Flood Management in Japan

“Making space for water” in innovative ways under land limitation

JICA River Management Advisor
AKIHISA OKUDA
1. Japan’s National Land Conditions

2. Comprehensive Flood Control Measures
   - River Measures
   - Basin Measures
   - Damage Reduction Measures

3. Recent Developments
Japan, a country of mountains

About 70% of its national land is mountainous.

Naka river in Shikoku region
<table>
<thead>
<tr>
<th>Japan</th>
<th>The Netherlands</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Geography</strong></td>
<td><strong>Geography</strong></td>
</tr>
<tr>
<td>• Area: 378,000km(^2)</td>
<td>• Area: 42,000km(^2)</td>
</tr>
<tr>
<td>• Many short steep rivers.</td>
<td>• Rhine River, Maas River, Schelde River as mild slope international river</td>
</tr>
<tr>
<td>• Sediment problems because of poor soil</td>
<td>• Delta and low area</td>
</tr>
<tr>
<td>• Flood plain area is located by alluvial fan and riverside</td>
<td></td>
</tr>
<tr>
<td>• Population: 127.4 mil. (Density 337.1 /km(^2))</td>
<td>• Population: 16.6 mil. (Density 400.4 /km(^2))</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>River</th>
<th>Name of River</th>
<th>Tone River</th>
<th>Rhine River</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basin Area</td>
<td>About 17,000km(^2)</td>
<td>About 185,000km(^2)</td>
<td></td>
</tr>
<tr>
<td>length of river</td>
<td>322km</td>
<td>1,320km</td>
<td></td>
</tr>
<tr>
<td>Average bed slope</td>
<td>About 1/175</td>
<td>About 1/2,600</td>
<td></td>
</tr>
<tr>
<td>largest flow discharge</td>
<td>17,000m(^3)/s (1947)</td>
<td>13,000m(^3)/s (1926)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Climate</th>
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</tr>
</thead>
<tbody>
<tr>
<td>annual mean rainfall</td>
<td>1,718mm</td>
</tr>
<tr>
<td>100 year daily precipitation</td>
<td>376mm (Tokyo)</td>
</tr>
<tr>
<td>100 year hourly precipitation</td>
<td>94mm (Tokyo)</td>
</tr>
</tbody>
</table>
Vulnerability to water hazards

- **Proportion of assets**: Approx. 75%
- **Proportion of population**: Approx. 50%
- **Proportion of land area**: Approx. 10%

Source: Japan Rivers, Learning to Live with River, CIA The World Fact book

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Topography of Tokyo

- **Altitude (m)**: ranging from -10 to 40
- **Regions**: Kita-ku, Arakawa-ku, Adachi-ku, Katsushika-ku, Misato City, Matsudo City

- **Rivers**: Sumida River, Arakawa River, Ayase River, Naka River, Obra River, Edo River, Saka River, Shinsaka River, Joban Line, Musashino Line, National Route 6

Source: Japan Rivers, Learning to Live with River, CIA The World Fact book
Typhoon Kathleen (1947) killed more than 1,100 people and submerged over 300,000 houses in Tokyo area.

A dike in Tone River collapsed and floods reached as far as Tokyo.
Typhoon Vera (Typhoon Ise Bay) in 1959 left 5,098 persons dead or missing, 38,921 injured, and some 1.2 million houses damaged.

- Dikes collapsed because of storm surge and river flood. Drifting woods increased casualties.
- Low-lying areas continued to be covered with water for more than 120 days.

Source: *Jidai ni Hikitsugu ano Kyokun Isewan Taifu* (Handing down the Lessons Learned from the Ise Bay Typhoon to the Next Generation) compiled by the Executive Committee of the 30-year Ise Bay Typhoon Project

Excluding figures for the Kyushu region.
Significant Decrease in Number of Casualties Due to Implementation of Continuous Flood Control Measures

Number of dead and missing (Persons)

- Typhoon Kathleen
- Torrential Rains in Southern Kii
- Toyama Typhoon
- Isewan Typhoon

First flood control plan (5 years)
Second
Third
Fourth
Fifth
Sixth
Seventh
Eighth
Ninth flood control plan (7 years)

First priority plan for social infrastructure development

1. Japan’s National Land Conditions

2. Comprehensive Flood Control Measures
   - River Measures
   - Basin Measures
   - Damage Reduction Measures

3. Recent Developments
River Measures

- Dams, retarding basins and discharge channels
- River improvement (embanking, dredging)

Basin Measures

Water retaining area
- Preservation of natural / agricultural lands
- Flood control ponds
- Rainwater storage facilities
- Permeable pavements and rainwater infiltration inlets

Water retarding area
- Preservation of natural / agricultural lands, restriction of constructing mounds

Lowland area
- Drainage facilities
- Floodwater storage facilities
- Promotion of flood resistant buildings

Damage Reduction Measures

- Warning and evacuation systems
- Flood-fighting
- Announcement of inundation records and flood hazard areas
- Promotion of flood resistant buildings
- Awareness raising of local residents

River Administrator

Basin Authority (Prefectures, Municipalities)

River Administrator

Basin authority
River Measures
River channel improvement
Construction of levees
Integrated operation of existing dams

Optimum capacity re-division of related dams based on present situations of dam operation, precipitation and flow characteristics of each sub basin.
Ara River First Retarding Basin

- **Location**: Saitama City & Toda City, Saitama Pref.
  (28.8 - 37.2km from estuary of Arakawa river)
- **Operation Start**: Year 2003
- **Area of Reservoir**: 580 ha
- **Total Capacity for Flood Control**: 39 mil. m³
- **Valid Capacity**: 10.6 mil. m³
- **Control volume**: 850m³/sec

Flood Control in Aug. 2006

Photo by Arakawa Upstream River Office
Retarding basin (Kitakami river)
For the Ara River running through Tokyo, a floodway was constructed following the great flood of 1910.

Population in Tokyo city
3.7 million (1920)
12.6 million (2005)

Construction: 1913 – 1930
Length: 22 km
Discharge Channel (Hii river)

Japan Sea (Taisha Bay)

Discharge channel (widening)

Discharge channel (excavation)

Under construction

Kando river

Hii river
The floodway was constructed to drain floodwater in low-lying Naka river basin (suburban Tokyo), where frequent inundation caused severe damage. Due to the land restriction, the floodway was build underground.
**Underground discharge tunnel (Outer metropolitan area)**

**Shafts** Shafts Nos. 1 to 5
- Shaft No.1: Inside diameter 31.6m, Depth 71m
- Shaft No.2: Inside diameter 31.6m, Depth 63m
- Shaft No.4: Inside diameter 25.1m, Depth 63m
- Shaft No.5: Inside diameter 15m, Depth 65m

**Shaft No.3:** Inside diameter 31.6m, depth: 68m

**Tunnel**
- Length: 6.3km
- Inside diameter: About 11m
- Depth: About 50m

**Surge tank**
- Length: 177m
- Width: 78m
- Height: 25.4m
- Piller (Number 59, Height: 18m)

**Gas Turbines x 4**
- Discharge: 50m³/s

**Pumps**
- Maximum discharge: 200m³/s

**Wheel**
Super Levees to avoid a catastrophic disaster

High-standard levees are built in order to prevent catastrophic damage due to dyke breach in low-lying highly urbanized areas, such as Tokyo and Osaka.
Super Levees (effects of disaster reduction)

With their extreme width, built in tandem with urban renovation projects, super levees can withstand
1) Overtopping flow,
2) Seepage during floods,
3) Earthquake (liquefaction and landslides).

High standard levee

Integrated urban planning and super levee zone

Levee height (h)

Special high standard zone: 30h (About 30 times the levee height)

River zone
Super Levees (effects of urban landscape, environment)

Super levees can enrich urban environment by creating open public spaces along the river.

Arakawa River and Shinden districts in Adachi City
Basin Measures
Due to the rapid increase of population, plateaus and hilly areas near large cities were developed rapidly on a large scale.

Tsurumi River (Tokyo and Kanagawa Pref.)

1958
Urbanization rate: 10%

1975
Urbanization rate: 60%

1997
Urbanization rate 84.3%
Progress of urbanization heighten the risk of flood on low grounds

**Before Development**
Most of rainwater is infiltrated into the ground or reserved in paddy fields: the flow into the downstream is controlled.

**After Development**
Since the surface has been covered by concrete or asphalt, and forests and paddy fields have disappeared, the water flow to the downstream has increased.

The background for the introduction of “Basin Measures”
Flood control ponds

Kirigaoka reservoirs
(Tsurumi river)

normally

flooded
Storing rainwater in a schoolyard

normally

flooded
Permeable pavements

- permeable pavement
- permeable tile pavement

Tokyo
Rainwater storage between buildings in apartment complexes
Damage Reduction Measures
Increase of Damage Potential due to Urbanization

Flood damage in Fukuoka City (June, 1999)
A city with approximately 1.5 million people.

Urban area were flooded with some 1 meter high
Submergence at the underground facilities in urban areas

Oct. 2004
Azabu-juban Sta.
(Tokyo metro)

Jul. 2003
Hakata Sta.
(Fukuoka municipal subway)
Increase of vulnerability due to the aging population

Most of fatalities and missing (60%) are aged persons

Notes: 1. The graph above totals the 145 fatalities and missing caused by the flood and landslide disasters out of the 232 fatalities and missing caused by main typhoons and flood disasters.
2. We classified the victims according to the ages and main causes of death or missing based on the Fire Agency disaster information. For the unknown parts, we refer to the newspapers and the results of the hearing survey conducted by the government research group; some explanations are added by the River bureau and classified.
Designation and publication of flood-prone areas

Based on the article 14 of the flood-fighting Act, river administrators (MLIT and prefectural governments) designate areas that may be inundated in the event of flooding as flood-prone areas.
Preparation and dissemination of flood hazard maps

Based on the article 15 of the flood-fighting Act, municipalities prepare and disseminate flood hazard maps to residents on the basis of flood-prone area maps.

Information transmission routes
Names, locations of evacuation sites
Contact information (government offices, hospitals, public utilities)
Location of underground facilities
Tips, things to bring when evacuating
Designated flood-prone area and expected depth
Flood-related symbols
JIS Z8210:2006

[Flood]
This symbol indicates that the area concerned may be affected by floods.

[Evacuation site (building)]
This symbol shows a safe building that provides a shelter when a disaster occurs.

Indication of Flood Hazards in Town
Provision of river information

Provision of river information by MLIT in real time, 24 hours a day, 365 days a year.

Nationwide data are measured and sent by telemetry

Data are collected, processed and edited into an easy-to-use form and transmitted

Collection
Data from 17,300 stations nationwide every 10 minutes.

Processing • Editing
Into easily understood tables, graphs, maps, diagrams etc.

Transmission
(Information by time/location provided as needed)

Sent to users

River manager
Municipalities
State depts.

Flood
Radar rainfall data
River water level/flow rate
Rainfall measurements
Landslides
Dam influx/discharge
Provision of River information by mobile phone

Information provided on the internet

Contents
- Precipitation by hyetometer
- Precipitation by radar rain gages
- Water level etc.
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3. Recent Developments
Damage caused by torrential downpour in Chugoku and Northern Kyushu districts in July 2009

- Hourly rainfall of 116 mm (Fukuoka city, Fukuoka pref. (Hakata))
- Hourly rainfall of 72.5 mm (Hofu city, Yamaguchi pref. (Hofu))
- Damage caused by debris flow, etc. in Northern Kyushu and Chugoku districts

Deaths: 31
Houses flooded above floor level: 2,152, Below floor level: 9,285

※H21.9.3現在（消防庁発表）

Damage caused by "guerrilla downpour" in Itabashi Ward, Tokyo on July 5, 2010

- Hourly rainfall of 114 mm (Itabashi Observation Station (Shakujii River Basin))
- Hourly rainfall of 82 mm (Aogishi Bridge Observation Station (Zanbori River Basin))
- Shakujii River flooded, causing inundation damage in Itabashi.
  Houses flooded above floor level: 58, Below floor level: 50

※数値は速報値

Itabashi Observation Station

Change of water level in Shakujii River

Water level rose by 3.45 m in 10 minutes from 19:50 to 20:00.
Occurrence of Heavy Rain with Total Rainfall of over 1,000 mm

**2005**
- Total rainfall of over 1,000 mm due to Typhoon No.14 (Southern Kyushu)
- Oyodo and Gokase Rivers overflowed their banks

<table>
<thead>
<tr>
<th>Region</th>
<th>Deaths</th>
<th>Houses flooded above floor level</th>
<th>Houses flooded below floor level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chugoku Region</td>
<td>4</td>
<td>1,678</td>
<td>2,969</td>
</tr>
<tr>
<td>Kyushu Region</td>
<td>19</td>
<td>3,960</td>
<td>5,085</td>
</tr>
</tbody>
</table>

**2006**
- Total rainfall of over 1,200 mm due to torrential downpour in July
- Sendai and Komenotsu Rivers overflowed their banks

<table>
<thead>
<tr>
<th>Event</th>
<th>Deaths</th>
<th>Houses flooded above floor level</th>
<th>Houses flooded below floor level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Torrential downpour in July</td>
<td>5</td>
<td>899</td>
<td>2,674</td>
</tr>
</tbody>
</table>

**2007**
- Total rainfall of over 1,000 mm due to Typhoon No.4
- Midori River caused inundation damage

<table>
<thead>
<tr>
<th>Typhoon No.4</th>
<th>Deaths</th>
<th>Houses flooded above floor level</th>
<th>Houses flooded below floor level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
<td>169</td>
<td>1,152</td>
</tr>
</tbody>
</table>

**2010**
- Total rainfall of over 1,200 mm due to torrential downpour on seasonal rain front in July
- Slope failure occurred in Kagoshima Prefecture, etc.

<table>
<thead>
<tr>
<th>Seasonal rain front, etc.</th>
<th>Deaths</th>
<th>Houses flooded above floor level</th>
<th>Houses flooded below floor level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12</td>
<td>1,921</td>
<td>3,821</td>
</tr>
</tbody>
</table>

Deaths: 4
Houses flooded above floor level: 1,678
Houses flooded below floor level: 2,969

Deaths: 19
Houses flooded above floor level: 3,960
Houses flooded below floor level: 5,085

Deaths: 5
Houses flooded above floor level: 899
Houses flooded below floor level: 2,674

Deaths: 3
Houses flooded above floor level: 169
Houses flooded below floor level: 1,152

Deaths: 12
Houses flooded above floor level: 1,921
Houses flooded below floor level: 3,821

Deaths: 4
Houses flooded above floor level: 1,678
Houses flooded below floor level: 2,969
Increase of intense rainfall

Occurrence of hourly rainfall over 50mm is significantly increasing

- The annual number of occurrence of over 50mm/hr precipitation
- Analyzed with 1,300 national AMEDAS spot data
- Per 1000 spots

Source: JMA

Number of days with rainfall over 200mm is increasing

(observation value of 51 spots nationwide)

Source: JMA
Recommendation

Multiple implementation of “Basin Measures” to counteract the growing external forces in addition to “River Measures” where the principal emphasis is placed on coping with a certain design discharge through river channel improvement and the construction of flood control facilities.

Those policies in river basins involve
(i) flood control facilities such as retarding basins,
(ii) runoff control facilities such as regulating reservoirs and rainwater storage and infiltration facilities,
(iii) the use of setback (secondary) levees, ring dikes, roads and railroad embankments to prevent the spread of flood water
and should be applied with proper consideration of the mode of local land use.
Designated as “disaster hazard zone” (bylaw based on the Building Standards Act)

Flood control measures in concert with land use

An ordinary method (takes long time to complete)

Application of more flexible methods

Example (Ring Levee along Omono River)
1) Preserve or create the environment for the inhabitation, growth, bleeding of natural life, which rivers inherently have.

2) Preserve or create the diversity of river landscapes

3) Consideration for harmonization with lives, history and cultures of each region
Utilization of the characteristics and mechanism of river environment

1. Preserve or create the environment for Inhabitation, growth, bleeding of natural life, which rivers inherently have.
   e.g. creation of the transition zone (ecotone)

2. Preserve or create intricate geomorphologic features by utilizing works of rivers themselves.
   e.g. riffles and pools, riverside forest
“Basic guidelines for Nature-oriented river works”
October 2006

Utilization of the characteristics and mechanism of river environment

3. Ensure space to allow for the works of rivers.
   e.g. Large river width to promote formation of a good water route
   Disturbance of river and land by floods

4. Preserve and restore river continuity
   e.g. fish ways

5. Enrich river landscape
Combination of flood control works and creation of wetland

After a devastating flood in 2004, river excavation was implemented. The work contributes to both increase flow capacity and creation of wetlands for storks.
When the river was widened to increase flood capacity, a meandering channel alongside a hill was preserved.
Flood Management in Japan

Characteristics

• Consistent Basin-based comprehensive flood management plans, according to respective characteristics of basins

• Combination of various “Hard (structural)” and “Soft (non-structural)” measures

• Innovative measures to under the constraints due to the land limitation

In the face of the Climate Change...

• Further development is needed to “make space for water” through the utilization of limited land.
Dank u zeer veel.

*Kereppu* (Krib) groyne in Kiso river,
Introduced by Johannis de Rijke in Meiji era