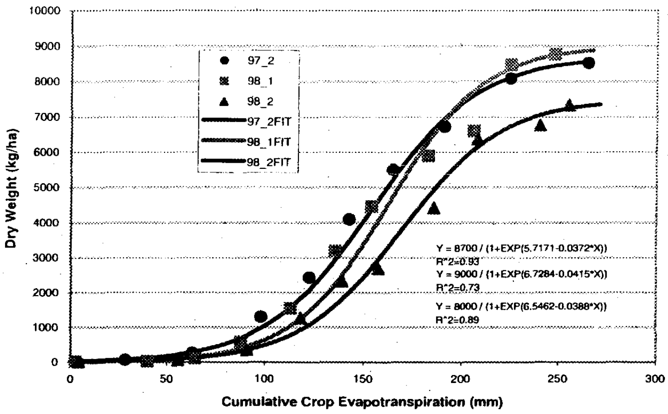


Figure 4. Cumulative Crop Evapotranspiration as a predictor for the biomass accumulation of rice plants.

These results point out that cumulative crop evapotranspiration can be used to construct phenology models, which have great potential in applications for integrated pest management.

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Linking Quality of Agroecosystem at National Level and Sustainable Development of Agriculture

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Abstract: Increasing demand of agricultural products associated with growing population and enhancement of living condition both, reduction of quality of agroecosystem, shortage of fresh water are big challenges for agricultural development in China today. Entry of WTO, leading requirement of adjustment of agriculture infrastructure, will steadily change feature of China's agriculture, but likely make another problems more, food safety, for example. It should be noticed that intensive agriculture, characterized by heavy use of hybrid seeds, irrigation, mechanization, fertilizers and pesticides has been predominated in the last two decades and already caused many social, economic, environmental and ecological problems that, in return, has become a big barrier for sustainable development of agriculture in China. Sustainable development of agriculture must meet several requirements: namely, social, economic, environmental and ecological requirements, facilitating more viability and competitiveness and friendly environment. Whether the agriculture can establish sustainable development is greatly relied upon the quality of agroecosystem, that consists of polyculture for crop planting and livestock farming as well as soil quality, at national level as whole. Or deeply speaking, biodiversity at various levels is a core component for the ecosystems. In prospect of the agriculture in China, addition of organic matter into soil to make it rich, enhancement of biodiversity of agroecosystem to make it high quality, careful utilization of farm-chemicals, extension of integrated pest management (IPM) and integrated crop management (ICM), and wise use of fresh water on irrigation to increase its ecological efficiency, at national level are deemed to be feasible strategies, towards sustainable development of agriculture in China.

Retrospection

According to newest statistic data, China had the largest population of 1.2858 billion people in the world at the end of 2000, with an averaged increase rate of 0.8%, annually. On the other hand, the farmland in China has not increased very significantly in the last 2 decades (see Table 3). From the period of 1980 to 2001, the farmland area increased by just one fourth or less. That means farmland for agriculture is just 0.1 ha. per capita now! To feed this huge population, obviously, agroecosystem in China has been under intensive management for this period, which was characterized by heavy utilization of hybrid seeds, fertilizers, pesticides, irrigation, machinery, aiming at produce as much foods as possible, and the intensive agricultural operation has been inevitable in the past period as a whole (see Tables 1, 2). In fact, the agricultural development obtained a significant achievement in the last decades, having produced enough foods of grains, fruits, vegetables and especially livestock and aquatic products produced and generally met the need for national economy.

Recently, however, the agriculture in China is facing a critical difficulty: reduction of income for farmer, tardiness of rural economy, and stagnation of agricultural development, which is often so called “Three Problems on Agriculture”. There may be several reasons causing the problem, including political, economical, social and so on. It is believed that one of the reasons must be due to the reduction of quality of agroecosystem, especially a dramatic reduction of soil quality at national level. Because of this, ecological efficiency of inputs by farmers to agricultural industry exhibits a significant reduction, therefore, they can acquire much less than they should have and sometimes even nil. From Tables 1, 2, 4, and 5, it can be seen that yield of major crops was no longer increasing at the rate it once was. For instance, the yields of crops in China increased very rapidly at the early 1980's, was generally proportion with the fertilizer's inputs, but remained to be either identical or even decreased during the latter of 1990's, even, more inputs such as fertilizers injected into the agroecosystem, revealing much low productivity and resulting in low income for farmers generally in comparison with other countries (see Table 4).

Agroecosystem is regarded as communities of plants and animals interacting with their physical and chemical environments that are modified by people aiming at producing food, fiber, fuel, medicine and other products for human consumption or processing. The quality of the system may be defined as a conformity of biodiversity of all involving plants, animals and microorganisms as well as the exhibiting dimension of ability of multifunction towards productivity potential, environmental safety, ecological balance and so on.

Agroecosystem firstly, of course, needs to produce a variety of agricultural commodities for human-being. From FAO's statistics, in the period between 1980 and 2001, China was using more chemical fertilizer (see Table 1) and pesticide (236 thousand T a.i annually) than ever before on its agricultural production. Intensive agriculture has been capable of playing a dominated role in the last two decades in national economy of China in order to feed its growing population as whole. During the initial period of 1980's, the inputs of farm was generally proportion to yields. However, during the 1990's, especially, the latter 1990's, the yields of agricultural products was remained at almost unchanged, even more fertilizers were injected onto agriculture (see Table 5). On the other hand, this type of agricultural practice has already resulted in many environmental problems, which, in return, become a major threatening factor for sustainable agriculture in China today. The problems may include dramatic reduction of organic matter in soil, leading to reduction of quality of agroecosystem, which further results in eutrophication of surface- and ground-water, soil degradation, reduction of biodiversity, frequent outbreaks of insects, contamination of agrochemicals residues on food chain, emission of greenhouse gases into atmosphere, and so on. Perhaps, one of the most serious problems today is of land degradation, associated with deterioration of environment. It is believed that land degradation can cause either non-point pollution in the presence of abundant precipitation in the South, or inducing sand-dust storm in the presence of exiguous rain in arid or semiarid regions in the North and West in China. In fact, both eutrophication and sand-dust storm are twin devil associating with land degradation national-widely. These catastrophes have not only been deteriorating environment, but also seriously hampering sustainable agriculture for China. The problems mentioned above are obviously caused by degradation of the quality of agroecosystem at national level as whole, thus, occurrence of reduction of ecological efficiency for inputs and resistance against environmental stresses both of the agroecosystem, is inevitable, leading a series of economic, social, environmental and ecological sequences.

Table 1. Chemical fertilizer use on agriculture during the period of 1980-2000 in China

	1980	1983	1986	1989	1990	1993	1995	1996	1998	2000
Fertilizer use in 10^6 T										
Nitrogenous Fertilizers	12.11	13.68	13.58	18.86	19.56	18.00	23.78	25.28	22.89	22.69
in %	100.00	112.94	112.09	155.67	161.47	148.64	196.34	208.68	188.96	187.32
Phosphate Fertilizers	2.74	3.73	3.03	5.27	5.85	5.54	8.91	8.12	9.46	8.49
in %	100.00	135.87	110.25	192.10	213.26	202.04	324.72	295.80	344.59	309.39
Potash Fertilizers	0.48	0.81	0.72	1.30	1.86	1.53	2.89	2.59	3.49	3.47
in %	100.00	169.45	150.86	272.02	389.61	320.22	603.72	541.82	728.98	724.80
Total Fertilizers	15.33	18.22	17.32	25.43	27.27	25.08	35.58	35.98	35.83	34.65
in %	100.00	118.80	112.97	165.82	177.86	163.55	232.02	234.66	233.65	225.93

Table 2. Trends of water and machinery uses on agriculture during the period between 1980-2000 in China

	1980	1983	1986	1989	1990	1993	1995	1996	1998	2000
Irrigation area in 10^6 ha	45.47	45.06	44.66	45.35	47.97	49.87	49.86	50.96	52.88	54.40
in %	100.00	99.10	98.21	99.74	105.49	109.69	109.65	112.08	116.29	119.64
Agricultural machine										
Tractor in use (X1000)	747.90	847.92	876.47	858.03	824.11	734.33	685.20	684.29	739.29	841.07
in %	100.00	113.37	117.19	114.73	110.19	98.18	91.62	91.49	98.85	112.46
Harvest-threshers in use (X1000)	27.05	35.73	30.95	36.58	38.72	56.27	75.44	113.40	181.78	200.00
in %	100.00	132.11	114.42	135.26	143.17	208.05	278.95	419.30	672.14	739.51

Table 3. Variation of land use pattern on agriculture during the period between 1980-2000 in China

	1980	1983	1986	1989	1990	1993	1995	1996	1998	2000
Permanent Crops (10^6Ha)	3.30	3.68	6.20	7.72	7.72	8.92	10.64	10.92	11.22	11.42
in %	100.00	111.71	188.04	234.17	234.26	270.68	322.94	331.44	340.55	346.62
Permanent Pasture (10^6Ha)	334.00	356.00	378.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00
in %	100.00	106.59	113.17	119.76	119.76	119.76	119.76	119.76	119.76	119.76
Agricultural Area (10^6Ha)	434.22	470.90	505.00	531.00	531.40	532.78	534.70	535.08	535.37	535.56
in %	100.00	108.45	116.30	122.29	122.38	122.70	123.14	123.23	123.29	123.34
Arable Land (10^6Ha)	96.92	111.22	120.80	123.29	123.68	123.86	124.06	124.16	124.14	124.14
in %	100.00	114.75	124.63	127.20	127.60	127.79	128.00	128.10	128.08	128.08

Table 4. Efficiency of Agricultural Production for Major Nations and Region in the World (based on 2000 data of FAO/UN)

	GDP in billion $	Per capita $	Agriculture in share of (%)	Ag Population X1000	Ag Value in billion$	Ag Labor Number X1000	Per capita of Ag Labor $
Australia	416.2	22200	3	876	1.25	475	26,286
Canada	722.3	23300	3	785	2.17	483	44,863
Japan	4897.0	35700	2	4,923	9.79	3385	28,934
South Krea	625.7	13300	5	4,101	3.13	2640	11,850
Germany	1864.0	22700	1.2	2,062	2.24	1134	19,725
France	1373.0	23300	3.3	1,985	4.53	1000	45,309
U.K	1290.0	21800	1.7	1,072	2.19	292	75,103
USA	9255.0	33900	2	6,290	18.51	3523	52,548
Russia	1120.0	7700	7	1,526	7.84	9900	7,919
China	1190.0	928	15	853,715	17.85	350000	510
China (Taiwan)	386.0	17400	3		1.16	784	14,770

Table 5. The trends of crop production, yield during the period between 1980-2001 in China

Cereals	1980	1983	1986	1989	1990	1993	1995	1996	1998	2000	2001
Area Harvested 10^6 (Ha)	95.05	92.80	90.39	91.45	93.56	89.31	89.77	92.64	92.53	85.64	82.41
in %	100.00	97.63	95.10	96.21	98.42	93.95	94.44	97.46	97.35	90.10	86.70
Yield (T/Ha)	2.95	3.72	3.90	4.02	4.32	4.57	4.66	4.90	4.95	4.76	4.90
in %	100.00	126.31	132.09	136.34	146.60	154.91	158.16	166.07	168.01	161.30	166.31
Production (10^6Mt)	280.29	345.63	352.08	367.64	404.41	407.93	418.66	453.67	458.40	407.33	404.13
in %	100.00	123.31	125.62	131.16	144.29	145.54	149.37	161.86	163.54	145.33	144.18
Fruit Primary											
Area Harvested 10^6(Ha)	1.89	2.13	3.81	5.54	5.34	6.60	8.25	8.71	8.69	9.08	9.68
in %	100.00	112.73	201.64	293.19	282.61	349.29	436.62	460.96	459.90	480.54	512.30
Yield (T/Ha)	4.45	5.20	4.01	3.73	3.92	4.93	5.38	5.60	6.52	7.11	7.00
in %	100.00	116.72	90.00	83.79	88.10	110.62	120.83	125.76	146.45	159.70	157.20
Production (10^6Mt)	8.42	11.08	15.26	20.66	20.95	32.50	44.42	48.78	56.69	64.61	67.77
in %	100.00	131.69	181.31	245.47	248.96	386.18	527.83	579.58	673.56	767.75	805.21
Vegetables&Melons, Total											
Area Harvested 10^6(Ha)	3.83	4.83	6.49	7.42	7.25	9.39	10.79	11.86	13.80	15.26	15.86
in %	100.00	126.06	169.50	193.78	189.31	245.26	281.82	309.88	360.34	398.50	414.31
Yield (T/Ha)	14.46	15.95	17.11	16.93	17.71	18.30	18.77	19.07	18.22	19.19	19.06
in %	100.00	110.31	118.33	117.10	122.45	126.57	129.82	131.89	125.98	132.71	131.77
Production (10^6Mt)	55.37	76.99	111.05	125.63	128.34	171.87	202.57	226.28	251.34	292.80	302.27
in %	100.00	139.05	200.57	226.91	231.80	310.42	365.87	408.69	453.95	528.84	545.94

Furthermore, the recent entry of WTO for China has also created a new challenge more to be seriously dealt with for its agricultural development. Now, many politicians, government employees, scientists, even farmers in China have more or less realized the critical situation in front of sustainable development on its agriculture. They are debating many newly appearing problems, such as adjustment on current agriculture structure, development of exported agricultural products, injection of money into aquatic fishing and livestock farming and so on, aiming mainly at taking part in competition of international food market. Unfortunately, few people are paying attention on improvement and enhancement of quality of agroecosystem that is a "root" to sustainable agriculture for China, and Few have realized the possibly appearing impacts of deteriorated agro-environment on agricultural sustainability if we just simply switch our attention from crop plantation to livestock farming. In prospect of future, China still mainly relies on intensive agriculture, as whole, to produce enough foods and fiber to meet the needs for the country, although it can switch from mainly concentrating on production of crop grains, so-called sector relying on land resource, to emphasizing on livestock industry, so-called sector relying on labor hand; from only considering domestic market to international market in terms of its food security system. To establish a feasible mode of sustainable development of agriculture in China, we must answer the questions related to the current agricultural development as following:

- Context of pollution problems resulted in from intensive agriculture;
- Principle for sustainable agriculture;
- Components of agroecosystem;
- Quality of agro-environment meaning;
- The inherent connotation and function of biodiversity of agroecosystem;
- How should we do to make agriculture sustainable?

Principle

Agriculture, as a most importantly anthropogenic activity, has been running for thousands years. Thanks to modern agriculture, human has created today's civilization, like global population of 6 billion enjoying modern life. However, the modern agriculture, like 1960's "Green Revolution" as a representative, has not only generally been capable of providing foods to feed the growing population, but also becoming a threat to our environment. As mentioned above, the modern agriculture in most cases is under intensive management by using a great lot of farm-chemicals, pesticides, irrigation, machinery, and hybrid seeds. Thus, the agricultural management has already resulted in serious consequences including depletion of nutrients, losses of organic matter, compaction, acidification, reduction of biodiversity in soil as well as monoculture and simplification on agroecosystem. In fact, human activity has already disturbed the geo-chemical cycling of many elements such as carbon, nitrogen, water, etc at global scale. And this situation is much more serious than local land contamination by industrial wastes, namely, heavy metals or organic pollutants.

For example, in terms of nitrogen:

- Overall human activity adds as much fixed N to terrestrial ecosystems as do all natural sources combined (Vitousek et al., 1997): Industrial N fixation in fertilizers has risen from less than 10 Tg/yr 1950 to 80 Tg/yr 1990; production of more than 135 Tg/yr is expected in 2030.

- Cultivated legumes can only totally fix 40 Tg N/year.
- Fossil fuel combustion releases 20 Tg N/year.
- More than 50 Tg/yr is released during land transformations each year.
- The natural global rate of nitrogen fixation on land is between 90 and 140 Tg N/yr.
- Humanity now uses 26 percent of total terrestrial evapotranspiration and 54 percent of runoff that is geographically and temporally available (Postel et al., 1996).

In terms of carbon, a lot of C loss from intensive agricultural activity by:

- Release of soil C associated with land transformation (to agriculture) contributes approximately 20% of current anthropogenic CO^2 emissions; annual net accumulation of CO^2 averaged 3.2 b metric tons recently (Vitousek et al., 1997).
- Agricultural activities contribute about 70% of all anthropogenic N_2O emissions and about 65% of all anthropogenic CH_4 emissions (Delgado and Mosier, 1996).

Nutrient leakage from agriculture is a prime cause of degradation of groundwater, surface waters and estuarine and coastal marine systems, and via the atmosphere affects other terrestrial systems (Matson et al., 1997). The release of greenhouse gases mainly including CO_2, CH_4 and NOx and losses of nitrate and phosphate from agriculture result in not just only environmental pollution, but also depletion of nutrients those would be available for crops.

- Eutrophication, associated with inputs of N and P is a prominently environmental problem in many freshwater systems and in coastal regions; while P dominates eutrophication processes of freshwater systems. Eutrophication of coastal marine environments can cause oxygen depletion of stratified waters leading to loss of valuable fish and shellfish, and can lead to nuisance blooms of algae including toxin-producing forms that cause fish deaths or make fish and shellfish inedible
- Nitrate contamination of groundwater is common in agricultural areas around the world; high nitrate in drinking water is a human health concern and influences health of natural systems.
- Inadvertent fertilization associated with NOx and ammonia transported from agricultural systems and deposited downwind in gaseous or solution form can lead to acidification, eutrophication, shifts in species diversity and effects on predator and parasite systems

Therefore, it is believed that the impacts of the intensive agriculture on environment are global, potential, hazardous and long-term.

Agricultural ecosystems or agroecosystems are those "ecosystems that are used for agriculture" in similar ways, with similar components, similar interactions and functions. Agroecosystems can comprise polycultures, monocultures, and mixed systems, including crop-livestock systems, agroforestry, agro-silvo-pastoral systems, aquaculture as well as rangelands, pastures and fallow lands. They are found all over the world from wetlands and lowlands to drylands and mountains and their interactions with human

activities, including socio-economic activities and sociocultural diversity, are determinant.
Agroecosystem is generally composed of soil ecosystem and field ecosystem where vegetation or livestock may together or individually exist. Soil is not just only a key component of agroecosystem, but also an interface between agriculture and environment.
Organic matter in soil plays a very important role in maintaining soil quality and biodiversity in agroecosystem, because organic matter can be regarded as foods for soil microbes (Kennedy A.C, 1995).
Soil organisms contribute a wide range of essential services to the sustainable function of all ecosystems, by acting as the primary driving agents of nutrient cycling, regulating the dynamics of soil organic matter, soil carbon sequestration and greenhouse gas emission; modifying soil physical structure and water regimes, enhancing the amount and efficiency of nutrient acquisition by enhancing plant health. It has been known that the nutrients added to soil are only available for crops and, in the meantime, do not loss as pollutants to environment, if soil contains enough amount of organic matter. These services are not only essential to the functioning of natural ecosystems but constitute an important resource for the sustainable management of agricultural systems.
Reduction in the use of biodiversity in agriculture is driven by the increased pressures and demands of urban and rural populations and by the global development paradigm, which is favoring specialization and intensification. However, it is inevitable to cause both environment and ecological problems for such this agricultural model. Moreover, high quality of agroecosystem characterized by abundant biodiversity at various levels usually exhibits a strong function capable of eliminating constraint factors for agricultural production, as well as a safety towards environment and ecosystem.
It can be concluded that sustainable agriculture is heavily relied on the high quality of agroecosystem, which mainly consists of diversification of plantation and livestock farming cultures and soil ecosystem; while the biodiversity in the soil is mainly determined by organic matter and fractions. Although neither a simple mathematical formula nor a model can quantitatively express the term of quality of agroecosystem up to now, this situation does not influence its importance for the function of the system.

Multifunction of agriculture
It should be emphasized that agriculture plays a multifunction in our life and national economy, not just only provides foods, but should be responsible for protecting environment, safeguarding food safety, providing entertainment, increasing employment positions, guaranteeing animal welfare and so on. That means agroecosystem is no longer regarded as a bioreactor, which more input into, more foods would produce from; while soil is no longer regarded as a mixture of inert materials plus ions available for crops, either. In fact, soil is a very big filter for cleaning our air and water, can determine the whole quality of our environment.
The first aim of agriculture is to produce foods, of course. But the meaning of foods must be extended, foods do not mean just only grains, instead, meats, eggs, milks, fruits, vegetables, aquatic products, mushrooms are also included, too.
In addition to foods, agriculture can also provides us many services more, such as tourist places, raw materials for medicines, raw materials for fiber (mainly cotton, linen and silk) industry, and so on.

It is noticed that the quality of agroecosystem is closely linked with our food safety. Food safety means the foods consumed by human, free of undesirable substances or their existing at an allowable level. Today, from field to eating table, from cradle to tomb, there is always a potential pollution on our foods by xenobiotics. In terms of xenobiotics, hundreds even thousands of unintended substances may become pollutants in our foods. These pollutants either are pathogenic or non-pathogenic; inorganic or organic; endogenetic or ectogenic. However, agroecosystem is the first and probably a most important stage responsible for the food safety. Whether our foods can be safe is at a great degree relied upon the health of agroecosystem, because high quality of agroecosystem, associated with abundant biodiversity and high quality soil, can exhibit:

- a strong function against pest attack, resulting in less or no use of pesticides and further reduction even elimination of contamination of agro-chemicals on food chains;
- a strong buffer action, making pollutants in soil deactivate, resulting in alleviation of less pollution on our foods;
- a strong ability against erosion by water, wind, physical or chemical agents, resulting in less eutrophication of aquatic system which further prevent aquatic foods from contamination of phycotoxins such as ASP, DSP, NSP, PSP and microcystins; and
- a strong capacity of fixing nitrogen from air and making fixed elements in particles into available for plants.

It is also imagined that, high quality of agroecosystem will release less greenhouse gases, which makes not just only less contamination on atmosphere, but also enhances ecological efficiency of agricultural inputs, favorable to viability and competition of agriculture sector.

In recent years, agriculture around metropolitan cities sometimes is becoming an attractive place for urban residents as a tourist selection. Now, in many cases, agriculture just provides high-tech, some rare variety of crops in greenhouse or something else. It is possible to form a new thriving sector for agriculture. However, it will certainly be more favorable if this trend is to resume rural landscape and to optimize local agroecosystem. This agricultural sector will not only make more environmental, ecological, economic benefits, but also create more employment opportunity.

The quality of agro-environment is also closely associated with animal health, while good health for livestock means little drugs are needed for remedy of animal diseases in this agricultural sector. To protect the animal health is extremely important as we intend to adjust agriculture infrastructure, making more livestock commodities enter international food market for competition. It should be pointed out that if foods derived from animals are contaminated by veterinarian drugs or hormones, resulting in not available for being exported, the adjustment of agriculture infrastructure will be of non-sense. In addition, animal welfare is a new topic, which is not just only an ethical value, but also is closely associated with food safety.

Challenges on sustainable development of agriculture in China

Generally, there are 3 major obstacles in front of China's agricultural development sustainability, namely, shortage of fresh water, land degradation and deterioration of

agro-environment (Bai Q.Y., 2001).
According to related data, fresh water amount per capita in China is just 2201 cubic meters, only a quarter of the averaged level of the whole world. In addition, spatial and temporal distribution of precipitation is very uneven (Bai Q.Y., 2001). As high as 77% of total fresh water is used by agriculture now in China; while 18% by industry. Over thirds fourth of run off for Yellow River, the second longest river in China, is being utilized for various purposes, including irrigation, industry and drinking. Table 7 illustrates the distribution and proportion of fresh water, population, and arable land at various regions in China. Obviously, the shortage of fresh water is very critical throughout China. The shortage will be continuing in next decades, forecast by many experts.

Table 6. Organic Matter Contents in Farmland in China (%)

OM	Paddy	Glebe	Total
>4.0	2.2	8.5	10.7
3.0-4.0	4.3	5.2	9.5
2.0-3.0	8.3	10.1	18.4
1.0-2.0	6.3	29.7	36.1
0.6-1.0	0.6	19.6	20.2
<0.6	0.2	4.9	5.1

The newest published data show that as many as 164.88 km^2 and 190.67 km^2, lands are undergoing water and wind erosion, respectively, totally equivalent to 38.7% of the whole territory of China. According to newly published data, the contents of soil organic matter have already decreased to a dangerous level as whole (NSSO, 1998) in China, compared with another nations where soil organic matter contents, in most cases, are in a range of over 3%-around 5%. The decline of organic matter in soil should be responsible for national-wide land degradation. Such this infertile soil can neither support agricultural productivity, nor protect our environment and foods from pollution. In a simple word, reduction of organic matter in soil at national level has become a biggest barrier for the development of sustainable agriculture in China.

The data are derived from a report conducted by National Soil Survey Office and published by Chinese Agricultural Publishing House, 1998.

The deterioration of agroecosystem is partly caused by industrialization and urbanization, and partly caused by agriculture itself. Millions even billions tons of solid, liquid and gases wastes are released from industry, yearly, threatening to agroecosystem at national wide. It should be pointed out that the town and village enterprises (TVEs) contribute a great share of the pollution. In recent years, authorities have recognized this situation and already taken some countermeasures against the pollution. It seems not very easy to make the wastes released at a control level. But we really need to pay the efforts to protect our agro-environment from this the pollution.

Table 7. Distribution and proportion of fresh water, population, and arable land at various regions in China

Watershed	Water share in (%)	Popul. in (%)	Arable L. in (%)	Per capita (M^3/year)	Per ha. Arable L. (M^3/year)
Northeast	6.9	10	19.8	1,497	9,560
Hai-Luan River	1.5	10	10.9	225	3,760
Huaihe River	3.4	16	14.9	389	6,310
Yellow River	2.6	16	14.9	656	5,730
Yantze River	34.2	34	24	2,369	39,300
South	16.8	12	6.8	3,465	67,950
Southeast	9.2	6	3.2	2,999	73,800
Southwest	20.8	2	1.7	31,679	327,000
Inland	4.6	2	5.8	4,832	21,850
Total	100	100	100	2,323	28,000

For the agroecosystem at national level, it is also some feature with monoculture or less diversity to be mentioned. Because economic benefits are often prevailing target for many local people, the monoculture of both crop plantation and livestock farming is dominating in many regions and places. Such this agricultural model may be easily managed for creating economic profits in a short period, but the management often leads rural landscape completely disappearing, leaving a fragile agroecosystem. A great deal of inputs sometimes may mask potential risks by producing more products in a short period, but nothing can cover the contamination on water system and disappearances of biodiversity for the low quality of agroecosystem, which, in return, hampers sustainable development of agriculture. For example, the soil containing low organic matter is characterized by poorly physical and chemical properties with low WHC, CEC and less biodiversity, such this soil can not provide available nutrients to crop plants. In case of intensive farming, someone can apply fertilizers or another chemicals on it, but the infertile soil is not able to remain them, as its structure has little capacity for preservation of the chemical inputs. Furthermore, the inputs may easily loss by either leaching or evaporation, both becoming pollutants. Agricultural monoculture for either crop plantation or livestock farming is characterized by less biodiversity and low quality of agroecosystem. Such this system is liable to be attacked by pests and, therefore, is forced to receive more agro-chemicals and fertilizers, thus, often exhibits risky for both environment and ecosystem, making it very difficult for sustainable development of agriculture and further formulating a detested cycle.

Sustainable development of agriculture in action

Sustainability of agriculture may be defined as meeting requirements of both today's and future's food security, at the same time, creating acceptable impacts on eco-environment.

Food security is vital for a country in the word today, thus it is directly related with sust ainable development of agriculture. Food security means all people, especially, the most vulnerable and least resilient have dignified and unthreatening access to the quantity a nd quality of culturally appropriate food that will fully support the physical, mental, em otional and spiritual health. That means everyone is able to access to safe, healthy, local ly produced affordable, and environmentally friendly foods.

Until today, terrestrial and aquatic-terrestrial system employed by agriculture for cropping, fishing and livestock farming are mainly responsible for providing mos t foods for human being. On the other hand, in terms of economic section, agri cultural development in China must be in accordance with international market o f agricultural products, because it can only get relatively rapid development whe n it has reasonable shares of the market. Therefore, how to manage and optimiz e the ecosystems are of essence in retrieving cleaner foods, prevention of enviro nment from pollution, and maintenancc of balance of ecosystem, facilitating susta inable development for not only agriculture, but also environment.

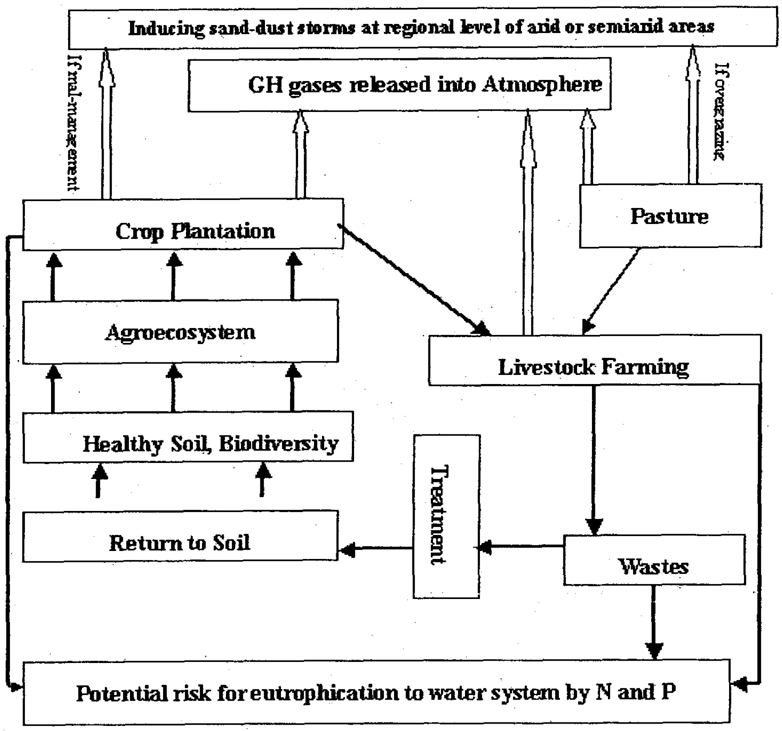

Figure 1. Components and Function of Agroecosystem

In addition, sustainable development of agriculture in China must meet four challenges:

- an economic challenge, the structure of agriculture industry in China should be optimized by strengthening the viability and competitiveness of the agricultural sector, including net economic profits gained from management of agriculture;
- a social challenge, the agriculture should be steadily developed in improving the living conditions and economic opportunities in rural areas, especially, enhancement of farmer's income;
- an ecological challenge, agricultural development should be accompanied by promoting good agricultural practices as well as the provision of services linked to the maintenance of habitats, biodiversity and landscape; and

an environmental challenge, agricultural development should be associated with, for example, guaranteeing food security and safety as well as alleviation of eutrophication and land degradation.

However, the model for sustainable development of agriculture in China is likely to be different from developed countries, at least, we can not just clone it from oversea's models. For instance, such as utilization of fallow, neither at regional, nor at national level is disseminated, neither is non-tillage, as China is still a developing country with a huge population, low-quality farmland, 900 million farmers having no high awareness and consciousness, 15% of GDP from agriculture, and so on. However, we need really to balance a variety of sectors, including economic, social, environment, ecological; recent need and future requirement; today's and tomorrow's benefits; our profits and the advantages of our offspring for our agricultural sustainability.

To deal with the challenge and to keep agriculture in China at the track on sustainable development, there are steps at various management levels and hierarchy levels to be taken immediately, including:
At national level, it is urgent to formulate a new agricultural development policy. The implementation of the policy will require strategy designing of agriculture distribution, better integration of industry fertilizers, manufactory pesticides, addition of organic matter, wise use fresh water etc. Firstly, the new ADP needs to put the enhancement of quality of agroecosystem at national level as a priority of consideration. Such these actions may also include:

- Reduction of intensive use of farmland for crop plantation by import grains from oversea market;
- Re-evaluation of the past agricultural development strategies in some regions. For example, are the continual "Soybean Planting Region" in Northeast and such the "Wheat-Maize-Wheat-Maize" planting system year by year in North of China appropriate?
- Careful or gradually reducing exploitation of farm-chemicals and agro-chemicals by expert management of nutrients in soil, for example, fertilization according to a real need in soil, and by widely implementation of integrated pest management;
- Recycling organic wastes mainly consisting of agricultural residues, manures, organic municipal wastes and even night soil and appropriate disposal on farmland to increase organic matter in soil;
- Comprehensive extension of mulch over soil using agricultural residues, or cover crops;
- Discharge, or, at least, not encourage the past monoculture of crop plantation in several agricultural zones, such as "Maize Region", "Wheat Zone", "Raising Pig County", "Vegetable Town", and so on. Instead, encourage of diversification of agricultural practice and mixture of plantation and livestock farming;
- Integrated Crop Management / Good Agricultural Practice;
- Initiation of diversion of water from South to North and effective utilization of water by increasing ecological efficiency.

To facilitate China's sustainable agriculture, it is imperative that improvement and enhancement of the quality of agroecosystem be ranked at the first consideration for its agricultural policy. In dealing with the dramatically reduced amounts of organic matter in soil nationwide, at least incorporation of treated organic wastes on agriculture shall

be one of the most vital steps.
Figure 1 shows the components and functions of agroecosystem and Figure 2 shows an optimized model for sustainable development of agriculture in China.
According to the model, firstly, it is needed to make soil rich by addition of treated organic wastes or another actions such as using cover crops, constructing terrace and so on. The high quality of soil is a core component for high quality of agroecosystem. To keep a high quality of agroecosystem, polyculture consisting of crop plantation and livestock farming in both time and space should be designed at national level in enhancement of biodiversity.

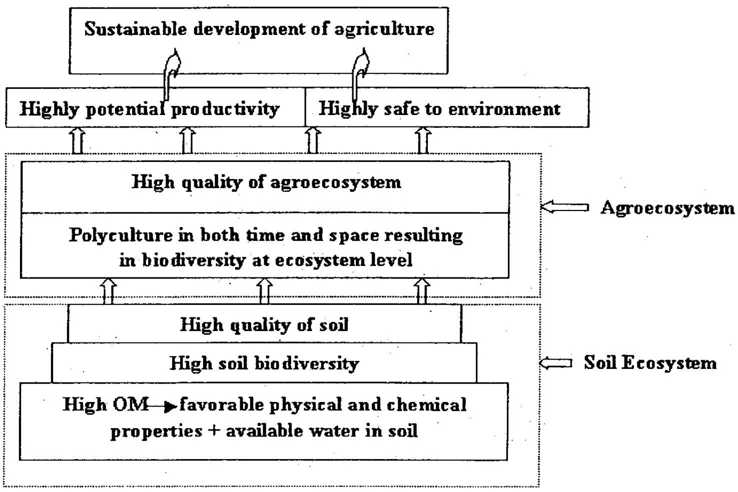

Figure 2. An optimized model for sustainable development of agriculture in China.

The Soil Science Society of America (1995) defines soil quality as the capacity of a specific kind of soil to function, within the natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation.
The appropriate recycling of organic wastes consisting of livestock manure, agricultural residue, municipal wastes, bio-solids and even night soil is absolutely necessary, although good agricultural practice is also another effective approach in maintaining quality of agroecosystem and sequestration of carbon in soil. The enhancement of organic carbon in soil at national level will make agroecosystem more healthy, leading to either highly potential productivity or strong ability against both water and wind erosion. The resources consisting of organic matter now comprise the following:

- Livestock manure and sewage from livestock farms;
- Agricultural residues from crop planting;
- Municipal wastes from garbage, sludge derived from sewage treatment plants;
- Bio-solids from food, timber, beverage and related industries; and
- Night soil from huge population in both urban and rural areas.

The total amounts of the organic wastes mentioned above are estimated to contain 600-700 million T organic carbon and around 65 million T nutrients (Bai, Q.Y, 2001).

Those are invaluable fortune and resources if they are appropriately treated well and reused effectively on farmland.

The biological and environmental consequences of agricultural intensification are increasingly understood. The challenge, therefore, is to realize for increasing production, while avoiding appearance of adverse effects detailed above. The development of more ecologically designed agricultural systems that reintegrate features of traditional agricultural knowledge and add new ecological knowledge into the intensification process can contribute to meeting this challenge, or at least, alleviating the various currently existing problems.

The renewed interest in agroforestry, intercropping, and mixed arable-livestock systems is an indication of the interest in ecologically designed systems. Moreover, integrated nutrient-organic matter management and pest management approaches are receiving increasing attention as pathways to sustainable high-production agriculture and reduction of off-site problems. Broad implementation of such strategies will require the contributions and interactions of social as well as natural scientists, national and international agricultural research institutions, industry, policymakers, and farmers.

The capacity of the soil ecosystem to supply nutrients and to retain applied nutrients is undermined by practices that diminish the role of soil organisms and lead to depletion in soil organic matter. One key to nutrient use efficiency lies in the spatial and temporal matching of nutrient resources and plant demand

There are many alternatives for enhancement of the quality of agroecosystem at strategy level, i.e. various strategies to restore agricultural diversity in time and space include crop rotations, cover crops, intercropping, crop/livestock mixtures, and so on, which exhibit the following ecological features:

1. Crop Rotations. Temporal diversity incorporated into cropping systems, providing crop nutrients and breaking the life cycles of several insect pests, diseases, and weed life cycles. This practice can also overcome the biological and chemical barriers caused by continually planting just one or two crops.

2. Polycultures. Complex cropping systems where tow or more crop species are grown within sufficient spatial proximity, associates with competition or complementation, thus enhancing yields, as diversity increases, so do opportunities for coexistence and beneficial interactions between species that can enhance agroecosystem sustainability. Greater diversity often allows better resource-use efficiency in an agroecosystem. There is better system-level adaptation to habitat heterogeneity, leading to complementarity in crop species needs, diversification of niches, overlap of species niches, and partitioning of resources. In addition, there is a greater abundance and diversity of natural enemies of pest insects, including beneficial predators, parasites, pollinators, soil fauna and antagonists - that are of importance for the entire system.

3. *Agroforestry Systems.* An agricultural system where trees or bushes are grown together with annual crops and/or animals, resulting in enhanced complementary relations between components increasing multiple use of the agroecosystem. Such the practice can reduces risk for farmers, especially in marginal areas with more unpredictable environmental conditions. If one crop does not grow well, income from others can compensate to farmers.

4. *Cover Crops.* The use of pure or mixed stands of legumes or other annual plant species under fruit trees in orchards for the purpose of improving soil fertility, increasing nitrogen fixed, enhancing biological control of pests, and modifying the orchard microclimate.

5. Animal integration in agroecosystems aids in achieving high biomass output and optimal recycling.

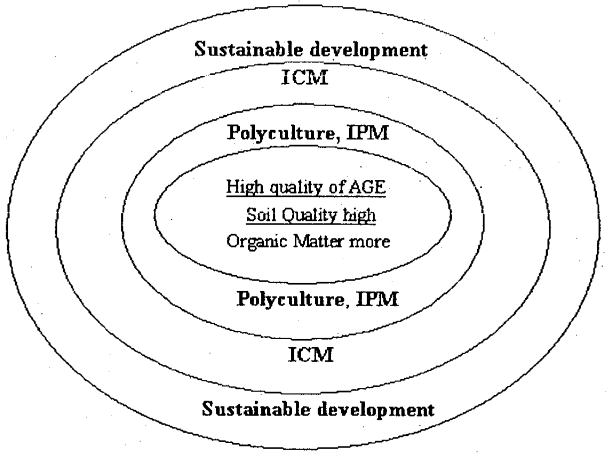

Figure 3: Principle of the sustainable development of agricutlure

Diversified cropping systems often display a great advantage of diversity in an agricultural setting (Vandermeer 1989, Altieri 1994) and of value in agroecosystems for several reasons (Gliessman 1998):

- As biodiversity increases, so do opportunities for coexistence and beneficial interactions between species that can enhance agroecosystem sustainability.
- Greater diversity often allows better resource-use efficiency in an agroecosystem. In contrast, monoculture of crops is often associated with great crop losses from both insects and fungi attack of less diversity but high density.
- Ecosystems where plant species are intermingled possess an associated resistance to herbivores as in diverse systems there is a greater abundance and diversity of natural enemies of pest insects keeping in check the populations of individual herbivore species. It is estimated there are 10-20 natural enemies, either parasites or predators, for each pest under an optimized ecosystem, while over 95% pest control is still contributed by biodiversity of ecosystem.
- A diverse crop assemblage can create a diversity of microclimates within the cropping system that can be occupied by a range of non-crop organisms - including beneficial predators, parasites, pollinators, soil fauna and antagonists - that are of importance for the entire system.
- Diversity in the agricultural landscape can contribute to the conservation of biodiversity in surrounding natural ecosystems.

Diversity reduces risk for farmers, especially in marginal areas with more unpredictable environmental conditions. If one crop does not do well, income from others can compensate.

Generally, greater abundance of biodiversity within an agroecosystem in both time and space exhibits a greater potential productivity, stronger function against pest attack, better efficiency of inputs, requires less fertilizer and pesticide inputs. Such this system is capable of not only providing food security, but also facilitating sustainable development.

It is concluded that the sustainable development of agriculture in China will become a reality if we can manage steadily increase of organic matter in soil, integrated management of nutrients, wide utilization of IPM for plant protection, careful employment of agrochemicals, strengthening ICM, enhancement of biodiversity on agroecosystem, just like the Figure 3, as well as wise use of fresh water at national level as whole. It is certainly a very hard work to achieve the target of agricultural sustainability, but we have no alternative at all.

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Drainage Water Recycling: Sustaining Productive Rice Environment

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Abstract

The advantage of recycling drainage water for rice irrigation in the Muda region was determined through the SAS combined statistical analysis of systems over location and seasons using the Expected Mean Square Model. Areas under water recycling, with clay soil cation exchange capacity of 15 to 20 cmol(+)kg^{-1}, obtained 26% higher yield than areas without such practice. However, similar practice of drainage water recycling in Seberang Perai, with soil cation exchange capacity of 7 to 10 cmol(+) kg^{-1}, recorded only about 12% yield increment.

There were no significant differences in the nutrient concentration and weed population in the recycling and non-recycling systems. Both water sources were also equally polluted with fecal coliforms (*Escherichia coli*) and fecal streptococci and could be classified as not suitable for domestic and recreational purposes. *Eichornia crassipes* formed the dominant weed species under both condition. The accumulation of soluble salts was considered to be low and post no danger for re-irrigation use.

The application of zeolite of the potassium clinoptilolite type with cation exchange capacity range of 90-120 cmol(+) kg^{-1} into the irrigation water at the rate of 200-1000 kg/ha reduces nitrogen losses up to 43%. Correspondingly, there were also significant improvements in the soil fertility level. Grain yield from this zeolite-treated irrigation water on low cation-exchange capacity rice soil plots was significantly improved by about 41%. Zeolite use in the drainage water recycling practices not only conserves water resources but also reduces nutrient loss from the farm thus creating a sustainable and productive intensive rice cultivation system.

Key words: drainage water, recycling, rice, water quality, zeolite, cation-exchange capacity.

Introduction

The stability and availability of water supply for the sustainable intensive double-cropping of rice in the Muda region of Malaysia, had been the subject of many studies (Thavaraj 1977; Embi and Shahrin 1982; Kimata et al. 1983; Teoh 1986). There were signs, in fact; as early as 1975; when double cropping was mooted in the Muda region, of the impending and cyclical water shortages. In the even of droughts, water for rice irrigation could no longer be withdrawn from the existing Pedu and Muda dams, since the diminishing stored water had to be conserved for basic domestic and industrial uses in the Muda plain. The Muda Authority had in the past, abandoned the even normal rice

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planting operation, as evident in 1978, to maintain this priority in water resources distribution. Undeniably, this action could destabilize the national rice production as well as causing unwanted hardship to the farmers involved.

Several strategies had been developed by the Muda Authority to overcome the problems of water shortages in the irrigation scheme as reported by Teoh 1986. Basically, it plans to practice maximum utilization of the available rainfall at the field level, advocate the principle of conservation in farming operations and finally to reduce water demands from the dams with the hope of maximizing the water storage levels of the Pedu and Muda dams in times of rainfall. One of the proposed measures was through drainage water recycling (DWR) practices.

Performance and impact indicator studies in the Muda irrigation scheme had indicated great potential in DWR practices. DWR system uses drainage water from rice field for re-irrigation uses. Instead of going into the sea, water in the drainage canals was put back into the irrigation canals for reuse through a single or series of pumps. Constant shallow flooding of rice field would ensure better weed control and crop yield. This study reports on the impacts of DWR on rice crop yield and the changes in the water quality and its environment in the Muda irrigation scheme. The results are compared to another DWR scheme at the MARDI Research Station outside Muda with steps taken to improve nutrient recycling improvement.

This study covers the period between 1985 and 2002 in the Muda and Seberang Perai rice irrigation areas.

Methodology

Experimental sites

The main study areas in Muda involved six sites, three with DWR facilities and another three without DWR facilities (NDWR). The Sg. Padang (*Figure 1*) area was served by recycled water from the ALBD9 canal while the Sanglang area obtained its water from the ALBD8a (non-recycle) canal. The Kepala Tanjung (DWR) site received its water from the Tunjang Drain while its NDRW Tunjang block received water from the Alor Changileh Canal. The Sg. Tajar block (DWR) received water from the Sg. Tajar Pump-house, while the Jabi (NDWR) block received water from the Main Central Canal. The cation-exchange capacities (CEC) of these areas were in the range of 15-20 cmole+/kg. The water pumping and recycling facilities at MARDI Research Station at Seberang Perai, as a comparision, was used to test recycling effects on low CEC soils (7-12 cmole +/kg) and the effects of zeolite input in improving crop performance under such condition. Zeolite of the clinoptilolite type was used as soil-water amendment at the rate of 300 – 400 kg/ha applied along with the fertilizer recommendation (Colella and Mumpton 2000; Andrews and Kimi 2001).

Crop performance monitoring

Each crop monitoring area was about one hectare in size as marked in *Figure 1*. Crop cutting test was done on five 5m x 5m sample plots from each treatment site. Local rice varieties produced by MARDI (MR 71, MR 84, Q34 and MR 219) were used in the system evaluation. Crop planting till harvest was done according to recommendation.

Water sampling and analysis

Water quality sampling and monitoring were carried out at two weekly intervals

(GEMS 1978). Parameters determined were as recommended by Ayers and Westcot (1985) and analysis were done using USDA Handbook 60 procedures (Richards 1969) and Black (1965). The Pedu dam water was also collected and analyzed to provide basic nutrient composition of the water source.

Aquatic weed population analysis

The distribution of aquatic weeds was determined from five 1m x 1m quadrats at each monitoring point along the canals as shown in *Figure 1*. The Importance Value of each species was determined using the method of Kim and Moody (1980). Weed species were identified according to the methods of Pancho and Soerjani (1978), Moody (1981), and Noda et al. (1985). Soluble reactive phosphate in water was analyzed following the method of Harwood et al. (1969); soluble ammonia-nitrogen following the of Solorzano (1969); and alkalinity and turbidity according to the GEMS procedures (1978). These parameters were then compared with the distribution pattern of the weed population in the canals.

Aquatic bacterial population

Important indicator bacteria for water pollution were determined. They include total coliforms, fecal coliform, *Escherichia coli* and fecal streptococci using the procedures of DHSS (Anon. 1969).

Enumeration of total coliforms Total coliforms were enumerated using the most probable number (MPN) 5-tube 3-dilution fermentation tube series. The first dilution contained double-strength McConkey broth, while the second and the third dilution series contained single-strength McConkey broth. After 48 hour of incubation at 37°C, Tubes containing positive results were recorded. The MPN score was determined using the MPN table as provided by Meynell and Meynell (1970).

Enumeration of fecal coliform and E.coli From the total coliform enumeration, samples with positive results were subcultured in brilliant-green bile lactose broth (BGLB, Merck) and also in peptone water. All the samples were incubated at 44.5 °C. After 24 hours of incubation, the production of gas in the BGLB tubes positively indicated the presence of fecal coliforms. After 48 hours of incubation in the peptone, the presence of indole was tested. All tubes that showed positive results with BGLB and indole were considered to have *E.coli.*

Enumeration of fecal streptococci The procedures was similar to the total coliform test but the medium used was dextrose azide broth (DAB, Merck). After 48 hours of incubation at 45°C, tubes showing acid production were considered to have fecal streptococci.

Statistical analysis

The SAS GLM combination analysis (1982) with Expected Mean Square comparison was used to analyze the performance of DWR and NDWR systems over locations and seasons. The DWR and NDWR systems formed the variable factors with six locations and four seasons formed the fixed random factors. The final model is represented by :

$Y_{ijkl} = u$ + system$_i$ – season$_j$ (system x season)$_{ij}$ + system (location)$_{kj}$ + season x location

$(\text{system})_{ijk}$ + sample {system $(\text{location})_{ijk}$} + E_{ijkl}
Where Y = yield dependent on factors i, j, k, l
E = error term
u = yield independent of other factors
the significant level was set at 5%

The zeolite performance on water recycling nutrient efficiency improvement evaluation was done using ANOVA from the InStat Statistical Tests (Motulsky 1998). The results from this 1985 to 2002 study thus represent the current situation in both the Muda and Seberang Perai rice irrigation areas.

Results

Impacts on crop yield

The average total yield from areas served by recycled and non-recycled water over the four seasons of cropping are presented in *Table 1*. The Expected Mean Square model under the General Model Combination Analysis isolated the results into the DWR and NDWR components. Areas with DWR facilities consistently showed higher yield irrespective of seasons and locations. The final results indicated a significantly higher yield in DWR systems as compared to the NDWR facilities by 25.73%. The results thus indicated the merits of adopting the DWR systems in rice farming.

Impacts on water quality and nutrient composition

The concentration of nitrogen, phosphorus, and potassium in the farm water did not indicate any significant differences between the two areas. Both water sources were shown to have undergone an enrichment process as the result of farming activities (*Table 2*). The ratio of N:P exceeded 2, thus showing high eutrophication level in the water bodies. However, there were no signs of any drastic water quality degradation under the water recycling system. There were also no significant changes in the water quality condition in the farm as compared to the original water source from the Pedu dam. The general water quality condition of this irrigation area was very much controlled by the precipitation mechanism as reflected by the earlier work by Sani (1991).

Impacts on the population distribution and the growth of aquatic weeds

A group of weed populations were observed on the banks of the canals. The clearing of canal banks allowed some less dominant weeds to emerge. However, these weeds would be taken over later by the dominant species. The most dominant weed in both the DWR and NDWR areas was *Eichornia crassipes* (*Table 3*). *Ludwigia adscendens* and *Ipomoea aquatica* were found to be dominant in some parts of the NDWR areas. No significant difference in the nutrient concentration was observed in the DWR and NDWR canal waters (*Table 4*).

Impacts on the bacterial population and distribution

The distribution of the bacterial population and the probable sources are presented in *Table 5*. Results indicated that the total coliforms, fecal coliforms, *E. coli* and fecal streptococci were widely distributed in both the DWR and NDWR areas. However, in cases where fecal coliforms and *E.coli* were not detected, the presence of fecal streptococci alone is sufficient to indicate the presence of fecal contamination (Barrow

1977). Likewise, when fecal streptococci were not detected, the presence of fecal coliforms and *E.coli* is sufficient as indicators of fecal contamination.

Sources of fecal pollution The ratio of fecal coliform to fecal streptococci (FC:FS) has been used to determine the sources of fecal pollution (Feachem 1975; Clausen et al. 1977; Anon 1985). A ratio of > 4.0 indicates pollution due to human feces, while ratio of < 0.7 indicates pollution due to animal sources. The ratio of between 0.7 and 4.0 indicates a mixture of both. Results of the study indicated that both DWR and NDWR waters were polluted with human feces (39%). Pollution due to animal feces could be considered to be minimal (11%). Samples polluted with both sources were also minimal (12%). The FC:FS of about 38% of the collected samples were not detected thus their bacterial pollution status could not be determined.

Pollution status in the Muda region Fecal coliform counts were used in this to determine the pollution status of the DWR and NDWR waters. According to Suess (1977), the water can be categorized as very heavily polluted (MPN > 2000 per 100 mL), heavily polluted (MPN 1000 – 2000 per 100 mL), moderately polluted (200 – 1000 per 100 mL), slightly polluted (50 – 200 per 100 mL), and satisfactory (<50 per 100 mL) with fecal counts. There was no significant difference in fecal coliform counts between the DWR and NDWR systems. Some were slightly polluted (6%), 21% was moderately polluted, 24% was heavily polluted, irrespective of their recycling systems. Only 15% of the water samples were considered satisfactory, while 34% had doubtful results.

The above findings are in agreement with the results shown in *Table 6*. Using fecal coliform counts of < 100 MPN to be the safe level, it was concluded that almost 50% of the DWR and NDWR waters in the Muda area were unsafe for any form of human use. The main source of this pollution came directly from human feces discharged from the settlements from these areas.

Impacts of zeolite amendments

The beneficial effects of lime and zeolite treatments on recycling systems are as presented in *Table 7* and *Table 8*. Observation from four cropping seasons showed that yield from DWR plots was about 12% better than from the NDWR plots. However, under liming at 2mt/ha, yield was increased by 26%. For NDWR plots with liming at the same rate, yield was increased by 10%, about similar to the DWR advantage.

The addition of zeolite powder at 400 kg/ha helped increase system CEC thus reducing the loss of nutrients from the plot. Under non-planted plots with water depth of about 2 cm, the reduction of total nitrogen in irrigation water ranges from 13 to 43%. With the presence of growing rice crop, the reduction of nitrogen loss could be expected to be higher. The use of zeolite to increase system CEC managed to increase crop yield by 41% (*Table 8*) and the most effective method of application is through zeolite powder (< 1.5 mm) blended with fertilizer. At 400 kg/ha treatment soil CEC was improved by 3%, % exchangeable bases by 25% and soil extract ionic strength by 39%.

Discussion and conclusion

The advantage of DWR practices was realized with the production of higher yields. There was no significant difference in the environment of the DWR and NDWR systems in the Muda region. This situation happen as there was actually no clear demarcation between DWR and NDWR zones. Irrigation water may seep or move around freely from one area to another. The main advantage of having DWR facilities is that water can be supplied to the field whenever it is needed. The used water can then be recycled to meet crop need without depending upon or waiting for new water supply from the irrigation canals. This in fact creates an independent water service area in the total farming scenario.

Some changes however, need to be introduced to make DWR system to be more effective. One of the changes is by enlarging the drainage receptacles and canals so that more wastewater could be tapped for reuse. Secondly, the use of zeolite could widely be incorporated into the system so that better soil solution is available for crop use thus ensuring better nutrient reuse thus producing higher crop yield.

The were possible negative effects in DWR due to weed colonization, water quality degradation and bacterial pollution but all could be controlled with better human and farm management system. All these should not hinder the development and expansion of drainage water recycling system, especially in Malaysia, and possibly in all rice growing areas, as this a one workable solution that is able of minimizing water shortages and crop failures.

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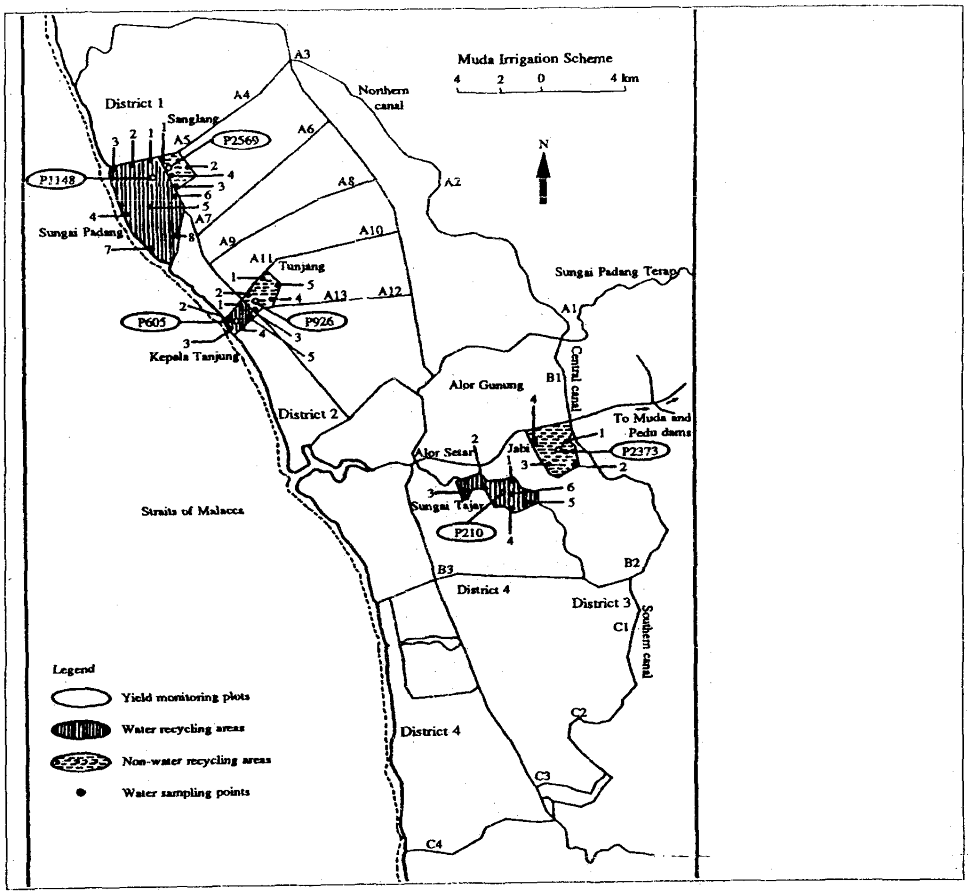

Figure 1. DWR and NDWR study sites in the Muda Irrigation Area

Table 1. Yields from DWR and NDWR areas in the Muda region

Systems	DWR yield (t/ha)			NDWR yield (t/ha)		
Seasons	Sungai Tajar	Sungai Padang	Kepala Tanjung	Jabi	Sanglang	Tunjang
Off S –1	4.06	4.21	3.53	4.01	2.80	1.91
Main S-1	3.11	3.61	3.73	2.86	3.00	3.29
Off S-2	5.13	4.31	4.21	3.89	2.40	3.70
Main S-2	4.46	6.09	5.12	3.34	5.84	4.00
Total	16.76	18.22	16.59	14.10	14.04	12.90
Mean	4.19	4.56	4.15	3.53	3.51	3.23
C.V. (%)	20.16	23.44	17.07	15.03	44.82	28.69
System mean	4.30 a*			3.42 b		

*Significant at $p < 0.05$

Table 2. Quality and nutrient composition of DWR and NDWR in comparision to the original dam water source

Master properties			Nutrient composition (mg/L)			
Systems	EC dS/m	pH	Nitrogen	Phosphorus	Potassium	Chloride
DWR						
S. Tajar	0.07	5.56	3.58	0.40	3.05	9.93
S.Padang	0.13	6.16	4.11	0.54	4.35	34.69
K.Tanjung	0.15	7.69	3.50	0.96	10.57	32.88
Mean	0.12	6.47	3.73	0.63	5.99	25.85
NDWR						
Jabi	0.06	5.80	3.78	0.26	3.75	9.33
Sanglang	0.10	6.06	3.56	0.26	4.71	22.95
Tunjang	0.12	5.62	3.76	0.51	4.96	20.45
Mean	0.09	5.83	3.70	0.34	4.47	17.58
Pedu dam	0.05	6.45	2.30	1.18	3.53	6.50

Table 3. Ranking of aquatic weeds based on importance value

Drainage water recycling areas Sg. Tajar	Sg. Padang	Kepala Tanjung
Eichornia crassipes (60) *Limnophila heterophylla* (22) *Nymphoides indica* (6)	*Eichornia crassipes* (37) *Nymphides indica* (22) *Polyginum barbatum* (18) *Ludwigia adscendens* (17) *Scirpus grassus* (2) *Ipomoea aquatica* (2) *Nymphea nouchalis* (1) *Marsilea crenata* (0.9)	*Eichornia crassipes* (62) *Ipomoea aquatica* (21) *Nymphoides indica* (7) *Ludwigia adscendens* (3) *Polygonum barbatum* (2) *Nelumbo sucifera* (2) *Scirpus grossus* (1) *Nypmphea nouchali* (1) *Pistia stratiotes* (0.2) *Salvinia molesta* (0.1)
Non-water recycling area Jabi	Sanglang	Tunjang
Ludwigia adscendens (38) *Hydrilla verticillata* (25) *Utricularia aureas* (15) *Salvinia molesta* (11) *Nymphoides indica* (10)	*Ipomoea aquatica* (51) *Nymphoides indica* (32) *Bracharia nutica* (14) *Salvinia molesta* (3)	*Eichornia crassipes* (81) *Polygonum barbatum* (16) *Ludwigia adscendens* (3)

Table 4. Nutrient concentrations of water in the DWR and NDWR canals at weed sampling areas

Areas	EC – dS/m	pH	Nutrient composition			Alkalinity (meq/L)	Secchi disc (m)
			NO_3 - N	NH_3-N	Sol. React. P		
DWR							
Sungai Tajar	0.12	5.68	3.64	0.17	0.24	1.07	0.09
S. Padang	0.20	6.49	3.87	0.18	0.40	2.36	0.16
K. Tanjung	0.30	5.83	5.62	0.35	0.17	3.26	0.19
Mean	0.20	6.00	4.38	0.23	0.27	2.23	0.15
NDWR							
Jabi	0.07	5.91	3.14	0.12	0.15	1.68	0.45
Sanglang	0.16	6.40	3.43	0.20	0.24	2.63	0.16
Tunjang	0.13	5.38	6.46	0.20	0.16	1.46	0.19
Mean	0.12	5.90	4.34	0.17	0.18	1.92	0.27

Table 5. Bacterial population at various sampling stations in DWR and NDWR areas and the probable sources of pollution

Sampling occasion	Sampling Stations	Most probable nos./100 mL sample*				Fecal coliform:Fecal streptococci ratio	Probable pollution source
		Total coliform	Fecal coliform	*Escherichia coli*	Fecal streptococci		
Sg. Tajar and Jabi Areas							
1	ST3	920	nd	nd	70	<0.7	animal
	ST4	240	nd	nd	79	<0.7	animal
	ST5	>1600	nd	nd	130	<0.7	animal
	J1	1600	nd	nd	49	<0.7	animal
	J2	1600	nd	nd	nd	rnd	rnd
2	ST3	540	nd	nd	nd	rnd	rnd
	ST4	>1600	nd	nd	nd	<0.7	rnd
	ST5	>1600	nd	nd	2	rnd	animal
	J1	920	nd	nd	nd	<0.7	rnd
	J2	>1600	nd	nd	2	rnd	animal
	J3	920	nd	nd	nd	rnd	rnd
3	ST3	>1600	tnu	tnu	13	rnd	rnd
	ST4	>1600	tnu	tnu	8	rnd	rnd
	ST5	>1600	8	8	nd	>4.0	human
	J1	>1600	5	5	2	2.5	mixture
	J2	>1600	5	8	2	2.5	mixture
	J3	>1600	8	13	2	>4.0	mixture
4	ST3	>1600	8	8	nd	>4.0	human
	ST4	>1600	9	9	nd	>4.0	human
	St5	920	tnu	tnu	nd	rnd	rnd
	J1	>1600	23	8	nd	>4.0	human
	J2	>1600	7	4	nd	>4.0	human
	J3	>1600	tnu	tnu	nd	>4.0	rnd
5	ST1	>1600	>1600	1600	11	>4.0	human
	ST2	>1600	>1600	1600	4	>4.0	human
	ST3	>1600	>1600	1600	14	>4.0	human
	J1	>1600	>1600	1600	220	>4.0	human
	J2	>1600	>1600	1600	2	>4.0	human
	J3	>1600	>1600	1600	14	>4.0	human
6	ST1	170	170	170	49	3.5	mixture
	ST2	350	350	350	170	2.0	mixture
	ST3	>1600	>1600	>1600	540	3.0	mixture
	J1	350	tnu	tnu	49	rnd	rnd
	J2	920	540	240	70	>4.0	human
	J3	-	_	-	-	-	rnd
Sg. Padang and Sanglang areas							

1	SP1	>1600	>1600	tnu	280	>4.0	human
	SP2	>1600	tnu	tnu	1600	rnd	rnd
	SP7	>1600	tnu	tnu	350	rnd	rnd
	S1	920	170	110	tnu	rnd	rnd
	S2	>1600	1600	1600	>1600	rnd	rnd
	S3	>1600	920	920	tnu	tnd	rnd
2	SP1	>1600	1600	1600	tnu	rnd	rnd
	SP2	>1600	1600	1600	tnu	rnd	rnd
	SP7	170	170	79	tnu	>4.0	human
	S1	>1600	1600	1600	110	>4.0	human
	S2	>1600	920	920	540	1.7	mixture
	S3	>1600	>1600	>1600	920	1.7	mixture
Kepala Tanjung and Tunjang areas							

	KT2	>1600	>1600	>1600	tnu	>4.0	human
	KT3	>1600	>1600	>1600	170	>4.0	human
	KT5	>1600	>1600	>1600	14	>4.0	human
	T3	>1600	>1600	>1600	tnu	rnd	rnd
	T4	>1600	>1600	>1600	43	>4.0	human
	T5	>1600	>1600	>1600	33	>4.0	human
2							
	KT2	>1600	920	920	540	1.7	mixture
	KT3	>1600	540	540	549	2.9	mixture
	KT5	>1600	920	920	21	>4.0	human
	T3	>1600	>1600	1600	350	>4.0	human
	T4	>1600	>1600	1600	79	>4.0	human
	T5	>1600	920	920	79	>4.0	human
3							
	KT2	>1600	920	920	1600	<0.7	animal
	KT3	>1600	920	920	280	3.3	mixture
	KT5	>1600	1600	1600	170	>4.0	human
	T2	>1600	200	220	240	0.9	mixture
	T3	>1600	>1600	1600	350	>4.0	human
	T4	>1600	540	540	920	<0.7	animal
4							
	KT2	>1600	tnu	tnu	920	rnd	rnd
	KT3	>1600	tnu	tnu	240	rnd	rnd
	KT4	>1600	130	130	23	>4.0	human
	T2	>1600	920	920	70	>4.0	human
	T3	>1600	tnu	tnu	350	rnd	rnd
	T4	>1600	350	350	240	1.5	mixture
5							
	KT2	>1600	tnu	tnu	20	rnd	rnd
	KT3	>1600	140	140	350	<0.7	animal
	KT4	>1600	tnu	tnu	170	rnd	rnd
	T2	>1600	tnu	tnu	130.	rnd	rnd
	T3	>1600	tnu	tnu	130	rnd	rnd
	T4	>1600	tnu	tnu	1600	rnd	rnd
6							
	KT2	4	nd	nd	11	<0.7	animal
	KT3	>1600	tnu	tnu	nd	rnd	rnd
	KT4	>1600	tnu	tnu	110	rnd	rnd
	T2	920	tnu	tnu	33	rnd	rnd
	T3	>1600	540	220	920	<0.7	animal
	T5	>1600	tnu	tnu	540	rnd	rnd
7							
	KT2	1600	1600	200	22	>4.0	human
	KT3	1600	tnu	tnu	27	rnd	rnd
	KT4	>1600	tnu	tnu	70	rnd	rnd
	T2	>1600	280	170	2	>4.0	human
	T3	>1600	170	170	8	>4.0	human
	T5	>1600	>1600	1600	tnu	rnd	rnd

* nd = not detected
tnu = triplet test not useful
rnd = ratio could not be detected

Table 6. Classification of DWR and NDWR with WHO *E.coli* counts

Stations	No. of samples		Frequency of *E. coli* no. per 100 mL sample		
DWR	Studied	Non-useful triplets	100	100-1000	>1000
ST3	11	2	4	3	7
ST4	11	3	3	4	1
ST5	11	2	5	2	2
SP1	3	1	0	0	1
SP2	4	1	0	0	1
SP7	4	1	1	0	0
KT2	7	2	1	3	1
KT3	7	3	0	3	1
KT5	7	3	0	2	2
Total	65	18	14	17	16
NDWR					
J1	10	3	5	1	1
J2	11	2	4	3	2
J3	10	3	3	3	1
S1	2	0	0	1	1
S2	2	0	0	1	1
S3	2	0	0	1	1
T2	5	2	0	3	0
T3	7	2	0	2	3
T4	7	2	0	2	3
T5	2	0	0	1	1
Total	58	14	12	18	14

Table 7. DWR and NDWR system improvement with lime

Treatment	Crop yield – kg/ha					
	OS 96	MS 96	OS 97	MS 97	Mean	Improvement %
NDWR	1620	4508	2418	2430	2744	0
NDWR-liming	2153	4702	2817	2439	3028	10.34
DWR	2119	4727	2859	2534	3060	11.51
DWR-liming	3096	4894	3339	2497	3457	25.98

Table 8. Effects of zeolite addition on soil, water and crop yield under DWR sites

Parameters	Zeolite treatments – kg/ha					
	0	200	400	600	800	1000
Soil exch. bases %	26.30	27.05	32.83	35.29	37.00	40.00
Soil CEC +cmol/kg	9.60	12.80	13.40	13.40	13.40	14.20
Soil extract. EC dS/m	0.18	0.24	0.25	0.32	0.33	0.40
Drainage water Tot. N mg/L	14.00	12.00	12.00	10.00	10.00	8.00
Crop yield - kg/ha	3610	4092	4189	4364	4727	5093

Food Security and Sustainable Food Production in China by the Early 21st Century

Mei Fangquan*

Development of China's food security is a key issue that attracts a worldwide attention. The foundation for realizing food security is sustainable development to ensure the balance of total amount and structure between food supply and demand. Therefore, it is essential for China to realize the dual goal of food security and improvement of resource and environment.

I. Changing trends in China's basic conditions

It is estimated that by the year 2010 China's population will increase to about 1.4 billion and will increase to its peak at about 1.6 billion in 2030, per capita arable land will decrease to 0.08 ha., per capita national income and expenditure on food will increase by folds.

I.1. Continuous increase of population

During the past 18 years, China has her population increased from 987 million in 1980 to 1246 million in 1998with an average of 13.5 million (1.2%) annually. According to prediction by multiple ways, China will have her population increasing to 1400, 1470-1540 and 1570-1630 million, respectively, by the year 2010, 2020 and 2030, that will be a period with a biggest population. Thus, it is essential for China to have a strict control on her population increase. The following analyses on food development are based on the above-predicted population.

I.2. Continuous decrease of arable land and per capita water resource

a. Continued decrease of cultivated land area, during 18 years between 1980 and 1998, decreased from 99.3 million ha. to 95 million ha. and from 0. 1 ha. to 0.08 ha. per capita. However, recent findings from satellite, remote sensing, aerial photography and land survey, indicate this number was incorrect and the actual land is closer to130 million ha.(an increase of 38 % over earlier estimates).

b. Currently, per capita quantity of water resources is only 2400 m^3, and only one-fourth of average world level, and will decrease to 1900 m^3 by the year 2010 and become the largest limited factor to food and agriculture development, especially in north China. About 80% of total quantity of water are used for irrigation and utilization rate of irrigation water is only 40%.

I.3. Continuous growth of national economy and people's purchasing power increased by folds

The nationwide residential consumption increased by 2.63 times, i.e. from 630 yuan in 1978 to 1659 yuan RMB in 1995, of which expenditure for food increased from 422 yuan to 896 yuan (The Engel's index decreased from 67% to 54%). It indicates a significant improvement in people's living standards.

By the year 2010, The nationwide residential consumption will be 3680 yuan

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RMB (calculated with a comparable price in 1990, the same in the follows) and The expenditure for food (the Engel's index will decrease from 49% in 1999 to 46% in 2010) will be 1680 yuan. There will be a big increase in the demand for food and the people's living standard will upgrade from better off to wealthy (According to the FAO classification standards, the better off level has the Engel's index 40-49%).

II. Changing Trends on Grain and Food Security in China

The main animal and other plant foods in China are closely associated with the grain, greatly based on the grain. Therefore, the grain situation determines the status of the China's foods.

II.1. Growth of Consumption and Demand of Major Food

By the years 2010, China will have a total grain demand of 560-590 million tones, with 38% of them used as animal feed.

(1) Great changes have taken place in quantity and structure of food grain and food consumption during the past 20 years.

China had a total grain consumption increased from 300 million tons in 1978 to 480 million tones in 1998; per capita food grain consumption, from 300 kg to 384 kg; and the proportion used as animal feed from 12% to 30%. At the same time, there was a trend of rapid increase in consumption of animal food, with per capita consumption of meat, egg and aquatic products increased from 8.86 kg, 1.97 kg and 3.5 kg in 1978 to 28.91 kg, 11.75 kg and 12.09 kg in 1995, respectively; and edible oil, sugar and fruits, from 1.6 kg, 3.42 kg and 6.6 kg to 6.29, 5.42 kg and 30.94 kg. The long-term significant increase in consumption of animal foods and fruits has greatly improved nutritional conditions of the Chinese people.

Major food consumption in 1999:

(Based on the data calculated from" China Statistical Yearbook" and "Introduction of National Agricultural Statistics")

	Amount of Demand (10000 tones)	Consumption/per capita (kg)
Grain	46,010	218.00
Meat	5003	26.90
Eggs	1,574	11.75
Milk	695	7.00
Aquatic-products	2,240	12.09
Fruits	4,117	30.94

(2) By the year 2010, the food structure and level of consumption of residents both in cities and towns in China will be in the mid-stage of comparatively well-off. Food quality would be improved obviously.

Amount of major food demand by the year 2010 (average)

	Total demand (10000 tonnes)	Demand per capita (kg)	Consumption per capita (kg)
Grain	56,000-59,000	400-420	193
Meat	6,700	48	34
Eggs	2,640	19	16
Aquatic-products	3,800	24	18
Milk	2,240	16	14
Fruits	6,160	44	40

(3) By the years 2010, 38% of the total grain demands will be used as animal feeds.

If we adjust the planting structure , carry out the triple-structure engineering, speed up development of the integrated production and manage systems of grain crops-feed crops-economic crops, planting-breeding-process, production-process-marketing, benefit of high quality feed crops will be 50% higher than that of grain varieties eaten directly by human which are used as feed. The changing trends of grain consumption demands in the future would be better analyzed from the viewpoint of the benefit of the structure changes.

II.2. Growth of Production and Supply of Major Food

The main animal and other plant foods in China are closely associated with the grain, greatly based on the grain. Therefore, the grain situation determines the status of the China's foods. By the years 2010, the total grain production could be about 540-560 million tons, just by implementing advanced technology presently available .

(1) During the past 10 years, the area planted to grain remained nearly 110 million ha. This area should continuously remain above 110 million ha in the long term .

By the year 2030, the arable land (statistical area) will be reduced from 130 million ha. in 1993 to 123 million ha., but the multiple crop index would be increased from the present 156% to above 160%, the total crop area will approximately be 145 million ha. with 74% for planting grain, area sown to grain will be about 107 million ha. (The ratio of the grain planted area: the total crop area equals 74% in 1993).

(2) By the year 2010, the total grain production will probably be near 560 million tonnes.

The fertilizer utilization will be increased from 35.95 million tonnes in 1995 to 43 million tonnes (standard fertilizer). The irrigated land will be 57 million ha, with 62% of arable land. Giving the corresponding input and economic management policies, the grain yield will probably increase from 4245kg./ha. in 1995 to 5100-5250 kg/ha., similar to that in early 1990s in Jilin, Liaoning, Beijing, Zhejiang, Jiangsu, Shanghai, Guangdong and Hunan. It may exceed that level if breakthroughs are made in grain production technology and comprehensive management.

(3) Major animal food products will continue to grow into the 2030s.

The continued growth of grain with basic support and advancements of science and technology will overflow into animal food production and continue to improve the utilization efficiency of food resources. The per capita production of meat, egg, milk and aquatic products will reach, respectively, 47.2, 17.4, 16.7 and 29.0 kg by the year 2010, indicating that the demand for improving diet will be basically satisfied.

(4) During the early 21st century basic demand-supply balance for food grain and major foodstuff can be realized

In order to realize this goal, the proper guarantee of material, technology, capital and effective economic regulatory policy must be attained. Food grain imports can be restricted to 20-30 million tonnes. The shortage of grain and foodstuff lies mainly in feed grain. In view of the comparative advantage of grain in the international markets and the adjustments of grain demand-supply structures, wheat is chosen as the major grain to be imported and the increased domestic grain supply is used mainly as animal feed to increase animal food products and adjust dietary composition.

III. Food Security and International Trade

The Chinese Government and the majority of experts believe that, with regard to grain and food security issue, China must adhere to the policy of "relying mainly on our own efforts while making appropriate import subsidiary for variety adjustment", and actively promote multi-forms and multi-products international trade. This will contribute to achieve food security and favor the realization of stable, coordinated and sustainable development of grain and food in China and the world. This issue is further analyzed in the following paragraphs.

III.1. In the past, grain import in China was mainly used to adjust surplus and shortage among regions and varieties.

Experiences gained during the past 50 years indicate that China's reliance on world grain market is not strong. China was a net grain exporter during the 1950s and 1960s, and both import and export occurred during the 1970s. From 1978 to 1995, a period of high-speed economic development owing to the opening and reform policy in China, the average net amount of imported grain was 6.56 million tons, accounting for less than 2% of the country's total grain production. During the past 20 years, the proportion of imported grain to the country's total grain production exhibited a declining trend: being 3.2% from 1978 to 1984, 1.2% from 1985 to 1990, and 0.4% from 1991 to 1995. Reasonable grain import by China dose not threaten the world, furthermore, it has promoted international trade for grain and food.

III.2. China is making great efforts to scale up international trade for food and agricultural products.

China is also a major net food exporting country. From 1985 to 1995, China's food export and import were valued at 75.6 and 34.0 billion US dollars, respectively. China needs to continue to import grain while the country is constantly increasing its export of other food varieties. Exports of poultry and eggs assume great significance in the world market and that of meats is on the rise. China has vast hilly regions and water areas, and the exports of newly developed unique food products are increasing. Food processing industry is developing rapidly, and exports and added value continue to increase. The ratio of food processing industry's production value to that of agriculture has been very low, but now China is accelerating industries restructuring and developing high yield, quality and efficiency agriculture, industrialized agriculture and foreign exchange earning agriculture. So the exports of processed food and agricultural products will continue to increase with great prospects, and will promote international trade of processed food and agricultural products.

III.3. As China imports massive grain, grain prices in the world market will go up.

1995 was the year in which China's grain import set a historical high record, reaching 20.81 million tons and accounting for 4% of the total domestic consumption of that year. In 1995, the average price of imported grain was 179 US dollars/ton, which stimulated immediate and sharp increase of grain price in the world grain market. In 1996, China imported 12.23 million tons of grain and the components were virtually the same as those imported in 1995, but the average price went up to 242 US dollars/ton, an increase as high as 35%. And at the same year, wheat price also rose from 175 to 229 US dollars/ton. Some grain importing countries expressed their discontentment. In 1996, world market prices for wheat and corn exceeded the highest prices during the grain crisis in the early 1970s. This, of course, closely correlates with the constant decline of global grain reserves. If China greatly increases its grain import with this background, grain price will be doomed to go up sharply.

III.4. China and other major grain exporting countries should also consider the serious problem of grain shortage faced by many developing countries.

There are about 800 million people in the developing countries who are living under long-term malnutrition and about 200 million children under the age of 5 who lack protein and energy. And in the western grain exporting countries there are 34.5 million hectares of arable land that are transferred to other uses or left fallow. Nowadays, more countries are suffering from urgent grain shortage. In 1997, there were 31 countries that fell into the urgent grain shortage category, adding 6 more to the 1996 figure. Most of the urgent grain shortage countries are located in Africa (20). During the past 10 years, the increase of world grain output was significantly lower than population growth, and the per capita grain availability declined from the peak value of 346 kg in 1984 to 295 kg in 1995. The world has to settle the imbalance between demand and supply with its grain reserves. From 1991 to 1996, the world turnover grain reserves declined from 339 to 229 million tons, the lowest level in history that could meet the consumption by the world for only 48 days. This is considered a very dangerous level. The number of countries and people lacking grain is on the rise, and on the other hand, international grain aid is on the decrease, indicating that the situation of grain shortage in the whole world is still serious. China should not and will not compete with these countries for world market grain. Therefore, developed countries that export massive grain should pay more attention to the urgent needs of these countries facing serious grain shortage.

The next 30 years represent a long period of time, in which international market may change substantially, and China's and the world's grain and food trade will achieve great development.

IV. Reasonable Utilization of Food Resources and Environment Protection

Foundation for realizing food security is sustainable food production, which depends on reasonable development and utilization of agricultural resources, protection and improvement of ecological environment so as to gradually attain coordinated development between food production and ecological environment.

IV.I. To realize sustainable food production, resource must be protected and utilized reasonably

a. Implementing the protection policy of arable land, take about 80% of arable land as basic farmland protection area. At the same time, strengthening transformation of medium and low-yielding farmland and raising land productivity.

b. Increasing supply of water for agriculture and irrigation ability. By the year 2000, expand national irrigation area from 48.65 million ha. in 1993 to 53.33 million ha., meanwhile popularize irrigation technology of saving water and raise utilization rate of water resource.

c. Increasing forest-cover rate from 13.6% in 1993 to 15-16 in 2000, eliminate the deficit of wood forestry and improve the quality and benefit of forestry.

d. Raising grassland productivity. By 2000, artificial and improvement grassland will reach 33.33 million ha., fence grassland 20.00 million ha., and artificial and improvement grassland will make up about 10% of total available gradually grassland gradually. 20 natural protection as of grassland should be constructed to basically control degradation tendency of grassland and its ecological environment.

e. Protecting resource of water field, strictly banning over-catch and control making farmland through enclosing dam to return the farmland to fishery in some area. Protect and increase the resource of economical fish along coast by efficient way.

f. Integrated preventing the soil and water erosion, increasing average control area from 20 thousand to 40 thousand square kilometers per year. By the year 2000, area of integrated control will reach 320 thousand square kilometers. Identifying 920 thousand kilometers land (national light erosion as protection) as priority to set up key protection area, and renew vegetation so as to basically control soil and water erosion.

At same time, Adopt effective integrated administration for realizing sustainable use of Food and agricultural resource

a. Scientific monitor and management system should be formed for development and utilization of major agricultural resource such as land, water, forestry, grassland and biological resource, and organically combine development and use, protection and administration, and reproduction of resource.

b. Resource accounting should be strengthened, carry out resource pricing and rewarded use, and put resource accounting into national economy accounting system and operation system of market-oriented economy.

c. Optimum combination function of resource should be played to form an agricultural ecology system of sustainable balance with various characteristics.

d. Integrated treatment of soil and water erosion should be strengthened to establish protection forestry system with various forms.

IV.2. Environment must be protected strictly for realizing sustainable food production

a. Effective policy, taw and regulations must be taken in order to protect agriculture and rural environment from industrial waste substances.

b. Rural drinking water should gradually concentrate supply. By the year 2000; a sound circle of water resource, water quality and water ecological system should be accomplished.

c. Under situation of continued increasing of chemical fertilizer application, speed up adjustment of variety structure of chemical fertilizer, research, manufacture and extend new variety of chemical fertilizers to improve applied measures of chemical fertilizer and reduce of fertilizer pollution.

d. Controlling utilization of pesticide and plastic film with high-residue, extending high-efficiency, low-poison, low-residue pesticides and no-residue plastic film.

e. Decrease of damage from natural disaster ought to adopt integrated prevention and control. On one hand, the ability of adaptation and resistant to natural disaster on the agriculture and living things should be strengthened; on the other hand, land deserting, soil and water erosion should be controlled, return farmland to fishery and forestry, establish sound circle environment system.

f. Overall planning and rationally locating township enterprises, strengthen capital construction of facilities and prevent the pollution by industries, establishing and improving the system for environment protection and pollution control for township enterprises, insisting on the principle of combination between leading and limiting, emphasis on pollution control in region and sector.

IV.3. Implement Strategy of Sustainable Regional Development

In the eastern district controlling the over and imbalance use of agricultural chemical, controlling the over utilization of crop land and water area resources are important.

In the central areas with agriculture as the main industry; protection of the rural ecological environment should be strengthened; improvement in soil fertility of medium and low-yielding croplands and increasing the productivity of agricultural resources are important strategies.

In the under developed western area, much attention should be paid to water and soil erosion caused by the over utilization of resources, irrational development, over reclamation and over grazing of grassland. This will protect the environment.

V. Strategic Selections for Food Development

In order to attain the basic balance between demand and supply of staple food and to satisfy the ever-increasing demand for higher living standards in the early years of the 21st century, economic system reform and the 2 fundamental changes in economic growth mode must be carried out and at the same time the 2 strategies, sustainable development and rejuvenating the nation through science and education, must be implemented.

V.1. Guide the Consumption of Food and Adjust the Policy of Food and Nutrition Composition.

The consumption and production of grain should be recognized in food and nutrition as a whole. Firstly, strengthen the popularization of scientific knowledge on the diet and nutrition, disseminate Chinese diet guideline are recommended by the scientists engaged in nutrition research; Secondly, guide food consumption by economic adjusting measure and market operation; Thirdly, adopt legislation and economic intervention measures, encourage scientific consumption and avoid waste performance .

V.2. Strengthen Agricultural Infrastructures and Increase Agricultural Inputs.

The acreage under effective irrigation should be increased as soon as possible, from 49.37 million ha in 1995 to 53.33 million ha in 2000, 56.7 million ha in 2010 and 73.0 million ha in 2030, bringing 80% of farmland under irrigation. Fertilizer input should be increased from 35.95 million nutrient tonnes in 1995 to 37.50 million tonnes in 2000 and 43 million tonnes in 2010. Meanwhile soil improvements should be accelerated for middle and low productivity farmlands, the goal is to improve 3.33 million ha each year for the next 15 years, so as to secure a stable productivity for the farmlands.

V.3. Management System Combined between Family Economy and Cooperative Service should be insisted.

Stabilize and improve the system for long term use of farmland by farmers on base of collective ownership, farmer's related stable rights of contract, manage, transfer in the law should be recognized. Define relationship of collective property right and develop cooperative economy by stock system, so that both collective and farmer's benefits wouldn't be harmed. Improve family economy and, at the same time, expand economy scale in a step by step manner, emphasis on speeding up the development of technical extension service system and supply and marketing cooperative service system as well as financial cooperative service system etc., so as to speeding up the change of micro-economy system.

V.4. Establish a Macro Management System Combining Production, Proceesing and Marketing.

In order to enforce effective macro regulation, it is urgently needed to set up a perfect and integrated system which takes into account of the national grain and foodstuff as well as an agricultural stock system, risk foundation system and a price protection system, and to incorporate multi-sector management mechanisms in agriculture, commerce, water conservancy, chemical industry, foreign trade, price, planning etc. into a unified and harmonious system.

V.5. Promote Agricultural Industrialization and change of economic growth pattern.

During the transfer to market orientated economy system, implement integrated management of planting-animal raising-processing industries as well as trade-industry-agriculture sectors, organize numerous small household by various ways to enter a big market in a step by step manner through benefit relation mechanisms. Promote deep processing on the bases of preliminary production of large agricultural products, realize multi-increasing of value, and accelerate deep utilization of resources and raise efficiency of resource utilization .

V.6. Establish a National Food Security and Early Warning System.

A perfect and sensitive food security and early warning system needs to be developed, which is an essential and powerful tool for macro regulation and plays an important role in the timely prevention, elimination and alleviation of the influences resulting from the total amount, structures and regional imbalance in food grain and staple foodstuffs.

V.7. Highlight the Regulation of Price Structure to Promote Stable Growth of Food Production.

As China's grain and staple foodstuff prices have reached the level prevalent in international markets, keeping the same price level is required by the long-term strategies for the whole national economy and international trade. Measures must be taken to guarantee farmers' income by regulating the price parities between industrial and agricultural products, especially the price of the means of agro-production. If control over the price of agricultural inputs is difficult to realize, the direct in-kind exchange of such means of production as fertilizers, energy etc. for grains can be used to maintain stable grain prices and agriculture's comparative benefit.

V.8. Accelerate implementation of "trio-structure Engineering" to Increase Overall Benefits of Food Resources.

Changing the farming sector from its traditional dual structure of "food crops-cash crops" to a trio-structure of "food crops-feed crops-cash crops". This is characterized by coordinated crop cultivation and animal husbandry development and integration of production, supply and marketing while promoting the quick formation of new and highly profitable industrial agricultural systems. In order to push on the project, comprehensive measures and effective policies are urgently needed and the feed industry should be treated as a relatively independent sector.

V.9. Implement Sustainable Food and Agricultural Technology Policy.

As most new varieties of food grain and foodstuffs and new technologies for their production create mainly social benefits, effective policies need to be made to give priority support to food and agricultural technologies. At the same time priority support should also be given to those advanced practical technologies which make rational use of agricultural resources, protect the environment and favor high-yield, superior-quality and high-efficiency agriculture combined with sustainable development. Focus should be on strengthening rational location of township and village enterprises and preventing pollution by industries and large farming operation.

V.10. Implement Strategy of Sustainable Regional Development

In the eastern district controlling the over and imbalance use of agricultural chemical, controlling the over utilization of crop land and water area resources are important.

In the central areas with agriculture as the main industry; protection of the rural ecological environment should be strengthened; improvement in soil fertility of medium and low-yielding croplands and increasing the productivity of agricultural resources are important strategies.

In the under developed western area, much attention should be paid to water and soil erosion caused by the over utilization of resources, irrational development, over reclamation and over grazing of grassland. This will protect the environment.

From the above analysis it can be concluded that the time from the present to the 2030s is a critical period for China's food and agricultural development. More than 1 billion Chinese people not only can feed themselves but also be able to step forward from the comparatively well-off level into the well-off food consumption period with more balanced diets. With this, Chinese people can make a greater contribution to the world.

Policies and Guidelines on Sustainable Agricultural Development in Malaysia[1]

Lim Jit Sai[2]

ABSTRACT

Malaysia is a strong advocate of sustainable development. In the agricultural sector, it has introduced and implemented several measures that direct and ensure judicious land use for agricultural production that does not adversely affect the environment. The measures undertaken include formulating and implementing policies, technical guidelines, and legislation, and promoting environment friendly practices such as soil conservation measures, and the recycling and proper disposal of bio-wastes.

Two major policies that ensure the sustainable use of land for agricultural and forestry development are the National Agricultural Policy and the National Forestry Policy. The National Agriculture Policy emphasizes increasing productivity through the efficient use of resources and discourages the opening of new for land for agricultural production. This objective is to be achieved on the basis of sustainability by introducing agro-forestry; integration of cattle and sheep rearing with rubber and oil palm holdings; rehabilitation of idle land; amalgamation of small land parcels land into larger and more economic units; more efficient use of lakes, ponds and mining pools for aquaculture; raising the productivity of existing or declining land area by using new and environmentally friendly technologies; planting of high value crops; and improving the productivity of problem soils such sandy beach soils (BRIS), acid sulphate, ex-mining

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land and peat.

The National Forestry Policy, on the other hand, focuses on forest preservation, rehabilitation and reforestation of logged forest land. About 4.84 million hectares of forested land are designated as Permanent Reserved Forest to be managed sustainably for the benefit of both the present and future generations. This comprises 36.8% of the total land area in Peninsular Malaysia. These forest lands are secured in their tenure as they are gazetted in accordance with the National Forestry Act 1984.

A decision made by the National Forestry Council in 1998 to prohibit the development of land above 1000 mapl is a positive taken by the Government to protect the highlands and their fragile mountain ecosystems and to preserve them as catchment areas for the continuous supply of water.

These two policies, the recent Government's decision to prohibit land development 1000 masl together with the other environment friendly practices and land degradation mitigation measures, have contributed significantly to sustainable agricultural and forest production and the preservation of the environment.

Planning and technical guidelines are implemented to ensure sustainable development. The main planning guidelines include the *Land Capability Classification (LCC)* by the Economic Planning Unit of the Prime Minister's Department, and the *Soil-Crop Suitability Classification of the Department of Agriculture (SCSC-DOA)*. The technical guidelines for on-site implementation of projects are *Guidelines for Developing Sloping Land* by the Department of Agriculture; *Guidelines for Prevention of Soil Erosion and Siltation* by the Department of Environment; and EIA (Environment Impact Assessment) by the Department of Environment.

The laws enacted to ensure sustainable agricultural production and protect the environment include the *Land Conservation Act, 1960*, the *Environmental Quality Act, 1974* and *National Forestry Act, 1984*.

Other efforts undertaken to ensure sustainable agricultural production include the monitoring soil erosion losses according to soil types on the various terrain classes. The Department of Agriculture has produced the Erosion Risk Map of Peninsular Malaysia. The map identifies areas with low; moderate, moderately high, high and very high risk of soil erosion. Using these maps, planners and implementers alike are well informed on the potential risk of soil erosion in existing and proposed project sites and are in a better position to take appropriate measures to prevent and combat soil erosion and land degradation.

Recycling wastes into value-added products has significantly reduced land, water, and air pollution, and fire and haze hazards, and increased the farm income. Paddy straw is recycled as compost, plant waste such as maize stalks and leaves made into silage and pineapple waste processed into cattle feed. Empty oil palm fruit bunches are used as mulch, fuel or composting materials. In replanting oil palm, the trunks are either poisoned and allowed to rot or are fell, chipped, stacked and left to decay in the field. The use organic waste products such as animal dropping, empty oil palm fruit bunches, palm oil mill effluent (POME) and compost to improve the soil fertility reduces the use and import of mineral fertilizers. Malaysia imported 14.5 million tons of chemical fertilizers valued at RM 1.32 billion in 2001. Successful treatment and recycling of some of these organic wastes which are otherwise hazardous to the environment if disposed of indiscriminately is an encouraging sign in the combat of pollution and the preservation of the environment in a healthy state.

INTRODUCTION

Land as a resource has unquestionably contributed significantly to the growth and overall development of Malaysia. Forest produce and minerals are among some of the land resources that have contributed to the economic growth of the country. In the early years of the country's independence, there was also an abundance of suitable land, which Malaysia used effectively to develop a strong agricultural sector, which became the mainstay of the country's economy for at least two decades after the independence. The conducive environmental conditions favoured the cultivation of the country's two major crops-rubber and oil palm-which helped to build and shape the economy of Malaysia. Since their cultivation in the early 19th century, Malaysia has become the main producer of rubber and palm oil in the world.

Although the contribution by the agricultural sector to the nation's economy has declined in recent years, agriculture remains the main user of the land in the country. The fast tempo of development of the agricultural sector has resulted in a rapid depletion of most of the agriculturally suitable land in the country. However, the demand for land continues to increase in both the agricultural and the non-agricultural sectors as increasingly, more economic activities are being generated in these sectors. With the launching of the Vision 2020 to make Malaysia an industrialized nation by the year 2020, more pressures will be placed on the land and its resources to support the overall process of working towards fulfilling this vision.

The successful development of the agricultural sector on a sustainable basis in Malaysia is due in part to the proper planning, utilization and management of the land. Efforts are constantly being undertaken to introduce more efficient, environment friendly farming methods to raise productivity which are not detrimental to the environment. Guidelines and regulations also have been drawn up and laws enacted to ensure the judicious use of land which prevents the unscrupulous exploitation of its resources and the indiscriminate destruction of the environment.

This paper gives an insight into policies, guidelines and legislation which are used in Malaysia to ensure sustainable agricultural production in Malaysia.

LAND USE

Land use statistics collected by the Soil Management Division of the Department of Agriculture for 1966, 1974, 1984, 1990 and 1997 (Department of Agriculture, 2002), a period of 31 years, reveal distinctive trends and patterns in major land uses (Table 1). Forest and swamps, and agriculture are the major land uses between 1966 and 1997. Collectively, forest and swamps remain the single biggest user of the land but the area occupied by them has declined by 2.6 million ha from 9.64 million ha in 1966 to 7.08 million ha in 1997. Agriculture is the next important user of the land and showed a significant increase of 2.51 million ha from 2.7 million ha in 1966 to 5.21 million ha in 1997. For the same period, urban land and water bodies have also increased significantly although the area they occupy is much lower than that of agriculture. The substantial increase in the urban land is due to more land being used for housing and other industrial uses.

Table 1: Changes in Major Land Use Categories in Peninsular Malaysia 1966-1997 (in hectares)

Land use	1966	1974	1984	1990	1997
Forest & Swamps	9643814	8820891	7918233	7619980	7086270
Agriculture	2703978	3470087	4405553	4747833	5213746
Urban & related activities	134130	200289	263434	314078	447429
Water Bodies	132624	151434	172421	220470	233365
Others	558812	530657	413717	270997	192548
Total	13173358	13173358	13173358	13173358	13173358

Table 2: Major Agricultural Lands Use Changes in Pen. Malaysia between 1966 and 1997 (in hectares)

Land Use	1966		! 974		1984		1990		1997	
	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%
Oil Palm	99579	4	485068	14	1243534	28	1606044	34	2209515	42
Rubber	1777665	66	1938892	56	2003456	45	1960149	41	1859460	36
Paddy	400416	15	428612	12	447624	10	433384	9	421692	8
Mixed Horticulture	194112	7	236543	7	277006	6	284807	6	327451	6
Coconut	175947	7	197235	6	209196	5	202944	4	149263	3
Pineapple	17296	1	22026	1	18358	0	8113	0	5865	0
Cocoa	454	0	13080	0	44758	1	58291	1	8336	0
Orchard	6549	0	19877	1	28498	1	63143	1	104000	2
Annual Crops	0	0	70967	2	54970	1	48900	1	38601	1
Others	31960	1	57787	2	78153	2	82058	2	89563	2
Total	2703978	100	3470087	100	4405553	100	4747833	100	5213746	100

In the agricultural sector, oil palm and rubber together occupy more than 70% of the land under agricultural production for the period 1966 to 1997 (Table 2). Oil palm shows the most significant increase in the last 31 years, commencing with only 99,579 ha (4%) in 1966 and increasing to 2.2 million ha (42%) in 1997. Rubber covered 1.77 million ha in 1966, increased to 1.93 million ha in 1974 and 2.0 million ha in 1984 but decreased gradually to 1.9 million ha in 1990 and 1.85 million ha in 1997. The paddy land is quite constant and occupies slightly more than 400,000 ha since 1966.

POLICIES, GUIDELINES AND LAWS ON SUSTAINABLE AGRICULTRAL PRODUCTION

In Malaysia, the planning of land for both agricultural and non-agricultural uses is a continuous and elaborate process that takes into consideration many factors, principally the physical, socio-economic, and environment factors. Comprehensive studies have been commissioned and master plan studies drawn up by various agencies directly involved in or responsible for the use of land, to ensure its efficient and judicious use. In the era immediate after the nation's independence the urgent agenda of the nation was to eradicate poverty, raise the standard of living of the people especially those living in the rural areas, restructure society and to build up the economy. This policy guideline forms the main thrust of the country's nation building process that was actively pursued for at least 2 decades and is still being addressed today. Land was seen as the single most important physical resource that could be used help to fulfill these objectives. Rich mineral deposits in the soil were mined, and timber in the forest extracted for immediate economic benefits, and the land cleared for agricultural projects.

A review of the relevant policies, guidelines and laws of the country on agricultural land and other uses shows that some of them have been in existence for the last 2 or 3 decades when Malaysia embarked on her development programme. Sustainability of land use, environment protection and conservation of resources were given due consideration by the early these guidelines and laws even though environmental problems which are encountered today did not even exist at that time. In present-day context, they are undoubtedly out-of-date as they are not very effective in dealing with issues on land degradation and pollution. These weaknesses have been rectified and from time to time, amendments are made to strengthen existing policies, guidelines and laws, and in some instance, new policies, guidelines and laws are introduced to ensure sustainable development in all sectors.

In addition to policies, guidelines and laws. efforts are also made to promote environment friendly activities and technologies in agricultural production. Recycling of agricultural wastes into value-added products is also an important aspect of sustainable production. Recycling of the massive amounts of agro-wastes not only protects the environment from pollution by indiscriminate disposal of these wastes, but also increases farm income.

POLICIES

i. National Agricultural Policy (1992-2010)

Presently, there is one national policy which deals with the use of agricultural land on a sustainable basis, namely, The National Agricultural Policy (NAP) (1992-2010) (Ministry of Agriculture, 2000). The NAP stresses on the maximization of income through optimization of resources. Although not stated in explicit terms, the NAP discourages the opening of new land and calls for a more efficient use of the land which will result in higher productivity. This objective is to be achieved on the basis of sustainability by introducing agro-forestry; integration of cattle and sheep rearing with rubber and oil palm holdings; rehabilitation of idle land; amalgamation of small land parcels into larger and more economic units; more efficient use of lakes, ponds and mining pools for aquaculture; raising the productivity of existing or declining land area by using new and environmentally friendly technologies; planting of high value crops; and improving the productivity of problem soils such as the sandy beach soils (BRIS), acid sulphate, ex-mining land and peat.

Mixed Farming

To promote the efficient use of land and to raise the farm income, mixed farming is implemented in rubber and oil palm smallholdings. In conventional rubber planting, 85% of the exposed areas is drastically reduced to 45% in second year and completely covered at the end of third year (Abdul Ghani and Zulkefly, 2001). The hedge row planting system in rubber results in more efficient use of the land which also contributes to raising farm productivity and income on a sustainable basis both during the immature and productive phase of growing rubber. Besides permitting continuous cultivation of short and medium- term crops, this system also permits simultaneous incorporation of perennial fruit trees or pastures to support high stocking rates of ruminants or poultry, apiculture or mushroom.

Table 4: Income Improvements of Some Mixed Farming Enterprises

Main Crop	Value Added Components	Period from Establishment (main crop)	Mean Additional Income with Mixed Farming (RM)
Rubber (1.8 ha) Conventional Planted	Vegetable (0.2 ha)+ banana interow	7 years	580/month
Rubber (2.02 ha) Hedge planted	Chili, long bean, groundnut, spinach, sweet potato, maize, banana, bread fruit, coffee, & autocarpus	6.25 years	386/month
Rubber (2.02 ha) Hedge planted	Sugar cane	2 years	1,389/month
Rubber (2.4 ha) Perimeter planted	Cash crop & chicken rearing	4.25 years	1,784/month
Rubber (0.57 ha) Hedge planted	Chili, long bean, cucumber, Water melon & lemon grass	2.5 years	579/month
Rubber (5.2 ha) Conventional planted	Pineapple	2 years	1,958/month
Rubber (1 ha) Conventional planted	Pineapple	3 years	3109/season
Oil palm (1 ha) Hedge planted	Sugar cane – intercrop Banana - intercrop Pineapple – intercrop	22 months 20 months 15 months	533/months 832/months 231/months
Petai (*Pakia speciosa*) or Forest Plantation High Density Planting	Mixed ginger +lemon grass + turmeric	5 years	300/months
Oil Palm (4 ha) Conventional Planting	Cattle	Mature plants	216/months

Source : Abdul Razak, *et al* 2001

Similarly, in oil palm plantations and smallholdings, several crops have been found to be suitable for integration with immature oil palm. Work by Malaysian Palm Oil Board in collaboration with smallholders has shown that with the planting of yellow sugarcane, banana and pineapple in immature oil palm, a net profit of RM 11,731.00 (US$ 3,087) from of 2 ratoons of yellow sugarcane can be obtained. Two harvests of banana intercrop yielded RM16,644.00 (US$ 4,380) and one round of pineapple resulted in RM 3,470.00 (US$ 913) per hectare (Tayeb, 2001). Income improvements of some mixed farming enterprises are as in Table 4.

The integration of livestock in crop plantations such as oil palm is another efficient way of optimizing land use on a sustainable basis to maximize income. Introduction of animals has benefited farmers especially in saving labour cost up to 50% per hectare per year, reducing weeding cost by 30–50%, increasing oil palm fresh fruit bunch by 6–30% and lowering usage of chemical fertilizers and the improvement of soil structure through addition of organic matter to the soil (Azizol, 2001, Tayeb, 2001). The ruminants evaluated on their potential for integration in oil palm holdings are buffalo, cattle, sheep and goat. Beef cattle integration in commercial crop plantation is found to be viable. This is led to the implementation of the Beef Integration Scheme by Department of Veterinary Services (Azizol, 2001). The Scheme is a systematic method of cattle production in plantation area which is managed scientifically with electric fencing and rotational grazing. The stocking rate for cattle integration is 1 head to 4 hectares. In year 2000, 2,122 participants in 6 states were involved in raising 57,613 heads of cattle are involved in this project.

Another approach to the efficient land use on a sustainable basis in addition to raising the farm income is the integration of sweet corn planting with cattle fattening by feedlot system. In this project, the residues of corn plants are shredded and made into silage to feed the cattle after the cobs have been harvested and sold. One hectare of corn can provide sufficient raw materials for 12 head cattle in a year. This successful project has increased the income of farmers to as high as RM 1000 (US$ 263) per month (Department of Agriculture, 1999). Outside the paddy granary areas where only one rice crop is planted a year, the DOA has also introduced another integrated system of farming which includes the planting of short-term crops after the rice crop, chicken and duck rearing and aquaculture. With the intensification of land use, the income of farmers has increased from RM 580 (US$ 153) to RM 1000 (US$ 263) per month (Department of Agriculture, 2000).

Rehabilitation of Ex-tin Mining Land

Approximately 200,000 ha of land have been mined for tin ore in 1960s and 1970s. The main methods of mining tin are open-cast, gravel pump and dredging. The tin tailings left behind by these activities are highly impoverished by the washing process to extract the tin ore. In all cases, the sand and clay fraction of the soil were separated and dumped separately as sand and slime (mixture of sand and clay). The depth of the disturbed sediment varies from 10 m for dredging to ½ km for open-cast mining.

Several ex-tin mining areas have been successfully rehabilitated for crop production and mixed farming involving agricultural and aquaculture production. In rehabilitating tin tailings, application of 20-40 kg of organic matter in the planting holes is a normal practice. Fruit trees like carambola (*Averrhoa carambola L.*), ciku (*Achras zapota L.*) papaya (*Carica papaya L.*) and mango (*Mangifera indica L.)* have been observed to produce yield similar to normal soil. POME (Palm Oil Mill Effluent) and oil palm empty bunches are also used in the planting holes to improve water and nutrient holding capacities. The sand tailing areas are much sought after to produce quality mango.

Some of mining pools are used successfully for the rearing of ducks for export overseas especially Singapore.

Similar efforts are also being undertaken to raise the productivity of the BRIS (Beach Ridges Interspersed with Swales) soils. The BRIS landscape consists of the alternating parallel sandy beach ridges and low depressional areas which are commonly found in the east coast of Peninsular Malaysia. The BRIS areas contain infertile soils which are composed predominantly of inert sand particles. The sandy nature of these soils results in low inherent soil status, poor nutrient and water holding capacities, excessive drainage, high surface temperatures and evapotranspiration and a very high moisture stress. The low-lying swales are prone to flooding during the monsoon. Although some of the BRIS areas have been cultivated successfully for tobacco, cashew nut, roselle and other annual crops, they constitute some of the most under-utilized land in the country.

Rehabilitation of Idle land

Idle agricultural land is caused by rural-urban migration, adverse soil conditions such as the presence of acid sulphate soils, and complex land tenure system which results in land fragmentation, uneconomical farm size, absentee landlord and difficulty in locating owners to lease their land. The Department of Agriculture has identified 12,000 hectares of land which are suitable for agricultural development. Tangible efforts are being made to rehabilitate idle land despite the complex physical and socio-economic problems encountered. Already 2000 hectares have been rehabilitated for commercial farm production. A target has also been set to rehabilitate 4000 hectares of idle land from year 2003 to 2005. Reviving the use of idle land contributes to intensifying land use to raise agricultural production, and lessen the need to open up new land thereby contributing to the preservation of the environment.

Farming Under Rain Shelters

Increasingly, there is a noticeable move towards using rain shelters for the production of high value annual crops such as vegetables. Modern techniques such as fertigation and automation are employed. This farming system is more productive and uses less land compared to open farming, and hence reduces the demand for the opening up of new forest land for agricultural production.

ii. National Forest Policy (1978 and revised in 1992)

The National Forest Policy (Department of Forestry, 1978) is introduced to provide guidelines for the management, conservation, utilization, development and protection of forest. The main features of the Policy are the establishment of Permanent Reserved Forest (PRF) to ensure sustainable forest management, rehabilitation and reforestation of logged forest land. About 4.84 million hectares of forested land are designated as Permanent Reserved Forest to be managed sustainably for the benefit of both the present and future generations. This comprises 36.8% of the total land area in Peninsular Malaysia. These forest lands are secured in their tenure as they are gazetted in accordance with the National Forestry Act 1984. The policy protects forest land from indiscriminate exploitation and helps to preserve the rich biodiversity of the forest ecosystem.

GUIDELINES

i. General Guidelines on Opening of Forest Land

In Malaysia, land with slopes more than 25^0 is classified as steepland and is not recommended for agricultural development. For land with slopes less than 25^0, conservation measures are recommended including the construction of terraces, silt traps, contour ditches and proper drainage system, and planting of cover crops.

The National Forestry Council which is the highest national body overseeing the management the country's forest assets made a decision in 1998 to prohibit the opening of land above 1000 metres above sea level for any form of development. The decision was made to protect the unique ecosystem that exists in mountainous areas and to safeguard the mountain catchment areas which are vital for trapping rain water to ensure uninterrupted supply of water.

The steepland and the mountains together are the largest fragile ecosystem and occupy 15.7 million ha of land in Malaysia (78% of the total fragile land or 48% of the nation). It is estimated that in Peninsular Malaysia, 10% of the steepland has been developed (Lim and Chan 1993).

The use of these two guidelines has to a great extent regulated the use of land for agricultural production as only suitable land which is used for crop cultivation

ii. Guidelines

The following technical are among some of the important guidelines which have drawn up to ensure sustainable agricultural production and the judicious of natural resources:

i. Planning Guidelines
   a) Land Capability Classification
   b) Soil-Crop Suitability Classification

ii. Development Guidelines
   a) Guidelines for Developing Sloping Land
   b) Guidelines for the Prevention of Soil Erosion and Siltation

Planning Guidelines

a) Land Capability Classification (LCC)

To ensure the efficient use of the land and its resources, the Economic Planning Unit (EPU) of the Prime Minister's Department introduced the Land Capability Classification (LCC) (Economic Planning Unit, 1967) to classify and rank land and its resources into four major activities - mining, agriculture, forestry and recreation. The LCC prioritizes the use of land resources on economic gains which could be accrued from the use of the land, in the following order: mineral development > agriculture > forestry >recreation. Land with minerals is given the highest ranking (Class 1) because of the quick economic returns that could be obtained from mining. Agriculture is allocated land belonging to Classes 2 and 3 in the LCC, forestry, Class 4 and recreation, Class 5.

The total land area in Classes 2 and 3 alone amounts to 10million hectares of which 6.2 million hectares are in Peninsular Malaysia. Land Capability Class II corresponds to Soil Suitability Classes 1 and 2 of the Soil-Crop Suitability Classification for Peninsular Malaysia (Wong, 1986) of the Department of Agriculture while Land Capability Class III is equivalent to Soil Suitability Class 3 and some of the soils in Soil Suitability Class 4. The classification of Land Capability Classes II and III for agricultural land is still valid today. Land Capability Classes IV and V are almost synonymous with Soil Suitability Class 5 of Soil-Crop Suitability Classification for Peninsular Malaysia.

The LCC has been criticized for its emphasis on economic gains without giving due consideration to sustainable development, soil conservation and the environment preservation, especially for activities that are related to mining. This criticism is not entirely true as conservation measures are built into the LCC by the other systems such as the *Soil-Crop Suitability Classification for Peninsular Malaysia* (Wong, 1986) which contributed input to the development of the LCC. With the collapse of the tin industry and widespread outcry against an absence or lack of the environmental considerations, the use of LCC is discontinued although general principles of the LCC in land use planning remain relatively unchanged.

b) Soil-Crop Suitability Classification

The Soil-Crop Suitability Classification (Wong, 1986) is designed to determine the extent of agriculturally suitable land and the suitability of crops for different soil types. Following similar approach, Sarawak and Sabah have developed their own systems (Maas, 1979 & 1986). The extent of the 5 soil suitability classes in the 3 regions of Malaysia is shown in Table 3.

In this system, land for agricultural development is classified into 5 soil suitability classes. Only Classes 1 to 3 soils are recommended for agricultural development. Class 4 soils are marginal soils and are only recommended for agricultural development after adequate land improvement and conservation works are carried out with a high level of management instituted. Class 5 land is not recommended for agricultural development because of the risk of soil erosion and land degradation (subsidence, stoniness and extreme acidity).

Some of the criteria used in the classification are to ensure the sustainable land use. For instance, the slope limit of 25^0 is used to demarcate agricultural land from the steepland. The use of this slope limit restricts the conversion of steepland to agricultural land because of the very high risk of soil erosion.
The system also determines the suitable crops for each of the 5 classes, the management and soil conservation measures to be undertaken for the continuous and prolonged of the land.

Table 3: Extent of Soil Suitability Classes in Malaysia

State	Soil Suitability Classes (ha)					Total
	1	2	3	4	5	
Pen. Malaysia	2,646,801 (20%)	1,324,453 (10%)	2,249,959 (17%)	1,314,413 (10%)	5,637,732 (43%)	13,173,358 (100%)
Sarawak	0	297,334 (2%)	1,476,978 (12%)	1,956,516 (16%)	8,514,078 (70%)	12,244,906 (100%)
Sabah	7,461 (0.1%)	606,406 (8%)	1,532,383 (21%)	762,004 (11%)	4,313,200 (59.9%)	7,221,454 (100%)
Total	2,654,262 (8%)	2,228,193 (7%)	5,259,320 (16%)	4,032,933 (12%)	18,465,010 (57%)	32,639,718 (100%)

On national basis, the order of abundance of these classes is Class 5 (57%) > Class 3 (16%) > Class 4 (12%) > Class 1 (8%) > Class 2 (7%) (Table 3). The extent of Class 5 soils exceeds the combined area of the other 4 classes of soils. On a regional basis, this is also true for Sabah and Sarawak with the latter having more 70% of its land under Class 5 soils. However, the reverse is true in Peninsular Malaysia where the combined area of Classes 1-4 exceeds the extent of Class 5 soils.

Implementation of this system has to a certain extent helped to create a fairly stable agriculture landscape characterized by distinctive cropping patterns consisting of rubber on undulating to hilly terrain where erosion is minimal; oil palm in the flat and more fertile alluvial soils to the rolling sedentary soils with minimum erosion; paddy in the flat, poorly drained fertile alluvial plains, pineapples, oil palm and sago on peat lands; mixed horticulture and orchards in mostly flat to undulating topography. In all these crop landscapes, soil erosion poses only minor problems, and all these pointing to sustainable land use management.

As the demand for more suitable area for agriculture increases, pressures to utilize marginal land such as acid sulphate soils, peat, sandy soils of BRIS and ex-mining lands are expected to increase. Research and developmental support have contributed much to the success of growing selected crops on these 'problem soils'. Many of the agricultural practices employed are sustainable and these include applying organic mulch and manure to increase fertility of sandy soils; water table management to control acidity in acid sulphate soils and the planting fruit trees in agro-forestry in the steeper areas.

Development Guidelines

a) Guidelines for Developing Sloping Lands, 1993

Guidelines for hill slope development have recently been drawn up to ensure sustainable agricultural development (Department of Agriculture, 1993). In 1993, several government agencies, led by DOA, met and prepared guidelines for the development of sloping lands for both the lowlands and the highlands. The guidelines provide definitions for agriculture land and steepland, define the maximum slope limit for agriculture use, make recommendations on the types of crops to be grown on the various terrain classes, and outline conservation and management measures to be undertaken for the cultivation of crops on sloping land. Although these guidelines have been prepared for agricultural use, they can also be used for non-agricultural uses on sloping land. They will also serve as input for the revision of the Guidelines for the Prevention of Soil Erosion and Siltation currently being undertaken by the Department of Environment.

b) Guidelines for the Prevention of Soil Erosion and Siltation, 1996

These guidelines were drawn up the Department of Environment (DOE) in 1978 and revised in 1996 to provide comprehensive guidelines to control erosion damage to the environment, water pollution and floods. They are confined to four main types of activities, namely, housing development and road construction, logging, agriculture and mining and quarrying activities. Though limited to only four activities, these guidelines are referred to when soil erosion is evaluated in projects which are subjected to the Environment Quality (Prescribed Activities) (Environment Impact Assessment) Order, 1987 which became mandatory on April 1, 1988. For the agricultural sector, the guidelines are taken from the *Guidelines for Developing Sloping Land, 1993* described above.

LEGISLATION

In Peninsular Malaysia, references to the utilization of land for both agricultural and non-agricultural purposes are made in four laws as follows:

i) Land Conservation Act, 1960
ii) National Forestry Act, 1984
iii) Environment Quality Act, 1974 and Amendment (1985)
iv) Pesticide Act, 1974

i. Land Conservation Act, 1960

This Act relates to the conservation of hill land and the protection of soil from erosion and the inroad of silt. This Act requires a declaration to be made on "hill land" for the purpose of conservation. This declaration can only be made by the Ruler in Council or the Yang Di-Pertuan Negeri (State Head) by notification in a state Gazette as specified in Section 3 of the Act.

According to section 3 of the Act, "any area or class or description of land in the State" can be declared as hill land for the purpose of the Act. Unfortunately, there are no definitions, explanation or descriptions, technical or otherwise, on the term "hill land" and as such, any land including the flat land can be gazetted as hill land for the purpose of conservation. From the point of view of soil and land conservation, the ambiguous usage of the term "hill land" is advantageous as it empowers the state to gazette any land as conservation land. Unfortunately, in practice, gazettement is seldom carried out.

As soon as a piece of land has been gazetted as hill land, it is accorded with a some protection as provided by sections 5 and 6 which prohibit the planting of annual crops on such land and the removal of the vegetative cover from it. Unfortunately, both these sections are weakened by an escape clause which allows the Land Administrator to permit the cultivation of such land if he is satisfied that the cultivation of such will not cause appreciable soil erosion.

The control of soil erosion is explained in Section 11 of the Act which allows the Land Administrator to take action against land owners who are responsible for causing soil erosion and damage to the land. This is only possible if the Act is adopted by the state governments.

ii. National Forestry Act, 1984

The purpose of the National Forestry Act, 1984 is to provide for the administration, management and conservation of forests and forestry development within the states of Malaysia and for connected purposes. In this Act, the protection of the hill land is provided by Section 10. In this section, the Director of Forestry is empowered to classify every permanent reserved forest under or more of the following categories:

a. Timber production forest under sustained yield
b. Soil protection forest
c. Soil reclamation forest
d. Flood control forest
e. Water catchment forest
f. Forest sanctuary for wildlife
g. Virgin jungle reserved forest
h. Amenity forest
i. Education forest

j. Research forest
k. Forest for federal purposes

Using the above classification, the protection of steepland can be made by gazetting it as land under soil protection forests or as soil reclamation forests. There is also provision to rehabilitate degraded land under the functional group of soil reclamation forest As in the Land Conservation Act, the gazettement of a permanent reserved forest into any one of the 11 categories is only of a temporary nature as Section 11 (1) of the Act allows the State Government to excise it for other uses. Amendments to the definition of soil protection forest are needed to incorporate the definition of steepland so that such land can be more effectively protected.

iii. Environment Quality Act, 1974

This Act relates to the prevention, abatement, control of pollution and enhancement of the environment, and for purposes connected therewith. Overall nineteen categories of activities are subject to EIA .For the agricultural sector the sub-sectors of agriculture, drainage and irrigation and fisheries are involved. The prescribed activities for each of these agricultural sub-sectors is as follows :-

The prescribed activities for each of these agricultural sub-sectors is as follows

Agriculture

The EIA requirements for agriculture are those related to land development, resettlement of people and development involving landuse changes. The requirements are as follows :

a. Land development schemes covering an area of at least 500 hectares that will bring forest land into agriculture production
b. Agricultural programs necessitating the resettlement of at least 100 families
c. The development of agricultural estates covering an area of at least 500 hectares and involving changes in the type of agricultural use.

Drainage and Irrigation

The EIA requirements for Drainage and Irrigation is as follows :

a. Construction of dams and man-made lakes and artificial enlargement of lakes with surface area of 200 hectares or more.
b. Drainage of wetlands, wildlife habitat or of virgin forest covering an area of 100 hectares or more.
c. Irrigation schemes covering an area of 5000 hectares or more.

Fisheries

The EIA requirements are related to fish landing habours and aquaculture development and are listed as follows :

a. Construction of fishing habours
b. Habour expansion involving an increase of 50% or more in fish landing capacity per annum

c. Land based aquaculture projects accompanied by clearing of mangrove swamp forest covering an area of 50 hectare or more.

The mandatory requirement for an EIA for the development of land schemes is commendable as it is intended to protect the environment and to ensure the success of the proposed projects. However, size alone as required in Para (i) and (iii) should not be the only criterion used to determine the need for an EIA. In addition to size, the topography and the soil on the land should also be considered as even on a small piece land consisting predominantly of steep topography, erosion hazards and land degradation can be of the same intensive as those on a larger piece of land, especially when sandy and shallow soils are also present. There is a need to amend the above four categories of land development to take into consideration the topography and the soils on the land.

iv. Pesticide Act, 1974

In Malaysia, environmental contamination caused by pesticide use has been reduced and controlled by the Pesticide Act 1974, the principal legislation for the regulation of the pesticide industry. The main aspect of this Act is to regulate the manufacture and import of pesticides through registration. The registration process in Malaysia is similar to that practiced by many other countries and involves the evaluation and approval before they are allowed to be imported or manufactured in the country. Malaysia has adopted a registration scheme, in accordance with the guidance stipulated by FAO and WHO. Registration and regulation of pesticide use invariably minimize environmental pollution caused by pesticides.

The Act empowers the Pesticide Board (i) to monitor the quality of pesticide in the market to minimize adulteration of pesticides and entry of unregistered pesticides, toxic, problematic and pesticides of dubious bio-efficacies; (ii) to issue license premises which store and sell pesticides; (iii) to withdraw problematic pesticides which are hazardous to human life and environment; (iv) to educate the general public on safe pesticide use; (v) to control advertisements especially those that mislead the general public and (vi) to monitor the pest residues in accordance to the permissible limits set by the Food Act 1983.

Guidelines have been set for the use of pesticides especially those related to aerial spray ing of large areas. Prior approval is needed from the Pesticide Board as well as the Dep artment of Civil Aviation and an Aerial Application Certificate must be obtained before aerial spraying can be done. For smaller farms the adoption of such plant protection met hods as the Integrated Pest Management (IPM) system is being encouraged to minimize the use of chemical pesticides.

With such measures judicious use of hazardous pesticides especially on a large scale is monitored and controlled . In this way there will be little or no over usage of pesticides and the probable presence of excess pesticide in the soil which will invariably leach into neighbouring streams and waterways is reduced.

The Act also limits the use of the type of pesticides especially for food crops and vegetables and also in the plantation industry. For example the use of such weedicide as paraquat dichloride is controlled and monitored because of its injurious effect on health.

OTHER GUIDELINES AND MITIGATION MEASURES TO ENSURE SUSTAINABLE AGRICULTURAL DEVELOPMENT

i. Erosion Risk Map

The production of the Erosion Risk Map of Peninsular Malaysia by the Department of Agriculture in 1996 is another guideline use mitigate land degradation and ensure sustainable agricultural development. The Department of Agriculture is presently monitoring soil erosion losses according to soil types on the various terrain classes. Results from this exercise are used to produce and update the Erosion Risk Map of the country. Five categories of soil loss have been established, namely, (i) low (0-10 tons/ha), (ii) moderate (10-50 tons/ha, (iii) moderately high (50-100 tons/ha), (iv) high (100-150 tons/ha and (v) very high (>150 tons/ha). Areas with high risks of soil erosion can be identified immediately and excluded from development to prevent land degradation. If development of such areas is unavoidable, stringent soil conservation measures are imposed or strict surveillance carried out to prevent undesirable consequences arising from severe soil erosion.

ii. Fire Hazard Map

Recent haze problems in Southeast have made it necessary to examine the current farming methods in order to minimize haze pollution. Haze is caused by opening burning of plant wastes either from forest clearing or crop residues and the problem is especially accentuated in peat land. Excessive amounts of smoke are released into the atmosphere due incomplete combustion of the peat which exists in different stages of wet and dry conditions. The fire can burn over large areas and for long durations because of the high reserve of wood in the peat. As a contribution towards reducing incidences of fire and haze, DOA has recently completed the fire hazard map for Peninsular Malaysia (Lim *et al*, 2002). The map classifies Peninsular Malaysia into with 4 fire risk classes-very high risk, high, moderate and low risk. The purpose of the map is to help fire fighters to focus their operations in areas prone to fire hazards and haze emission especially those from the peat areas. It also serves as a guide land operators to take special precautions when using such land to minimize the emission of the hazardous haze. The public especially the farmers are advised to refrain from open burning as it carries a heavy penalty of RM 500,000.00 (US $131,579).

iii. Promoting Good Agriculture Practices (GAP)

In promoting agricultural development in the country, the Department of Agriculture emphasizes on sustainable development. Through its extension service over the last few decades and presently, its Farm Accreditation Scheme, it is promoting Good Agriculture Practices (GAP) and proper waste management to both farmers and commercial planters. Through the use of GAP and proper waste management, pollution of the environment by bio-waste disposal is reduced. GAP include among others precision farming, IPM (Integrated Pest Management), crop rotation and fallowing. Crop rotation, land fallowing and IPM can be used effectively to prevent a build-up in the pest and disease population. With these methods, burning the crop residues and the use of chemicals are drastically reduced.

iv. Waste Management

Waste from the oil palm industry perhaps forms the largest portion of total agricultural waste in Malaysia. Most of the waste from the oil palm plantations such as dead fronds and empty fruit bunches are recycled back into the plantation usually as mulch. In the replanting of oil palm, the trees are either poisoned and allowed to rot in the field, or are fell, chipped, stacked and allowed to rot in field. In this way open burning is avoided and the risk due to smoke emission which often results in haze is averted. Haze pollutes the air, causes respiratory diseases and poses dangers to air traffic. This technique also allows the replanting process to proceed immediately after felling and shredding so that the length of time the surface soil is exposed is shortened.

Empty fruit bunches can also be processed into excellent compost which is a good soil ameliorate and fertilizer supplement. The compost is actively being promoted to replace the non-bio-degradable plastic sheet as mulching materials.

Palm oil mill effluent (POME) is another form of agricultural waste in the oil palm industry whose disposal is being controlled. Oil palm holdings that have oil palm mills are required to take measures to prevent the indiscriminate disposal of mill effluents into nearby streams and rivers. Collection ponds are to be set up to contain this effluent which is then treated and used as organic fertilizers or enriched fertilizers for crops. The disposal and treatment of POME is control by Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations, 1977 and (Amendment) 1982

The palm kernel is processed into palm kernel cake as a nutritious animal feed and is used as feed supplement for the fattening of beef cattle under the feedlot system.

The Department of Agriculture (DOA) is teaching farmers to make compost from the waste products such as rice straws, rice husks, maize stalks and leaves and even saw dust from saw mills. Preliminary studies by DOA have shown that with proper use of compost, the fertilizer requirement for vegetable crops can be reduced to 1/5 of the total nutrient requirement applied in the form of chemical fertilizers. Collection of straws by hand is tedious and inefficient. To overcome the problem, DOA has fabricated a small straw baler which is cheap and easy to use in rice fields. The rate of collecting straws using the baler is 2.47 hour/ha compared to 31.45 hours/ha for manual operation. Plant waste such as maize stalks and leaves are made into silage and pineapple waste processed into cattle feed. The making of compost and silage from plant waste which used to burnt causing air pollution, is now providing additional income to the farmers and farm entrepreneurs as feed to fatten beef cattle raised in the feedlot system.

v. Organic farming

With the growing preference by consumers for organically produced food due to health reasons, the demand for animal waste for organic farming is expected to increase sharply. Organic farming has a potential in Malaysia. At present, there are several privately owned organic farms. Since chemical fertilizers and pesticides are not used, labour requirement is high in organic farming leading to high cost of production. The organic products especially vegetables fetch a much higher price, normally 3 times the normal vegetable price. Some high-grade enzyme-enriched compost, fermented organic fertilizers are being used. Recycling of nutrients is done by decomposing the unwanted plant materials collected within the farm.

DOA has recently completed the Malaysia Standards for Organic Farming based on FAO/CODEX guidelines. The standards also provide guidelines for the production, processing, labeling and marketing of organically produced food. Organic farming also contributes towards sustainable development as it recycles bio-wastes for healthy food production and reduces tremendously the use of chemical fertilizers which may pollute the soil and water with prolonged use.

CONCLUSION

Policies, technical guidelines, legislation and other mitigation measures implemented in Malaysia have contributed significantly to sustainable agricultural production. The National Agricultural Policy provides guidelines for the proper and efficient use of the land by emphasizing on the efficient and optimal use of the land to raise productivity, and this reduces the need to open up new land for agricultural production. The National Forestry Policy safeguards the forest land from indiscriminate clearing of forest for other uses. Planning and technical guidelines ensure that only suitable land is identified and developed for agricultural purposes, while appropriate on-site management and conservation measures are implemented for sustainable production. Stringent legislation especially the Environment Quality Act 1974 prevents indiscriminate use of the land by imposing heavy penalties on defaulters. Other mitigation measures especially recycling of bio-wastes into useful economic products are sustainable production methods which help to keep the environment clean and healthy.

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The Research on Development Models of Sustainable and High Efficiency Agriculture In Tai Lake Region

– A Case study of Changshu city of Jiangsu Province

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Abstract

As a represent of coastal economically developed area and Tailake region of Jiangs u province, a development model for countywide sustainable and high efficiency agricu lture and the way of implement were studied in Changshu city. External circumstances of county was evaluated, the adjustment of countywide agricultural structure, rural indu strial structure were analyzed. It is explored for the development of sustainable and high efficiency agriculture in developed area.

According to the analysis results for external circumstances and evaluation r esult for countywide agricultural Eco-economy system, the development model fo r sustainable and high efficiency agriculture in Changshu city was proposed as "the export-oriented development model integrating installed agriculture and green agriculture". Aimed at increasing the ratio of output to input of agriculture, agri cultural products will be marketed to international market instead of domestic ,pr ovincial market ,Growing area of staple crops will be reduced greatly ,such as g rain ,cotton ,oilseed ,etc .The priority will be given to develop installed agricultu re ,green agriculture ,export—oriented agriculture and sightseeing agriculture . Th e development strategy integrating agriculture and food industry should be carrie d out.

Key words: Sustainable and High Efficiency Agriculture, Development Model, The carrying out channel

1. Foreword

The Tailake region in Jiangsu province usually denotes three cities: Suzhou, Wuxi and Changzhou. Its land and population take 18% around of whole province, rural social tot al output value takes 52% of whole province. It is one of the developed regions in the w hole province and our country. Have been completed to change from traditional agricult ure into modern agriculture step by step from last century since 90 decade, agricultural modern index goes to 70% of 1997 from the raising of 45% of 1987. Enter new century, how to develop further to realize sustainable and high efficient agriculture in developed district, is the problem that is worth for to discuss and think deeply. In this paper, we ta ke a case of Changshu city, to study for the development model of sustainable high effic ient agriculture find implement channel in economic developed regions, to offer a refere nce for the development of agriculture in coastal economically developed area.

2. Material and method

This research is taking the systematic analysis method of ecology as foundation, T he economic, social and ecological factors were considered, the external cause and inter nal cause affecting the development of sustainable and high efficient agriculture in the c ounty were carried out comprehensively. Overall inquiry was combined with typically a nalysis, a model of sustainable and high efficiency agriculture development was summa rized for typical county (Changshu city), and design as pattern carries out optimization, and the development strategy was explored.

The data collected were economic information of Changshu (1949 – 2001), nation-wide agricultural yearbook (1995-2001), Changshu city partition, land program and the profit information of agricultural products; Investigate agricultural tap enterprise, the development of agricultural products base etc.

3. Result

3. 1 . The nature and social condition of Changshu city

Changshu is located in open area of Yangtze Delta. It is a port commerce and tourist city by the Yangtze River adjacent to sea. Its area is 1264sqiuare kilometers and population 1.04 million. The cultivated area is 63900 hectares, 0.93 mu per person, and water area is 34800 area hectares. Changshu that city locates in the coastal area of subtropical zone, climate is moist, monsoon is current, sunshine is adequate, rain heat same season, four seasons distinct, rich smooth, hot, water resource has offered superior condition for agricultural production.

The soil in Changshu city is rich; it is suitable for planting paddy, wheat, rape and cotton. The cropping system along river district is cotton – wheat mainly, while the cropping systems of Yu west district with high level and Kun Cheng low region district are wheat- rice and rape- rice

As a State City of Famous History and Culture, Changshu has prosperous education and notables come forth in great number. With green hills, clear water and picturesque scenery; it becomes a famous scenic spot for tourism and vacationing. Shanghu Lake, one of the main scenic spots of Taihu Lake Scenic Area, Yushan Hill, a State Forest Park, the well-known Shajiabang (reed marshes) and other numerous culture and historic spots, are so charming to tourists from home and abroad.

It is Changshu that the traffic of land and water in city is convenient and Changshu port is a State First-class pot. Changshu city is one of coastal economic developed counties of our country, Changshu has kept the laurel of national " Ten Plutus counties (cities) " for years, stood at the head of the 100 strongest counties concerning comprehensive strength in the country, former Mao. Changshu city is a typical representative of Tailake region in the Jiangsu Province and the eastern department coastal area of our country.

3.2 Analysis of agricultural ecological economic system of Changshu city

3.2.1 The economic development condition of Changshu city

In 2001 it is Changshu that the city Gross National Product reaches 30 billion Yuan, financial income 3.46 billion Yuan. The ratio of 1, 2, 3 industry is 5: 55: 40, the average per person of gross domestic product is 29,183 Yuan, the social turnover of average per capita of consumer goods is 8,149.2 Yuan, town staff average income 10,600 Yuan and the peasant 5800 Yuan of per capita.

3 .2.2Analysis of agricultural ecological economic system of Changshu city

According to Shen Hengli (1993,), Wu Wenliang (2000) and Liu shaomin(2001) analysis, from agricultural natural resource, rural manpower resource and rural economic development level 3 aspects come Gou build county level agricultural ecological economic systematic type, partition index system,

From the basic condition of agricultural development, agricultural water conservancy and mechanization horizontal higher, agricultural socialization service system are improved, the agricultural role of science and technology is obvious, the industry of small towns is developed; See from development stage and the type of agricultural ecological economic system, Chang shu is agricultural resource relative shortage, rural manpower resource relative rich, rural economic relatively developed type, its agricultural located stage is developed stage, the rural social total output value as well as peasant per capita of average per capita are very high. Changshu and capital, the rural quantity of labor force, the area of average per capita of water area, water resource measure the aspect such as agricultural climate resource to have comparison advantage, the land of average per capita, forest land etc. agriculturally the aspect such as resource as well as the rural cultural quality of labor force have comparison inferior position and the price of labor force is compared higher.

3.3 The structure analysis of agricultural ecological system of Changshu city

3.3.1 The structure of agricultural

In the structure of agricultural ecosystem, the countywide industrial structure of Changshu city and rural industrial structure already go to more high-grade stage, but the evolution of agricultural structure and planting structure are relative behind, major expression is: In agricultural structure, planting proportion is greater. In planting structure, the proportion of grain crop is exceptional.

3.3.2 The structure of energy

Seeing from efficiency and the function of agricultural ecosystem, the energy level of putting N, P2O5 K2O and capital in is very high in Changshu city, in which the proportion of throw chemical fertilizer into is higher, the producing effluent level of N, P2O5, K2O and capital are also higher, but the ratio of producing and throwing is low, the using efficiency of put in material is not high.

3.4 sustainable high efficient agricultural development pattern of Changshu city

3.4.1 The development strategy of sustainable high efficient agriculture of Changshu city

Changshu city is located at eastern coastal developed area, lean Shanghai, Suzhou, and Wuxi city tightly, the traffic of land and water is convenient, market potential is greater and Changshu port is a State First-class pot, it makes a fast and convenient channel for its agricultural products to throw into international market.

According to above-mentioned advantage and inferior position, in the future, the development strategy of sustainable and high efficient agriculture of Changshu city should be as follows:

(1) Agricultural products saling should change from provincial and national markets to international market. Aimed at raising ratio of producing and throwing, facility agriculture, green agriculture (include developing organic, green or agricultural products with no pollution etc.), extrovert type agricultural and sightseeing agriculture should be developed in the first.

(2) The structure of agricultural and planting should be adjusted, developing fishery and animal husbandry vigorously, reducing the planting area of rice, wheat, cotton, rape and other grains of land dense type substantially, products should be focused on the development of agriculture with the type of technology intensive, capital dense and massed labor;

(3) Carrying out the strategy of incorporating agricultural and food industrial into an organic whole development, building a fair industrial crowd with agricultural products,

food processing, sales and meal in one body, so that agriculture benefit can be raised.

In words there should be a pattern of "facility + green " extrovert type for sustainable high efficient agricultural development in Changshu city.

3.4.2 The leading industrial of sustainable and high efficient agriculture in Changshu city

According to the environment of agricultural products market in our country and the conditions of district position and resource ambient in Changshu city, the future Changshu agricultural products should focus on foreign market and the home market of big or middle cities (as Shanghai, Nanjing, Wuxi, Suzhou etc.). Aimed at " raising rate of putting in to producing ", following agricultural leading estates should be established:

(1) In planting trade, the bean kinds of vegetable facing international market (include Dutch beans, green soybean, pea, broad bean, kidney bean and young soybean etc.) and Water raw vegetable(include water celery , water chestnut , lotus root , red water caltrop , white water caltrop etc.) as well as the fruit vegetable and melon facility with " famous special good " will be developed vigorously, proper development is taken with the high quality paddy production aimed at exporting, the planting area of flowers, grass and sprout wooden will be increased;

(2) In animal husbandry, production of the high quality pig with lean meat will be developed vigorously, at the same time, duck and goose will be feeded, and have an appropriate developments of cow breeding;

(3) In fishery, the "famous special and good " production of aquatic product such as shrim, Lou the shrimp of natural pond , China Rung Ago crab as well as high quality fish kind(including eel, perch fish, leather beard Nina , globefish , soft-shelled turtle etc.)should be developed vigorously. The production of the conventional aquatic product with 4 nonmal fishes should be reduced substantially;

(4) Developing vigorously SajiaBang with the dissolute natural view of reed marshes , Yushan green ecological agricultural sightseeing garden district , and Sang lake scenery view, combinating with development of Changshu " famous, special , good " agricultural products (such as Changshu city tradition shout to melt chicken , duck blood glutinous , YangCheng lake crab , sweet-scented acanthus wine , sweet-scented acanthus chestnut , Jianmen green tea etc.); A sightseeing agriculture with fair agricultural sightseeing , the culture of folk custom, relax agriculture, general educational and business trade campaign in one body, so that the overall development with the agricultural, travel trade and business will be promoted in Changshu city.

3.4.3 Carrying out the channel of sustainable and high efficient agriculture in Changshu city

Agricultural estate melts to manage is an implement channel mainly at present and in the future longer time. Now it is Changshu city that it has established a base of specialization production, has duplicated some agricultural tap enterprises, has developed many trade markets of agricultural products, has cultivated a batch of economic popular support, intermediary organization, has improved socialization service system, has formed the Changshu city setup of sustainable and high efficient agricultural industrial operation preliminarily.

Seeing from the region distribution of urban areas, 4 industrial belts based on connection forms of two vertical and two horizontal have already begun with scale. The 4 industrial belts are:the vegetable belt of Dongzhang as a tap is taken, driving the vegetable development of Wu Shi ,Beixi,Xushi, Dong Bang, Zhenmen, Meili, Heshi and other towns; the aquatic product belt centraled by Tangshi town, connecting the aquaculture trade development of towns of Sajiabang, Renyang, Mochen, Xingzhuang, Eouqu, and other places; the animal husbandry farming by Tianpong limited company of industry ,promoting the development of animal husbandry of Dong Bang , Guli , Baimao , Tangshi,Sajiabeng and other towns; the green project belt with Yu mountain as its main body, promoting the planting trade development of Funong, Fushan, Yushan , Yangyuan and other forest farms.By the forms of "company + base + farmer + technology",the sustainable and high efficient agriculture of Changshu city has been pushed forward.

4. Conclusion and discuss

4.1 Conclusion

According to the analysis results for external circumstances and evaluation result for countywide agricultural Eco-economy system, the development model for sustainable and high efficiency agriculture in Changshu city was proposed as "the export-oriented development model integrating installed agriculture and green agriculture". Aimed at increasing the ratio of output to input of agriculture, agricultural products will be marketed to international market instead of domestic, provincial market, Growing area of staple crops will be reduced greatly, such as grain, cotton, oilseed, etc .The priority will be given to develop installed agriculture, green agriculture, export—oriented agriculture and sightseeing agriculture. The development strategy integrating agriculture and food industry should be carried out.

4.2 Discussion

(1) Now there is very few about the theoretical research of countywide sustainable high efficient agricultural development, though, this paper suggests according to the intension of sustainable high efficient agriculture that area can develop continuously the theoretical basis that develops theoretical etc. with agricultural ecological economic system to develop as countywide sustainable high efficient agriculture, however, if Gou build a economic system of relatively complete sustainable high efficient agricultural development to discuss further yet.

(2) The agriculture of economic developed area is directly faced with the throughout the country outside impact of market. How to use high-tech means develop the high additional agriculture of high quality that worths and reduce environmental pollution and the processing of agricultural products, are the key of coastal economic developed area sustainable high efficient agricultural development, remain to explore further practice.

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Best Practices on Agriculture Sustainable and Rural Development (SARD) in China

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Abstracts: On the bases of 25 sustainable development pilots, three cases about sustainable agriculture and rural development (SARD) were introduced, and five experiences were put foreword.

Key Words: Best practices, SARD, China

Since 1994, with the advent of China's Agenda 21 and the establishment of the sustainable development strategy, the Chinese government has stepped up efforts to implement the program of Sustainable Development. In 1997, 25 experimental zones were redefined to pilot sustainable development, includes in cities, towns and districts in large cities. As an important factor, sustainable agriculture and rural development (SARD) in local levels was elected to experiment with some pilot county or towns. Many counties have implemented the program in search of a path suited to local conditions. Especially, three cases about sustainable agriculture and rural development set up some examples. In these cases, Gongcheng Yao autonomous county in Guangxi Zhuang Autonomous Region represented the mountainous areas in the Western Region, Maoji sustainable community in Anhui province represented the little town's construction in the rural, and Zhengding county in Hebei Province represented the traditional agricultural community in the Central Region.

1 Introduction of the case

1.1 Case 1: Sustainable agriculture in poor mountainous areas by Gongcheng Yao autonomous county, Guangxi Zhuang Autonomous Region

Case background: Located in northeastern Guangxi, Gongcheng Yao Autonomous County is a mountainous region that is not near the sea, the border, railways or even road. Of its total population of 280,000, 51.94%(143,600) is the Yao nationality. In 1981, the county was designated as one of the least developed counties in the autonomous region by Guangxi government.

In the late 1970s and early 1980s, the main form of fuel in rural areas here was firewood and straw. Poor management, coupled with a rapidly growing population, led to excessive deforestation, which in turn damaged the ecological environment. The result was soil erosion, drying up of rivers, and frequent occurrence of natural calamities. To address the energy problem, protect forest resources and develop local economy, Gongcheng began to promote methane in 1983 by the Eco-agriculture Project. After 18 years of hard work, the county has forged a new path of development characterized as a trinity, which refers to livestock raising, methane, and plantation: the manure of livestock raised is used to produce methane, and the methane is used as energy for lighting and cooking, and the residue form methane production is used as fertilizer for fruit trees and vegetables.

Case description: the sustainable agriculture characterize as eco-agriculture in Gongchen went through 3 stages. The 1rst stage (1983-1988) was largely exploratory. The waste of the methane was used to fertilize fruit trees and vegetables, which can raise incomes for households. A wave of methane development swept through the county from 1986-1988. A total of 2475 methane pool were built, laying the foundation for rapid development that was yet to come.

The second stage (1989-1997) saw full-swing application of the methane technology. Having savored the benefits of methane, locals were enthusiastic about adopting the technology in a hope to shed poverty. The county government encouraged farmers to raise pigs, built methane pools, and planted fruit trees. The number of methane pools increased by 2000 a year. By 1997, a total of 32000 pools had been built and 16667 hectares of fruit trees planted.

The 3rd stage (1998-present) has been marked by consolidation and improvement. Eco-agriculture has become the mainstay of the county's economy. Both quantitative and qualitative improvement has been made. Since 1997, more than 3000 new methane pools have been built a year, bring the total 43000 today. The county has also planned and built 4 fruit production bases, which total acreage of fruit plantation in the county amounts to 200000 hectares, fruit production stands at 277000 tons. The livestock industry has thrived with 2480000 pigs raised and 30% of the rural households had built cement-and-steel house. Today, the forest coverage in Gongchen stands at 77% in ecological benefits. By 1999, the impoverished population dwindled to 7350 according to the new standard of 900 yuan per capita in social and economic benefits. This bold yet useful endeavor with local characteristics may well represent a viable approach to sustainable development in the Western Region.

1.2 Case 2: Promote urbanization through industrial restructuring by Maoji sustainable community, Huannan city, Anhui province

Case background: Maoji is located in Huaibei Plain, a juncture between the Huaihe River and Xifeng River. As a traditional agricultural community, is constantly threatened by floods. During the flooding season, the government has to spend a huge amount of financial and material resources to fend off floods. This has seriously affected local economic and social development. In particular, rural enterprises have been developing slowly, the agricultural sector is fragile, and the living standards of local residents have not been improved for a long time.

Case description: First, further optimize the agricultural product mix and stabilize the acreage of plantation. Increase the yield per unit and promote utilization of improved plant varieties. Promote the use of greenhouses and inter-crop plantation; promote hybrid corn plantation; develop livestock raising and aquaculture; and improve cost effectiveness. Second, step up rural reform by promoting the reasonable flow of land use rights and the concentration of land; promote integration of trading, industry and agriculture and the integration of production, supply and sales; raise the economics of scale for agricultural production. Third, increase spending in agriculture and boost capacities for flood control, irrigation and disaster alleviation. Fourth, improve the socialized service system. Steps to be taken include promoting specialization of quality variety supply and sales, mechanization of agricultural production, commercialization of plant and animal pest control, formulation of fertilizer application, improved efficiency of irrigation, commodity of products, and serialization of forestry. In 1999, the total industrial and agricultural output of Maoji amounted to 796.97 million yuan, of which 789.96million yuan was generated by rural enterprises. In 2001, disposable income for urban residents averaged 4642 yuan and rural residents 2580 yuan (figure 1), an increase 2487 yuan and 1410 yuan over 1994.

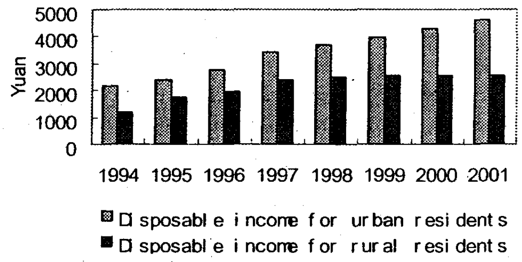

Figure1 The Status of Economy in Maoji Sustainable Community From 1994-2000

1.3 Case 3: Sustainable development through straw recycling by Zhengding county, Hebei Province

Case background: Zhengding sustainable community is noted for its high yield of grain, with an annual plantation of 16000 hectares of corn and 19000 hectares of wheat. Traditionally, the straws of crops are used as fuel, feed or fertilizer. With evolving means of production and rising living standards, however, many farmers simply burn the straws during the harvest season. This not only wastes useful resources but also causes environmental pollution and traffic problems.

Case description: in the mid-1990s, the county made stalk recycling part of a long-term development plan for 1996-2000, and a priority project for experimentation with sustainable development. Five types of technology were applied: first, grinding technology that grind straws into fertilizer and spreads it directly into the field; second, feed-making technology that converts fresh straw into high-efficiency bio-feed; third, burning technology that uses straws for methane production or gas stoves; fourth, technology that uses straws as raw materials for paper-making, furfural of charcoal; fifth, technology that uses stalk to produce edible fungus. Today, straw is processed in several different ways: 33000 hectares of farmland (70% of total) directly grinds the stalk and spread into the field; 6000 hectares (13% of total) of farmland converts the straw into feed for animals; 2000 hectares of farmland uses the straw as fertilizer; 1000 hectares converts into feed or edible fungus; and 1333 hectares buries it deep in orchards. Overall, 96% of crop straws is recycled. In addition, the recycling program has also facilitated the restructuring of the agricultural sector. Crop cultivation has shrunk for several years in a row in terms of acreage, but crop yield remains stable. Animal husbandry, on the other hand, has grown rapidly. Livestock raising now accounts for two thirds of the agricultural output of the county, and dairy production has become a pillar industry. Given the fact that China is an agricultural economy, huge potential exists for the exploitation of stalk. Recycling of stalk can not only improve the environmental quality but also optimize the agricultural structure and increase farmer's income. This is a technology that has great application potentials in China.

2 Experience and Summary

Three case's experience in different region may be valuable to other localities that have same conditions, resources and environment in the follows:

- Consistently uphold sustainable agriculture and ecological preservation as guidelines for local economic development. Various administration of the county refrained from taking expedient action for short-term benefits, and adhered to the principle of sustainable development and maintained the consistency of policy.
- Ensure the local government support, organization and guidance. Developing pilot programs were conducted to demonstrate the benefits to farmers. At same time, leading officials are crucial to the success of Sustainable agriculture and rural development (SARD) program.
- Rely on science and technology. Training of technicians to help farmers solve problems was key to success of the sustainable agriculture.
- Development is the key. Only with economic development can it be possible to achieve social development. Science and technology should be accorded special importance in boosting economic development. Conversely, economic development needs to be accompanied by social development. This can be improved rural resident conditions, community building, urban construction, cultural facilities; it can also be human development through education and training, social security, and protection of public interests.
- It is the key and essential to create a self-sustainable mechanism to allocate resources and device incentives to motivate everyone involved.

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Current Status and Countermeasures for the Development of the Safety of Agricultural Transgenic Organisms in China

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Abstract: Based on the detailed reviews on the situation for the development of the

safety of agricultural transgenic organisms in China, some countermeasures, such as perfecting safety management system, enhancing import and export management, and raising the public safety consciousness to transgenic foods, were put forward to enhance the safety of the agricultural transgenic organisms.

Key words: Agricultural transgenic organisms, Safety, Countermeasure

The statistics reflect, that since the first transgenic plant started the field experiment in 1994, till to the April of 1999, there are totally 4987 transgenic plants being approval to field all over the world, among them 47 transgenic products have entered the market. The extension areas of transgenic plants have increased by 26 times to be 4420×10^4 hm^2 in 2000 from that of 1700×10^4 hm^2 in the year of 1996 in the whole world, and the trends will predicted to be increased with a larger extent in the future 5 years. The vigorous development of the modern biological technology with the key technology of transgenic will bring the opportunity to solve the problem of population expanding, grain shortage, went short of resources, pollution of environment and energy crisis etc., and itself probably will become to be the main industrial in 21 centuries.

Gene engineering is a new technology, by the way of regrouping genes, can transfer the genes among the animals, plants and microorganisms mutually, which having broken the borderlines between the species, whether it is safety or not of this kind of consequence not only influence the health of consumers, but also concern the normal development of a nation's economy, the stabilization of the society and the prestige of the government, therefore it's needed to carry out tracking research of transgenic organism over a long period of time. As well as the rapid development of gene engineering, lots of nations laid a series of safety management measures in the form of the law to keep away the latent danger, and in order to avoid the unfavorable influences to the human being and ecology & environment. Especially the great foodstuff safety incidents such as mad cattle disease etc.,which spur the publics think much of the food safety than anytime before as today. Among them the clearest example is, as an excuse for safeguarding the national safety, and human, animals and plants health, to set technology trade rampart (TBT), which hinders the free trade of agricultural products. So the concerns to the safety of transgenic organism are getting much more attentions from nations in the world.

1. Current Status of Safety Development of Agriculture Transgenic Organisms in China

1.1 The general situation of research and development of Transgenic Organisms

China is the first nation to plant transgenic crop (a special cultivar of tobacco) as commodity in the world. By the end of 2000, there are totally 47 transgenic plants being under researching and developing which involving 103 various genes, but general developments of transgenic technology are still under lower level.

China started to expand planting transgenic crops in the small scope in the period of 1996-1997. In the May of 1998, Bioengineering Safety Committee of Ministry of Agriculture ratified 6 transgenic plants by the way of the safety evaluation (Bt cotton etc.). Among these 6 transgenic crops, Bt cotton has the largest planting areas, and which can enter the international market with a larger scale. The export of Bt cotton in 1998 was measured with the number of 451t and 563 thousand dollars, and increased to the 58.5 thousand tons and 61178 thousand dollars. Generally, although the export of Bt cotton are increasing rapidly, the gross is still not too larger. Due to the quality of Bt cotton is poor than that of other cotton producer of countries, therefore being at the inferior in the international market competition, while cotton price is 30% higher than that in international market.

1.2 The thinking highly to the safety of agricultural transgenic organisms needs to be strengthened

At present, it's uncertainty whether the transgenic food are safe to human health or not, and it may probably occur unexpected issues such as super weeds and super viruses which will further influence the biodiversity. So we need to hold an attitude of carefulness to face the R & D of transgenic plants and animals, strictly manage and monitor the process of research and application, As can as possible to implement the complete tracking inspection. Since 1999, the import of transgenic food should be undertaken constraint safety evaluation in Australia and New Zealand. In Taiwan province, there are also relative regulations that transgenic food should be proved no danger to health before on sale. In the mainland of china, there are nearly 80 institutes focusing on the research of gene engineering, but only 19 Institutes declared safety evaluation. So it's still necessary to enhance the safety evaluation of transgenic organisms.

1.3 The management system for the safety of Transgenic Organisms is being in imperfect

Currently, the development of transgenic technology is still under the situation of inadequate maturation, during the process of production, packaging, transportation, reposition, some transgenic agricultural products probably threaten the biodiversities, ecological environment and mankind's health, in case of happening of this kinds of events, will probably occurs the suffering consequence, therefore the safety management systems of transgenic products must be established. Due to the different understanding of safety of transgenic technology and products, so there are different kinds of safety management systems in the world. Generally the international policy for the safety management of transgenic agricultural products mainly divides into the encouragement and wariness. China is an important import country of transgenic agricultural products, the main sources come from America, Argentina and Canada. And the export products mainly belong the non-transgenic agricultural products. In the view of safety management, safety management of transgenic agricultural products and the trade management in China are turning to the road of legal system. But shortcomings still existed, such as the overlap of organization, lag of law, not do best of implementation etc..

1.4 The influences of the shock from the international trade seem to be serious

China has entered the WTO, from the sight of development, China will have to face the opportunities and challenges from the trade of import and export of transgenic agricultural products. In fact, some countries set technology trade rampart (TBT) as an excuse for food safety to restrict and prohibit the import of agricultural products, so the situation of export of agricultural products in China is being much more austerity. In China, transgenic and non-transgenic agricultural products have not been separated completely in trade market, some countries in Europe and Asia require the testimonial of non-transgenic agricultural products when they import agricultural products from China. So it is urgent to perfect the system of attestation and inspection of transgenic and non-transgenic agricultural products.

2. Countermeasures for the safety development of agriculture transgenic organisms in China

Developmental trends of transgenic agricultural products remind us that we must formulate management system on time to effectively solve the safety issue of transgenic agricultural products, to enhance the competition capability of transgenic products in the global market, and to maintain the state's benefits. At the same time, with the advance of Chinese science and technology, the transgenic technology certainly should be applied to the agricultural production, and we should do the preparation ahead, and positively probe into replying the technology rampart of transgenic agricultural products set up by other countries especially the developed countries.

2.1 To speed up the R&D of the transgenic technology

As a big country of agriculture, China should fully dig up, protect and take use of the particular and abound gene resources, and study on the transgenic technology matching to the Chinese ecological environment, and speed up the development of home transgenic technology, and catch up with the advanced standard of the world as quickly as possible, and raise the relative research and commercial extension. The nation should adopt many kinds of policies to encourage the development of transgenic technology and develop the promising transgenic product. Special attentions need pay to those transgenic technology and products with great suspicion for the safety, or concerning the great problems such as religious belief and ethics & morals etc, for those we should hold the cautious attitude to face it.

2.2 To perfect the management system for safety of the transgenic organisms

Ministry of Science and Technology had issued "Gene Engineering Safety Management Method" in Dec. of 1993. Based on this method, Ministry of Agriculture laid down and issued "Agricultural gene engineering safety managements implementation methods" in the July of 1996. The special office was established in MOA for the safety management of agricultural gene engineering, and with the responsibility for the execution of the implementation methods. But using experiences of Japan and Europe Union for reference, we still need to formulate a series of relative safety management measures of transgenic products in the form of law, and prudently prevent the latent danger. It is urgent to harmonize the functions of governmental organizations, carry out special legislation, perfect and strictly implement risk evaluation, testified system and IP's management system.

2.3 To implement the mode of management in region for the production of transgenic organisms

Different countries have the different standards to assess the safety of transgenic products, large changes of demand for transgenic and non-transgenic products occurred in different countries' markets of agricultural products. In order to acclimate this change, it's needed to implement the regional management for the production of transgenic organisms so that to avoid intermixing the different cultivars. Meanwhile implementing separated management for transgenic and non-transgenic products is very useful to insure our agricultural products can smoothly export.

2.4 To strengthen the management of imports and exports of transgenic agricultural products

After joining to WTO, the tax of custom reduced in a large scale, and the measures of non-custom reduced too, which lead to the low-priced transgenic agricultural products from overseas shocked the Chinese agriculture, therefore China can not loosen the strict management for the safety of transgenic products. Chinese custom and Sanitation quarantine branches should have the ability of inspecting transgenic components. Meanwhile it is necessary to enhance the latent risk assessment of transgenic products, and establish relative standard. Strengthening to inspect the transgenic agricultural products which crossing the boundary and to build the tracking system. According to the inspect ability, to put forward the standard of import port, and appoint the import port; Enhancing professional personnel training to suit the needs of development of Chinese transgenic agricultural products, protect Chinese farmers' benefits, and promote the development of agriculture and rural economy. At the same time, adopting effective measures to raise competition ability of non-transgenic products, which not only can substitute the imported transgenic agricultural products, but also enlarge the export.

2.5 To raise the public consciousness to the safety of the transgenic food

At present, the consciousness of Chinese residents to the safety of transgenic products is fairly weakness. Therefore it's necessary to take full use of public medium such as the newspaper, television, and network etc, as well as all kinds of dissemination activities to do education and training on the safety of transgenic organisms. Popularizing safety knowledge of transgenic agricultural products, and building up the consciousness of risk, self-protection, abiding by the law, finally to raise consumer's safety consciousness.

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Discussion on the Evaluation of Sustainability of Agro-ecosystem

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Abstract: Based on the detail analysis of the concepts of sustainability of agro-ecosystem and the importance of its evaluation, an important evaluation index-- Carbon and Nitrogen (C & N) Balances of agro-ecosystem was put forwarded, and the methodology of biogeochemical model to the certain evaluation was also introduced, finally, the priorities of the evaluation on the C & N balance in the agro-ecosystem were listed.

Key Words: Agro-ecosystem, Sustainability, Carbon and Nitrogen Balances, Evaluation

Sustainable agriculture is the general trends of the development of world agriculture. China is an agricultural country with huge population, being at a status of transferring from traditional agriculture to the modern agriculture, which not only need to raise the intensive level and land productivity by inputting modern substance and taking advantage of sciences and technologies, but also adopt correct measures and methods to avoid and stop threatening the environment safety. Chinese agriculture will face the huge task with the increasing of population and improvement of the life, it's significant to keep sustainable development of agro-ecosystem.

1. The Concepts of agro-ecosystem sustainability and the importance of its evaluation

1.1 The Concepts of agro-ecosystem sustainability

Currently there is not a unified concept of sustainable development of agriculture or sustainable agriculture in the world. Integrating the common characteristics of the development of world agriculture especially concerning the problems occurred in Chinese agricultural development, the main content and task of sustainable agriculture have the common senses among the academe, mainly including stably raising of yield and improvement of quality, improvement of production condition, going to ration of the structure, strengthening policy and management, increasing of farmer's income, improvement of the environment et. al. In a word, the sustainability of agro-ecosystem should embody that not only guarantee high yield, high benefit and better quality of products, but also keep the ecosystem stable and have the sustainable productivity.

1.2 Advances in the studies on sustainability of agro-ecosystem

Started from the analysis of preliminary production of agro-ecosystem, the research branches related to sustainability of agro-ecosystem consist of three indivisible parts, studies on the crop growth regulations and the relations between the input and output, studies on environment of field ecosystem with the key issue of soil eco-environmental change and its adjustment, studies on the components and function of endogenesis resources with the key of soil biome, all of these studies unfolded the thorough studies on the sustainability of agro-ecosystem from the sight of own specialty and accumulated abound experience. But they can't clarify the mechanism of sustainable agricultural production. The studies on the mechanism of breeding endogenesis of agro-ecosystem and its adjusting approaches can preferably solve this problem, which can open out the mechanism of interior stability between the plant and environment, and put forward effective adjusting approach for breeding endogenesis of agro-ecosystem and bring forward optimal production mode. Due to localization of field experiments and short of strong methodology, the integrated analysis of the sustainability of agro-ecosystem need to be enhanced.

1.3 The importance of the evaluation of agro-ecosystem sustainability

So far, the development of Chinese agriculture is pursuing high yield in some extent, and obtaining great achievement. While the agro-ecosystem with high yield has the property of high input and high output in which the marginal reward is reducing, and occurring inefficient utilization of resources, having the danger to the environment, the ability of self-adjustment is weakening and excessively relying on the outside input. How to keep not only the trends of high production but also the sustainability of agro-ecosystem, keeping the permanent soil fertility and rationally relying on the outside input, reducing pollution, organically combining the economy, environment and production. First of all, It's significant to solve the evaluation of the sustainability of agro-ecosystem.

2. The important index of the evaluation of the sustainability of agro-ecosystem --- C and N balance

Soil organic carbon (SOC) is one of the key issues for agricultural production and plays a central role in nutrient availability, soil stability and the flux of trace greenhouse gases between land surface and the atmosphere. It represents a major pool of carbon within the biosphere and acts as both a source and a sink for carbon and nutrients (Jing, 1999). In agro-ecosystem, loss of SOC will cause soil degradation, which does not only undermine sustainable yield but also affect environmental safety. Since Soil organic carbon is an essential element determining soil physical and chemical properties. Overuse of fertilizers will not only degrade the soil quality but also cause the regional and global environmental problem. The SOC in agro-ecosystem in mainland of China is at a situation of passive balance due to the unreasonable practices (Li, 2000). Desertification and dust storm currently prevailing in China are one of the inherent consequences of SOC loss at regional scale.

The C & N balance in agro-ecosystem implies the status of income and imbursement of soil carbon and nitrogen during the process of agricultural production. Net increasing of soil carbon in the agro-ecosystem means the soil carbon is at positive balance which guarantee enough organic carbon can be mineralized to provide more organic nitrogen to support the plant growth. Contrarily the passive balance of soil carbon means the income of carbon can't pay the imbursement. We advocate the nitrogen balance mainly realized relying on the carbon balance, not depending on the input of huge amount of fertilizers. While the incomes of soil carbon come from the input of litters, crop residue and organic fertilizers. High-yield field should ensure the soil carbon at the positive balance with a high level of circulation, in one hand inputting lots of organic carbon, and on other hand rationally applying the fertilizers, which can take full advantage of inner function of system stability, put an end to threaten the environment safety.

So the C & N balance is a comprehensive index for the evaluation of sustainability of agro-ecosystem, which can match the current demand of the certain evaluation of agro-ecosystem not only guarantee the high yield, efficient and better quality, but also keep the ecosystem stable and environment safety.

Table 1 The components of C and N balance in agro-ecosystem

C & N Balance	Inputs items of carbon	Outputs items of carbon	Objectives
Soil C balance	Litters, Crop residue, Organic fertilizer	Soil & root respiration - CO_2, CH_4 emissions, DOC leaching	Reduce leaching and CH_4 emission, increase inputs SOC
Soil N balance	Mineralization, Chemical fertilizer, Rain-N Deposit, N- fixation	Crop growth uptake, N le aching, emissions of N_2, NO, N_2O, and the volatili zation of NH3	Reduce leaching and emissi on of NH_3 and N_2, NO, N_2O , finally reduce inputs of che mical fertilizer

3. The methodology of the evaluation of the C and N balance in agro-ecosystem

We can see, from table 1, quantified evaluation of C & N balance in agro-ecosystem will be a comprehensive engineering which should be supported from scientific theories and methodologies.

3.1 The specialties concerned in this evaluation

The soil carbon dynamic is influenced by multiple factors, such soil temperature, moisture, Eh, content of clay, biomass and erosion et. al., while these environmental condition further affected by ecological driving factors, such as Climate, soil texture, plant and human activities. So any change happening in these factors and interactions will influence the quality and quantity of soil carbon in the agro-ecosystem. And it's necessary to use process-oriented model for the quantified evaluation of C & N dynamic. So the evaluation work is a comprehensive research, concerning the knowledge of biogeochemistry, agro-ecology, agronomy, soil sciences, plant nutrients et. al., the biogeochemical model of agro-ecosystem integrated and linked the above knowledge which becoming the ideal methodology and tools for the quantified evaluation of C & N balance in agro-ecosystem.

3.2 Biogeochemical model of agro-ecosystem

Resent 10 years a lot of biogeochemical models have been established for estimation of soil organic carbon storage and loss from arable land under the hot background of global change, among them some models have good performances, such as CENTURY (Parton et al., 1996), DNDC (Li et al., 1992), ROTHC (Jenkinson et al., 1987), CANDY (Franko et al., 1996), DAISY (Mueller et al., 1996), NCSOIL (Molina, et al., 1996). A common characteristics of these models is using the driving factors of climate, soil, land-use and practices, then mathematically modeling the process of producing, decomposition, and transferring of soil organic matter in the ecosystem, finally reaching the target of predicting the dynamics of soil organic carbon (Qiu, 2002).

The DNDC model, for example, is a process-orientated simulation tool of soil carbon and nitrogen based on biogeochemistry and has been discussed in detail elsewhere (Li et al., 1992, 2001). The model contains six interacting sub-models: (1) Soil climate and the thermal-hydraulic sub-models use soil physical properties, air temperature, and precipitation data to calculate soil temperature and moisture profiles and soil water fluxes through time. The results of the calculation are fed to the other sub-models. (2) Nitrification sub-model and (3) Denitrification sub-model calculates hourly denitrification rates and N_2O, NO, NH_3 and N_2 production during periods when the soil has greater than 40% water filled pore space. (4) Decomposition sub-model simulates decomposition of each SOC pool, i.e. calculates daily decomposition, nitrification, ammonia volatilization processes, and C_2O production (soil microbial respiration). (5) Plant growth sub-model calculates daily root respiration, N uptake by plants, and plant growth. (6) Fermentation sub-model calculates daily methane (CH_4) production. DNDC is suited to both site and regional modes.

The DNDC model have been validated throughout the world by using the long-term and short-term experimental data to test its behavior on the modeling of the carbon biogeochemical process in agricultural soils. DNDC have the good properties of easily obtaining input parameters, friendly interface et. al.. Quantified evaluations of C & N balances for agro-ecosystem by using DNDC have been reported (Xu, 1999; Qiu, 2002).

4. The priority filed of the evaluation for C and N balance in agro-ecosystem

The objectives of quantified evaluation of C & N balance for agro-ecosystem is to surround the main line of analyzing C & N circulation, put forward the high efficient production mode and relative practices with keeping balance of soil fertility, high efficient utilization of nutrient elements, reducing inefficient losing of nutrient, reducing pollution, and optimizing cost, by using the advanced biogeochemical model.

The priorities of the evaluation on the C and N balance in the agro-ecosystem should be focused on the typical Agro-ecosystem, currently, especially for the agro-ecosystem type of high production or fragile ecology in which respectively undertake the sustainable high production and ecological construction.

As for high production agro-ecosystem, for example, the evaluation started from choosing typical high production filed, by using the biogeochemical model, carrying out the quantified comparison the effects on the C & N balance influenced by different type of planting mode and different cultivation practices, confirming the adjust approach, further optimizing the cultivation, determining the latent of super high production, and finally proving up the characteristics and mechanism of C & N balance, sustainability and sustainable management approaches for the certain agro-ecosystem. While the test and validation of the biogeochemical model is needed before unfolding the evaluation by using the model.

5. Conclusion

Based on the detail analysis of the concepts of sustainability of agro-ecosystem and the importance of its evaluation, an important evaluation index-- C and N Balances of agro-ecosystem was put forwarded, and the methodology of biogeochemical model to the certain evaluation was also introduced, finally, Author considered that the priorities of the evaluation on the C and N balance in the agro-ecosystem should be focused on the typical Agro-ecosystem, currently, especially for the agro-ecosystem type of high production or ecological flimsy.

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Microirrigation——One of the Most Advanced Irrigation Techniques for Sustainable Agriculture

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Abstract Water resource balance and environmental quality are the two important indexes of sustainable agriculture. Overuse of water resources is the main reason to cause water shortage. The reasons to cause environmental degradations includes soil pollution due to overuse of chemicals, groundwater pollution due to deep percolations of chemicals and contamination, soil pollution due to waste and sewage water irrigation using traditional surface irrigation, etc. Therefore, in order to maintain the development of sustainable agriculture, major efforts must be devoted to developing modernized water-saving irrigation techniques for increasing water use efficiency, fertilize use efficiency, safety use of low-quality water, and preserving soil and groundwater environments. Microirrigation has advantages of water saving, high water use efficiency, high fertilizer application and use efficiencies, groundwater quality preventing by decreasing deep percolation of chemicals, possibility of using saline water and sewage water. Therefore, widely use of microirrigation is propitious to sustainable agriculture.
Keywords microirrigation, water use efficiency, fertilizer use efficiency, environmental conservation, sustainable agricultural

The behindhand irrigation method and irrigation scheduling are the main reasons to cause the overuse of water resources in agriculture. In order to guarantee the development of sustainable agriculture, we must develop modern water-saving irrigation techniques and do some work to widen water resources, reduce water consumption, and protect the environment of soil and groundwater. Water saving is mainly includes to increase water use efficiency. The widening of water resources mainly includes the utilization of rainwater, saline water, sewage water and so on. The protection of soil and groundwater environment mainly includes the restriction of soil and groundwater pollution by fertilizer and pesticide.

Micro-irrigation includes drip irrigation (surface drip irrigation and subsurface drip irrigation), micro sprinkler irrigation and bubble irrigation. It is thc slow application of water on, above, or beneath the soil. Microirrigation method is characterized by the following features: (1) water is applied at a low rate; (2) water is applied over a long period of time; (3) water is applied at frequent intervals; (4) water is applied near or into the plant's root zone; and (5) water is applied by a low-pressure delivery system (Bucks and Davis, 1986).

The advantages of micro-irrigation are as follows: (1) increased beneficial use of available water; (2) enhanced plants growth and yield; (3) reduced salinity hazard to plants; (4) improved fertilizer and other chemical application; (5) limited weed growth; (6) decreased energy requirements; (7) improved cultural practices ((Bucks and Davis, 1986).

Due to the above characteristics, microirrigation plays an important role in keeping the balance of water resources and protecting agricultural environment. Many countries have regarded micro-irrigation as a main method of insuring the development of sustainable agriculture and an agricultural way of environmental protection in the next century.

1. The function of microirrigation on maintaining the balance of water resources

1.1. High water use efficiency in agriculture

Micro-irrigation supplies water with high irrigation uniformity to crop root zone according to crop water requirement. Water is transferred through pipe network completely without water losses in the process of water transportation. Except micro sprinkler irrigation, the wetting range of soil surface is small and soil surface evaporation is few under microirrigation. In addition, deep percolation of irrigation water decreases due to the highly controlled irrigation amount. Therefore, unfavorable water consumption is minimized under microirrigation.

Under microirrigation, irrigation water meets optimal crop water requirement, soil temperature doesn't decrease sharply, and soil aeration keeps well all the time. Thus, crop yields increase dramatically and crops mature earlier. Both experiments and production practices prove sufficiently that water saves by about 30~60% (66.4% in table 1), yields increase by over 30~50% (66.7% in table 1), and crops mature 1~2 weeks earlier under microirrigation.

Microirrigation decreases water consumption of crops, which is very important for the balance of water resources. In some regions such as the Northwest of China and some regions channeling water for irrigation, water savings by microirrigation can extend irrigation areas to insure the food need of increasing population. On one hand, the increment of yields brings great economic profit; on the other hand, allowing for the total balance of food, land reclamation is reduced accordingly, hence, the overuse of surface water and the over-exploitation of groundwater due to increased irrigation area can be alleviated.

The premature of crops often brings considerable economic profit, shortens the growing periods of crops and thus decreases water application. The shortcut of growing periods also means water saving because the main component of water consumption is transpiration, especially in the mid-final growing period.

1.2. Utilization of rainwater

In many areas short of water resource, we not only obtain considerable water by the use of rainwater but also decrease the summit of flood to conserve soil and water. In recent several years, following the development of deficit irrigation principle, rainwater catchments agriculture applying supplementary irrigation theory in water-short areas develops greatly, especially in semi-arid regions. In past research work, we applied spray irrigation on mushroom cultivation by adopting advanced spray tape under low operating water pressure head (5~8 m). In this mode, spray irrigation system meets mushroom need on moisture, makes temperature drop in summer, and makes it possible to cultivate some mushroom that can't endure high temperature. It is primarily predicted that culturing mushroom using spray irrigation system on rainwater catchments agriculture can make some farmers wealthy. The reasons are: the water requirement of culturing mushroom is commonly less than that of vegetable in greenhouse, the climate of semi-arid is fit for drying process of mushroom, and it is convenient for transportation and store in regions with poor traffic conditions. Of course, there are many studies on the cultivation of cash crops using other microirrigation in our country and many of these works make farmers wealthy too.

In rainwater catchments agriculture, it is very important to adopt highly water-saving irrigation method because a majority of rain-catching settings are water vaults and small pools, which collect only a small amount of rainwater. In recent years, some farmers in part regions adopt mobile system of drip irrigation or micro sprinkler irrigation. Farmers may accept mobile drip or micro sprinkler irrigation system if irrigation materials can be chosen properly and the investment on grain crops is reduced. Of course, farmers can mostly accept micro irrigation for protected agricultural. In some places such as Loess Highland and stony mountainous regions, elevation difference caused by landform can sufficiently meet the pressure need of micro irrigation, the energy and operation cost will be very low.

1.3. The use of saline water resource

In many regions of our country, there is great amount of saline water resources. Much of saline water resource can't be applied in agriculture under traditional flood and furrow irrigation. It is a common fact that in some areas, on the one hand, there is deficiency in water resource, on the other hand, saline water resource are not used.

In nature, water moves from a point with higher water potential to a point with lower water potential and so does the process on water uptake of crop roots. The higher the soil water potential, the more easily water taken up by roots; the lower the soil water potential, the more difficult water uptake by roots. Water potential approximate the sum of matric potential and osmotic potential. Matric potential is determined by soil water content. For the same soil, high water content means high matric potential and low water content means low matric potential. Osmotic potential is determined by soluble soil salt content. For the same soil, high soluble salt content means low osmotic potential and low soluble salt content means high osmotic potential. When adopting traditional flood and furrow irrigation method in saline water irrigation, salt gradually accumulates in tilth layers because of strong intensity soil surface evaporation. Part of salt under tilth layer enters into tilth layer following with the water movement and this also leads to the increment of salt content in soil, which results in the drop of soil osmotic potential. Water content keeps at low level in long time under surface irrigation, making soil matric potential very low and osmotic potential also very low, which results in lower soil water potential. When water potential drops to certain degree, water moves to roots very slowly or can't move. That is, root water uptake is very difficult or can't extract necessary water to keep alive, the growth of crops is affected or lead to wilt even death. Under sprinkler irrigation, although irrigation cycle of sprinkler irrigation is shorter than that of flood irrigation and soil water status is improved, it can't resolve the problem radically. In addition, salt in saline water can burn the leaves and canopy of crops and can result in the death of crops. Hence, we can't use highly saline water to irrigate under sprinkler irrigation.

Surface drip irrigation supplies water frequently from the soil surface to the root zone by point resource. Water application is determined by the crop requirements, Some salt move downwards with water, and the goal of salt leaching is achieved. Part salts move out of root zone with water, salt concentration of soil close to that of irrigation water. Except there are some accumulation of salt due to soil evaporation in the small wetting range around emitter on the surface, no salt or little salt accumulates in the range of root zone, its osmotic potential is slightly lower than that of saline water. Because soil water content always keeps in a good condition, soil matric potential is high, therefore the total soil water potential is high. If salt concentration is not too high, crop root can extract water and crop grows well. The research in Israel shows that vegetables irrigated with saline water of certain salinity grow well, their yield and quality are even better than those irrigated with freshwater.

The above discussion is only about the mechanism of saline water irrigation, which suggests that saline water can be applied for irrigation. When drip irrigation is conducted using saline water irrigation in practice, studies on vegetable salt-tolerance and irrigation techniques should be curried out.

1.4. Use of sewage resource

Because of the high irrigation uniformity, the ability to control irrigation amount accurately and water distribution in the soil using micro irrigation, sewage treated in a certain standard can be applied in agriculture irrigation instead of freshwater. Many studies on this aspect have been done in developed countries.

Of course, we have to do some studies to insure the safety of sewage irrigation before using sewage. These researches are as the follows: (1) effect of contaminants on food safety; (2) natural purifying ability of soil microorganism; (3) the rule of contaminant movement and transportation in representative soils under different micro irrigation method.

2. The function of microirrigation in environment protection

2.1. Reducing the potential of environment contamination by fertilizer

The adverse influence of fertilizers on soil environment includes degradation of soil physical and chemical properties, the decline of land productivity, and so on. At the present time, the amount of organic fertilizer is very limited. It is very difficult for organic fertilizer to meet the further development of agriculture. Thus, the application of fertilizer will be unavoidable.

The influences of fertilizers on soil environment are mostly related to fertilizer application methods and irrigation techniques. If the application of fertilizer is adjusted just to meet the crop requirements, the adverse influence on soil environment can be limited. Under microirrigation, fertilizers are dissolved in irrigation water and supplied to the crop root zones in a small rate frequently according to crop requirements. The application amount of fertilizers is fewer while the fertilizer use efficiency is high, and it is good for environment protection. Table 1 shows the results of the experiment in melon fields using drip irrigation and furrow irrigation in Texas, USA (Fipps and Perez, 1992). The nitrogen applied 68 kg/hm^2 under drip irrigation, which is 38.4% of that under furrow irrigation. N-fertilizer use efficiency was 18.1 containers/kg.hm^{-2} while it is only 4.2 containers/kg.hm^{-2} under furrow irrigation. The melon yield increased 66.7% by using drip irrigation.

Table 1. Quantity of irrigation water, amount of fertilizer application, melon yields, water use efficiency and nitrogen use efficiency

items	drip irrigation	furrow irrigation
precipitation (mm)	66	66
irrigation amount (mm)	112	333
irrigation times	8	7
fertilizer-N (kg/ha)	68	177
melon yields (box/ha)	1235	741
water use efficiency (box/mm)	6.9	1.8
fertilizer-N use efficiency (box/kg • ha)	18.1	4.2

2.2. Preventing groundwater contamination potential of fertilizer and pesticide

The irrigation uniformity of traditional irrigation methods, such as flood irrigation and furrow irrigation, is very low. Consequently, in order to make all plants receive the desired irrigation water, much deep percolation will occur. Fertilizer and pesticide move downwards into groundwater and pollute groundwater. But, under microirrigation, fertilizer and pesticides along with irrigation water are applied to crop root zones in high application uniformity, and fertilizer and pesticide use efficiency is increased accordingly. Moreover, liquid fertilizer is frequently applied with irrigation water in a small rate according to the crop requirements. The deep percolation of fertilizer can be reduced. Phene et al. found that the nitrogen leaching was not obvious under drip irrigation according to their experiments under drip irrigation using weighing lysimeter for seven years (Phene, 1995). Therefore, microirrigation can reduce groundwater contamination by fertilizer and pesticide.

2.3. Preventing environmental pollution of sewage water

Because microirrigation has high irrigation uniformity, irrigation amount and the distribution of irrigation water in soil can be highly controlled, and deep percolation is not obvious, sewage water treated to a certain standard can be used for irrigation using microirrigation system. If the quantity of sewage water is controlled well, contaminants can be purified because microbe in soil can decompose or absorb the contaminants. If all the sewage water is used for irrigation, rivers and lakes pollution can be lightened.

3. Conclusion

Microirrigation has advantages of water saving, high water use efficiency, high fert ilizer application and use efficiencies, groundwater quality preventing by decreasing chemical seepage, possibility of using saline water and sewage water. Therefore, widely use of microirrigation is propitious to sustainable agriculture.

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Study on Ecological Agricultural Model Suitable for Metropolis Characteristics

------Research on the Model of Shanghai Metropolis Ecological Agriculture

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Abstract: Varieties of the models of domestic and international ecological agriculture were introduced, the importance of metropolis ecological agriculture was brought up, and the model's characteristics and development strategies of metropolis ecological agriculture were elucidated finally in this paper.

Key words: Metropolis; Ecological Agriculture; Model

1. Varieties of ecological agricultural model

It is very important for ecological agriculture to pay more attention to the harmony of agriculture and environment. Ecological agricultural model should be designed on the base of your own resources and society economic conditions.

Development models of ecological agriculture in the world were different because of distinctness of national conditions. For example, although developed countries do not exclude moderate agricultural intensivism, they further attach importance to environmental protection. Environmental protection and traditional ecological technology are mainly characteristics of developing countries that depended on devotions of external materials and achieved economy increasing.

In addition, ecological agricultural models of different areas of the same country could also be different because of variant society, nature and economy conditions. For example, there are multiple crop and rotation in plain, farmhouse courtyard of the south and marsh ecological agricultural model in the middle area and in other areas of Mexico. In China, there are pertinent domains combination models, such as compound model of cultivation and breeding focused on domestic animals and poultry breeding, and compound ecological models on the base of region environment characteristics, such as plain compound, mountainous region and hill compound and water compound ecology models.

Metropolis suburb ecological agriculture is located in compound space of country and city with the characteristics of agricultural product function and important ecologic al function. Its characteristics of stronger intensified, industrialization and manufactory are different from ecological models of other countryside areas.

2. Importance of metropolis agricultural ecological model

It is actual, pressing and important to research on metropolis agricultural ecological models with the needs of metropolis society and economy development and important status in China.

First, there are unique nature and economy conditions in metropolis. Agricultural ecological models in the areas with low devotion agriculture in China are similar to those of developing countries. Metropolis provides admirable conditions for country intensivism, industrialization with the quick suburbanization to improve circumstance of country economy, technology and society remarkably. At present, agricultural machine power of Shanghai suburb is two times as much as that of our country average level and more, machine plough land area is 90 percent of total cultivated area and 34 percent increase than that of our nation. Modernization levels of modern assembly greenhouse, industrialized raise seedlings and sprinkling irrigation in Shanghai are higher than the average level in Japan. So agricultural ecological models of metropolis are incompletely uniform with those of the whole nation.

Second, there are unique realistic problems, which must be solved. With the quick development of metropolis, a lot of industry wastes and living rubbish are gradually polluting agricultural environment. The contents of poisonous substances and heavy metal in soil of Shanghai countryside are several times and even ten times higher than the national standard. In addition, agriculture own pollution is also very serious. Such as fertilizer, average application amount of total nitrogen is 411 kg, 530 kg and 200kg in the whole nation, Shanghai and America per hectare respectively. 1/3 is absorbed by crop, 1/3 retained in the soil, and 1/3 flowed into river respectively. So ecological function of metropolis agriculture must be strengthened recently.

Third, there are strict demands on agriculture in metropolis. In order to construct first class cities of the world, we must build ecological agriculture based on the positive cycle of energy and materials. In the city, the function of agriculture is also involved the effects in ecology, society and psychology. So metropolis agriculture not only supplies food to the city but also contributes to the beauty, cleanliness and non-pollution of the city.

The agriculture in Shanghai will have the production function as well as the important ecological effects. Then, on the base of positive cycle of energy and materials, in the good environment of green agriculture, the agriculture in Shanghai can be developed into the ecological agriculture without pollution and with little or without artificial synthesized materials.

Fourth, there are functions of service, demonstration and dispersion of metropolis agriculture for the whole country. In the past few decades, sustainable developments have been achieved ignored the ecological environment, threatened environment and resource. The "pollute, then control" experience of overseas does not be suitable to us. Hereafter, we will build a new agricultural production system with corresponding technical system to replace the used routine agricultural system of high input. And the metropolis agriculture could and should be have the function of service, demonstration for the whole country.

3. The characteristic of metropolis ecological agricultural model

Different from the agriculture of the common rural area, metropolis ecological agricultural model has the characteristics as follows:

(1)"Macro-system and macro-cycle" will be the most important characteristics of metropolis ecological agricultural model because of efficiency. The ecological agricultural cycle of other regions in our country is on the base of village and family, while that of Shanghai is kept balance in the city or region. So the organic fertilizer factory and organism fertilizer factory will be constituted in the city to realize the agricultural waste reuse, which is the necessary step of the ecological agriculture.

(2) The suburb ecology is combined with the city ecology, and has three notable effects on ecology, economy and society. The pollution came from countryside must be controlled, and at the same time, the environment of city should be improved depending on the improving environment of countryside.

(3) "Highly intensivism" will be the another important characteristic of Shanghai ecological agriculture. We will try to resolve the contradiction of intensive and ecological agriculture, as well as modern and traditional. The efficiency of the ecological agricultural system will be increased on the prerequisite of keeping positive ecological balance with the relatively abundant resource of science, technique and industry instead of the relatively lack resource of nature.

The elementary requirement of metropolis agriculture is in accordance with that of metropolis ecological agriculture emphasized development and environment protection.

Because metropolis ecological agriculture is a necessary component part of the metropolis ecological system, it is different from non-metropolis agriculture having particular metropolis characteristics, and is a kind of efficient and artificial ecological agricultural system, namely, modern intensive ecological agriculture. Moreover, metropolis agriculture has the functions of service and demonstration for the whole country. For all of above, metropolis ecological agriculture is a kind of ecological agricultural model, having three most significant characteristics: intensive feature, ecological and service function.

So the strategies of metropolis ecological agricultural model should be put into effect as follows:

1). Strategy of suitable intensive.

Change from the high intensive agricultural model to the suitable intensive metropolis ecological one.

2). Strategy of change from routine agricultural technique to ecological technique.

Change from the external agricultural production mode depending on the high input of non-regenerated resources to the internal agricultural production mode depending on the base of ecological balance and reasonable utilization resource by improving ecological function.

3). Strategy of industrialization of ecological technique service.

Science, technique and industry in Shanghai are in lead all over the country, so the technique and equipment of industrialization of ecological agricultural technique can be serviced.

Land Resource Assessment Using GIS for Sustainable Agriculture in Vietnam.

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Abstract

Extensive agriculture activities have been taken place in Vietnam that bring strong impacts on agricultural resources. Natural land and cultivation land per capita are low and tend to reduction due to high population growth rate. Land resource use is found unreasonable and inefficient. Evaluate land resources and employment conditions of these resources becomes urgent and realistic requirements.

GIS has been introduced in Vietnam and rapidly improved as an effective tool of assessment of land resources supporting proper land resources utilizations towards a sustainable agriculture of Vietnam. In order to be applicable of GIS for land resource assessment two methods are implemented, namely agro-ecological zoning and land evaluation. The advantages and disadvantages of each method are examined in this paper. Some models of land suitability assessment for major crops in Dak Lak province are introduced. The models are promising to be applied for all land use types in other areas in Vietnam.

1. Problem statements

Agricultural land in 2000 is 9,345,300 ha which is occupied 28,4% of total area by General Department of Land Administration (GDLA) statistics. Natural land and cultivation land per capita are low (0.4 and 0.1 ha respectively) and tend to reduction due to high population growth rate (1.8%). Land resource use is found unreasonable and inefficient. 3/ 4 of total natural land is slopping land, but in agricultural land use structure, annual crops account for more than 70%, perennial crops is fewer than 20%. Land use coefficient is low (really 1.6%). Advantages of forestry, perennial crop plantation and cattle raising in mountainous and hilly land are not much mobilized. Shifting cultivation, extensive cultivation and mono cultivation are still popular in mountainous area, especially in remote area. The result has been a built up pressure on soil environment: leaching, erosion, deterioration, poor fertility and balance nutrition, salinization, acidification, pollution, deforestation, drought, dertification, inundation organic deduction, landslide, poor in crop patterns, loosing soil productivity.

The qualitative and quantitative land resources inventories by utilization types and impact assessments are oriented forward suitable land use planning for agricultural activities in Vietnam, that bring into play the advantages and overcome the shortcomings in building development strategies, giving guidance in production and initiating technology solutions guaranteed for economically effective and sustainable land use. So, to evaluate land resources and employment conditions of these resources becomes urgent and realistic requirements which are concentrated in providing the fundamentals for appropriate agricultural land use planning projects.
GIS has been introduced in Vietnam and rapidly improved as an effective tool of assessment of land resources supporting proper land resources utilizations towards a sustainable agriculture of Vietnam. In order to be applicable of GIS for land resource assessment two methods are implemented, namely agro-ecological zoning and land evaluation.

2. Gis applications for land resource assessment in vietnam

GIS has been introduced into Vietnam since 1990's and developing rapidly. There are numerous GIS-based system have and are currently being installed, and many of these already playing an important role in natural resource and environmental management. Nowadays using GIS for agriculture becomes increasingly requirements. GIS technology incorporating science researches on landuse/crop/farming system provides scientists and decision makers with alternatives forwards land use planning and agricultural development strategies. Two methods using GIS for land resource assessment in Vietnam are introduced.

2.1 Agro-ecological zoning (AEZ) method for agricultural land use planning

2.1.1 What is AEZ

The AEZ concept involves the representation of land in layers of spatial information and combination of the layers using a Geographic Information System (GIS). The combination/overlay of layers produces agro-ecological cells. In this way a land resources database is created which contains information on the AEZ cells. AEZ integrates in the database various kinds of geo-referenced datasets, which can include topography, administrative boundaries, rivers/water bodies; geology; soil; landform; rainfall; temperature; land use/land cover; ...

A step of land resource assessment process is to characterise and delineate agro-ecological zones that distinguish between each other in terms of suitability for agricultural practice. These zones are specified by climate, soil and landform. So, agro-ecological zones are mapping units generated from physical requirements of land utilization types. AEZ simply is one kind of land evaluation or land resource quantification.

2.1.2 AEZ method

AEZ is a sustainable land use evaluation system that provides a framework including the activities below:

- Characterization of environment and land use measures.
- Quantification of the agro-ecological zones where specific land use measures have been performed.
- Quantification of environmental sensitivity to land use measures.

Definition of optimal land use structure that meets specific technology and social objectives in a study area.

FAO AEZ method consists of following steps:

i. Select and define land use types
ii. Crop categorise based on physio-ecological characteristics related to temperature, radiation and define crop physical requirements
iii. Collecting information on land requirements regarding to production inputs
iv. Creating quantitative climate data based on major climate conditions and cultivation period.
v. Collecting soil data by each region.
vi. Overlay climate and soil data of the study area to generate climate/soil, agro-ecological units.

2.1.3 Agro-ecological classification in Vietnam

Based on the nature and ecological systems of Vietnam agro-ecological zoning has been established at three levels: national, regional and provincial with the following division system:

⇒ AE zone,
⇒ AE sub zones,
⇒ AE units,
⇒ AE sub-units.

Agro-ecological zoning at national level included 9 zones and 62 sub zones.

(See the map of agro-ecological zones of Vietnam)

Agro-ecological zoning at regional level has been performed for each of 9 agro - ecological zones.

Agro-ecological zoning map at provincial level

The study developed a comprehensive database on the present status of related agricultural resources exploitation by agro-ecological divisions which can be used for present and potential land use planning.

2.2 Land evaluation method

The result of a land evaluation is a prediction of the use potential of land for several actual or proposed land use systems. In other words, land evaluation predicts how each land area would behave if it were used according to each of these systems. Its main purpose is to inform the process of allocation of land uses to land areas by individuals, collectives, or governments. As such, it is a tool for strategic decision making. A complementary purpose of land evaluation is to describe the limitation to land use, and based on these, appropriate management methods.

2.2.1 Land evaluation concepts

Land evaluation may be defined as " the process of assessment of land performance when used for specified purposes ". As such, it attempts to predict the behavior of each land unit for each actual and proposed land use.

The term "land" includes soil, vegetation cover, hydrology, terrain and climate. Thus, these definitions are similar to agro-ecological characteristics defined by FAO AEZ method. Actually, AEZ can be considered as a land evaluation method for large territories.

Principal FAO land evaluation terms are:

Land utilization type (LUT) is more specific than a major kind of land use. It is characterized by its key attributes, i.e. those biological, socio-economic and technical aspects of land use that are relevant to the functioning of the land utilization type.
Land characteristics (LC) are simple attributes of land that can be measured or estimated in routine survey.
Land qualities (LQ) are complex attributes of land which influence the suitability of land.
Land use requirements (LUR) are the conditions of land necessary for the successful and sustained practice of a given LUT. Notice that land use requirements express the demands of a land use, whereas land qualities express the supply, i.e. what a particular land area can offer.
Land mapping units (LMU) are land areas with all attributes which influence a selected land utilization type.
In a land evaluation exercise, the land use plamner matches LMU with LUT to determine the relative suitability of each land area for each land use.
The suitability of each land mapping unit for each land utilization type is computed by:

1. Determining (measuring or estimating) the actual land characteristic values for the land units, by field survey, laboratory measurements, remote sensing, etc.;
2. Combining these land characteristic values into land quality values (i.e., inferring the LQ from the set of LC's);
3. Matching the land quality values with land use requirements;
4. Combining these land quality values into land suitability classes (i.e., inferring the suitability from the set of LQ's).

2.2.2 Land evaluating using GIS methodology

FAO land evaluation method requires to process data in various types and huge volume, that is time consuming and not accurate process if carried manually. Therefore automated land evaluation has arisen. Land evaluation using GIS incorporating ALES software is applied to meet these requirements.

What is ALES ?

The Automated Land Evaluation System, or ALES, is a computer program that allows land evaluators to build expert systems to evaluate land according to the method presented in the FAO " Framework for Land Evaluation ". The entities evaluated by ALES are land map units. " Evaluators build their own expert systems with ALES, taking onto account local conditions and objectives. ALES is not by itself an expert system, and does not include by itself any knowledge about land and land use. ALES is a framework within which evaluators can express their own, local, knowledge " (Rossiter, 2000).
ALES land evaluation model conforms to following procedure:

1. Define land utilization types to be evaluated,
2. Define the land utilization types in terms of their land use requirements,
3. Define the land use requirements in terms of their land characteristics,
4. Enter tabular data and maps for land characteristics,
5. Build computer models for land evaluation
6. Compute the evaluation
7. Calibrate the results

8. Present the results to GIS.

There are two kinds of land suitability:

- Physical suitability, which expresses the degree to which the sustained implementation of the land utilization type on a certain land unit is feasible without unacceptable risk to the human or natural community; and
- Economic suitability, which is based on a calculation of the economic return which may be expected if the land utilization type in question is implemented on the land unit.

In this paper we focused on the physical suitability.

Geographic information system

In land evaluation process GIS is served as a computer-aided tool for thematic data gathering, geographic data manipulating, data integrating in order to formulate land unit maps, and finally, simulating land evaluation results by producing suitability map for each land utilization type.

The entities evaluated are land map units. On land unit maps each unit is a geographic area which discriminates between neighbors by soil characteristics, surface water conditions, salinity, agricultural climate, ... In a GIS, especially ESRI software, the result of map automation, topology building is attribute table in which a record stores all the information about one occurrence of a feature and an item (field) stores one type of information for all features in the database. This structure itself permits of easily handling land units with all related attributes. At the same time, these xBase-format database files allow data exchange with other software, especially with ALES.

Geographic information systems are ideal tools for spatial analysis, and the results of ALES analyses may easily be used as data layers (suitability maps) in GISs.

3. LAND SUITABILITY ASSESSMENT FOR MAJOR CROPS USING GIS : A CASE OF STUDY IN DAKLAK PROVINCE

Dak Lak province lies in the western Highlands of central Vietnam, to south and east which is bounded by Truong Son mountain, and to west by the border with Cambodia. Dak Lak is one of the richest basalt soil areas in Vietnam and suitable for perennial crops and cattle-breeding. extensive plantations of some crops, namely coffee, tea, fruit-tree ... and expanses of cultivated land for foods have resulted to deforestation gone out of control, vegetation cover evidently reduced, floods frequently and frightfully occurred.... Long drought, lowered water-level have made thousands ha of yield loss coffee plantation cut down, and bring adverse impacts on productivity of other irrigated crops. Unsound fertilizer utilization caused critically soil degradation.

To evaluate land resources and employment conditions of these resources forwards appropriate agricultural related resources utilization become urgent and realistic requirements. The technology being used to establish land suitability assessing includes GIS software, for instance ArcInfo, ArcView GIS, incorporating ALES.

3.1 GIS agricultural database development

Agriculture database has been constructed to allow for a spatial analysis and modeling capability. This approach involves creation of a multi-layer GIS database in which each component layer is allowed to change. The GIS database includes many thematic layers in professional ESRI GIS formats (ArcInfo, ArcView), namely:

⇒ Soils associations,
⇒ Soil texture,
⇒ Soil thickness,
⇒ Slope,
⇒ Elevation,
⇒ Agro-climate,
⇒ Land use,
⇒ Irrigable capacity....

These data layers have been converted into raster format with resolution 25m x 25 m.

3.2 Setting up land suitability criteria for specific crops

The mentioned above parameters are examined and classified by land requirements of selected land utilization types. Results of integrating and overlaying maps are land unit maps. Separate land unit maps are generated for each land utilization type.

Field survey of land use existing and structure in 2000 showed there are about 30 land utilization types in Dak Lak. In the scope of this study we only examine four agricultural cultivation types, namely :

- Winter-spring irrigated rice,
- Summer-autumn irrigated rice,
- Upland rice,
- Coffee.

3.3 Establishment of crop suitability maps

A essential tool of land evaluation is the set of decision trees final outputs of which are land suitability classes defined by the maximum limitation method and included 3 suitable classes and one unsuitable.

3.4 CONCLUSIONS

GIS is a powerful tool in land resource assessment, can reduce the time and cost of evaluation process and can assist the land use planners in selection of an appropriate strategy. It is necessary to perform a multi-faceted evaluation of land resource capacities. A ideal method to achieve this evaluation, is using GIS incorporating other expert software, like ALES in which land suitability is examined based on thinking through a multiple of objectives. The model of land suitability assessment for major crops using GIS in DAKLAK province are promising to be applied for all land use types in other areas in Vietnam.

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Study on the Evaluation Index System of Ecological Agriculture

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Abstract: General situation of evaluation index System of ecological agriculture in China was introduced, and design principles design, evaluation objects, practice, quantity standard, calculation of index system, and index system calculation model suitable for use were discussed in this paper.

Key words: Ecological Agriculture; Evaluation; Index System

Introduction: Index system and evaluation index of ecological agriculture is embodiment of ecological agricultural internal mechanism and characteristics. Ecological agricultural development can be effectively analyzed and inspected with index system and evaluation index research, which came into being almost at the same time with ecological agriculture research. In early 1980s, evaluation system of ecological agriculture was studied and designed by some scholars in China, but no uniform index system is accepted until now. Because of different points of view, experience and specialty, scholars educe different index designs. We bring forward some viewpoints to discuss them with you.

1 General situation about studies on index systems of ecological agriculture in China

In China, some ecologists pay more attention to the characteristics of ecosystems despite of considering the social and economical function as a component of ecosystems. For example, some ecologists put the index of agricultural ecosystem into following aspects, such as primarily ecosystem, hypoecosystem and processing ecosystem, thus put the economic benefit into the processing ecosystem (agricultural environment protection, September, 1990). But other scientists emphasize that the index of ecological agriculture should be branched out into two parts, which can reflect internal structure and function (General situation of agricultural ecological economics. Law Press, 1993). It is quite right from view of ecosystems. However other economists consider this question from more viewpoints of economics. For example, the evaluation index was fallen into four parts in 《Study on sustainable development and integrated productivity in China agriculture》 (Shandong science and technology Press,1995) edited in chief by Lu Liangxu and Mei fangquan including output of farm product, input of agriculture, diathesis of agricultural laborer, and utilization of resources and environment. Apparently the ratio of input to output was largely considered above. Recently, more and more scientists thought much of the function about resources and environment in the course of index designing, generally putting the index system into three parts: utilization of resource, environmental protection and economic benefit (Ecological agriculture in China, China agricultural science and technology Press, 1996). This classification was propitious to putting the characteristics of above two aspects together. This made the ratio and calculation of index correspondingly unification, and mostly was took classification and ambiguous evaluation method, thus the calculation of ratio was defined generally by Terrffy method. Therefore the conformation of ratio was always related to experts' recognizant ability. Moreover these index systems generally only reflect the status importance of index among them, but can not reflect the relationship between each other. Actually, ecological agriculture is a complex system, and the relationship between each element is quite compact.

2. Design of ecological agriculture index systems

2.1 The principle followed in design

Design must be scientific, useful and brief. Scientific design means reflecting on the essential characteristics of ecological agriculture. Useful design means propitious to controlling ecosystems by analyzing the index, and brief design means the acquiring and analysis of data should be simple.

The index should be different from the social economical index such as agricultural modernization. The index systems must be designed according to agricultural ecosystems, but different from that of general ecological systems. The economic and social function of agriculture should be considered.

Design of index should reflect the mutual influence and restriction between each other, which can reflect the complex of agricultural ecosystems actually, and the objective practice of ecological agriculture based on ecological balance exactly.

Design of index should be propitious to evaluating effect on the key technology of ecological agriculture.

2.2 Design of index systems

Besides followed by above principles, we think that we should carefully summarize other scholars' achievement during the process of designing index systems, which made the index systems reflect the interior mechanism of ecological agriculture more exactly and the relation between each element. Therefore, we put forward the following assumptions including our thoughts on present designs of index systems.

Design of the first index

The first is structural index of ecological agriculture, which reflects the status of systems from interior constitutes of agricultural ecosystems. The second is function index of ecological agriculture, which reflects the status of inter mechanism from the function of agricultural ecosystems. The third is the index of external input of ecological agriculture, namely, external factors of systems. When these factors are accepted by ecosystems, becoming ecosystems' well-liking factors, the function index will produce good reflection.

Design of the second and third class index

Structural index of ecological agriculture

It reflects the status of resources and environment such as soil, water, air and so on. For example, there are some indexes of soil including organic content, nutrient proportion, amount and structure of beneficial organisms, and content of harmful matters. In the past, these index were too specialization to be deleted. But in fact, the interior situation of agricultural ecosystems was difficult to be reflected without these index.

The functional index of ecological agriculture

The first was economic function. In the past, substantial index much used to be utilized, whereas substantial index had no much meaning under market economic condition, economic benefit index was mainly used, such as average production value per mu. The second was ecological index, such as photosynthesis efficiency, ratio of input to output of energy, incidence of disease of domestic animals and poultry and so on. The third was social benefit which should be defined according to specific situation, because the social benefit function of ecological agriculture was indirect, such as greenbelt increase, climate improving, environment beautification, percentage of Gross National Product enhancing and so on.

Index of external input

It mainly indicates substantial indexes (such as establishment, fertilizer, pesticide and other farming production materials), index of laborer, science and technology input and funds input.

2.3 Evaluation of ecological agriculture index systems

The objects of evaluation including three aspects:

Benefit evaluation of agricultural environment controlling. Through the evaluation on the index of external input, especially the comparison between index of technical input and structural index of ecology we can get the cost and effect of environment controlling. It is fit to evaluation on side and spot governing technology of agricultural ecosystems especially. For example, soil improving technology were compared with structural index of soil and we could get the effect of this technology.

Effect evaluation of ecological agriculture

The purpose of constructing a satisfactory agricultural ecological environment is to produce good effect. So the evaluation systems is key. It is evaluated through external input of agriculture compared with effect index, however structural index of ecological agriculture served as restrictive condition, such as some kinds of input, with the increasing amount of fertilizers, economic income was enhanced, but index of soil and runoff decreased. The additional effect would not be accepted in this evaluation system, since above mentioned performance was not in correspondence with the objective of agricultural benefit based on environmental protection and agricultural ecological balance, which was required by ecological agriculture.

General evaluation of ecological agriculture

This is a total evaluation of above three parts of index systems. For example, after applying the organic agriculture technology, the structural index of ecological agriculture was improved better, and ecological, economic and social functions of the ecological agriculture index can behave quiet better, so these results showed that the total evaluation index of the technology perhaps was very high.

Single evaluation We will know about the status of environment and resources in agricultural ecosystem through single evaluation on structural index of ecological agriculture, for example, intensive level may be reflected through single evaluation on external input index of ecological agriculture.

2.3 Application of evaluation systems

Decision This is beneficial to establishing region evaluation and management information systems to provide data for government.

Management This is beneficial to controlling agriculture production process, such as non-hazard and organic products standard and the whole process environment quality management.

Prediction This is beneficial to safety supervision on agricultural environment and products.

3. Calculation of evaluation index systems of ecological agriculture

3.1 Quantitative standard of index

Establishment of scientific quantitative standard is the evaluation premise on index of ecological agriculture through two methods conformation. One is Terffy method, namely, specialists investigating method, which defines ratio of all sorts of indexes; another method is to previously design. We regard economic benefit index as one of conditional indexes, but we do not accept all benefit increasing, and can accept them only under the condition of some important which structural and ecological index is not decreasing. For some ecological and structural index to establish alert point, the nearer from the alert point, the more minus score, the score was zero in the alert point, below the zero point it was negative score. Some non-destructive factors were denied by one ticket, and the scores of this system were all canceled to correctly reflect the characteristics of ecological agriculture, which based on ecological balance and strong relationship of systems.

3.1 Calculation of system index

Calculating evaluation coefficient Index data are analyzed with non-unit method and evaluation coefficient of some index is devised as the index ratio of years, calculation formula as follows:

$Yit=\{Cit/Cio$ as Ci was positive index;

$Yit=Cio/Cit$ as Ci was negative index

In the formula, Yit means evaluation coefficient of i index on t year, Cit and Cio means statistics of i index on t year and base year

Conformation of index ratio Relative importance of every factors was derived from mutual comparison and judgement by layer-analysis method

General evaluation General evaluation to ecological agriculture according to following formula:

$$Zt=\Sigma Wi \cdot Yit$$

In the formula, Zt means coefficient of general evaluation on t year; Wi means ratio of i index; Y it means evaluation coefficient of i index on t year.

3.3 Model suitable for index calculation

Establishing input and output table of energy (including organic and inorganic) and materials (including N, P, K) according to Lianchiff' input and output table.

Balance mechanism and mutual relationship of systems were revealed through input and output of energy (organic and inorganic) and materials (including N, P, K) among industries. Input and output benefits of model energy were calculated to devise a new model of multi-ecological balance and goodness circulation.

Establishing optimal regional model of ecological agriculture through multi-object function

The internal structure of ecological agriculture and absolute index of ecological function served as restrictive condition, of ecological, the economic and social function can be regarded as the relative index

Policies toward a Sustainable Agriculture: The case of Chile

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1. INTRODUCTION

Chile has such a wide geographically and climatically diversity. Therefore, its agricultural and forestry industries offer an unusually wide range of products. This is both an advantage and a challenge. Chile's location in the Southern Hemisphere, its high phytosanitary and zoo-sanitary conditions and the quality of the human resources sector put Chilean Agriculture in a privileged position to meet new international challenges.

Chile has been opening it commercial process through the integration to the principal commercial blocks of the world and through the signature of a great number of free trade agreements. Therefore, the challenges that the agricultural sector face are related to the development of a competitive agriculture capable of adapting to this opening process and capable of been inserted in the international economy.

The levels of economic efficiency, through production costs reduction and/or increases in the national agriculture productivity, are reaching in many items to its limit. The international prices of agricultural products, often distorted by high levels of subsidies, constitute a roof to the possibilities of competition. This creates the need to generate new alternatives that make this agricultural development possible.

In the future, it is expected that food demand will be strongly connect to consumers preference for quality and innocuousness food as well as for environmental conditions in which these products are produced. Therefore, the general trend favors to those countries such as Chile, countries that have a good base of natural resources and its agricultural development is based on the protection of the ecological environment and reasonably use of its resources.

In order to implement the above-mentioned strategic option, an agricultural policy is needed, meaning a set of decisions and actions from the public authorities is needed. Because in a democratic state multiple actors, from the private and the public sector, participated in the agricultural process, it is very important that public policies be base on a process of negotiation. Therefore, in order to face successfully this challenge, an essential condition had been to narrow the collaboration between the public and the private sector. This alliance has a strategic value to define the long terms goals and to implement the diverse initiatives associated to these goals.

2. Chilean Agriculture State Politics (2000-2010 Period)

The agricultural policy of Chile, supported by the Ministry of Agriculture, has been defined in the base on a constant dialogue with the main actors of the agricultural world through a unique way of action called "The Agricultural Round Table". In September

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2000 it was signed the "Act of Agreements of the Agricultural Round Table", whit a number of formal statement in order to face the problems that affect the Chilean agricultural sector. In the year 2001, a document called "A Chilean Agriculture State Policy (2000-2010 Period)" was signed by all the members of the Agricultural Round Table, defining a medium and long term strategy to promote the sustainable development of the sector.

The Chilean Agriculture State Policy is based on three fundamental goals:

- To generate conditions for the development of a profitable and competitive agriculture with capacity to adapt to the process of opening and insertion in the international economy that Chile has adopted as strategy of development.
- To contribute that benefits from the agricultural sector reach the small and medium farmers, rural workers and rural inhabitants to improve their income and the quality of life and the economy of all the agricultural regions of the country.
- To contribute to the full development of the agricultural sector, base on a frame of sustainable agricultural development (environmental, economic and social).

2.1 Challenges for Agricultural Policy

The principal challenge for the implementation of this agricultural policy in the next years is to achieve a sustainable and balanced development of all farms and all agricultural regions of the country. This development must be orientated towards to a quality agriculture that goes beyond the production of commodities and respects the environment. In this context of increasing demand for high-quality products, international integration and technological change, the main challenges for Chilean Agricultural Policy are the following:

- To generate a stable business horizon for producers, including access to financing.
- To develop and perfect markets opening new exports markets and improving the flow of information within the domestic market.
- To enhance the productivity of Chile's natural resources by fostering the sustainable use of land and water, as well as the conservation of the country's phytosanitary and zoo-sanitary advantages.
- To increase competitiveness within the industry as trade barriers are reduced, with particular emphasis on the import-substitution sector.
- To develop clean, high-quality products not only within the export sector, but also for the domestic market.

These five challenges for the agricultural sector required an integrated approach that considers the entire production chain. Quality controls and certification, if implemented at all stages of the chain, will facilitate the task of opening new markets.

2.2 Challenges and Conditions for Agricultural Policy

It is also important to work in the following conditions:

- It requires policies and regulations that generate a frame of stability for the development of the sector, so farmers can innovate, invest and continue improving its productive processes.
- It is necessary to rely on proactive instruments of support, well designed and specially focus to help the less supported areas (north and south regions of Chile)

and to help the small and medium owners.

- It is necessary to implement policies and instruments that allow the gradual opening of the agricultural economy in a process of modernization and productive transformation of the whole sector. This includes the export sector as well as the familiar rural agriculture sectors that is spread over the whole country.

This projection of the Chilean agriculture supposes a change on the productive sector, base on the new paradigm of quality. For this, it is necessary that strategic goals must be established for all the productive areas as well as policies and budgetary resources must be clearly articulated in order to allowed a coherent execution of above mentioned policies and initiatives. In addition, from the farmers, is essential their commitment in order to improve its financial management; to adopt new productive and environmental techniques; to increase their association levels; and to participate in the management of the agricultural politics. The coordinated action of the leaders of farmers unions with its public counterparts, is also an indispensable condition for the success of this agricultural policy.

The Chilean agriculture has competitive advantages such as: its sector size, climate, sanitary patrimony, counter-station production, lands diversity, accesses to markets, infrastructure and qualification of the workforce. These attributes reveal a great potential of development, which justifies and compromises the public and private efforts in the implementation of a suitable Politics of State, which be useful and be functional to the interests of the country.

3. Areas of Work

Base on the goals outline on the document "A Chilean Agriculture State Politics (2000-2010 Period)", seven specific areas of work were defined:

I. **Confidence and safety for the agricultural producers.** This is a fundamental aspect in order to generate the stability that agriculture needs for its modernization. Among the planned measures, in order to reach this stability, are:
   - Implementation of a agricultural insurance system to face adverse climate conditions
   - Maintenance of the price band system
   - Development of new instruments to reduce the risks of the agricultural activity (such as use of future markets, warrants, exchange insurance); and
   - A stock exchange of agricultural products; among others.

II. **Market Development.** Area aimed to achieve the preferential opening of new markets, secure the access of our exports, elimination of the trade restrictions, protect our international investments, and the development of export with bigger built-in technology. In the same way, this opens new productive possibilities to the farmers through exporting promotion instruments, in the same way that guarantees the normal functioning of the internal markets to facilitate the transactions of the private actors.

   Among the measures for external markets are:
   - Creation of a permanent consulting group with the private sector in order to incorporate its point of view on the international trade negotiation.
   - New markets opening through sanitary agreements.
   - New free trade agreements, among others.

For the internal markets some of the measures are:

- Upgrading several Chilean Official Standards.
- Upgrading the Food Sanitary Regulation.
- Set up of reference laboratories.
- Implementation of an Internet National Program for the agricultural sector, concentrate on farmers and rural organizations.

III. **Improvement of natural resources productivity.** This area of work contemplates several areas of action applied to the physical resources or assets of the farmers: These areas had received a special attention by the Ministry of Agriculture in the last years.

- **Degraded Soils Recovery Program.** This program will cover 2.500.000 ha and 150.000 farmers in a 10 years period.
- **Encouragement of Forest Plantations.** Contemplate a state subsidy for forestation (law 701,1975) which encouraged the increase of forest plantations. The system has to be upgrading in order to facilitate the access of small and medium size farms.
- **Improvement of the Phytosanitary and Zoo-sanitary Patrimony.** Keep and maintain the actual program of defense, vigilance, control and eradication of pest and diseases applied by the agrarian and livestock service (SAG). Also, contemplate the creation of a Found for Sanitary Emergencies in order to react rapidly against this type of situations.
- **Economic Appraisement and Protection of the Genetic Resources.** Intend the development of a sector policy to protect the Chilean genetic resources and allow farmers to obtain an economic compensation if they maintain and develop these types of resources. Also, try to reinforce scientific and technological investigation programs and to promote productive programs in order to value in a monetary way these resources.

IV. **Development of the competitiveness.** In order to develop these component, several issues has to be taken into consideration.

- **Human resources development.** The upgrading of the technological and innovation capacities of the farmers is one of the most important pillars on the development of the competitiveness. For this reason it will be promote a National Training System with the Ministry of Education and the Ministry of Labor. Also, it will assure the access to the use of internet and the development of a system of accreditation of work performance.
- **Innovation and investigation.** The idea is to support the development of investigation in animal and crops health issues and in hygiene and food safety.
- **Technology transfer and management modernization.** The Institute of Agricultural Development (INDAP) role as factor of support to small farmers should be reinforced. Their work and their assistance should focus to small farmers but with a clear strategy of productive development against a vision of assistance.

- **Irrigation development.** The irrigation is a main factor on the generation of products coming from the agricultural sector. The Irrigation Promotion Law need to be improved in order to enhanced the access of the farmers to its benefits. In addition, the program for the development and implementation of medium and large irrigation systems, will be keep it.
- **Financing.** It has been proposed the creation of new financial instruments to small and medium agricultural enterprises and the creation of agricultural banks by the private sector.
- **Promotion of farmers cluster.** Finally, this line of work contemplates the promotion of farmers cluster in order to achieve an effective work with the public sector.

V. **Safe and Quality Agriculture.** The Chilean Agriculture State Politics has defined, as one of its strategic orientations, to advance towards a safe and quality agriculture. This strategic orientation is one of the essential issues of the institutional redesign that the Ministry of Agriculture had initiated. This line attempt to define an institutional framework in charge of the food safe and quality. The strategy of food quality development passes for valuing the diversity of agricultural systems that the country has. This includes, valuing the ecosystem diversity, to satisfy the variety of consumer's demands and the increasing requirements of the national and international consumers.

VI. **Forest development.** Line of work that contemplated the creation of a New Forest institution, which allows fulfilling with efficiency the diverse public functions that are necessary for the development of this sector. Other aspects are the promulgation of a legislation that promotes the rational and sustainable utilization of native forest and implement the environmental certification system in order to reach a more sustainable forest management.

VII. **A new rural world.** Because of the multiple diversity of Chilean rural areas and the multisectorial character of its problems, the Ministry of Agriculture should have an active role in order to coordinate and support the initiatives destined to foment the rural development. The coordination with other organizations that also work in rural areas will be deepened in order to achieve a complete endowment of infrastructure of drinkable water, electrification, telephony, roads, housing and other public services. Among the organizations are: the National Service of Training and Employment (SENCE), Department of Planning and Cooperation, Department of Public Works, Ministry of Transport and Telecommunications, among others.

These seven strategic lines have been implemented through multiple measurements of politics applied by the Ministry of Agriculture with the support of other public and private organizations that operate in the rural sector.

4. To Advance Towards a Safe and Quality Agriculture.

For an agriculture with dimensions as the Chilean one, and in a context of economic opening, a goal of a safe and quality agriculture appear as an almost the only way. Chile has interesting advantages to advance in this perspective. It has wide geographical areas, in general, very little affected and, therefore, with natural clean resources; handles interesting phytosanitary and zoo-sanitary conditions; and its managerial actors have been taking increasing conscience on the relevancy of this option. It is in this context that it is very important to view the agriculture as an "Agri-Food" sector, one that it goes from the primary process realized in the field up to the food that the consumer get.

Today do not exist any doubt that the quality is been one of the attributes more definite of the competitiveness and that it constitutes an increasing exigency of the international markets. Qualities products not only can mean better prices, but also the possibility of entering or not to certain markets. From a point of view of the internal markets, the existence of a normative framework that assure safe and quality agricultural products constitutes a task of the State, which demands an agricultural politics that considers more the interests of the consumers.

At present, many initiatives exist in this perspective in Chile, but they not always had been good articulated and had had a common strategic management. The task consists, then, to illustrate and to share the need for a clean and quality agriculture. For this, actions must be carried out in the design and implementation of an institutional framework for food safety and food quality; regulations; and education and promotion.

4.1. Institutional framework for the development of food quality.

Product of the "mad cows disease" and other cases that have make consumers more sensitive about food safety, a debate without precedents it is experienced about which are the best institutional framework in order to assure healthy food and quality food to their population. The principal challenge to the Ministry's of Agriculture of the world, is how the agricultural policies better incorporates the consumers interests. The approach that the authorities of the Chilean Ministry of Agriculture had take in order to have a Ministry of the Agriculture, Nourishment and Rural Development assumes and gives response of a concrete way to this challenge.

To develop agricultural quality, we must strength the public–private work. For this reason, one of the actions related with agricultural quality was to create the National Council of Good Agricultural Practices (GAP), as an example of public–private instance of work.

4.2.**Regulations and Promotion for the quality**

The establishment of clear quality regulations, guarantee, to the farmers, a transparent market avoiding the unfair competition; and to the consumers, the true of the attributes that can not be verify at the moment of acquiring a certain product. Therefore, the following topics will have to be approached:

- **Implementation of Good Agricultural Practice National Program.** The GAP program promotes the accomplishment of productive activities that respect international procedure related to the environment and the fulfillment of the labor legislation. The GAP is support with certification and accreditation systems. Already, the GAP had been implemented at the fruit export sector. In the future, this program would be spread to other productive sectors such as vegetables and cattle production.
- **Modernization of the food inspection systems.** It is contemplated the incorporation of insurance quality system as HACCP, promoting its use in the

different stages of food production.

- **To improve the system of regulation of the genetically modified organisms (GMO).** From the development of a GMO's Chilean Policy, is expected to strengthen the regulations with regard to GMO's production and its use in food and in agricultural products. In addition, national criteria are expected to be establish, for the labeled of products that contain MGO.
- **Improvement of the National Pesticides Policy.** It is expected to coordinate better the different competitions of the public organizations with attributions in the matter. In order to improve the safe managing and use of pesticides, the Agricultural and Livestock Service (SAG), from the year 2002 begin the implementation of a National Program of Accreditation of Pesticides Applicators.
- **Strengthening the mechanisms of traceability.** It will give emphasis to those safety attributes where the resource or original process is determinant for its marketing. There will be created a Identification National System and Registry of Bovine Animals.

Establishment of a Quality Mention System. This system will allow the development of private initiatives such as Integrated Production or Appellation of Origen. Its contemplates the development of regulations for the certification and the accreditation of these attributes of quality.

IPM and its Practice in China

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I. What is IPM? – The origin and the definitions

Integrated pest management (IPM) has become a term widely used and understood today. In a compendium of IPM definitions (Bajwa and Kogan, 2002) more than 60 definitions of integrated control, pest management or integrated pest management, dated from 1959 to 2000, have been compiled. These definitions expressed different understandings of and the emphasizing on the concept.

The concept of 'Integrated Control' was first arose in USA in 1950s (Michelbacher and Bacon, 1952), originally limited to combination of chemical and biological control of pests. A complete definition of such concept is: 'Applied pest control that combines and integrates biological and chemical control. Chemical control is used as necessary and in a manner that is least disruptive to biological control. Integrated control may make use of naturally occurring biological control as well as biological control effected by manipulated or induced biotic agents.' (Stern et al. 1959) The concept was explicitly defined at a FAO sponsored symposium in Rome in 1966 and greatly expanded as: 'Integrated control is a pest management system that in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains the pest population at levels below those causing economic injury.' (FAO, 1967) The concept of 'Pest Management', however, was first proposed by two Australian ecologists (Geier and Clark, 1961). It gained greater recognition after three publications in Annual Review of Entomology (Geyer, 1966), National Academy of Science Publication (NAS, 1969), and the proceedings of a conference held in North Carolina (Rabb and Guthrie, 1970), respectively. Rabb and Guthrie defined the concept as: 'Pest management is the reduction of pest problems by actions selected after the life systems of the pests are understood and the ecological as well as economic consequences of these actions have been predicted, as accurately as possible, to be in the best interest of mankind. In development of a pest management program, priority is given to understanding the role of intrinsic and extrinsic factors in causing seasonal and annual change in pest population.' The synthesis of the two concepts 'integrated control' and 'pest management' into 'Integrated Pest Management' opened a new era in the protection of agricultural crops against the attack of arthropod pests, plant pathogens and weeds.

In the United States, USDA defined IPM as: 'Integrated Pest Management (IPM) is a sustainable approach to managing pests by combining biological, cultural, physical and chemical tools in a way that minimizes economic, health and environmental risks' (USDA ERS, 1996). Kotan (1998) has attempted to synthesize the seemingly current thought with emphasis in 'system': 'IPM is a decision support system for the selection and use of pest control tactics, singly or harmoniously coordinated into a management strategy, based on cost/benefit analyses that take into account the interests of and impacts on producers, society, and the environment'.

In China, the situation was more or less the same. 'Integrated control' was mentioned in some of the working reports in early 1950s (Li, 1990). The purpose of this was to combine cultural, chemical, biological and physical techniques to improve the control efficacy and compensate the weakness of the individual techniques. The China Ministry of Agriculture and Forestry (MOAF) then entrusted the Institute for Plant Protection, Chinese Academy of Agricultural Sciences, to hold the First Symposium on the Integrated Control of the Main Crop Pests in Guangdong in 1974. 'Give priority to precautions and implement integrated control' was then first raised as the guideline of plant protection. In 1975, MOAF confirmed in this as the guideline of plant protection in China and stated that 'Give priority to precautions' should be the instruction in implementing the guideline. The 3rd Annual Meeting of China Society of Plant Protection, held in Qingdao, Shandong Province, in 1981 agreed to take 'Integrated Pest Control' as the synonym of Integrated Pest Management in China in order to avoid confusion due to the constant change of the concept. The IPM was defined as: 'Integrated pest management is a scientific management system to pests. It stands on the whole of agro-ecosystem to bring into play fully the action of natural control factors based on the inter-relations between pests and the environment, coordinate and employ necessary measures according to local conditions and suppress the pests below the economic threshold and obtain the best effects of economy, ecology and society' in 1986 after several revisions (Li, 1990).

The raise of the IPM reflected the problems existed in plant protection in early days. Before the 1940s, people used various means including cultural, physical, biological, and chemical techniques to control crop pests. The effects of these measures, however, were so limited that the world suffered great losses whenever there was an outbreak of the pests. Since the synthesis of organic chloral pesticides such as DDT, BHC, etc., chemical control became the most important technique due to its high efficacy and the simplicity of application. The pesticide industries had been developed rapidly thereafter. However, the dependence upon the chemical control, due to the abundance of inexpensive, effective, synthetic pesticides and limited knowledge of the long-term effects of pesticides on organisms and the environment, caused serious negative impacts on farm profits, human health and environment. Three primary factors involved are pesticide resistance, effect of pesticides on non-target organisms and increased regulation.

1. Resistance

Most pathogens, insect pests and weeds have short life cycles, a wide geographic range, and large populations. Consequently, there is substantial genetic diversity found in pest populations. When these populations are all sprayed with the same toxic chemical, a few individuals are not killed because they are genetically resistant. These individuals survive to reproduce, quickly resulting in localized resistant populations which then spread. Consequently, higher and higher doses are needed to kill pests and finally new chemicals must be developed. Then the cycle begins again, resulting in increased costs, increased amount of chemical use and ever decreasing effectiveness of products. Resistance has been reported in about 500 species of insects and mites, 100 species of plant pathogens, 50 species of weeds, 5 species of rodents and 2 species of nematodes (Georghiou, 1986).

2. Effect on Non-target organisms

Secondary pest outbreaks:

Broad-spectrum chemicals kill many types of organisms indiscriminately. This effect can be useful for controlling several pests at once. Often however, insects that were not a problem in the cropping system then suddenly become pests. This is because most insect species are kept under control naturally by other parasitic or predaceous insects, mites or spiders. The use of these pesticides kills the "beneficials", resulting in "secondary" pest outbreaks and the need for yet more chemical use.

Other effects:

Use of pesticides affects other parts of the ecosystem as well. For example, commercial beekeepers lose between \$20 - \$50 million dollars annually due to pesticide impacts on their bee populations in the United States (11). Pesticide use has led to groundwater contamination, death of fish and bird, accumulation of certain compounds in the food chain, poisoning of individuals working with the chemicals improperly and even from ingesting food contaminated with chemicals improperly used or applied.

3. Regulation

As a result of the problems associated with pesticides, regulations and registration actions have been taken and education on environmental protection have been increased. China Ministry of Agriculture (MOA) has modified the regulation on use of pesticides with high toxicity. It phased out DDT, HCH, dibromochloropane, chlordimeform, nitrofen, EDB, fluoroacetamide, gliftor, arsena, tetramine, mercury compounds, plumbum ompounds In 1980s. It reinforced the administration and cut the registration to five high toxicity organophosphorus pesticides methamidophos, parathion, parathion-methyl, monocrotophos and phospamidon in 2000 and will phase out them by 2007. Aldicarb, carbofuran, demeton, phorate, omethoate, isocarbophos, terbufos, phosfolan-methyl, sulfotep, isofenphos-methyl, methomyl and their combinations will not be allowed to be registered in fruits and vegetables. The registrations of some pesticides with high toxicity used in fruit trees and vegetables were withdrawn. The Proclamation

199, MOA May 2002, announced that use of 18 varieties of pesticide are forbidden completely and 19 others are not allowed to be used in vegetables, fruit trees, tea and medicinal plants (Cao, 2002). New restrictions on pesticides with high toxicity will be released further.

The recognition of these problems was the driving force towards the direction of IPM. The strategies or tactics have been proposed suitable for different crops systems. As a whole, however, there are some main common approaches or principles that will be discussed below.

II. The Principium and approach of IPM

Important Components

There are three aspects that are essential to establishment of an IPM system.

Information is a fundamental component of IPM for two reasons. Firstly, an understanding of the agricultural ecosystem is essential to preventing pest problems. Secondly, IPM relies upon close monitoring of pest populations in order to determine when a population has reached an economically damaging threshold.

Economic thresholds are developed from research that takes three main factors into account: the physical damage caused by the presence of the pest at a known level of infestation, the revenue losses resulting from that damage, and the costs of treatment.

Scouting is the primary method of monitoring pest populations to determine if an economic threshold is reached. It refers to the periodic and systematic sampling of pests in the field in order to estimate population levels. Computer models based on weather conditions and other factors are used also to predict the onset and severity of a pest outbreak. Monitoring is employed in tracking populations of beneficials as well as pests.

Approach of IPM

As defined above, IPM is a system so that it is composed of differently combined and integrated tactics with emphasis on different aspects based on specific pest in ecosystem. The tactics may include:

- legal control – quarantine regulations implemented by state and provincial guidelines designed to prevent the spread of pests
- biological control - using beneficial organisms (predators, parasites, microorganisms) to suppress pest organisms
- cultural control - using rotations, cultivation, sanitation and other farm practices that reduce persistent pest problems
- physical control - using barriers, traps, trap crops, adjusting planting location or timing to evade or diminish pest pressure
- ecological regulation – changing the ecological conditions of the crop or the pest such as restricting the growing area of a favorable crop to a pest
- genetic control - choosing resistant plant materials to avoid pest problems
- chemical control - using conventional pesticides, biopesticides, pheromones and other chemicals to prevent or suppress a pest outbreak

Precautions to Chemical Control

The use of conventional pesticides in an IPM program may differ from that of a "traditional" chemical program. Under IPM, an attempt should be made to choose materials that are:

- only one of many actions taken over the cropping cycle to manage the pest

species
- specific to the pest species (as nearly as possible)
- used at the lowest effective rate
- short-lived in the environment
- be least toxic to beneficials and humans
- alternated with other chemicals to help prevent resistance

As the term "chemical control" has been expanded to include substances such as insect feeding attractants, pheromones, and toxins derived from biological sources, new application technologies are arising that help target the specific pests.

IPM in Practice

By carefully monitoring pest populations and the crop in the field, the farmer determines how serious a problem is and what management options are available before action is taken. This contrasts with routine preventative chemical treatments 'just in case' or treatments in response to any pest presence regardless of how small the infestation will be.

Using IPM requires the grower to understand how the crop grows, how different pest populations develop, what the control options are in each specific pest management case, and what the return on investment of these control options is along with the potential impact on the environment and health. To attain the benefits of an IPM program, more information must be gathered, integrated into a body of knowledge and implemented.

This means that farmers or the local technicians will have to spend more time observing and interpreting the potential impact of pest populations. The extra work can be offset by the resulting benefits from reduced costs of chemicals inputs, cleaner environment, and decreased resistance problems.

III. IPM Practice in China

As mentioned previously, understanding of the agricultural ecosystem and the development of a pest population in it are essential to preventing pest problem. IPM relies upon close monitoring of pest populations in order to determine when a population has reached an economically damaging threshold and what action can be taken. I'll review a few examples taken from the history of IPM in China to show how a system can change in accordance with the specific pest and the ecosystem.

1. RICE BLAST

Rice is the first important grain crop in China. The growing area of rice was 31.77 million hectares while the total yield was 200.47 million tonnes in 1997. There are more than 300 different diseases and insect pests recorded in rice. More than 10 of them caused serious losses in history. Rice blast is among the most damaging diseases.

Rice blast caused by *Magnaporthe grisea* is the most important rice disease in the rice growing areas in the south part of China and it may be the same case in many parts of Asia. The traditional control of this disease includes two main techniques: use of resistance cultivars and chemical spry (Dong et al. 1963; Duan et al. 1989 and Peng et al. 1994). The use of cultural technique was emphasized in China in early 1980s and proved a feasible method. However, the outbreak of the disease still occurred every a few years as a result of the loss of cultivar resistance and the increased pathogen resistance to fungicides due to the sole use of cultivar resistance sources and chemicals. The loss of the rice yield caused by blast reached, for example, 1-1.25 million tones in southwest and central China in 1985, when the diseased area was 2-3 million hectares counted for about 10% of the total rice growing area.

In recent years, a group of Chinese plant pathologists headed by Dr. Zhu, with the assistance from IRRI, attempted to manage the damage of rice blast by practicing mixtures between rice cultivars and varieties, *indica*, *japonica* and glutinous rice, with different resistance and combining a fungicide spray in large scale (Zhu et al. 1998, Wang et al. 1998; Zhu et al. 2000). The result was very promising. They got 93.7-99.2% efficacy of spike blast for glutinous rice, which is a traditionally high valued rice variety, and 3.9-25.3% for *indica* rice in the mixture of these two varieties while it was 2.1-23.1 for japonica rice in the mixture of glutinous and *japonica* rice. The only chemical application was spraying tricyclazole once for spike blast (Zhu et al. 1998). The explanation for this phenomenon is complex. The presence of several varieties in a mixture provides a physical barrier to the spread of fungal spores among the plants of one variety. Along with this, there is an immunization process among mixed plants. If a form of pathogen that is unable to infect a plant attempts to do so, the plant's disease-resistance mechanisms are activated in the part of the plant affected. Any genetically different spores that would normally be able to infect the plant fail to do so if they try to invade at the same place (Wolfe, 2000). Zhu et al. (2000) pointed out that the net result is a damping of the development of epidemics within the field. Here, increase of crop diversity and change of ecosystem for the pathogen population became excellent key techniques in control of rice blast.

2. ARMY WORM

Wheat is the 2nd important crop in China. The growing area was 30.06 million hectares and the total yield was 123.29 million tonnes in 1997, which was about 26.6% and 24.95%, respectively, of those of the grain crops (China Agricultural Yearbook, 1998).

There are more than 50 sorts of diseases and more than 100 sorts of insect pests in wheat. Among them, more than 10 diseases and insect pests are the most commonly occurred. Wheat rusts, powdery mildew, scab, sharp eyespot, locust, armyworm and wheat midge are among the most important insect pests (Ye & Lin, 1993). Great losses have been recorded due to the outbreaks of the diseases and insect pests in history.

Army worm (*Mythimna separata*) distributed widely in China from 27-39° north latitude. They produce 6-8 generations in different regions in a year. The key regions responsible the outbreak of army worm is the population size of the first generation in the regions south to 27° north latitude, where army worm can survive the winter normally and from where army worm become the primary source of the insect injury. Then, this raise another question: from where do the army worm come from in the North? Migration is the only reasonable explanation. A large scaled investigation of migration was implemented by marking the insects with red paint in China from 1950s-1970s. It has been ascertained that there are 4 migration activities for armyworms in China in a year. Armyworms migrate from low latitude regions to high latitude regions or from low sea level regions to high sea level regions in the spring and the summer, respectively, and migrate back from regions in the autumn. They reproduce and cause injuries on their way of migration (see Fig. 1) (Ni et Li, 1990).

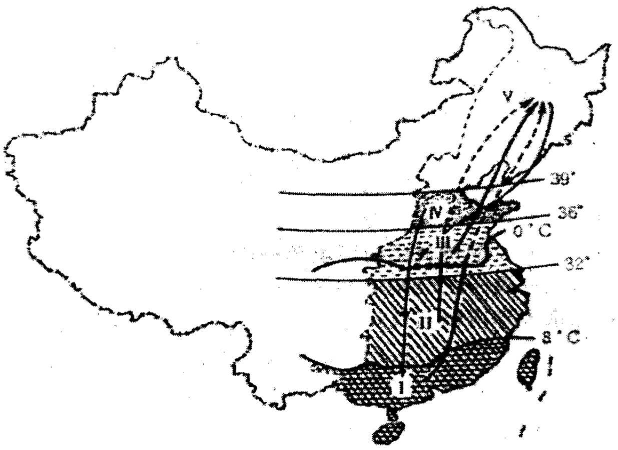

Fig. 1 The migration route of armyworm in the east of China (after *Crop pests in China*, 1979).

The strategy for the IPM of armyworm was proposed. That is to control the first generation of armyworm at regions south to isotherm 8℃ in January by chemical control, biological control or ideally by changing cultivation system. According to the later idea, the wheat area in the regions have been greatly decreased, especially due to the farmers' choice—they prefer to grow more cash crops rather than wheat. Armyworms have never been an outbreak since 1978. They occur only in some regions but cannot cause big loss generally.

3. YELLOW RUST IN WHEAT

Yellow rust, *Puccinia striiformis* Westend. f.sp. *tritici* Eriks is among the most important and damaging wheat diseases. Wheat production suffered great loss in three severe outbreaks in the history of the People's Republic of China. The first one was in 1950 when the wheat loss was six million tonnes, which was about one third of the total wheat production that year. The second epidemic occurred in 1964 when 3.2 million tonnes of wheat was lost and the loss was 2.65 million tonnes in the heavy epidemic in 1990. The change of physiological races of the rust pathogen was the main reason for each of the outbreak (Zhang 1993).

Conditions for the epidemic of yellow rust and the monitoring the change of physiological races are the first steps towards the understanding of the occurrence of the disease and the 'loss' of the resistance in wheat host and form the bases for making the IPM strategies. The epidemic conditions for yellow rust and the base of the pathogen source were clarified after many years' tracing of the dispersal route of the pathogen and recording the environmental factors affecting the occurrence of the disease (Li & Liu 1956, 1957, Chen & Zhou 1957, Wang et al. 1988, Li & Shang, 1989, Li et al. 1989, Xie 1990).

In China, yellow rust pathogen can survive the hot summer in regions where the averaged temperature per ten days is below 20℃ in last ten days in July to the first ten days in August while it can not survive the summer in regions where the temperature is higher than 23℃. The temperature conditions can fulfill the requirement of over-wintering of yellow rust in many wheat-growing regions in China. Rust pathogen is carried away from the bases for over-summering by air current to other wheat growing regions and become the source of pathogen in seedlings in the autumn (Chen & Zhou 1957). Over-summering therefore becomes a critical condition for the disease cycle of the yellow rust in many regions in China.

The 'hot spot' of yellow rust epidemic was proved by an observation made in 90s', when there was an outbreak of yellow rust. South Gansu Province was then the only location where the disease occurred in the autumn and became the source of the pathogen. South of Gansu Province was therefore proven to be the most important base for yellow rust to survive in the summer. The climate there is cool and the wheat is grown vertically on the hills of the area and all year round. It becomes an area where the pathogen variation, maintain, propagation and dispersal are very much favoured. It was observed that new races were developed first in the south Gansu Province and it was 3 years earlier than those in other parts of China. The routes of dispersal of yellow rust among different regions were outlined (Fig. 2) (Wang et al. 1990). A new strategy was made after obtaining the above results (Wu et al. 1999).

Because yellow rust is a strict biotroph and highly specific to resistance genes, the main measures used in control of yellow rust is to grow resistant cultivars combined with the spray of triazole fungicides currently. The 'loss' of resistance due to the change of races happens very frequently and has become the main reason of the outbreak of the disease. New strategy, however, can be complemented after we understood the evolution route of the pathogen.

The strategy is to interrupt the epidemic route of yellow rust in south Gansu Province. Wheat growing area has been reduced and replaced by other crops such as vegetables

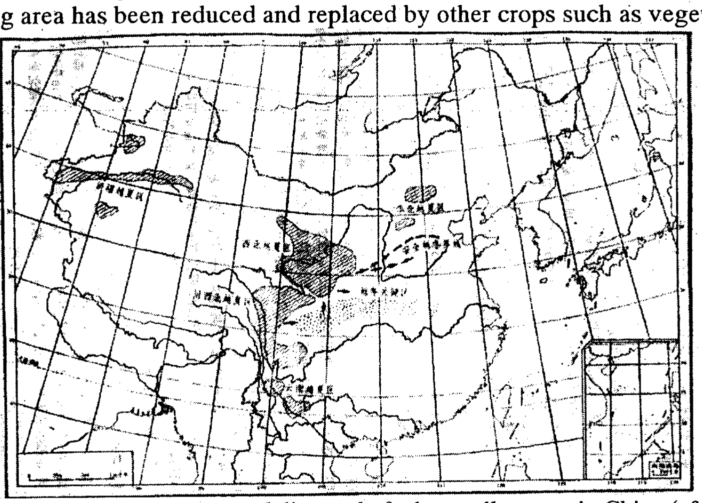

Fig. 2 The over summering zones and dispersal of wheat yellow rust in China (after Wang et al. 1990)

and maize. Fruit trees, forest and grasses are also the suggested optional plantations in the area. Diversification of crop species is expected to change the situation of the pathogen source base for yellow rust. We hope this ongoing huge project can alleviate the serious situation every time when the physiological races overcome the cultivar resistance.

4. POWDERY MILDEW IN WHEAT

Wheat powdery mildew, *Erysiphe graminis* DC f.sp. *tritici* Marchal, is another important fungal disease in wheat. The first recorded historical outbreaks occurred in both 1990 and 1991 when the diseased area reached over 12 million hectares in both years, which was over 40% of the wheat growing area and surpassed yellow rust those years. The estimated loss was 3.2 million tonnes in 1990 (Liu et al. 1998). It is also a specific biotroph as yellow rust but it can survive both the winter and the summer in many wheat-growing regions. The strategy is therefore different from yellow rust. The change of the pathogen virulence is somehow more rapidly and the structure of populations is more complex than yellow rust because it has sexual stage once a year. Increasing the diversity of cultivar resistance becomes the most important tactic when combined with spraying of fungicide. Wheat cultivars with different specific resistance genes are suggested to be release more or less the same time to the fields and wheat cultivars with adult resistance or slow-mildewing are under screening and breeding. Fungicides with different actions are recommended.

5. COTTON BOLLWORM

China is the largest cotton production country in the world. The growing area and the total year yield was 4.49 million hectares and 4.60 million tonnes, respectively, in 1997. After 1990, cotton boll worm formed another peak of outbreak following 1970s. There were four outbreaks from 1990 -1994. The area infested by cotton bollworm was some four million hectares in 1992 when there was an extremely severe outbreak. The incidence of cotton bollworm was over 20 times of the normal years. The occurrence of cotton bollworm was 7-10 days earlier than it in normal years with generation overlapping. The loss of cotton was over 50% in provinces Shandong, Hebei and Henan, where the incidence of cotton bollworm was heavy. The control or management of the insect was once more became a very urgent issue (Guo, 1998).

During the countrywide outbreak of cotton bollworm in 1992, an IPM strategy was implemented at a demonstration site in Xinxiang County, Henan Province, by the Institute for Plant Protection, Chinese Academy of Agricultural Sciences, with the support from the local government and extension stations. The ginned cotton yield maintained at 70 kg, which was 15% less than the normal years while it was 30-40 kg with the loss of 50-80% outside the demonstration site.

The key points for IPM of cotton bollworm in Yellow-Huaihe River Valley include (Guo, 1998):

1. Scout the first generation of the insect population in wheat fields as the predicting information for the 2nd generation while do not take any measures in the normal situation.
2. The 2nd generation of cotton bollworm injures the tip of cotton stem, cotton buds and young leaves. When the air temperature is low, the growth of cotton stem is slow and the growth point will be injured so that when temperature is low, the chemical spray can be applied for the 2nd generation cotton bollworm

concentrating on the tip of cotton plants. Otherwise, it is not necessary to control the 2nd generation.

3. When the cotton bollworm develops into the 3rd generation, a lot of adults fly to other fields like maize, peanuts, legume, sesame and vegetables and lay eggs. The incidence of cotton bollworm is obviously fewer. The most important thing at this stage is to strictly scout the insect and apply chemicals strictly follow the index of control.
4. The 4th generation of cotton bollworm injures cotton boll. Bolls will suffer from moulding in raining season but there are more natural enemies at this stage. If the weather is dry with little rainfalls, the chemical control becomes very necessary, i.e., the control of the 4th generation is to protect cotton bolls.

In general, the injury of cotton bollworm in Yellow-Huaihe River Valley is: the 2nd generation>the 3rd generation>the 4th generation. The control tactic is therefore mainly: scout in 1st generation; protect the tip in the 2nd generation; protection buds in the 3rd generation and protect bolls in the 4th generation.

While Bt cotton becomes more and more popular nowadays, the incidence of cotton bollworm and other cotton insect pests are surely changing. New strategies therefore are absolutely necessary according the changed situation.

IV. Conclusions

1. Investigation of the growth of crops and the biological and ecological characteristics of pests and the dynamics of the populations are the base of designing forecast method, scouting and establishing the IPM system.
2. Forecast is the key point for the control of pests and suppress the loss under the economic threshold.
3. Loss assessment is necessary for the target crop so that a reasonable control threshold can be decided and this can prevent the abuse of chemicals.

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Farming System in China

-Outline for the training

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1. Resources

China is a big country with diversified resources and most population in the World.

Land Characteristics

Total land area: 9,600,000 km^2
Mountains: 3,200,000
Plateaus: 2,500,000
Basins: 1,800,000
Plains: 1,150,000
Hills: 950,000

Land Use

Cultivated Land: 130,040,000*
Forest 158,940,000
Water area in Land: 17,470,000
Area of Grassland: 400,000,000
Useable Area: 313,330,000
Others: 253,550,000
* Survey data in hectares, The MOA data in 2000 is 95,466,510

Water

China's total water average: 2800000 million cube meters, ranged 4th position in the World, about 7% of the World water supply; Water per capita is 2300 cube meters, about ¼ of World average, ranged 110 in the World, and is one of 13 countries with water deficient (3000－1000)Uneven Distribution of Water South has more than North, Water per capita in South is more than 3000 cube meters, but the North is only 1000 cube meters.

The water shortage areas are Gansu, Ningxia. Shanxi, Beijing, Tianjin and Hebei. Here are the agricultural bases with highest productivity. It has 34.7% of population and 38.5% of cultivated lands, but only has 7.5% of water.

Viewed from the whole country, the 15 provinces north of Yellow River produced 57.2% of grain (1998) with less than 20% of water (34.4% rain fall). The other 16 provinces, with 80% of water, produced 42.8% of grain.

Population: 1,265,830,000 (2001)

2. Cropping System

China made a great achievement in her agriculture development. For the Grain Production, China can basically produce enough food for her need.

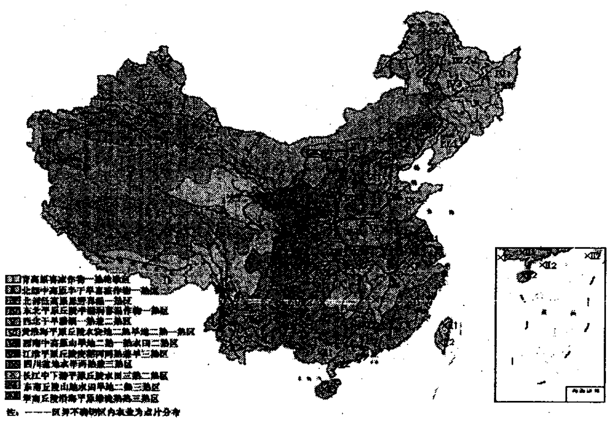
•1949: 1035kg/hm^2 , 210kg /person
•1984: 3284kg/hm^2 , 380kg /person
•1998-2000: about 500 million tons ± 4million tons, 4758kg/hm^2, 414kg /person

Crop Composition and Allocations

•Crop Composition: crops, variety, areas, etc.
• Allocation ： Allocation in regions or fields.
•Cropping fashion ：Sequential cropping, intercropping, relay cropping, mixed cropping, crop rotation, continuous cropping

•Ripe : times of harvest of one field in a year
•Multiple cropping : two or more crops are planted in the same field in a year.
•Sequential cropping: two or more crops are planted in the same field in a year in succession.
•Relay cropping: planting the second crop before the harvest of first crop in the rows or between individual plant.
•Inter cropping: planting two or more crops in their own row(s) at the same field and in the same season.
•Mixed cropping: mixed planting two or more crops at the same field and in the same season.

Feature of regional cropping system
China has three ripe zones and 12 regions.
The 3 ripe zones are: Single cropping, double cropping, and treble cropping.
•Single cropping: areas of cumulative temperature less than 4000-4200 ℃ (> 0℃)
•Double cropping: areas of cumulative temperature 4000-4200~5900-6100 ℃ (> 0℃)
•Treble cropping: areas of cumulative temperature more than 5900-6100 ℃ (> 0℃)



•Single-cropping regions: Northeast, Northwest, North China and hilly dry lands in Southwest
•Double cropping regions: North China, Southwest, Yangtze-Huai area, middle-low reach of Yangtze River, hilly areas in Southeast China.
•Triple cropping regions: basin of Southwest, middle-low reach of Yangtze River, paddy fields in Southeastern and South China.

Main Types of Multiple Cropping
Some Symbols:"-" - sequential cropping,"/"- relay cropping, "//" - inter cropping
1. Inter or rely cropping of wheat and corn: such as wheat//corn, wheat/corn: Xinjiang, corridor in Gansu, Yinchuan plain, Hetao in Inner Mongolia, and Northeast Plain.
2. Double cropping of winter wheat-corn: Huanghuaihai Plain, also three types:

wheat/corn, wheat-corn, and wheat/spring corn/summer corn.

3. Relay cropping of winter wheat/cotton: in cotton areas of Yangtze River, Yellow river and short of Xinjiang.

4. Multiple cropping of rice: Hunan, Hubei, Jiangxi, Zhejiang, Southern Anhui, Guangdong, Guangxi, and Fujian. The types include:

wheat (rapeseed)-early rice-later rice,
early rice-later rice,
wheat (rapeseed)-middle rice.

5. Multiple cropping in winter of southern China (南方冬闲田):

vegetable- early rice-later rice,
feed- early rice-later rice,
rapeseed-early rice-later rice,
grain- early rice-later rice.

6. Multiple cropping of grain and forage in southern China(南方水田水旱粮饲多熟):

wheat(barley, rapeseed, potato)/corn-rice;
vegetable-corn-rice,
corn(sorghum)-later rice or early rice-corn(sorghum, peanut, soybean);
wheat-middle rice-sweat potato(as feed).

7. Middle rice and regeneration rice(中稻加再生稻): in south China, there are 6 million hectares of single middle rice cropping, in areas with altitude less than 350m, regeneration rice is possible: middle rice- regeneration rice, barley(rapeseed)-cross rice - regeneration rice , vegetable- middle rice- regeneration rice.

8. Double cropping in lower dry lands of South China (南方低中山旱作两熟): cool-like crops (wheat, barley, rapeseed, potato, horse bean) //or / warm-like crops (corn, sweet potato, soybean, peanut) ; warm-like crops (corn, sweet potato, tobacco) "/" or "-" warm-like crops (corn, sweet potato, peanut).

9. Multiple cropping of wheat, crop and sweet potato in hilly areas of South China (南方丘陵旱地麦玉薯间套多熟): wheat/corn/sweet potato, potato (barley, rapeseed, horse bean)/corn (peanut, vegetables, soybean) , rapeseed/sweet potato(soybean, peanut).

10. Inter or relay cropping of perennial crops and annual crops

Grain crop distribution

- ◆ To the south of Qinling mountain and Huai River, and to the east of Qinghai-Tibet Plateau, the wide southern warm-humid areas: mainly rice with some wheat, sweet potato, corn, beans, and so on;
- ◆ The semi-drought, semi-humid and warm North China: mainly winter wheat and corn, also has some sweet potato, soybean, millet, sorghum, etc.
- ◆ Northeast and semi-humid region: mainly corn, soybean, millet, spring wheat, and sorghum, also has some rice.
- ◆ Northwest with semi-drought conditions: mainly spring wheat, millet, corn, and some other mall crops.
- ◆ Qinghai-Tibet Plateau with cooling conditions: mainly highland barley(□稞 and spring wheat

Wheat 小

Most between latitude 27-57°

Winter wheat is about 82% of the total wheat, mostly in areas of HuangHuaiHai Plain and along Yangtze River; Spring wheat about 18%, mostly in Northeast, Northwest, QingHai-Tibet Plateau, North Xinjiang, Hexi Corridor, and HeTao areas. Tibet has both winter and spring wheat.

China's wheat can be divided into 6 regions:HuangHuaiHai(), Yangtze River (winter),
Northeast(spring), Northwest(winter),
Southwest, QingHai-Tibet Plateau

Rice 水 稻

Rice is planted widely in China
Rice can be divided:

- •Semi-humid Northeast: single cropping (japonica rice)
- •Drought Northwest: single cropping (early or semi-late japonica rice)
- •Semi-humid North China: single or double of semi-late rice
- •Humid Southwest: double or treble cropping
- •Humid Central China: double cropping
- •Humid South China: treble or double cropping

Corn 玉米

Mostly along the area from Northeast – North China – Southwest (corn belt)
Corn can be divided:

- •Northern spring sown corn
- •HuangHuaiHai summer sown corn
- •Southwest and Southern hill corn
- •South China winter sown corn

Soybean 大豆

Distribution is the same as corn

- •Northern China spring soybean
- •HuanHuaiHai summer soybean
- •Yangtze River summer soybean
- •Southern China autumn soybean

3. Soil Management

Basic Tillage—翻lowing)

Types:

Totally turn of soil
Half turn of soil
Layer turn

Basic Tillage—深oil Sub-loosing)

•Prevent wind erosion and water loss as as well as loosing soil.

•Not good at cover fertilizer, weeds.

Basic Tillage—翻pin Tillage•Loosen or break soil clod
•Till depth: 16－18cm, mostly 10－12 cm. May cause damage to soil structure

Surface Soil Tillage

1.耙harrowing):
A kind of shallow plough, to destroy stubble, clod, harden or weeds
Time: after harvest or plough, before sowing or seedlings

2. □地(dragging) ：mostly used for smooth, prevent water lose or break soil clod. Applied after harrowing or sowing.

3. 中耕(inter till) ：during crop growing, to loosen surface soil, adjust water, temperature, kill weeds.

4.□packing) ：make soil compaction, crush clod.

5.作bedding) ：

6. 起□ ridge forming) ： ridge planting (□作 is quite common in north China. Good at increasing temperature, prevent wind and water logging

Selection of Soil Tillage

•1. Weather
•2.Soil (land): physiognomy, soil type, plough character
Soil plough character: easy or not, tillage quality
Factors: texture, organic matter, soil structure, soil water
•3.Crops: different needs
•4.Economic aspect

Conservation Tillage is the necessary way to prevent Topsoil loss

•Conservation tillage (>30% residue cover)
No tillage, Mulch tillage, Strip tillage, Zone tillage
•Minimum or Reduce Tillage (15-30% residue cover)
•Conventional tillage (0-15% residue cover)

Chinese Conservation Tillage

•Equal height tillage(耕
•Mulch tillage （□覆
•Wind-erosion control
•Sub-loosen tillage(深
•Strip tillage （□耕
•Ridge （□株

4. Development Trends of Chinese Farming System

(1) The industry structure is getting optimized in the rural. First industry decreased by 20%, second industry increased 14%, and third industry increased 6%.

(2) Cropping and stock raising are the main parts of agriculture, and the structure is

getting adjusted.

(3) Cropping structure is getting better. Grain crop decreased, cash crop increased.
(4) Farming lands is getting protected.
(5) Cropping Index in 2000 increased by 18% than in 1985.
(6) Crop structure is getting optimized. Specialized production region has be basically formed.
   a) Among grain crops, rice and wheat areas are decreasing, beans, corn and potato areas are keeping increase.
   b) Among cash crops, the regional character is even clear. Cotton is getting more in Xinjiag with other region's decrease. Rapeseed is mainly centralized in the Yangtze River areas.
(7) The sown areas of grain is decreasing, but the output is increasing.
(8) Cropping pattern is getting more abundant. Developing towards the direction of labor-intensive and technical-intensive.
(9) Crop rotation and continuous cropping develops toward either fostering soil or high yield and high efficiency.
(10) Ways of Soil tillage develop with regional characters, towards no-tillage, minimum tillage or sub- loosing.
(11) Soil fertility maintaining mainly relay on the input of inorganic fertilizer, the fertilizer structure has been improved: ratio of N:P:K changed from 1:0.39:0.1 in 1990 to 1:0.49:0.16 in 2000.
(12) Agricultural input is keeping increased. Progress of science-technology is the main factor in promoting agricultural development.

From 1985 to 2000, agricultural input is keeping increased. Production conditions have been greatly improved. Machinery power increased by 3.47 times; Chemical fertilizer increased by 3.69 times; Irrigation land increased 19.7%.

GIS Technology and its Application for Management of Agricultural Resources

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1. Basic Introduction on GIS

1.1 Definition of GIS

GIS = Geographic Information System

A GIS is mapping software that links information about where things are with information about what things are like. So that GIS is something like a tool through which you can analyze spatial data, interpret spatial information. Simply put, a GIS combines layers of information about a place, integrate various objects like the houses, roads, water-faces, vegetation, parks, including all the land covers or landscape inside the place to give you a better understanding of that place and the interrelations among all these objects. What layers of information you combine depends on your purpose—such as finding the best location for the construction of a new road, making a spatial allocation for some crops like winter-wheat, corn and paddy-rice, analyzing

environmental damage, viewing the transportation inside a city and to utilize the land rationally in a region, and so on.
At the same time, in a broad view, a full GIS is not only a mapping software but a combination of Robust computer, Powerful software, Special data and Thinking explorer. That is, I n the strictest sense, a GIS is a computer system capable of assembling, storing, manipulating, and displaying geographically referenced information, i.e. data identified according to their locations. GIS requires hardware, software, data, trained users, and sound analysis methods for interpreting the results generated by the GIS. The user manipulates the hardware, which engages the software, to work on the data. Together, they handle:

- Computerizing of information (data entry, either through digitizing, scanning, keyboard entry, or data transfer)
- Data selection and query (information processing through database manipulation and advanced math analysis functions)
- Data display (map creation through drawing capacity)

GIS is not "canned maps." It is, instead, the ability to construct maps, showing what you want (and have data for) in the way you define. The software draws the integration of data: geographic coordinates (or "where things are") and sets of attributes (or "what things are like"), processed according to rules set by the user. This requires high computer power, since you can draw an infinitely variable set of coordinates at infinitely variable scales.

1.2 Advantages of GIS

Unlike with a paper map, where "what you see is what you get," GIS has great advantage, maybe you know a GIS map can discriminate and integrate many layers of information.
To use a paper map, all you do is unfold it. Spread out before you is a representation of cities and roads, mountains and rivers, railroads and political boundaries. The cities are represented by little dots or circles, the roads by black lines, the mountain peaks by tiny triangles, and the lakes by small blue areas.
As on the paper map, a digital map created by GIS will have dots, or points, that represent features on the map such as cities; lines that represent features such as roads; and small areas that represent features such as lakes.
The difference is that this information comes from a database and is shown only if the user chooses to show it. The database stores where the point is located, how long the road is, and even how many square miles a lake occupies.
Each piece of information in the map sits on a layer, and the users turn on or off the layers according to their needs. One layer could be made up of all the roads in an area. Another could represent all the lakes in the same area. Yet another could represent all the cities.
Why is this layering so important? The power of a GIS over paper maps is your ability to select the information you need to see according to what goal you are trying to achieve. That is to say, different layers of information can be organized to satisfy different demands.

1.3 What can we do with GIS

1.3.1 Mapping Where Things Are

Mapping where things are lets you find places that have the features you're looking for, and to see where to take action.

- Find a feature--People use maps to see where or what an individual feature is.
- Finding patterns--Looking at the distribution of features on the map instead of just an individual feature, you can see patterns emerge.

1.3.2 Mapping Quantities

With GIS, we can analyze the spatial difference of quantities precisely. People map quantities, like where the most and least are, to find places that meet their criteria and take action, or to see the relationships between places. This gives an additional level of information beyond simply mapping the locations of features. So with GIS, people can obtain more and thorough information for special purpose.

For example, a catalog company selling children's clothes would want to find ZIP Codes not only around their store, but those ZIP Codes with many young families with relatively high income. Or, public health officials might not only want to map physicians, but also map the numbers of physicians per 1,000 people in each census tract to see which areas are adequately served, and which are not. Still or, food producer has to consider how many kilos per hectare but he has to find out what will happy if he compares his production with the market demand (the population in his region).

1.3.3 Mapping Densities

While you can see concentrations by simply mapping the locations of features, in areas with many features it may be difficult to see which areas have a higher concentration than others. A density map lets you measure the number of features using a uniform areal unit, such as acres or square miles, so you can clearly see the distribution.

Mapping density is especially useful when mapping areas, such as census tracts or counties, which vary greatly in size. On maps showing the number of people per census tract, the larger tracts might have more people than smaller ones. But some smaller tracts might have more people per square mile--a higher density. High density of some parameters concerning agricultural resources means great potentials, such as high population density means high potential demand of agricultural goods, and high density of agricultural land means high production of crops.

1.3.4 Finding What's Inside

Use GIS to monitor what's happening and to take specific action by mapping what's inside a specific area. For example, a district attorney would monitor drug-related arrests to find out if an arrest is within 1,000 feet of a school--if so, stiffer penalties apply.

1.3.5 Finding What's Nearby

Find out what's occurring within a set distance of a feature by mapping what's nearby. For example, a city planner may need to notify all residents within 500 feet of a proposed liquor store, regional planner may be interested in the population within a certain distance of the central city in the region, and along a certain planned road how many people will benefit from its construction.

1.3.6 Mapping Change

Map the change in an area to anticipate future conditions, decide on a course of action, or to evaluate the results of an action or policy.

- By mapping where and how things move over a period of time, you can gain insight into how they behave. For example, a meteorologist might study the paths of hurricanes to predict where and when they might occur in the future.
- Map change to anticipate future needs. For example, a police chief might study how crime patterns change from month to month to help decide where officers should be assigned.
- Map conditions before and after an action or event to see the impact. An environmental analyst might map the change in quantity of pollutants before and after a regional manufacturing plant to see where and how the plan is more effective.

1.4 How To Do GIS Analysis

1.4.1 Frame the question.

Start your GIS analysis by figuring out what information you need. This is most often in the form of a question:

- Where were the areas with higher production of winter wheat last year?
- How much forest is in each watershed?
- Which parcels are within 500 feet of this liquor store?

Be as specific as possible about the question you want to answer. This will help you decide how to approach the analysis, which method to use, and how to present the results.

1.4.2 Select your data.

The type of data and features you work with help determine the method you use. Or, if you know you need to use a specific method to answer your question, you may find you need additional data.

Data can come from any number of sources--databases within your organization, contact managers, CAD files, the Internet, commercial data providers, government organizations, and so on.

The data you choose and where you get it depends on your needs and budget. Most critical is that the data be good quality, accurate data.

Visit the Data section for a more in-depth discussion of data types, data models, and sources of data.

1.4.3 Choose an analysis method.

Decide which analysis method to use based on your original question and how the results of the analysis will be used.

For example, if you are doing a quick study of burglaries in a city to look for patterns, you might just map the individual crimes and look at the maps. If the information will be used as evidence in a trial, however, you might want a more precise measure of the locations and numbers of assaults for a given time period.

1.4.4 Process the data.

Once you've selected the analysis method, you'll need to process your data in a way that makes sense for your goal.

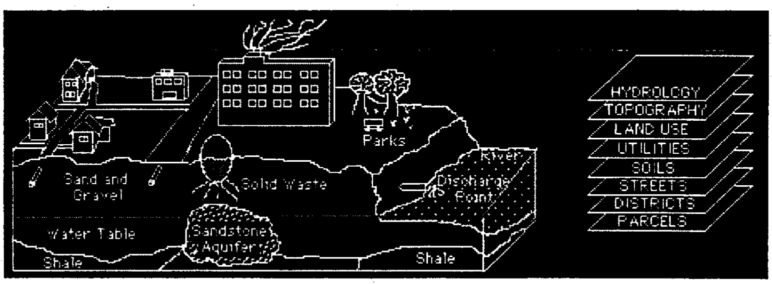
If you are mapping where things are located, you may need to assign geographic coordinates, such as latitude and longitude or address, to your data and assign category values to the data.
If you are mapping quantities, such as number of vegetation types in a state park, you may need to choose a classification scheme and decide on how many classes to represent your data.
If you are trying to find out what is inside, you may need to measure an area or combine different layers of information.

1.4.5 Look at the results.

The final step is to look at the results of your analysis and take action based on those results.
Your results can be displayed as a digital map, printed as a paper map, combined with spreadsheet-like tables or charts, or displayed as such. Though a lot of emphasis in GIS is in making maps, the software is flexible enough to allow you to display your results in the format that best suits your needs.

1.5 Why Use GIS?

The main goals for us to use GIS are to explore relationships between features distributed unevenly over space, seeking patterns that may not be apparent without using advanced techniques of query, selection, analysis, and display.
Here's a simple analogy: Imagine a set of map transparencies about an area, one transparency for each feature type (land use, elevation, ethnicity, dominant language, electrical wiring, transportation corridors, soil types, etc.). You can overlay the desired transparencies, zoom to the desired scale, and ask questions that display relationships across layers. You can also change the questions, scale, or layers, make a new display, and seek new understanding.



1.5.1 Improve Organizational Integration

One of the main benefits of GIS is improved management of your organization and resources. A GIS can link data sets together by common locational data, such as addresses, which helps departments and agencies share their data. By creating a shared database, one department can benefit from the work of another—data can be collected once and used many times.

1.5.2 Make Better Decisions

The old adage "better information leads to better decisions" is true for GIS. A GIS is not just an automated decision making system but a tool to query, analyze, and map data in support of the decision making process.

For example, GIS can be used to help reach a decision about the location of a new housing development that has minimal environmental impact, is located in a low-risk area, and is close to a population center. The information can be presented succinctly and clearly in the form of a map and accompanying report, allowing decision makers to focus on the real issues rather than trying to understand the data. Because GIS products can be produced quickly, multiple scenarios can be evaluated efficiently and effectively.

1.5.3 Make Maps

For simplicity's sake we often call GIS "mapping software." We most often associate maps with physical geography, but in fact GIS is flexible enough to map any kind of terrain, even the human body. GIS can map any data you wish.

Making maps with GIS is much more flexible than traditional manual or automated cartography approaches. A GIS creates maps from data pulled from databases. Existing paper maps can be digitized and translated into the GIS as well.

The GIS-based cartographic database can be both continuous and scale free. Map products can then be created centered on any location, at any scale, and showing selected information symbolized effectively to highlight specific characteristics. A map can be created anytime to any scale for anyone, as long as you have the data.

This is important because often we say "I see" to mean "I understand." Pattern recognition is something human beings excel at. There is a vast difference between seeing data in a table of rows and columns and seeing it presented in the form of a map. The difference is not simply aesthetic, it is conceptual—it turns out that the way you see your data has a profound effect on the connections you make and the conclusions you draw from it. GIS gives you the layout and drawing tools that help present facts with clear, compelling documents.

2. GIS for Management of Agricultural Resources

Geographic information systems (GIS) technology can be used for scientific investigations, resource management, and development planning. For example, a GIS might allow emergency planners to easily calculate emergency response times in the event of a natural disaster, or a GIS might be used to find wetlands that need protection from pollution.

As global population continues to grow, mankind must learn to balance consumption and conservation of the planet's scarce commodities. GIS technology brings a new perspective to the challenges faced by natural resource managers: How can agricultural yields be improved without depleting the soil? Where should timber be cut to best protect endangered species? How can landscapes be restored after the extraction of oil or minerals? What can be done to keep land development from choking rivers and coastlines with silt?

GIS, with its focus on location-based information and its ability to manage vast amounts of data, is the key to helping government and commercial entities monitor the environment more efficiently and cost-effectively. It also is the key to helping organizations comply with the multilateral environmental regulations that are the result of growing global markets.

If you could relate information about the rainfall of your State to aerial photographs of your county, you might be able to tell which wetlands dry up at certain times of the year. A GIS, which can use information from many different sources, in many different forms can help with such analyses. The primary requirement for the source data is that the locations for the variables are known. Location may be annotated by x,y, and z coordinates of longitude, latitude, and elevation, or by such systems as ZIP codes or highway mile markers. Any variable that can be located spatially can be fed into a GIS. Different kinds of data in map form can be entered into a GIS.

A GIS can also convert existing digital information, which may not yet be in map form, into forms it can recognize and use. For example, digital satellite images can be analyzed to produce a map like layer of digital information about vegetative covers.

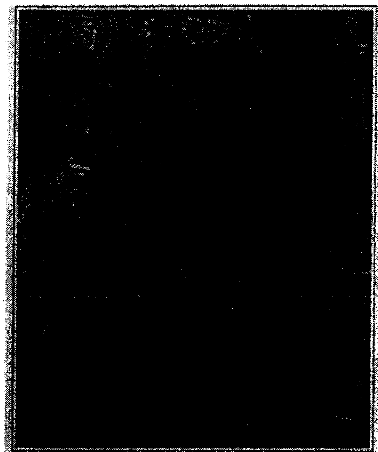


Figure 4. Satellite image data in fig. 3 has been analyzed to show classes of vegetative cover.

Likewise, census or hydrologic tabular data can be converted to map-like form, serving as layers of thematic information in a GIS.

529001	1	Shuteye			
		Br	529001	19	Mu
529001	36N	Frk South	Fabius		
			529001	54	Da
529001	71	Hickory			
Northern			529001	89	St
529001	106	Dogwood			
		Road	529001	124E	Po
529001	141	Meadow			
		Ave	529001	159W	Ma
529001	176E	Hickory			
		St	529001	194E	Wa
529001	211N	Don			
		St	529001	229N	Ma
529001	246S	Cottage Grove			
		St	529001	264E	Br
529001	281E	Link			
		Dr	529001	299	Be
529001	316	Clg Park			
		St	529001	334	Lo
529001	351	Brushy			
mut			529001	369	El
529001	386	Surratt			

Figure 5. A portion of a census data file containing address information.

LOCATION.--Lat 39:15:16, Long 077:34:36, H

DRAINAGE AREA.-- 89.60 mi2 (232.07

PERIOD OF RECORD.-- 1971-1987

STREAMFLOW (CFS),

DAY	Oct	Nov	Dec	Jan
1	47	150	360	64
2	60	143	235	118
3	66	141	188	111
4	52	113	165	85
5	48	96	146	146
6	46	90	146	107
7	40	87	600	84
8	37	80	475	77
9	37	75	335	80
10	349	74	282	148

Figure 6. A portion of a hydrologic data report indicating recorded stream flow amounts for a particular stream gage.

A GIS can be used to emphasize the spatial relationships among the objects being mapped. While a computer-aided mapping system may represent a road simply as a line, a GIS may also recognize that road as the border between wetland and urban development.

Data capture - putting the information into the system - is the time-consuming component of GIS work. Identities of the objects on the map must be specified, as well as their spatial relationships. Editing of information that is automatically captured can also be difficult. Electronic scanners record blemishes on a map just as faithfully as they record the map features. For example, a fleck of dirt might connect two lines that should not be connected. Extraneous data must be edited, or removed from the digital data file.

2.1 Data integration

A GIS makes it possible to link, or integrate, information that is difficult to associate through any other means. Thus, a GIS can use combinations of mapped variables to build and analyze spatial characteristics of agricultural resources just as displayed in the following figure.

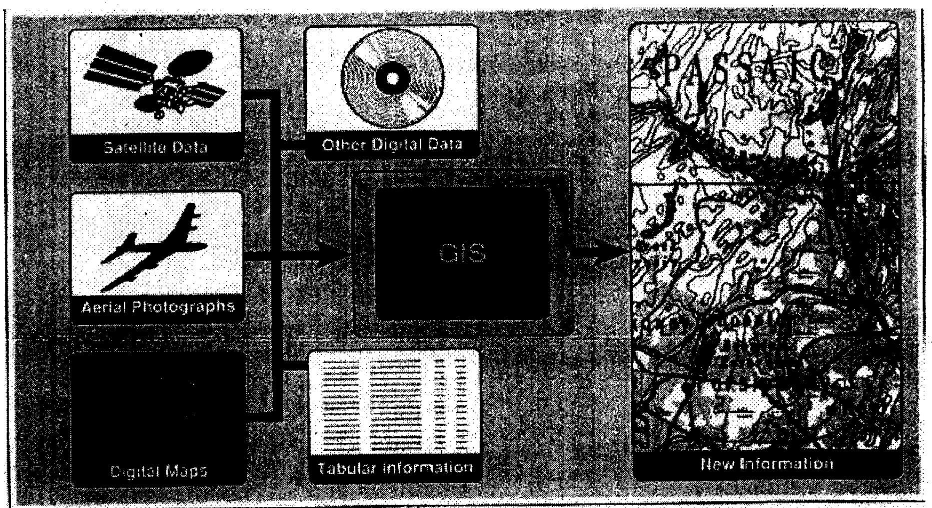


Figure 9. Data integration is the linking of information in different forms through a GIS.

2.2 Projection and registration

A property ownership map might be at a different scale from a soils map. Map information in a GIS must be manipulated so that it registers, or fits, with information gathered from other maps. Before the digital data can be analyzed, they may have to undergo other manipulations - projection conversions, for example - that integrate them into a GIS.

Projection is a fundamental component of mapmaking. A projection is a mathematical means of transferring information from the Earth's three-dimensional curved surface to a two-dimensional medium - paper or a computer screen. Different projections are used for different types of maps because each projection is particularly appropriate to certain uses. For example, a projection that accurately represents the shapes of the continents will distort their relative sizes.

Since much of the information in a GIS comes from existing maps, a GIS uses the processing power of the computer to transform digital information, gathered from sources with different projections to a common projection.

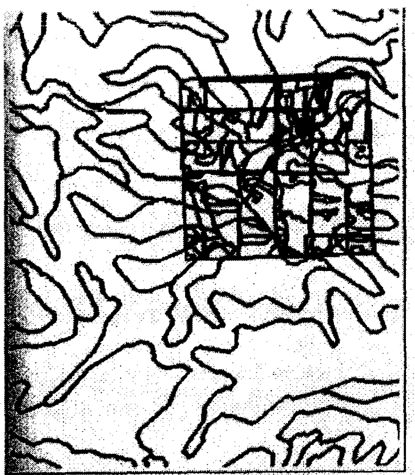


Figure 10a. A property ownership map is shown in green on top of a soils map in red. The two maps have different scales and projections.

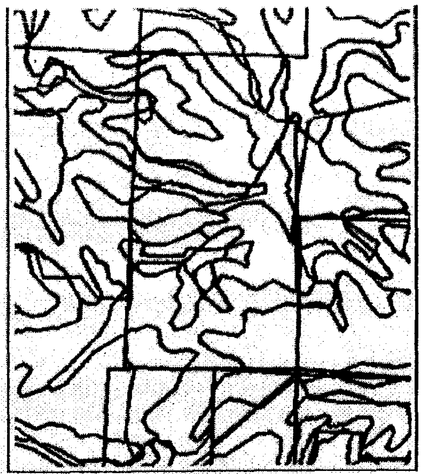


Figure 10b. The property map (green) has been reprojected to match the projection and scale of the soils map (red).

2.3 Data structures

There are now various data concerning agricultural resources, which we can use for our analysis or decision. Can a property ownership map be related to a satellite image, a timely indicator of land uses? Yes, but since digital data are collected and stored in various ways, the two data sources may not be entirely compatible. So a GIS must be able to convert data from one structure to another.

Image data from a satellite that has been interpreted by a computer to produce a land use map can be "read into" the GIS in raster format. Raster data files consist of rows of uniform cells coded according to data values. An example would be land cover classification.

1	1	1	3	3	3	3	3	3
1	1	1	3	3	3	3	3	3
1	1	2	2	2	2	3	3	3
1	1	2	2	2	2	2	3	3
1	2	2	2	2	2	3	3	3
3	3	3	2	2	2	3	3	3
3	3	3	3	2	3	3	3	3
3	3	3	3	3	3	3	3	3
1 Residential 2 Water 3 Farmland								

Figure 11. Example of the structure of a raster data file.

Raster data files can be manipulated quickly by the computer, but they are often less detailed and may be less visually appealing than vector data files, which can approximate the appearance of more traditional hand-drafted maps. Vector digital data have been captured as points, lines (a series of point coordinates), or areas (shapes bounded by lines).

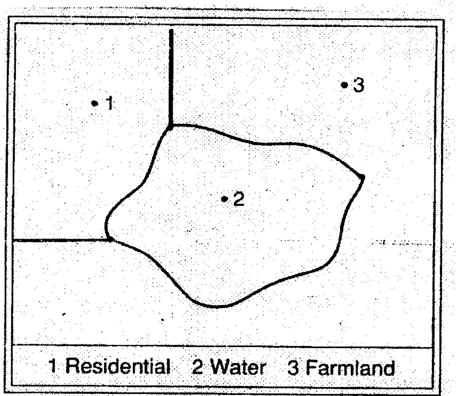


Figure 12. Example of the structure of a vector data file.

An example of data typically held in a vector file would be the administrative boundaries for any kind of information classification.

Data restructuring can be performed by a GIS to convert data into different formats. For example, a GIS may be used to convert a satellite image map to a vector structure by generating lines around all cells with the same classification, while determining the cell spatial relationships, such as adjacency or inclusion of crops.

2.4 Data modeling

It is difficult to relate wetlands maps to rainfall amounts recorded at different points-the sparsely distributed meteorological stations. A GIS, however, can be used to depict

two- and three-dimensional characteristics of the Earth's surface, subsurface, and atmosphere from information points.
For example, a GIS can quickly generate a map with lines that indicate rainfall amounts.

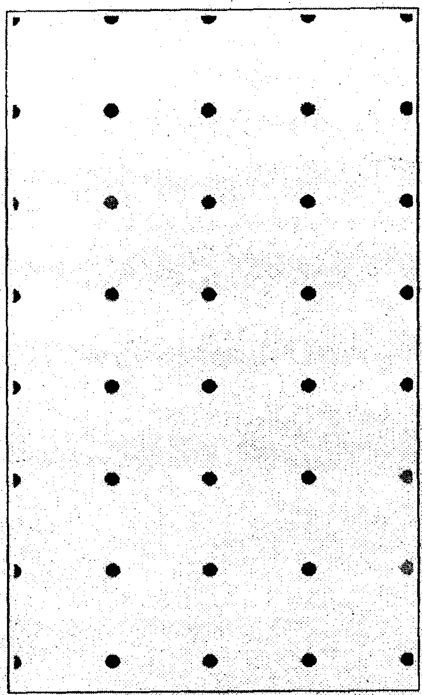


Figure 14. Points with known amounts of rainfall, ranging from high (yellow) to low (black). These points will be used to create a contour map.

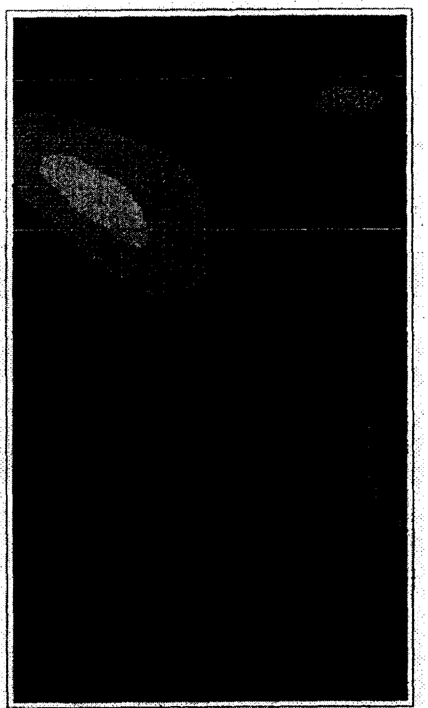


Figure 15. Contour map made from rainfall points shown in fig. 14. Areas with the highest amounts of rainfall are shown in yellow, and the lowest, in black.

Such a map can be thought of as a rainfall contour map. Many sophisticated methods can estimate the characteristics of surfaces from a limited number of point measurements. A two-dimensional contour map created from the surface modeling of rainfall point measurements may be overlain and analyzed with any other map in a GIS covering the same area.
Thus a GIS can be used to analyze land use information in conjunction with property ownership information, or with population distribution or with economic income.

2.5 Information retrieval

What do you know about the swampy area at the end of your street? With a GIS you can "point" at a location, object, or area on the screen and retrieve recorded information about it from off-screen files.

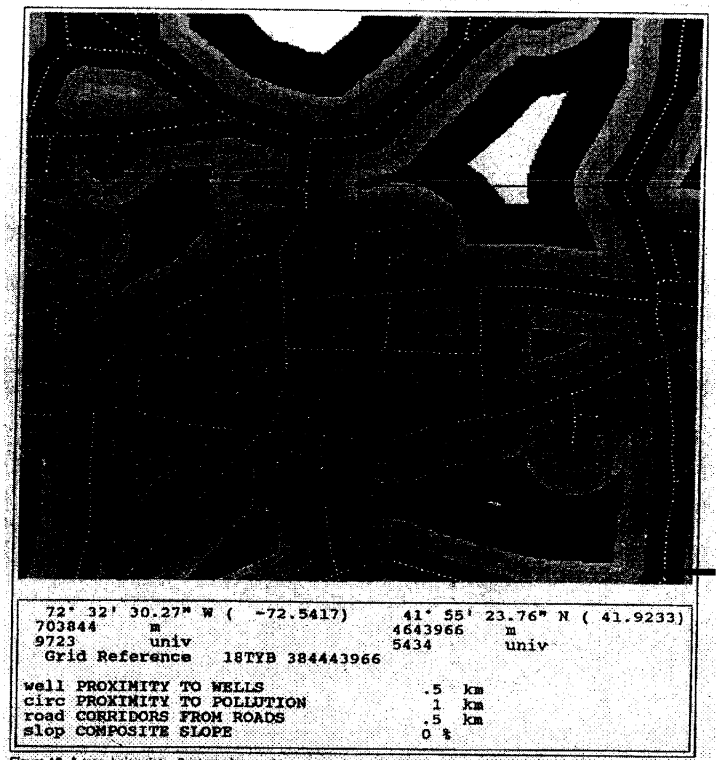


Figure 16. A crosshair pointer (top) can be used to point at a location stored in a GIS. The bottom illustration depicts a computer screen containing the kind of information stored about the location—for example the latitude, longitude, projection, coordinates, closeness to wells, sources of pollution, roads, and the slope of the land.

Using scanned aerial photographs as a visual guide, you can ask a GIS about the geology or hydrology of the area or even about how close a swamp is to the end of a street. This kind of analytic function allows you to draw conclusions about the swamp's environmental sensitivity.

2.6 Topological modeling

Still further, you may ask in the past 35 years, there were any gas stations or factories operating next to the swamp or any within two miles and uphill from the swamp. A GIS can recognize and analyze the spatial relationships among mapped phenomena. Conditions of adjacency (what is next to what), containment (what is enclosed by what), and proximity (how close something is to something else) can be determined with a GIS. This is quite normal and important to the management of agricultural resources.

Figure 17. Sources of pollution are represented as points.
The colored circles show distance from pollution sources.
The wetlands are in green.

2.7 Networks

If all the factories near a wetland were accidentally to release chemicals into the river at the same time, how long would it take for a damaging amount of pollutant to enter the wetland reserve? A GIS can simulate the route of materials along a linear network. It is possible to assign values such as direction and speed to the digital stream and "move" the contaminants through the stream system.

Figure 18. A GIS can simulate the movement of materials along a network of lines. This illustration shows the route of pollutants through a stream system. Flow directions are indicated by arrows. On the left, flow is superimposed on aerial photography of the area; on the right, flow is shown on a schematic drawing of the streams.

2.8 Overlay

Using maps of wetlands, slopes, streams, land use, and soils, the GIS might produce a new map layer or overlay that ranks the wetlands according to their relative sensitivity to damage from nearby factories or homes.

2.9 Data output

A critical component of a GIS is its ability to produce graphics on the screen or on paper that convey the results of analysis to the people who make decisions about agricultural resources. Wall maps and other graphics can be generated, allowing the viewer to visualize and thereby understand the results of analyses or simulations of potential events.

2.10 Mapmaking

Researchers are working to incorporate the mapmaking experience of traditional cartographers into GIS technology for the automated production of maps.

Each scale reduction required edge matching, or paneling, of the larger scale maps to produce the next small scale map. In addition, through the process known as generalization, the amount of information was reduced to make the smaller scale map readable.

2.11 Emergency response planning

GIS has been very often used for early-warning system for the utilization and management of agricultural resources. For example a GIS can be used to combine population distribution and regional economic development information with meteorological information to analyze the effect of an flooding on the response time for rescue and loss evaluation. Sure for this purpose GIS must be integrated with on-time data sources like remote-sensing image.

2.12 The Idea of the Expert Systems

If a database has been designed to store information about spatial, functional, and logical relationships, the user can pose more complex questions of the data. That is, the user can program the system to consider a variety of spatial, functional, and logical conditions during query or analysis. Such efforts result in what are termed expert systems or, if carried further, artificially intelligent systems. At there simplest, expert systems allow the user to set "rules" that must be followed as data is analyzed. These rules are written to mirror the way an experienced user would compare or judge data. As more and more rules are written, the system becomes more adept or "expert" at finding solutions with less directed guidance by users.

The point of expert systems is to build sets of rules that reflect the sorts of comparisons and judgments that experienced users would make. By programming these rules into the system, more and more of the work of decision making can be passed on to the computer system--including complex comparisons that may be difficult or time consuming for even experienced users to undertake.

Such systems are of great interest to GIS practioners in the field of agricultural resources analysis. Complex issues involving zoning and land use can often be written in terms of rules that need to be followed.

At the same time, following rules in only a step toward "intelligence." The difference between expert systems and artificial intelligence is much in debate. But to be truly "intelligent" a system must be able to "learn," "think," or "reason," perhaps really to write its own rules from experience. The definition of artificial intelligence is, in fact, still a contentious issue. So far, it has been very difficult to program computer systems to provide a semblance of human thought processes. Yet, the potential of such systems makes the effort irresistible. The idea that computer systems might one day be able to reason about real- world environmental and geographical problems and issues is a reason why GIS theorists maintain an interest in developments in the area of artificial intelligence.

2.13 Graphic display techniques

Traditional maps are abstractions of the real world, a sampling of important elements portrayed on a sheet of paper with symbols to represent physical objects. People who use maps must interpret these symbols. Topographic maps show the shape of land surface with contour lines. The actual shape of the land can be seen only in the mind's eye. Graphic display techniques in GIS's make relationships among map elements visible, heightening one's ability to extract and analyze information.

Depicted as in the following figure, two types of data were combined in a GIS to produce a perspective view. The digital elevation model, consisting of surface elevations recorded on a 30-meter horizontal grid, shows high elevations as white and low elevation as black.

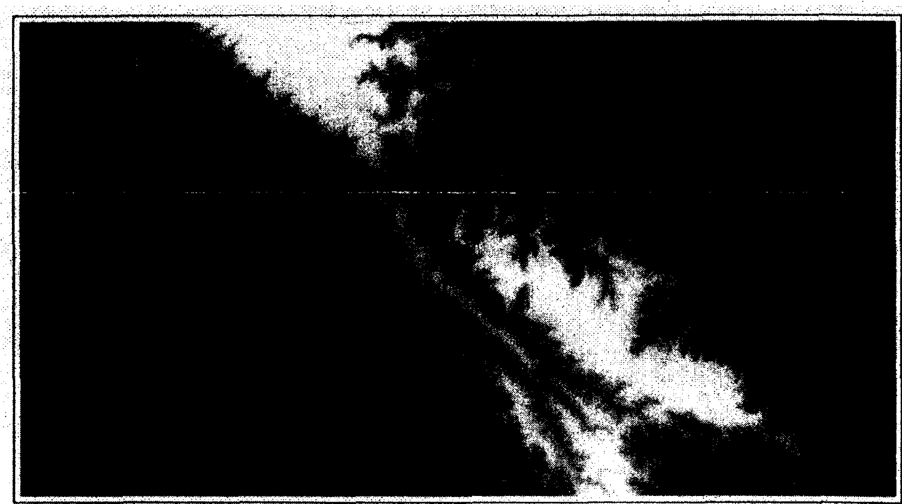


Figure 28. Digital elevation model of San Mateo County, CA.

The accompanying Landsat Thematic Mapper image shows a false-color infrared image of the same area in 30-meter pixels, or picture elements. A GIS was used to register and combine the two images to produce the three-dimensional perspective view looking down.

Figure 29. Landsat Thematic Mapper image of San Mateo County, CA.

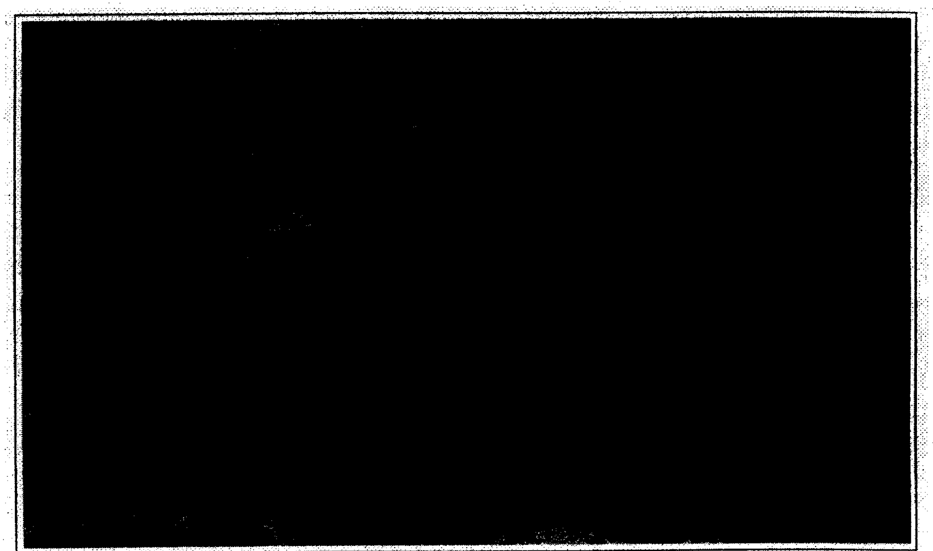


Figure 30. Perspective view of San Mateo County, CA.

2.14 Precision Agriculture

In today's competitive market, obtaining the optimum crop yield is critical to the success of farming. The key to achieving such results is "precision agriculture," which means knowing and responding to the specific conditions of the field.

GIS lets farmers perform site-specific spatial analyses of agronomic data. The results identify the interactions between physical, chemical, and crop data that can be the cause for variations in yield.

The map to the upper left shows soil types along with land use/land cover, topography, and flood hazards for the state of Missouri. This information can be used with GIS to help manage agricultural use of the land.

3. The future of GIS

Many disciplines can benefit from GIS techniques. An active GIS market has resulted in lower costs and continual improvements in the hardware and software components of GIS. These developments will, in turn, result in a much wider application of the technology throughout government, business, and industry.

Maps have traditionally been used to explore the Earth and to exploit its resources. GIS technology, as an expansion of cartographic science, has enhanced the efficiency and analytic power of traditional mapping. Now, as the scientific community recognizes the environmental consequences of human activity, GIS technology is becoming an essential tool in the effort to understand the process of global change. Various map and satellite information sources can be combined in modes that simulate the interactions of complex natural systems.

Through a function known as visualization, a GIS can be used to produce images - not just maps, but drawings, animations, and other cartographic products. These images allow researchers to view their subjects in ways that literally never have been seen before. The images often are equally helpful in conveying the technical concepts of GIS study subjects to non-scientists.

The condition of the Earth's surface, atmosphere, and subsurface can be examined by feeding satellite data into a GIS. GIS technology gives researchers the ability to examine the variations in Earth processes over days, months, and years. As an example, the changes in vegetation vigor through a growing season can be animated to determine when drought was most extensive in a particular region. The resulting graphic, known as a normalized vegetation index, represents a rough measure of plant health.

Working with two variables over time will allow researchers to detect regional differences in the lag between a decline in rainfall and its effect on vegetation.

These analyses are made possible both by GIS technology and by the availability of digital data on regional and global scales. The satellite sensor output used to generate the vegetation graphic is produced by the Advanced Very High Resolution Radiometer or AVHRR. This sensor system detects the amounts of energy reflected from the Earth's surface across various bands of the spectrum for surface areas of about 1 square kilometer. The satellite sensor produces images of a particular location on the Earth twice a day. AVHRR is only one of many sensor systems used for Earth surface analysis. More sensors will follow, generating ever greater amounts of data.

GIS and related technology will help greatly in the management and analysis of these large volumes of data for the management of agricultural resources, allowing for better understanding of terrestrial processes and better management of human activities to utilize resources rationally, to maintain world economic vitality and environmental quality.

GIS can also be used to study agricultural trends on a global scale. The map below shows types of farming and typical crops found in different parts of Africa.

Governments around the world are increasingly required to streamline business practices while adhering to complex political and regulatory requirements. To do so, they must digest an immense amount of information to perform their duties in a fair and reliable manner. Almost all of this information is in some way tied to a geographic element such as an address, parcel, postal code, census block, or some other component. GIS technology provides a flexible set of tools to perform the diverse array of functions handled by government agencies. More important, GIS technology makes data sharing among departments easier so that the government can work as a single enteiprise.

As globalization of businesses and economies brings our world closer, problems increasingly cross international boundaries with widespread implications. GIS helps national governments collate and analyze the quantities of data needed to address these issues.

GIS cuts across nearly all disciplines, provides a common language for discussion, and acts as a means to bring governments, agencies, and constituents together in the decision making process.

The great appeal of GIS stems from their ability to integrate great quantities of information about the environment and to provide a powerful repertoire of analytical tools to explore this data. The example above displayed only a few map layers pertaining to urban transportation planning. The layers included would be very different if the application involved modeling the habitat of an endangered species or the environmental consequences of leakage from a hazardous materials site.

Imagine the potential of a system in which dozens or hundreds of maps layers are arrayed to display information about transportation networks, hydrography, population characteristics, economic activity, political jurisdictions, and other characteristics of the natural and social environments. Such a system would be valuable in a wide range of situations--for urban planning, environmental resource management, hazards management, emergency planning, or transportation forecasting, and so on. The ability to separate information in layers, and then combine it with other layers of information is the reason why GIS hold such great potential as research and decision-making tools.

Reference: www.gis.com