Effectiveness Analysis of Multi-purpose Dam : Socio-hydrology Modeling Approach

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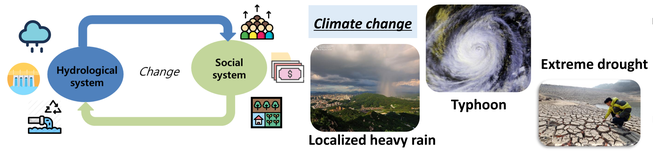
Introduction



Keywords: Climate change, Multi-purpose dam, Socio-hydrology

- Human(social) systems and hydro-systems interact each other, thus a research on socio-hydrology that can consider both systems is gaining attention.
- This study aims to develop a socio-hydrology model to quantitatively analyze the effects of a multi-purpose dam on the downstream society
- Additionally, climate change and socio-economic scenarios were applied to analyze the future effects of the multi-purpose dam on the population change, regional economy, water supply, and flood damage prevention of the target area.

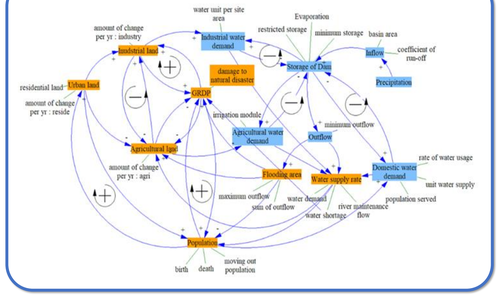
METHODOLOGY

1) Identify target area and target facility
2) Collect historical data of social and hydrological components of the target area
3) Identify the causal relationship between components using the causal loop diagram
4) Estimate the relational formulas between components based on their causal relationships
5) Construct the socio-hydrology model using a system dynamics technique
6) Develop future scenarios (e.g., climate change, socio-economic)
7) Run model and analyze the simulation results

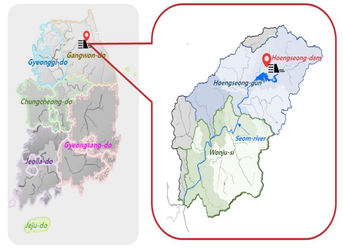
Data collection and causal relation framework development ≫ Conceptualization
≫ Develop the model
≫ Simulation

Flow chart of study

Causal Loop of Socio-Hydrology Model



Study Area



Location of Hoengseong multi-purpose dam

- Location
Gangwon-do, South Korea
- Dam construction period
1993/12 – 2000/11
- Dam operation starts at 2002
- Hoengseong-dam specification

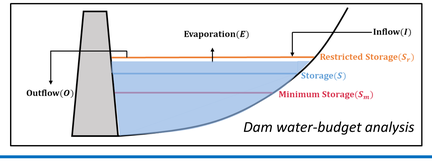
Length	205.0 m
Height	48.5 m
Basin area	209 km^2
Total water storage	86.9 million m^3

- Components of Socio-Hydrology model

Socio-sectors	
Population	Flooding area
Land use	Flood/drought damage
Gross Regional Domestic Product	Water supply rate

Hydro-sectors
Domestic, Industrial, and agricultural water demand
Dam operation
Annual rainfall
River maintenance flow

- Dam operation

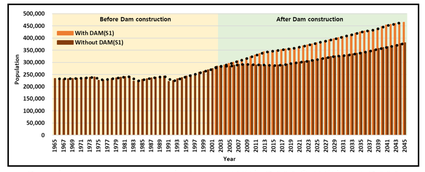


Dam water-budget analysis

RESULTS

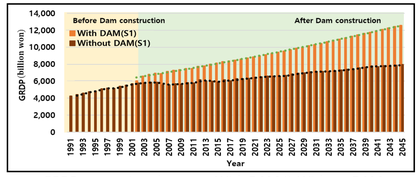
① Scenario 1 – w/ and w/o DAM

- Population in 2045
: 460,000 (With DAM), 380,000 (Without DAM)



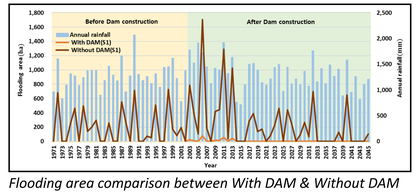
Population comparison between With DAM & Without DAM

- GRDP(Gross Regional Domestic Product) in 2045
: 12 trillion won (With DAM), 8 trillion won (Without DAM)



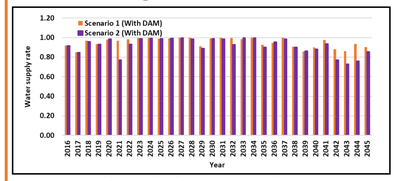
GRDP comparison between With DAM & Without DAM

- Total Flooding area
: 15ha (With DAM), 4,500ha (Without DAM)
≫ Flood Damage is approximately 90 billion won



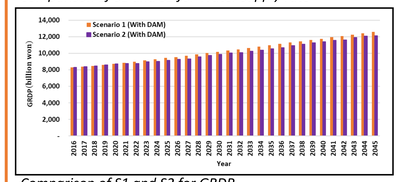
Flooding area comparison between With DAM & Without DAM

② Scenario 2 - Extreme climate change



Comparison of S1 and S2 for Water supply rate

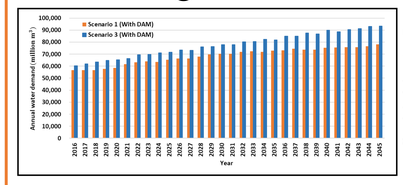
- Water supply rate(30yr avg.)
: 0.95 (S1), 0.91 (S2)
→ S2 reduced by approximately 4% due to extreme droughts.



Comparison of S1 and S2 for GRDP

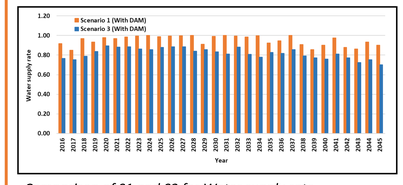
- GRDP in 2045
: 12 trillion won(S1), 11 trillion won(S2)
→ Resulting in a difference of approximately 1 trillion won

③ Scenario 3 – Urbanization/Industrialization



Comparison of S1 and S3 for Annual water demand

- Assumptions
1) Higher-than-expected birth
2) Increase in water consumption
3) Increase in production per unit of industrial land
- Increased GRDP → Population influx → Soar demand for living and industrial water
- Total water use in 2045
: 78 million m^3 (S1), 95 million m^3 (S3)
- Water supply rate(30yr avg.)
: 0.95(S1), 0.81(S3)



Comparison of S1 and S3 for Water supply rate

CONCLUSION

➢ Results summary
- Sce. 1 – By constructing the dam, the downstream society receives positive impact of population, GRDP, flood prevention, water supply
- Sce. 2 – The massive damage caused by extreme climate change will not occur in the area with proper dam operation. GRDP and population are expected to increase consistently
- Sce. 3 – The water consumption continuously increases due to urbanization and economic revitalization. The average water supply rate of Sce. 3 is expected to be approximately 0.81, which is significantly lower than that of Sce. 1

➢ The developed socio-hydrology model can be used as a decision-making tool to policymakers who are planning the construction of new multi-purpose dams. It can also be applied to the effectiveness analysis and planning of other water resource facilities.

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