Flood Control and Prevention under Climate Change Impact in Taiwan

Deputy Director-General
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Introduction
Challenges of Water Environment
Flood Control and Prevention Actions
Conclusions
Introduction
Geographic location of Taiwan

Area: 36,188 km²
Tallest Mount.: 3952-meter
Challenges of Water Environment
Typhoon routes across north-west Pacific Ocean in 2013
Natural Conditions

- Narrow and steep river valleys → Limited capacity of water storage

- Young and fragile geology
  → Tend to induce debris flows and form barrier lakes
  → Cause high turbidity of raw water
  → Cause sedimentation and driftwoods
### Natural Conditions

**High annual average rainfall,**

**Low annual precipitation per capita**

<table>
<thead>
<tr>
<th>Country</th>
<th>Annual rainfall (mm/yr)</th>
<th>Annual per capita of rainfall (cubic meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Philippines</td>
<td>2,502</td>
<td>4,074</td>
</tr>
<tr>
<td>Japan</td>
<td>2,360</td>
<td>9,320</td>
</tr>
<tr>
<td>India</td>
<td>1,718</td>
<td>5,114</td>
</tr>
<tr>
<td>England</td>
<td>1,170</td>
<td>3,795</td>
</tr>
<tr>
<td>Italy</td>
<td>1,064</td>
<td>4,415</td>
</tr>
<tr>
<td>US</td>
<td>1,000</td>
<td>5,258</td>
</tr>
<tr>
<td>France</td>
<td>750</td>
<td>25,565</td>
</tr>
<tr>
<td>China</td>
<td>660</td>
<td>7,001</td>
</tr>
<tr>
<td>Canada</td>
<td>522</td>
<td>4,958</td>
</tr>
<tr>
<td>Australia</td>
<td>460</td>
<td>167,100</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>100</td>
<td>188,550</td>
</tr>
<tr>
<td><strong>World</strong></td>
<td>973</td>
<td>21,796</td>
</tr>
</tbody>
</table>

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*Only 20% of the world avg.*

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18th thirstiest
**Hydro Features**

— Significant Impact from increased Frequencies of Flood and Drought Occurrences

### Annual Rainfall (1949~2010)

<table>
<thead>
<tr>
<th>Year</th>
<th>Rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet Year</td>
<td></td>
</tr>
<tr>
<td>1953</td>
<td>3,180</td>
</tr>
<tr>
<td>1972</td>
<td>3,240</td>
</tr>
<tr>
<td>1990</td>
<td>3,144</td>
</tr>
<tr>
<td>1998</td>
<td>3,322</td>
</tr>
<tr>
<td>2005</td>
<td>3,568</td>
</tr>
<tr>
<td>Dry Year</td>
<td></td>
</tr>
<tr>
<td>1963</td>
<td>1,830</td>
</tr>
<tr>
<td>1980</td>
<td>1,605</td>
</tr>
<tr>
<td>1993</td>
<td>1,645</td>
</tr>
<tr>
<td>2002</td>
<td>1,572</td>
</tr>
<tr>
<td>2010</td>
<td>2,334</td>
</tr>
</tbody>
</table>

Challenges of Water Environment

- **Hydro Features**
  - Significant Impact from increased Frequencies of Flood and Drought Occurrences
Extreme rainfalls lead to Multi-Hazards

- Extremely Torrential Rain
  - High Intensity → Large Peak Flow
  - Long Duration → Multi-Hazards
  - Wide Area → Widespread Disaster Area

- Mountain Collapse
- Fracture
- Flood
- Water Recourse/Bridge Infrastructures Damage
  - Channel/Reservoir Severely Deposits

- Debris flow
- Breaching
- Mud Deposits
- Barrier Lake
Most vulnerable place to natural hazards on Earth

Over 90% of population in Taiwan is threatened by two types of hazards

Natural hazards: Earthquake, Typhoon, Flood, and Drought

2009 Typhoon Morakot

Morakot Rainfall features
- Long, intensive and wide coverage
- More than 50mm/hr for 24 hours in certain area
- Biggest accumulated rainfall 2,884mm

Record-breaking disasters
2012 Typhoon Tembin

Record-breaking (daily, hourly) rainfall hit Hengchun

Floods hit 3 local hospitals

Checheng rainfall station
151.5 mm/ highest hourly rainfall, reaching 415 mm in 6 hours

Hengchun rainfall station
167.5 mm/ highest hourly rainfall, reaching 464 mm in 6 hours

County | Flood areas
---|---
Pingtung County | 26 areas
Flood Control and Prevention actions
Flood control and prevention principles

A. Promote land use planning based on disaster prevention concept – Runoff Distribution and Outflow Control

B. Accelerate flood control and disaster rehabilitation works

C. Establish comprehensive disaster defense and preparation system

D. Empower local and public abilities to disaster defense

Engineering measures + Non-engineering measures
A. Promote land use planning based on disaster prevention concept – Runoff Distribution and Outflow Control

- Highly vulnerable area (flood-prone and severe land subsidence areas) should be restricted to develop.
- Natural resources should be considered for land use planning.
Climate Change Impact
- Increase frequency of extreme rainfall
- High intensity rainfall
- Long duration rainfall

Urbanization
- Rainwater storage capacity reduced
- Short concentration time
- Peak discharge increased

Flood discharge exceeded
- Flood discharge exceeds river and regional drainage volume
- Designed flood control facilities based on historical records are no longer adequate for the need

Exceed Capacity of Flood Control Facility

Climate change impact

New Strategy

Runoff Distribution

Outflow control
Framework of Runoff Distribution and Outflow Control promotion

- Integrated river-basin management
  - current flow calculation
  - Comprehensive water control strategies
  - Runoff Distribution
  - Outflow Control

- Consider watershed land use

- Competent authorities adopt comprehensive water control strategies ensure runoff emissions less than planned $Q < Q_{allow}$

- Integrated rain water sewer flow and regional drainage
- Changing urban planning or regional plan
- land use and drainage monitoring and verifying

- All types of drainage interface convergence

- Outflow calculation
  - Regulation of river (including flood diversion way)
  - Large Detention/Retention Facilities

- Land development outflow control
  - Water authorities ensure no peak discharge increment by drainage projects control
  - $Q_{post} \leq \text{Min}(Q_{pre}, Q_{allow})$
Region of applicability

Watershed Conservation
- Rainwater sewer (CPAMI)
- Agricultural drain (COA, EY)
- Crops preservation (AFA, COA, EY)
- Aquaculture drainage (FA, COA, EY)
- Outflow Control
- Bridge reconstruction (MOTC)
- Drainage Section (WRA, MOEA)

Hillside water conservation (SWCB, COA, EY)

Low Impact Development (CPAMI)

Project work items (central competent authorities)
B. Accelerate flood control and disaster rehabilitation works

Governments have invested over 5.69 billion US dollars in flood control and regulation works for flood-prone areas over the period from 2006 to 2013. In the next 6 years, another 4.07 billion will be invested.

Case 1: Flood regulation work in Tainan County

Case 2: Detention pond in Chia-Yi County
## Rivers, Drainages, Coastal Area Regulation Budget

<table>
<thead>
<tr>
<th>Classification</th>
<th>Items</th>
<th>Region of regulation</th>
<th>2009~2014 Budget (billion)</th>
<th>2015~2020 Budget (billion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central government jurisdiction</td>
<td>river</td>
<td>26 rivers</td>
<td>2.44</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>drainage</td>
<td>42 drainages</td>
<td>0.40</td>
<td>0.40</td>
</tr>
<tr>
<td></td>
<td>coastal</td>
<td>-</td>
<td>0.18</td>
<td>0.27</td>
</tr>
<tr>
<td>Classification</td>
<td>Items</td>
<td>Region of regulation</td>
<td>2006~2013 Budget (billion)</td>
<td>2014~2019 Budget (billion)</td>
</tr>
<tr>
<td>Local government jurisdiction</td>
<td>river</td>
<td>92 rivers</td>
<td>2.67</td>
<td>1.40</td>
</tr>
<tr>
<td></td>
<td>drainage</td>
<td>1,615 drainages</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Example of effective regulation project for flood-prone area during Typhoon Kong-Rey 2013

<table>
<thead>
<tr>
<th>Inundation events</th>
<th>Typhoon Kong-Rey, 2013</th>
<th>Typhoon Kalmaegi, 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfall (mm.)</td>
<td>636</td>
<td>508</td>
</tr>
<tr>
<td>Inundation area (ha.)</td>
<td>8,089</td>
<td>11,448</td>
</tr>
<tr>
<td>Inundation depth (m)</td>
<td>0.3 ~ 1.2</td>
<td>0.2 ~ 1.5</td>
</tr>
<tr>
<td>Inundation duration (day)</td>
<td>0.5</td>
<td>1</td>
</tr>
</tbody>
</table>
C. Establish comprehensive disaster defense and preparation system

- **Flood Disaster**: Different emergency operation/response systems respond to different 24-hour accumulated rainfalls.

Central Emergency Operation Center (Executive Yuan)

MOEA proposes to set up

Emergency Response Teams of Ministry of Economic Affairs

WRA proposes to set up

Emergency Response Teams of Water Resources Agency

Extremely Torrential Rain

Torrential Rain

Extremely Heavy Rain

Heavy Rain
Reinforce disaster warning system and evacuation plan to achieve the goal of zero casualty and minimum loss.
Varify disaster prevention tools with the aid of information and communication technology

- **Smart Phones APP**
  - iPhone
  - Android
  - Win8

- **WRA Websites**
  - fhy.wra.gov.tw

- **Facebook**

- **Landlines/Cellular Phones**

- **Enterprise/Communities**
  - 7-ELEVEN google.org
Landlines broadcasting system

- Disabled Assistance Organization
  - 268
- Nursing Home
  - 1033
- Schools
- M.Camps
  - 72
- Industrial
  - 138
- General Public

LV.1 Warning

Landlines
Registration
On internet

※4 workshops held in Taiwan
The WRA has a system set up with 7-11. Inundation warning information is updated hourly and alert message is replayed for 10 seconds every 10 minutes
Government - Private Cooperation

- integrate civil power into hazard prevention and mitigation mechanism

- 264 Disaster resistant communities
- 1560 Flood volunteers

8600 sites for reporting flooding areas

Disaster investigation reports by enterprises and public

Disaster prevention practice

Flood volunteers
D. Empower local and public abilities to disaster defense

- Assist local governments making prevention plan

Flood Potential Map

Evacuation Map

With these maps, local governments can make hazard prevention/mitigation plan, such as designing the evacuation routes, preparing pumps, sandbags in response to flood potential.
1. Extreme weather conditions caused by climate change, such as drought, storm, and flood would not stop. **Only positive response and co-existence with nature could take us through.**

2. Water environment is complicated. **Only through endless professional research that we can find problems and solutions, building up proper adaptive action plan.**
3. Water issues relate to almost all fields. Authorities concerned in water resource management can not fight on their own. Coordination of cross-sectoral functions will be our major focus.

4. Cooperation between private and public sectors will lead to consensus and create projects fulfill all needs, so as to establish no-regret, trusted and low-risk environment for quality life.

5. Connect to the world via “global view and local perspective”, share experiences and learn from one another.
Thank you for your attention.