Guidelines for efficient irrigation water use

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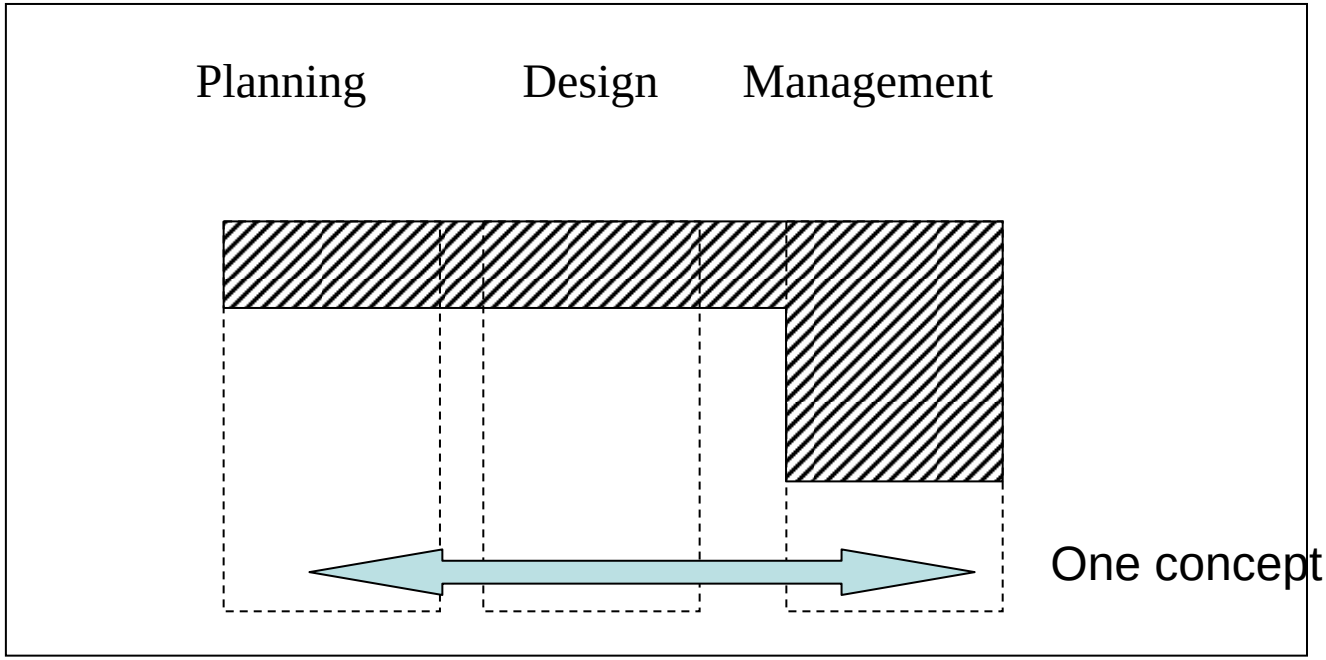
Objectives and Scope

The purpose of this guideline is to describe options to improve irrigation efficiencies of the irrigation systems in the Mekong river basin.



3 Phase of irrigation project and scope of this guideline

Features of irrigation projects in the Mekong river basin

	Mekong river basin	
Canal Type	Open channel	Pipeline
Farm size	Small farms	Estates
Main crop	Rice	Upland crop
Irrigation	Supply oriented	Demand oriented
Climate	Tropical monsoon	

Contents of the guideline

7. Technical and managerial aspects

Water requirement
Monitoring
Organization

1.Water allocation (Seasonal Irrigation plan)

2.Water Distribution (Irrigation scheduling)

3. Canal operation

4. Water management of tertiary canal

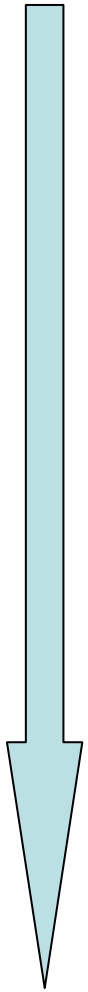
5.Institution

6.Improvement of physical structures

Reliability

Flexibility

Equity

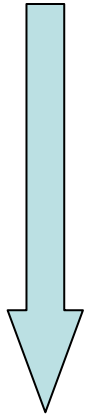


1.Water allocation (Seasonal Irrigation Plan)

articles	contents	Related analysis
Seasonal Irrigation plan	What is the irrigation plan?	
Procedure	How are water users involved in the decision making process?	
Monitoring and survey	What should be measured or surveyed prior to seasonal irrigation plan?	
Estimation available water and water requirement	How are water supply and water demand compared?	
Optimal Reservoir operation	How much water can be used in reservoir storage?	Simulation Dynamic Programming
Functions	What should be decided in the seasonal irrigation plan? What would be limited if available water is less then water demand?	
Allocation of irrigated area	How is restriction on irrigated area allocated?	
Area water level control	Irrigation plan of tidal irrigation area	Water balance , inundation analysis
Announcement	Irrigation plan should be informed to farmers.	

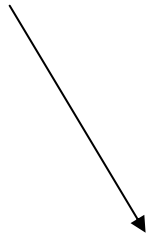
Estimation of available water and water requirement

	Estimated water resources	Effective rainfall
Pessimistic	Present reservoir storage	0
	Using record of draught year or other certain year	
Optimistic	Present reservoir storage + average inflow into reservoir	Estimated based on average rainfall



High production
Failure of water supply

$$\text{Irrigation area} = \frac{\text{Estimated water resources} - \text{water demand for other purpose}}{\text{Irrigation demand for unit area} - \text{estimated effective rainfall}}$$



Optimum Reservoir operation

Dynamic programming (DP)

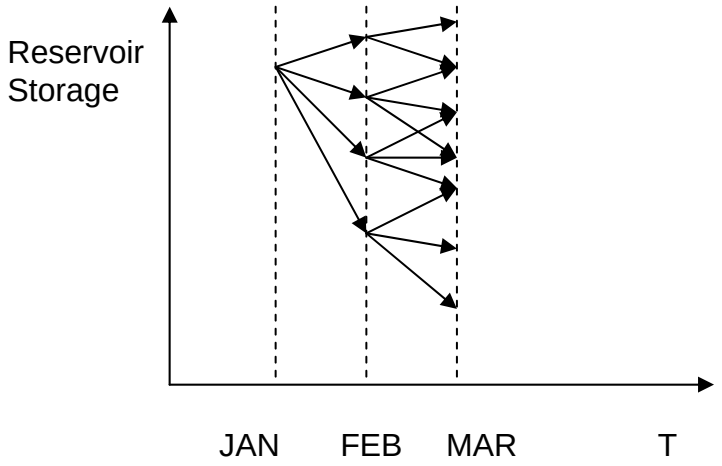
When reservoirs are large enough to keep water storage beyond one irrigation season, estimation of reservoir storage change is estimated for a longer period.

- Dynamic programming is the method that can directly find the policy that can generate the maximum benefit under conditions given and an evaluate function such as the rice production.

$$f(S_i) = \max_{R_i}\left(\sum_{Ii} P(I_i)\left(g(R_i) + f(S_{i+1})\right)\right)$$

$$S_i + I_i - R_i = S_{i+1}$$

R: Release from reservoirs
I: Inflow into reservoirs from catchments
g(R): Function which stand on benefit caused by release
S: Storage
f(S): Evaluate function

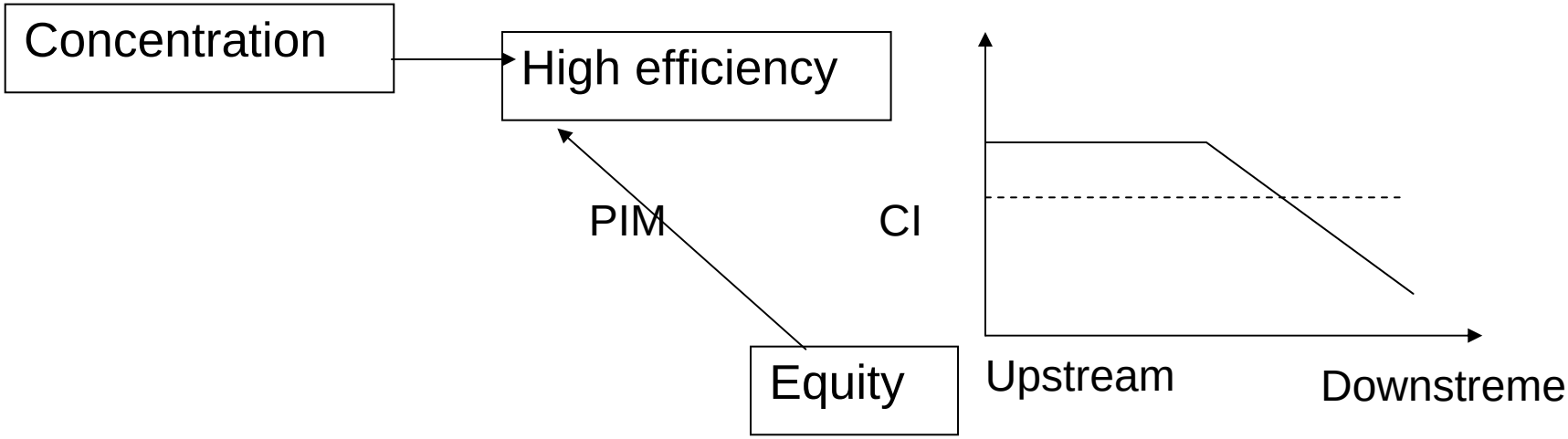


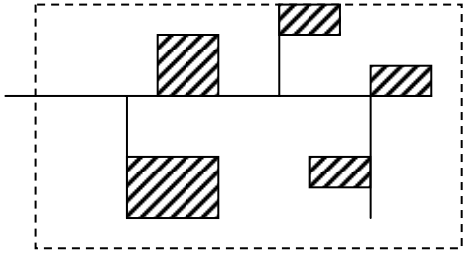
Restriction

The seasonal irrigation plan is calculated after comparing estimated available water and irrigation water demand calculated by a temporal plan. When the former is less than the latter at any period of next irrigation season, a temporal plan must be revised as for cultivated crop, irrigated area, crop establishment, The staring date of irrigation.

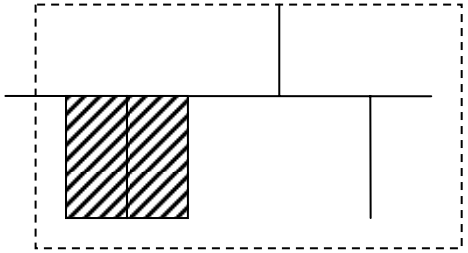
- Cultivated Crop
- Irrigated area
- Crop establishment method
- Delay of planting

Allocation of irrigated area

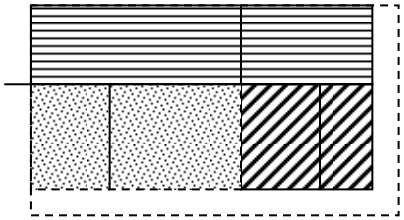




Distributed irrigation area



Concentrated irrigation area



irrigable area

irrigation area

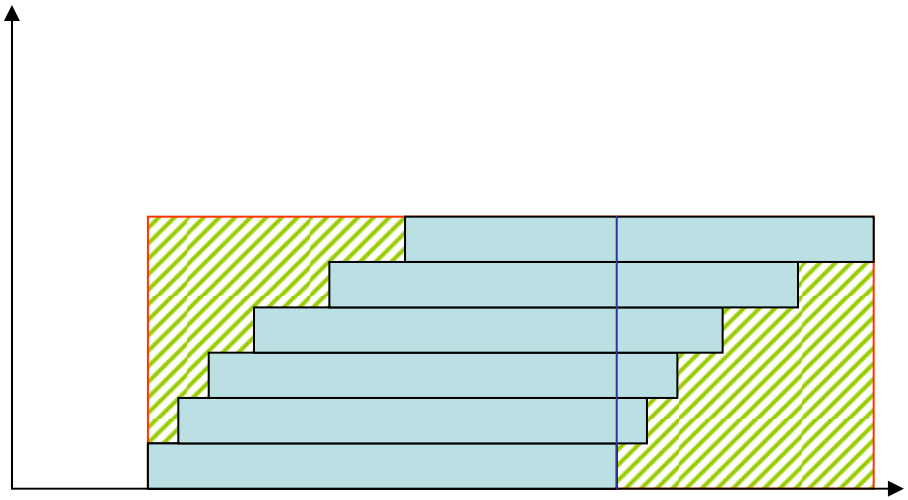
1st year

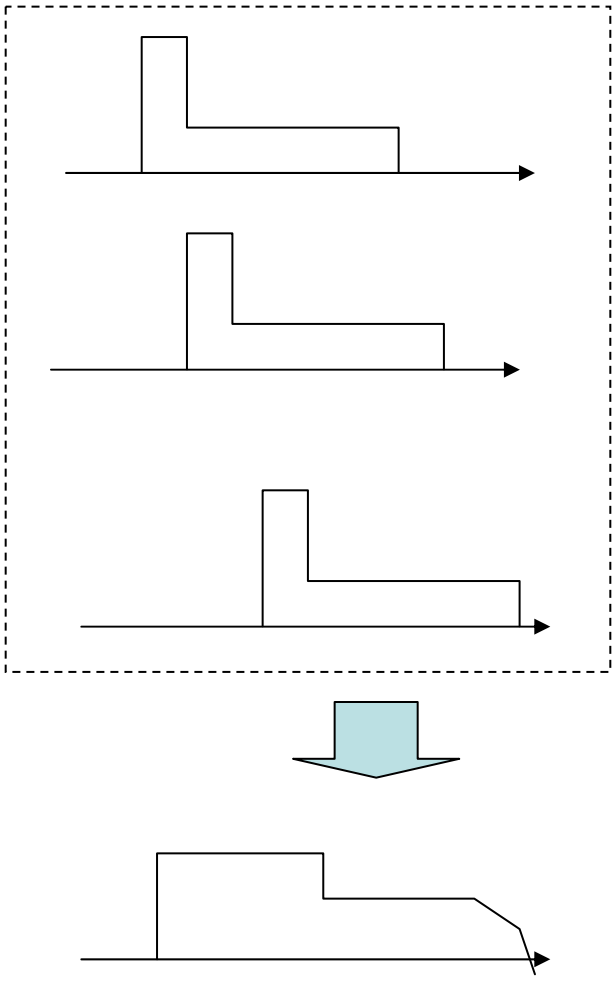
2nd year

3rd year

Distribution of irrigation implementation

Irrigation should be started at the same time at tertiary level to reduce the duration of irrigation.
While, start date of irrigation should be distributed for cut peak of water demand (land preparation) at project level

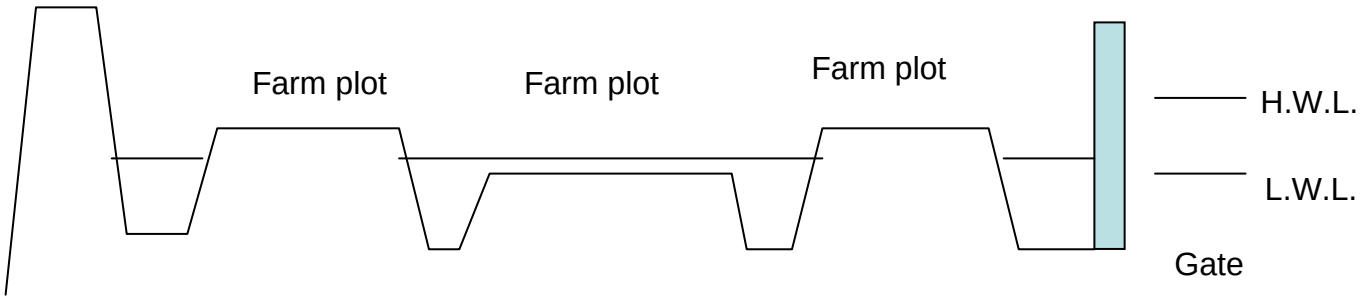




Area water level control (1)

- Water can be distributed evenly if irrigation project area is very flat and canals have enough capacity. This irrigation system called as Tidal Irrigation etc. can achieve high irrigation efficiencies by controlling water level. Target water levels should be decided at some points and in some periods. Target water level depends on the location of irrigation project.

Tidal Irrigation
Creek Irrigation
Flood Irrigation
Storage Irrigation



Are water level control (2)

Inundation analysis
Flood estimation
Unsteady flow model (river)
Basin water balance

Canal

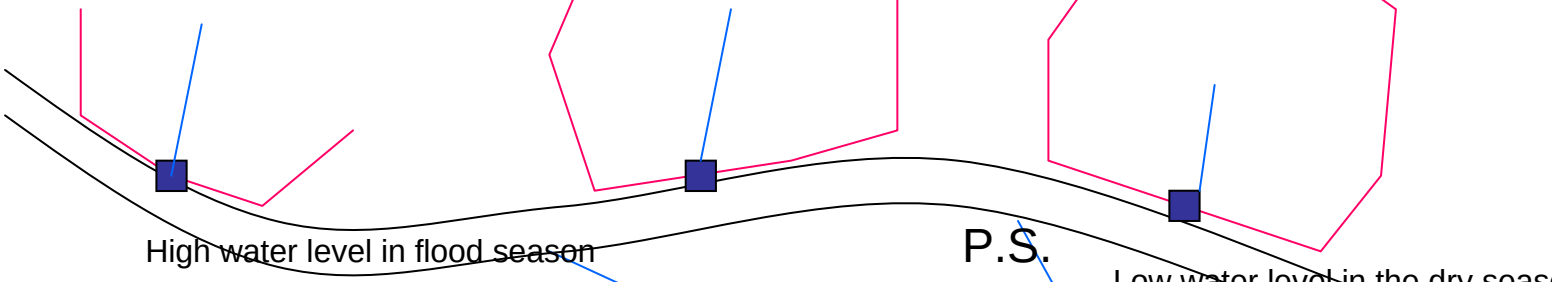
Gate

Dike

A:
Insufficient dike system
Flood intrudes to the area

B:
Surrounded by dike system,
Drainage is impossible in flood season

C:
Surrounded by dike system,
Irrigation water cannot be taken from rivers in dry season

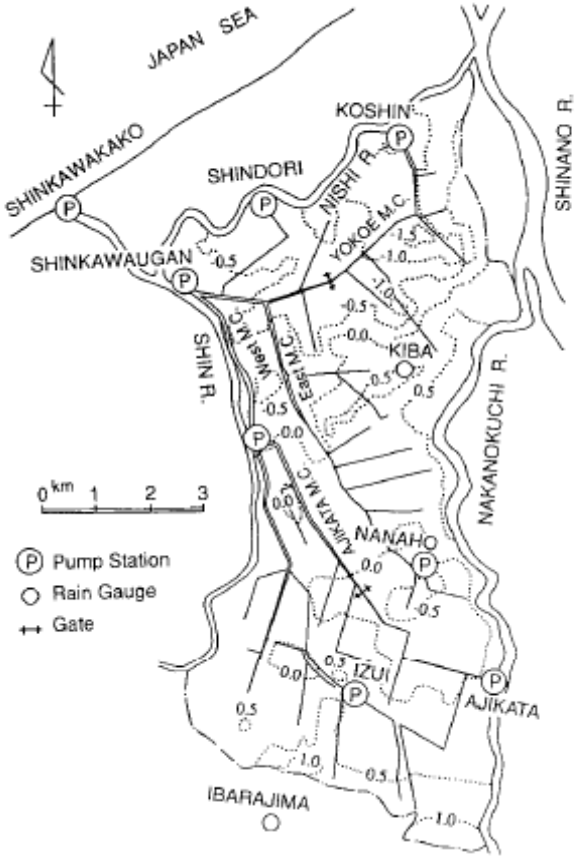


	Dry	Flood	Dry
A			
B			
C			
D			

Controlled W.L.

D:
Surrounded by dike system,
Irrigation facilities are installed so that irrigation water can be taken in the dry season

Inundation analysis

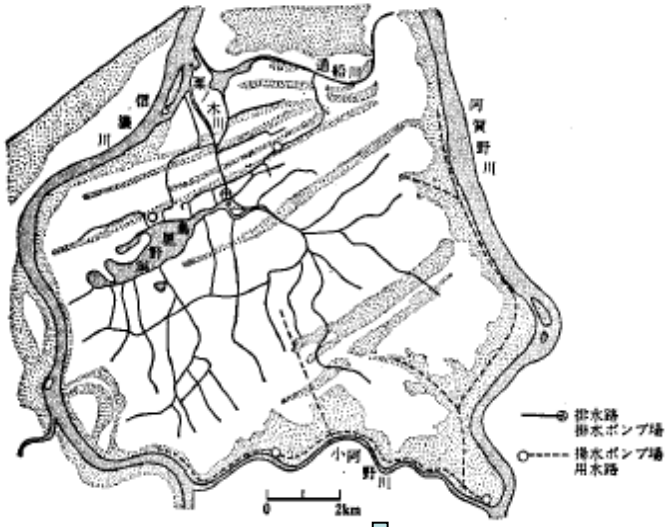


Schematic diagram of channel networks

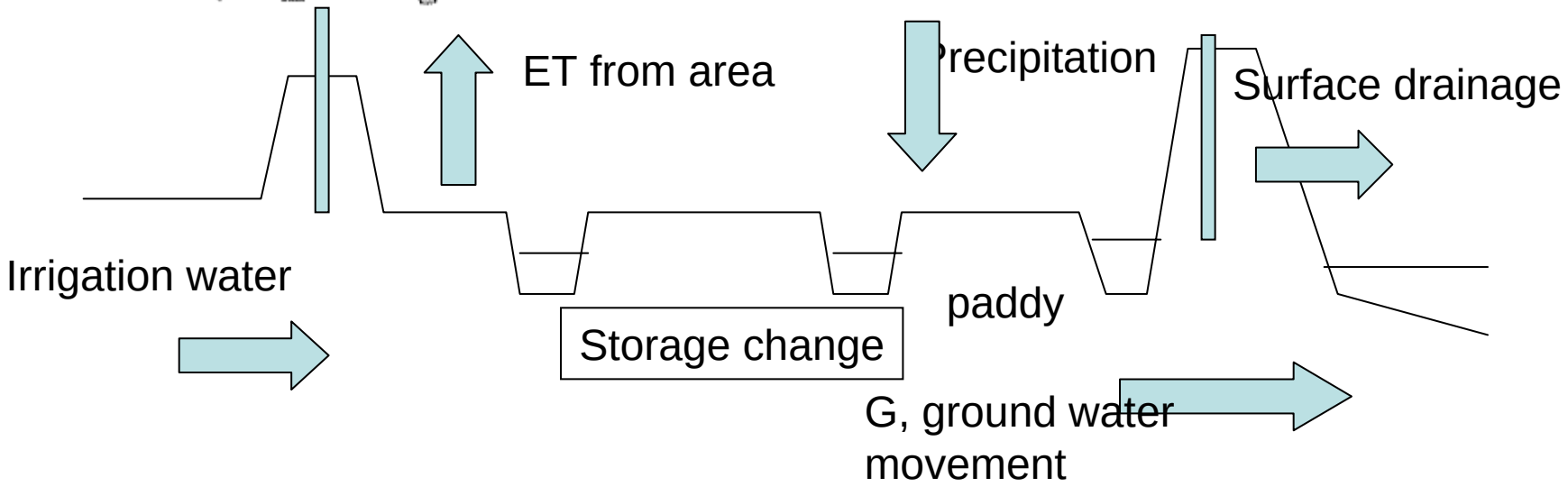
Forecasting of operation

Design of canal system and structures

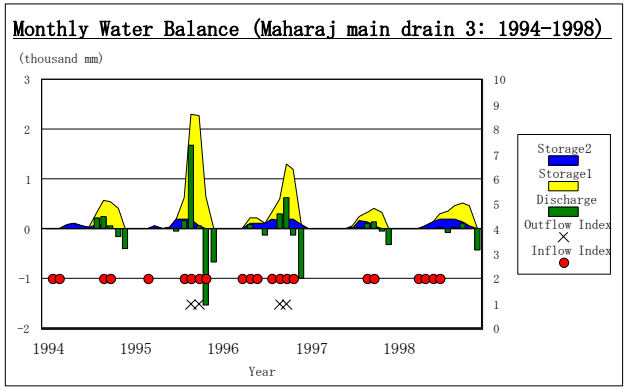
Basin Water balance

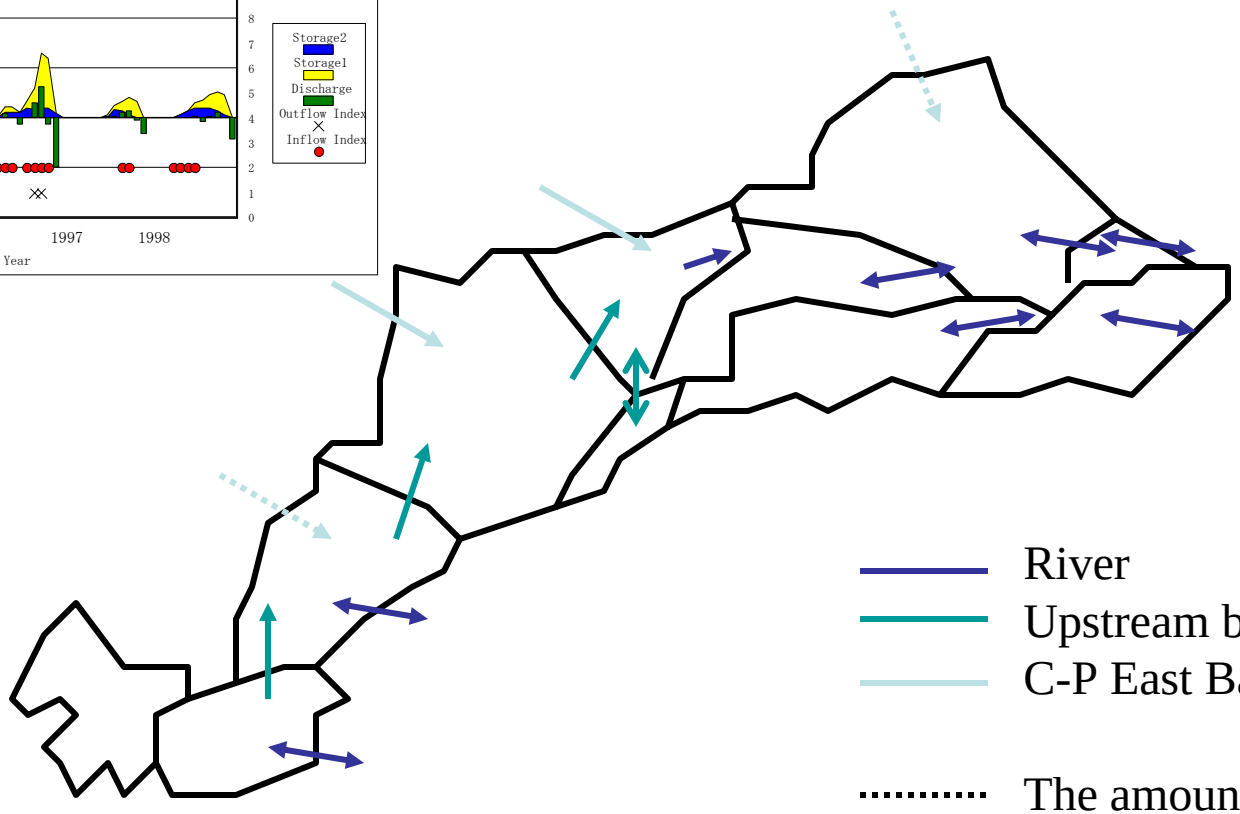


Monthly storage change
Ground water movement



Flood water intrusion estimation





River

Upstream block

C-P East Bank

The amount is too small to be estimated

2.Water distribution (Irrigation Scheduling, weekly or daily distribution plan)

	contents	Related Analysis
Irrigation scheduling	What is the irrigation scheduling	
Type of water distribution	Flexibility and water distribution	
Interval, frequency	When is the water distribution decided.	
Monitoring and Procedure	How is it decided.	
Continuous water supply and intermitted water supply	Which can improve irrigation efficiencies	
Flood introduction	Management to utilize water resources	
Reservoir operation	Water management in water shortage	Simulation

Flexibility and water supply method

Supply - oriented water control is control in which manager of irrigation canal have initiative. In open channel farmers use water within the amount which is intake or conveyed. The amount of water diverted into canal have no relation with the water demand witch cause on farm fiscally. The water manager decide the amount to divert or distribute by their own judgment .

The most simple method to supply water is to distribute fixed discharge to each branch canal . In this method it may create water which go through in valid . To decrease ineffective water the water manager must estimate water demand correctly . It is difficult to estimate water demand . In Japan there are three method to estimate water demand practically . As special case , the water manager operate to irrigate each farm plot instead of farmers in some irrigation project . This case is classified to supply oriented water control .

Demand oriented water control
Supply oriented water control
- Fixed distribution without reflect water demand change
- Distribution in obedience to water demand
  - Estimate by field survey
  - Estimate by monitoring
  - ordering
- Distribution to farm plot by water manager
- Others

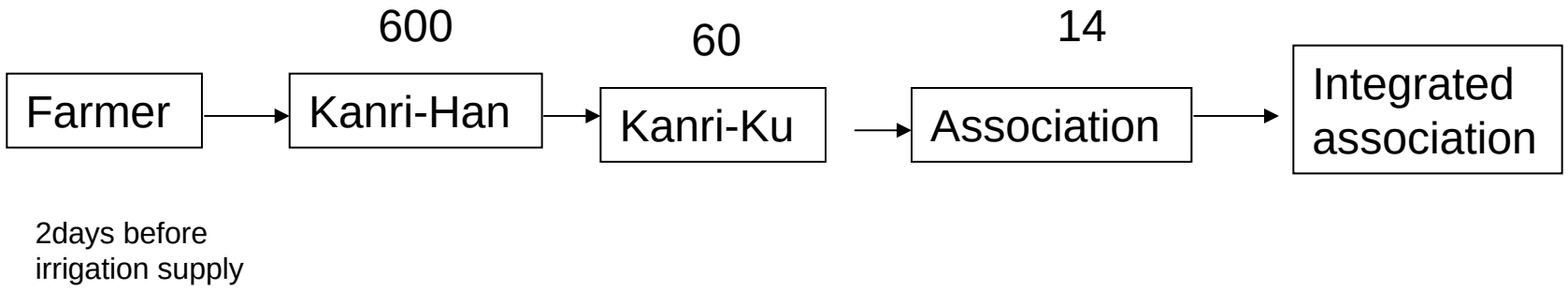
Mixed water control

classification of water supply method

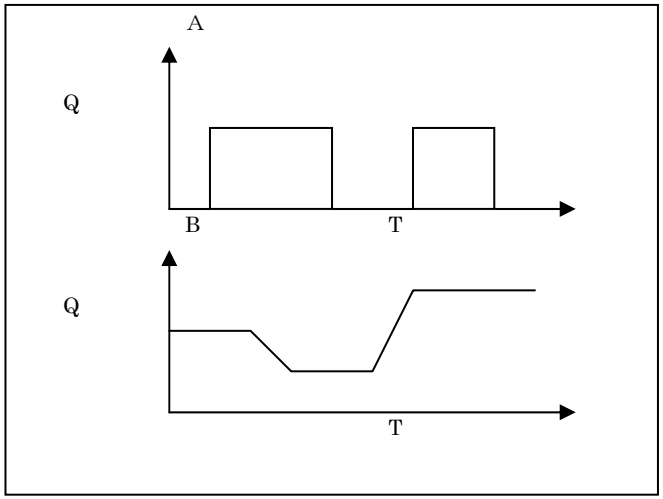
Procedure of ordering

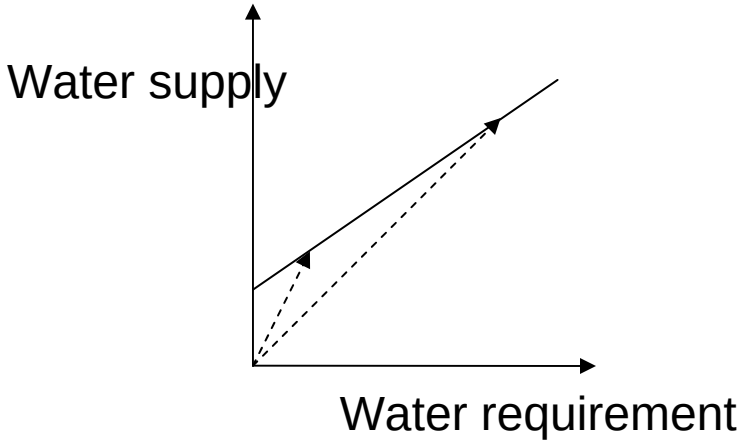
In some projects, farmers apply for irrigation water to water manager in advance . The water manager divert water from intake to main canal and distribute to each branch canals according to farmers application . If farmers use water as much as they applied , there is no difference between supply and demand . In general farmers careless about saving water . In this project area , water demand is more than their maximum of water supply . Water shortage happen every year . Farmers recognize that it is important to save water and this water management system can be carried out .

Example



Continuous irrigation supply and intermitted (on-off) irrigation supply

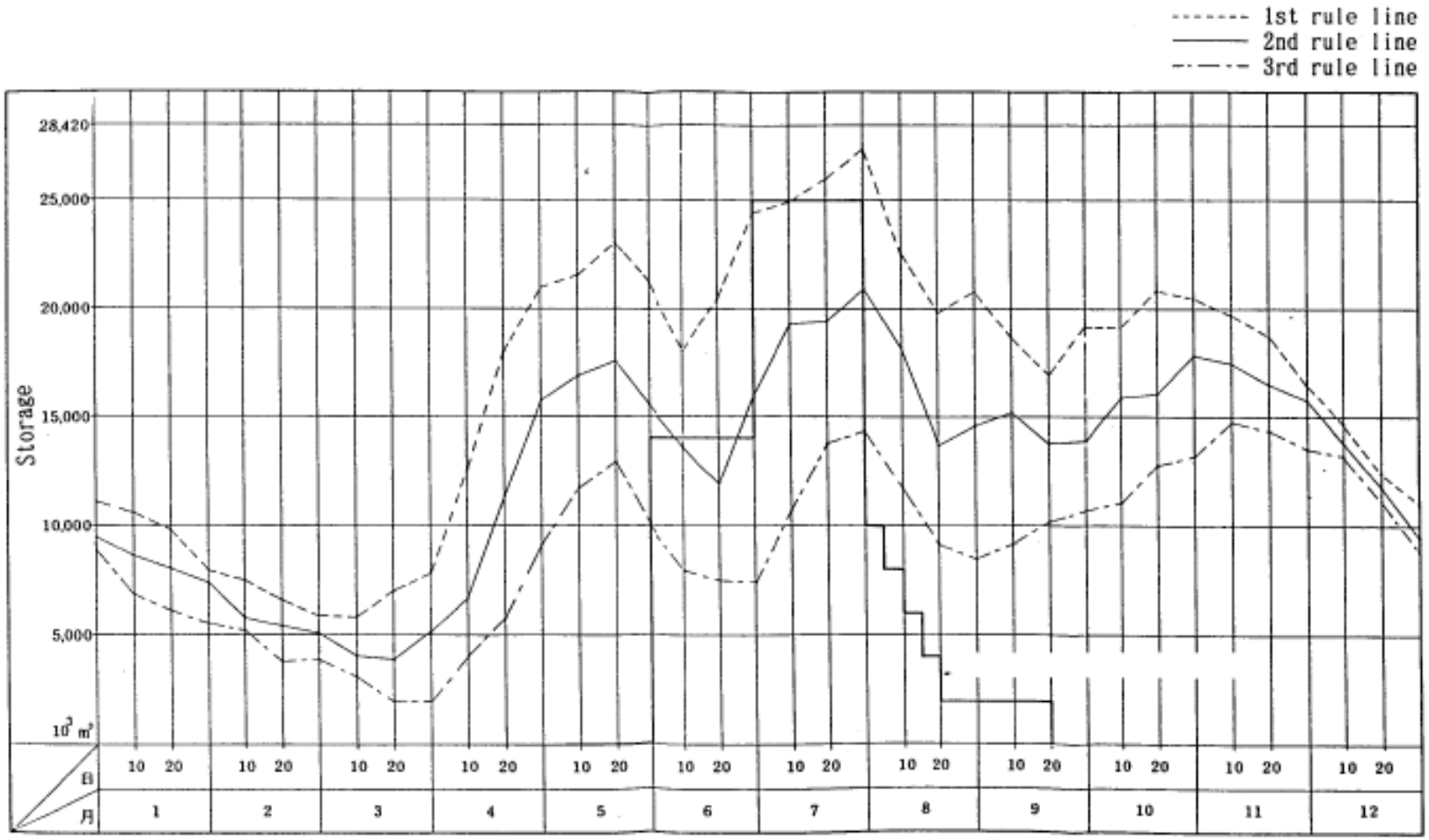




Continuous	Control supply volume by flow rate Flexible Main canal
On-off	Control supply volume by duration High irrigation efficiency, equity with poor management Tertiary canal

Multiple use
Minimum flow

Reservoir operation rule

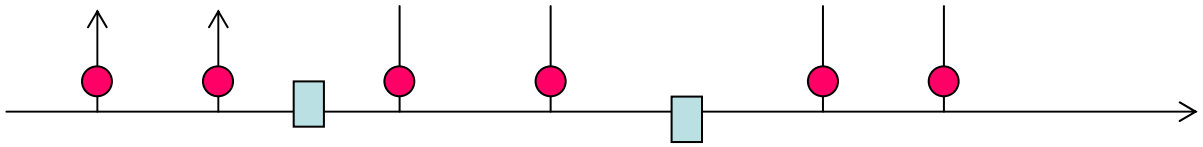


3. Canal operation

Canal operation and spill	To reduce spill from main or secondary canals
Operation of turnout works	Monitoring and control
Operation of cross regulator	Upstream control or Downstream control
Communication	Communication between operators

Control of turnout works

		Operation
A	Flow rate control (measurement) at main turnouts	From upstream to downstream
B		Several times a day (long canal system)
C	Flow rate control (measurement) at key points Water level control (measurement) at main turnout	Several trial or experience
D	Water level control (measurement) at main turnouts	Several trial or experience
E		Rotation between turnouts
F		Proportional distribution without reflection of changing demand

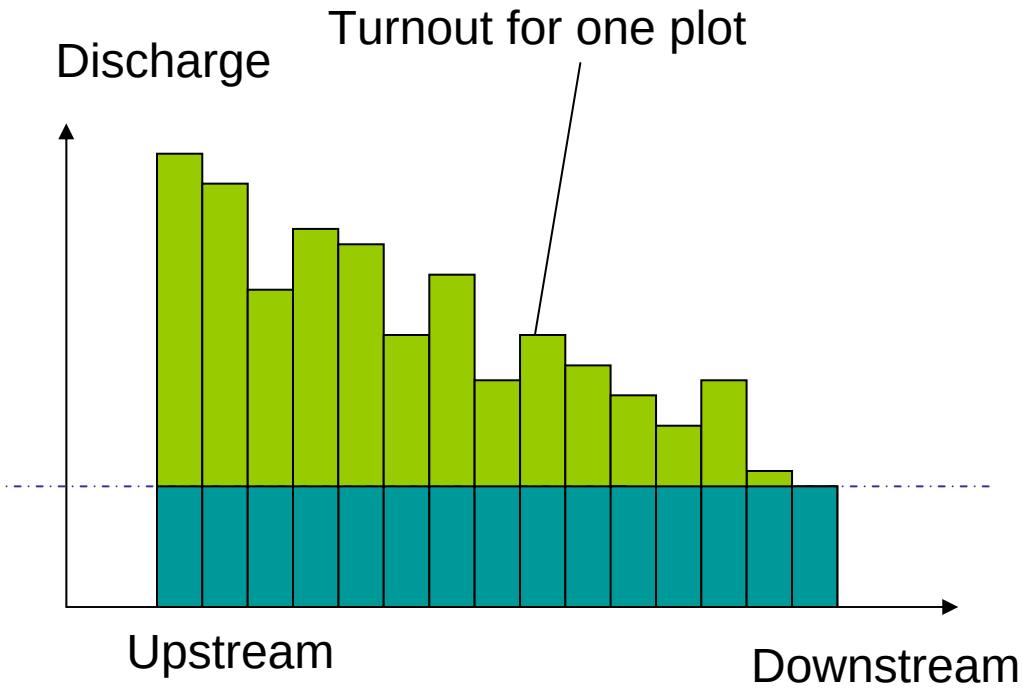


Once flow rate measurements is established, flow rate control is easier than Water level control.

Operation of cross regulator

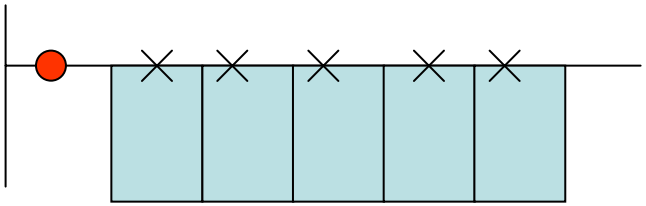
- the gate which keeps constant upstream level automatically was introduced to irrigation canal system in some projects.
- This gate keep upstream level mechanically at division points . Introduction of this type of gates makes operation simple . Managers only have to operate intake gate and division gate which discharge must be varied . The open degree of division gate obey only its discharge .
- But some problems remains or caused . In irrigation canal system , upstream branches have advantage than down stream branches . If there were no check gates , even most upper weir can't get their require water . But if there were check gates , upstream weir can get all they want . There is no problem if operators of branch gate follows general manager of total canal system instructions . Thus construction of the automatic weirs which control constant upper level may cause water shortage at last .

4.Water management of the tertiary canal

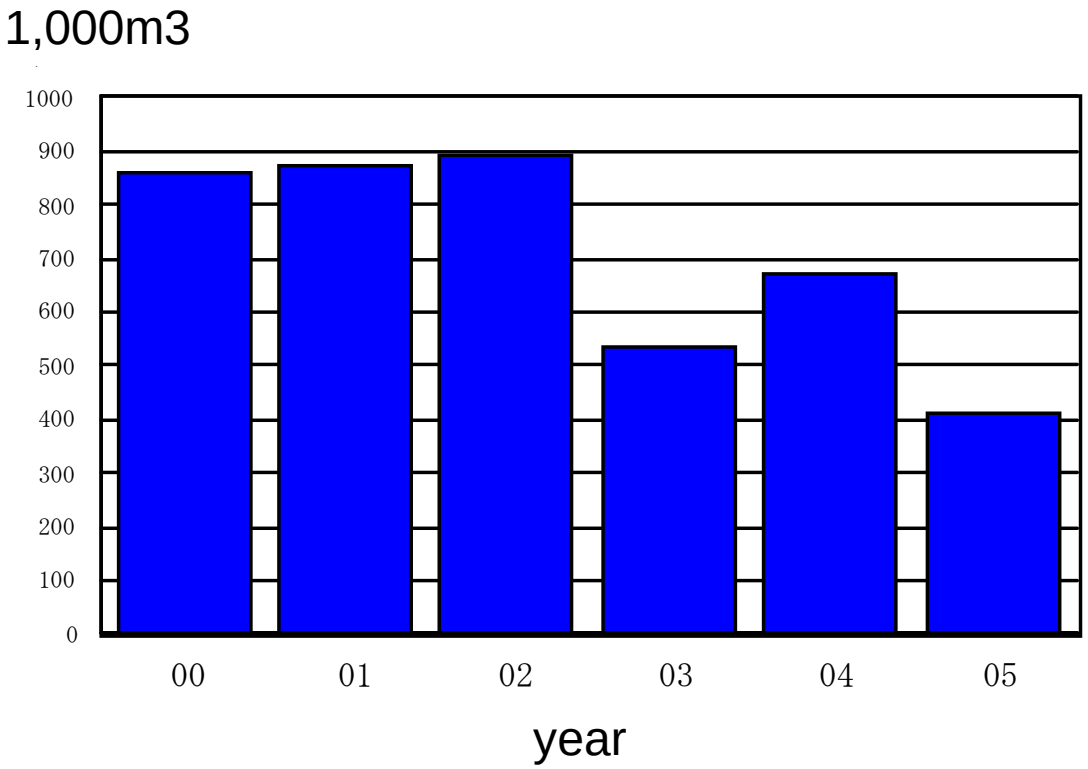


Water user association
Special treatment
Rotation between tertiary
Plot to plot irrigation

W.R.



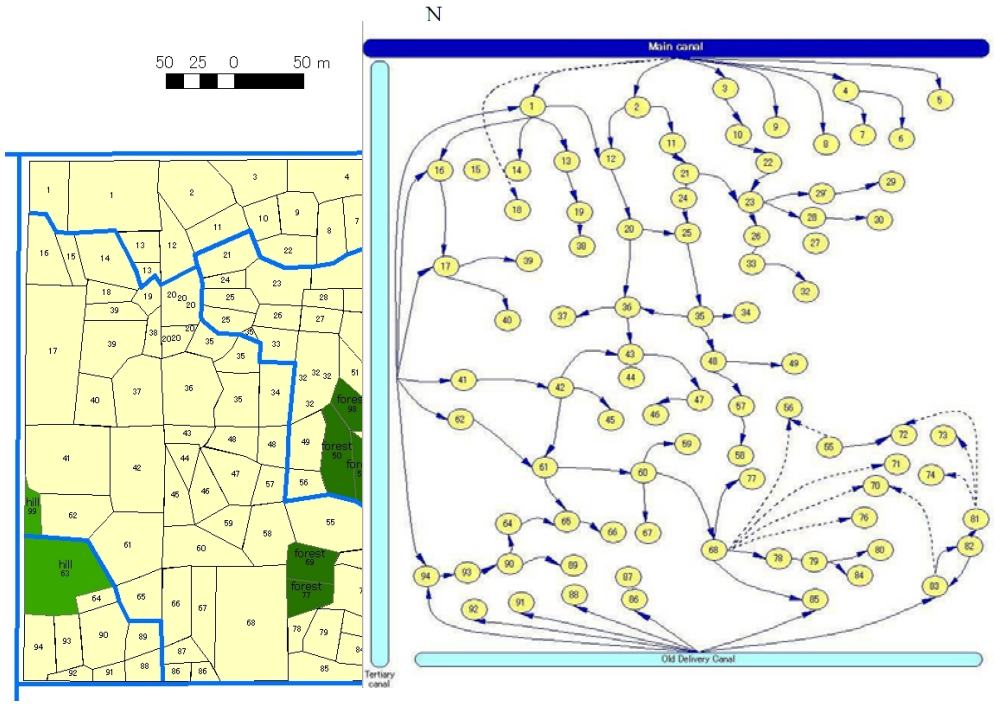
Special treatment



Annual water volume for terticary canal

Water Use Mapping
(water flowchart by farmers)

- Creation of a water flowchart (creation of water flowchart to show the flow of water in and out by plot to plot irrigation of each farmer's own fields based on paddy field maps) to confirm the relationships between farmers and to create communication for carrying out collective work



Tomosho et al.(2006), JIID(2007)

5.Institution

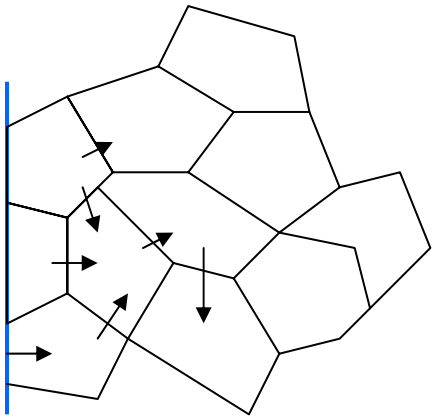
- Water right
- Restriction of land use
- Water quality protection rule
- Re-plotting system in land consolidation

6. Improvement physical structures

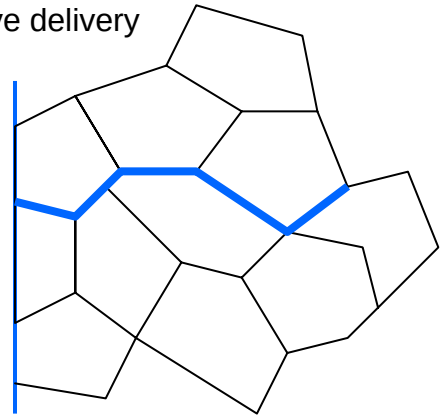
	Contents	Related analysis
Regulation reservoir	Capacity needed	Unsteady flow model
Cross regulator	Weir and gate	
Canal system	Reduction of direct turnout	
Tertiary canal	Advantage and disadvantage	
Remote monitoring and remote control system	Outline	
Automated gate	What is controlled?	

Construction of tertiary canal

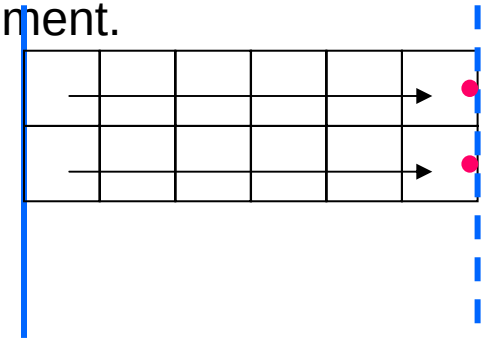
Number of spill points
Traveling time

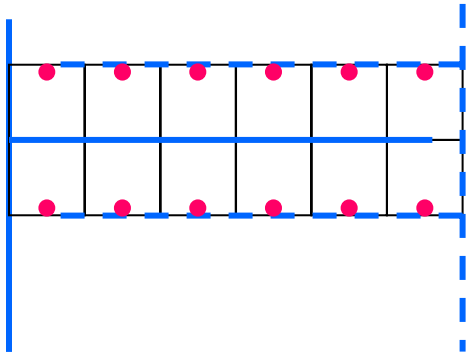


Effective delivery



Construction of tertiary canal would improve irrigation efficiencies of plot to plot system. But high density of irrigation canals may sometimes result in low efficiency with poor water management.





Increase of spill points

Spill point

Low irrigation efficiency with poor water management

Remote monitoring and control system(1)

It is desirable to operate facilities in higher degree by less stuff . To enable this , remote control and monitoring systems are introduced in Japan. Remote monitoring system collects many data such as rainfalls , water levels and water discharges . Water manage can observe these data at control center .

Collected data are displayed to digital or analog meter on graphic panel (panel graph) .

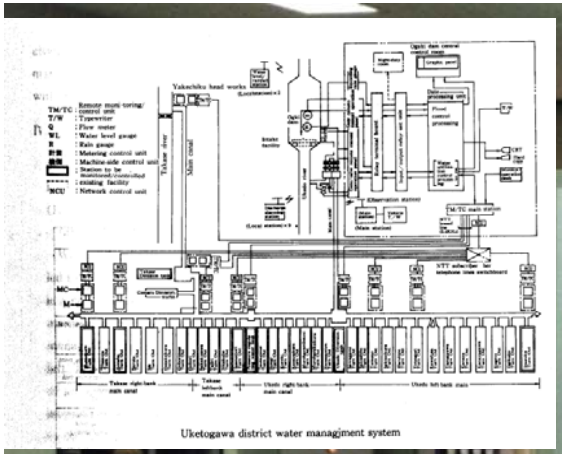
The manager decide how to operate water facilities such as gates , bulbs and pumps by judging according to observed data . Facilities operations are executed by using operation console .

As a communication between control center and on -site station , there are three types communication. There are wireless , exclusive communication line and commercial line .

The purpose of remote control and monitoring system is as follows .

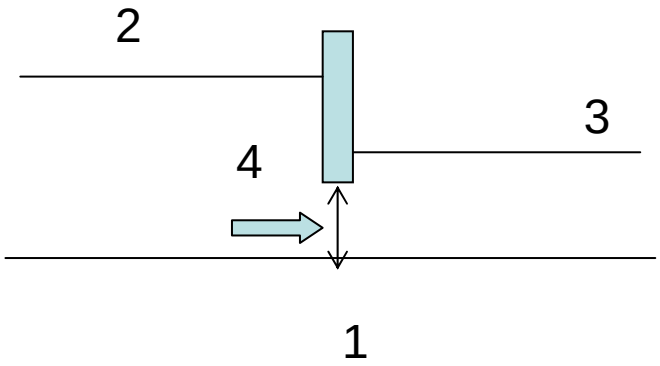
1 Equal water distribution
2 Utilization of water resources without wasting
3 Elimination of labor
4 Prevention of disaster in facilities
5 Adjust of data

Remote monitoring and control system(2)



Uketogawa district water managiment system

Automated gate



Automatic gate
Sluice gate controlled by computer

1. Gate opening
2. Upstream water level
3. Downstream water level
4. Flow rate (discharge)

Stability

feedback

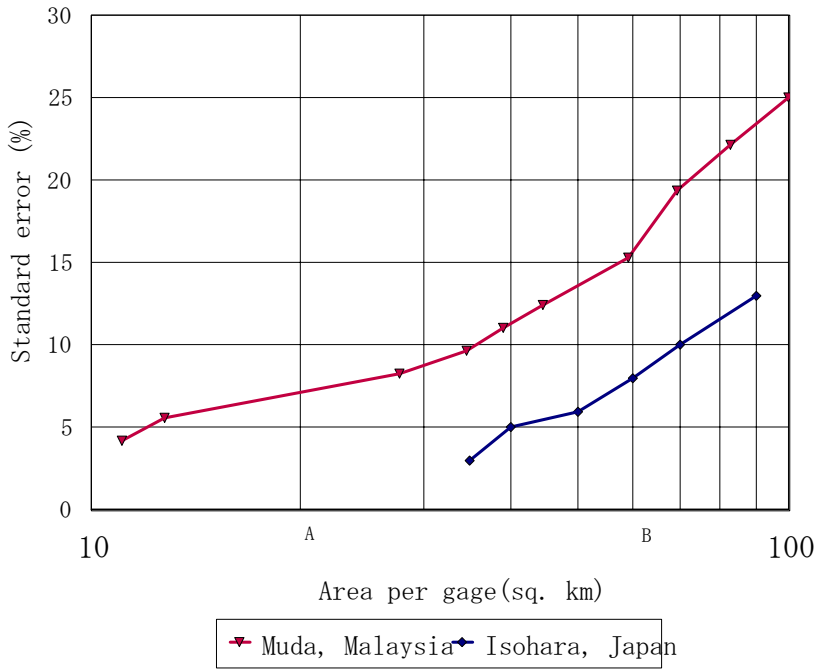
7.Managerial and technical aspects

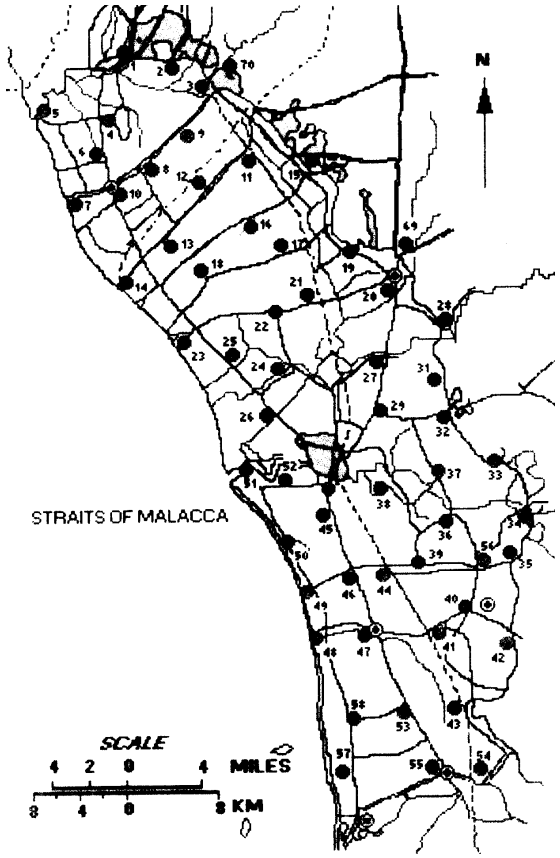
Monitoring
- Frequency and period
- Rainfall
- Reservoir
- Flow
- Field survey
- Farmer requests

Water requirement
- Net water requirement
- Gross water requirement
- Irrigation efficiency
- Effective rainfall
- Pre-saturation water depth

Organization
- Structure
- Operator
- PIM

Monitoring Rainfall　Depth area analysis

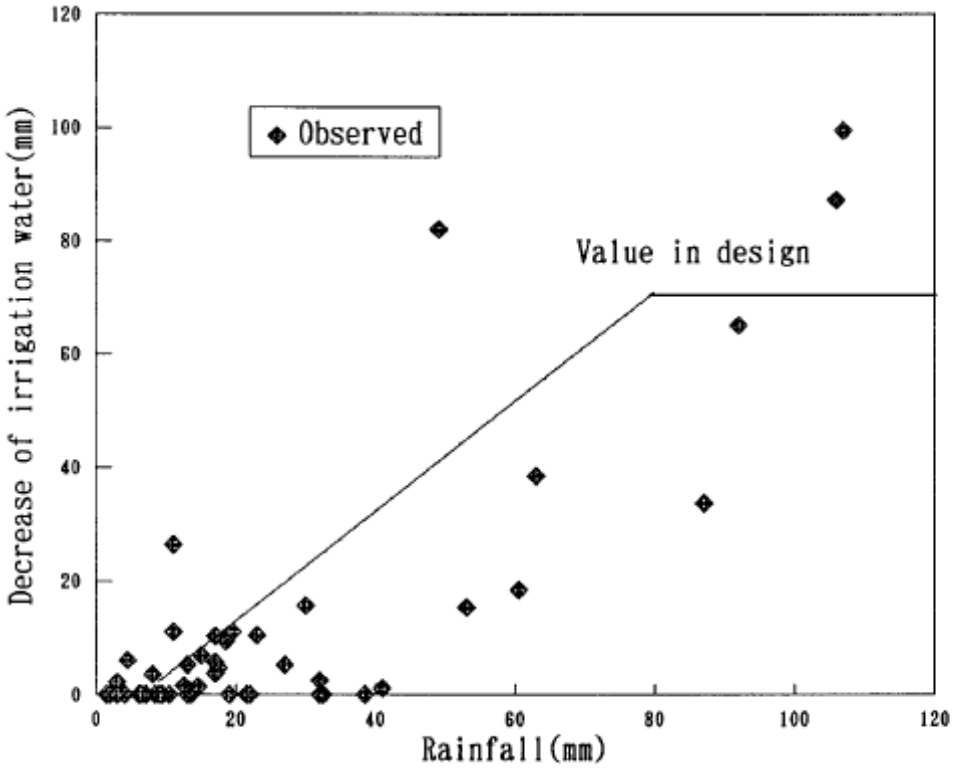




Large-scale irrigation projects consisting of reservoirs contribute towards stabilizing rainy season rice cropping in Southeast Asia, but the water storage capacity of some reservoirs is not sufficient for double cropping. Therefore it is necessary to promote appropriate release reduction by monitoring the average am0unt of rainfall in irrigation systems. This study aims to propose a method for evaluating rainfall station density.

Water requirement: Effective rainfall

Concept of water requirement estimation is same used for seasonal irrigation plan and irrigation scheduling. When the same was used for irrigation project planning, related factors, such as irrigation area, irrigation efficiencies etc. should be revised



PIM and irrigation efficiency

Objectives of Participatory Irrigation Management

- Establishment of communication between irrigation projects and water users
- Effective irrigation managements

→ Improvement of Irrigation efficiency

- Sustainable water management (collection of water fee)
- Irrigation Management Transfer

→ Temporary lower irrigation efficiency

Thank you for your attention