A high-pressure pipeline system for irrigated agriculture in the Ishigaki Island, Japan

- Brief overview of historical development of irrigation and drainage in Japan
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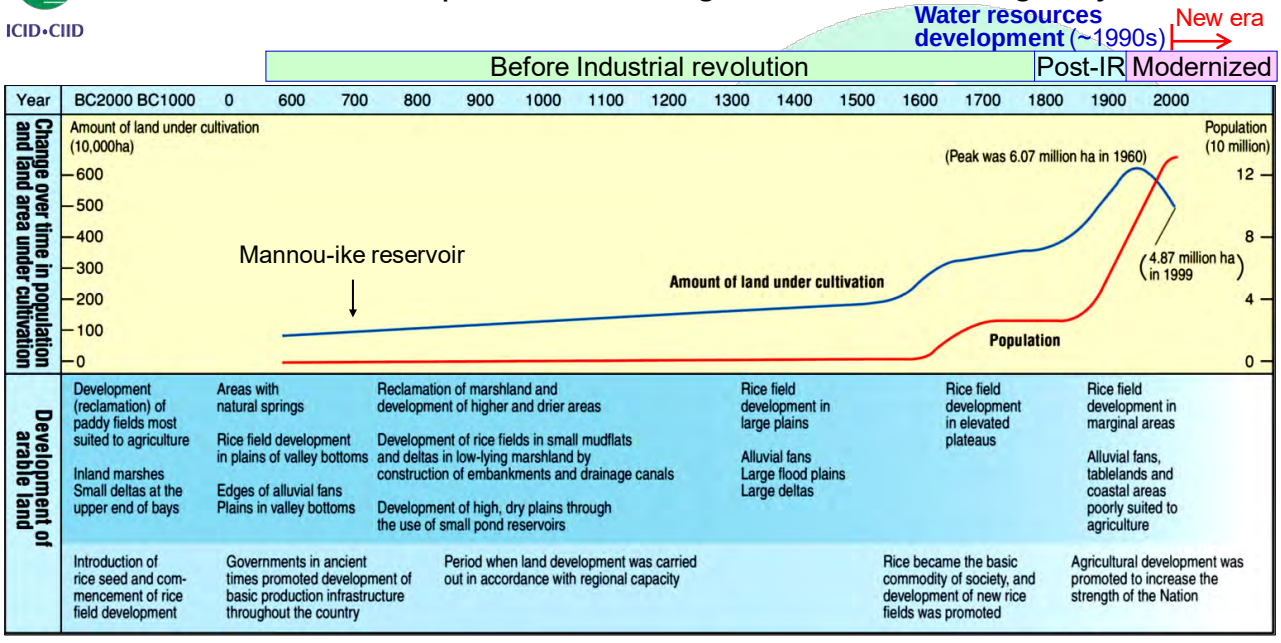
- Summary and way forward

Historical development of irrigation & drainage systems



Development of irrigation & drainage systems (source)

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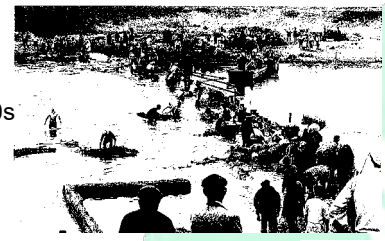
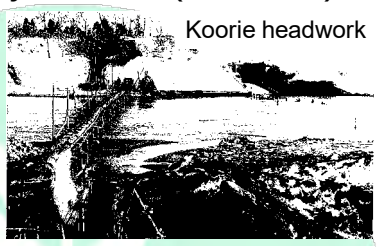
Concrete dams

Weirs

1950s
-1960s



Koorie headwork



1990s

Present

Rock-fill dams
Earthen ponds

Development of irrigation & drainage systems (plot)

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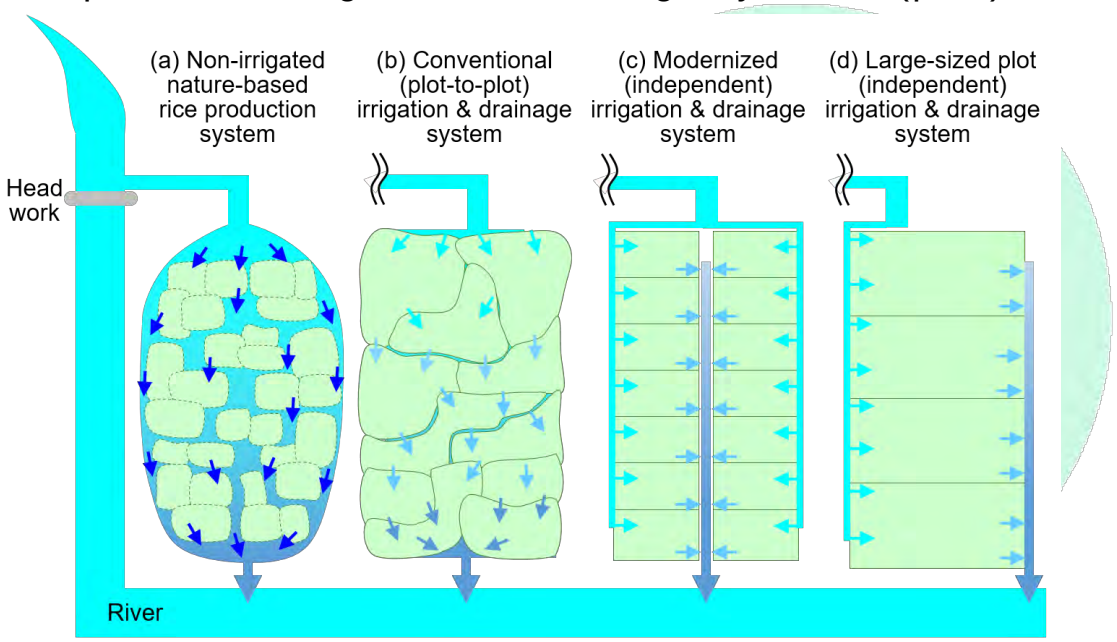

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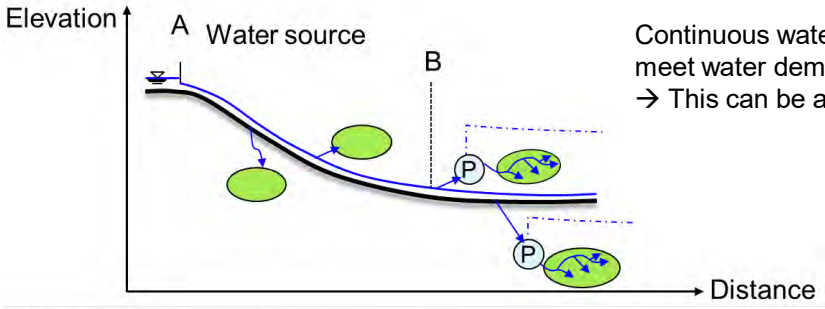
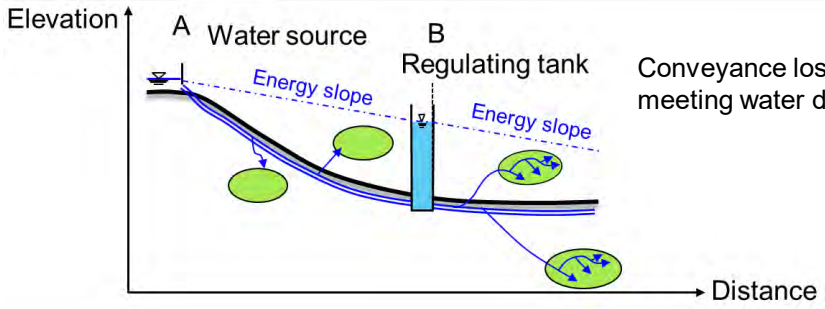
Development of irrigation & drainage systems (pipeline)



Continuous water flow is needed in order to meet water demands by multiple farmers
→ This can be accounted as a loss



Conveyance loss can be minimized while meeting water demands by multiple farmers

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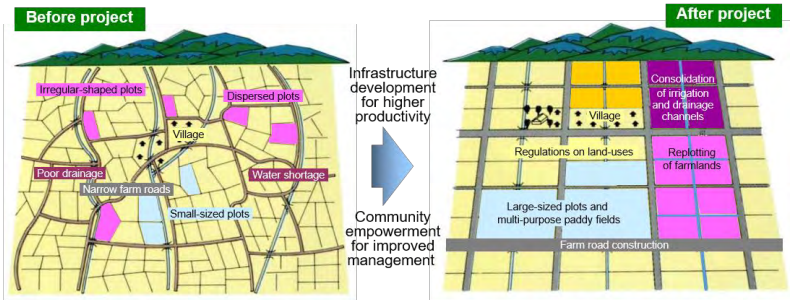
Development of irrigation & drainage systems (land consolidation)

- **Improving agricultural productivity and efficiency**
  - ✓ Replotting
  - ✓ Land readjustment
  - ✓ Irrigation & drainage facilities
  - ✓ Farm road construction
  - ✓ Soil dressing
  - ✓ Underdrainage



Construction/management of irrigation and drainage systems

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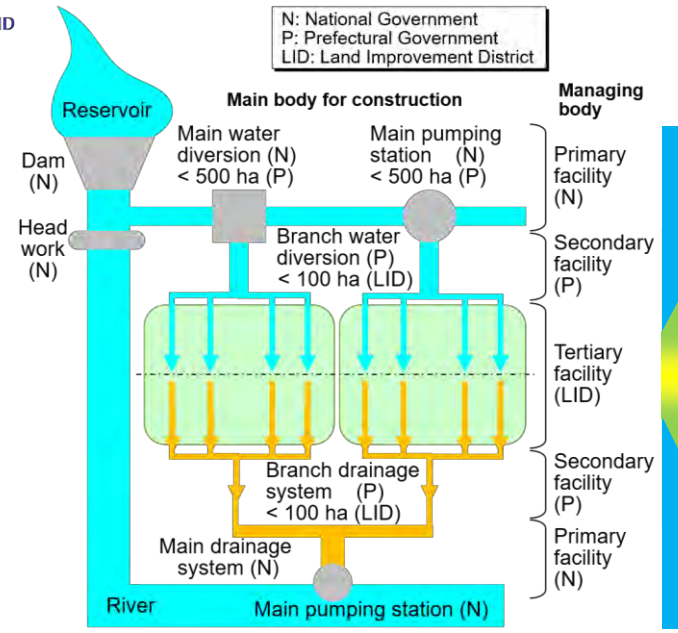

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Proportion of the cost for constructing an irrigation and drainage system (%)

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Main body	Project type	National Gov.	Guideline		Farmers (example)
			Prefectural Gov.	Local Gov.	
National Gov.	Irrigation	66.6	17.0	6.0	10.4
	Disaster	66.6	30.0	3.4	0.0
	Land improvement	66.6	24.4	5.0	4.0
Prefectural Gov.	Irrigation	50.0	25.0	10.0	15.0
	Disaster[1]	50.0	29.0	14.0	7.0
	Disaster[2]	50.0	37.0	13.0	0.0
	Land improvement	50.0	27.5	10.0	12.5

1: Irrigation reservoir, etc.
2: Flood prevention, etc.

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Policy—Long-term Land Improvement Plan

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1949: the Land Improvement Act // 1961: Basic Law of Agriculture

Relief program for unemployed	Increase in food production	Improving agricultural productivity	Upland farming in paddy fields Rural infrastructure development	Agricultural structure reform Development of permanent residence in rural areas	Capacity development for food supply, stock management, disaster prevention/disaster risk reduction, and cooperative system for agricultural production and rural management

1945–	1965–	1973–	1983–	1993–	2003–	2008–	2012–	2016–
-Postwar rehabilitation -Food production	-Selective farmland consolidation -Development of primary irrigation-drainage system	-Generalization of paddy field -Expansion of rural infrastructure development -Quality control of irrigation water	-Accumulation of farmland to core farmers -Improving community infrastructure	-Prioritizing farmland consolidation with plot enlargement & farmers' capacity development -Conservation of rural landscape	-Quantitative assessment for better project management -Revising project period from 10 to 5 years	-Promoting stock management -Regional cooperative activities for maintenance works	-Enhancing food production -Rehabilitation from disaster/ enhancement of disaster prevention/risk reduction -Revitalization of rural community	-Higher profitability -Capacity development -Cooperative system & rural landscape -Rich society with sound material cycle -Strategic management of irrigation systems -Resilience against disaster

Long-term land improvement plan

The main characteristics of the Act are described as follows:

1. Not the land owner but the cultivator shall participate in the land improvement projects as the beneficiary.
2. The prior conditions for starting the land improvement project are farmers' application and agreement.
3. Construction and management works can be implemented with more than a certain amount of agreement, usually two-thirds. Although less than one third of the beneficiaries opposed to the project, they shall be involved in the project and shall shoulder the related costs regardless of their will.

Development of irrigation & drainage systems (Asset Management)

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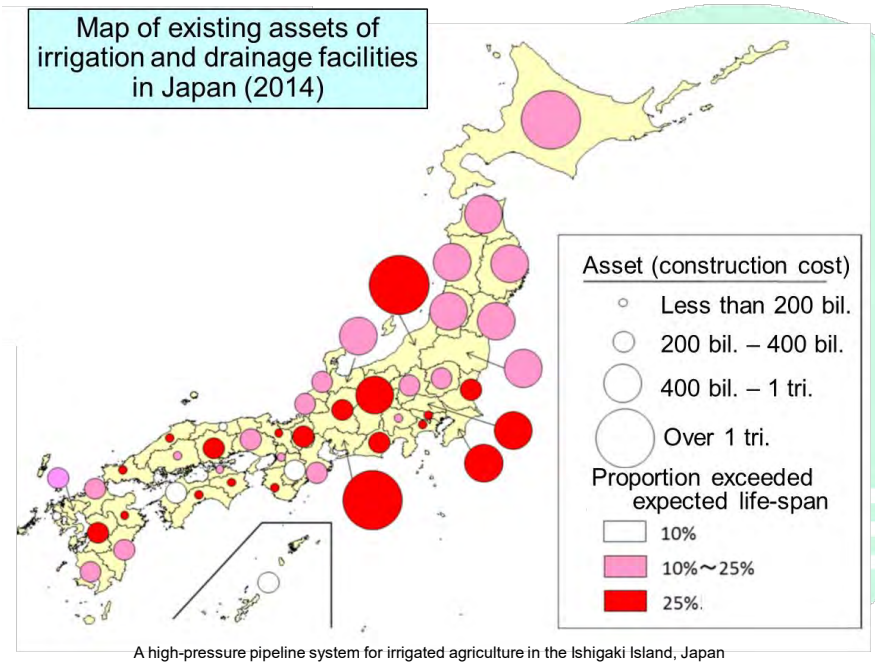

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A high-pressure pipeline system for irrigated agriculture in the Ishigaki Island, Japan

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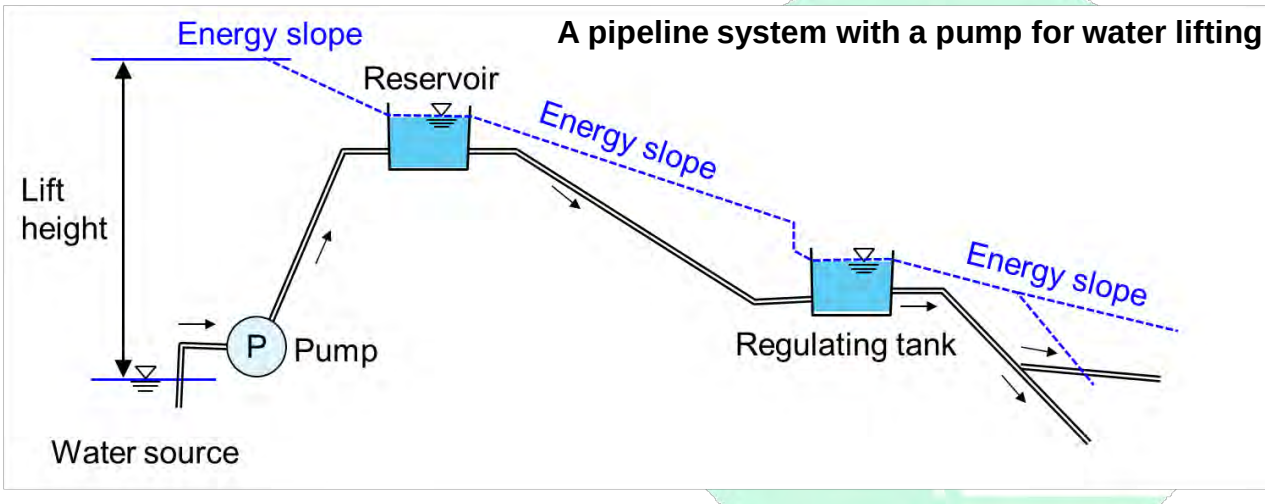
Case studies of pipeline systems in Japan

A pipeline system with a pump for water lifting



Two case studies of Japan

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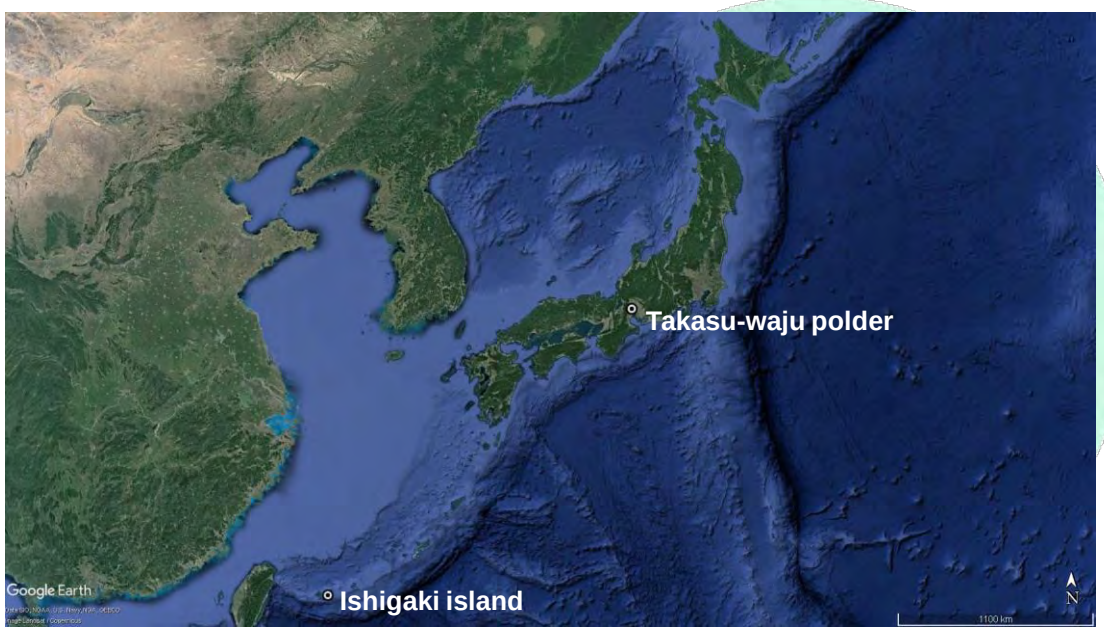

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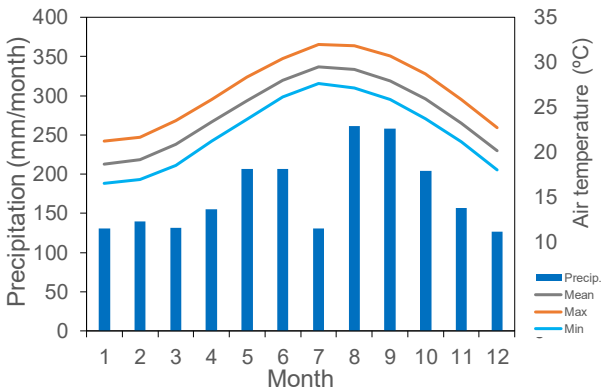

- ✓Mountainous on northern and western side, mostly sloping regions with limited flat areas
- ✓Most rivers are short with a small catchment (9 watersheds with 23 rivers/streams)
- ✓Rainy in May-June and August-September (annual precipitation: 2106.8 mm)

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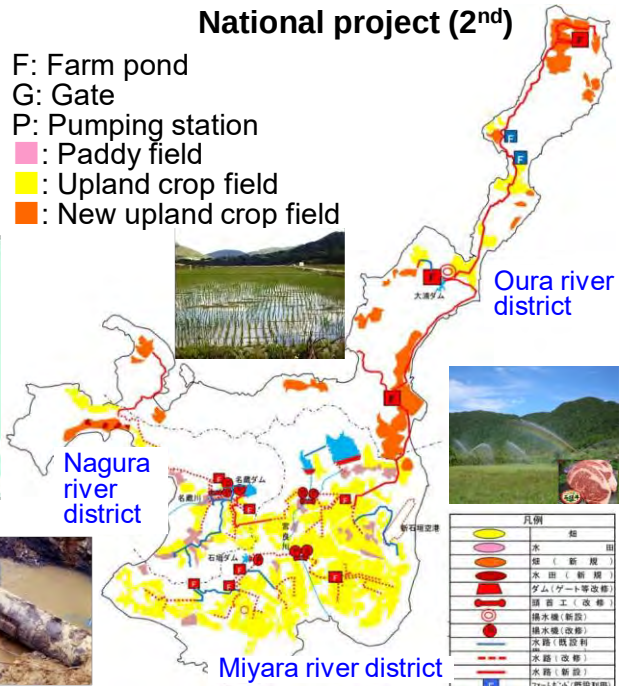

Ishigaki-jima Irrigation and Drainage Project

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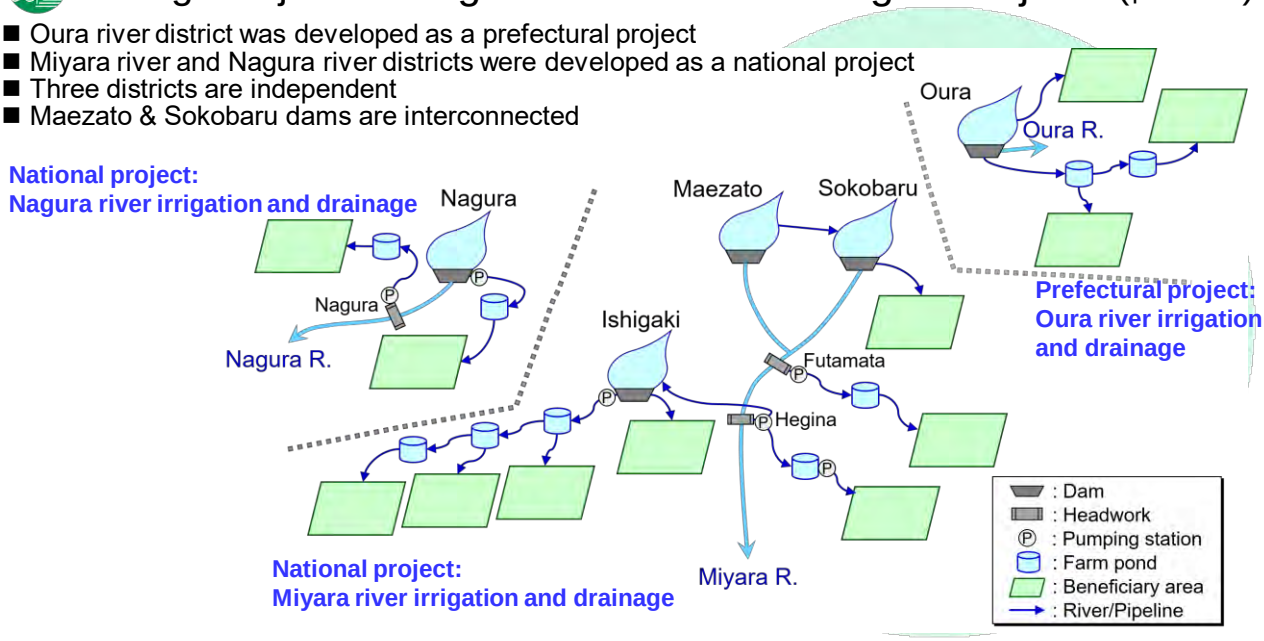
Objectives	Irrigation improvement
Beneficiary area	4338 ha (Paddy: 265 ha; Crop fields: 4073 ha)
Year	2014
Cost	28.1 billion JPY (194 million USD) (price in 2012)
Dam	Sokobaru, Maezato, Ishigaki, Nagura, Oura
Headwork	Futamata, Hegina, Nagura
Pumping station	Hegina, Ishigaki, Banna, Miyara, Futamata, Nagura, Takada, Oura, Tohri
Farm pond	Hegina left-side, Hegina right-side 1–3, Futamata, Nagura, Takada, Oura 1-2&5, Tohri
Pipeline	Hegina right-side bank, and 41 other pipelines (105 km-long new pipelines)
Control station	Central control station
Target crops	Rice, Sugarcane, Tabaco, Sweet potato, Okura, Pumpkin, Bitter gourd, Pineapple, etc.

Ishigaki-jima Irrigation and Drainage Project (pre-2nd)

- Oura river district was developed as a prefectural project
- Miyara river and Nagura river districts were developed as a national project
- Three districts are independent
- Maezato & Sokobaru dams are interconnected

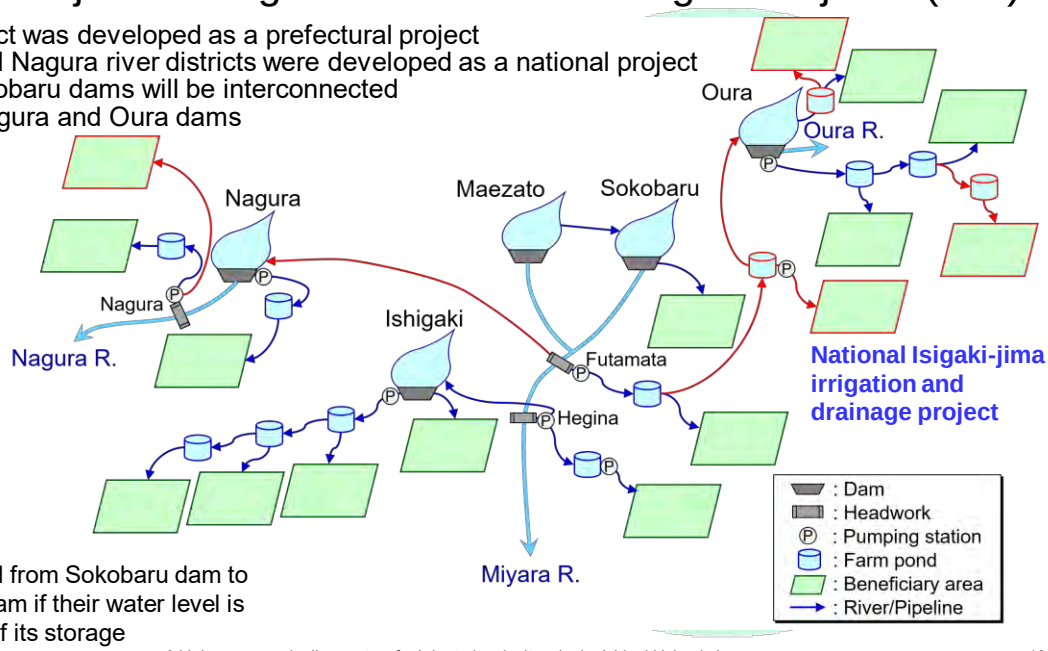


Ishigaki-jima Irrigation and Drainage Project (2nd)

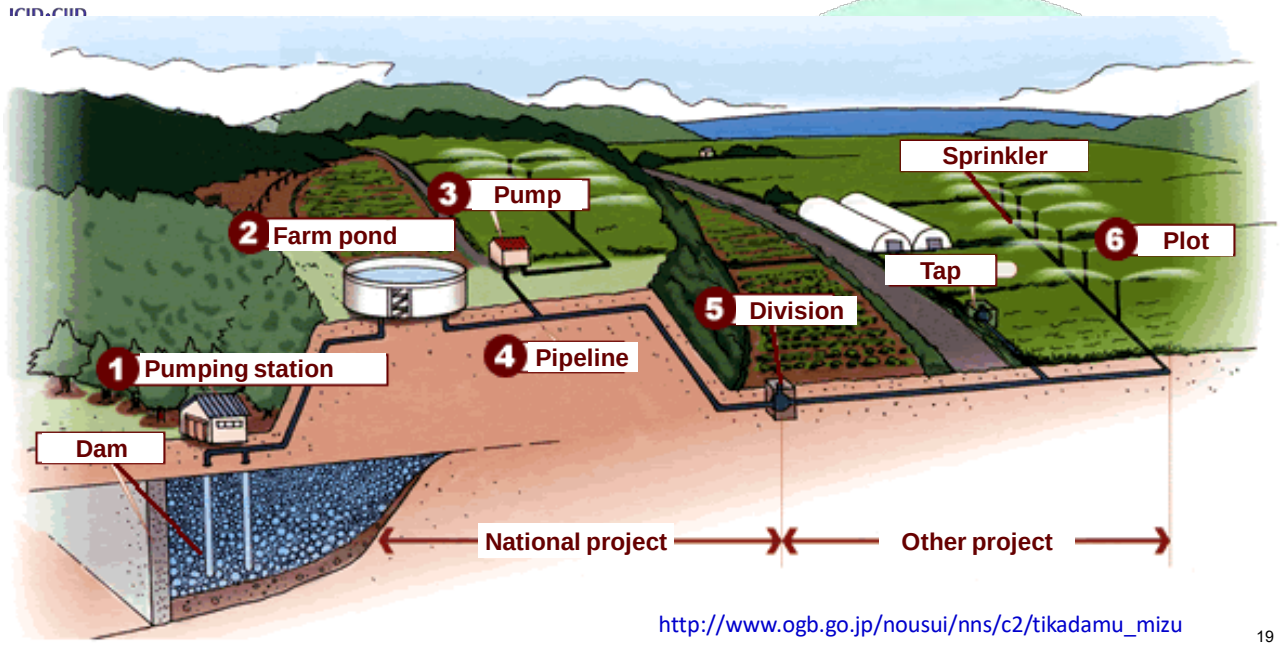
- Oura river district was developed as a prefectural project
- Miyara river and Nagura river districts were developed as a national project
- Maezato & Sokobaru dams will be interconnected with each of Nagura and Oura dams

Rules of water conveyance from Sokobaru dam

- ✓Use water of Sokobaru dam prior to water conveyance from Maezato dam
- ✓Water is <u>not</u> conveyed if water level at Sokobaru dam is below 25% level of its storage
- ✓Water is conveyed from Sokobaru dam to Oura or Nagura dam if their water level is below 50% level of its storage



Underground dam for an island with limestone



http://www.ogb.go.jp/nousui/nns/c2/tikadamu_mizu

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A high-pressure pipeline system for irrigated agriculture in the Ishigaki Island, Japan

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Takasu-waju polder

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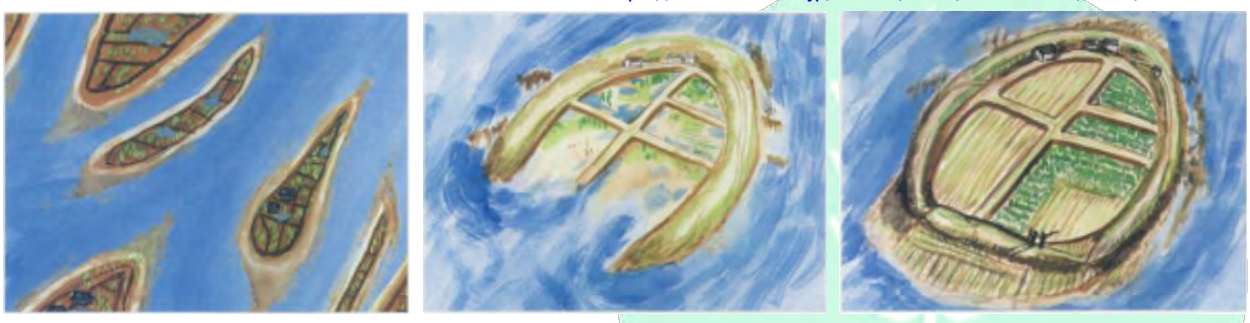
https://suido-ishizue.jp/kokuei/tokai/Prefectures/2104/2104.html



Natural river bank

Man-made bank without downstream bank

Man-made bank with closed downstream bank

- There are 45 waju polders from Gifu city (45 km from river mouth) to Bay of Ise
  → Nobi Plain is wide flat low-lying area
- Flooding and drought events occurs occasionally, resulting in severe damage in production
- Needs for mechanization in agriculture and for multiple uses of paddy fields increased with economic growth in the region

Takasu-waju polder

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Takasu-waju polder (a little bit closer)

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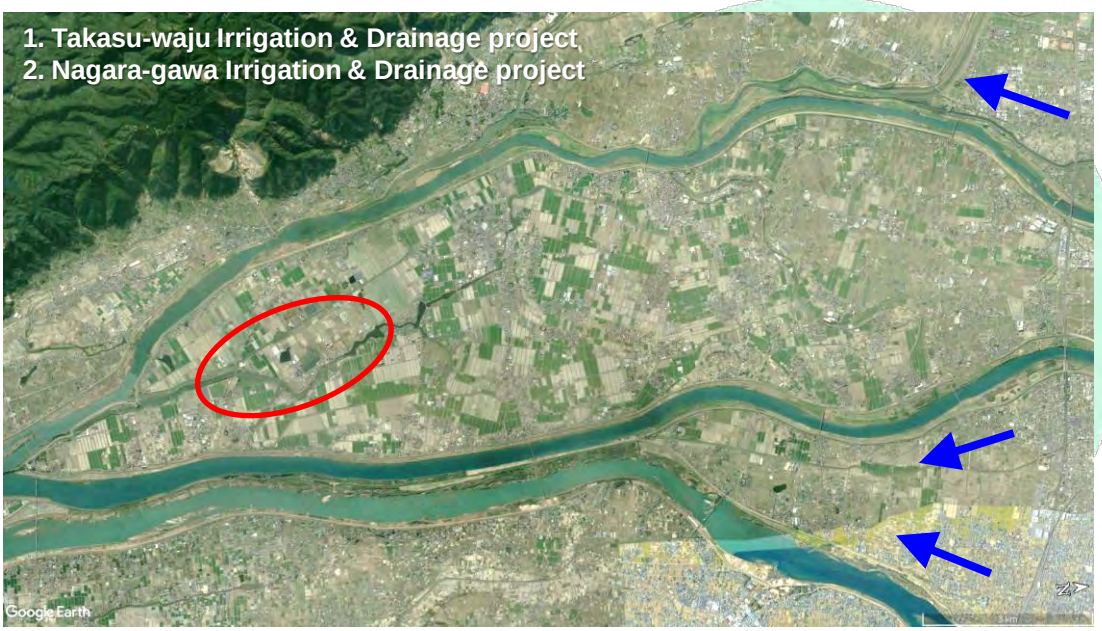

Takasu-waju Irrigation & Drainage project

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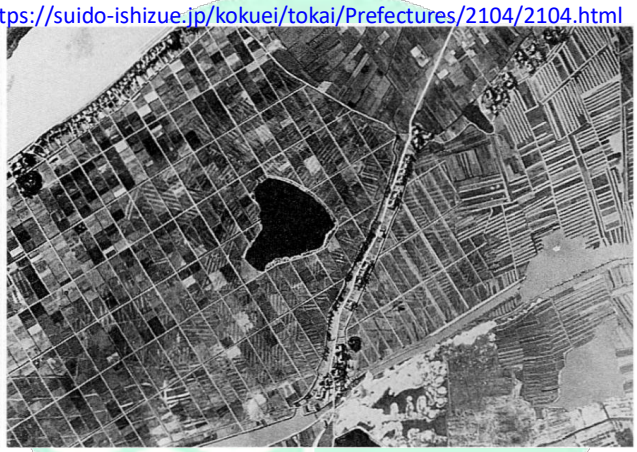
https://suido-ishizue.jp/kokuei/tokai/Prefectures/2104/2104.html

Before the project



After the project

- Objectives: Enhancement of drainage capacity (5 pumping stations) and land reclamation
- Beneficiary area: 3116.8 ha
- Additional project: Prefectural Irrigation and drainage project: primary open channel for irrigation

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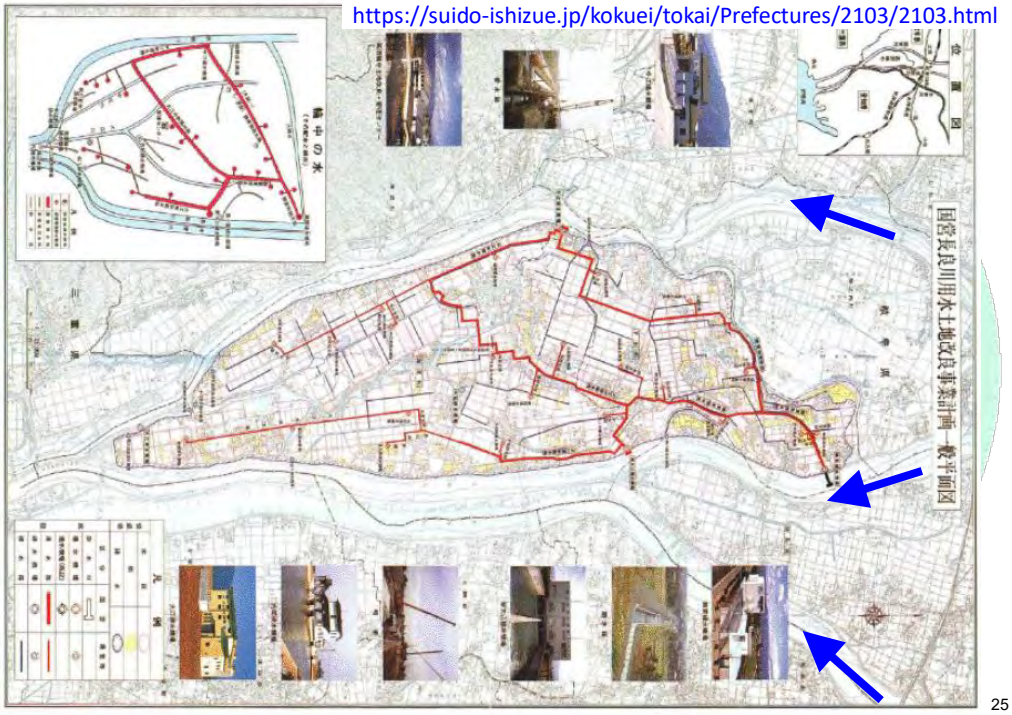
Nagara-gawa Irrigation and drainage project: overview

https://suido-ishizue.jp/kokuei/tokai/Prefectures/2103/2103.html



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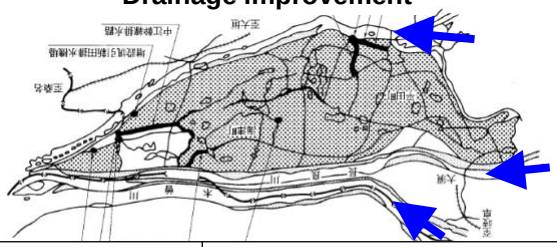
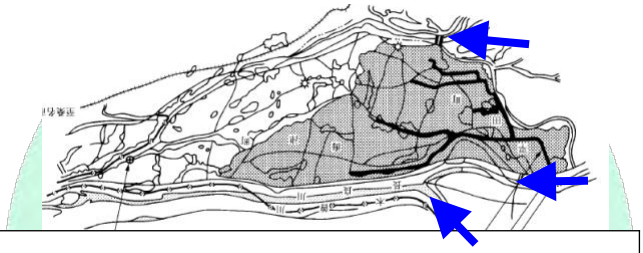
Nagara-gawa Irrigation and drainage project

Drainage improvement



Irrigation improvement



Objectives	Irrigation and drainage
Beneficiary area	3030 ha
Year	1980–1997
Cost	22.0 billion JPY (194 million USD) (price in 1997)
Pumping station	2 pumps for irrigation 2 pumps for drainage
Irrigation channel	1 open channel and 5 pipelines (totaled 12 km long)
Related projects	Prefectural I&D project: 1 district (A: 3030 ha; Cost: 6.3 billion JPY), 1980–1996 Primary drainage project: 11 districts (A: 1679 ha; Cost: 5.3 billion JPY), 1978–1991 Pref. land consolidation: 3 districts (A: 2937 ha; Cost: 24.7 billion JPY), 1980–1999

https://suido-ishizue.jp/kokuei/tokai/Prefectures/2103/2103.html

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Nagara-gawa Irrigation and drainage project

☐ Achievement

1. Establishment of highly productive agricultural district

- ✓ Primary irrigation and drainage facilities for stable water supply and reduced risks of inundation
- ✓ Land consolidation projects for enlargement of paddy fields, which enabled mechanization of agricultural production
- ✓ Multiple uses of paddy fields for rice, wheat, soy bean, and greenhouse-grown vegetables such as tomatoes, cucumbers, and strawberries.

2. Reduced operation and management costs

- ✓ Central control of primary irrigation and drainage facilities reduced costs and time for O&M
- ✓ Farm roads and farmland enlargement improved production efficiency
- ✓ Some farmers shared agricultural machines to further reduce production costs

3. Creation of comfortable rural landscapes

- ✓ In addition to agricultural production, rural landscapes were improved
- ✓ Reduced inundation risks and traveling time for works, schools, etc. improved local lives
- ✓ Farmers' market became a good place for consumers and farmers as a lively community

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- ☐ **Summary and way forward**

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Summary and way forward

- **Pomp-based pipeline systems can be useful for various landscapes including hilly and flat low-lying farmlands (Ishigaki-jima & Takasu-waju)**
- **A pipeline system can be useful for improving land drainage in a flat low-lying fields (Takasu-waju, Gifu)**

Fundamental projects for agricultural production
More information exist regarding revitalization of facilities

- **Toward sustainable irrigation and drainage**
  - **➔ Communities including both farmers and non-farmers need to be empowered for better planning, operation and management of the systems → payment for multifunctionality enhancement**
- **One of the biggest challenges to meet spatiotemporally varying water demands in an irrigation system**
  - **➔ Information and communication technologies (ICT)-based irrigation and drainage systems have been constructed, but maintenance and/or renovation cost is extremely high**
- **Water-Energy-Food-Ecosystems nexus can be a key for sustainability**

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Irrigation & Drainage Systems for Enhancing Agro-ecosystems

Appendix

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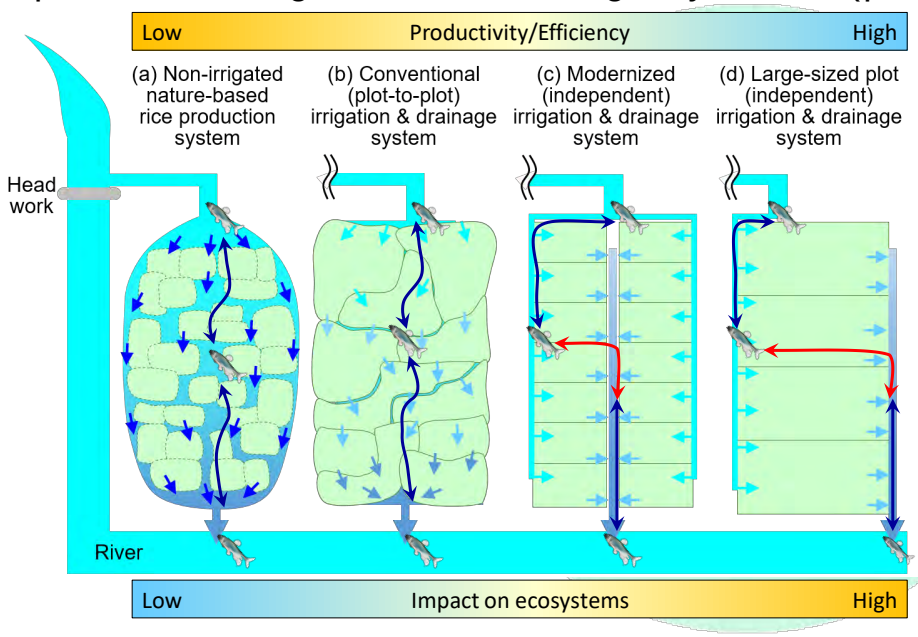
Development of irrigation & drainage systems (plot)



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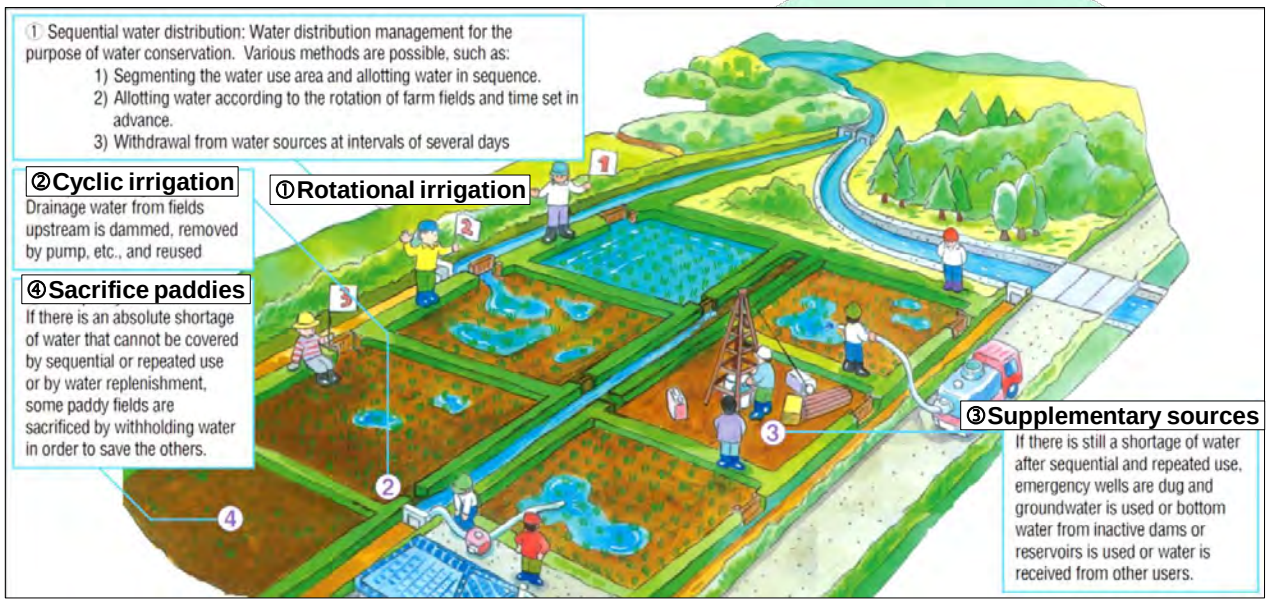
Water-saving irrigation approaches **(Farmers' efforts)**

mainly by Land Improvement District (LID)



A high-pressure pipeline system for irrigated agriculture in the Ishigaki Island, Japan

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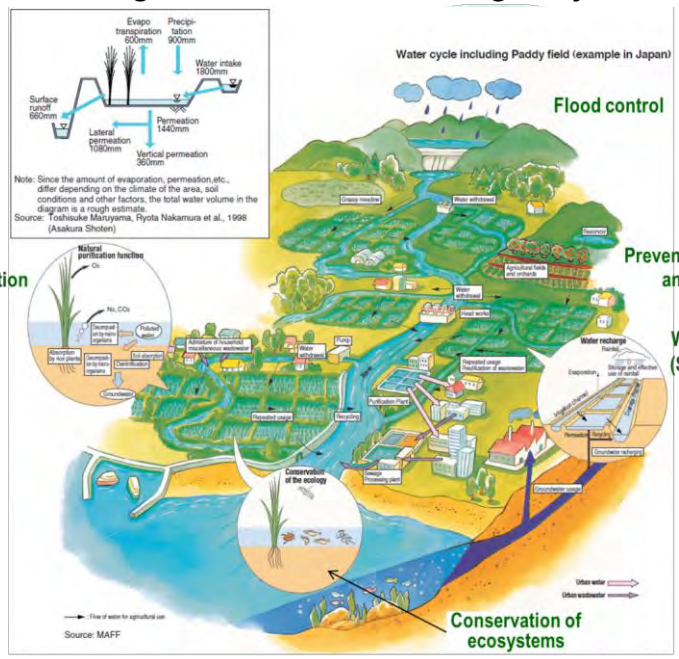
Multifunctionality of irrigation and drainage systems

In Japan, irrigation water is not only for agriculture but also for <u>domestic uses</u> in the region.



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Payment for multifunctionality enhancement

A) Farmland maintenance


Weeding (levee)


Dredging


Weeding (bank)


Farm road maintenance

B) Resource improvement


Filling cracks


Surface maintenance


Planting


Removing invasive species

Price in JPY	Prefectures except Hokkaido			Hokkaido		
	A	B (qual. Imp.)	B (revital.)	A	B (qual. Imp.)	B (revital.)
Rice paddies	3,000	2,400	4,400	2,300	1,920	3,400
Upland/fruit	2,000	1,440	2,000	1,000	480	600
Grassland	250	400	400	130	120	400