行政院及所屬機關出國報告

出國報告（出國類別：訓練）

降低災害風險
與氣候變遷調適訓練暨研討會
AARDO Disaster Risk Reduction and Climate Change Adaptation Workshop-Cum-Training

服務機關：行政院農業委員會林務局農林航空測量所

行政院農業委員會水土保持局

姓名職稱：陳聖元技士

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派赴國家：尚比亞

出國期間：105年5月7至5月15日

報告日期：105年10月25日

摘要

2016年度「降低災害風險與氣候變遷調適」訓練暨研討會舉辦於5月9日至13日期間，係由亞非農村發展組織(AARDO)及Mulungushi 大學共同舉辦並提供經費，地點在尚比亞Mulungushi 大學。該訓練暨研討會由AARDO 各會員國選派代表人員參加研習，旨在探討氣候變遷與災害間的關係，以及氣候變遷所帶來災害對人類的影響性，進而發展規劃降低災害風險以及調適氣候變遷的對策。

本訓練暨研討會計有24位會員國代表參加，亞洲地區包含臺灣、韓國、馬來西亞、印度、孟加拉、斯里蘭卡、巴基斯坦等國；中東地區則有巴勒斯坦、黎巴嫩、伊拉克等，以及非洲地區如蘇丹、模里西斯、肯亞、迦納、布吉納法索、奈及利亞等國家。研討會透過多位專家發表專題演講，以及與會各會員國代表提出國情報告及相關減災應變機制，於會議中共同研討。期間另有安排至Makululu聚落，一個因礦場關閉而安置礦場勞工的聚落，聽取該聚落面臨的衛生設施、教育、醫療、就業，以及極高的愛滋盛行率等處境，與相關援助計畫運作情況。

藉本訓練暨研討會，促進各AARDO會員國間認識彼此國家之災害性質，及各國對於災害所採取之防災或減災措施，論其異同，研討交流，彼此借鏡，並思考氣候變遷對於未來可能造成之影響，作為未來進行相關業務推展之參考。

關鍵字:AARDO、氣候變遷調適、災害管理、降低災害風險、Makululu

目次

一、目的

AARDO（African-Asian Rural Development Organization, AARDO）是「亞非農村發展組織」，總部位於印度新德里，1962年成立，旨在發展農村建設，消弭亞洲及非洲地區國家飢餓、貧窮及疾病，並促進教育及發展農村建設。台灣自1968年加入AARDO組織，並積極參與該組織許多合作計畫。

如AARDO舉辦的「降低災害風險與氣候變遷調適」訓練暨研討會，提供員額予各會員國參與，我國的「財團法人國際合作發展基金會」及「國際土地政策研究訓練中心」每年亦提供AARDO各會員國相當員額來台參訓，交流互動密切。由於台灣地區位於太平洋西岸火環，地震頻傳，並且也在颱風行經路徑上，每年夏秋之際颱風侵襲頻仍，近年因極端降雨或是颱風帶來短時間大量降雨，造成山區崩落混合泥水形成土石流災害。由於各種天然災害頻傳，台灣在災害防救領域有豐富經驗，為國際上亟欲學習借鏡之對象。

2016年「降低災害風險與氣候變遷調適」訓練暨研討會於5月7日至5月13日期間，於非洲尚比亞Mulungushi大學舉辦，該大學位於卡布韋市(Kabwe city)，在首都盧沙卡市北邊2小時路程處。本研討會有來自亞洲、非洲及中亞地區個國家，共計24位參與者。

於三天的研討行程中，研討會安排數個專題演講，讓各國參與者了解國際上對於災害防救目前採取的措施，另亦特別安排各國參與者準備各國國情報告，讓所有來自世界各地參與者，能藉各國國情報告認識各國的災害種類，面臨不同的災害防救問題、採取的措施及困境，更藉由互動式的討論、研習，進行各種國情文化、地理位置及氣候、季節及災害種類、災害防救知識、災害防救經驗等各方面深度交流，更藉此交流，強化深化各會員國的合作關係。

二、行程摘要

日期	行程	備註
5月7日	去程：台北-香港-約翰尼斯堡-尚比亞	
5月8日		
5月9日	研討會D1：專題演講 野外考察：Makululu Compound	
5月10日	研討會D2：專題演講	
5月11日	研討會D3：國情報告	
5月12日	參訪行程：The Victoria Falls	往程約10小時 夜宿李文斯敦
5月13日	參訪行程：The Victoria Falls	返程約8小時 臨別晚宴
5月14日	返程：尚比亞-約翰尼斯堡-香港-台北	
5月15日		

三、訓練暨研討會內容

（一）課程安排

日期	議程	題目	講者
5月9日	開幕致詞 成員介紹 專題演講1：研討會暨工作坊介紹，目標及期望。 專題演講2：全球災害風險管理綱領—仙台減災綱領 2015-2030 Field trip- Makululu Compound	 Dr. Adrian Phiri Dr. Mitulo Silengo	
5月10日	專題演講3：尚比亞災害減災及氣候變遷調適制度 專題演講4：災害管理及氣候變遷調適—孟加拉經驗 專題演講5：減災及氣候變遷對健康的影響 專題演講6：尚比亞農業與氣候變遷調適	DMMU Dr. Kamrul Ahsan, Bangladesh Dr. Muzaffer Ahmad, India SNAR staff	
5月11日	國情報告		

（二）專題演講摘要

1.議題：研討會暨工作坊介紹，目標及期望

講者：Dr. Adrian Phiri

隸屬單位：Mulungushi 大學災害管理中心

摘要：

IPCC（Intergovernmental Panel on Climate Change, 政府間氣候變化專業委員會）於2014年的研究報告指出，近來氣候變遷，已對全世界及人類造成負面影響，包括南北極冰原融化、海水面上升、全球暖化等現象，亦對人類民生及經濟活動造成許多負面影響。極端氣候所帶來的強降雨、洪水、暴風雨及暴風雪，更造成許多生命財產損失。另「仙台減災綱領-2015—2030」亦指出，氣候變遷影響全球，全世界沒有任何國家能倖免。因此國際間必須合作、互相研擬對策，來調適氣候變遷所帶來的影響，降低災害風險。

由於亞洲及非洲國家主要經濟以農業為主，氣候變遷直接影響農作物生產，造成減產或歉收，糧食的短缺不只削弱經濟，更帶來饑荒、疾病，使得原本貧困的國家更加困頓，氣候變遷調適及減災，於亞洲及非洲地區顯得尤其重要。

然而防災措施以及災後重建，需要耗費極大資本，位於易受氣候影響的農業小國，對於氣候變遷的適應及防災措施，往往不足以應付氣候變遷所帶來的災害，更容易受其影響。

本研討會旨在訓練研討降低災害風險及氣候變遷調適基本知能，了解國際間對氣候變遷調適所做的努力及處置，及現況面對的問題。更藉由各會員國準備的國情報告，了解各國地理位置、氣候概況、近年來面臨的氣候變遷挑戰，與各國政府為降低災害風險所提出的方針、對策，以供互相借鏡、研討，強化會員間氣候變遷調適與減災知能。

2.議題：全球災害風險管理綱領—仙台減災綱領 2015-2030

講者：Dr. Mitulo Silengo

隸屬單位：Mulungushi 大學災害管理中心

摘要：

「仙台減災綱領 2015-2030」是於2015年3月18日，來自世界187個國家的政府代表，在日本仙台舉行「第三屆世界減災會議」，會議中通過2015年後15年的全球減災策略。本綱領歸納了全世界數十年來的重大災害，制定出七大減災目標與四大優先推動事項。

七大減災目標為：

(1)減少全球災害死亡率

(2)減少受災害衝擊之人數

(3)減少災害造成之經濟損失

(4)減少災害對關鍵基礎設施的破壞，避免服務中斷，發展耐災的能力

(5)增加參與氣候變遷調適之國家及地區的數目

(6)促進國際合作

(7)加強複合型災害之早期預警系統，促進民眾對災害風險資訊的了解。

四大先優先推動項目包括：

(1)了解災害風險

(2)強化災害風險管理

(3)投資減災工作，增強耐災能力

(4)強化防災整備應變工作，達成「更耐災的重建」目標

3.議題：尚比亞災害減災及氣候變遷調適制度

講者：Dr. Adrian Phiri

隸屬單位：Mulungushi 大學

摘要：

尚比亞政府組織的合作框架，乃是透過中央政府，制定相關政策，制定相關法規，並調度相關資源，整合相關單位，如公民團體、NGOs、CBOs、學術單位、媒體及私人機關，共同協調合作。

尚比亞的減災及氣候變遷調適，是透過以社區需求為單位，設立相關計畫（Community Demand Driven (CDD) Projects），並與政府組織充分合作，達到資源分配、訊息傳遞、災害教育的目標。

4.議題：災害管理及氣候變遷調適－孟加拉經驗

講者：Dr. Kamrul Ahsan

隸屬單位：Bangladesh Academy for Rural Development (BARD)

摘要：

氣候變遷帶來的災害，乃是全球性的，沒有一個國家、地區能倖免。災害的發生會破壞民生基礎設施，諸如城市排水設施、自來水供應，阻隔交通，使得運補困難，造成食物短缺。醫療中心也有可能遭受到破壞，使得傷者無法獲得良好的醫療，或是災後造成傳染病無法醫治。

孟加拉為極易受氣候影響的國家，經常遭受許多不同災害如熱帶型颶風、洪水、嚴重的河岸侵蝕（侵蝕率為每年80平方公里）。如1998年的大洪水，淹沒70%孟加拉國土。孟加拉亦為世界人口密度最高的國家，每平方公里約1000人；國土大部分地區為恆河三角洲，為世界上最大的三角洲，三角洲南部蒲隆地擁有世界上最大的紅樹林森林，且擁有極長的海岸線，海岸線長達710公里。因位地勢低窪，海岸線長，並位處熱帶，孟加拉最容易受到洪水、海嘯、熱帶性颶風、河岸侵蝕及乾旱等災害。

目前因全球性氣候變遷，孟加拉面臨的困境如下：

1. 熱帶性低氣壓形成的頻率增加，侵襲孟加拉的熱帶性低氣壓變多，強降雨帶來洪水災害及河岸侵蝕。1988年洪水，死亡人數1,657人；1998年的大洪水，淹沒了孟加拉70%國土長達90天。
2. 乾旱。雨季延遲20-30天，造成作物歉收及饑荒。
3. 孟加拉位於印度洋板塊於歐亞大陸板塊碰撞帶，地震頻仍，2016年4月17日發生規模7.8的地震，造成550人死亡，2,500人受傷。
4. 河岸侵蝕是孟加拉常見的災害類型，雖然河水逐漸侵蝕帶走河岸的泥沙沉積物，仍然造成永久性的影響及破壞。平均每年河水造成的河岸侵蝕，帶走孟加拉陸地上240億噸的泥沙流入印度洋。
5. 溫度低於攝氏10度的寒流，影響防寒措施較不足的中下階級人民以及畜養的牲畜，造成死傷及經濟損失。
6. 地下淡水鹽化，指地下水受到海水鹽分的侵入，使得作物遭受鹽害無法生長，或生長不良。

作為以農業為主的國家，農業災害及乾旱是最重要的議題，其中於地下淡水鹽化的問題發展六種耐鹽品系的水稻（BRRI Dhan 28 (1-4 ds/m), BRRI Dhan (8-10 ds/m) and Bina-8 (12-14 ds/m)），在高鹽分環境下仍然能保持收穫。

在過去35年間，孟加拉政府以投資1000億美元建立更抗災的基礎建設，更能抵抗洪水、熱帶性颶風等災害。

5.議題：減災及氣候變遷對健康的影響

講者：Dr. Muzaffer Ahmad

隸屬單位：National Disaster Management Authority (NDMA), Government of India

摘要：

全球的災害發生數量約在1980年左右逐年攀升，於2000迄今達到高峰。災害帶來的經濟損失，於2005年一年中，全球因災害所造成的經濟損失達到最高4兆3300億美元。災害的發生除了造成經濟損失，同時也帶來許多傷亡，其中以地震與海嘯所造成的傷亡人數最多，熱帶颶風次之。

這些因氣候變化所造成的天然災害，大多影響到社會中下階層的人民，占影響人數的68%之多，因其居住條件較差，且經濟情況較無法負荷昂貴的醫療，使得中下階級的人民成為最容易受到這些天然災害影響的一群。因此災害後的重建以及減低災害風險，除了需要建構更為耐災的社區架構，同時必須提供倖存下來的災民人道支援，幫助流離失所的人重建家園。

於2015年3月18日，由世界各國制定的「仙台減災綱領 2015-2030」，包含四大先優先推動項目及七大減災目標，就是希冀藉由國際政府間合作，達成氣候變遷調適及降低災害風險，讓受到災害影響的人減少，與更少的經濟損失。

災害分為天然災害及人為災害，因此想要降低災害風險，則必須先分析災害的類型。分析災害發生的原因，方能找出癥結點，對症下藥，以達到降低災害風險，落實災害管理。災害管理亦可分為兩個層面，即災前管理與災後管理。災前管理包含識別風險、減低風險、轉移風險、以及預防措施；災後管理則包括災害應變與災後復原重建。

為了要有效落實災害管理，必須靠政府間緊密合作。故政府各部門之間的溝通與整合是最重要的環節。政府各部門必須了解各自的角色，於災前妥善溝通協調建立標準作業程序，才能在災前識別災害風險，預先降低、轉移風險，以避免災害的發生；或者是在災害發生時能有效率的做出應變措施，防止災害擴大或轉移，減少人員傷亡及經濟損失。

Risk=f(H,V,C)。此公式表示災害風險，是受到災害、地區的災害易受性與政府應變能力等因素所影響。因此欲降低災害風險可由減少災害、降低地區災害易受性與加強政府應變能

力著手。因此減災可由加強基礎設施抗災的硬體設備，以及由政府政策方針制定、災害知識教育推廣、公眾參與防災活動的軟體方法，達到災害管理及減災的目標。

此外，氣候變遷同時會造成人類健康問題。氣候變遷極端氣候，諸如熱浪、寒流、乾旱、洪水、地震，都可能破壞人們生活的基礎設施，如污水處理、食物污染、或破壞醫療中心等條件，影響到人類的健康。另外溫度的上升，更是容易加速細菌滋長，造成傳染病流行。此外熱浪使人類容易中熱衰竭，在烈日曝曬下使得人體衰弱暈厥缺水甚至死亡。氣候變遷使得作物收成歉收，糧食不足，營養不良，各種因素的作用下都會影響人類健康。溫度以及洪水帶來的積水，使得蚊蟲孳生，攜帶許多病原致病，也會造成如瘧疾與登革熱等傳染病流行。

6.議題：尚比亞農業與氣候變遷調適

講者：SNAR staff

隸屬單位：SNAR

摘要：

尚比亞一年雨量可分為三區，北邊最為濕潤（1000-1500mm/yr），南邊最為乾燥（<700mm）。尚比亞的農業型態，依照規模可分三種。第一種為勞動力受限的小型農耕系統，如傳統的遊耕（砍閥樹林耕種，俟地力減退後再另闢耕地耕作），或是使用鋤頭、牲畜協助耕作的農業，耕作範圍約5公頃左右，無灌溉系統，單純依賴自然降水。第二種為中型農耕系統，通常為中產階級或家族經營，耕作範圍15-50公頃，依賴自然降水及灌溉系統澆灌。第三種為大型農耕系統，耕作範圍可達500公頃，依靠自然降水以及完整的灌溉系統耕作。尚比亞主要的農作物為玉米、黃豆、花生、菸草、棉花、小麥、稻米、高粱等，飼養 的牲畜有牛、羊、家禽類及綿羊。

近年來的氣候變遷，造成尚比亞雨季延遲到來與提早結束，即雨季縮短。週年間乾旱少雨的時間加長了，夏季異常高溫的次數變多，冬季作物結霜的次數和時間增加，造成農作物減產及歉收。

尚比亞政府及NGO組織，為了協助農民對抗氣候變遷，推行許多計畫，包括教導農民飼養多樣化的牲畜，作物提前收穫及市場管理，如：

(1)倡導避免砍乏森林，以混農林業等方式替代傳統的砍閥或焚林，並且教育農民以掩埋代替焚燒樹木雜草，掩埋至土壤下作為肥料，以維持地力，永續發展。

(2)氣候直接影響農作物收成，因此政府亦加強氣象資料的傳遞，以將最即時可靠的氣象資訊，傳播讓農民知道，提早因應。

(3)教育農民以乾玉米草覆蓋土壤，除可減少水分蒸散，保持土壤濕潤外，亦可增加土壤有機質。

(4)教育農民選擇更抗旱，較能容忍環境變化的品種栽種，以確保農作產量。

（三）野外參訪

研討會第一天下午，結束一天冗長的演講，工作人員帶我們到Makululu compound進行野外參訪。天氣很熱，一群人擠上小巴士前往卡布韋鄰近的一個小聚落—Makululu Community。

車程約略一個小時即抵達Makululu ，當天下午所見聚落人並不多。小巴停在間較大的平房前，大家魚貫下車進了禮堂，禮堂外有一群年約12-16歲的孩子在大太陽下唸書，這就是Makululu compound的第一印象。

Makululu位於卡布韋市旁，卡布韋曾為尚比亞有名的採礦城市，盛產銅礦及鈷礦，但隨著國際銅價礦業重挫，礦場被迫關閉，原本的採礦工人失業，影響著無數個原以採礦薪資為主要收入的家庭，原本繁榮的卡布韋市頓時變成一個鬼城。原本的採礦工人，有的改行當漁夫，有的做起小生意，更多數的人流離失所，酗酒，生活貧苦。

這些人被安置在Makululu，總共有6萬人左右，家庭生活貧苦，小孩無法獲取足夠營養，忍受長期性飢餓，遑論好好上學唸書；再者，學校教師素質低落，亦無法提供良好的教育，孩子成長的未來一片黑暗。

環境衛生及健康方面，社區無良好汙水系統，時常造成傳染病流行，村子裡只有一個健康中心，能提供的藥物及醫療十分有限。此外，這裡的HIV/AIDS盛行率也是全尚比亞最高，達到24%的盛行率。

綜觀Makululu社區目前需求有以下幾點：

1. 更多家庭關照
2. 解決食物短缺問題
3. 缺少學前教育
4. HIV/AIDS的教育及安全性行為宣導
5. 增加收入及工作機會

目前尚比亞及相關NGO團體正在進行的計畫：

1. 提供學校所需的桌椅、窗戶等硬體設施，以完備學習環境
2. 提供孤兒及窮困學生上學所需用品及制服
3. 提供家庭環境照顧
4. 請社區選一個管理者，提供食物及基本家庭用藥供管理者分配給有需要的家庭或病患
5. 轉介病患到醫院及診所
6. 提供養雞場的工作機會並給予薪水

四、結論

（一）研討會中各國皆提出近年來極端氣候，包含極端降雨、雨季縮短或延長、旱害、熱浪、寒害及洪水所帶來的災害，以及災害後續引發的傳染病流行，尤其對經濟活動以農業為主，並且國家資本並不雄厚，基礎建設尚待加強的亞洲及非洲國家，影響更甚。

（二）災害可分為天然災害及人為災害，前者可為因氣候變遷，或是地球板塊運動等天然因素造成；後者則因錯誤的政策或決定導致，兩者並可同時發生。爰欲降低災害風險，首先應分析災害的類型，再著眼於減災策略與措施。分析災害發生的原因，以達到降低災害風險，落實災害管理。災害管理亦可分為兩個層面，即災前管理與災後管理。災前管理包含識別風險、減低風險、轉移風險、以及預防措施；災後管理則包括災害應變與災後復原重建。

（三）氣候變遷調適，於農業上的例子如尚比亞為因應延後的雨季造成的乾旱，採取教導農民飼養多樣化的牲畜，作物提前收穫及市場管理；加強氣象資料的傳遞，以利讓農民提早因應；教育農民以乾玉米草覆蓋土壤，保持土壤濕潤外並增加土壤有機質；教育農民選擇更抗旱，較能容忍環境變化的品種栽種，以確保農作產量.....等措施。或如孟加拉為因應海平面上升導致鹽水侵入地下水層造成鹽化現象，培育並推廣耐鹽的水稻品種，在高鹽分環境下仍然能確保水稻收穫量。

（四）氣候變遷所帶來的天然災害，透過破壞社會的基礎設施，如排污設備、維生管線以及道路運補路線等，帶來傳染病或是飢餓，影響人類的健康。另外如異常高溫帶來的熱浪，亦可直接使人類體溫升高造成中熱衰竭、脫水、昏厥甚至死亡。此外高溫也會造成病原菌增生，增加流病風險。洪水或降雨造成積水，配合高溫因子，也是造成登革熱及瘧疾流行的原因。

（五）2015 年舉辦的的第三次全球減災大會中訂定「仙台檢災綱領 2015-2030」，惟目前針對該綱領制定政策而實際施行的國家並不多，希望各國相關部門能儘快據以施行，方能有效改善現況，強化氣候變遷適應及減災效益。

五、出國心得與建議

（一）這次訓練暨研討會，雖然長途飛行，舟車勞頓，但是研習過程中，和會員國參與者交流了許多亞洲及非洲國家的發生的各種災害及政府採取的氣候調適及減災措施，互相研討交換經驗。本次研討會參與者來自世界不同角落，有的雖然操著難懂的英文口音，卻一樣熱情。友情及文化交流，與研習會上研討交流氣候調適防災減災的知識，都是此行的收穫。105年度AARDO workshop的參與者共同在臉書創立了本年度AARDO研習的粉絲頁，各會員國參加者除了在粉絲頁上分享研習及野外參訪照片及資料外，於研習結束後，大家仍不時在粉絲頁分享近況，關心彼此國家近來發生的重大災害。

（二）本年度我國與會單位，皆與防救災領域有密切關係，於國情報告時各國皆相當重視本國於土石流防災及航遙測應用於降低災害風險方面的技術及措施，其中各國對於本國莫拉克風災的航攝能力與土石流專員的設置及成功疏散實例，更是印象深刻。

（三）身為基層公務人員，很少有能出國研習的機會，雖然年輕的基層公務人員行政能力不一定很強，卻富有學習與適應能力。希望能提供更多出國研習、訓練的機會，讓更多基層的公務人員出國與其他國家政府機關或是專業人員交流，也算是培植未來文官拓展國際視野，提供訓練流利英文口說能力的機會。

（四）本次研習由AARDO支付旅費及食宿，雖然此行的住宿不如旅館般舒適，吃的東西可能有些不習慣，但相信Mulungushi大學已盡量提供並滿足參加的各國參與者，也在此致謝工作人員的辛勞。

六、照片集錦

各會員國與會人員及工作人員合影

研討會討論情況

國情報告

研討會後留影

參訪—維多利亞瀑布

結業暨頒發結業證書

七、附件

（一）國情報告

International Workshop-cum-Training Programme on "Disaster Risk Reduction and Climate Change Adaptation"

Mulungushi University, Kabwe, Zambia

9 May- 13 May 2016

The Challenge of Disaster Management Under the Climate Change in Taiwan

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Abstract

Taiwan is located on the edge of Eurasian Sea Plate and Philippine Sea Plate. The mountains in Taiwan are high and steep, and the terrain is highly variable, as well as the elevations. Earthquakes occur frequently in Taiwan. The rainy season in Taiwan is caused by rainfall along a persistent stationary front between spring and summer; and typhoons are influencing Taiwan mostly in the summer and autumn. The annual average rainfall is more than 2,500mm.

There is abundant rainfall in Taiwan; there are many rivers in Taiwan. Variable rainfall duration and intensity leads to floods and debris flow disasters. Since the 1999 Chi-Chi earthquake (ML=7.3) occurred, the frequency of the disasters, which are caused by landslides, complex landslides, debris flows and soil erosion, has increased more than before.

And under the climate change, the annual rainfall difference in Taiwan is getting bigger and bigger. It means we have more flood and drought. The average of annual rainfall does not change a lot, but rainfall hours have the tendency to reduce, this means rainfall intensity had increase a lot in the last decade. And the number of typhoons per year increased from 3.2 (1951-2000) to 6.8 (2001-2009). It shows the extreme weather condition will happened more frequently in the future. Disaster management under the climate change becomes a huge challenge.

The article will focus on the debris flow disaster management because it is the most frequent disaster in Taiwan. Through that we shows how we did for disaster risk reduction under climate change. This article is consisted of some parts. The first part contains introduction to the debris flow disaster in Taiwan. Next it will introduce the procedure of debris flow disaster management. Usually the hazard preparedness, emergency response and recovery are the three main stages. Among them, all the works are the mitigation work of the disaster. The last part will make some conclusion.

A. Introduction

Taiwan is located on the edge of Eurasian Sea Plate and Philippine Sea Plate. The maximum length and the average width of Taiwan is about 395 kilometers and 144 kilometers respectively. And the total area is about 36,000 km2. The mountains in Taiwan are high and steep, and the terrain is highly variable, as well as the elevations. (Taiwan's highest point is Yu Shan, also called Jade Mountain, which is at 3,952 meters) In Taiwan, the plains are narrow, which is only occupied with one-third of Taiwan. Earthquakes occur frequently in Taiwan. The rainy season in Taiwan is caused by rainfall along a persistent stationary front between spring and summer; and typhoons are influencing Taiwan mostly in the summer and autumn. The annual average rainfall is more than 2,500mm.

There is abundant rainfall in Taiwan; there are many rivers in Taiwan. Variable rainfall duration and intensity leads to floods and debris flow disasters. Since the 1999 Chi-Chi earthquake (ML=7.3) occurred, the frequency of the disasters, which are caused by landslides, complex landslides, debris flows and soil erosion, has increased more than before. Before the Chichi Earthquake, Taiwan had experienced 27 major debris flow disaster events between 1981 and 1999. The area of landslides from the Chichi Earthquake of 1999 was about 8,600 ha, and was increased to more than 22,000 ha by Typhoon Toraji in 2001, that caused 16 major debris flow disasters, resulting in an increased number of landslides and debris flow hazard-prone areas. There were 485 debris flow potential streams in Taiwan before the Chichi Earthquake of 1999, afterwards, this number has been increased to 722, even the number of torrents has been increased to 1678 now (2016).

B. Disaster Management

The so-called "Disaster Management" is a continuous, dynamic process of management planning in order to reduce the uncertainty and possibility of danger. In terms of management, types of disasters, how to prevent, time of occurrence, response plan, recovery plan, policy review and so on all belong to the field of disaster management.

Four Stages of Disaster Management

The process of disaster can be divided into four stages: mitigation, preparedness, response and recovery. Each stage are closely linked together, a stage not ready will influence the next stage. In fact, prevention is better than cure, so among these years Disaster Management gradually focusing on mitigation, because mitigation is the most fundamental and long-termed disaster management measures.

1. Mitigation

Mainly through the policy management and a variety of response measure to prevent the occurrence of disasters or mitigate the impact of disasters. In general, the mitigation can be divided into two types.

(1) Structural:

Refers to the construction of specific equipment as preparedness, such as constructing reservoirs, dikes and water pollution equipment, and updating fire distinguisher equipment.

(2) Non-structural:

Making overall plans for all time, not just making specific constructions to solve problem. Such as: reservoir safety assessment, strengthen slopeland conservation and

management, enhance treatment and maintenance of soil and water conservation by stages and areas and exercise strict control over developments in restricted areas, legislate for construction laws and so on.

2. Preparedness

Be full prepared before disaster occurs and be familiar with the operation of disaster prevention program can decrease the damage loss. The disaster often occurred as sudden as lightning, has to be unruffled, to avoid the expanding of disaster and damage loss, and be fully prepared to cope with various disasters situations. There are three major tasks:

(1) Training:

Establish the division of authority and responsibility in emergency operations, reserve resources to support disaster prevention operations. The training is about disaster management, disaster response capabilities and implementation. Through training can rapidly understand about the operation plan and equipment, further more can enhance operational efficiency.

(2) Planning:

Planning Is The Basis Of Control, Action Is Its Essence. Draw up disaster management plans beforehand, then can make a quick response during the disaster. A good response plan can not only make good use of the resources, but also can reduce the damage loss.

(3) Warning

Remind the public to be aware and be prepared before the disaster occurred.

3. Response

Response measures during disaster, except for the Disaster Prevention and Response Plan, according to different urgency can separate into emergency reporting for disasters period and Emergency Operation Center period.

(1) Emergency reporting for disasters period

It is a period before Emergency Operation Center period; it is to make an efficient disaster response, also to make an instance notification to disaster prevention and

response duty ministry during or before disaster.

(2) Emergency Operation Center period

The Emergency Operation Center period begins with the establishment of Emergency Operation Center. Its main task is to make instant response and start Emergency Medical Service System, rescue human lives and property at once, also to make a quick evacuation and sheltering.

4. Recovery

Recovery is an operation that co-operate with mitigation operations that facilitates the reconstruction of public works, social and economic orders in reverting to original circumstances (or even better). Recovery operations can be divided into a short-term recovery policy and a long-term recovery policy.

A short-term recovery policy is to fulfill basic lifeline systems that include electricity, communication, water, gas and transportation system that reach residents' basic need for food, clothing and shelter.

A long-term recovery policy is to take emergency response measures for lifelines, basic living facilities and public facilities and equipment to ensure the livelihood of citizens and the maintenance of public security.

5. Current Situation in Taiwan

Disaster Prevention and Protection Act in Taiwan have divided the four stages of disaster into three parts: disaster prevention, disaster response and disaster recovery (disaster prevention combine from "mitigation" and "preparedness"), and explicitly assigned the duties of regulating authorities for various disasters.

C. Risk of Debris Flow Potential Torrents

1. Definition of Debris Flows

If we want to prevent the debris flow disasters, the first thing we should do is to define

“What Are Debris Flows?” A debris flow is a natural phenomenon where a mixture of mud, sand, gravel, rock and water rushes down a slope due to gravity. The movement of a debris flow can be divided into three steps: initiation, transit and deposition. In the initial step, a slope collapses causing debris to begin to move downhill, usually down a curved ravine covered with sparse vegetation. Next, as the debris flow continues downhill, it erodes the bank of the ravine into U-shape, mostly taking place in valleys or downstream. Finally, the debris flow is deposited at the mouths of gullies and forms debris fans, which are tongue-shaped with large boulders deposited on the surface or on the edge of the fans

The elements which allow debris flows to form include an abundant source of loosely packed, fine-grained rock and soil debris, large volumes of water, and steep slopes. Near unstable hillsides, weathered rock, sand and soil accumulate in valleys or foothills below due to landslips, landslides and rock-falls. Heavy precipitation induces slope failure. Intense rainfall saturates permeable sediment deposits on steep slopes, which absorb the runoff. The loose rock material, mixed with runoff water, moves down the slope due to gravity, resulting in debris flows.

Debris flows are a natural phenomenon, but when a debris flow results in casualties, damage to buildings, bridges or infrastructures, or causes loss of life or property, it is called a debris flow disaster.

2. Investigation of Potential Debris Flow Torrents & Landslides

There are two things we have to do about debris flow. First is the investigation of potential debris flow torrents, after the investigation, we found out that there are 1,678 potential

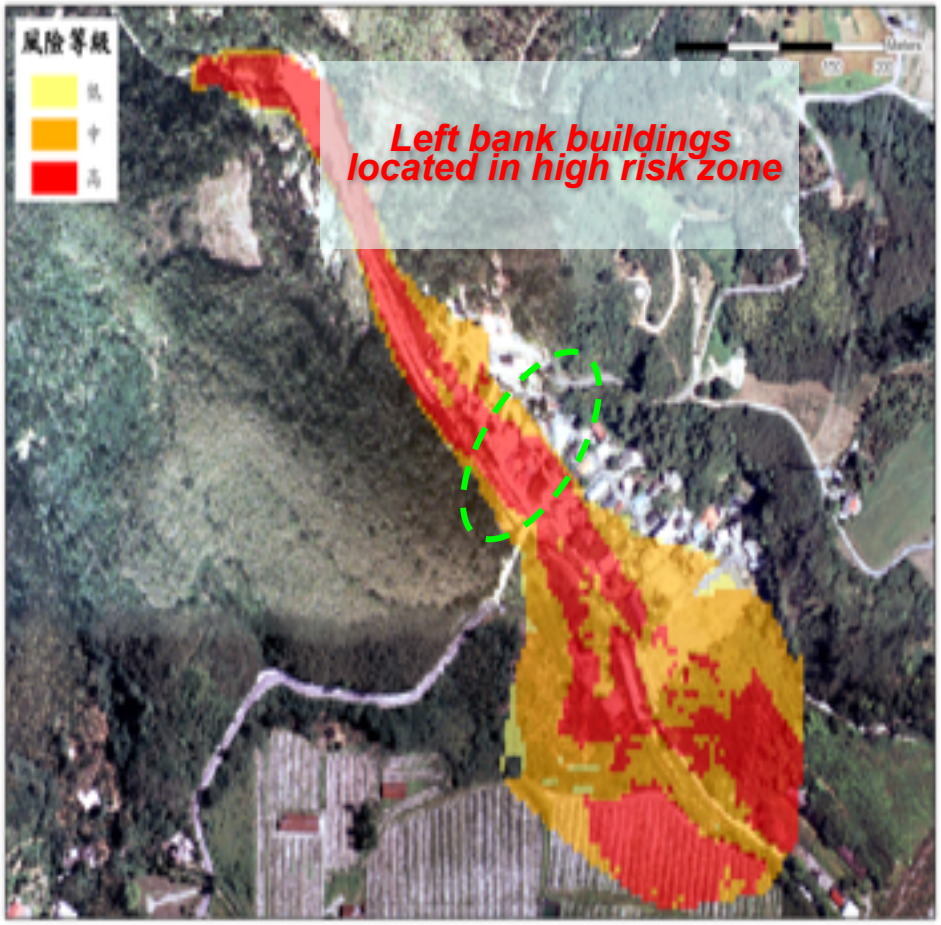
debris flow torrents in Taiwan in 2016.

Then we have to find the affected area of those potential debris flow torrents, and define the risk of them. The recognition of potential debris flow torrents is base on the probability factors and the assured safety. Probability factors including watershed area, slope, geological condition and so on. Assured safety means county, village or structures like bridge or road. And has divided potential risk degree into three levels, the low, mid and high risk level.

Risk		***Probability***		
		Low	***Mid***	***High***
Assured Safety	***Low***	***Low***	***Low***	***High***
	Mid	***Low***	***Mid***	***High***
	High	***Mid***	***High***	***High***

Risk degree of debris flow potential torrents

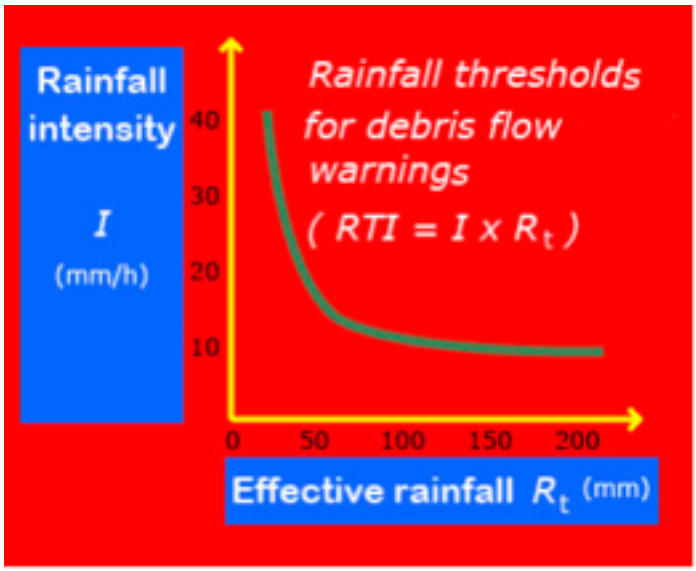
After that, we want to know if the debris flow occurred, what region may be covered by the debris, the possible affected area of debris flow. A map showing the potential hazard area can be drawn based on model simulation results and GIS map layers. According to these results, we can figured out where and who we should consider in the disaster prevention plan.



3. Rainfall Threshold Value for Debris Flow Warnings

Using rainfall data from Central Weather Bureau, a rainfall triggering index (RTI) is produced by multiplying Effective Accumulated Rainfall (mm) by Rainfall Intensity (mm/ hour). The first step in determining a debris flow area's rainfall threshold is to identify potential debris flows in the watershed that have similar properties and group them together. The second step is to compute rainfall thresholds with statistical models, using data from past debris flow occurrences in similar areas. The final step is to simplify these thresholds into accumulated rainfall values, which are used to issue debris flow warnings and evacuation orders.

When the effective accumulated rainfall in a specific area is greater than the threshold, a debris flow could occur. Rainfall thresholds are divided into nine categories by amount of rainfall, every 50 mm from 200 to 600mm. They are reviewed and revised every year according to rainfall data and any natural hazards affecting debris flow areas, such as earthquakes and typhoons.



D. Awareness of Local Community

1. Debris Flow Volunteer Specialist

To strengthen grassroots disaster prevention capacities, the Soil and Water Conservation Bureau enlists soil and water conservation volunteers, hillside investigation inspectors, emergency contacts and the manpower of social groups to establish groups of debris flow volunteer specialists in disaster prone areas. The main task of debris flow volunteer specialists is to teach residents about typhoons and extremely heavy rains, and how to use simple rain gauges and rainfall monitoring, enhancing the understanding of residents of debris flow disaster prone areas. They also encourage local residents to establish a disaster resistant community and to be dedicated to works such as debris flow monitoring, rainfall monitoring, and disaster notification and emergency evacuation. Their ultimate goal is to give every resident in mountainous areas disaster prevention knowledge. Volunteers will

receive a certificate of debris flow volunteer specialist training and an agreement of employment, stating they will assist the government in times of disaster.

A debris flow volunteer specialists monitored the rainfall condition with a rain gauge.

2. Disaster Resistant Community

Disaster Resistant Communities are those which possess emergency response abilities, which can mitigate disasters, which can withstand and respond effectively during disasters, and which recover quickly after a disaster. A disaster resistant community also is a sustainable community that makes a rapid post-disaster reconstruction.

Everyone in the community wants to live in a safe, comfortable environment, and a Disaster Resistant Community's goal is to create a "safe" community which generally includes three essential elements:

- The ability to withstand adversity
- The ability to respond effectively to and recover quickly from adversity
- The ability to adapt to the changed environment resulting from adversity.

Disaster Resistant Communities reduce disaster losses through community-based mitigation programs and measures. Once a disaster has occurred, residents quickly prevent disaster expansion and reduce disaster losses while also quickly responding with recovery and reconstruction work.

The World Conference on Disaster Reduction (WCDR) held in Japan in 2005 proposed the Hyogo Declaration. It indicates the importance of strengthening community level capacities to reduce local disaster risk and considering appropriate disaster reduction measures that enable the communities and individuals to significantly reduce their vulnerability to hazards. Disasters remain a major threat to the survival, dignity, livelihood and security of peoples and communities, particularly the poor.

Therefore there is an urgent need to enhance the capacity of disaster-prone developing countries, especially the least developed countries and small island developing states, to reduce the impact of disasters. This can be done through strengthened national efforts and enhanced bilateral, regional, and international cooperation, such as technical and financial assistance.

In the next decade the international disaster mitigation strategy will focus on the promotion of disaster resistant communities through specific policies, network promotion, strategic plans for volunteer resource management, clear terms of reference and responsibilities, and the involvement of public power and authority to facilitate community participation in disaster prevention. Meanwhile, encouraging community-based training and volunteering will help mitigate disasters and strengthen disaster response capabilities.

(1) Implementation Model

Village offices and Community Development Associations integrate with community-based organizations (such as the patrol team, neighborhood rescue team, the Phoenix volunteers, production classes, women's groups, etc.) as well as external units (such as township offices, fire departments, health centers, and local police stations). They work together, carry out their duties, and strengthen the interactive participation of the residents. Experts provide their professional expertise in disaster prevention, analysis of vulnerability, and disaster prevention strategy. The Opinion Leader is responsible for guidance, discussions, comments and feedback of the community and volunteers during training, discussions, and meetings, as well as for resolving conflicts between differing views.

(2) Procedure

The purpose of promoting Disaster Resistant Community is to reduce factors that may induce disasters through residents' active participation, the acquisition of disaster relief and prevention knowledge, the learning of disaster prevention skills, and the promotion of disaster mitigation and disaster prevention precautions.

(3) Preparedness Work

Being fully prepared with these disaster preparedness items can enhance your and your community's ability to keep calm in emergency situations. They include disaster relief materials for your home, evacuation planning and evacuation shelter preparedness for the community, and how to set up a simple rain gauge for voluntary disaster prevention monitoring. These drills should be completed before flood season.

(4) Self-Monitoring

Check to see the conditions of a Disaster Resistant Community, such as "Does the community you live in is located in a potential debris flow torrents area? Disaster prevention work items are completed?"

Item	*YES*	*NO*
Location and basic attributes		

	1. Located in potential debris flow torrents area		
	2. Vulnerability of community environment:		
	-- Debris accumulation in nearby rivers or streams		
	-- Bridges and culverts are blocked		
	-- Check dams - severe debris accumulation		
	-- Behaviors that damage forests such as unlawful land use, deforestation, dumping, and burning		
	-- Abnormal debris in slopeland		
	3. Are has experienced past disasters		
	Community Autonomy		
	1. Community cohesiveness		
	2. Community residents are actively involved in community disaster preparedness		
	3. Community disaster prevention organizations have been established (ie: volunteer police and fire fighters, neighborhood rescue teams, and the Phoenix Volunteer Team)		
	4. High mobilization capacity of disaster prevention organizations in community		
	The Promotion of Disaster Prevention Awareness.		
	1. Adequate understanding of community environment		
	2. Adequate understanding of debris flows and debris flow disasters		
	3. Active participation in disaster prevention illustration meetings and advocacy, and interactive discussions		
	4. Participation in community disaster prevention drills and professional training		
	5. Improvement of disaster prevention knowledge, awareness of past disasters, and response capabilities		
	Disaster Prevention and Rescue Resources		
	1. Community possesses enough disaster prevention equipment (ie: health care resources, ambulance equipment, destructor set, generators)		
	2. Adequate reserve of supplies in the community		
	3. Functioning community warning and notification system		
	4. Open communication channels between relevant government agencies or non-governmental organizations		

E. Formosa Emergency Management Action System (FEMA)

In order to prevent life and economic losses due to landslide, complex landslide,debris flows and soil erosion, Soil and Water Conservation Bureau (SWCB) has put lots of efforts in Formosa Emergency Management Action (FEMA), which is integrated multiple high techniques, to enhance the efficiency on debris flow disaster prevention response. Since 2001, FEMA has given a brilliant performance in more than 100 events including typhoons, extremely heavy rain and earthquakes. It not only provides SWCB a simple platform to manage debris flow disaster events but also the related information for decision-making

The information platform FEMA is not only a torrents monitoring and decision-making support system, it also has interfaces (include website, smart phone app) to announce disaster prevention information to all people.

Moreover, to have more time to evacuate people from dangerous areas, we integrated three precipitation forecasting system from CWB, including Ensemble based Typhoon Quantitative Precipitation Forecast (ETQPF), Quantitative Precipitation Estimation and Segregation Using Multiple Sensors (QPESUMS) and QPF for upcoming 24 hours, as the model for analyzing and issuing debris flow warning. It greatly increases the quality for SWCB to analyze the information model of debris flow.

At last, to promote disaster prevention, the historical sediment-related photos collecting event was held to raise the consciousness of crisis. We have built a platform for people to upload, query, visualize the pictures of historical disasters. Through the event, we expect that the natural disaster could raise the awareness of disaster prevention.

Conclusion

1. The decision support system integrates various kinds of information and provides the most important decision-making support to different levels of the governments in Taiwan.
2. The ranfall-based debris flow warning model has been proved to be effective for evacuation operation. However, its accuracy is still not satisfying for lack of geological and hydrological consideration. Besides, the up-to –date rain fall prediction techniques such as QPESUMS and

ETQPF also can be adopted for more precise warnings in the future.

3. The accuracy and reliability of debris flow risk analysis is depended on the completenessof basic data, though numerous debris flow hazard had occurred in the past few decades, few data were remained for debris flow simulation verification, which made hazard analysis more difficult. In the future, debris flow hazard information should be recorded and mapped in GIS format and imported to database, for future hazard analysis and vulnerability research.

（二）國情報告簡報

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International Workshop-cum-Training Programme on "Disaster Risk Reduction and Climate Change Adaptation"

The Challenge of Disaster Management Under the Climate Change in Taiwan

[1] CHEN, Sheng-Yuan
[2] YAN, Ke-Wei

1. Technician, Aerial Survey Office of Forest Bureau
2. Engineer, Debris Flow Disaster Prevention Center of Soil and Water Conservation Bureau

May 11 2015

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Introduction of Taiwan(R.O.C.)

General information	
Area	36,000 km^2
Population	23 million ppl
Forest area	60.71%
Slopeland	73.3%
Annual Rainfall	2,600 mm/yr

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Attractions of Taiwan


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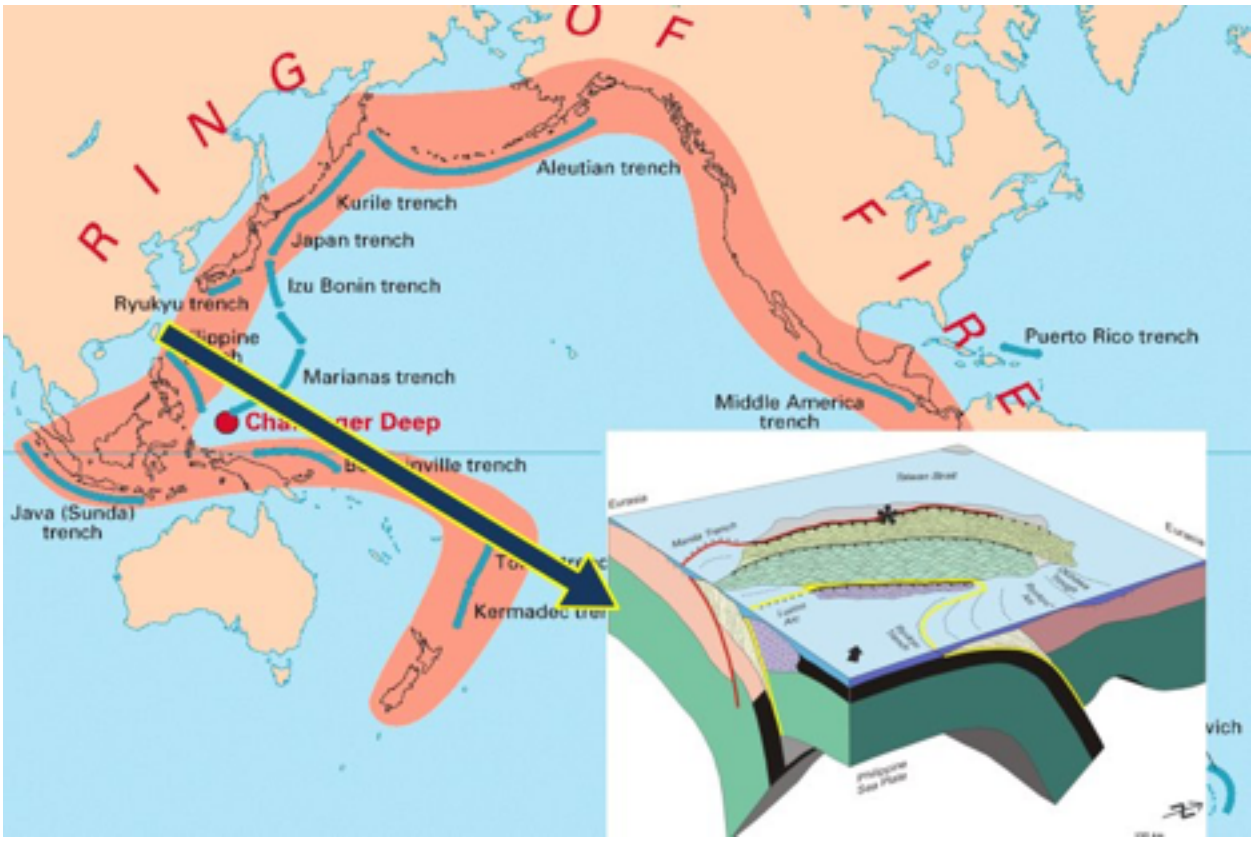
5


11,000 km
6



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Major Types of Natural Disasters

- *Meteorological disasters : typhoon, tornados, heavy rain, droughts, snow etc.*
- *Flood disaster : flood, river overflow, water flooding etc.*
- *Geologic hazard : earthquakes, landslide, mudflow, volcano eruption, land subsidence etc.*
- *Agriculture disaster : crops diseases and insect pests*
- *Maritime disasters : tsunami, sea level rise etc.*
- ***Forest disaster : forest diseases, forest fire.***

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Jan 24th , 2016. Snow event

Location: Suburban mountains in Northern Taiwan

Extreme Climate!

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Debris Flow Disasters in Taiwan

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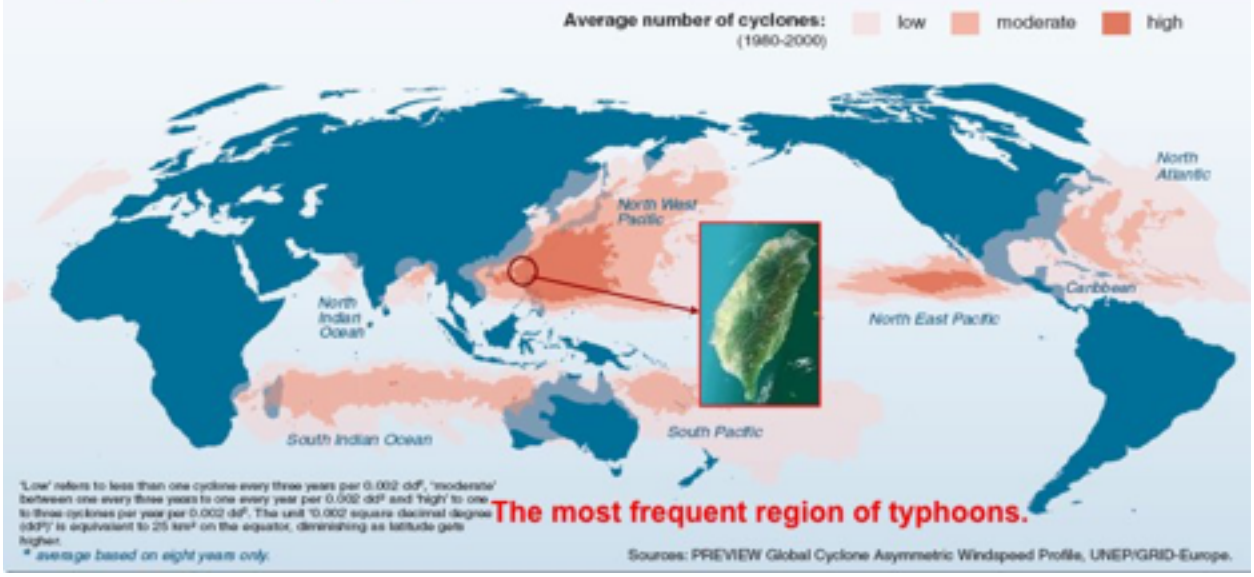
Climate Change Impact

- Temperature increases about 1.4°C in the last 100 years (1901-2006).
- Number of typhoons per year increased dramatically after 2000.
  From N=3.2(1951-2000) to N=6.8 (2001-2009)

Tropical cyclone frequency



'Low' refers to less than one cyclone every three years per 0.002 ddF, 'moderate' between one every three years to one every year per 0.002 ddF and 'high' to one to three cyclones per year per 0.002 ddF. The unit '0.002 square decimal degree (ddF)' is equivalent to 25 km² on the equator, diminishing as latitude gets higher.
* average based on eight years only.

The most frequent region of typhoons.

Sources: PREVIEW Global Cyclone Asymmetric Windspeed Profile, UNEP/GRID-Europe.

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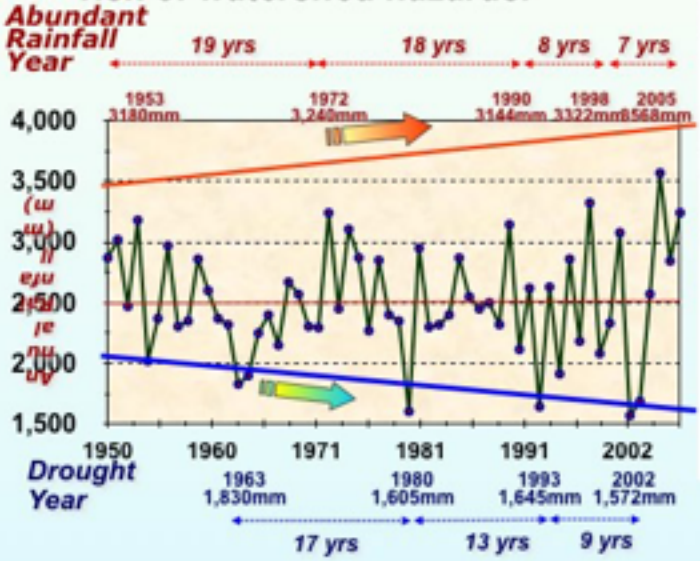
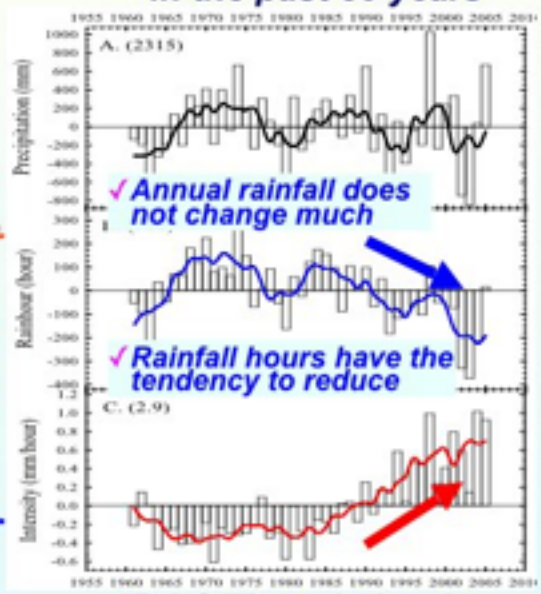
Variation of rainfall pattern of Taiwan in last 50 years

Significant change of rainfall and dry-rainy seasons increases the risk of watershed hazards.



Annual rainfall of Taiwan in the past 50 years



✓Annual rainfall does not change much

✓Rainfall hours have the tendency to reduce

✓Rainfall intensity has the tendency to strengthen

Data resource : WRA

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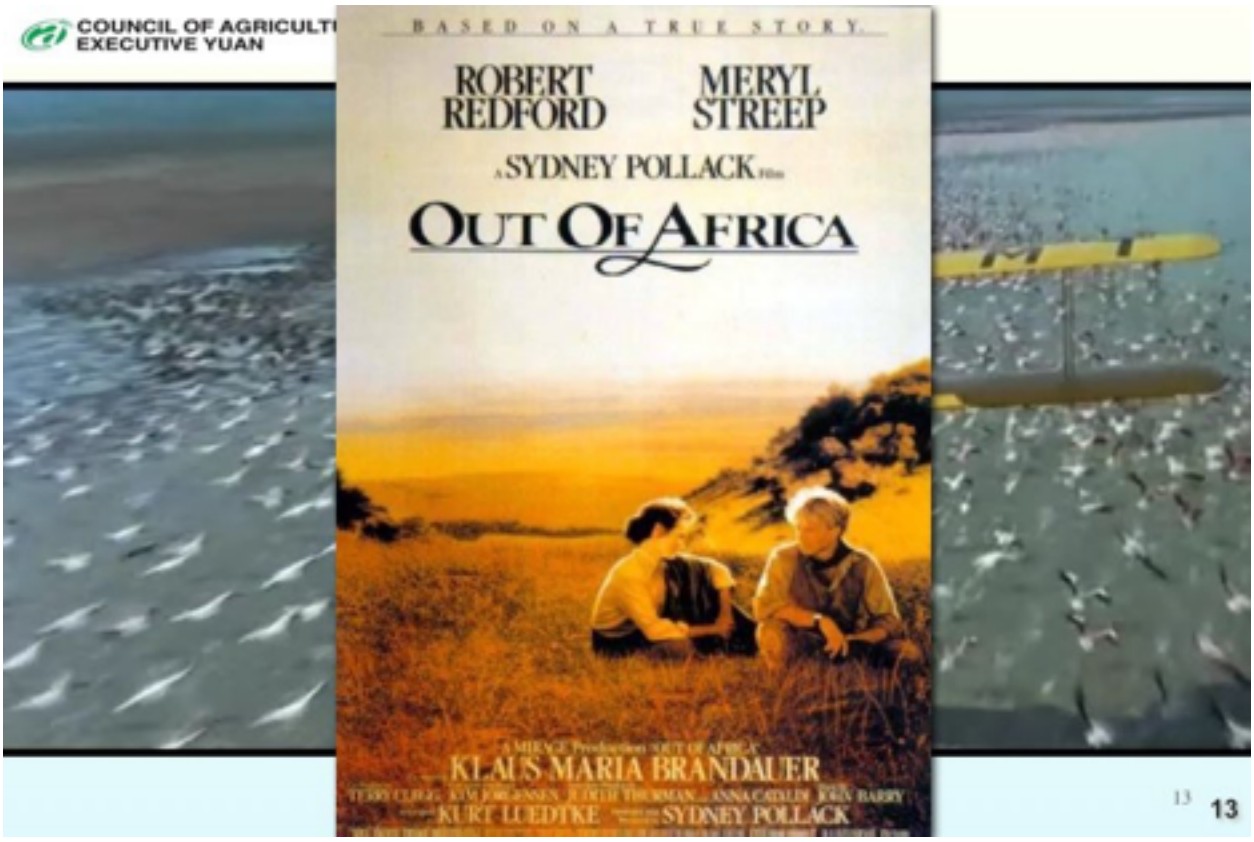

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Applications of remote Sensing

- **Forest management**: Forest disasters, such as forest fire, forest disease, landslides caused by earthquake, heavy rain or typhoon.
- **Agricultural statistics**: Crops plantation distribution and area.
- **Disaster management**: Flood, landslide, earthquake, tsunami, forest.....etc. large-scaled disasters.
- **Academic research.**
- **Records of landscape transformation.**
- **Mapping purpose.**

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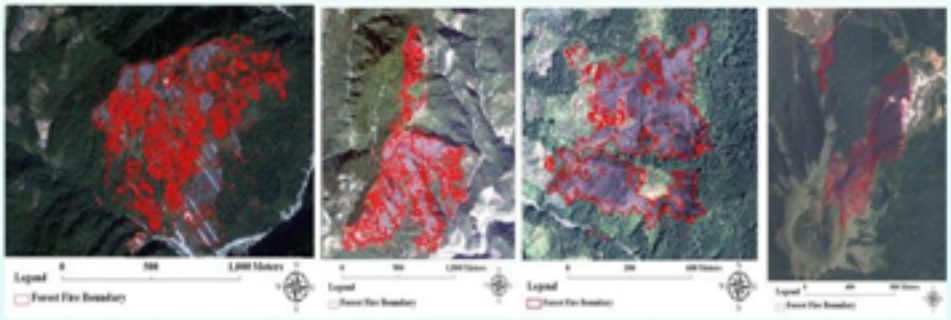
Emergency Standard Operating Graphic Data Procedures

- Surveying disaster location and information
- Surveying aerial and satellite data
- Interpret disaster location and mapping GIS data
- Providing images and vectors through web map services (WMS)



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Typhoon Morakot as an example

Task period	12th, Aug. ~ 11th, Sep., 2009
1/5000 Ortho-Image Produced	1,545
Total Flight Mileage	6,814 km (4,234 miles)

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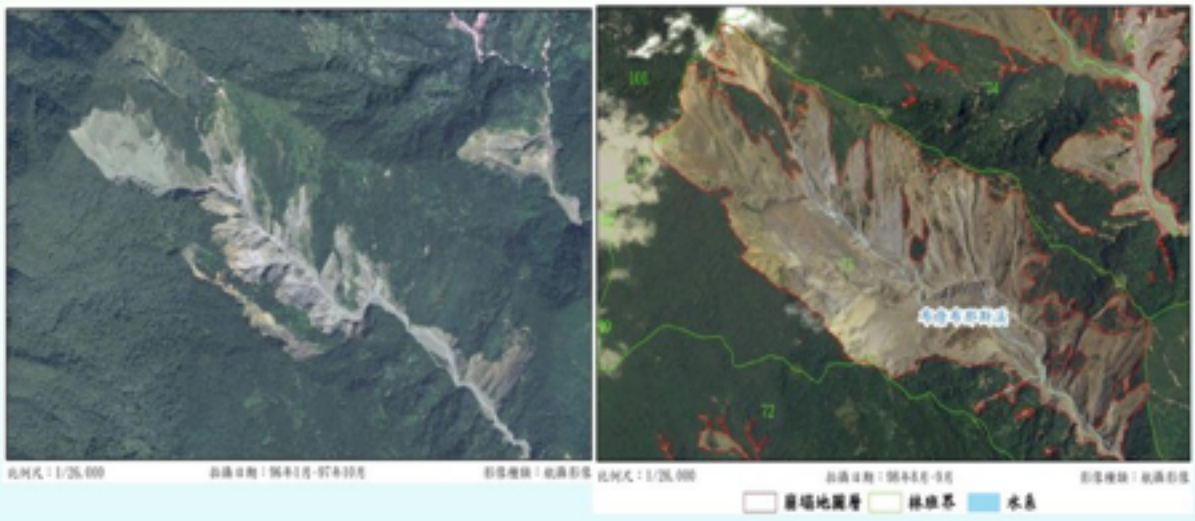
Comparison of Butangbunasu Stream Before and After Typhoon Morakot



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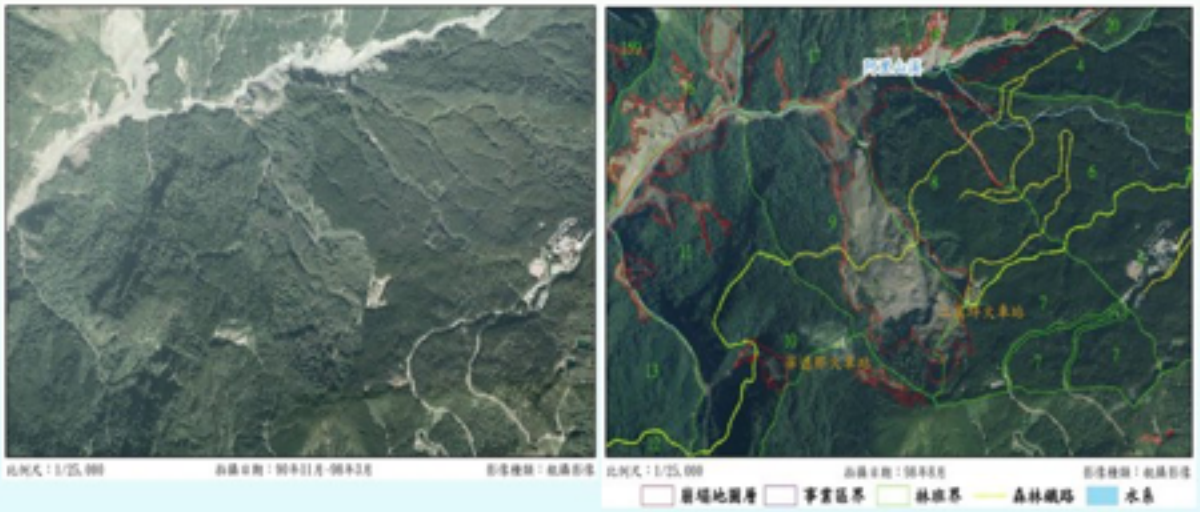
Comparison of Mt.Ali Train Station Before and After Typhoon Morakot



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Debris Flow Disaster Management

Hazard Response and Prediction

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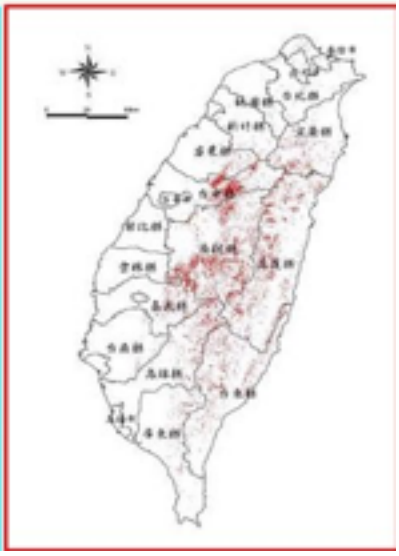
Investigation of Potential Debris Flow Torrents & Landslides

- *Potential Debris Flow Torrents*

1,678 Torrents

Potential Debris Flow Torrents

Historic Landslides Distribution



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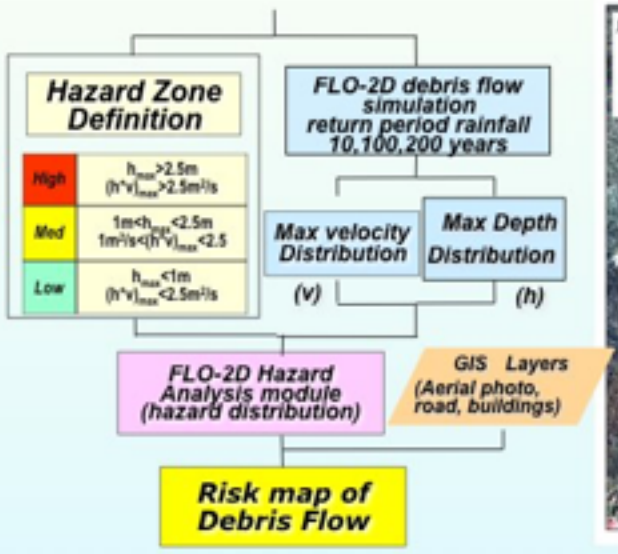
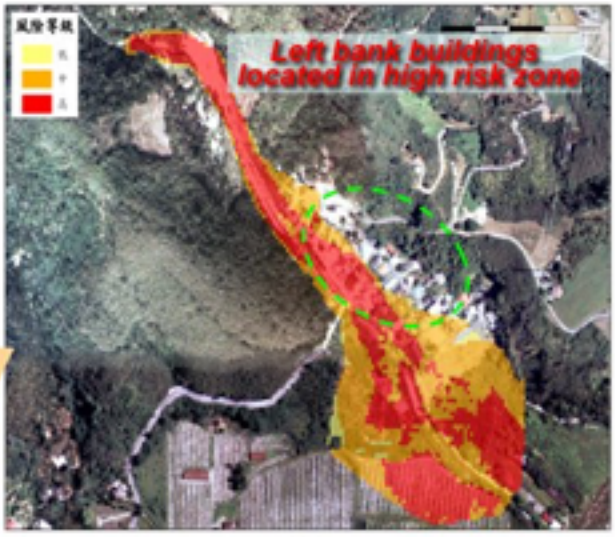
Risk Mapping

Debris Flow Risk Mapping



Warning Simulation of Debris Flow Disaster Condition



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Announce of Debris Flow Warning in Taiwan

- Rainfall Threshold for Debris Flow Warning : 200 ~ 600mm

Predict Rainfall > Threshold

Real Rainfall > Threshold

Accumulative rainfall

-30hr. -18hr. -12hr.

Sea typhoon alarm

Sea & land typhoon alarm

Yellow warning

Red warning

Rainfall forecast

Advise Evacuation

Enforce Evacuation

*Local government should **Advise** the inhabitants evacuation.*

*Local government should **Enforce** the inhabitants evacuation.*

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Evacuation Routes and Drills for Debris Flow Disaster Mitigation

Debris Flow Volunteer Specialist

- *662 Evacuation routes planned*
- *600 debris flow evacuation drills held*
- *1336 Debris Flow Volunteer Specialists*

Location of Evacuation Projects

Evacuation Route Map

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Debris Flow Emergency Operation Center of SWCB

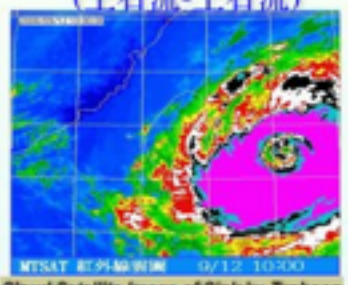
Emergency Response during Typhoon

- Rainfall monitoring: Every 10 min.
- Typhoon: Cloud satellite image
- Announce: Debris Flow Warning
- Inform emergency messengers
- Heavy equipments standby at dangerous areas

Toll-free Hotline

0800-246-246

(土石流-土石流)



Cloud Satellite Image of Sinlaku Typhoon

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Debris Flow Warning and Evacuation

- During the typhoon Morakot period, the SWCB had issued 21 debris flow warnings to the public and local governments based on the real-time weather information from CWB.

Debris flow warning	Warning ravines	County (City)	Town	Village
Red alarm	519	12	61	230
Yellow alarm	338	14	58	163

9,100 **people** were evacuated by local governments according to the warning. Among them, 1,046 **people** escaped from the possible casualties.

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Successful Evacuation

Shinshan village, Nantou County

*Although **21 houses** were destroyed by flash flood and debris flows, the **village head Ms. Mei-Ling Lin** (**also the debris flow volunteer specialist**) successfully evacuated **135 villagers** according to the red alarm issued by the COA (SWCB). No one got hurt. At least **63 people** escaped from the possible casualties.*

President Ma highly praised the village head

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Restrictions of Rainfall-based Debris-flow Warning Model & Solutions Thinking

Restriction A.

- Debris flow events are not enough to build a good forecast model.

Restriction B.

- Shortage of monitoring system.
- Uncertainty of the sequel rainfall.

Restriction C.

- Understanding of local residents is not enough

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Watershed-oriented Monitoring Network

- Point→Line→Plane: extended to upper stream and the source of debris, considering a whole watershed.
- Combining on-site, mobile, and grid stations.
- Integrating data from different agencies.

Emergency Operation Center 33

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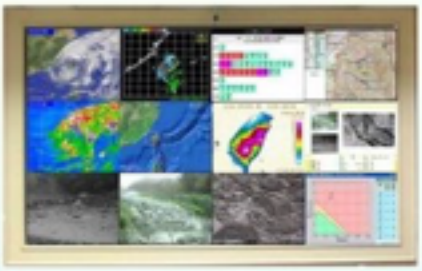
On-site (fixed) debris flow monitoring station

Monitoring Sensors

Satellite Transmission

Information Display



Instrumental cabin

Data-processing

Power-Supply

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Mobile Stations and Portable Units

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Apply QPESUMS for Rainfall Estimate

預測雨量整合

- *Forecast 1 and 3 hour rainfall*
- *Data analysis: compute the rainfall value in the villages and rainfall stations*
- *Assess the timing of warning declaration*

Shorten Evacuation time

Cooperation with NOAA, Water Resources Agency & Central Weather Bureau

Spatial resolution ：1.3km
Time resolution ：10min

Data reception → Analysis → Applications

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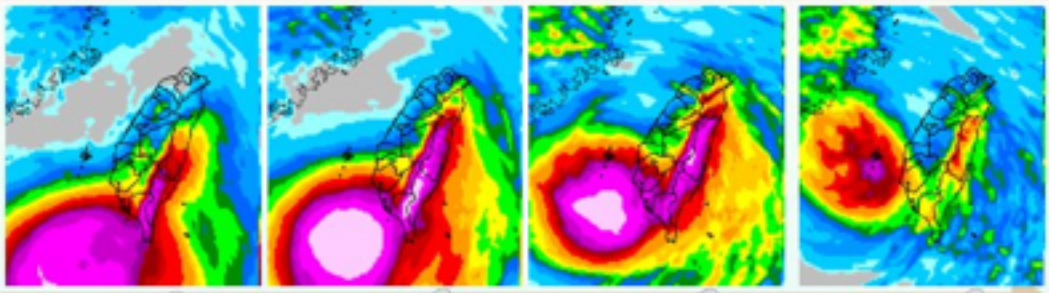
Forecasting Time: 9:00, July 7

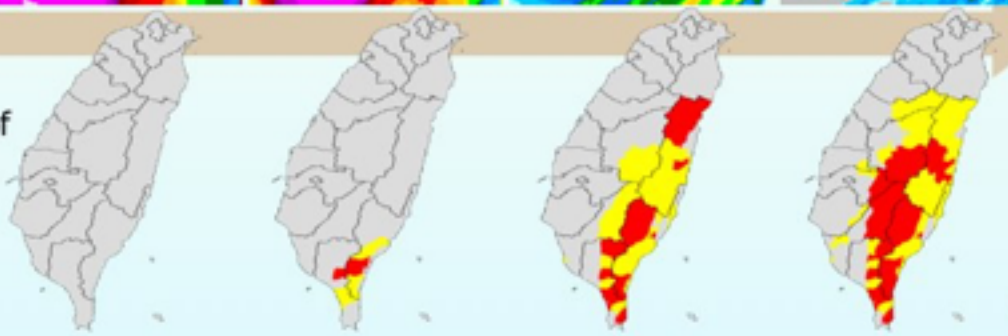
Warning	17:00 July 7th	05:00 July 8th	17:00 July 8th	05:00 July 9th
Yellow	0	3	32	47
Red	0	2	14	23

Rainfall Intensity

ETQPEF Model



Distribution of Warning



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Local Awareness & Preparation

- Expand the training of **Debris Flow Volunteer Specialist**
- **Disaster Resistant Community**
- Evacuation mechanism
- Evacuation routes, drills and propaganda

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Debris Flow Disaster Prevention in Education

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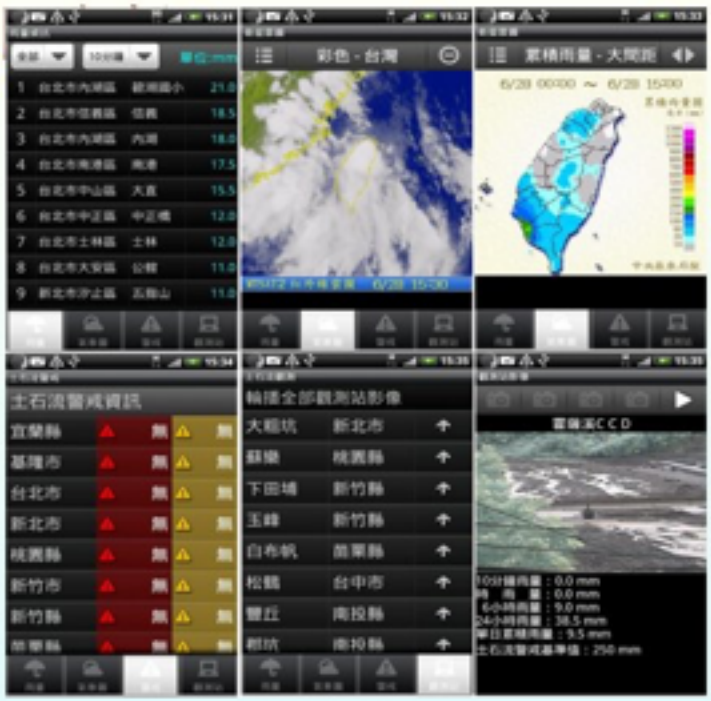
Application of Smartphone (APPs for iOS & Android system)

- *Realtime information :*
  - Ä *Rainfall*
  - Ä *Satellite image*
  - Ä *Announce of Debris Flow Warning*
  - Ä *Data of debris flow monitoring stations*
- *It lets residents easily know when to evacuate, and helps government to making decision anywhere*



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Application on Google Crisis Response
Real-time Information for Publishing and Response
Google Crisis Response
Making critical information more accessible in times of disaster


Thank You for Your Attention
Hope we can see you in Taiwan soon