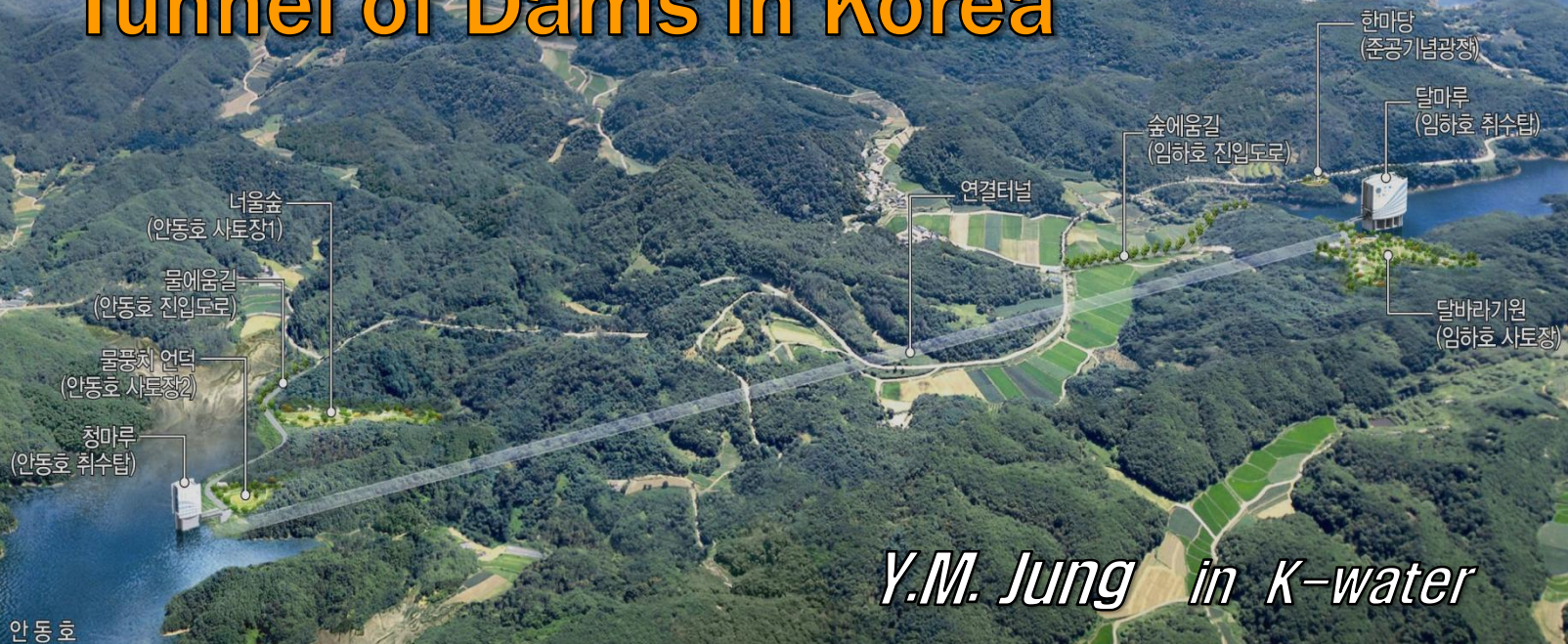


# The Strategy for Securing Water Resources through Connection with the Tunnel of Dams in Korea



*Y.M. Jung in K-water*



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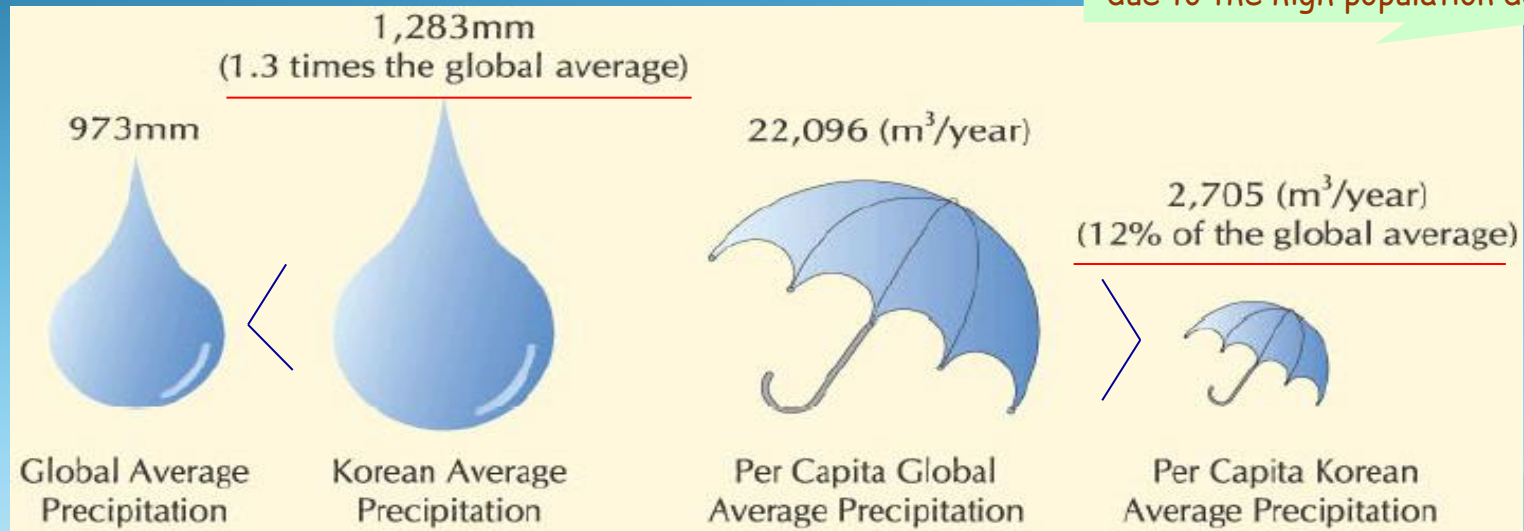




# Introduction

# I . Introduction

## ● Precipitation



- annual precipitation of Korea is 1.3 times higher than that of the global
- precipitation per capita of Korea is **only 1/8 of the global average**
- 70% of the **precipitation is concentrated** from June to September



# I . Introduction

## ● Topography

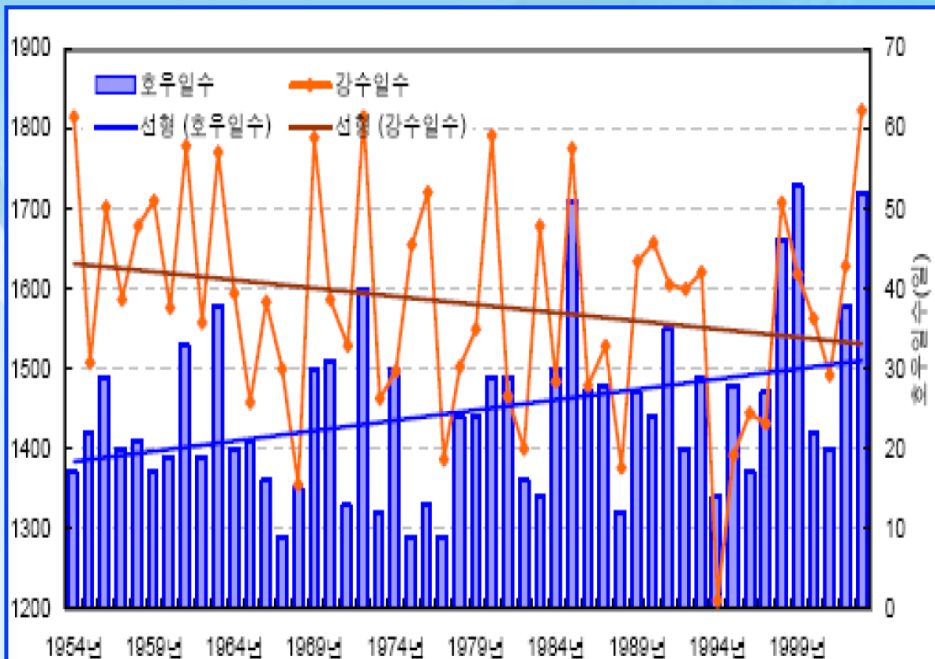
- **Total Area : 222,135 km<sup>2</sup>**  
(100,000 km<sup>2</sup> for South Korea  
; forest 65.7%, farmland 21.9%, ...)
- **About 70% of land is mountainous**  
(river slopes are steep)
- **Most rivers flow into the west and south sea**
- **floods run off immediately**



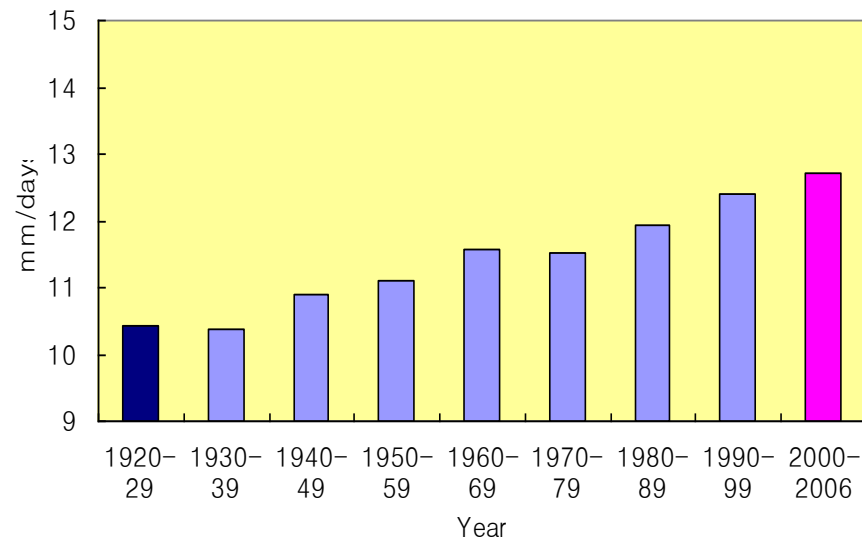
# I . Introduction

## ● Unexpected Climate

- Precipitation pattern changed by unexpected climate (recent 20years)
  - Annual precip. 7%↑, Rainy days 14%↓, Intensity 18%↑
- Imply the necessity of **risk management**
  - drought, flood, dam break, etc.



## <Increase of Intensity of Precipitation>



# I . Introduction

## ● Dams in Korea

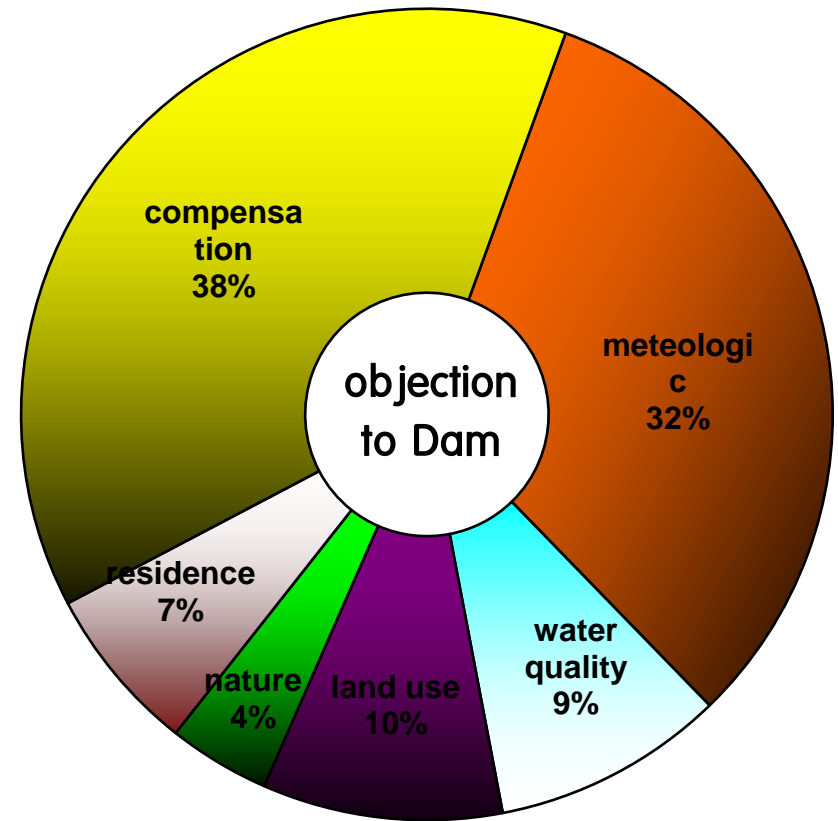


- **Present** : Totally 18,000 dams
  - 15 Multi-purpose / 14 Water supply / Others (Irrigation, etc.)
  - Water Supply( $17.7 \text{ km}^3/\text{yr}$ ), Flood Control( $2.8 \text{ km}^3$ )
- **Under construction (~ 2012)**
  - 5 Multi-purpose
  - Water Supply( $95 \text{ km}^3/\text{yr}$ ), Flood Control( $360 \text{ km}^3$ )
- **Future (~2016)**
  - 7 Small size and rehabilitation of agricultural dams(2)
  - Water Supply( $0.76 \text{ km}^3/\text{yr}$ )

# I . Introduction

## ● Difficult new dam project

- Dam construction is large-scale development
- It's becoming more difficult due to the
  - shortage of appropriate location
  - damage to environments
  - objections from residents
- need alternative method of solving water problem



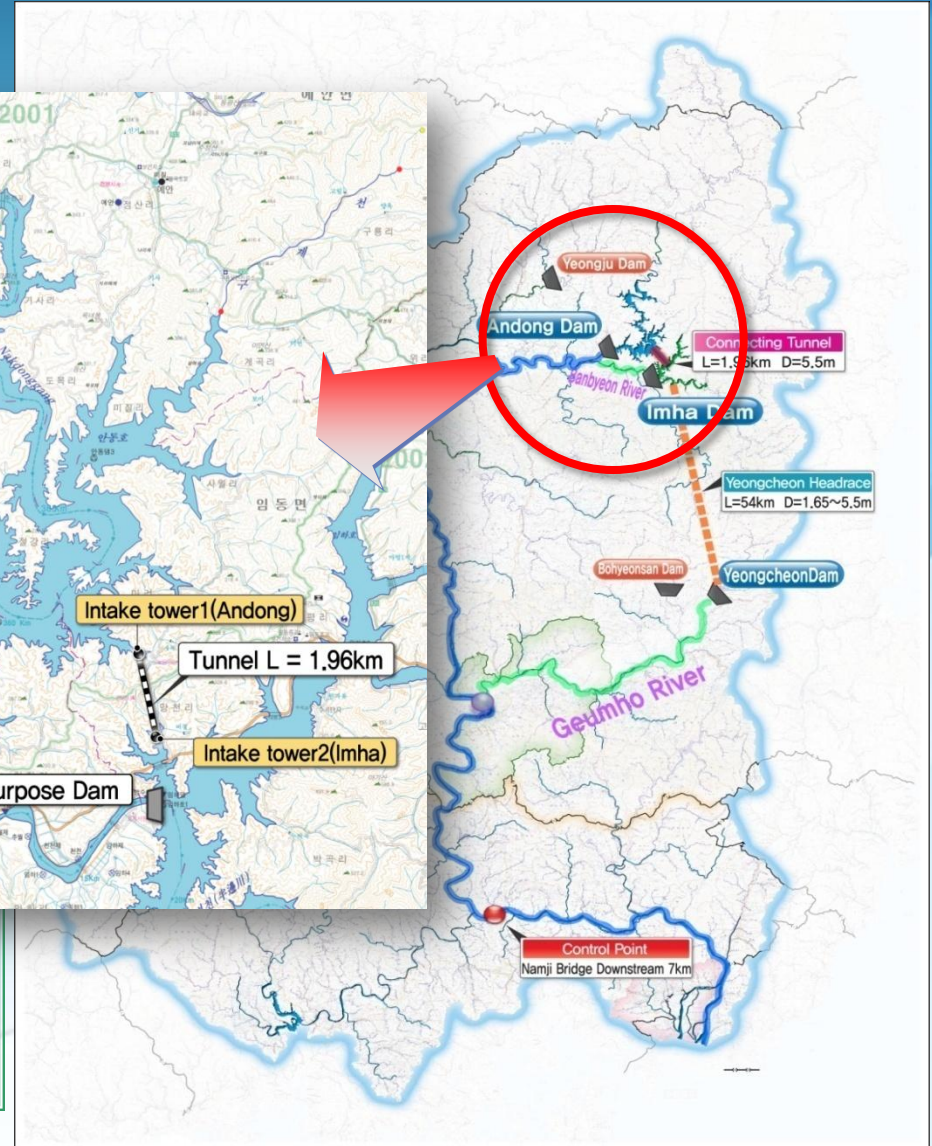
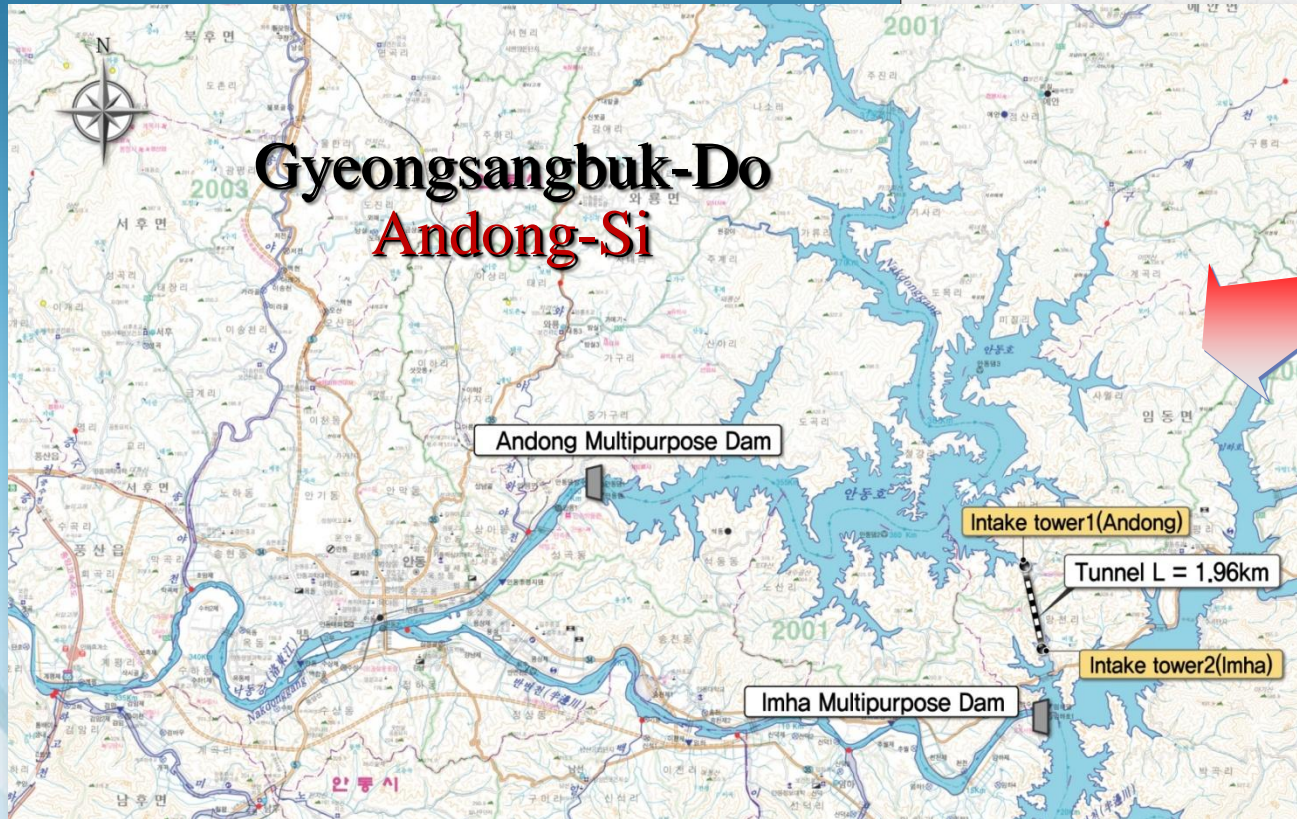




## Methodology

# II. Connecting existing Dams

## ● Location & Description

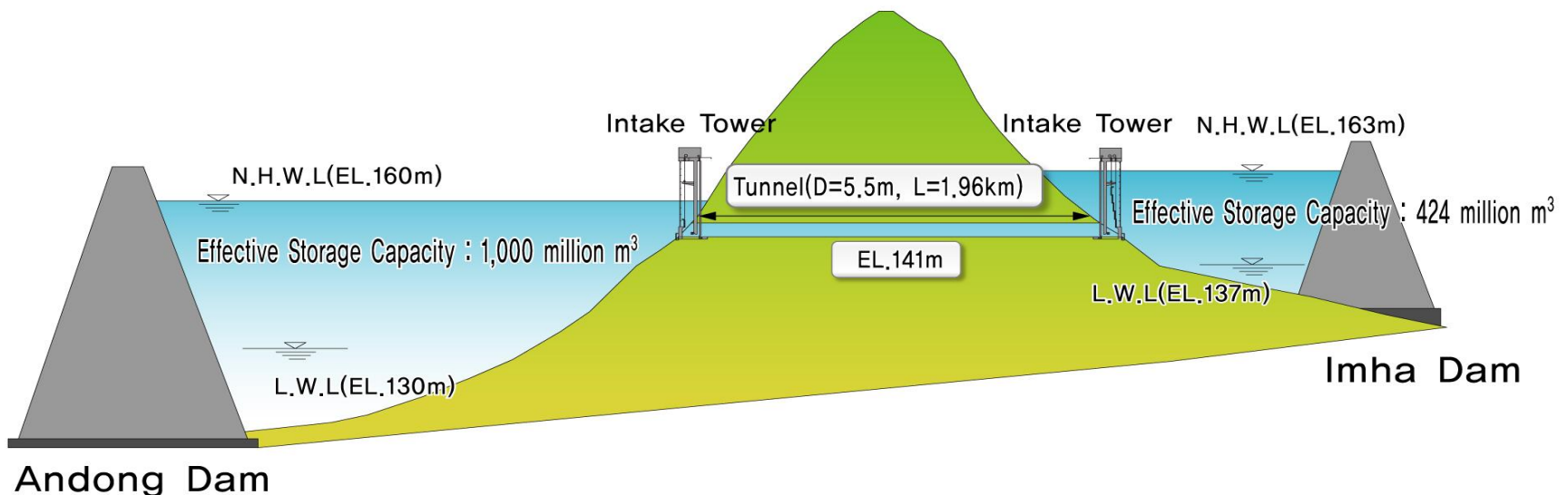


basins

# II. Connecting existing Dams

## Dam connection project

- **Definition :** Securing abundant water resources,  
Improving water quality (Nakdong and Geumho rivers)
- **Scope :** connecting tunnel(D=5.5m, L=1.96km), 2-Intake tower ,  
facilities as access road
- **Effect :** Supplementary water supply 24 million m<sup>3</sup> / yr

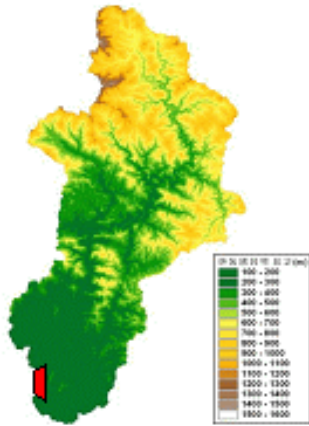
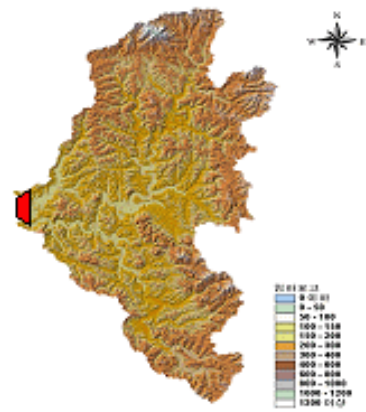




# II. Connecting existing Dams

## ● Information of two Dams

- Similar basin area but highly storage capacity difference (double)
- In Imha, frequently occur spillway discharge (7/17 yrs) by basin form

Basin contents	Andong Dam	Imha Dam
DEM		
Basin area	1,584km <sup>2</sup>	1,361km <sup>2</sup>
Shape	Thin, long, rectangle	Fan-shaped actiniform
Storage capacity	12 billion m <sup>3</sup>	6 billion m <sup>3</sup>
Water usable	84%	38.7%
Spillway frequency	2 in 34years (fourth)	7 in 17years (twelfth)

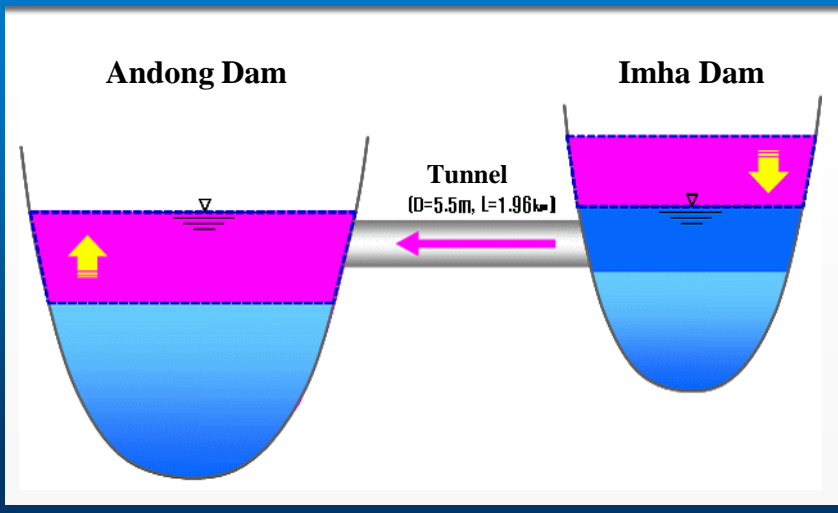
# II. Connecting existing Dams

## ● Water securing concept

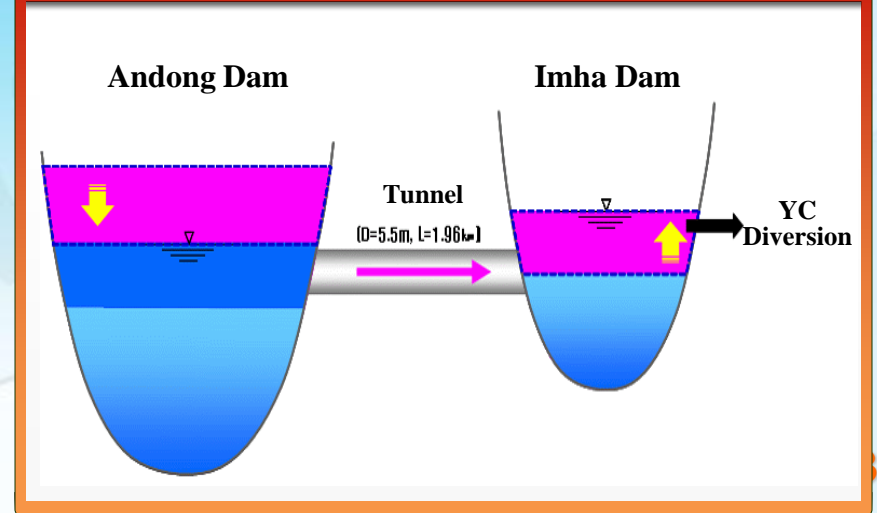
- Flood season : 22.8 million  $\text{m}^3/\text{yr}$  securing water by outflow reduction
- Unflood season : 1.2 million  $\text{m}^3/\text{yr}$  securing water by optimum operating

Contents	Flood season (Outflow reduction)			Unflood season (optimum operating)	Total
	Spillway	Turbine	Sub Total		
Securing water (million $\text{m}^3/\text{yr}$ )	15.7(65.6%)	7.1(29.4%)	22.8(95%)	1.2(5%)	24.0(100%)

### Flood season(outflow reduction)



### Unflood season(optimum operating)



## II. Study subject

- ☞ compared the impacts on environments, society and economic of the new dam construction and connecting existing dams
  - The five Dams being constructed in the Nakdong-River basin
  - Connection with the tunnel of existing Dams (AD & IH Dams)

	Basin Area(km <sup>2</sup> )	Dam Size		Total storage(10 <sup>6</sup> m <sup>3</sup> )	Flood control(10 <sup>6</sup> m <sup>3</sup> )	Water supply(10 <sup>6</sup> m <sup>3</sup> )
		Height(m)	Length(m)			
GW Dam	87.5	45.0	390.0	48.7	3.1	38.3
SD Dam	41.3	58.5	274.0	24.8	4.2	20.6
BH Dam	82.0	64.0	472.0	42.6	12.3	36.3
YJ Dam	500.0	55.5	390.0	160.4	75.0	203.3
BS Dam	62.6	57.0	245.0	17.9	3.5	14.9

- the major dimensions of the five Dams in construction



# II. Study subject

BH Dam



GW Dam



BS Dam



AD-IH Connecting tunnel



YJ Dam



SD Dam



# II. Study method

## Environmental Impacts

- using the environmental impact assessment reports (EIA)
- wild animals & plants (were protected legally)  
were compared in terms of the two projects

## Social Impacts

- using the compensation survey reports
- the moved residents & submerged living infrastructures (houses, farmlands, roads, etc) were compared

## Economic efficiency

- using the feasibility survey reports and design reports
- the unit cost of water quantities to be secured by the projects  
were compared by summing up the costs

## **Results & Discussion**



# III. Environmental Impacts

## ● Affected organisms

- The affected organism are not particularly different
- Tunnel connects already formed lakes with an underground tunnel  
→ no direct effects (removing animals and plants living on the ground)

	No. of Species inhabited		Protected legally in Korea	
	animals	plants	fauna	flora
GW Dam	49	545	otter	Korean Berchmia
SD Dam	55	379	otter, sable	Korean Berchmia
BH Dam	52	416	otter	—
YJ Dam	67	420	otter, wildcat & 2 fishes	—
BS Dam	33	334	otter	—
Connecting Tunnel	52	192	otter	—

# III. Environmental Impacts

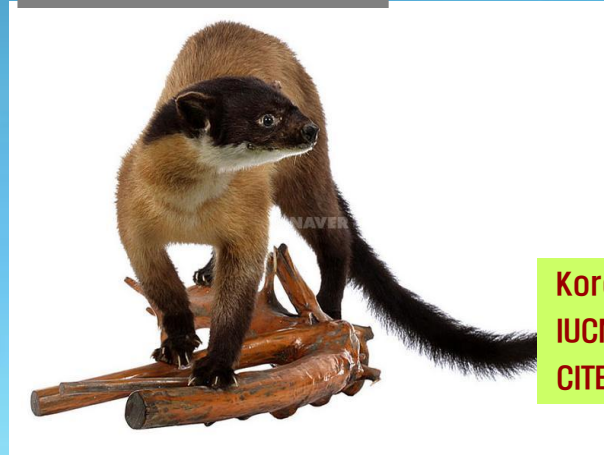
## ● Species protected legally

Otter



Korea : class 1  
IUCN Red List : NT  
CITES : Appen. I

Sable



Korea : class 2  
IUCN Red List : LC  
CITES : Appen. III

Wildcat



Korea : class 2  
IUCN Red List : LC  
CITES : Appen. I

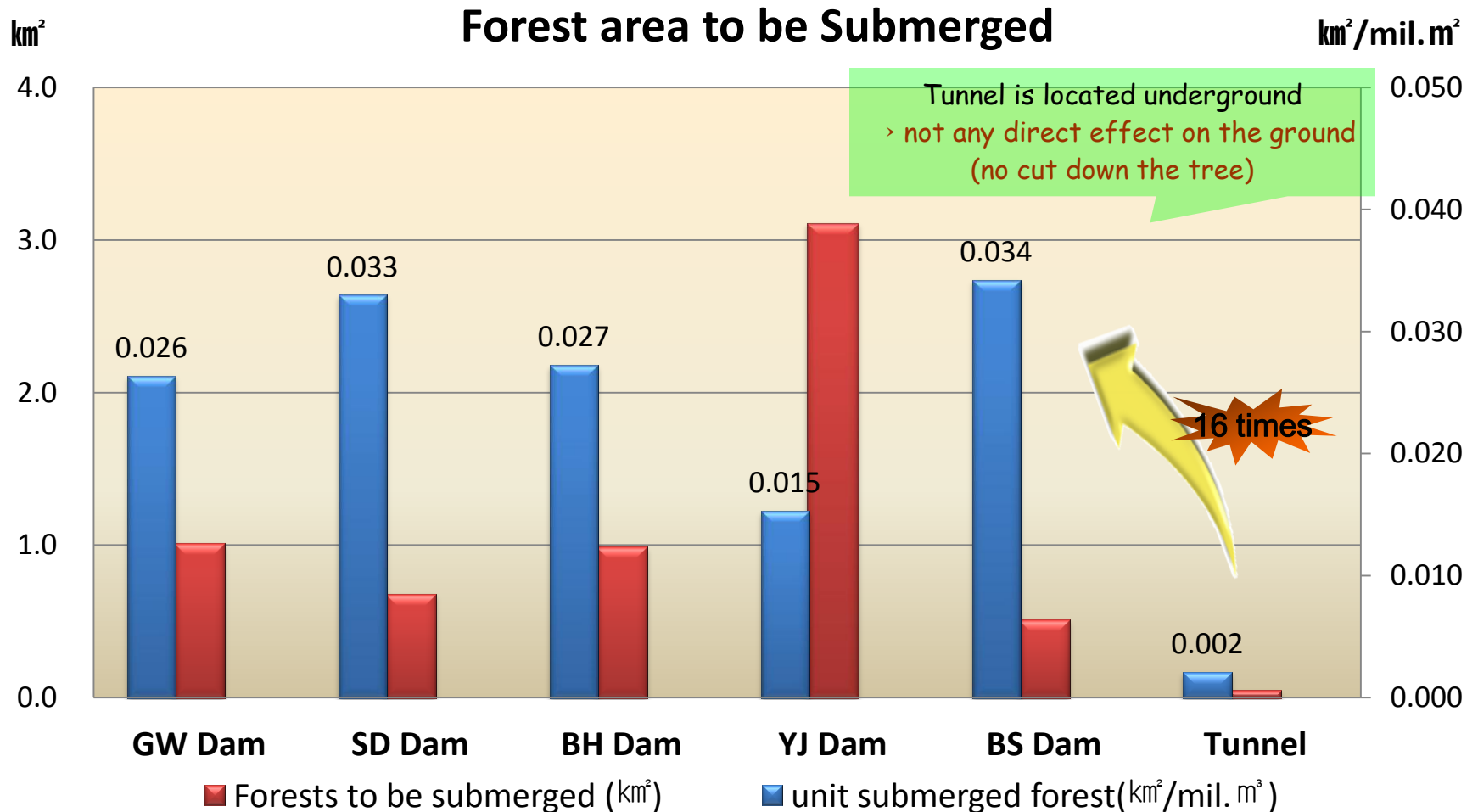
Korean Berchmia



Korea : class 2  
IUCN Red List : NE  
CITES : –

# III. Environmental Impacts

## ● Forests to be submerged





# III. Social Impacts

## ● Movements & submergence

- New dam construction : Avg. 4.74<sup>km<sup>2</sup></sup> lands will be included,  
Avg. 687 residents will be moved
- Connecting tunnel : 0.19<sup>km<sup>2</sup></sup> of lands, no residents will be moved

	Moving population(no.)		Areas included in the projects(km <sup>2</sup> )			
	houses	persons	Rice paddy	Field	Road	Total area
GW Dam	288	520	0.53	0.67	0.16	3.61
SD Dam	100	319	0.21	0.31	0.09	1.93
BH Dam	285	769	0.46	1.11	0.16	3.43
YJ Dam	564	1,564	2.59	1.68	0.59	12.71
BS Dam	120	267	0.38	0.42	0.13	2.04
Connecting Tunnel	0	0	0.00	0.02	0.00	0.19

# III. Social Impacts

**Pull down houses**



**Relocation of cultural assets**



- ◆ Changes in the social environments (moving residents, lost value of cultural assets, lands) because of dam submergence
- ◆ Connecting tunnel is effective while minimizing social/cultural impacts.

# III. Economic Efficiency

## ● B/C on the dam project

### Benefits

Flood control

Domestic & Industrial water supply

Electric power

Irrigation benefits

Recreational benefits

### Cost

Construction

Compensation

Design cost

Management cost

Refurbishment



# III. Economic Efficiency

## ● Cost for water supply

### ● The amount of securing water

0.6(BS Dam)~8.5(YJ Dam) times more than connecting tunnel

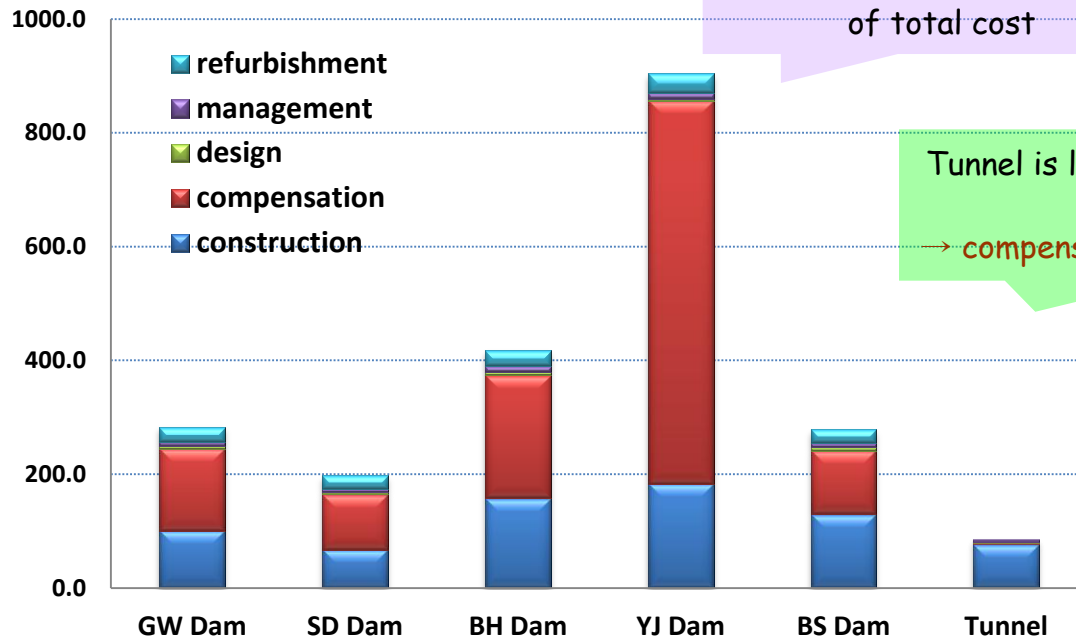
### ● project costs

3.3(BS Dam)~10.7(YJ Dam) times more than connecting tunnel

	Water supply (10 <sup>6</sup> m <sup>3</sup> /yr)	Total project cost (10 <sup>6</sup> \$)	Unit cost	
			(\$/m <sup>3</sup> )	Relat. comparison
GW Dam	38.3	282.4	7.4	2.1
SD Dam	20.6	197.6	9.6	2.7
BH Dam	36.3	417.0	11.5	3.3
YJ Dam	203.3	904.4	4.5	1.3
BS Dam	14.9	278.8	18.7	5.3
Connecting Tunnel	24.0	84.6	3.5	1.0

# III. Economic Efficiency

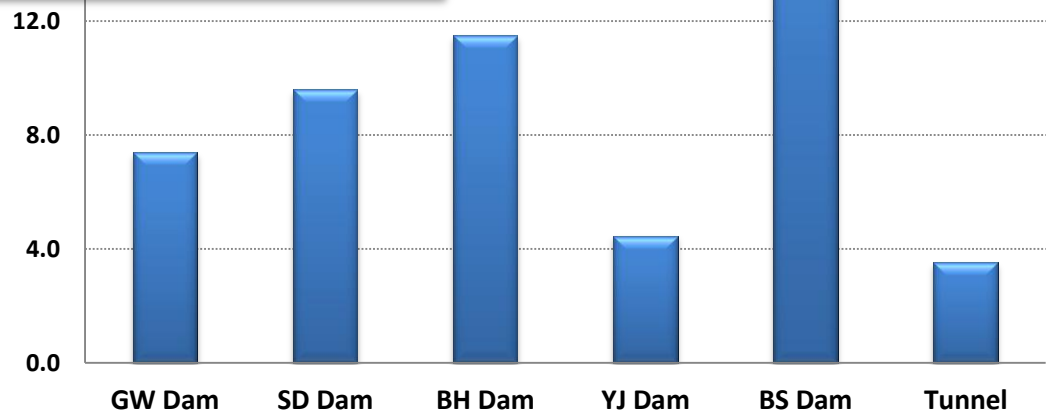
Project Total Cost (10<sup>6</sup> dollars)



Compensation is **avg. 53.3%** of total cost

Tunnel is located underground & using the existing dams  
→ **compensation cost less than new dam**

Project Unit Cost (dollars/m<sup>3</sup>)



- Unit cost required per water supply 1.0 m<sup>3</sup>
- new dam : 10.3 \$/ m<sup>3</sup>
- Tunnel : 3.5 \$/ m<sup>3</sup>



IV

# Conclusions



# IV. Conclusion

- **The tunnel connecting is designed to temporarily store the spillway drift in flood seasons, from IH Dam(which has a relatively small storage capacity) to AD Dam (has the extra storage space) And return it to IH Dam in dry seasons, **securing an additional 24 m m<sup>3</sup> of water, without creating new dams.****
- **Connecting tunnels between dams in Korea is judged to be an economical method of securing water resources that minimizes the environmental & social impacts while maximally utilizing existing water resources.**



# Thank you

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