Water Accounting for Integrated Water Resources Management

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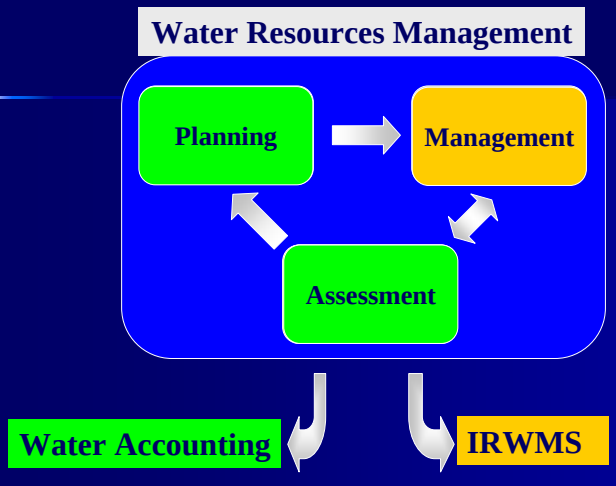
Introduction

Questions on managing water resources in the field

- How is water being used ?
- How is the recurrence ration of each water use ?
- How is the productivity of water ?
- How much water is available ?
- What is difference between planning and real operation?



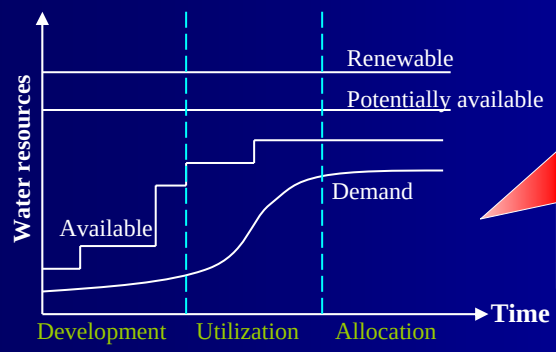
"Water accounting gives a clear view of their options and the scientific information to the planners and policy makers !."

Why do we do water accounting ?

- **Planning** and **real situation** are different !
  - W/A can account the real situation of basin water.
- **Water shortage** problem can be appeared !
  - W/A can improve productivity and efficiency of water.
- Not enough information about **water cycle** !
  - W/A give clear view of water resources management to planner.

Role of water accounting at each country

- Various concerns at different phases of river basin development



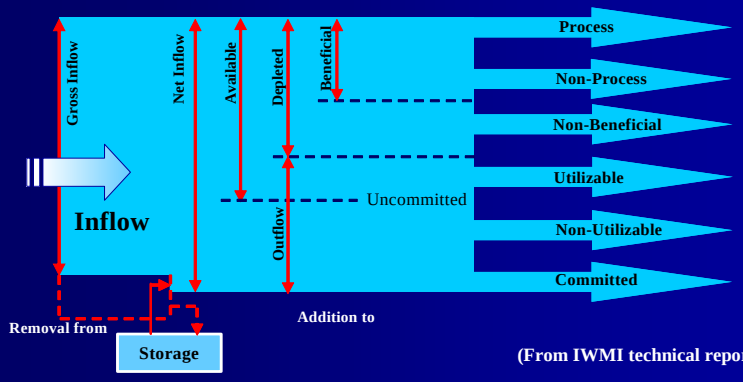
Water accounting gives clear view of water resources management at each country!

Various concerns at different phases of river basin development

Development	Utilization	Allocation
Construction	Improving O & M service	Shifting to higher value
Managing supply distribution	Investing in O & M	Managing demand
Low value of water	Increasing value of water	High value of water
Large structures	Modernization / rehabitation	Measurement, regulating
Utilizing groundwater	Conjunctive management	Regulating groundwater

Development	Utilization	Allocation
Diluting pollution	Emerging pollution / salinity	Cleaning up pollution
Fewer water conflicts	Within-systems conflicts	Between-system conflicts
Economic water scarcity	Localized water scarcity	Physical water scarcity
Water data-not so important	System water delivery data important	Basin water accounting data important
Including / excluding poor in development of facilities	Including poor in O & M decision making	Cutting off water to poor

Definition of water accounting



(From IWMI technical report)

Water accounting is quantifying and evaluating procedure of the each water components during water cycle !

Definitions of glossaries in water accounting field

Glossary	Definition
Gross inflow	The total amount of inflow crossing the boundaries of the domain
Net inflow	The gross inflows less the change in storage over the time period of interest within the domain. Net inflow is larger than gross inflow when water is removed from storage
Committed water	The part of outflow that is reserved for other uses
Fully committed basin	A water basin that has been developed to the extent that all water has been allocated or, in other words, all outflows are committed
Depleted fraction	The fraction of inflow or available water that is depleted by process and non-process use. Depleted fraction can be related to gross inflow

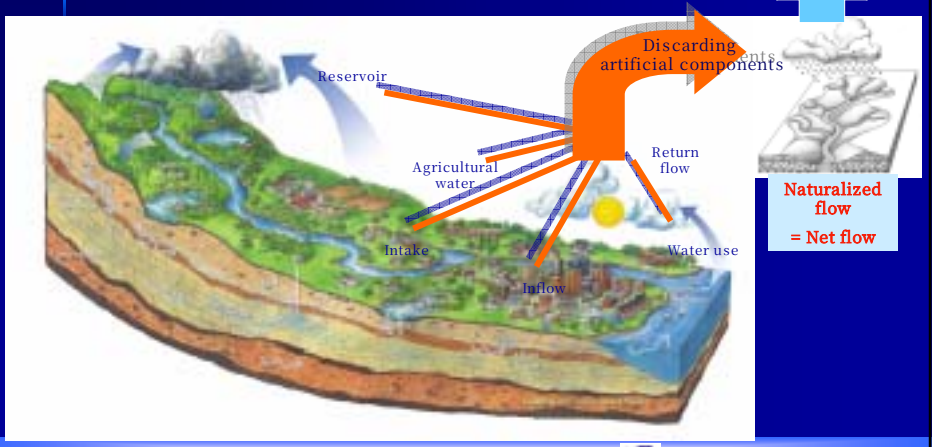
Definitions of glossaries in water accounting field

Glossary	Definition
Closed basin	A basin where utilizable outflows are fully committed
Open basin	A basin where uncommitted utilizable outflows exist
Process depletion	That amount of water diverted and depleted to produce an intended good
Process fraction	The ratio of process depletion total to depletion (Process fraction of depleted water) or available water (process fraction of available water)
Uncommitted outflow	Outflow from the domain that is in excess of requirements for downstream uses
Water depletion	A use or removal of water from a water basin that renders it unavailable for further use

Basic concepts of naturalized flow : Total available water resources

Basic information of water accounting

Available Water!!



Water balance equation

Essential work for water accounting

$$Q_{res} = Q_{dif} + T_m + T_{rum} - Q_{ex} - E - CU_d - ET_{pht} - ET_{crop} - \Delta S_r - \Delta S_a$$

- Q_{res} : Residual
- Q_{dif} : Difference between upstream and downstream inflow
- T_m : Measured tributary inflow to the reach
- T_{rum} : Unmeasured tributary inflow to the reach
- Q_{ex} : Water exported out of the basin
- E : Open-water evaporation
- CU_d : Agricultural, municipal, and industrial use
- ET_{pht} : Total estimated phreatophyte ET
- ET_{crop} : Total estimated crop ET
- ΔS_r : Change in reservoir storage
- ΔS_a : Change in storage in the alluvial aquifer

General procedure for water accounting

Data from observations, models (discharge, water use, etc.)	**Observation : discharge, water use monitoring** **Model : Rainfall-runoff model,**
Estimation of naturalized flow **Estimation of recurrence**	**Model : RRFS, NWS-PC, etc.** **Review : government reports**
Water balance	**Water Balance Equation**
Water accounting	**Index evaluation (DF, PF,)**
Assessment, Enhancement of basin water use	

Methods extracting water accounting components

- **Field monitoring : discharge, water use, etc**



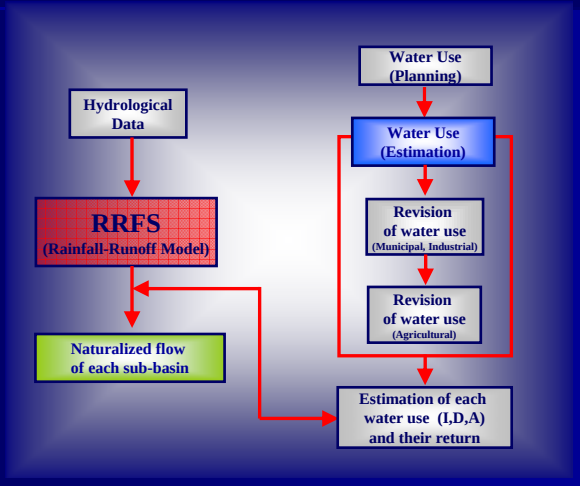
- **Computational simulation based on major observations**
  : Long-term runoff model, Water allocation model



RRFS, KORSIM, etc.

Next training course topic !

Example of estimating water accounting component using RRFS



Indexes of water accounting

Depleted Fraction

$$DF_{net} = \frac{Depletion}{Net\ Inflow}$$

$$DF_{gross} = \frac{Depletion}{Gross\ Inflow}$$

$$DF_{available} = \frac{Depletion}{Available\ Water}$$

Process Fraction

$$PF_{depleted} = \frac{Process\ Depletion}{Total\ Depletion}$$

$$PF_{available} = \frac{Process\ Depletion}{Available\ Water}$$

Productivity

$$PW_{inflow} = \frac{Productivity}{Net\ Inflow}$$

$$PW_{depleted} = \frac{Productivity}{Depletion}$$

$$PW_{process} = \frac{Productivity}{ProcessDepletion}$$

Consumption | **Utilization** | **Productivity**

Water accounting index refines the picture of water resources management !

Examples of water accounting

- **Sequence of water accounting**

Field-level

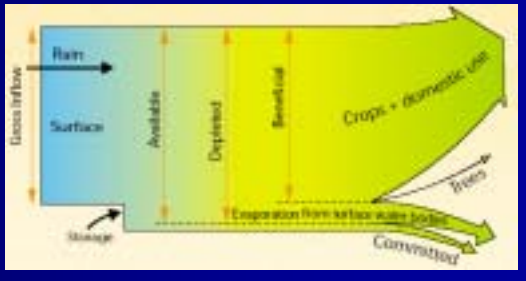
↓

Service-level

↓

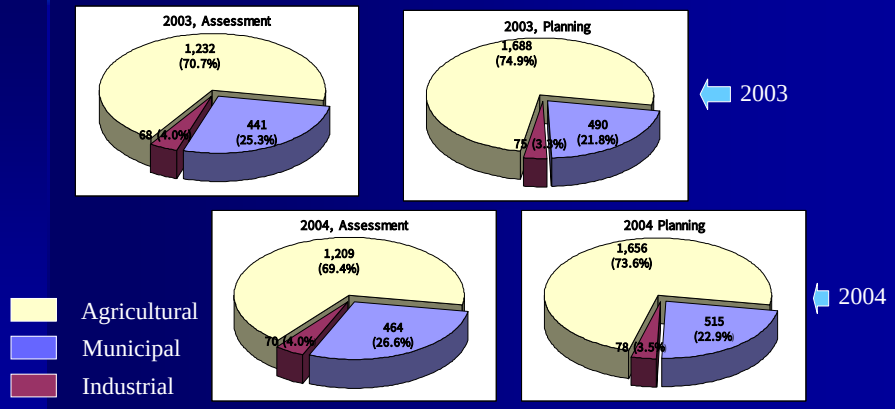
Basin-level

- **Case of 'closed' basin**

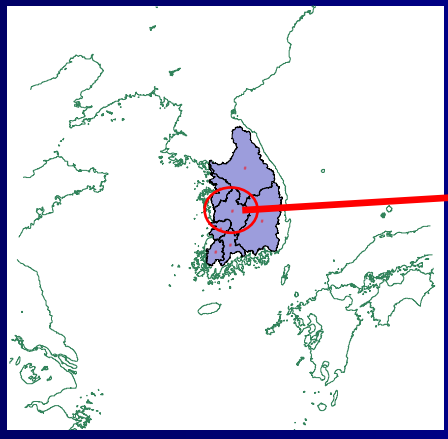


Pattern of water use in Korea

Pattern of water use in Korea : Planning VS. Assessment



Example of water accounting (Geum River)



- Third largest basin in Korea
- The beginning basin of **IRWMS** developed by KOWACO

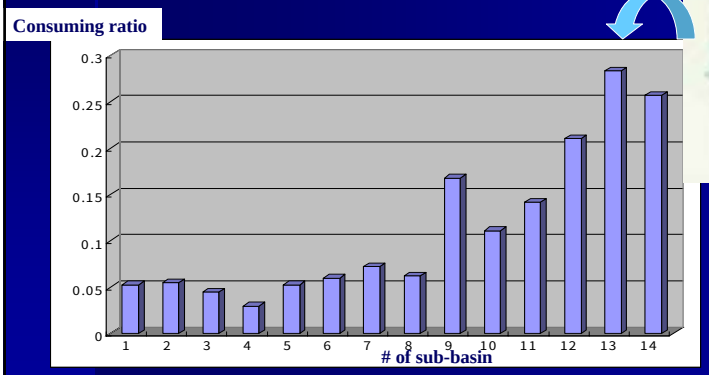
Example of water accounting : Basin-scale

- Case study of Geum River, Korea

	(cms)	Percentage
Utilizable	67.65	100%
1) River water	55.21	
2) Groundwater	4.99	
3) Reservoir outflows outside basin	7.45	
Outflow	37.21	55%
Reported Depletion	20.36	30%
1) From agricultural use	13.93	
2) From industrial use	2.17	
3) From domestic use	4.25	
Uncounted Depletion	10.08	15%

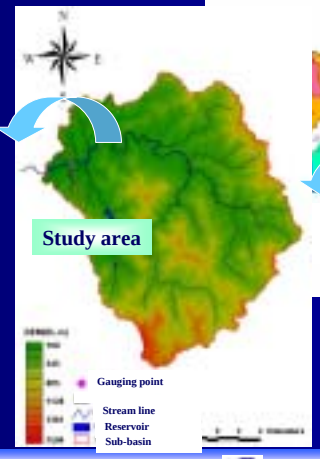
Consuming ratio (Average : 11%) : Downstream is larger than upstream !

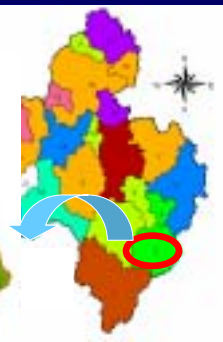
$$\text{Consuming ratio} = \frac{\textit{Water use}}{\textit{Available water}(\textit{natural water})}$$



Example of water accounting : Small-town

- Study area (Muju-Geun, Namdeacheon)





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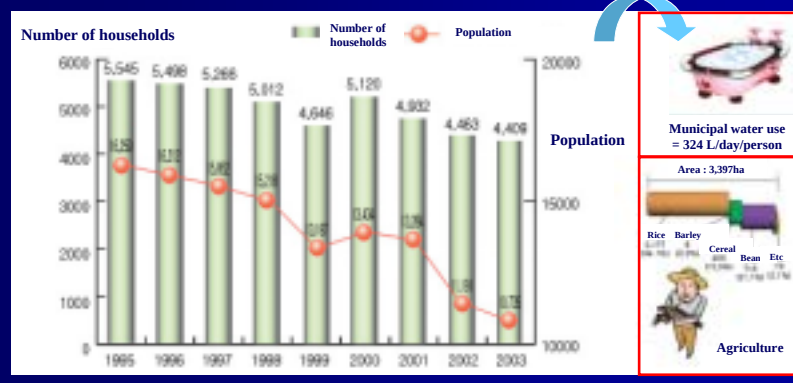
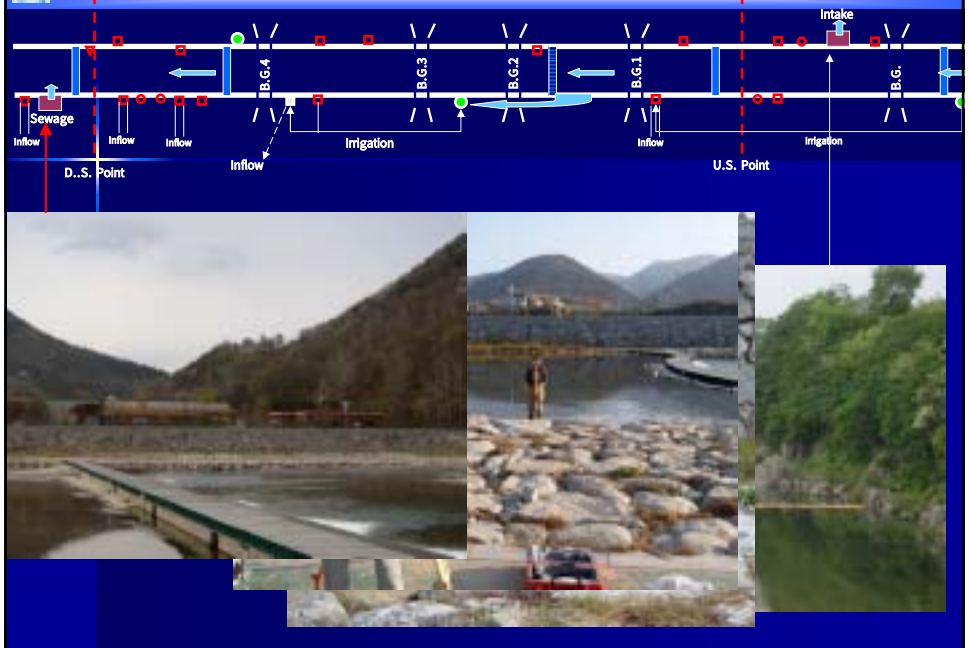
Example of water accounting : Small-town

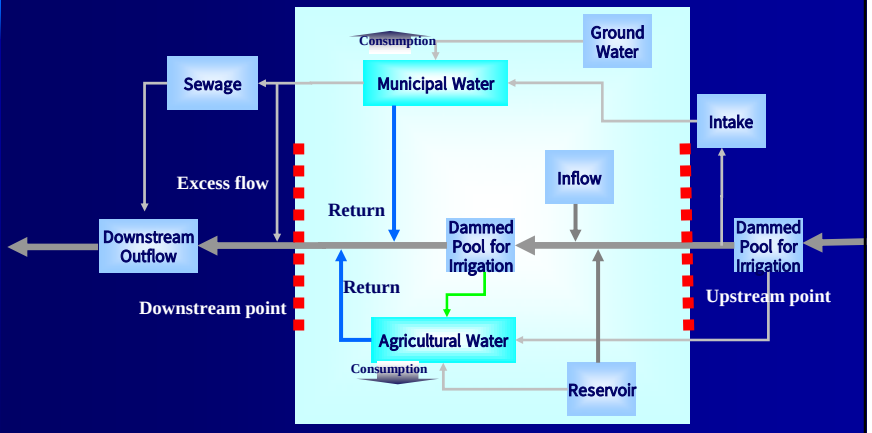
- Information about the study area : Muju-Geun



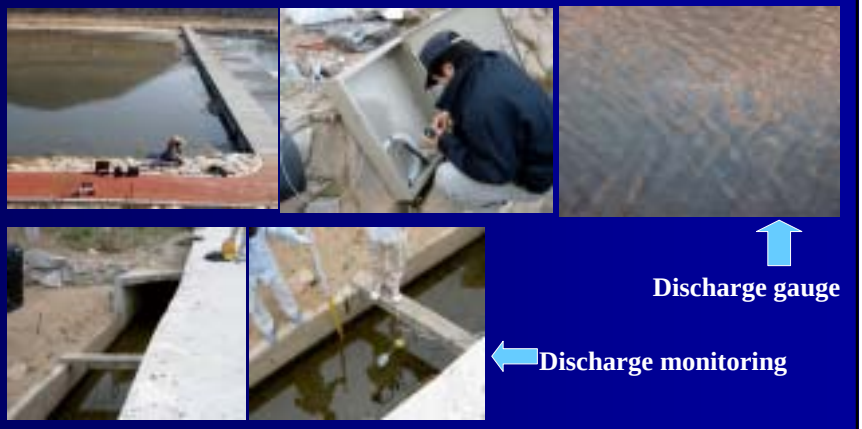
Korea Water Resources Cooperation



Schematic diagram of study area



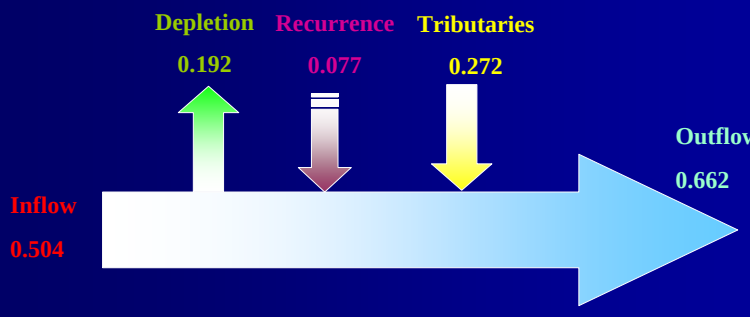
Discharge monitoring



Discharge gauge

Discharge monitoring

Summary of water balance (Namdae-Cheon, Korea, 2000)

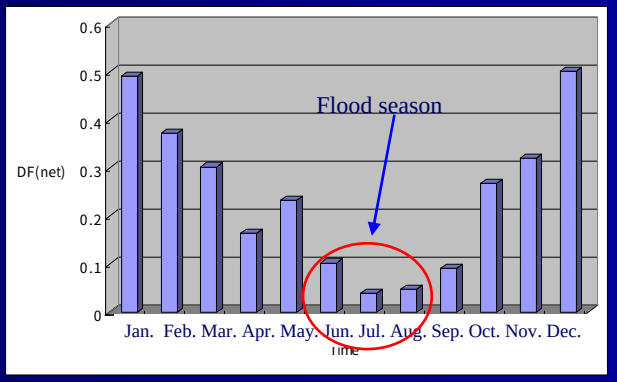


• Return ratio : 0.4

(Unit : CMS)

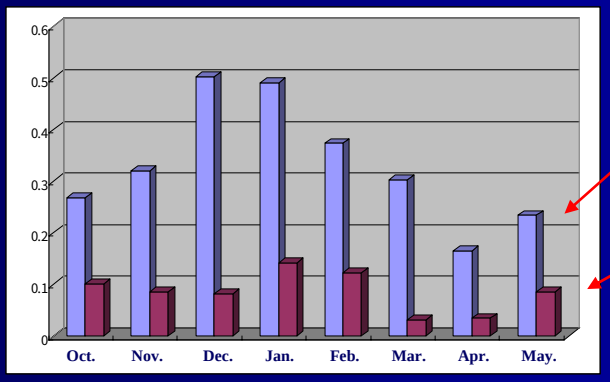
Water accounting (Namdae-Cheon, Korea, 2000)

Calculation of DF (net)



Difference between planned and monitored index

DF



Conclusion

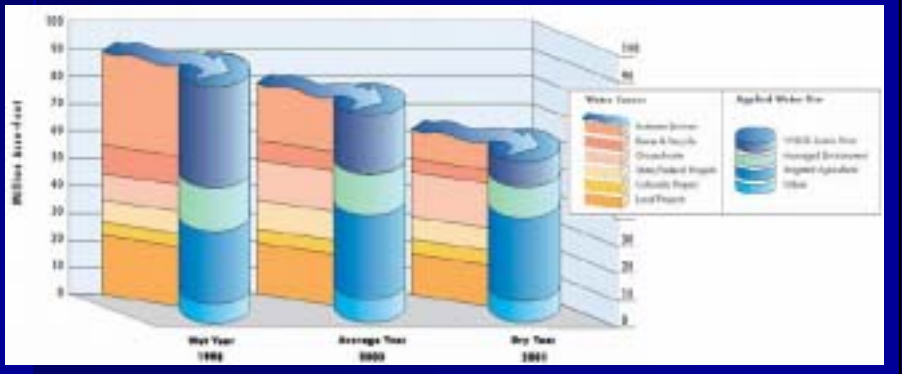
Water accounting helps :

- **Pinpoint areas where water can be transferred from lower-to higher value uses**
- **Evaluate the scope for improving productivity of water and target interventions**
- **Identify opportunities to reduce non-beneficial evaporation, pollution, or the flow of water into 'sinks'**

Refining the picture of water resources management
Increasing the productivity of water

Recommendations

- **Water balance is changing ! : Need of continuous monitoring**



Thank you!