CONTENTS

Detailed Program Schedule

List of Participants

1. **Main Strategy for Rural Development in Korea**
   (Mr. Lee, Seung-won, Deputy Manager, KRC)
2. **Agricultural Water Development for Field Farm**
   (Mr. Eo, Dae-su, Director, KRC)
3. **Computer Modeling for Agricultural Water Management**
   (Pr. Lee, Nam-ho, Professor, Han-Kyong University)
4. **Sustainable Agricultural Water Management in Korea**
   (Mr. Cho, Jin-hoon, Director, KRC)
5. **Groundwater Development**
   (Mr. Chung, Hyung-jae, Former Section Chief, KRC)
6. **Water Supply System & Practice**
   (Mr. Kim, Young-deuk, Deputy Manager, KRC)
7. **Introduction of Rural Development**
   (Mr. Lee, Ki-churl, Director, KRC)
8. **Water Resources Quality Management**
   (Mr. Eum, Myeong-chul, Deputy Director, KRC)
9. **The Water Managemenrt using GIS**
   (Mr. Kim, Dong-in, Deputy Director, KRC)

Detailed Program Schedule

Course Schedule

☐ **Duration : 1. September, 2009(Tue) ~ 17. September, 2009 (Thu) (17Days)**

Date	Schedule	Remarks
9.1(Tue)	Opening Session, Lecture, Welcome Party	KOICA
~ 13:30	ICC → KRC	
13:30 ~ 14:00	Registration	
14:00 ~ 14:30	Opening Session	
14:30 ~	Move to ICC	
9.2(Wed)	Lecture	KOICA
08:30 ~ 09:30	ICC → KRC	
09:30 ~ 12:30	Lecture : Water Supply System & Practice	
12:30 ~ 14:00	Lunch	
14:00 ~ 17:00	Lecture : Computer Modeling for Agricultural Water Management	
17:00 ~ 18:00	Move to ICC	
9.3(Thu)	Lecture, Field Trip	KRC
08:30 ~ 09:30	ICC → RRI	
09:30 ~ 12:30	Lecture : Sustainable Agricultural Water Management in Korea	
12:30 ~ 14:00	Lunch	
14:00 ~ 15:30	Rural Research Institute	
15:30 ~ 16:00	Move to RDA	
16:00 ~ 17:00	Rural Development Administration	
17:00 ~	Move to ICC	
9.4(Fri)	Lecture	
08:30 ~ 09:30	ICC → KRC	
09:30 ~ 12:30	Lecture : Groundwater Development	
12:30 ~ 14:00	Lunch	
14:00 ~ 17:00	Lecture : Agricultural Water Development for Field Farm	
17:00 ~ 18:00	Move to ICC	
9.5(Sat)	Korean Culture Excursion	
9.6(Sun)	Free time Lecture	KOICA
9.7(Mon)	Lecture	
08:30 ~ 09:30	ICC → KRC	
09:30 ~ 12:30	Lecture : Groundwater Development for Agricultural Water	
12:30 ~ 14:00	Lunch	
14:00 ~ 17:00	Lecture : Main Strategy for Rural Development in Korea	
17:00 ~ 18:00	Move to ICC	
9.8(Tue)	Field Trip(1st Day)	
09:00 ~ 10:30	Move to Asan	
10:30 ~ 13:00	Oiam Village & Lunch	

13:00 ~ 15:30	Transferring	
15:30 ~ 17:30	Deachung Dam (visite Barrage)	
17:30 ~ 18:00	Transferring	
18:00~	Dinner, Check-in and free time	Daejeon
9.9(Wed)	**Field Trip (2nd Day)**	
08:00 ~ 10:30	Move to Cheongwon	
10:30 ~ 12:00	TM/TC system site	
12:00 ~ 13:30	Lunch & Transferring	
13:30 ~ 16:00	Hoilyongpo village	Home Visiting
16:00 ~ 18:30	Move to Gyeong-ju	
18:30 ~	Dinner and Check-in	Gyeong-ju
9.10(Thu)	**Field Trip(3rd Day)**	
09:00 ~ 10:30	Moving	
10:30 ~ 12:00	**Gyeongju National Museum**	
12:00 ~ 13:00	Lunch	
13:00 ~ 15:00	**Bulkuk Temple and Sukgulam**	
15:00	Move to Seoul	
9.11(Fri)	**Lecture, Closing Session**	
08:30 ~ 09:30	ICC → KRC	
09:30 ~ 12:30	**Lecture : Water Resources Quality Management**	
12:30 ~ 14:00	Lunch	
14:00 ~ 17:00	**Lecture: The Water Management using GIS**	
9.12(Sat)	**City Excursion**	
9.13(Sun)	**Free time**	
9.14(Mon)	**Departure**	
08:30 ~ 09:30	ICC → KRC	
14:00 ~ 17:00	**Lecture : Rural Development in Korea**	
17:00 ~	Move to ICC	
9.15(Tue)	**Departure**	
08:30 ~ 09:30	ICC → KRC	
09:30 ~ 11:30	**Country Report**	
11:30 ~ 12:00	**Closing Session**	
12:00 ~ 15:00	Lunch & Farewell Party	
15:00 ~ 16:00	Transferring	
16:00 ~ 17:30	RAD	
17:30 ~	Move to ICC	
9.16(Wed)	**Field Trip**	
08:30 ~12:00	ICC → Buan	quartier libre
12:00 ~ 14:00	Lunch	
14:00 ~ 16:00	Saemangum	
16:00 ~	Move to ICC	
9.17(Thu)	**Departure**	

2009

Agricultural Water Resources Management(Senegal)

Aug 20 ~ Sep 4, 2009

KOICA Korea International Cooperation Agency

Korea Rural community Corporation

List of Participants

List of Participant

No.	Country	Name	Gender	B.O.D
1	Senegal	Mr.Ibrahima Diop	M	1957.01.22
2	Senegal	Mr.Babacar Mbodji	M	1950.08.30
3	Senegal	Mr.Mamadou Sambou	M	1962.09.13
4	Senegal	Mr.Modou Ndao	M	1963.07.10
5	Senegal	Mr.Bélal Bâ	M	1966.11.04
6	Senegal	Mr.Abdoulaye Mbaye	M	1969.04.02
7	Senegal	Mr.Mandoye Ngom	M	1956.10.01
8	Senegal	Mr.Mamadou Sané	M	1961.01.01
9	Senegal	Mr.Diop Modou Ndao	M	1978.01.28
10	Senegal	Mr.Idrissa Niang	M	1952.11.17
11	Senegal	Mr.Aïdara Sall	M	1958.10.02
12	Senegal	Mr.Ibrahima Ndiaye	M	1961.05.02
13	Senegal	Mr.Fossar Soune	M	1983.08.26

Korean Language & Culture (Rev. 090516)

Seok-Hoon You (Korea University; syou@korea.ac.kr, (822)3290-2176)

1. Introduction - Population & Speakers

- Population: 80 mil. (50mil. (SK) + 23.3 mil. (NK) + 7,044,716 (Overseas))
- Speakers: 78 million (11th / 3000 languages)

	Language (Speakers in million)		Language (Speakers in million)
1	Mandarin Chinese (1,051 million)	11	French (78 million)
2	Arabic (422 million)	11	***Korean (80 million)***
3	Hindi (366 million)	13	Wu (77 million)
4	English (341 million)	14	Javanese (75.6 million)
5	Spanish (322 million)	15	Telugu (69.7 million)
6	Bengali (207 million)	16	Marathi (68 million)
7	Portuguese (176 million)	16	Vietnamese (68 million)
8	Russian (167 million)	18	Tamil (66 million)
9	Japanese (125 million)	19	Italian (62 million)
10	German (100.1 million)	20	Punjabi (57 million)

1.1. Introduction - Seoul

- Population: 11.5 mil. (Size: 604Km^2)
- No. of Vehicles: 2,975,002 / 16,861,965 (as of Feb. 09)
- 86th on the list of 215 cities grading the **quality** of metropolitan life around the world (2007)
- Good Aspects: History & Tradition, Dynamicity, Accessibility, Transportation, IT
  Bad Aspects: Traffic, Air/Water Pollution, Limited Space, High Cost of Living
- Living Costs:

Big Mac Index	
Countries	Price (US$)
USA	3.22
Hong Kong	1.54
South Korea	3.08
Japan	2.31
Singapore	2.34
USSR	1.85
China	1.41

Prices	
Items	Price (US$)
Meal	**4-**
Bus	**1-**
Taxi	**2-**
Subway	**1-**

1.2. Introduction - Geographics

- Location: Eastern Asia, southern half of the Korean Peninsula, temperate weather
- Area: *S. Korea*: 98,480 km^2; *N. Korea:* 120,540 km^2
- (Limited) Natural Resources: coal, tungsten, graphite, molybdenum, lead, hydropower potential
  > Rich Human Resource with high level of education and technical training

1.3. Introduction - National Symbols

- Flower (*Mukunghwa;* hibiscus), Anthem (*Aegwukka*), Flag (*Thaekeukki*)

1.4. Introduction - History

- Foundation of *Gojoseon*: BC 2333 - BC 108
- The Three Kingdoms (BC57-AD935), *Balhae* (AD668-AD926), and *Koryo* (AD918-AD1392)
- *Joseon* Dynasty (AD1392 - AD1910)
- Japanese Annexation & Colonization (AD1910-AD1945)
- Korean War (1950-53)

- Industrialization: Success of 6 consecutive 5 year Economic Development Plans (1962-1991), GNP/capita: US$87 in 1962, US$20,000 in 2007
- Seoul Olympic Games (1988), World Cup/Asian Games (2002), World Baseball Classic, German World Cup (2006), Beijing Olympic Games (2008)

1.5. Introduction - Neighbors (Japan, China, Mongolia & Korea)
Blood Inheritance (appearance, ...), Chinese characters, Sticky rice (Chopsticks)

II. *Hangukeo* & *Hangeul* - Korean language and alphabet

- *Hangukeo* : (Altaic) language (Turkish, Mongol, Manchurian, Finish???), SOV word order
- *Hangeul:* 24 basic alphabet. Consonants depict relevant speech organs (lips, tongue, tooth, and throat) and vowels depict the heaven, earth, and man. (UNESCO World Heritage, 1997)
- a mixed script of *Hangeul* and Chinese characters.

You Seok Hoon 유 석 훈 劉 錫 勳

- Consonants and Vowels:

ㄱ (k/g)	ㄴ (n)	ㄷ(d)	ㄹ(l/r)	ㅁ(m)	ㅂ(b)	ㅅ(s)
ㅇ(ng)	ㅈ(j)	ㅊ(ch)	ㅋ(k)	ㅌ(t)	ㅍ(p)	ㅎ(h)

ㅏ (a)	ㅓ (eo)	ㅗ (o)	ㅜ (u)	ㅡ (eu)
ㅑ (ya)	ㅕ (yeo)	ㅛ (yo)	ㅠ (yu)	ㅣ (i)

- Syllable Composition:

ㄱ (k/g) + ㅏ (a)	가 (ka / ga)
ㄴ (n) + ㅏ (a)	나 (na)
ㄷ (t/d) + ㅗ (o)	도 (to / do)
ㄹ (r/l) + ㅗ (o)	로 (ro / lo)
ㅅ (s) + ㅓ (eo)	서 (seo)
ㅇ (0) + ㅜ (u) + ㄹ (r/l)	울 (ul)

III. Basic Expressions

1. *An-nyeong-ha-sey-yo.* 'How are you! How do you do! Good morning / afternoon / evening'
2. *(Ali) im-ni-da.* 'I am Ali.' (Put your name in the blank.)
3. *(Iraq)-saram im-ni-da.* 'I am Iraqi.' (Put your nationality in the blank.)
   Hankuk-saram 'Korean' *Vietnam-saram* 'Vietnamese'
4. *Ban-gap-sum-ni-da.* 'Nice to meet you.'
5. *Mi-an-ham-ni-da. Hanguk-eo jal motayyo.* 'Sorry. I don't understand/speak Korean well'
6. *Jal meo-geo-sum-ni-da.* 'I enjoyed the meal.'
7. (Cham / Aju) *Ma-si-sum-ni-da.* 'It's (very) delicious.'
8. *Ma-si-key-du-sey-yo.* 'Enjoy the meal, please.'
9. *Geon-bae* 'Cheers.'
10. *Kim-chi :* Chopped cabbage mixed with chilly pepper and other spicy ingredients, One of the World's five healthiest foods (Health Magazine, MAR 25, 2006); olive oil (reducing heart disease risk), soy bean paste (preventing cancer and osteoporosis), yogurt, andl entils)
11. *Bul-go-gi, Bi-bim-bap, Sam-gye-tang, Gim-bap, Naeng-myeon*
12. *Hwa-jang-sil eo-di-ye-yo*? 'Where is it?' *(hwa-jang-sil* 'toilet, restroom')
13. *Eol-ma-ye-yo*? 'How much is this?'
    Jom Kka-kka cwu-sey-yo. 'Give me some discount.'
14. *Gam-sa-ham-ni-da / Go-map-sum-ni-da.* 'Thank you.'
15. *An-nyeong-hi* ***ga****-se-yo. / An-nyeong-hi* ***gye****-se-yo.* 'Good bye'

Main Strategy for Rural Development in Korea

Mr. Lee, Seung-won
Deputy Manager
KRC

Rural Development Strategy

- Focusing on Rural Community Capacity Building-

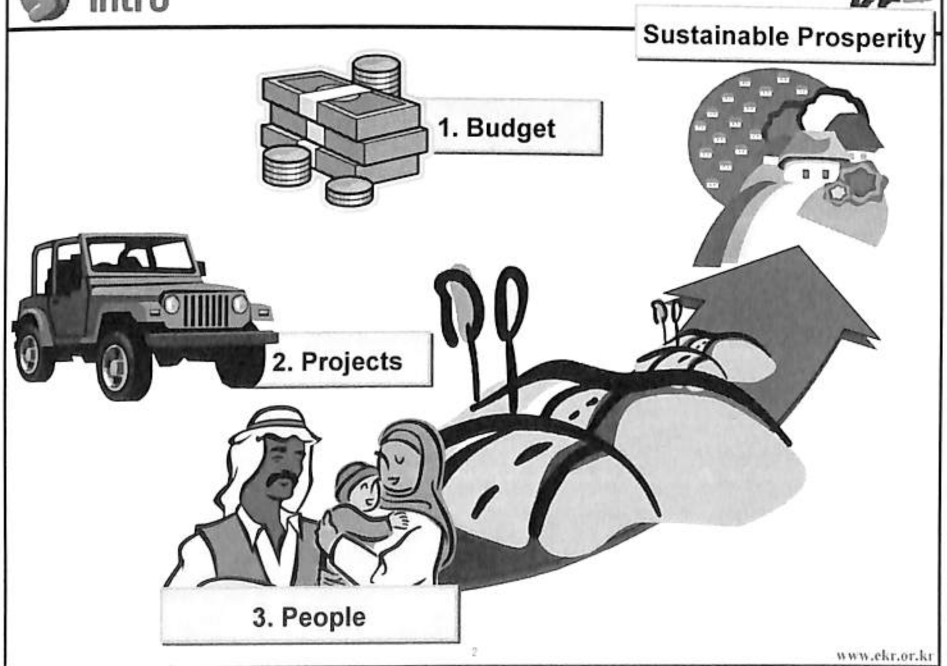
Lee, SeungWon

2009.08

http://www.ekr.or.kr

Korea Rural Community & Agriculture Corporation

Intro



Contents

Transition of Budget & Policies for Rural Development(RD)

Integrated Rural Community Development(IRCD) Project

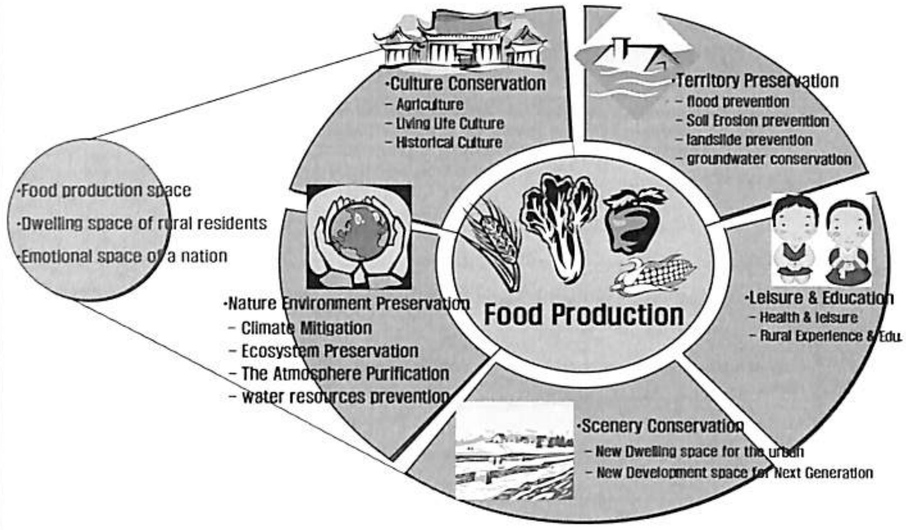
Rural Community Capacity Building Programs for RD

Developing of agri-rural policy in S.Korea

	50~70's	80's	90's	2000's
Agri. Policy	·Policy of increase production & land renovation ·Modernizing Agriculture	·System improving policy + price support policy ·expanding the scale of management & land restructuring		·Rice production control policy - Eco-friendly agriculture - Introducing direct payment program
	Rural Development Policy			
Basis of Policy	· Improving basic environment	· Experimenting comprehensive way of development	·Executing comprehensive small-scale development	·Expanding rural community development program
Main Projects	· Saemaul undong (New Village Movement)	·Comprehensive rural-costal area development	·Depressed Area Development ·Comprehensive Mountain Community Development ·Comprehensive Costal Community Development	·Green Rural Experience Model Village ·Beauty-Town Make-up Project ·Fostering Traditional Theme Village ·Fine Nature Ecological Village
meaning	· Industrializing the restructuring of rural living environment as a government policy	·Shift of managing mode (unit business→comprehensive development business)	·Expanding the scale of budget ·Joining several government stations	·Connected with income ·Comprehensive development mode by community unit ·Leading residents' participation

Paradigm Shift of Rural Area

Agricultural production-centered → Plural Functional Area



Paradigm Shift of RD

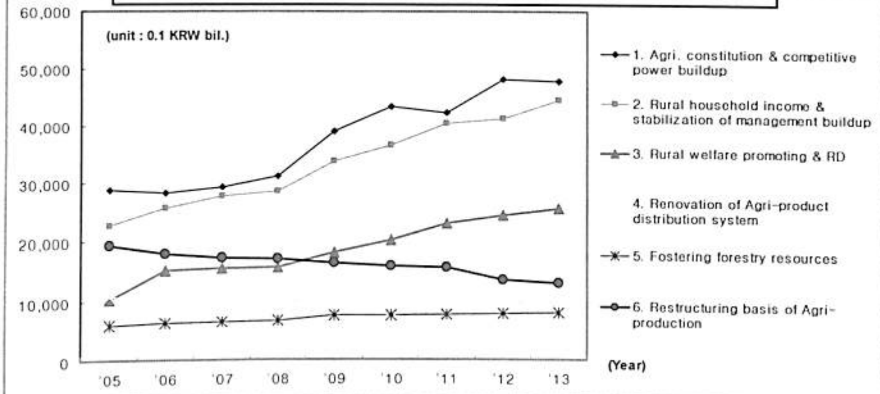
- Central Government initiative → **Local government & residents initiative**
- Providers & the rural centered → **Demand-driven (Considering Urban Demanders)**
- Sector Unit development → **Counter-sector development**
- Pursuit Comfort & Function → **Fostering the scenery bearing a rural character**

Change of Investment priority in RD

MAF expanding investment on rural development

- Increase the investment and loans for Rural household income, competitive power buildup, and RD parts
  - Rural welfare & RD parts : ('2005)8.6% → ('2013) 17.2%
- Decreasing the investment and loans for Restructuring basis of agri-production parts
  - ('2005) 32.6% → ('2013) 8.8%

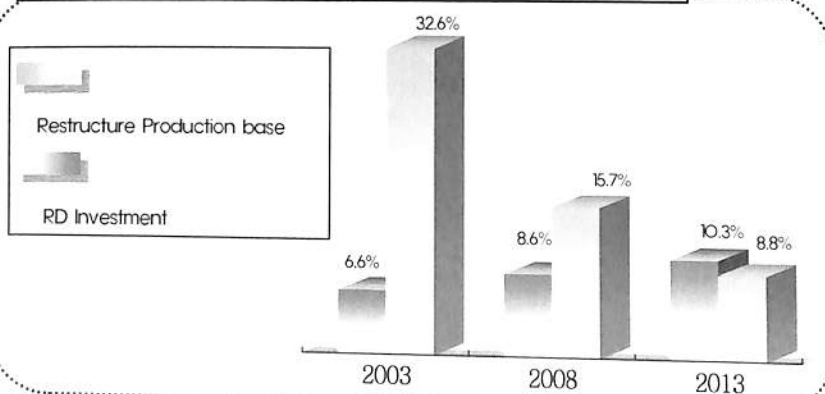
Plan of Investment and loans of ₩119 trillion($119 Billion) of MAF



Change in Driving Agriculture Policy

- From ₩119 trillion of a comprehensive counterplan for agriculture & rural area , planning of Investment ₩10.2 trillion(8.5%) on "Activating Rural area development" part
- The Investment on Rural area development part - Gradually expanding : annual average rate of increase 11.4% ('03~'13)

Investment rates by years for Total Budget



Change in Driving Agriculture Policy

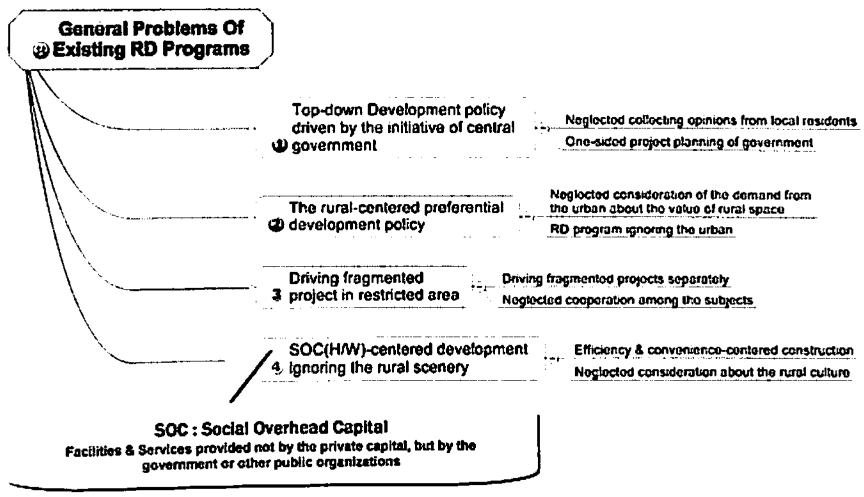
- Considering a comprehensive counterplan for agriculture & rural area and Planning investment and loans of ₩119 trillion ('04.2)
- Driving Demander-centered RD for leisure and residence
  - Comprehensive Rural Village Development Project
  - Preparation idyllic town project (custom-made idyllic residence, stay-at-farm on weekend, farm for the retired)
  - Driving other Rural plans & restructuring projects (theme cluster type RD. etc.)
- Basic plan for improving the quality of lives of Rural and costal residents('05.4) : Framing the system('04.3)
- Construction implements for stabilizing income of rural household (Expanding Direct payment system. Etc.)

Rural Development Programs in S.Korea

(Unit : KRW)

Program	Budget / Unit / Period	Program Detail
Rural-Costal House Environment Improvement	Repairing abandoned house(0.3Mill./house) Reorganizing Village (0.1~0.3Bill./area). etc.	○ House Renovation, Repairing abandoned house ○ Reorganizing Village in improving residence environment Zone. etc.
Small Town Fostering	1Bill. / year about 10Billion for 3years (National funds)	○ Improving residence environment of 194 eup, Road Repair, Distribution Facility Repair
Comprehensive Depressed Area Development	·.5Bill. / area (Total : 399 outback myeon)	○Facility of Living & Production Basis Improvement ○Improving residential environment, small river improvement. etc.
Comprehensive Islands Area Development	0.6Bill. / Island year (Total : 410 Islands)	○Driving Facilities of electricity, water supply, traffic, port, fishery harbor, agricultural warehouse, environment sanitation, medical service, and welfare etc.
Beauty-Town Make-up Project (stopped)	2Bill. / Village (Average)	○way of public contribution, village unit comprehensive development for increasing income
Integrated Rural Community Development	·.70Bill. / Zone (for 3~6years)	○Facilities for Basic living, increasing income, and expending function of multi-organization
Enhancing Rural Living Environment	4.6Bill./myeon (for 3~6 years)	○Improving residential environment, road repair ○Rural industry Development, culture welfare facilities ○Environment conservation, disaster prevention, house renovation etc.
Fostering Culture Village (stopped)	3~6Bill. for 2~3years	○Fostering homestead, Reorganizing basis facilities of village Water supply & waste system, Electricity & Communication, and Community center, etc
Green Rural Experience Village	0.2Bill. / Village	○ Leisure experience facilities for Rural Tour or Fostering village scenery
Rural House Environment Improvement	Kitchen+Bathroom(loans for rural house : 4.8Mill.) Eco-Friendly Toilet(4Mill./unit)	○Integrated from '97
Fostering Traditional Theme Village	0.2Bill./Village (for 2years)	○ Traditional Facilities, agricultural special product processing, and village environment improvement
Comprehensive Mountain Community Development Program	·.1.4Bill. / Zone for 3~4 years	○Production Basis, income source, improving living Environment. etc.
Comprehensive Costal Community Development Program	3.6Bill. / Zone (Average)	○Mooring fisherboat, a breakwater, Direct sales market. etc.
Costal Experience Village	0.5Bill. / Village	○ Information center, Village fishery, entry road, and parking lot. etc.
Fine Nature Ecological Village	Promotion Support for choosen village	To allow priority for Natural Environment preservation facilities and Basic Environment facilities, if requested

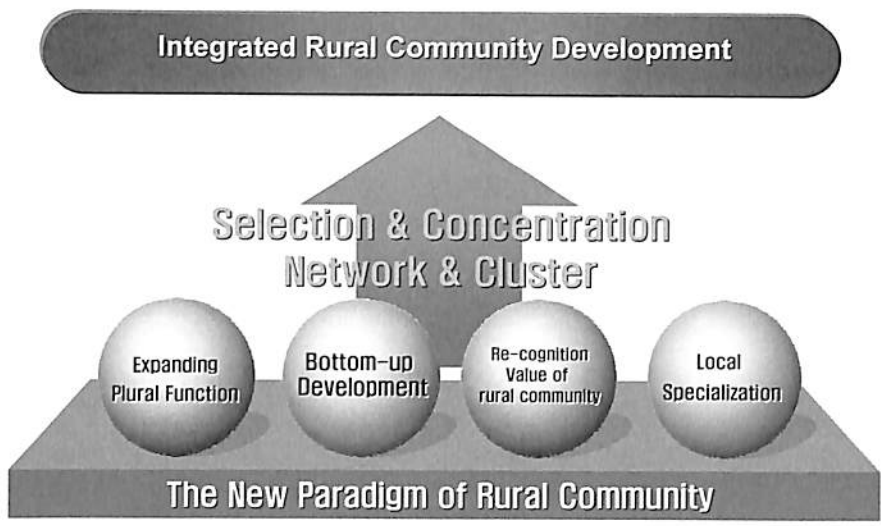
Problems of Existing RD Programs



Problems of Existing RD Programs

- Central government dependent & provider-centered development
  - controlled by program menu and driving mode of central government : the operator of policy funds
- Top-down way of development driven by central government : excluded opinions from local residents
- Locally specialized strategic development of fostering spontaneous ability are neglected
- Ineffective roll-play among program subjects : coordinative development neglected
- Overlap development : similar programs, various subjects for driving
- Declined amenity and comfort by driving SOC-centered program
- Neglected reflection of local characters by driving policy-centered development
- Neglected reflection of consumer's new demand of rural space.

Necessity of IRCD Project



The goal and Contents of IRCD Project

Project Goal

By Developing the rural area with same characters by small zone unit, Conservation & maintenance of Amenity, Promoting a comfort, Basic planning for improving the quality of lives of Rural and costal residents, and promoting stabilized development of the national territory.

Project Contents

- Selection of sustainable villages with autogenesis from 47,000 villages
  - 1,000 small zones for development till '2013 from now on

H/W & S/W

- Building Infrastructure for living convenience
- Expanding income basis
- Preservation and Recovery of the rural scenery

- Community development consulting & program
- Capacity Building of the rural residents & leaders
- Support management program development

Type of IRCD Project

Tradition Conservation | Eco-Friendly | Nature Ecological Preservation | Basic Scenery Formation | Scenic House centered

Rural Tourism Basis | **Local Specialization** | **Basic Life Welfare**

Case of Cambodia

One Village One Product(OVOP) Movement

-To promote local products and services, generate employment opportunities, and increase households' income.
-To increase value-added to local products through processing, improving quality and packaging.
-To promote market linkages between products and services at village level and domestic and export markets.

OVOP National Committee, 2007

Stay Another Day Cambodia

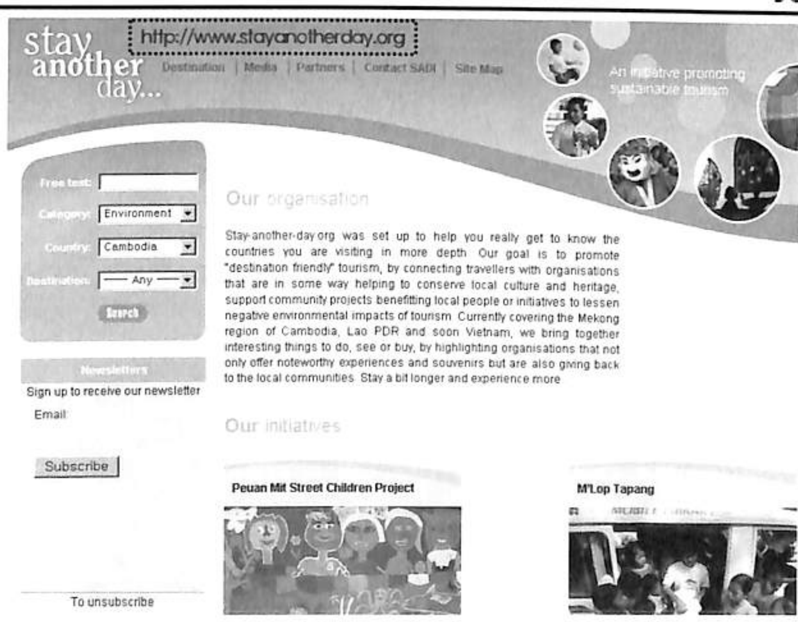
-Promoting Sustainable Tourism
-Commercially viable
-Creating broader benefits for society
-Supporting conservation of the natural, historic and cultural resources which tourism depends

GTZ

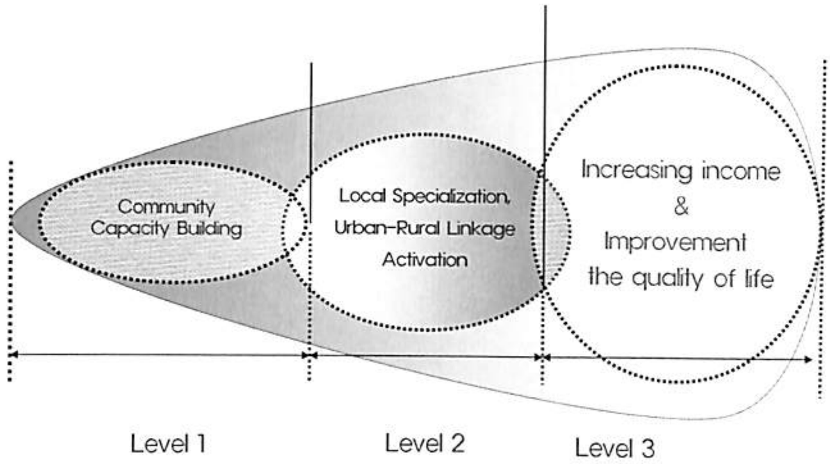
and more...

Case of Cambodia : One Village One Product

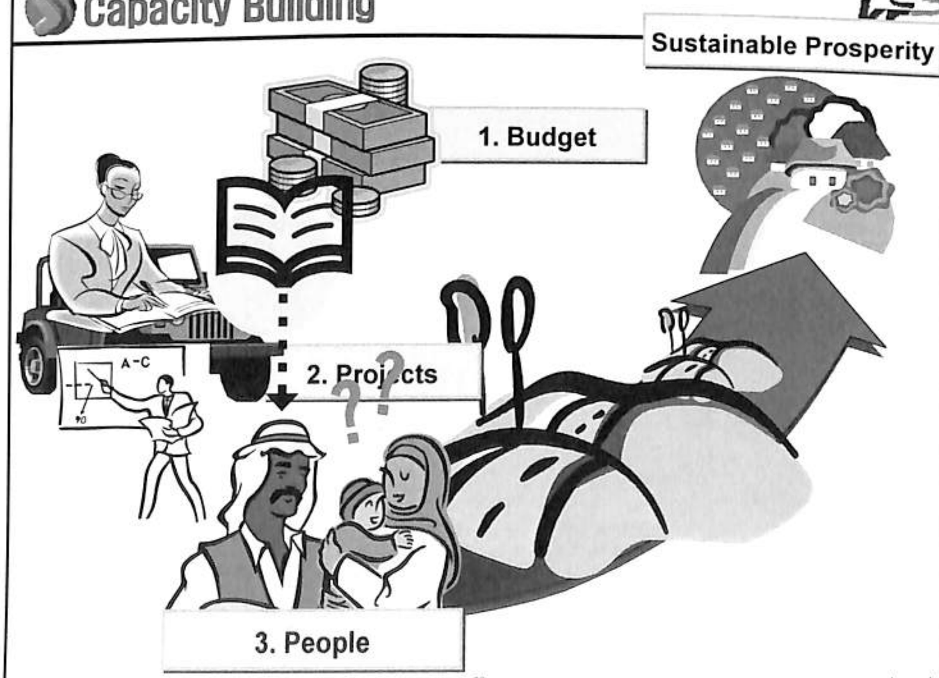
Case of Cambodia : Stay Another Day

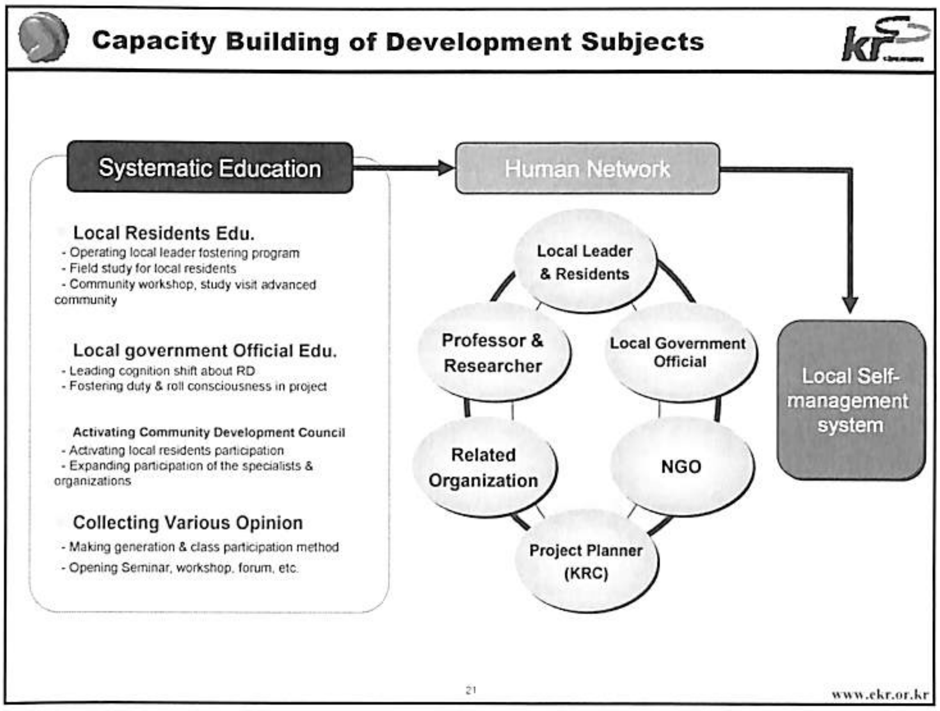


Level of Project Driving



Capacity Building




Capacity Building of Development Subjects
Systematic Education
Human Network
Local Residents Edu.
- Operating local leader fostering program
- Field study for local residents
- Community workshop, study visit advanced community
Local government Official Edu.
- Leading cognition shift about RD
- Fostering duty & roll consciousness in project
Activating Community Development Council
- Activating local residents participation
- Expanding participation of the specialists & organizations
Collecting Various Opinion
- Making generation & class participation method
- Opening Seminar, workshop, forum, etc.
Local Leader & Residents
Professor & Researcher
Local Government Official
Related Organization
NGO
Project Planner (KRC)
Local Self-management system
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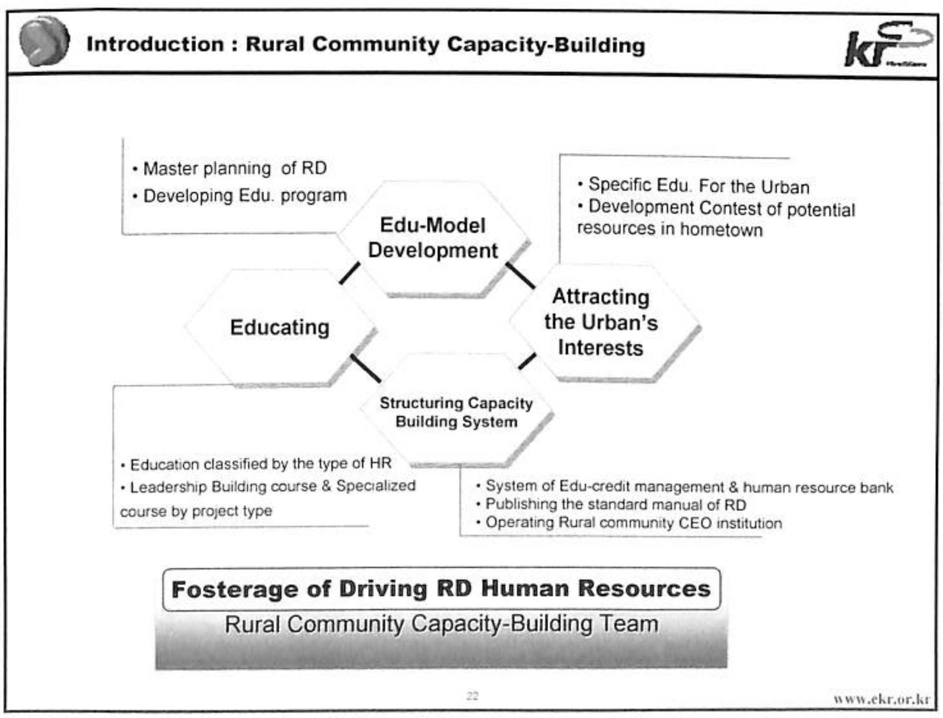
www.ekr.or.kr


Introduction : Rural Community Capacity-Building
• Master planning of RD
• Developing Edu. program
Edu-Model Development
• Specific Edu. For the Urban
• Development Contest of potential resources in hometown
Educating
Attracting the Urban's Interests
Structuring Capacity Building System
• Education classified by the type of HR
• Leadership Building course & Specialized course by project type
• System of Edu-credit management & human resource bank
• Publishing the standard manual of RD
• Operating Rural community CEO institution
Fosterage of Driving RD Human Resources
Rural Community Capacity-Building Team
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www.ekr.or.kr

Task Flow of Team

Goal	Rural Community Capacity-Building for Bottom-up RD	
Strategy	Edu. For fostering HR leading RD (Education)	Construction of support system for HR development (Edu. System)
Contents	• Leadership Building course for bottom-up way of RD • Motivation course for project participants • Specialized course by project type for fostering professional HR • Specific course for IRCD project • rural migration course for the urban	• Integrated system construction of Edu-credit management & specialists consulting support • Publishing and distributing standard manual of RD : "Conducing Villages by the residents participation)" • Certification of 'rural community CEO' • Development Contest of potential resources in hometown

'2007 Driving Plan : Education

Driving Specific RD Education program (10 courses 2,000 students)

1. HR Fosterage educations specialized by type of HR

Course	Driving Objective	Students	
		'06 Result	'07 Plan
Total		2,258	3,452
◦ RD Leadership building Course	◦ Fostering Leaders for bottom-up RD	290	260
◦ RD Motivation course	◦ Motivating residents for positive participation in RD projects	878	670
◦ Specialized course by RD project type	◦ Fostering RD related project driving ability	644	625
◦ Revitalization Project for the Development of Rural Areas	◦ Understanding of ideas and developing needed competence of people	-	100
◦ Specific course for IRCD project	◦Education for driving RD project	150	1,440
◦ Rural Migration course for the urban	◦Practical information and experience for the urban interested in rural migration	225	300
◦ RD Lecturers Workshop	◦Sharing updated RD policy and teaching skills	56	57

'2007 Driving Plan : Education

2. Expanding Edu-program modules of "specialized course by project type"

'06 (Total 10 courses)	'07 (Total 14 courses)	
RD Readership Building	RD Readership Building	Village Management Course
RD Motivation Course	RD Motivation – for IRCD Project	Trouble Management Skill
Specialized course by RD project type	RD Mot. – Green Rural Experience Vil.	Revitalization Project Specific Course
Specific course for IRCD project	Experience Activity Guide Training	IRCD Project Specific Course
Rural Migration course for the urban	Regional Resources Discovery	Idyll Housing Course
	PR & Marketing Course	Idyll Life Experience Course

3. Specific course for the urban interested in Idyll life

Target	Anyone who wants information about rural migration & idyll life (300 persons)
Contents	Understanding idyll life and RD & study visit rural community, experience activity

'2007 Driving Plan : Edu. System

2. Comprehensive support system construction for rural community capacity-building

Edu-credit management & HR bank

Built in Comprehensive Rural information Portal : http://www.nongchon.or.kr
- RD students management system & building DB associated with Edu-information
- On-line community service for activating exchange between Rural community & Specialists
- Furnishing related specialists information & activating consulting

Comprehensive Rural information Portal : http://www.nongchon.or.kr

Edu-credit Management		Main	Human Resource Bank	
Edu-credit	On-line Edu.	Community (students/consulting)	Specialists Search/Register	Consulting
Standard courses Other courses	Edu. Information	Information	RD information	Knowledge & Know-how Management

'2007 Driving Plan : Edu. System

RD Field Specialists (Rural Community CEO) Certification

- Among the core leaders finished RD Edu. Courses, choose & award for rural community CEO by consideration
- Executing PR project for awarded rural community

Development Contest of potential resources in hometown of rural emigrants

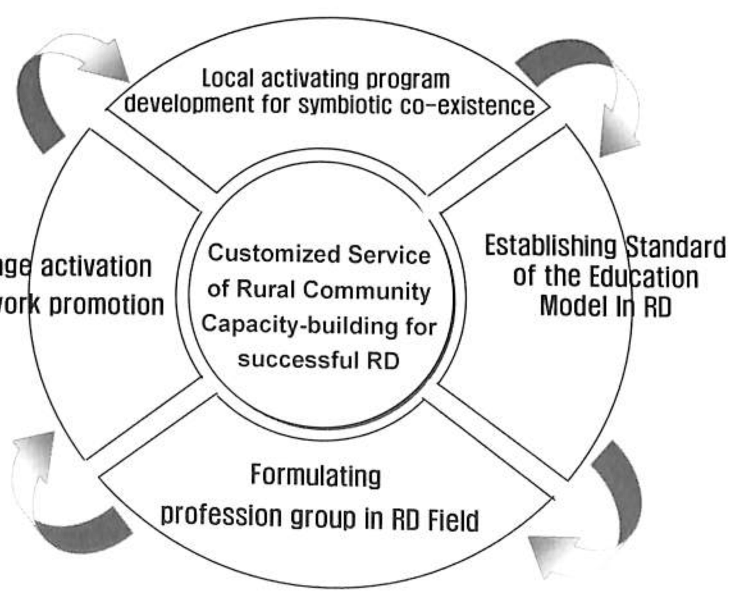
• Fostering interests about RD & searching applications
- Awarding & promoting profits suggested through various media

Publishing & Distributing Standard Manual of RD

• **Both a Book for theoretical understanding & a practical manual to follow-up in RD**
- Rural tourism, Scenery, Managing team, Trouble management, Marketing...

→ Comprehensive Support System for rural capacity-building

Future-oriented plan of our team



Agricultural Water Development for Field Farm

Mr. Eo, Dae-su

Director

KRC

Introduction to Lecture

– Agricultural Water Development for Paddy Field Farming –

Eo, Daesu

Rice has long been the major food source in Korea, and history of irrigation and drainage can't be described without explaining the rice cultivation. From the beginning of civilization, water resources management is presumed to be the major interest of the people and also rulers. Most rice cultivation regions in Asia are affected by the monsoon climate. Precipitation is the most limiting factor in rice cultivation, particularly in rain-fed rice culture regions, since it requires big amount of water. In this lecture, a brief discussion on general conditions for agriculture in Korea is first given, then, agricultural water development for paddy farming including irrigation water development, farmland consolidation and drainage improvement, land and water resources development in coastal areas, irrigation water management and others are discussed.

Agricultural Water Development for Paddy Field Farming

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1. Introduction

Rice has long been the major food source, and history of irrigation and drainage can't be described without explaining the rice cultivation. The history indicates that rice culture started in Bronze Age. Since then, water resources management is presumed to be the major interest of the ancient people and rulers. Historical records indicate that a number of hydraulic structures such as earth dams and canals were constructed for irrigation.

Most rice cultivation regions in Asia are affected by the monsoon climate. Precipitation is the most limiting factor in rice cultivation, particularly in rain-fed rice culture regions, since it requires large amount of water, e.g. 3,000 tons of water for one ton rice production. On the other hand, at the region in which the irrigation is possible, the rice productivity is largely depended on the temperature and solar radiation. It is difficult to define a simple formula between the climate and the yield of rice. Under the typical East Asian monsoon climate, more than 60% of annual precipitation occurs during rainy season.

An old Korean proverb says that "Agriculture is the foundation of human life". Many of Koreans admit that agriculture is an important link between human and nature. It plays an indispensable role in maintaining the balance of an entire ecosystem, and thereby sustaining human life. It has multifarious functions such as flood protection, prevention of soil erosion, groundwater recharge, and water purification etc.

Many developed countries asserted from time to time that an intensive agricultural activity has been increasing the contamination of natural ecosystem with chemicals and fertilizer, thus supported to an intensive agriculture should be stopped. However, it makes the Asian countries in consternation to follow this contention, since rice cultivation has a major source to supply food to the people and use of fertilizers is indispensable to obtain a sufficient yield and quality. In addition there exist much greater beneficial functions of rice production activities on the natural environment, even though use of chemicals and fertilizers exerted some adverse impacts on the nature. Korea is now facing various challenges ahead in agriculture such as environmental issues and water scarcity problems. We must consider the integrated impacts of rice cultivation on natural environment.

In this lecture, a brief discussion on general conditions for agriculture in Korea is first given, then, agricultural water development for paddy farming including irrigation water development, farmland consolidation and drainage improvement, tide land reclamation, irrigation water management and others are discussed

1.1 Rice farming and paddy irrigation

According to the IRRI statistics, about 23% of human energy and 16% of protein are provided by rice. For the majority of Asians who eat rice, the grains accounts for a high proportion of total caloric intake. Total world rice production reaches roughly about 600 million tons, and 91% is grown in Asia. Almost 90% of total rice harvest area of the world is in Asia. China has the largest harvest country, and India ranks the second, and followed by Indonesia and other Asian countries.

The unit yield of rough rice varies drastically from country to country mainly due to the irrigation facilities. The farming system is classified by the water regime of rice field: 1) Irrigated rice; 2) Rain-fed lowland rice; 3) Flood prone rice; 4) Upland rice. Rice farming by irrigation can be found in most countries of Asian monsoon region including China, India, Japan, Korea, etc. as well as in arid region including US and Australia, where the systems were established. Improved irrigation is vital in increasing the yield.

Improving the productivity of rice farming would contribute to poverty alleviation, food security and economic development of the nation. However, increasing rice production is not a quite simple problem to be tackled. Labor shortages, institutional ineffectiveness, resources depletion and environmental pollution problems give some constraints for rice production depending on the countries. Migration of youth to city area due to the lack of interest in farming has resulted in difficulties of effectiveness and in dropping the productivity.

Many irrigation practices can be applied to the different regions depending on their climate conditions, topography and soils and/or local culture, but in general, the irrigation can make significant contributions to reducing poverty and crop production. It is an indispensable activity for the livelihoods of people and more production of crops. The areas which are irrigated comprise only 17% of the world's cropland, but it contributes about 40% of the total food production. Per unit area, irrigated farmlands produce twice as much food as the non-irrigated lands.

When we are discussing the rice farming in paddy fields, another important issue is the environmental functions of paddy irrigation. Not only does rice production provide food, it also maintains rural amenities and preserves the natural environment by contributing to water resources management, soil conservation and biodiversity. Furthermore, rice farming itself contributes to rural viability, and helps preservation of traditional culture. Because these extra functions are closely linked with agricultural production, a certain reduction in agricultural activities may result in an environmental degradation, a food crisis, and damage to the rural economy and the cultural heritage. In general, multifunctional roles of rice farming in paddy fields are formed by the external economies of agriculture. They have the characteristics of the public goods. However, the general public goods that benefits from these multifunctional roles does not place a proper value on them. If these functions are not traded in the market, policy intervention may be required in order to maintain them.

1.2 Overview in Korean agriculture

Total area of Korea peninsular is about 222×10^3 km^2 where the Republic of Korea occupies some 99.7×10^3 km^2, approximately 45% of the total area. Almost 70% of the land is mountainous with steep slope of 15° or more mainly located in the east and north. Large portion of flat lands is located in the west and south of the peninsular. Most major rivers are originated from the east and north and flowing down to the west and south coast.

Soils are primarily composed of weathered residuum of sandy and acidic soils, except alluvial ones commonly revealed at the lower plain of the rivers and coastal regions. The most common type of soils is sandy soil formed by the weathered granite.

The total population in 2008 was estimated about 49 million, and the population involved in agriculture is 3,187 thousands or 6.5% in South Korea. The population density is 498 persons per km^2 and the growth rate is 0.3%.

There are a total $1,759\times10^3$ hectares of farmland. The land area of $1,046\times10^3$ hectares or 60% of the total is rice paddy, some 470×10^3 hectares or 26% of the total is used for upland cultivation, and remainder, 243×10^3 hectares or 14% of the total for orchard, grassland and others.

Many irrigation practices can be applied to the different regions depending on their climate conditions, topography and soils and/or local culture. History shows in Korea that the irrigation water was primarily supplied to cultivate rice with a supplemental irrigation manner. On the other hand, the major upland crops such as barley, maize and vegetables were irrigated by water intake of a required amount of water. These crops were mainly cultivated during the rainy season and not much irrigation was applied, except small area of horticulture and green house cultivation. Rain-fed cultivation still exists. Table 1 shows some statistics on agriculture in Korea.

Table 1 Overview of Agriculture in Korea as of 2008

Item or classification	Quantity or description
Annual precipitation (mm)	approximately 1,200
Arable land area ($\times 10^3$ ha)	1,759
- Paddy field	1,046
- Upland field	470
- Orchard	140
- Grassland for pasturing field	50
- Others	53
Irrigated paddy area ($\times 10^3$ ha)*	859
Rain-fed area ($\times 10^3$ ha)*	187
Major agricultural products	Rice, Barley, Vegetables, fruits

* Data from 2008 statistics

The practices of rural water development, which originally was focused on the supply of irrigation water for rice, has now been broaden to include irrigation water for upland crops, livestock water, and regional water such as domestic, industrial, and in-stream flow augmentation in rural areas. A total of 859×10^3 hectares or 82% of the total paddy field area of $1{,}046 \times 10^3$ hectares are now irrigated, while 187×10^3 hectares or 18% of total still rain-fed for rice cultivation as of 2008. Only about 478×10^3 hectares or 46% of total paddy fields are secure from droughts occurring at a 10-year frequency.

1.3 Water resources and agricultural use

Average annual precipitation of 1,245 mm produces 124.0×10^9 m^3 of water, of which an average of 72.3×10^9 m^3 or 58% discharges into rivers and streams and 51.7×10^9 m^3 or 42% evaporates and infiltrates as shown in Figure 1. Total use of water resources amounted to 33.7×10^9 m^3 or 27% of total water resources of Korea.

A total of 15.9×10^9 m^3 of water or 47% of water available was withdrawn for agricultural purposes. Of it, the intake of about 6.7×10^9 m^3 was from reservoirs, 1.7×10^9 m^3 from pumping stations, 0.8×10^9 m^3 from head-works, 1.4×10^9 m^3 from tube wells, 2.0×10^9 m^3 from other sources and 4.1×10^9 m^3 from effective precipitation. Other sources indicate that a large amount of water intake from the primary sources has been reused for agriculture. Table 2 shows the situation of water reuse for agriculture.

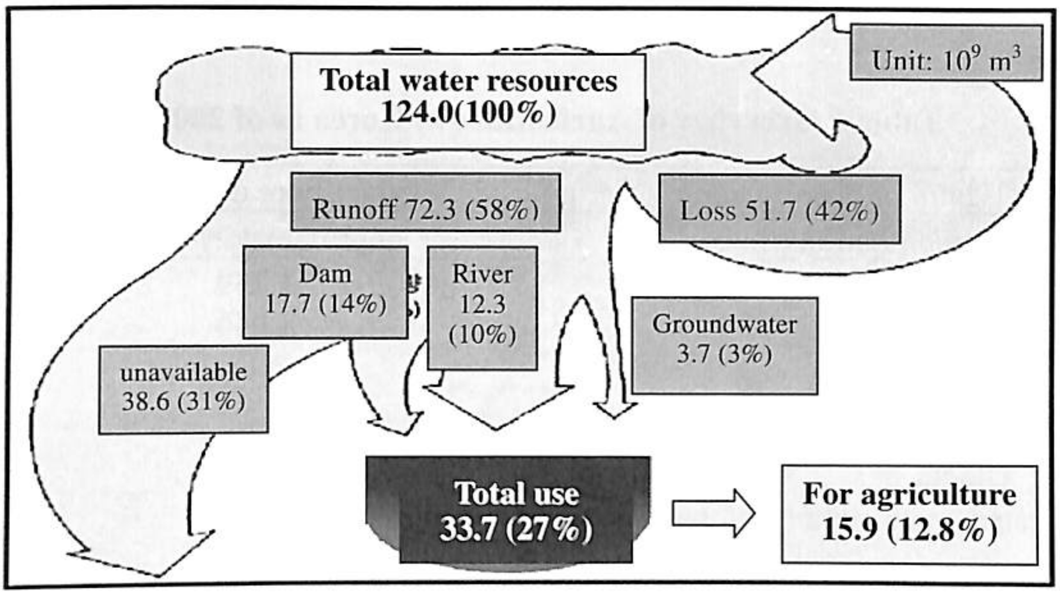


Figure 1 Average water resources and agricultural water use

Table 2 Water reuse for irrigation

Primary intake Facility	Amount of intake ($\times 10^6$ m^3)	Reuse ratio (%)	Amount of reuse ($\times 10^6$ m^3)
Dam reservoir	4,741	23	1,090
Desalinated reservoir	2,035	20	407
Pumping station	1,701	6	102
Headworks	794	1	8
Total	9,271	17	1,607

As far as water shortage is concerned, an evaluation of water resources based on the above average precipitation is almost meaningless. An annual precipitation of 890 mm with 20 year drought frequency produces only 88.5×10^9 m^3 of water, of which 35.4×10^9 m^3 or 40% of water discharges into rivers and streams and 53.1×10^9 m^3 or 60% of water evaporates or infiltrates. All 35.4×10^9 m^3 of discharged water must be used to meet 37×10^9 m^3 of water demand in the year 2011, which is impossible to occur. This is why Korea is classified into the country group experiencing water shortages. Furthermore, the seasonal variation of the precipitation is more extreme. The rainy season from June to September receives about 2/3 of the total precipitation and only 1/5 occurs during dry season as shown in Figure 2.

This extreme seasonal variation is the one of the culprits of occasional summer floods and droughts in spring and fall in the Korean peninsular. Thus, it would be most favorable to construct dams for storing floodwater in the reservoir.

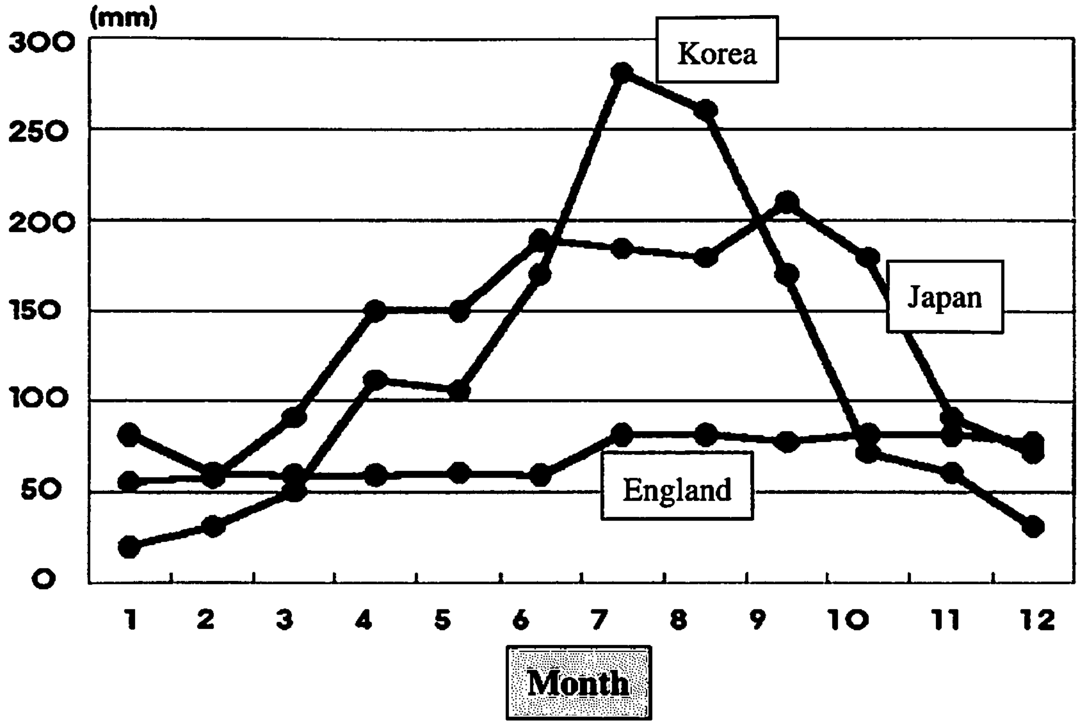


Figure 2 Seasonal variation of precipitation

2. Agricultural Water Development

According to the FAO statistics, rice is the staple food for about 59% of the world's population. And, almost 90% of total rice harvest area of the world is in Asia. For the majority of Asians who eat rice, the grains accounts for a high proportion of total caloric intake. It is inferred that the experience and technology for rice production in Asia can be the basis of solving the food problems of the world for the future.

In 1999, at the 17th Congress of International Commission on Irrigation and Drainage (ICID) held in Granada, Spain, the irrigation, drainage, and flood control for agricultural lands were declared to be no longer a kind of options. They are inevitably required for feeding billions of hunger people, providing employments to the rural inhabitants, and protecting the environment of rural area. The ICID stressed that dams have played and will continue to play an important role in the development of water resources for agriculture, particularly in the developing countries. A balance also needs to be found based on the requirements of society, acceptable side effects, and sustainable environment.

The purpose of the agricultural water development is to strive for convenient farming and to contribute stable agricultural production by providing irrigation water from the sources of water, say agricultural reservoirs and pumping stations to irrigation cannels and paddy fields in the areas of habitual drought. Recently in Korea, with the increased stock of rice, it has been suggested that the investment for infrastructure development should be considerably reduced. But only 484 thousand hectares (45%) of paddy fields can stand against the droughts occurring at a 10 year frequency and the rest are not stably irrigated. Therefore, it has to be continuously expanded to prepare for the droughts due to abnormal weather conditions and to ensure the stable crop production. The water problems should be fundamentally solved in rural areas. Water resources in rural area are now developed in various ways not only just for meeting the agricultural demand, but also for providing the function of tourism and recreational purposes.

2.1 Large-scale farmland and water development

Under the agricultural policy framework of Korean government, the large-scale comprehensive agricultural development projects have been executed for agricultural land and water development. The projects aim at improving the rural welfare with better farming practices. Agricultural productivity and farmer's income are significantly improved through installing more efficient rural infrastructure and introducing the rural industry complex. They include water resources development, farmland consolidation, and tideland reclamation for specific areas etc.

With Geumgang project started in 1970, total 21 projects have now been completed or being underway. Fifteen projects were completed by 1998 and six projects are under construction as shown in Figure 3. Total development area of 21 sites is 266×10^3 hectares with the project costs of US\$ 4.4×10^9.

The projects have been contributing to strengthen national food security resulted from expanding fertile farmland by 91×10^3 hectares. With the completion of the projects, freshwater lakes storing 3.05×10^9 m^3/year have been formed, providing to meet water demand for agriculture, industry and municipality etc. They also contribute to protect people's life and property living in low land from natural disaster of flooding and drought. Total capacity of flood control capacity reaches about 853×10^6 m^3/year. Increased rice production gained from the projects is 576×10^3 t/year and the benefits for farmers is about US\$ 918×10^6 every year.

According to the Ministry of Agriculture and Forestry (MAF), the amount of rural water demand in 2011 is expected to be 17.9×10^9 m^3, of which 15.5×10^9 m^3 will be used for agriculture, 0.7×10^9 m^3 for livestock, and 1.8×10^9 m^3 for municipality. The existed facilities can only supply 11.2×10^9 m^3, thus, the remaining 6.7×10^9 m^3 should be supplied by new irrigation facilities to be built by 2011.

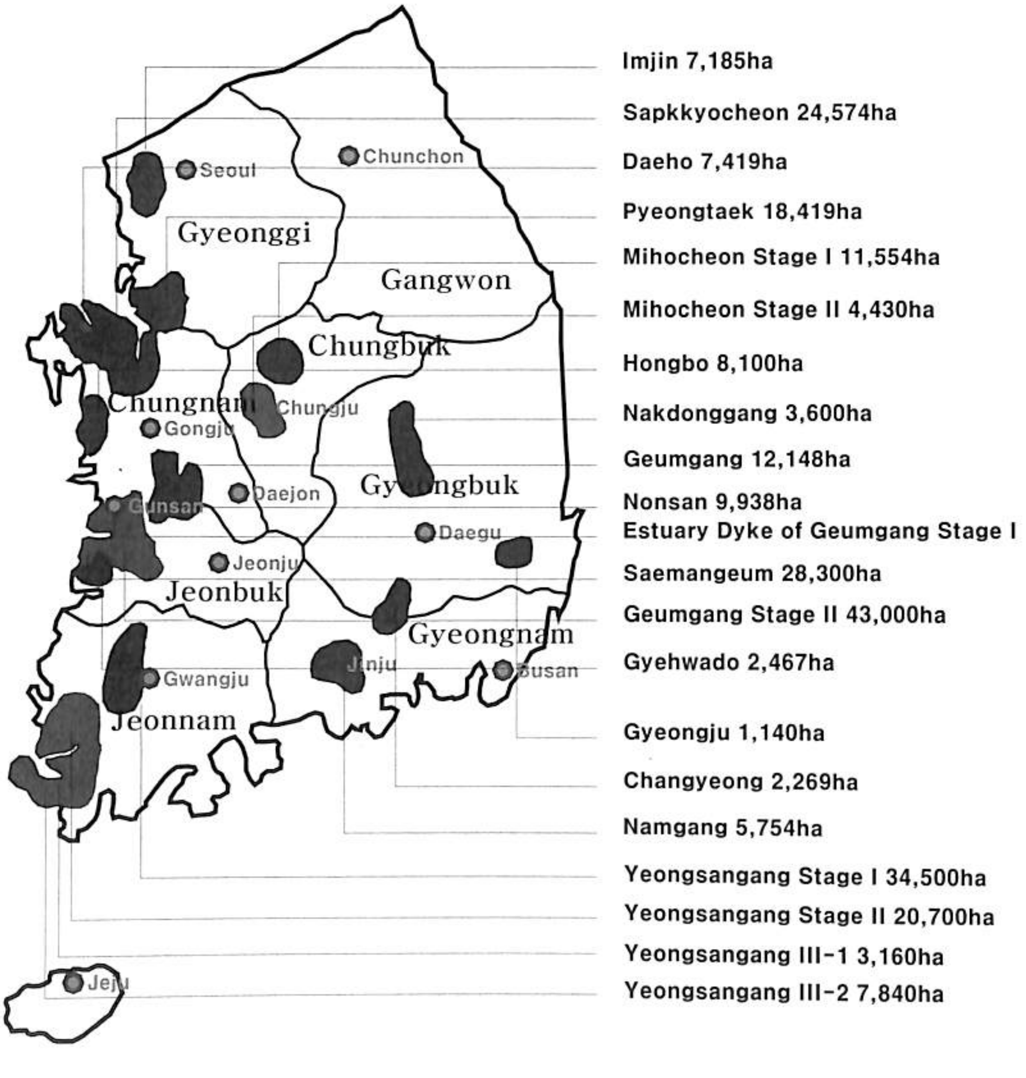


Figure 3 Map of large-scale farmland and water development projects, dark green indicates the completed and the purple under construction

The most critical issue is the construction of new facilities based on environmentally sound and sustainable way. Medium-size multi-purpose dams and reservoirs are advisable due to their many merits. Linked operation of dams in a basin and transfer of water between different watersheds are also some of the preferred methods although there are some limitations. The second issue involves water savings through efficient water management and reasonable maintenance. The relevant methods of water savings are rotational or intermittent irrigation with tele-metering and tele-control (TM/TC) system and direct seeding instead of transplanting.

2.2 Surface water development

Major irrigation facilities are reservoir, pumping stations, diversion weirs and tube wells as shown in Figures 4 to 7, respectively. A total of 475×10^3 hectares of paddy fields are irrigated through about 17,700 reservoirs, 202×10^3 hectares through 7,100 pumping stations, 96×10^3 hectares through 18,000 diversion weirs, 33×10^3 hectares through tube wells and 62×10^3 hectares through other facilities.

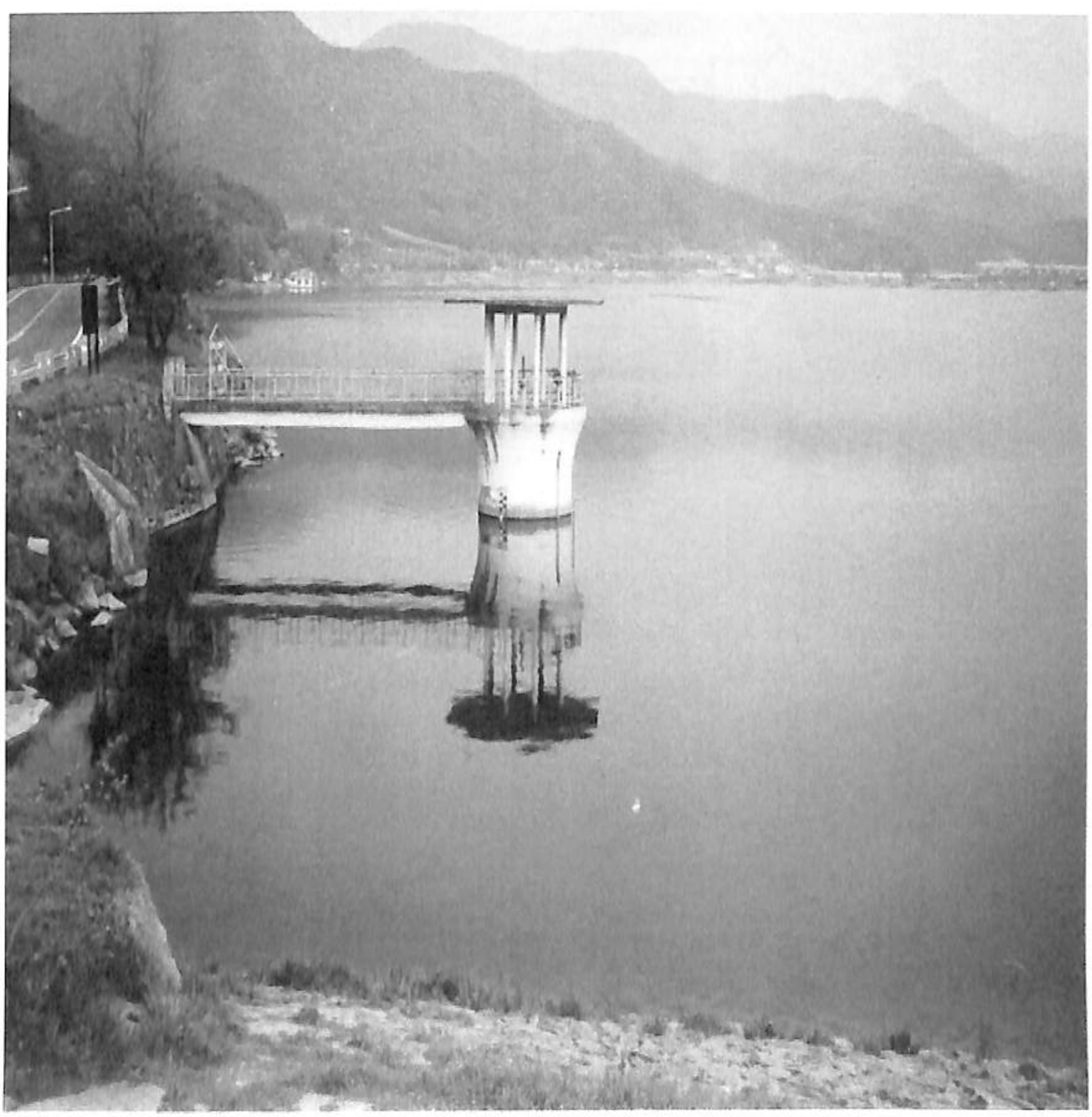


Figure 4 Reservoir and water intake tower for irrigation

Figure 5 Goheung pumping station

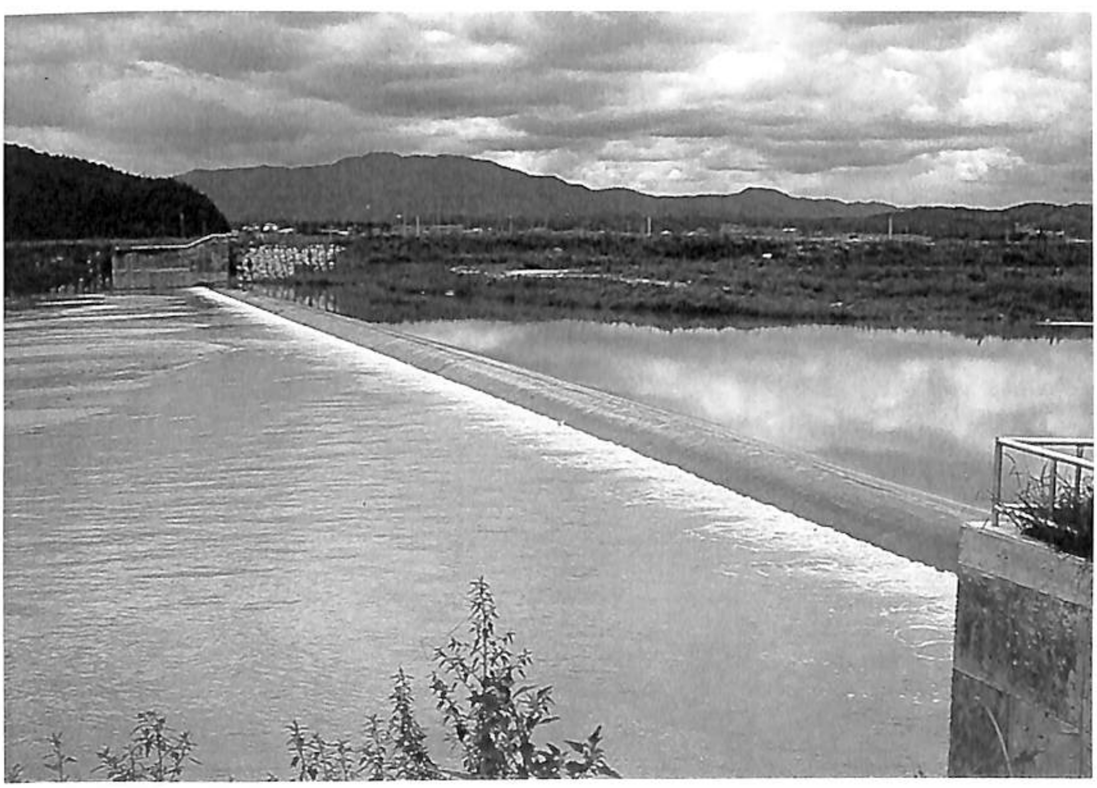


Figure 6 Diversion weir to supply irrigation water to paddy field

Figure 7 Groundwater exploitation and pumping test

Water is delivered through the irrigation canals to the paddy field. Depending upon the type of the canals, water delivery efficiency and loss show large differences. The rate of water loss in earth canals is estimated to be about 30 – 40% while that of concrete canals is estimated between 5 – 10%. Total length of the main irrigation canals is about 25×10^3 km, and concrete canals 11×10^3 km. National projects to convert earth canals to concrete and other canals that can minimize water loss and maintenance cost are being carried out. Figure 8 shows a concrete irrigation canal.

Figure 8 Irrigation canal made of concrete flume

2.3 Groundwater development

The history of groundwater development may record the same orientation with the irrigation water development to overcome the drought. In 1960's and 1970's, the projects contributed to supply the supplement water for dried farmland through aquifer development. In 1980's, it began to develop the groundwater under base rock with the advanced survey technology and equipment.

It was a great success to develop the large-scale ground water resources through the development of underground dams, radial water collection wells and the geographical ground water mapping for chronicle drought areas.

Figure 9 Drilling of tube well for groundwater exploitation

In 1990's, it was developing the ground water up to 200m or deeper depth to meet the increased water requirement for greenhouse farming facilities, upland infrastructure, and local water supply in rural areas.

Recently, environmental deterioration to ground water such as exhaustion, pollution and ground subsidence becomes serious problems due to excessive exploitation and pollutant spreading underground. A professional organization is required to implement a special mission for ground water conservation and to inspire the public awareness through a well- organized training program for public servants involved in local governments and engineers in private sector. It includes the training program for the survey and management of abandoned wells, planning of ground water conservation, and the periodical operation and maintenance technique of tube wells. In addition, an integrated management plan for groundwater resources in 464 rural water sectors is now prepared to ensure the optimal development, use, conservation and maintenance of the invaluable resources for all.

3. Farmland Consolidation

Farmland consolidation is carried out for the elimination of land fragmentation and improvement of the prevailing defective land ownership structure, which are primarily characterized by small holding size, intense land fragmentation, mixed land ownership, lack of farm loads, and irregularly shaped plots. All these features constitute major structural and technical obstacles to the rational development of rice farming. Figure 10 shows a conceptual map of farmland consolidation.

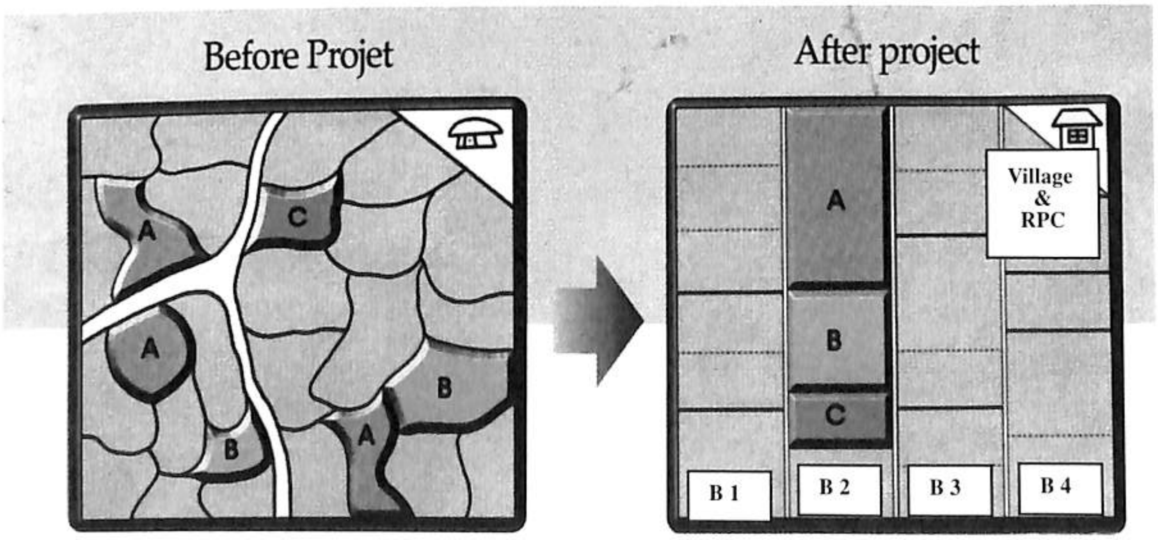


Figure 10 Conceptual map of farmland consolidation and re-plotting

3.1 Purposes of farmland consolidation

Farmland consolidation generally provides paddy fields with well-equipped irrigation and drainage canals, proper farm roads network, and changes irregularly shaped plots into large and rectangular-shaped plots. All these changes will lead to increases in crop production including capital and labor productivity, and the number of economically viable holdings with consequent rise in the agricultural income.

Sufficient and stable water supply provides paddies with optimum condition for rice growth. Maximized crop production can be achieved through the supply of irrigation water at an amount equivalent to the potential crop evapotranspiration. Water management involves the supply of water to crops at the right time and place with right amount, which are guaranteed by properly equipped water supply systems. Proper management of systems is effective for maximum crop production as well as water savings. Drainage systems prevent rice paddies from being inundated. In addition, they allow farmers to perform mid-season drainage in rice paddies needed for crop growth.

At present, rural regions are suffering from the shortage of young and qualified labor. One of the solutions for this problem is the farm mechanization, which can improve farming activities in rice cultivation such as puddling, transplanting, harvesting and others. Consolidated paddy field provides farm machinery with working space and good accessibility. Introduction of large-size machinery in the rice cultivation becomes possible the enlargement of paddy plots.

3.2 Achievement of farmland consolidation

Historically, farmland consolidation dates back to 1419 A.D., when the irrigation area of Nul-je was rearranged in rectangular shape for the purpose of equitable taxation. Until 1945, 43×10^3 hectares of farmlands were consolidated. However, government driven projects began in 1965, and is being continued to theses days. Total consolidated area is 720×10^3 hectares, about 67% of total paddy fields area of $1,070\times10^3$ hectares. Figure 11 shows the farmland after the consolidation works. Farm roads and canals are well arranged after the project as can be seen in the Figure.

The drainage improvement project has also been carried out for low lands in which experienced frequent inundation by flooding. About 134×10^3 hectares out of 188×10^3 hectares target area for drainage improvement are completed.

Figure 11 An aerial view of farmland consolidation

4. Land and Water Resources Development in Coastal Areas

Historical development of tideland reclamation comprising the tidal barriers in Korea has been described from 13th century to present, introducing a unique style of dike section and final closing method. Major changes in recent development in typical dike section in 1960's demonstrate that seaward slope has changed to 1:3.0 from 1:1.0 ~ 1.5 of previous practices, and landward slopes were finished by quarry stone. These changes in dike section subsequently led to seaward slope to 1:8.6 in dike number 4 of Saemangeum, which is presently under construction. Final closing technique also has been progressively developed to current unique method, employing gradual closure of opening in dike, of which the extensive utilization in dumping method of quarry stone with gabions to effectively resist strong current throughout the gap.

Tideland reclamation project which blocks tidal flows in and out the estuary or bay using the massive construction works has been historically well recorded in the Netherlands and Japan with well-organized documentation. However in Korea, there exists little documentation to refer to old reclamation projects, except the records stem from the Koryo dynasty. The origin and actual performance of the tideland reclamation project around the world may have been brought about their conditions of reclamation; economy and demands for the land. The technique of reclamation has been developed according to their economic capability and the degree of contribution of reclamation for creating land. In Korea, the technique of reclamation has developed rapidly as linking up with the state's economic development. As a result, there have been established new standard methods for embankment section and closing method of construction. In addition, Korea could develop a part of tideland economically and also preserve the others effectively as nature. Korea has the characteristic natural conditions comparing with other countries, for instance under the large tidal environment, sediments are continuously supplied from offshore of sea dikes, thus creating new flesh tidal flats

4.1 Evolution of tideland reclamation

Korea transferred its national capital city from Kekyung to Kanghwa Island in 1232 when the Mongolian troops of Won Dynasty had invaded Korea, the first time in 1231 (18th year of Kojong). During the war (1231 ~ 1259) food shortage was a major hardship. There exists a document stating about the General Choi Ou, who held political power in the dynasty at that time. He commanded his soldiers to make fortress with soil embankments around Kangwha Island in order to defend against landing of Mongolian army. These embankments for the purpose of defense were also functioned as cultivating land, thus Kim Bang-kyung, who was also a head of military forces in 35th year of Kojong (1248), ordered to cultivate paddy rice to supply with military provisions during the war. This document is believed to be the initiation of a tideland reclamation project recorded.

Tideland reclamation has been carried out for several centuries in the west and south coast of Korean peninsular. The west coast frequently runs in and out with a gentle grade sea bottom. Tidal range is so high that it reaches approximately 6 to 9 m at spring tide. The rivers flowing into the Yellow Sea delivers a lot of fine sediments to the estuary and coastal waters. These favorable conditions in geography and coastal hydraulics enable Korean Government to initiate the tideland reclamation projects. Furthermore, during the recent decades, more than 20×10^3 hectares of farmland have been transformed to residential and industrial uses every year. As a sense of compensation for decreasing trend of farmland area, tideland reclamation has been continued. Figure 12 shows tideland reclamation projects completed by 2000 and future resources in Korea.

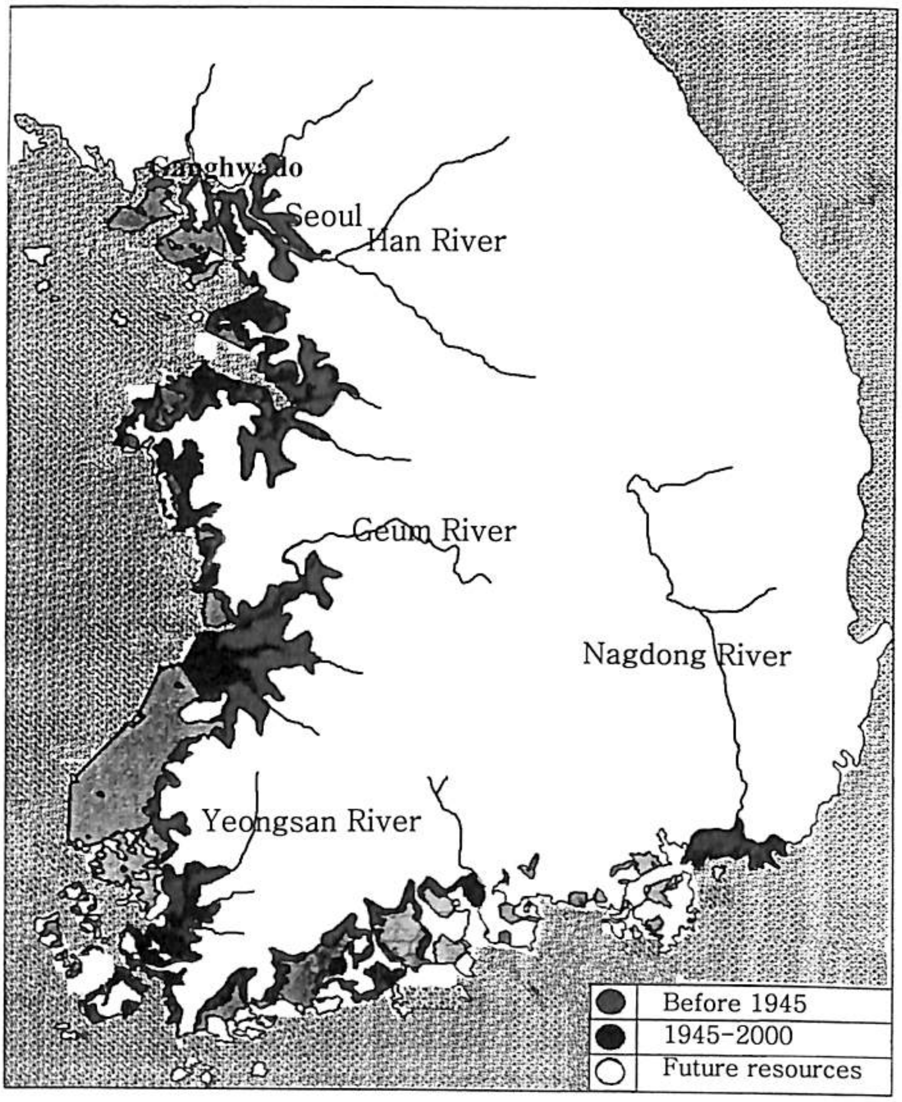


Figure 12 Tideland reclamation projects in Korea

Since 1945, about 76,000 hectares of tideland have been reclaimed for agricultural use in 185 project sites conducted by government or private sectors as shown in Table 3. During 1960's and 1970's, many small size reclamation projects were completed to increase food production through farmland expansion, irrigation water supply and protecting low land from flooding in the coastal region. Several large size projects were undertaken during 1980's and 1990's. During that period, two large-scale tideland reclamation projects made by private sectors other than the government, Gimpo (1,649 hectares) and Seosan projects (11,114 hectares) were completed. Figures 13 and 14 show the closure works of sea dikes performed in 1960's and 1990's, respectively.

Table 3 Development area from tideland reclamation (unit: hectares)

	Total	By government	By private sector
Completed	75,738	35,549	40,189
Under construction	59,854	59,854	
Future resources	21,074	21,074	
Total	156,666	116,477	40,189

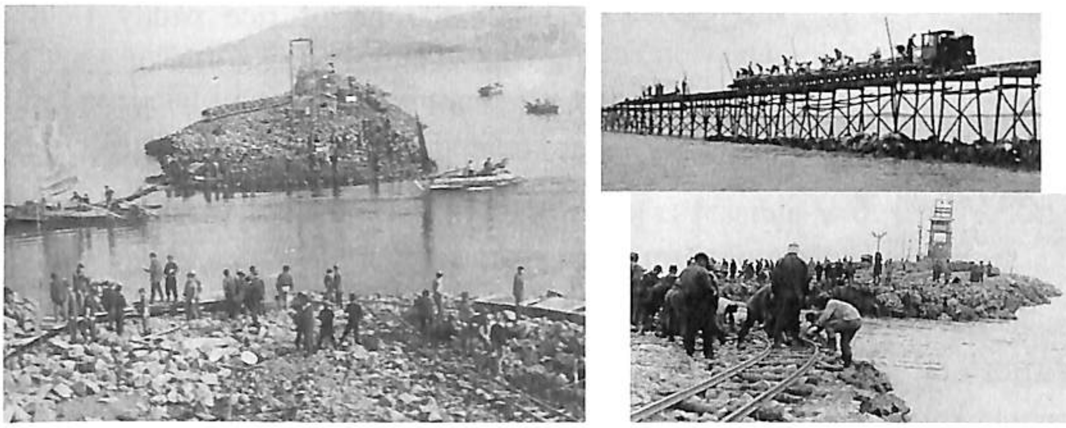


Figure 13 Final closure of Dongjin dike using stone dumping by railway (1960's)

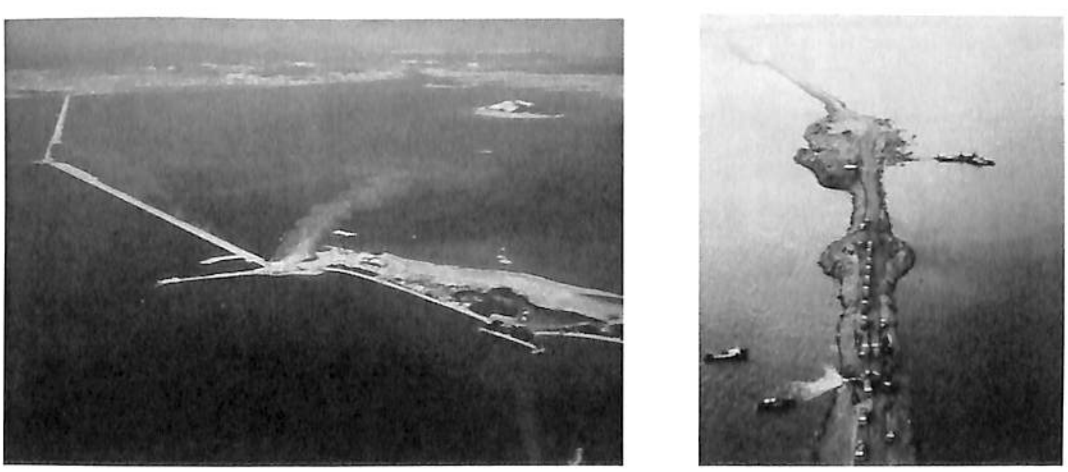


Figure 14 Closure works of Siwha dike (1990's)

4.2 Saemangeum tideland reclamation project

The Saemangeum (See Figure 15) reclamation project was first conceived in the 1970s with the aims of increasing useable national territory and of creating more land for rice culture, thus assisting in national food self-sufficiency.

A full economic feasibility study and environmental impact assessment performed from 1986 to 1991 led to the start of construction works for the Saemangeum Project in November 1991. The first phase of the project involved the construction of the outer seadikes. As proposed the wall will eventually dam off two estuaries in order to create 28,300 ha of rice paddy field and industrial land, and 11,800 ha of lake. Final closure of the sea dikes has recently completed in April 2006, with the conversion of the tidal flats to paddy fields following a few years later.

Figure 15 Location of Saemangeum

Construction costs of this outer wall (see example cross-section in Figure 16) which includes a 2 lane highway, were estimated at US$2.6 billion dollars in 2006, with the 33 km long dikes already connected in 2006.

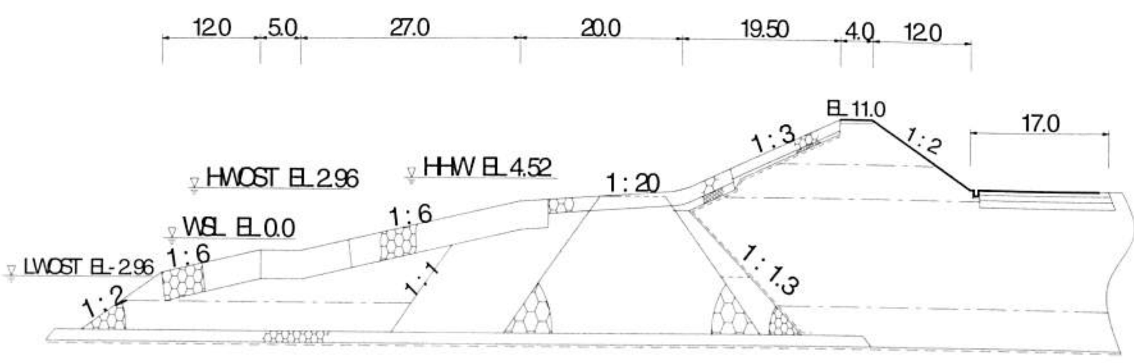


Figure 16 Cross-section through part of Seadike no.4, Saemangeum

In late 1998, concerns were raised by the public, led by non-governmental environmental organizations (NGOs), about the negative effects of the project on environment, water quality deterioration and its low economic feasibility.

In April, 1999, a Joint Committee of Public and Government under the Office of the Prime Minister was set up to survey and re-evaluate the Saemangeum Project. Their terms of reference were to re-evaluate environmental impact; economic feasibility; water quality preservation. The committee had 30 members, 20 specialists from public sector including NGO, 9 from the related Ministries and 1 Chairperson. The Committee submitted a re-evaluation report of Saemangeum to the Government on August, 2000. Their final recommendations may be summarized as:

- For water quality preservation, the final water quality of Saemangeum lake would meet the quality standard for agricultural use so long as certain river water mixing and pollution control measures were introduced.

- For environmental impact, they suggested that new technologies be developed to construct artificial tidelands to mitigate the negative impact of tideland loss due to the Project, particularly to provide habitat for native and migratory birds.

- The Committee concluded that the Project was feasible with benefit/cost ratio 1.25, although several committee members submitted a minority report.

Based on the recommendations of the Joint Committee of Public and Government, several public hearings and extended consultation with experts, the Office for Government Policy Co-ordination under Office of Prime Minister decided on 25 May 2001 to continue with the Saemangeum Project on the following terms:

- The dike construction works has been continued to completion by the year 2006. The Dongjin land (South side) will be developed first (for agricultural purposes.) The development of the Mangyeong land (North side) will be postponed until the water quality of Saemangeum lake meets the control standard.

- The Project will be implemented in an environmentally-friendly manner introducing various technologies such as polluted water treatment plant, settling basin, nature reserves, polluted water drainage culvert, fish ways, bird sanctuary, eco-parks as well as leisure facilities for the public. Environmentally sound and sustainable practices for agriculture should be adopted.

5. Rehabilitation and Modernization

The main problems of irrigation facilities are old aged and small size. About 55% of irrigation reservoirs and 31% of pumping stations are older than 50 and 20 years, respectively. In addition, 89% of irrigation reservoirs have an effective storage capacity of less than 1.0×10^6 m^3. The beneficial area from pumping station is less than 25 hectares each on an average. Diversion weir has the function to raise the river water level to the desired height and covers an irrigated area of 6 hectares on the average. The ability of irrigation facilities should be maintained through rehabilitation works.

Irrigation water is delivered through canals to the field. Earth canals are widely distributed throughout the country. These canals are generally old and poorly maintained. Water loss in the canal is also very high. To minimize water loss and improve water delivery reliability, earth canals are currently converted to lined channel, concrete canal or pipeline where necessary. There are many other reasons to convert earth canal into lined canal. Competition for water use and the value of water resources are increased, as agricultural, industrial and domestic water demands increased. Replacement of earth canal with concrete or pipeline results in the reduction of the land taken by the canal itself, then, the saved land can be utilized for agricultural production or other uses.

5.1 Rehabilitation

Korea has two distinctive dry and rainy seasons. Seeding and rooting season from early April to mid June belongs to dry season, during which severe drought and water shortage occur quite often. The dry season begins from late September, and stream flow during winter and spring are very low. Since many of agricultural reservoirs and canals were designed to cope with 10 year recurrence droughts, water supply from these reservoirs often does not meet the water demand even when a short drought occurs. When the demand is particularly high during transplanting period from late April to late May, when water resources are least available. Large seasonal variation in water demand has forced the development of integrated central water management systems.

The systems are not only built with computers and telecommunication equipments, but runoff measurement and estimation from watershed, accurate reservoir storage measurement, short and long term storage prediction, water delivery efficiency, real time monitoring devices, and equipments for water distribution are also needed. One of the prerequisite for setting up the integrated system is the canal rehabilitation.

In the beginning of irrigation system development, the uppermost priority was put on the expansion of irrigation facilities such as construction of reservoirs and canals. These hydraulic structures aged and were damaged with time. Rural water has multi-functions to supply not only irrigation water but also domestic, livestock, industrial, and environmental water to the rural area. However, development of new water resources and supply system are very difficult. Not only is the construction of new dams and canals very costly, but, the land price becomes also very high and water right complicated. In addition, environmental problems associated with new water resources development may cause serious disturbances and protests from civic environmental group. Therefore, the rehabilitation of the existing irrigation systems is considered to be good alternative to meet the increasing water demand. Maximization of water use and supply efficiency through repair and reinforcement of existing dams and canals, installation of TM/TC instrumentation systems, networking of water resources, and automation of water management have emerged as the major water management policies for large irrigation districts of 300 hectares or more. It is also believed that automated water management systems contribute to the conservation of natural resources and environment.

An economic and effective way of increasing the reservoir capacity without the construction of new dams is to raise the normal water surface level and dam crest. This method has been applied at many dams, though only when the dam or the spillway is structurally and hydro-logically safe. For example, dam crest and storage capacity in Wonseon reservoir located in Hampyeong were raised by 2.5 m and 56%, respectively. As a result, the irrigation area was expanded from 45 to 88 hectares. Another method of increasing reservoir capacity is to build a new dam downstream of the existing one. Dae-a dam is an example of this method. This was originally constructed in 1992 for agricultural use. The dam thus could not meet the increasing demand of rural water during the early 1980's. Therefore, a new dam was built 300 m downstream and the old one was partly removed and submerged. Installing 0.5 to 1 m high gates over the existing weir of the side channel spillway is a good alternative to raise reservoir level and increase its storage capacity. For example, the storage capacity of Giheung reservoir was increased by 10% with the installation of gates on the spillways in 1998. Dredging of bottom sediments can also be an alternative to increase reservoir capacity. Average sedimentation rate of reservoirs was surveyed to be about 8% of the total storage capacity. About 160×10^6 m^3 of water storage could be increased if the sediments are dredged.

5.2 Modernization

Water supply in rural areas has changed as the conditions of living, agricultural, and industrial environments improved. Old irrigation systems were designed solely to supply water for irrigation, mostly for paddy field. However, the current irrigation systems convey water not only for irrigation but also for household, industry, and livestock breeding as well as environmental conservation. Furthermore, these systems also often supply water to streams to secure a minimum stream flow and water quality. Patterns of irrigation have changed from seasonal rice irrigation to year-round irrigation for the agricultural productions both in the paddy field and upland. Peak water supply span also have shortened due to the mechanization of transplanting processes in rice cultivation. These changes have increased both the peak and normal water demands of the irrigation system far higher than originally assumed values. Therefore, modernization of irrigation structures and automatic control of water distribution are necessary to operate an irrigation system. Rational water distribution based on real time flow rate and water level monitoring can be achieved by installing TM/TC and central control system. Successful installation and operation of the central water management system require the improvement of canal structures and water delivery efficiency. In addition, prospective income sources such as low head hydropower generation in agricultural reservoirs and tourist resorts in and around the reservoirs need to be developed to alleviate the operating cost of the central water management system.

Modernization of an irrigation system equipped with an integrated central management system can increase agricultural production and farm earning by improving the efficiency of water use and timely water distribution. The modernization also helps prevent or reduce flood damage and labor, improves local environment, enables multiple use of water, and contributes to the advancement of water management techniques. An integrated central management must be a real-time system that can monitor, control and adjust water intake at a water source, allow delivery water through main and branch canals, and provide distribution at gates and regulators by adopting electricity, mechanics, electronics, telecommunication, and computer technology. In an integrated system, dams, reservoirs, pumping stations, headworks in streams, irrigation and drainage canals, and other hydraulic structures are integrated into one operating system.

Seongju integrated central water management system completed in 1998 is a typical example. Seongju irrigation district covers 3,530 hectares of farmland. Water is supplied from Seongju dam, 60 m high and 430 m long, with storage capacity of about 40×10^6 m^3. Watershed area of the dam is about 14,960 hectares. Irrigation canals of 240 km were built and repaired or reinforced to improve water delivery efficiency. The dam also supplies domestic water of 8,800 m^3 per day through irrigation canals, and hydropower electricity is generated during the irrigation season. The integrated central management system was found to contribute to the improvement of agricultural productivity and saving of a large amount of water. The saved water is used to expand irrigation area and the value of domestic water supply was assessed to be higher than the construction, maintenance, and operation costs of the system.

6. Prospects of Rural Development

The challenges to be solved in the 21st century include population increase, food shortages and environmental degradation to maintain favorable living condition on earth. The progressive increase in population demands increase in food supply for adequate feeding.

Rice is the principal staple food for half of world population, and Asian produces and consumes 90% of all the rice grown. Rice culture in the monsoon region of Asia has multi-functions, such as reliable food supply to meet increasing demand, economic development, land and environment conservation, and the vitalization of rural community. These multi-functions of rice culture will continue to be effective for the sustainable development of agriculture and rural areas.

Water is one of the most essential prerequisites for sustaining natural ecosystems and human development. Increasing human population and greater economic development require more water, and competition occurs among the water demands of agricultural, residential and industrial uses. Among the water uses, irrigation for rice cultivation ranks first, taking about 50% of the total water consumption in Korea for example.

The Ministry for Food, Agriculture, Forestry and Fisheries (MiFAFF) of Korea is executing the comprehensive rural development plan. The purposes of the plan are to insure:

- stable food supply;
- preservation of productive farmland;
- environmentally sound agriculture;
- reformation of agricultural marketing systems;
- improvement of rural living standards.

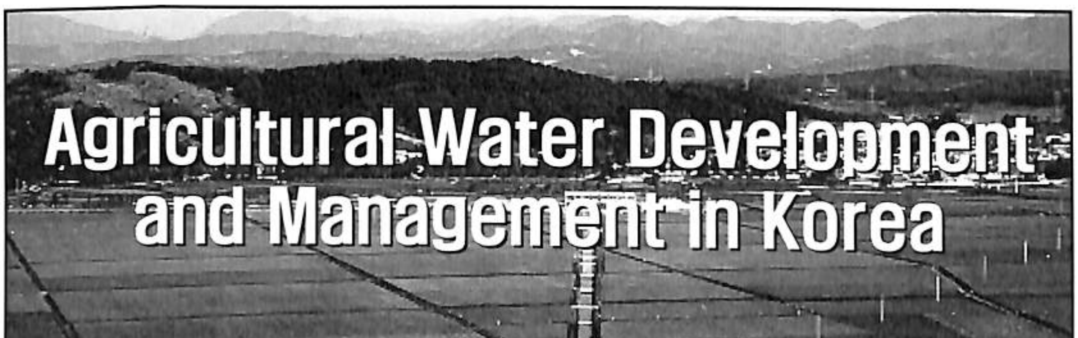
The on-going plan aims at increasing the ratio of irrigated paddy field from 79% to 88%, that of rural road pavement from 32% to 51%, and that of domestic water supply from 48% to 71%. National target of cultivated area holding is $1{,}850 \times 10^3$

hectares for agricultural use with $1,100 \times 10^3$ hectares for paddy field and 750×10^3 hectares of upland. A total of US$$10.3 \times 10^9$ have been allocated to the on-going plan.

In the mid and long term plan for 2005-2024, the MiFAFF plans to achieve the national goal of attaining self-sufficiency in staple food and establish rural life amenities. A harmonious policy should be considered in the agricultural sector for the reunification of Korea. A total of US$$29.1 \times 10^9$ will be invested for this purpose.

☞ **Senegal at a glance**

- Location: west end of Africa
- Annual precipitation: 600mm or low
- Area/Population: 197,000㎢/ 12.2mn('07)
- Capital: Dakar(2.5mn)
- Language: French, Wolof



I. Introduction

II. Agricultural Water Development

III. Farmland Consolidation

IV. Land and Water Resources Development in Coastal Areas

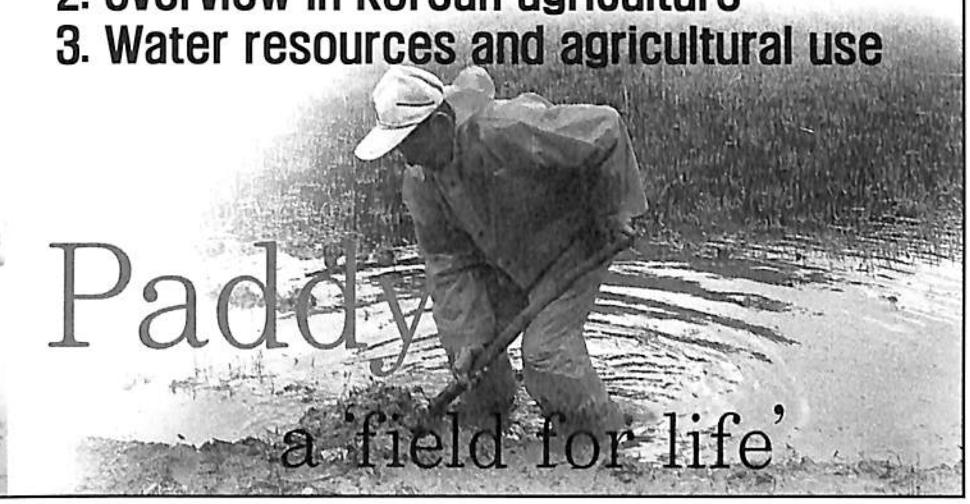
V. Rehabilitation and Modernization

VI. Prospects of Rural Development

Water for Food and Environment

I. Introduction

1. Rice farming and paddy irrigation
2. Overview in Korean agriculture
3. Water resources and agricultural use



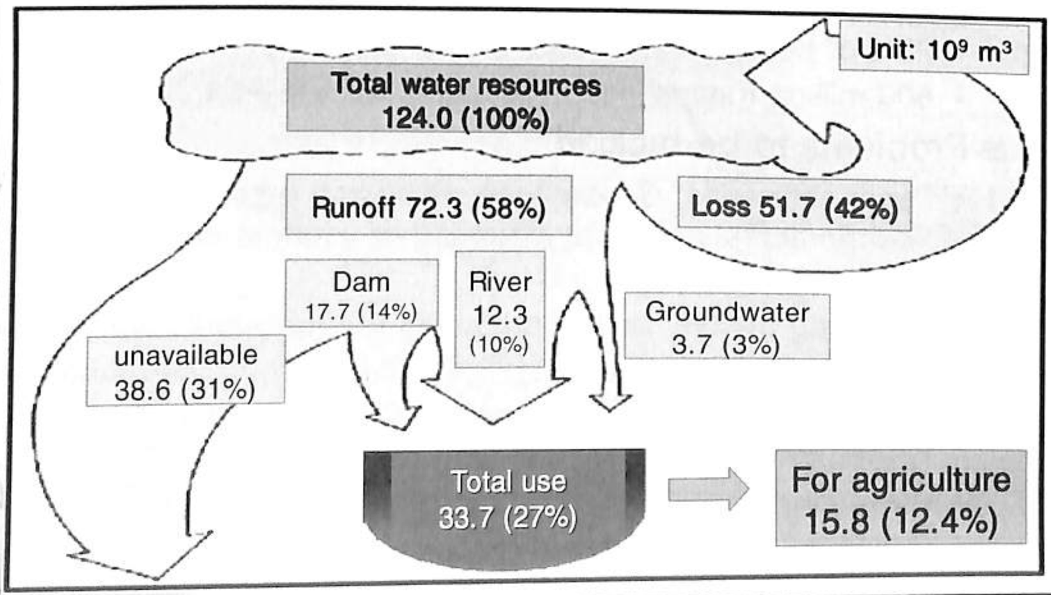
1. Rice Farming and Paddy Irrigation

- Caloric Intake, Rice Production in Asia
  - 23% of human energy and 16% of protein
  - 600 million tons of rice production; 90% in Asia
- Problems to be tackled
  - Labor shortages; Governance; Resource depletion; Environmental pollution; Migration of youth to city
- Irrigation Practices
  - Reducing poverty and Contributing to crop production
  - 17% of cropland irrigation produces 40% food production
- Environmental Functions of Paddy Irrigation
  - Flood control; Soil conservation; Biodiversity; Rural viability and Preservation of traditional culture
  - Public goods; Externalities

2. Overview in Korean Agriculture

- **Land resources**
  - Total area 223 x 10^3km^2, South K. 100 x 10^3km^2(45%)
  - Arable land is less than 30% of total area
- **Topography**
- **Population**
  - Total 49 x 10^6, Of it 6.5% for agriculture
  - Population density 498 person/km^2
- **Cultivated area for agriculture** (as of 2008)
  - Total 1,759 x 10^3ha
  - Paddy 1,046 x 10^3ha (59%), Upland 466 x 10^3ha (28%) Others 247 x 10^3ha

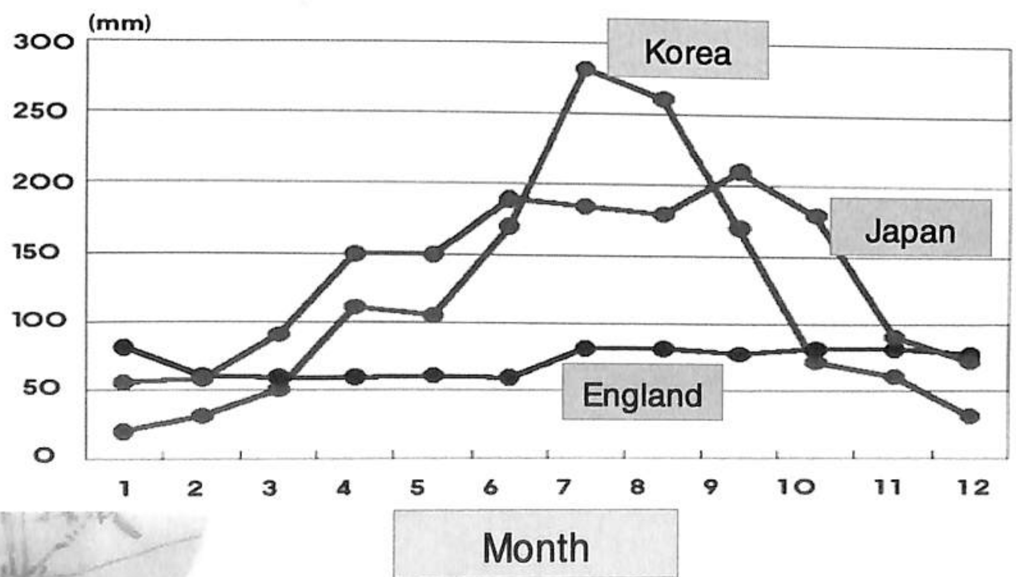
3. Water Resources and Agricultural Use

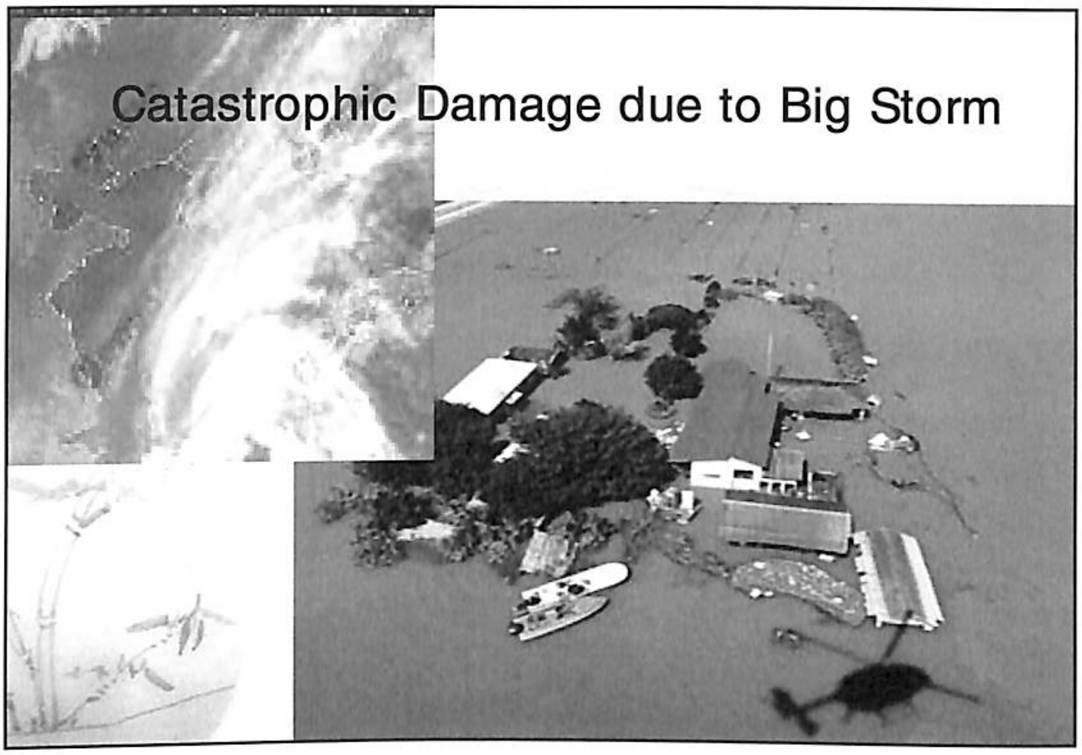


General Conditions

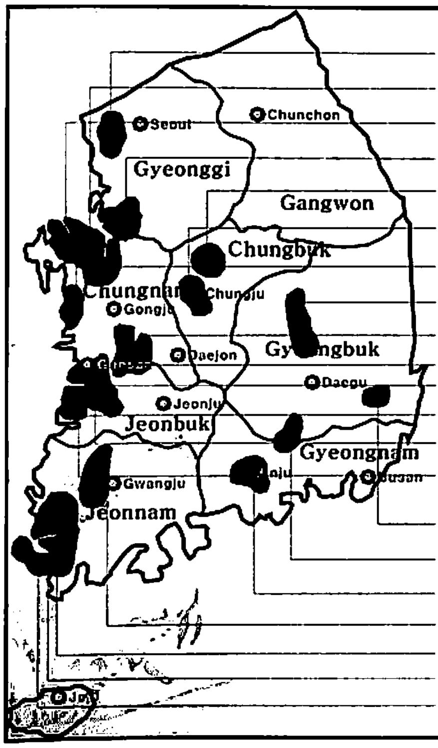
Item	Quantity
Annual precipitation	1,245 mm/yr
Arable land area	$1,759 \times 10^3$ ha
• Paddy field	$1,046 \times 10^3$ ha
• Upland field	470×10^3 ha
• Others	243×10^3 ha
Irrigated paddy area	859×10^3 ha
Rain- fed paddy area	187×10^3 ha

Monthly Distribution of Precipitation





What about in Dry Season?



II. Agricultural Development

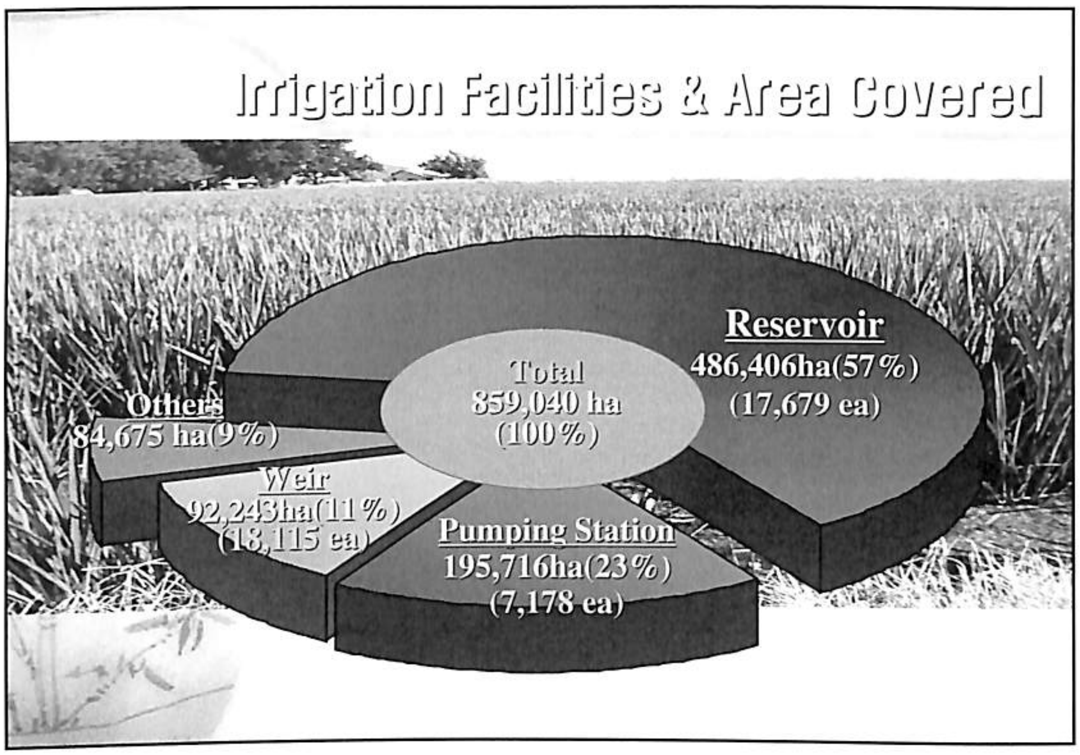
Large-scale 21 Projects

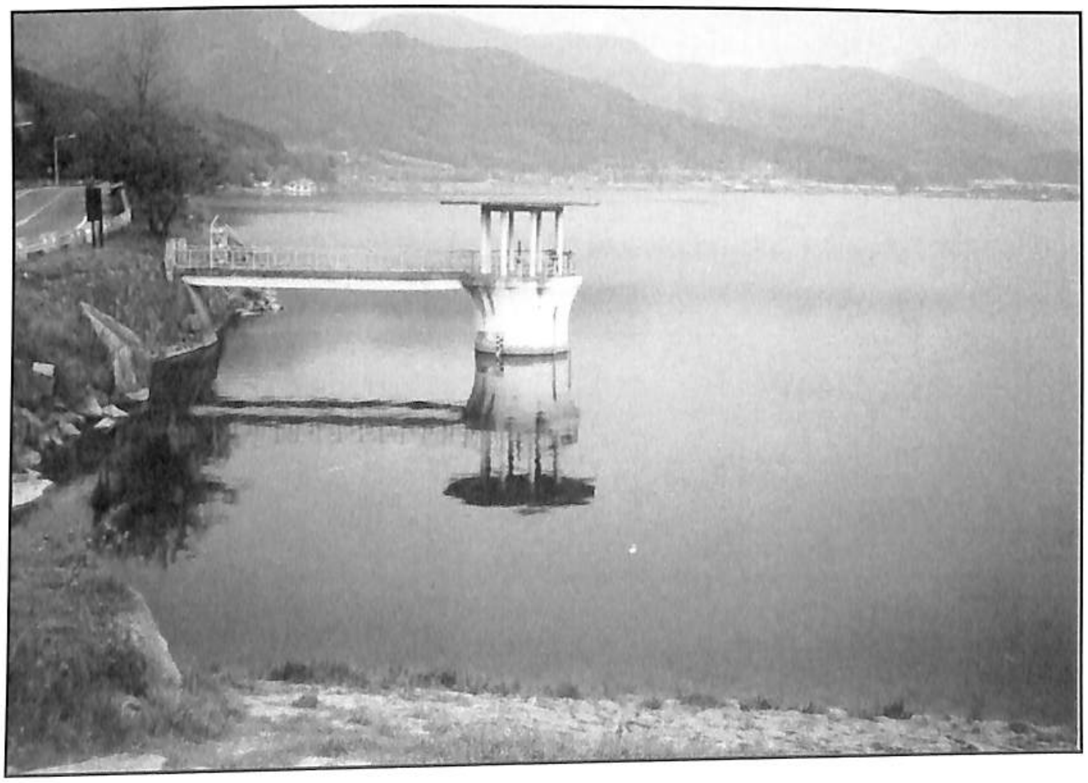
Dark green: Complt.
Purple: On- going

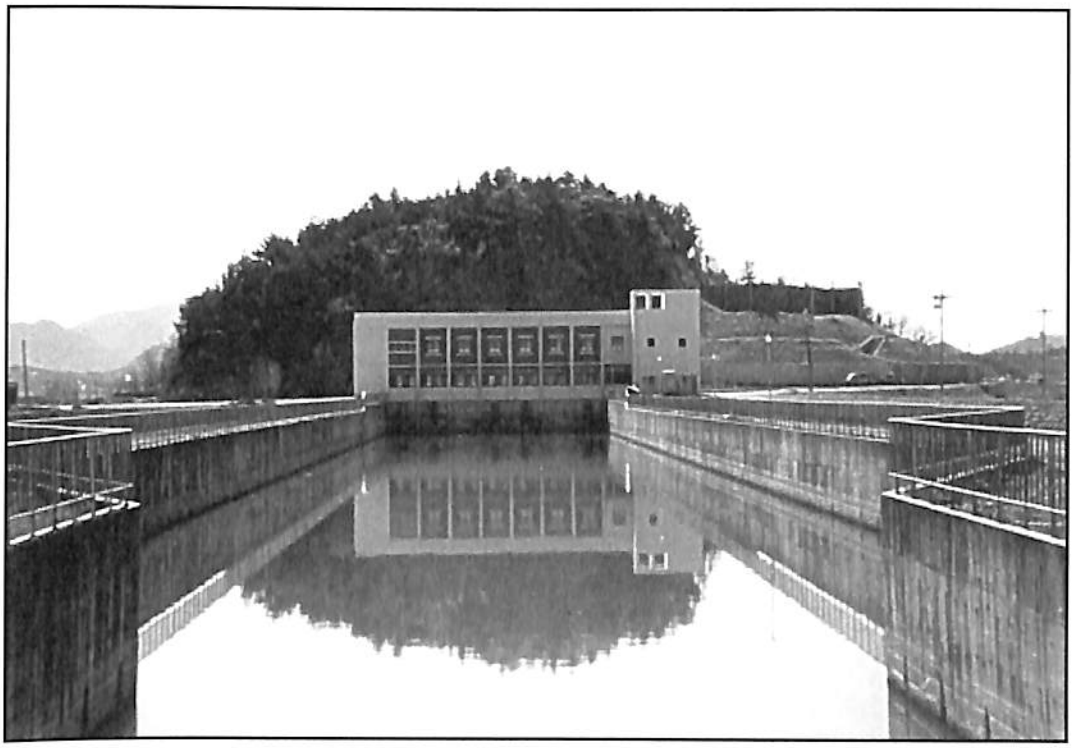
Surface Water Development

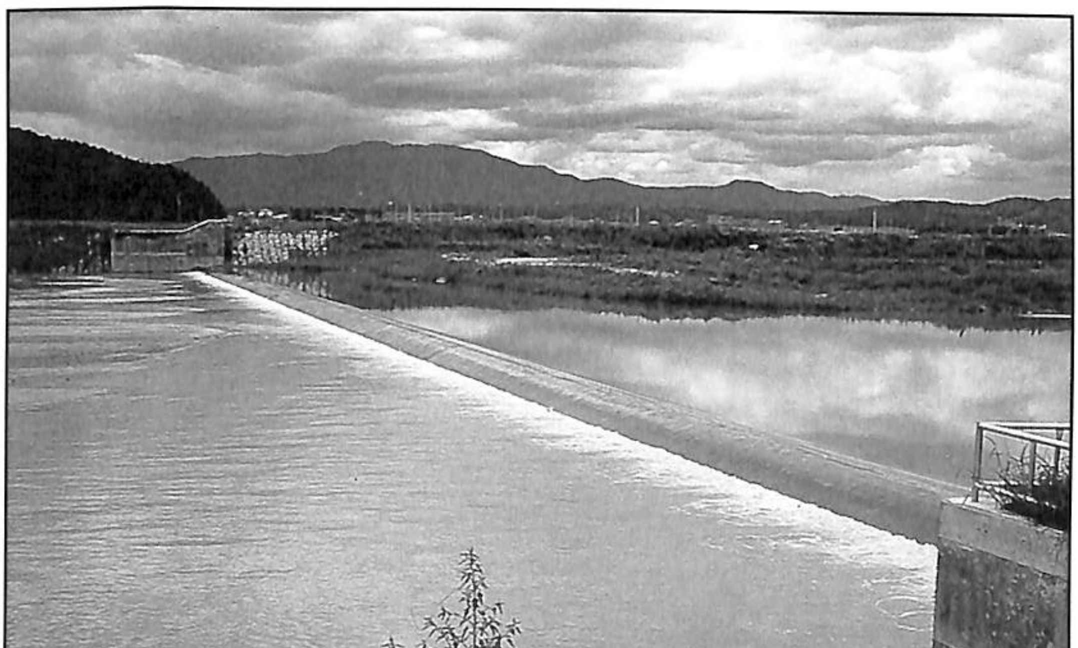
- Major facilities: Dam, Pumping station, Headwork, Well
- Irrigated area according to Intake

Intake	Numbers	Area (10^3ha)
Agri. Dam	17,679	486 (57%)
Pumping St.	7,178	196 (23%)
Diversion Weir	18,115	92 (11%)
Gr. well	?	33 (4%)
Others	?	52 (5%)
Total		859 (100%)


Irrigation Facilities & Area Covered
Reservoir
486,406ha(57%)
(17,679 ea)
Total
859,040 ha
(100%)
Others
84,675 ha(9%)
Weir
92,243ha(11%)
(18,115 ea)
Pumping Station
195,716ha(23%)
(7,178 ea)







Irrigation Canal

- Rate of water loss
  - Earth canal: 30 – 40%
  - Concrete: 5 – 10%
- Increase of water transfer efficiency
  - Convert earth canal to concrete canal or pipe
  - Introduction of automated system (TM/TC)

Ground Water Development

- Ground water well development
  - Supplementary irrigation system to overcome drought
  - in 1960s, 1970s: unconfined shallow aquifer
  - in 1980s: Deep well with technology innovation
  - after 1990s: Deep well beneath the base rock (200m)
    glass house, upland irrigation, domestic water

- Recent Issues
  - Ground sinking due to excessive exploitation
  - Ground water pollution through abandoned wells
  - Training program for ground water conservation

What are key issues?

- Sustainable development
  - Small scale project for land and water development
  - Water transfer
- Water savings
  - Efficient water management and maintenance
  - Automated system using TM/TC

Irrigated Water Reuse

Intake facility	Amount of intake (10^6 m^3)	Amount of reuse (10^6 m^3)	Reuse ratio (%)
Dam reservoir	4,741 (51%)	1,090	23
Desalinate reservoir	2,035 (22%)	407	20
Pumping station	1,701 (18%)	102	6
Diversion weirs	794 (9%)	8	1
Total	9,271 (100%)	1,607	17

Agricultural Water Development for paddy Field Farming

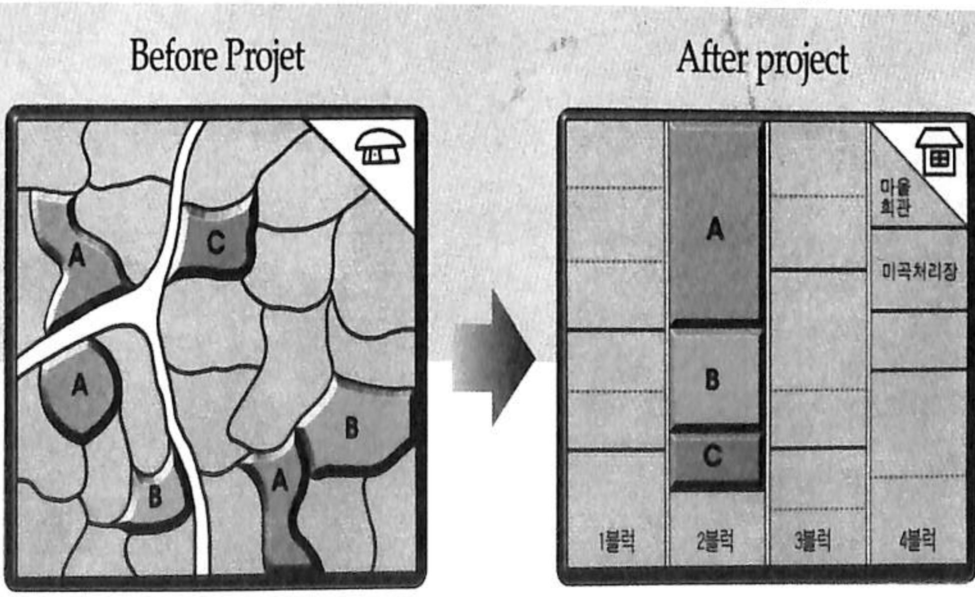
2008. 9.

Hydraulic Studies for Dam Spillway

Mr. Daesu EO

Rural Research Institute

III. Farmland Consolidation



Why Land Consolidation?

- Increase farmland production and farm income
  - Well equipped irrigation and drainage canal, road net
  - Changes irregularly shaped plots to large plots
- Efficient water management
  - Water supply at right time and place with right amount
  - Drainage system for preventing crops from inundation
  - Water savings
- Farm mechanization
  - Increase labor productivity
  - Large size machinery with good accessibility

Ⅳ. Land and Water Resources Development in Coastal Area

Saemangeum Project

KRC

Ⅴ. Rehabilitation and Modernization

Please refer to lecture note

Telemetring/Telecontrol of Irrigation Water

Objectives

Optimized water supply and operation

↑

Data base for automated system

↑

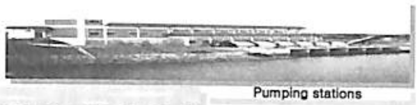
Rehabilitation of the existing structures Integrated water management

↑

Water savings | Cost down of O&M | Damage prevention

Examples of automated system

Reservoir operation



Pumping stations

Central control office

Check gate control

Turnout control

Ⅵ. Prospects of Rural Development

Plan for Comprehensive Rural Development

After 2000

Goal

- Stable Food Supply
- Preservation of Productive Farmland
- Environmentally Sound Agriculture
- Reform Agricultural Marketing System
- Improvement of Rural Living Standard

Targeted

- Irrigation Ratio: 76% ⇒ 88%, Rural Road Pavement: 32% ⇒ 51%
- Domestic Water Supply: 48% ⇒ 71%
- Total US\$ 10.3×10^9 invested

Thank you!

Computer Modeling for Agricultural Water Management

OK

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Computer Models for Rural Water Development

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I. Role of Models in Water Management

Water is a vital resource for food and fiber production. Irrigated farmlands in the semi-arid to arid regions of the world contribute about 36 percent of the total production. As the human population increases, more irrigation water will be needed to meet the greater food demand. However, the supplies of useable and renewable fresh water are scarce. Agriculture is already facing a stiff competition for fresh water supplies from drinking, industrial, and recreational uses, even in the U.S. that has vast resources. The only answer is to conserve water through judicious management for all uses. In agriculture, the management of soil water based on current scientific principles can help to increase water use efficiency, reduce losses, and prevent secondary salinization of groundwater resources, a common problem in irrigated areas of the world.

Water management involves development, control, protection, regulation, and beneficial use of surface and ground water resources. Services provided by the water management community include: water supply for agricultural, industrial, and municipal uses: wastewater collection and treatment: protection and enhancement of environmental resources: pollution prevention: recreation: navigation: hydro-electric power generation: storm water drainage: erosion and sedimentation control: and controlling flood water and reducing damages due to flooding. Water resources planning and management activities include: policy formulation; national, regional, and local resource assessment; regulatory and permitting functions; formulation and implementation of resource management strategies; planning, design, construction, maintenance, and operation of structures and facilities; scientific and engineering research; and education and training.

Computer models play important roles in essentially all aspects of water management. There is a great diversity of ways in which they are applied. During the construction era of the 1950s~1970s, model development was oriented toward the water management emphasis on planning and design of constructed facilities, and these types of applications continue to be important. However, water resources management and associated modeling applications shifted during the 1970s and 1980s to a major focus on resource management and operation of existing facilities. Protection of water quality and environmental resources has become a driving concern in recent years.

From the perspective of the scientist and researcher, the role of mathematical models is to contribute to a better understanding of real-world process. From the perspective of the water manager, the role of mathematical models is to provide quantitative information to support decision making activities. Models help both individual water managers and the water management community to make better decisions. They simply provide some additional information to consider. Models strengthen the knowledge base which supports decision making processes.

The findings from the assessment of the use of mathematical models in water resources planning and management are as follows;

- Models capable of analyzing many pressing water resource issues are available, and have significant potential for increasing the accuracy and effectiveness of information available to managers, decision makers, and scientist. Models have significantly expanded the ability to understand and manage water resources. Models have the potential to provide even greater benefits for water resource decision making in the future.
- Models are used in essentially every area of water resources planning and management.
- Water resource models vary greatly in their capabilities and limitations and must be carefully selected and by knowledgeable professionals.

II. Computer Simulation

A computer simulation, a computer model or a computational model is a computer program, or network of computers, that attempts to simulate an abstract model of a particular system. Computer simulations have become a useful part of mathematical modeling of many natural systems in physics (computational physics), chemistry and biology, human systems in economics, psychology, and social science and in the process of engineering new technology, to gain insight into the operation of those systems, or to observe their behavior.

Computer simulations vary from computer programs that run a few minutes, to network-based groups of computers running for hours, to ongoing simulations that run for days. The scale of events being simulated by computer simulations has far exceeded anything possible (or perhaps even imaginable) using the traditional paper-and-pencil mathematical modeling: over 10 years ago, a desert-battle simulation, of one force invading another, involved the modeling of 66,239 tanks, trucks and other vehicles on simulated terrain around Kuwait, using multiple supercomputers in the DoD High Performance Computer Modernization Program; a 1-billion-atom model of material deformation (2002); a 2.64-million-atom model of the complex maker of protein in all organisms, a ribosome, in 2005; and the Blue Brain project at EPFL (Switzerland), began in May 2005, to create the first computer simulation of the entire human brain, right down to the molecular level.

Simulation versus modeling

Traditionally, forming large models (spelt 'modeling' in American English) of systems has been via a mathematical model, which attempts to find analytical solutions to problems and thereby enable the prediction of the behavior of the system from a set of parameters and initial conditions.

While computer simulations might use some algorithms from purely mathematical models, computers can combine simulations with reality or actual events, such as generating input responses, to simulate test subjects who are no longer present. Whereas the missing test subjects are being modeled/simulated, the system they use could be the actual equipment, revealing performance limits or defects in long-term use by the simulated users.

Note that the term *computer simulation* is broader than *computer modeling*, which implies that all aspects are being modeled in the computer representation. However, computer simulation also includes generating inputs from simulated users to run actual computer software or equipment, with only part of the system being modeled: an example would be flight simulators which can run machines as well as actual flight software.

Computer simulations are used in many fields, including science, technology, entertainment, and business planning and scheduling.

History

Computer simulation was developed hand-in-hand with the rapid growth of the computer, following its first large-scale deployment during the Manhattan Project in World War II to model the process of nuclear detonation. It was a simulation of 12 hard spheres using a Monte Carlo algorithm. Computer simulation is often used as an adjunct to, or substitution for, modeling systems for which simple closed form analytic solutions are not possible. There are many different types of computer simulation; the common feature they all share is the attempt to generate a sample of representative scenarios for a model in which a complete enumeration of all possible states of the model would be prohibitive or impossible. Computer models were initially used as a supplement for other arguments, but their use later became rather widespread.

Computer model classification

Computer models can be classified according to several independent pairs of attributes, including:

- Stochastic or deterministic (and as a special case of deterministic, chaotic) - see External links below for examples of stochastic vs. deterministic simulations

- Steady-state or dynamic
- Continuous or discrete (and as an important special case of discrete, discrete event or DE models)
- Local or distributed.

These attributes may be arbitrarily combined to form terminology that describes simulation types, such as "continuous dynamic simulations" or "discrete dynamic simulations."

For example:

- Steady-state models use equations defining the relationships between elements of the modeled system and attempt to find a state in which the system is in equilibrium. Such models are often used in simulating physical systems, as a simpler modeling case before dynamic simulation is attempted.
- Dynamic simulations model changes in a system in response to (usually changing) input signals.
- *Stochastic* models use *random number generators* to model chance or random events;
- A *discrete event simulation* (DES) manages events in time. Most computer, logic-test and fault-tree simulations are of this type. In this type of simulation, the simulator maintains a queue of events sorted by the simulated time they should occur. The simulator reads the queue and triggers new events as each event is processed. It is not important to execute the simulation in real time. It's often more important to be able to access the data produced by the simulation, to discover logic defects in the design, or the sequence of events.
- A *continuous dynamic simulation* performs numerical solution of differential-algebraic equations or differential equations (either partial or ordinary). Periodically, the simulation program solves all the equations, and uses the numbers to change the state and output of the simulation. Applications include flight simulators, construction and management simulation games, chemical process modeling, and simulations of electrical circuits. Originally, these kinds of simulations were actually implemented on analog computers, where the differential equations could be represented directly by various electrical components such as

op-amps. By the late 1980s, however, most "analog" simulations were run on conventional digital computers that emulate the behavior of an analog computer.

- A special type of discrete simulation which does not rely on a model with an underlying equation, but can nonetheless be represented formally, is *agent-based simulation*. In agent-based simulation, the individual entities (such as molecules, cells, trees or consumers) in the model are represented directly (rather than by their density or concentration) and possess an internal *state* and set of behaviors or *rules* which determine how the agent's state is updated from one time-step to the next.
- Distributed models run on a network of interconnected computers, possibly through the Internet. Simulations dispersed across multiple host computers like this are often referred to as "distributed simulations". There are several standards for distributed simulation, including Aggregate Level Simulation Protocol (ALSP), Distributed Interactive Simulation (DIS), the High Level Architecture (simulation) (HLA) and the Test and Training Enabling Architecture (TENA).

Computer simulation in science

Generic examples of types of computer simulations in science, which are derived from an underlying mathematical description:

- a numerical simulation of differential equations which cannot be solved analytically, theories which involve continuous systems such as phenomena in physical cosmology, fluid dynamics (e.g. climate models, roadway noise models, roadway air dispersion models), continuum mechanics and chemical kinetics fall into this category.
- a stochastic simulation, typically used for discrete systems where events occur probabilistically, and which cannot be described directly with differential equations (this is a *discrete* simulation in the above sense). Phenomena in this category include genetic drift, biochemical or gene regulatory networks with small numbers of molecules. (see also: Monte Carlo method).

Specific examples of computer simulations follow:

- statistical simulations based upon an agglomeration of a large number of input profiles, such as the forecasting of equilibrium temperature of receiving waters, allowing the gamut of meteorological data to be input for a specific locale. This technique was developed for thermal pollution forecasting .

- agent based simulation has been used effectively in ecology, where it is often called *individual based modeling* and has been used in situations for which individual variability in the agents cannot be neglected, such as population dynamics of salmon and trout (most purely mathematical models assume all trout behave identically).

- time stepped dynamic model. In hydrology there are several such hydrology transport models such as the SWMM and DSSAM Models developed by the U.S. Environmental Protection Agency for river water quality forecasting.

- computer simulations have also been used to formally model theories of human cognition and performance, e.g. ACT-R

- computer simulation using molecular modeling for drug discovery

- Computational fluid dynamics simulations are used to simulate the behaviour of flowing air, water and other fluids. There are one-, two- and three- dimensional models used. A one dimensional model might simulate the effects of water hammer in a pipe. A two-dimensional model might be used to simulate the drag forces on the cross-section of an aeroplane wing. A three-dimensional simulation might estimate the heating and cooling requirements of a large building.

- An understanding of statistical thermodynamic molecular theory is fundamental to the appreciation of molecular solutions. Development of the Potential Distribution Theorem (PDT) allows one to simplify this complex subject to down-to-earth presentations of molecular theory.

Notable, and sometimes controversial, computer simulations used in science include: Donella Meadows' World3 used in the *Limits to Growth*, James Lovelock's Daisyworld and Thomas Ray's Tierra.

Computer simulation in practical contexts

Computer simulations are used in a wide variety of practical contexts, such as:

- analysis of air pollutant dispersion using atmospheric dispersion modeling
- design of complex systems such as aircraft and also logistics systems.
- design of Noise barriers to effect roadway noise mitigation
- flight simulators to train pilots
- weather forecasting
- forecasting of prices on financial markets (for example Adaptive Modeler)
- behavior of structures (such as buildings and industrial parts) under stress and other conditions
- design of industrial processes, such as chemical processing plants
- Strategic Management and Organizational Studies
- Reservoir simulation for the petroleum engineering to model the subsurface reservoir
- Process Engineering Simulation tools.
- Robot simulators for the design of robots and robot control algorithms
- Traffic engineering to plan or redesign parts of the street network from single junctions over cities to a national highway network, see for example VISSIM.
- modeling car crashes to test safety mechanisms in new vehicle models

The reliability and the trust people put in computer simulations depends on the validity of the simulation model, therefore verification and validation are of crucial importance in the development of computer simulations. Another important aspect of computer simulations is that of reproducibility of the results, meaning that a simulation model should not provide a different answer for each execution. Although this might seem obvious, this is a special point of attention in stochastic simulations, where random numbers should actually be semi-random numbers. An exception to reproducibility is human in the loop simulations such as flight simulations and computer games. Here a human is part of the simulation and thus influences the outcome in a way that is hard if not impossible to reproduce exactly.

Vehicle manufacturers make use of computer simulation to test safety features in new designs. By building a copy of the car in a physics simulation environment, they can save the hundreds of thousands of dollars that would otherwise be required to build a unique prototype and test it. Engineers can step through the simulation milliseconds at a time to determine the exact stresses being put upon each section of the prototype.

Computer graphics can be used to display the results of a computer simulation. Animations can be used to experience a simulation in real-time e.g. in training simulations. In some cases animations may also be useful in faster than real-time or even slower than real-time modes. For example, animations faster than real-time can be useful in visualizing the buildup of queues in the simulation of humans evacuating a building. Furthermore, simulation results are often aggregated into static images using various ways of scientific visualization.

In debugging, simulating a program execution under test (rather than executing natively) can detect far more errors than the hardware itself can detect and, at the same time, log useful debugging information such as instruction trace, memory alterations and instruction counts. This technique can also detect buffer overflow and similar "hard to detect" errors as well as produce performance information and tuning data.

III. Mathematical Model

A **mathematical model** uses mathematical language to describe a system. Mathematical models are used not only in the natural sciences and engineering disciplines (such as physics, biology, earth science, meteorology, and engineering) but also in the social sciences (such as economics, psychology, sociology and political science); physicists, engineers, computer scientists, and economists use mathematical models most extensively. The process of developing a mathematical model is termed 'mathematical modelling' (also modeling).

Eykhoff (1974) defined a *mathematical model* as 'a representation of the essential aspects of an existing system (or a system to be constructed) which presents knowledge of that system in usable form'.[1]

Mathematical models can take many forms, including but not limited to dynamical systems, statistical models, differential equations, or game theoretic models. These and other types of models can overlap, with a given model involving a variety of abstract structures.

Examples of mathematical models

- *Population Growth.* A simple (though approximate) model of population growth is the Malthusian growth model. A slightly more realistic and largely used population growth model is the logistic function, and its extensions.
- *Model of a particle in a potential-field.* In this model we consider a particle as being a point of mass *m* which describes a trajectory which is modeled by a function $x : \mathbf{R} \to \mathbf{R}^3$ given its coordinates in space as a function of time. The potential field is given by a function $V{:}\mathbf{R}^3 \to \mathbf{R}$ and the trajectory is a solution of the differential equation

  Note this model assumes the particle is a point mass, which is certainly known to be false in many cases we use this model, for example, as a model of planetary motion.

- *Model of rational behavior for a consumer.* In this model we assume a consumer faces a choice of n commodities labeled 1,2,...,n each with a market price p_1, p_2,..., p_n. The consumer is assumed to have a *cardinal* utility function U (cardinal in the sense that it assigns numerical values to utilities), depending on the amounts of commodities x_1, x_2,..., x_n consumed. The model further assumes that the consumer has a budget M which she uses to purchase a vector x_1, x_2,..., x_n in such a way as to maximize $U(x_1, x_2,..., x_n)$. The problem of rational behavior in this model then becomes an optimization problem, that is:

  subject to:

  This model has been used in general equilibrium theory, particularly to show existence and Pareto optimality of economic equilibria. However, the fact that this particular formulation assigns *numerical values* to levels of satisfaction is the source of criticism (and even ridicule). However, it is not an essential ingredient of the theory and again this is an idealization.

- *Neighbour-sensing model* explains the mushroom formation from the initially chaotic fungal network.

Modelling contains selecting and identifying relevant aspects of a situation in real world.

Background

Often when engineers analyze a system to be controlled or optimized, they use a mathematical model. In analysis, engineers can build a descriptive model of the system as a hypothesis of how the system could work, or try to estimate how an unforeseeable event could affect the system. Similarly, in control of a system, engineers can try out different control approaches in simulations.

A mathematical model usually describes a system by a set of variables and a set of equations that establish relationships between the variables. The values of the variables can be practically anything; real or integer numbers, boolean values or strings, for example. The variables represent some properties of the system, for example, measured system outputs often in the form of signals, timing data, counters, and event occurrence (yes/no). The actual model is the set of functions that describe the relations between the different variables.

Building blocks

There are six basic groups of variables decision variables, input variables, state variables, exogenous variables, random variables, and output variables. Since there can be many variables of each type, the variables are generally represented by vectors.

Decision variables are sometimes known as independent variables. Exogenous variables are sometimes known as parameters or constants. The variables are not independent of each other as the state variables are dependent on the decision, input, random, and exogenous variables. Furthermore, the output variables are dependent on the state of the system (represented by the state variables).

Objectives and constraints of the system and its users can be represented as functions of the output variables or state variables. The objective functions will depend on the perspective of the model's user. Depending on the context, an objective function is also known as an index of performance, as it is some measure of interest to the user. Although there is no limit to the number of objective functions and constraints a model can have, using or optimizing the model becomes more involved (computationally).

A priori information

Mathematical modelling problems are often classified into black box or white box models, according to how much a priori information is available of the system. A black-box model is a system of which there is no a priori information available. A white-box model (also called glass box or clear box) is a system where all necessary information is available. Practically all systems are somewhere between the black-box and white-box models, so this concept only works as an intuitive guide for approach.

Usually it is preferable to use as much a priori information as possible to make the model more accurate. Therefore the white-box models are usually considered easier, because if you have used the information correctly, then the model will behave correctly. Often the a priori information comes in forms of knowing the type of functions relating different variables. For example, if we make a model of how a medicine works in a human system, we know that usually the amount of medicine in the blood is an exponentially decaying function. But we are still left with several unknown parameters; how rapidly does the medicine amount decay, and what is the initial amount of medicine in blood? This example is therefore not a completely white-box model. These parameters have to be estimated through some means before one can use the model.

In black-box models one tries to estimate both the functional form of relations between variables and the numerical parameters in those functions. Using a priori information we could end up, for example, with a set of functions that probably could describe the system adequately. If there is no a priori information we would try to use functions as general as possible to cover all different models. An often used approach for black-box models are neural networks which usually do not make assumptions about incoming data. The problem with using a large set of functions to describe a system is that estimating the parameters becomes increasingly difficult when the amount of parameters (and different types of functions) increases.

Subjective information

Sometimes it is useful to incorporate subjective information into a mathematical model. This can be done based on intuition, experience, or expert opinion, or based on convenience of mathematical form. Bayesian statistics provides a theoretical framework for incorporating such subjectivity into a rigorous analysis: one specifies a prior probability distribution (which can be subjective) and then updates this distribution based on empirical data. An example of when such approach would be necessary is a situation in which an experimenter bends a coin slightly and tosses it once, recording whether it comes up heads, and is then given the task of predicting the probability that the next flip comes up heads. After bending the coin, the true probability that the coin will come up heads is unknown, so the experimenter would need to make an arbitrary decision (perhaps by looking at the shape of the coin) about what prior distribution to use. Incorporation of the subjective information is necessary in this case to get an accurate prediction of the probability, since otherwise one would guess 1 or 0 as the probability of the next flip being heads, which would be almost certainly wrong.[2]

Complexity

In general, model complexity involves a trade-off between simplicity and accuracy of the model. Occam's Razor is a principle particularly relevant to modelling; the essential idea being that among models with roughly equal predictive power, the simplest one is the most desirable. While added complexity usually improves the fit of a model, it can make the model difficult to understand and work with, and can also pose computational problems, including Numerical instability. Thomas Kuhn argues that as science progresses, explanations tend to become more complex before a Paradigm shift offers radical simplification.

For example, when modelling the flight of an aircraft, we could embed each mechanical part of the aircraft into our model and would thus acquire an almost white-box model of the system. However, the computational cost of adding such a huge amount of detail would effectively inhibit the usage of such a model. Additionally, the uncertainty would increase due to an overly complex system, because each separate part induces some amount of variance into the model. It is therefore usually appropriate to make some approximations to reduce the model to a sensible size. Engineers often can accept some approximations in order to get a more robust and simple model. For example Newton's classical mechanics is an approximated model of the real world. Still, Newton's model is quite sufficient for most ordinary-life situations, that is, as long as particle speeds are well below the speed of light, and we study macro-particles only.

Training

Any model which is not pure white-box contains some parameters that can be used to fit the model to the system it shall describe. If the modelling is done by a neural network, the optimization of parameters is called *training*. In more conventional modelling through explicitly given mathematical functions, parameters are determined by curve fitting.

Model evaluation

A crucial part of the modelling process is the evaluation of whether or not a given mathematical model describes a system accurately. This question can be difficult to answer as it involves several different types of evaluation.

Fit to empirical data. Usually the easiest part of model evaluation is checking whether a model fits experimental measurements or other empirical data. In models with parameters, a common approach to test this fit is to split the data into two disjoint subsets: training data and verification data. The training data are used to estimate the model parameters. An accurate model will closely match the verification data even though this data was not used to set the model's parameters. This practice is referred to as cross-validation in statistics.

Defining a metric to measure distances between observed and predicted data is a useful tool of assessing model fit. In statistics, decision theory, and some economic models, a loss function plays a similar role.

While it is rather straightforward to test the appropriateness of parameters, it can be more difficult to test the validity of the general mathematical form of a model. In general, more mathematical tools have been developed to test the fit of statistical models than models involving Differential equations. Tools from nonparametric statistics can sometimes be used to evaluate how well data fits a known distribution or to come up with a general model that makes only minimal assumptions about the model's mathematical form.

Scope of the model. Assessing the scope of a model, that is, determining what situations the model is applicable to, can be less straightforward. If the model was constructed based on a set of data, one must determine for what systems or situations the data is a typical set of data from.

The question of whether the model describes well the properties of the system between data points is called interpolation, and the same question for events or data points outside the observed data is called extrapolation.

As an example of the typical limitations of the scope of a model, in evaluating Newtonian classical mechanics, we can note that Newton made his measurements without advanced equipment, so he could not measure properties of particles travelling at speeds close to the speed of light. Likewise, he did not measure the movements of molecules and other small particles, but macro particles only. It is then not surprising that his model does not extrapolate well into these domains, even though his model is quite sufficient for ordinary life physics.

Philosophical considerations. Many types of modelling implicitly involve claims about causality. This is usually (but not always) true of models involving differential equations. As the purpose of modelling is to increase our understanding of the world, the validity of a model rests not only on its fit to empirical observations, but also on its ability to extrapolate to situations or data beyond those originally described in the model. One can argue that a model is worthless unless it provides some insight which goes beyond what is already known from direct investigation of the phenomenon being studied.

An example of such criticism is the argument that the mathematical models of Optimal foraging theory do not offer insight that goes beyond the common-sense conclusions of evolution and other basic principles of ecology.

IV. Water Management Models

BUDGET

It is composed of a set of validated subroutines describing the various processes involved in water extraction by plant roots and water movement in the soil profile. The water stored in the root zone is determined in the soil water balance model on a daily basis by keeping track of incoming and outgoing water fluxes at its boundary. Given the simulated soil water content in the root zone, the corresponding crop water stress is determined. During periods of crop water stress the resulting yield depression is estimated by means of yield response factors. By selecting appropriate time and depth criteria irrigation schedules can be generated.

CanalMan

It was developed for performing hydraulic simulations of unsteady flow in branching canal networks.The model can be used to simulate canal operations in a manual mode, and it can generate proposed operating schedules through a centralized automatic mode. Several common local gate automation schemes are also included in the model, and these can be easily selected and calibrated through the model interface. It is highly interactive and includes integrated data editing capabilities, with numerous options for canal system configuration, hydraulic simulations, and output of results. Structure settings and discharges can be specified through time graphs entered before a simulation, they can be changed at any time during a simulation, structure settings can be generated through "gate scheduling", and local gate automation algorithms can be applied.

CPED

Center Pivot Evaluation and Design is a Windows program for assessment of center pivot performance. The program simulates the water distribution under a center pivot from various commercial nozzles as well as performs an evaluation from catch can data. This scientific model was adapted by Beccard and Heermann to include the effect of topographic differences in the resulting application depths along the radii of the center pivot in non level fields. Included are pump and well characteristics specific to the system. The model was developed and is supported by ARS Water Management Research Unit in Fort Collins, Colorado.

CROPFLEX

CROPFLEX is a Window's 3.1 or greater computer tool. Developed by Colorado State University, it provides recommendations for producers on irrigation timing and nutrient scheduling. Crop development and irrigation needs are driven by local climatic inputs. Nutrient balances are determined and a seasonal accounting is made as to plant uptake depending on the health and vigor of the plant from appropriate timing and amounts of irrigation. Depending on plant health and vigor, a mid year correction is presented to allow for modification of nutrient applications. Nutrient needs are based on yields and input soil sampling information. Nutrients considered are manure, organic, and commercial. This includes prior year on crop residue and manure application. Accounting is made for the method of tillage, manure source and application, and method of commercial application. NLEAP nutrient handling technology is embedded in the model.

DailyET

DailyET is a simple Windows based calculator for estimating daily and monthly reference evapotranspiration (ETo) according to four methods using data collected from either conventional or electronic weather stations. The minimum input data required are maximum and minimum air temperature, relative humidity, sunshine duration, wind speed and the location of the weather station (latitude, height above sea level). The outputs are daily or monthly reference evapotranspiration in mm.

Geo-Hydro

It is an ArcView GIS interface to the WinTR-20 Version 1.11 hydrologic model. It operates with ESRI ArcView 3.3 and the Spatial Analyst extension. The interface is organized to complete the steps required to do a WinTR-20 hydrologic analysis. Using tools and menu selections, the user is guided step by step through the automated processes of defining the watershed boundary, dividing the watershed into sub-areas, developing cross sections, etc. The end result is a WinTR-20 execution with peak discharges, hydrographs, etc.

HEC-GeoRAS

HEC-GeoRAS is an ArcView GIS extension that provides the user with a set of procedures, tools, and utilities for the preparation of GIS data for import into HEC-RAS, and generation of GIS data from RAS output. While the GeoRAS extension is designed for users with limited geographic information systems (GIS) experience, knowledge of ArcView GIS is advantageous. Users, however, must have experience modeling with HEC-RAS and have a thorough understanding of river hydraulics to properly create interpret GIS data sets. ArcView GIS 3.2, for Windows OS, with the 3D Analysts Extensions is required. The Spatial Analyst extension is recommended. GeoRAS allows the preparation of geometric data for import into HEC-RAS and processes simulation results exported from HEC-RAS. To create the import file, the user must have an existing digital terrain model (DTM) of the river system in the ArcInfo TIN format. The user creates a series of line themes pertinent to developing geometric data for HEC-RAS. The themes created are the Stream Centerline, Flow Path Centerlines (optional), Main Channel Banks (optional), and Cross Section Cut Lines referred to as the RAS Themes. Additional RAS Themes may be created/used to extract additional geometric data for import in HEC-RAS. These themes include Land Use, Levee Alignment, Ineffective Flow Areas, and Storage Areas. Water surface profile data and velocity data exported from HEC-RAS simulations may be processed by HEC-GeoRAS for GIS analysis for floodplain mapping, flood damage computations, ecosystem restoration, and flood warning response and preparedness.

IWR

Irrigation Water Requirements (IWR) is a Windows 95 (or greater) crop consumptive use program developed specifically for NRCS use in development of Consumptive Use Table for the new NRCS Irrigation Guide. IWR uses the FAO Radiation method, the FAO Temperature method or the Blainey- Criddle method depending on the climate information that is available.

PumpCom

It combines head-discharge curves for individual irrigation pumps to create head-discharge curves for multiple unit pumping stations. Pumps can be combined in series and/or in parallel with any number and combination. All data are entered via WINDOWS® menus and pumping station layout is described graphically using WINDOWS® Icons. Minor losses between pumps are considered. Polynomial regression equations can be generated for both individual and total station head-discharge curves as well as for efficiency and NPSH curves for the total station.

RAINBOW

RAINBOW is a software package developed by Raes, et al. (1996, 2006) at the University of Leuven, Belgium. It allows to compute the magnitudes of events that can be expected for a selected probability or return period. This is a common problem in many areas of water resources engineering where the analysis of hydrological and meteorological data is needed for planning and design purposes. These estimates are required e.g. for the design of canals, pipelines, reservoirs, floodwater-spreading systems and hydraulic structures and for the proper management of floodwater and rainwater harvesting schemes as well as for irrigation and drainage projects. The selection of the probability or return period for design purposes is related to the damage the excess or the shortage of rainfall may cause, the risk which could be considered acceptable and the estimated lifetime of the project.

Such estimates can be obtained by means of frequency analysis on historical hydrological and meteorological data. For hydrological purposes, typically historical time series of meteorological and hydrological data are analysed to determine design rainfall depths, evapotranspiration levels, floods, etc. that could occur with a selected probability. The variability depends on the type of climate and the length of the considered period. Although time series of historic rainfall data are often characterised by their average and standard variation, these values cannot be blindly used to estimate design rainfall depths that can be expected with a specific probability or return period as they are only based on a normal distribution. Applying this technique to a data set can produce misleading results since the actual characteristics of the distribution are ignored.

To avoid this type of error, it is therefore essential that the goodness of the assumed distribution is checked before design rainfall depths are estimated. Although the required length of the time series depends on the magnitude of variability of the e.g. precipitation climate, a period of 30 years and over normally is thought to be very satisfactory. By assuming that the past and future data sets are stationary and have no apparent trend one may then expect that future time series will reveal frequency distributions similar to the observed ones. It is obvious that the longer the data series are the more similar the frequency distribution will be to the probability distribution. As the number of observations increases, the error in determining expected rainfall gradually diminishes.

REF-ET

It is a compiled, stand-alone computer program that calculates reference evapotranspiration. It provides standardized calculations of reference evapotranspiration for fifteen of the more common methods and equations that are currently in use in the United States and Europe. The calculations are based on the weather data measurements that are made available by the user. The two primary purposes of the model are to provide standardized calculations of reference ET and other intermediate micro meteorological parameters that can be compared to calculations by other programs for error checking purposes and to read weather data from a wide range of data file types, data unit types and time steps.

SIRMODIII

It is a multi-lingual version of Utah State University's comprehensive surface irrigation software package. The software package provides simulation, evaluation, and design capabilities for border, basin, and furrow irrigation. These systems can be studied under either continuous or surge flow operations. The simulation of the hydraulics of surface irrigation systems at the field level uses hydrodynamic, zero-inertia, or kinematic-wave algorithms which can be used to select an optimal combination of sizing and operational parameters that maximize application efficiency. The evaluation algorithms utilize the "two-point solution" of the "inverse" problem allowing the computation of infiltration parameters from the input of advance data. The design algorithms utilize a standard volume balance procedure. All of these algorithms are those reported by Walker and Skogerboe (1987)1 and Walker (1989)2.

SOLVMANN

It will find the solution to "Manning's" equation for trapezoidal canal sections from two distinct approaches: It will find a straight forward algebraic solution of the Manning Equation for the "velocity" and the resulting "discharge" when the cross-sectional geometry; the roughness factor, n; the longitudinal slope; and the depth of flow in the channel are given. SOLVMANN will also solve the Manning Equation for the "depth" of flow by the Newton-Raphson iterative procedure if the cross-sectional geometry; the roughness factor, n; the longitudinal slope; and the discharge are given. It then determines the resulting "velocity" of water movement in addition to the depth. Too, SOLVMANN will solve the Manning Equation for the required "slope" to carry a given discharge at a required depth in a channel cross-section of a design trapezoidal shape. The solution methodology is chosen by the user by selecting the appropriate option button in the user interface window. The Froude Number is also determined by all methods. If the Froude Number is found to be greater than 0.95, the user is alerted by an audible alarm and the number is shown in a "red" box. If the Froude Number is found to be greater than 0.85 but less than or equal to 0.95, an audible "beep" is sounded and the number is shown in a "yellow" box. These alerts are given only to bring the high Froude Number to the user's attention in the user interface window. SOLVMANN will present the user interface prompts and labels in either English or Spanish. The user need only choose the desired language by selecting the appropriate option button in the user interface window.

STEADY

The Steady-State Canal Hydraulic Model, Steady, is a software package developed for the calculation of flow levels, flow rates, seepage loss rates, and regulator gate and turnout settings in branched canal systems under steady flow conditions. The primary application is for analyzing possible canal system operating conditions, that is, different flow distribution scenarios based on given system demands by water users. Steady can be used as an operational tool for irrigation supply system managers, as a training tool for canal operators, and as a design and analysis tool for system planners.The software package consists of a canal configuration editor, a hydraulic simulation model, and four utility programs. The editor is an interactive, menu-driven computer program with context sensitive help messages. Using the editor, a canal system can be defined by inserting reaches, turnouts, control structures, and laterals. You can easily navigate through a branching canal system and enter data such as slopes, lengths, and dimensions in any convenient order. Two of the utility programs are for calculating hydraulic roughness and pump calibration coefficients from field data. The hydraulic roughness program solves for the Manning hydraulic roughness by matching calculated flow levels in a canal reach to measured flow levels. The calculated flow levels are based on steady, gradually-varied flow equations. The pump program calculates coefficients for an approximating equation to a pump characteristic curve.

Waters

It is a database application for performing many of the routine accounting and water delivery scheduling activities of irrigation districts and irrigation companies. You can use the program to manage various database files associated with water orders and billing, and to help organize the financial and water scheduling records. You can print reports with water user data, water orders, billing statements, contents of individual database files, and other cross-referenced database information.

WinFlume

WinFlume is a USBR/ARS Windows95 and 3.1 program that provides procedures for determining head loss and developing flume designs for specific applications. It pertains to long-throated flumes which describes a broad class of critical-flow flumes and broad-crested weir devices (also referred to as the Replogle Flume or ramp weir) used to measure flow in open channels. These devices are adaptable to a variety of measurement applications in both natural and man-made channels, and both new and existing canal systems.

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Sustainable Agricultural Water Management in Korea

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Sustainable Agricultural Water Management in Korea

26 Aug. 2009

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1. Concept of Sustainable Development

- **Appearance of the concept of sustainable development**
  - 1973, Meeting of "International Union for Conservation of Nature and Natural Resources" (IUCN) : Conservation of Environment is defined as "Maintaining air, water, soil, natural resources and bio-system including human to achieve sustainable living quality".
  - 1974, Cocoyoc declaration (adopted at the meeting of UN in Mexico) used officially in the first the term of "sustainable development"
  - 1974, UN Meeting on Human-Environment : An integral approach considering the reciprocal relation between population, resources, environment, and economic development was proposed.
  - 1987, World Commission on Environment and Development (WCED) submitted "Our Common Future", and here WCED defined the concept of sustainable development as "to satisfy the needs of current generation without impeding the ability of future generation to satisfy their needs".

- **Settlement of the concept of sustainable development**
  - 1992, UN Conference on Environment and Development (UNCED) in Rio Brazil
    - The main topic of conference was the sustainable development
    - Adopted "Agenda21"- the action plan for conservation of global environment
    - Decide to establish "United Nations Commission on Sustainable Development (UNCSD)" under UN Economic and Social Council (ECOSOC) to maintain and evaluate the progress of member countries for Agenda 21

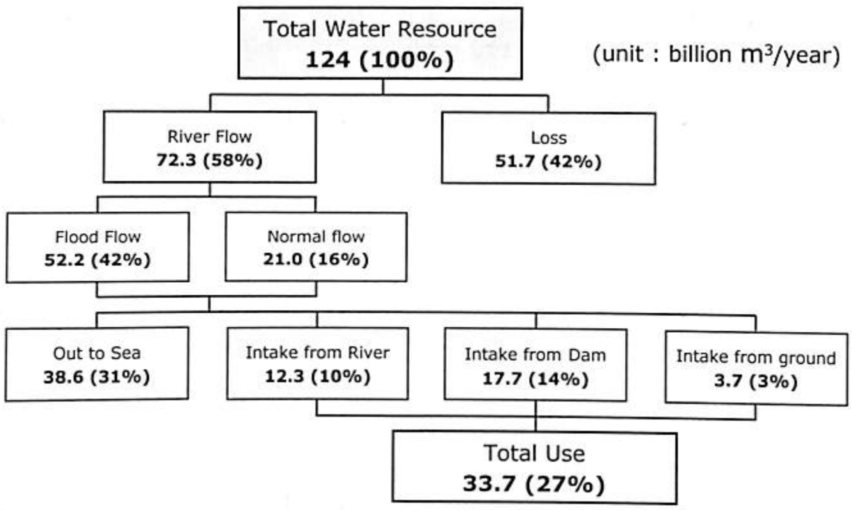
2. Water resource characteristics in Senegal

- **Country profile**
  - Area of country : 196,190 km^2
  - Population : 10.6 million
- **Precipitation**
  - Annual precipitation : varies from 270mm in the northern region to 1,793mm in the southern region
  - Annual total amount of water from precipitation : 146 billion ㎥
  - Annual amount of water per capita : 13,773㎥
  - Actually available amount of water : 39.4 billion ㎥ (27% of total)
  - Actually available amount of water per capita : 3,716㎥

3. Water resource characteristics in korea

- **Precipitation**
  - Annual precipitation : 1,245㎜ (average between 1974~2003)(about 1.4 times of world average 880mm)
  - Annual total amount of water from precipitation : 124 billion ㎥
  - Annual amount of water per capita : 2,591㎥ (Only about 1/8 of world average 19,635㎥)
  - Actually available amount of water : 72.3 billion ㎥ (58% of total)
  - Actually available amount of water per capita : 1,512㎥ (Classified as one of the water stressed country)
  - Relatively high water using rate may cause fragile circumstances on the water quality

Water resources and use

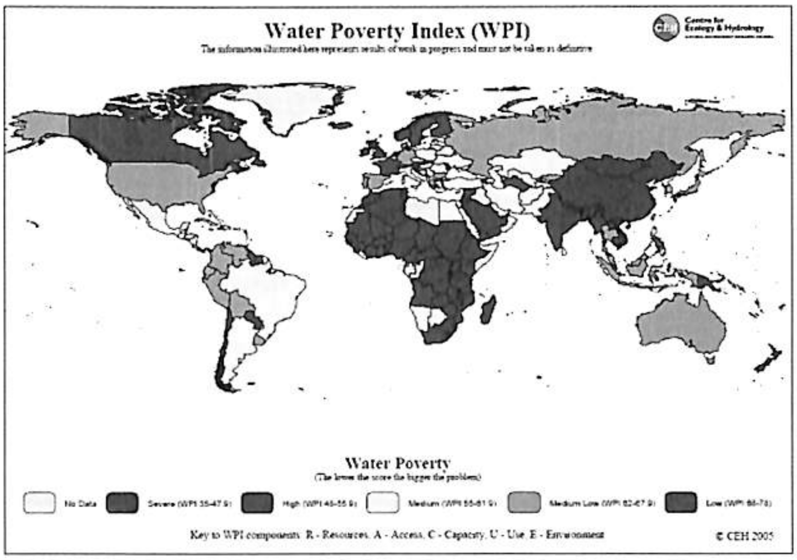


Classification of water stressed countries

River water take ratio	Water stress grades	Countries
Below 10%	low	New Zealand, Canada, Russia, etc.
10 ~ 20%	medium	China, Japan, U.S., England, France, Turkey, etc.
20 ~ 40%	Medium-high	Korea, India, Italia, S. Africa, etc.
Above 40%	high	Iraq, Egypt, etc.

Water Poverty Index

WPI of Korea : 62.4 (43th of 147 countries)



Climate and Topography

- Unfavorable condition for water management
- Seasonal variation of precipitation is great so that the level of river fluctuate highly
- About 2/3 of annual rainfall concentrates during short rainy season (6~9)
  - Flooding and drought occur very often
- 65% of topography is covered with mountains, and soil depth is shallow so that water keeping capacity is low, and the rivers have steep slopes
  - 'River regime coefficients' are very high (300~400)
  - Thames(8), Seine(34), Rhine(18), Nile(30), Mississippi(3)
- Annual rainfall has a tend to increasing since 1960, which strengthen the floods and droughts

Water using pattern

(unit : billion m^3/year)

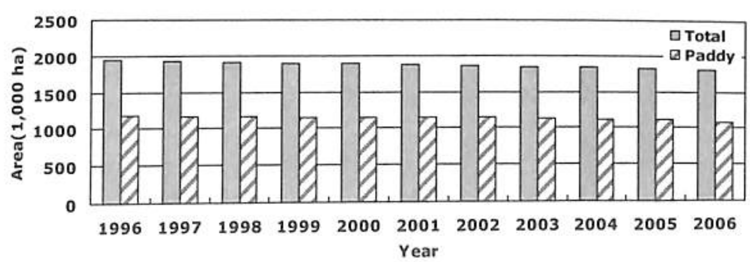
class \ year	1965	1980	1990	1994	1998	2003
Total water resource	110.0	114.0	126.7	126.7	127.6	124.0
Total use	5.12 (100%)	15.3 (100%)	24.9 (100%)	30.1 (100%)	33.1 (100%)	33.7 (100%)
Life	0.23 (4%)	19.0 (12%)	4.2 (17%)	6.2 (12%)	7.3 (22%)	7.6 (23%)
Industry	0.41 (8%)	0.7 (5%)	2.4 (10%)	2.6 (8%)	2.9 (9%)	2.6 (8%)
Agriculture	4.48 (88%)	10.2 (67%)	14.7 (59%)	14.9 (50%)	15.8 (48%)	**16.0 (47%)**
Maintenance	-	2.5 (16%)	3.6 (14%)	6.4 (21%)	7.1 (21%)	7.5 (22%)

4. General of Agricultural Water Management

- **Land use** (unit : ha)

Total Area		Agricultural Area						Forestry		Others	
	%	Sub Total	%	Paddy Fields	%	Uplands	%		%		%
9,967,812	100	1,800,470	18.1	1,084,024	10.9	716,446	7.2	6,389,393	64.1	1,777,949	17.8

- **Change of agricultural area**
  - For 10 years total reduced area was 145,010ha, in which 92,124ha(63.5%) is occupied by paddy fields



Division of agricultural area by water managing bodies

(unit: ha)

Year	Total	%	Irrigated Area						Non Irrigated Area	%
			Sub Total	%	KRC	%	Local Gov.	%		
1991	1,335,204	100	987,860	74.0	517,803	38.8	470,057	35.2	347,344	26.0
2000	1,149,041	100	880,444	76.6	520,355	45.3	360,089	31.3	268,597	23.4
2006	1,084,024	100	859,040	79.2	532,295	49.1	326,745	30.1	224,984	20.8

Irrigation facilities

(unit : ha)

Facilities	Total				KRC				Local Gov.			
	Places	%	Area	%	Places	%	Area	%	Places	%	Area	%
Total	68,461	100	859,040	100	13,056	100	532,295	100	55,405	100	326,745	100
Reservoir	17,679	25.8	486,406	56.6	3,319	25.4	354,873	66.7	14,360	25.9	131,533	40.3
Irr. Pump St.	6,314	9.2	162,555	18.9	3,275	25.1	132,635	24.9	3,039	5.5	29,920	9.2
Irr. Drain. Pump St.	120	0.2	30,105	3.5	103	0.8	29,752	5.6	17	0.03	354	0.1
Drain. Pump St.	744	1.1	3,055	0.4	583	4.5	655	0.1	161	0.3	2,401	0.7
Barrage	18,115	26.5	92,243	10.7	4,090	31.3	13,088	2.5	14,025	25.3	79,155	24.2
Collecting Conduit	2,828	4.1	14,378	1.7	332	2.5	1,137	0.2	2,496	4.5	13,241	4.1
Well	22,661	33.1	51,153	6.0	1,354	10.4	155.1	0.03	21,307	38.5	50,997	15.6
Others	-		19,145	2.2	-		-		-		19,145	5.9

Channel for irrigation drainage

(unit : km)

Channels	KRC								Local Government							
	Total		Main		Branch		Tertiary		Total		Main		Branch		Tertiary	
	Leng.	%	Leng.	%	Leng.	%	Leng.	%	Leng.	%	Leng.	%	Leng.	%	Leng.	%
Irr. Channel	**62,271**	**100**	16,201	100	18,175	100	27,896	100	**51,775**	100	13,028	100	18,142	100	20,605	100
-Earthen	29,954	48.1	4,814	29.7	7,655	42.1	17,485	62.7	32,578	62.9	7,787	59.8	11,679	64.4	13,112	63.6
-Structure	32,317	51.9	11,387	70.3	10,519	57.9	10,411	37.3	19,197	37.1	5,241	40.2	6,463	35.6	7,493	36.4
Drain. Channel	34,999	**100**	4,627	100	8,280	100	22,092	100	31,575	100	5,929	100	11,819	100	13,827	100
-Earthen	28,754	82.2	3,531	76.3	6,446	77.9	18,777	85	22,341	70.8	4,330	73	7,757	65.6	10,254	74.2
-Structure	6,245	17.8	1,096	23.7	1,834	22.1	3,315	15	9,235	29.2	1,600	27	4,062	34.4	3,573	25.8

Agricultural water demand

(unit : Million m^3/year)

Class \ Years	2003	2006	2011	2016	2020
Total Ag. Water Use	15,965	15,977	15,849	15,690	15,583
Paddy Fields	13,170	13,040	12,897	12,728	12,611
-Irrigated Area	10,904	11,068	11,323	11,497	11,630
-Non-Irrigated Area	2,266	1,972	1,574	1,231	981
Uplands	2,567	2,702	2,699	2,700	2,704
-Irrigated Area	1,317	1,451	1,593	1,775	1,920
-Non- Irrigated Area	1,250	1,251	1,106	925	784
Livestock	228	235	253	262	268

Agricultural water supply

(unit : Million m^3/year)

Class \ Source	Water Supply	Surface Water						Ground Water
		Total	Reservoir	Lake	Pumping station	Weir	Other	
Total	10,075	9,184 (2,675)	4,741 (516)	2,035 (2,035)	1,489 (124)	794	125	891
Paddy Fields	9,662	8,973 (2,464)	4,741 (516)	1,824 (1,824)	1,489 (124)	794	125	689
Uplands	413	211 (211)	-	211 (211)	-	-	-	202

Agricultural water use in foreign countries

(unit : billion m^3/year)

Country	Annual rainfall (mm)	Outflow	Use		Ag. Use		Remarks
			Use	%	Use	%	
Korea	1,274	69.7	30.1	43.0	20.1	67	* No. of Countries of each Continents - Asia(36) : 77% - Europe(27) : 26% - N.&M.America(16) : 67% - S. America(12) : 75% - Africa(49) : 71%
Japan	1,788	449.0	86.7	19.3	43.4	50	
Philippine	2,360	323.0	29.5	9.1	18.0	61	
India	1,170	1,780.0	355.0	20.0	330.0	93	
U.S.	760	2,460.0	447.2	18.2	188.0	42	
Canada	522	3,122.0	18.4	0.6	1.5	8	
England	1,064	122.0	10.9	9.0	0.3	3	
France	750	168.0	26.4	15.7	4.0	15	
Netherlands	750	10.0	1.6	16.0	0.5	34	
Australia	460	343.0	16.9	4.9	5.6	33	

Time lapses of Water Supplying Facilities

(unit: places)

Facilities	Number of Facilities		Time lapse									
			Bef.'45 (over 50yrs)		'46~'66 (40~50yrs)		'67~'76 (30~40yrs)		'77~'86 (20~30yrs)		'87~'06 (less 20yrs)	
		%	Num.	%	Num.	%	Num.	%	Num.	%	Num.	%
Total	68,461	100	14,355	21	6,526	9.5	13,372	19.5	10,867	15.9	23,341	34.1
Reservoir	17,679	100	9,380	53.1	3,783	21.4	3,123	17.7	875	4.9	518	2.9
Irr. Pump	6,314	100	106	1.7	315	5.0	955	15.1	2,305	36.5	2,633	41.7
Irr.& Drain. Pump	120	100	10	8.3	10	8.3	16	13.3	21	17.5	63	52.5
Drain. Pump	744	100	3	0.4	12	1.6	27	3.6	89	12.0	613	82.4
Barrage	18,115	100	4,720	26.1	2,301	12.7	5,380	29.7	3,694	20.4	2,020	11.2
Collecting Conduit	2,828	100	101	3.6	88	3.1	1,632	57.7	831	29.4	176	6.2
Well	22,661	100	35	0.2	17	0.1	2,239	9.9	3,052	13.5	17,318	76.4

Standard lifetimes of structures

(unit: places)

Class	Structures	Standard Lifetimes	Class	Structures	Standard Lifetimes
Reservoir	Earth Dam	60	Collecting Conduit	Conc.	15
	Conc. Dam	80	Irr. Channel	Conc.	40
Sea Dike	Dike	100		Earth	10~20
	Gate	50	Tunnel	Conc.	50
Barrage	Conc.	50	Gate	Iron	30
Pump St.	Mechanic	20		Wood	10

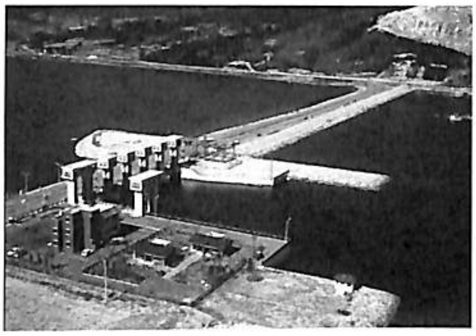
Barrages in the River Mouth

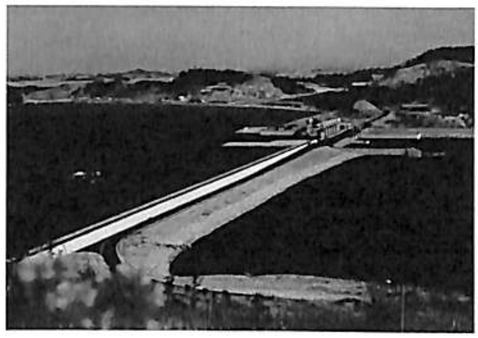
Names of Barrages	Area of Basin (km^2)	Area of Lake (km^2)	Storage Capacity (10mil. m^3)	Beneficial Area (1,000ha)	Construction Periods
Asan	1,634	28.00	12.30	14.41	1971-1976
Nampo	288	4.95	8.38	1.59	1985-2007
Daeho	278	21.50	12.20	7.70	1981-1985
Keumgang	9,828	36.50	13.85	43.00	1983-1990
Haenam	181	8.35	1.71	2.06	1985-1994
Namyang	209	8.00	3.15	4.01	1971-1976
Sapgyo	1,639	20.17	8.43	22.30	1976-1979
Saemangeum	3,319	118.00	53.45	22.55	Going on
Seosan-A	488	28.85	14.44	6.40	1980-1991
Seosan-B	157	17.02	9.70	3.77	1980-1991
Shihwa	477	56.50	33.23	8.10	1987-1994
Seokmoon	257	8.55	1.40	2.22	1987-1995
Youngsangang	3,470	34.60	25.32	0.70	1978-1981
Youngam	355	42.86	24.46	12.20	1988-1992
Keumho	184	23.30	13.31	0.49	1989-1997
Hongbo	140	5.82	1.93	4.72	Going on
Hwaong	236	14.52	5.44	3.57	Going on

Barrages in the River Mouth

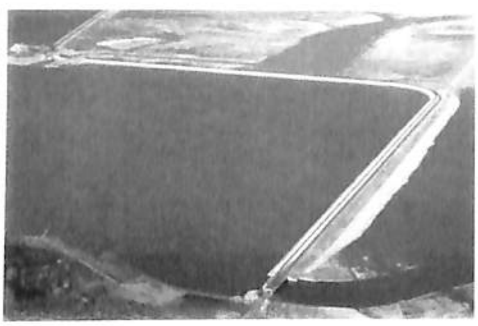
Keumgang

Keumho



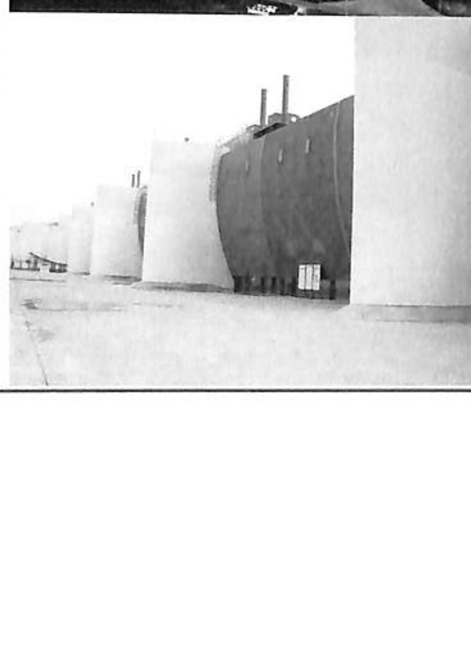


Daeho



Sapgyo

Saemangeum



Shihwa

Asan

Youngsangang

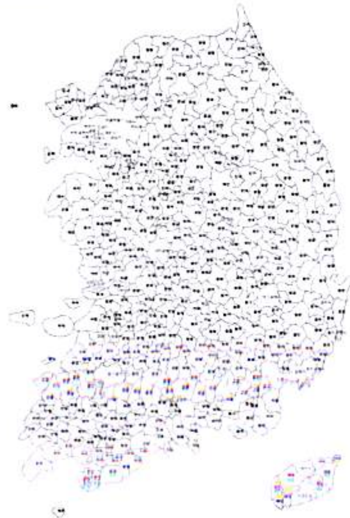
Youngam

Isahaya(Japan)

Absluit(Netherland)

5. Informatization of Agricultural Water Management

- **Periods**
  - 1st Step : 2002 ~ 2006
  - 2nd Step : 2007 ~ 2011
- **Purposes**
  - Creating a huge DB system which contains the information of agricultural facilities, real time hydrologic data, water quality data, irrigation sector data, and soil and land characteristics for 464 irrigation sectors
  - Analyse the data and share it with related institutions
  - Building a joint network between small streams and irrigation and drainage channels.



464 irrigation sectors

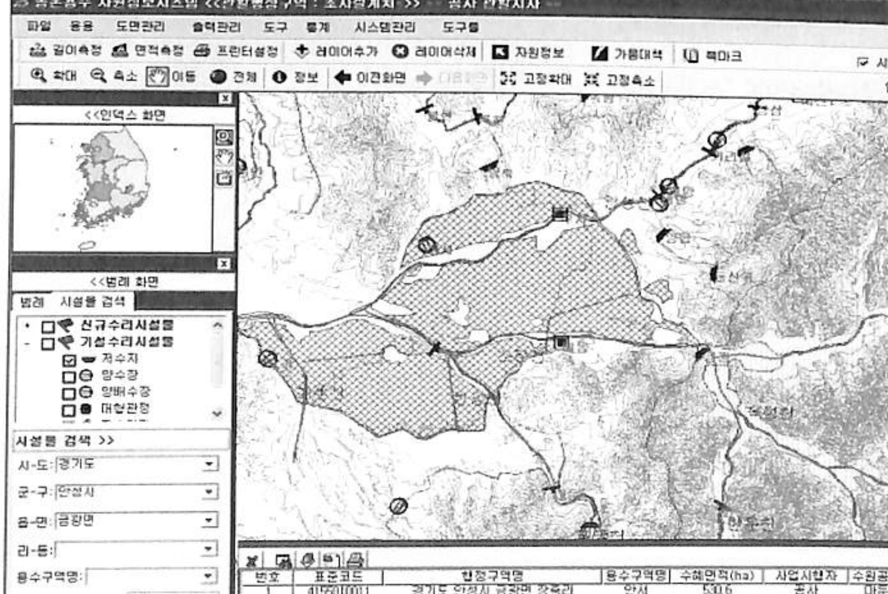
Contents of system

- Hydraulic facilities
  - Locations, Dimensions, Histories, Extent of covering, Reservoirs, Pumping stations, Intake barrages, etc.
- Irrigation Sectors
  - Area of farms, Area of superior farms, Land and soil, Catchment area, Land consolidation, Drainage improvement, etc.
- Hydrology of River
  - Climate and Rainfall, Branches, Water quality, Reservoir discharge, Networks between small streams and facilities, etc.

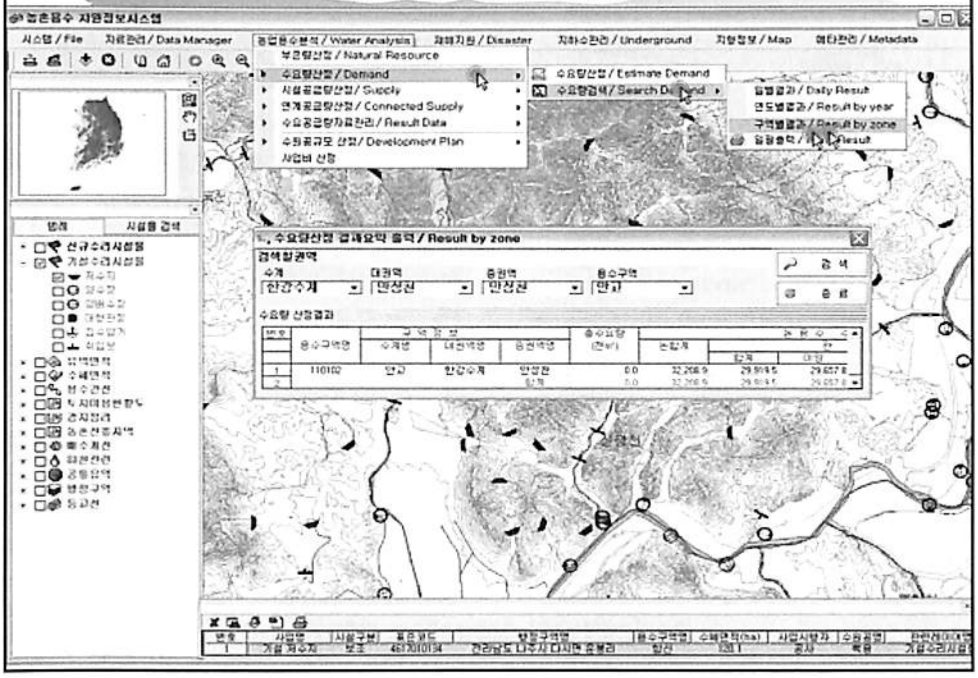
Items of analysis

- Water use
  - Estimation of water demand and supply, Amount of water resource, Outflow analysis, Water balance
- Mitigation of Disaster
  - Prediction of drought and flood, Monitoring of Water level
- Water Quality
  - Set up a network of water quality

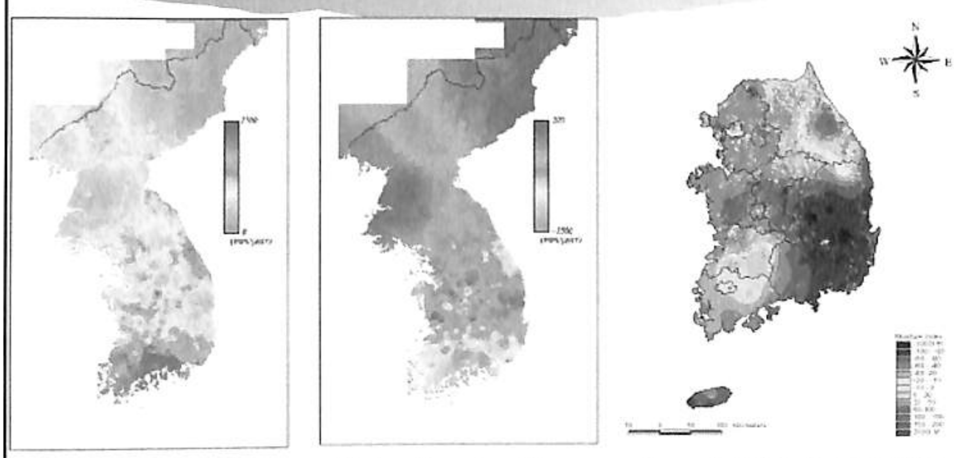
Data searching system



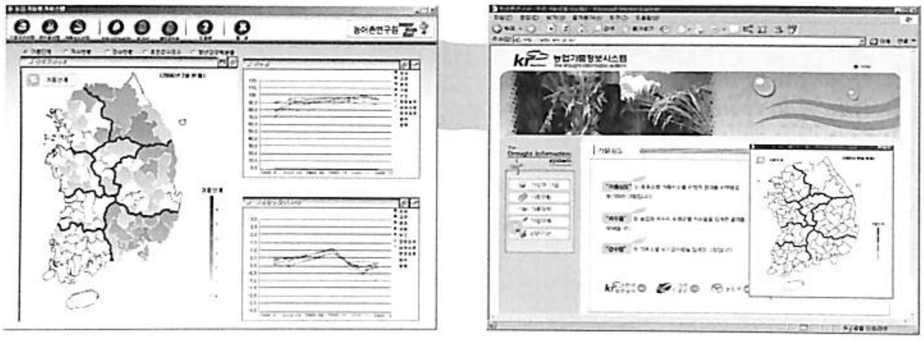
Water demand analysis



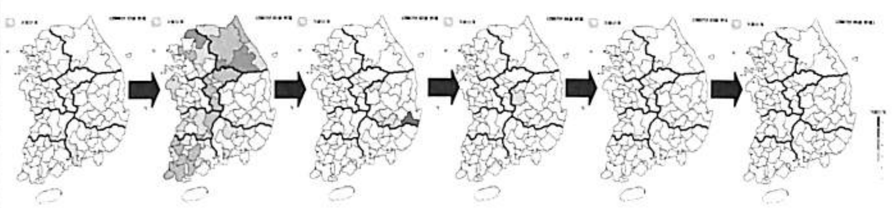
Drought Information System



Water Scarcity Map　　Water Surplus Map　　Drought Distribution Map



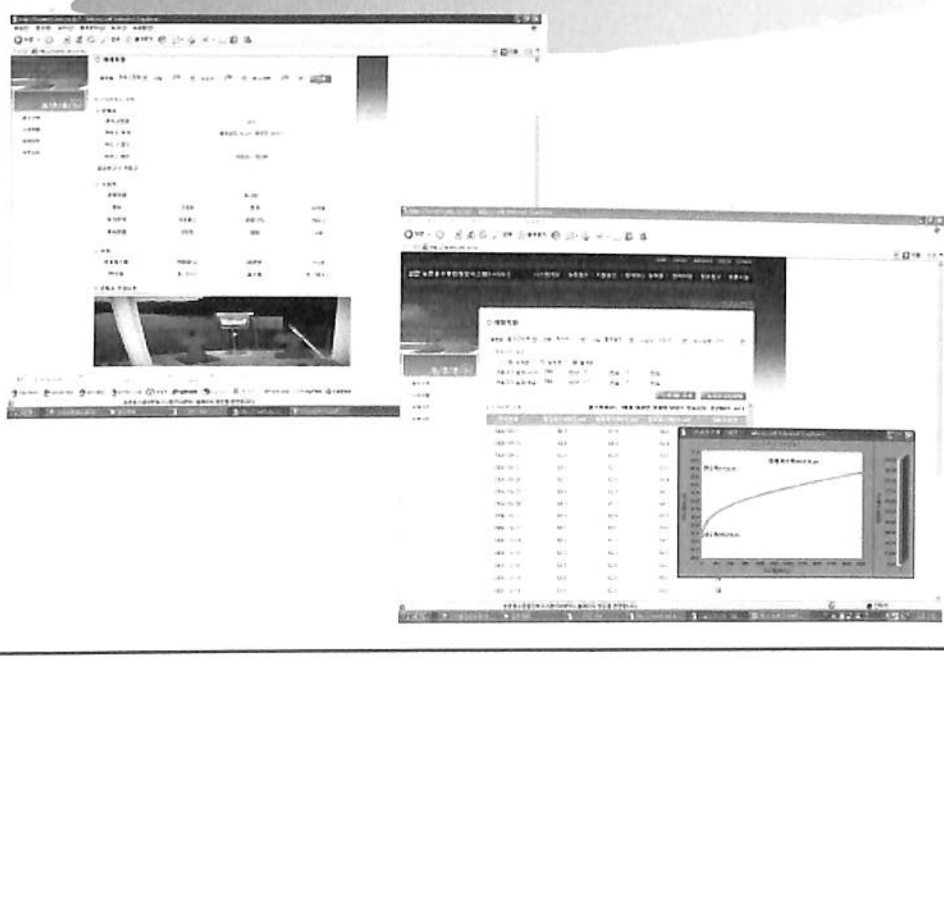
2007 Drought



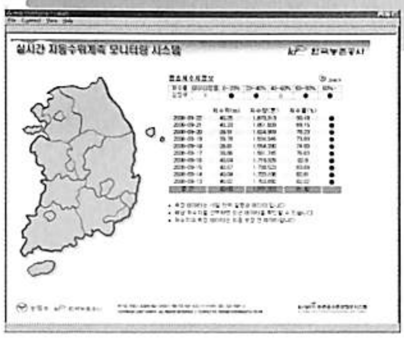
Jan. Feb. Mar. Apr. May June

Agricultural drought analysis

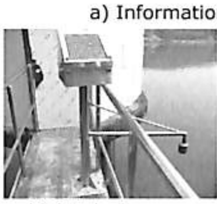
Real time reservoir monitoring



Real time reservoir monitoring



a) Information system (Web)



b) Intake tower

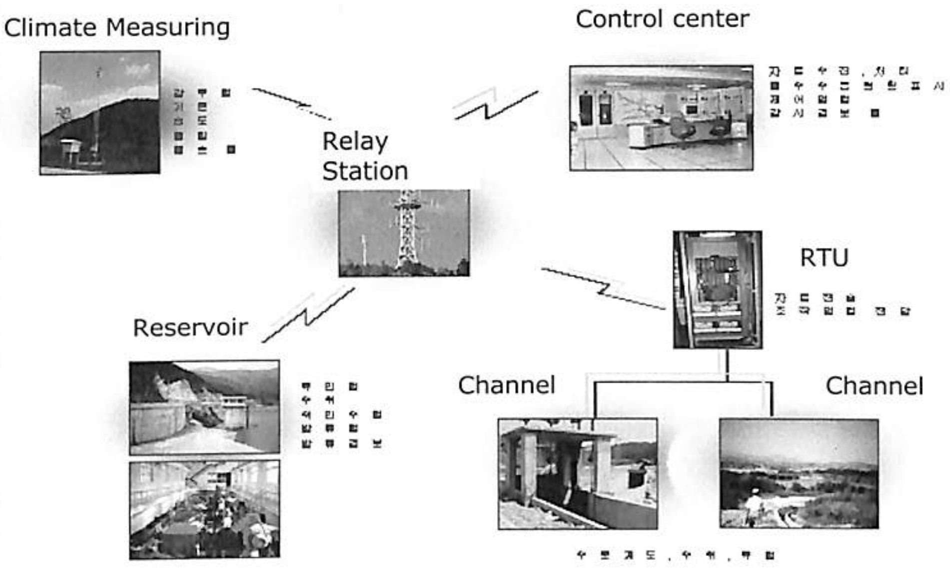
c) Inclined conduit

Monitoring system

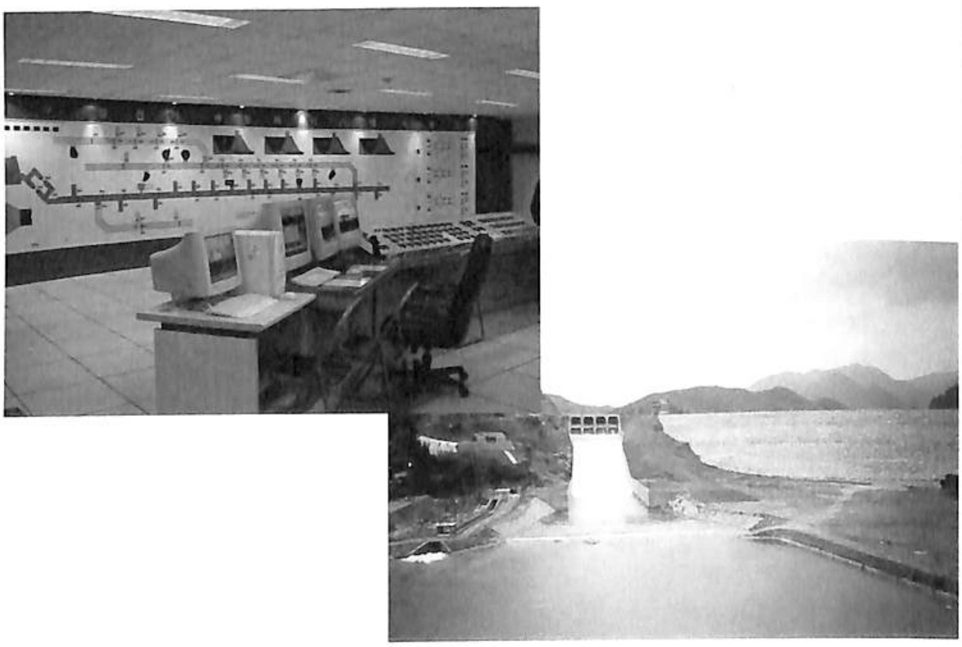
- Description :
  - Automatic water depth monitoring system with CDMA and ultra sonic sensor
  - Development : RRI, KRC, 2004
- Installation : 142 reservoir
  - 2006 : 68 reservoir
  - 2007 : 74 reservoir

6. Automization of Agricultural Water Management

- Tele-metering
  - Remote sensing and measuring by high-end electrical sensors at the main facilities like reservoirs, pumping stations, channels
- Tele-controlling
  - Remote controlling of structures from control center
  - Benefit for water and manpower saving, optimal water supplying



Conceptual Layout of Automization



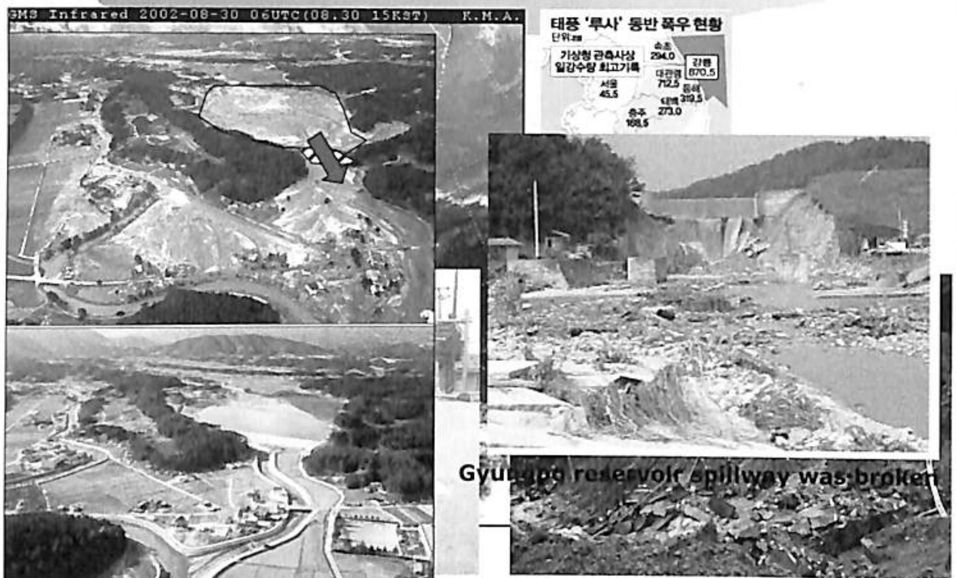
Sungju Dam and Control Center

Dongjin Control Center and Gates

7. Remodeling of Agricultural Water Facilities

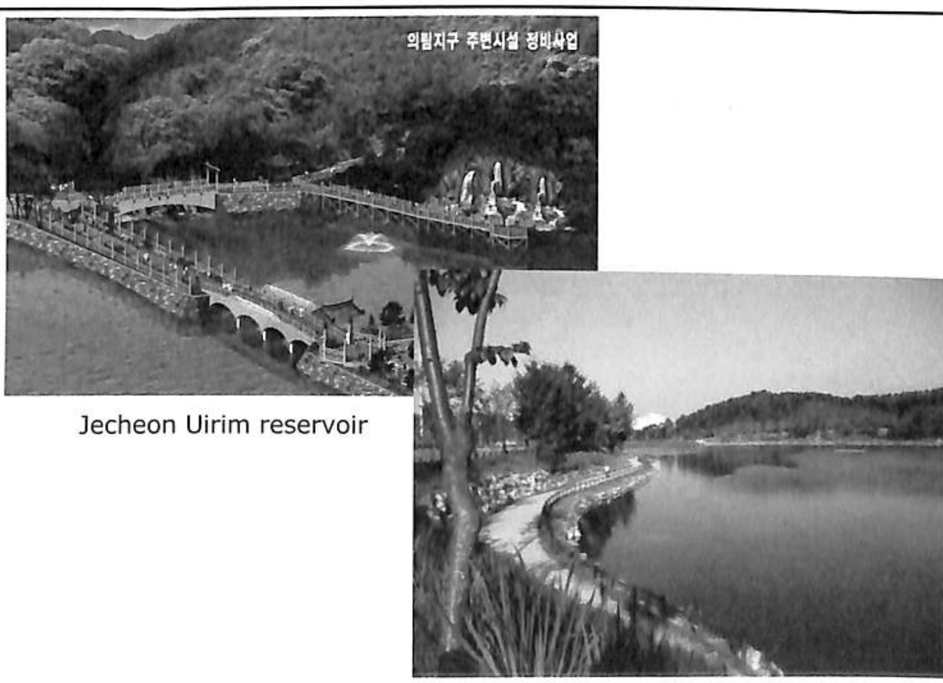
- **Direction of Policy**
  - Disaster Free Agricultural Infrastructures
    - Repairing and reinforcement of old facilities against increased flooding cause by global warming
    - Since 2007, 60% of remodeling budget is used to prevent disasters
  - Environmentally Friendly Remodeling
    - Preserve the biological and ecological environment
    - Improve the natural scenery
    - Secure the water front area for pleasant environment

Typhoon Rusa in 2002 brought 870.5mm of rainfall in Gangrung-city



Janghyun reservoir was broken

Sep. 1, 2002; Gangrung



Jecheon Uirim reservoir

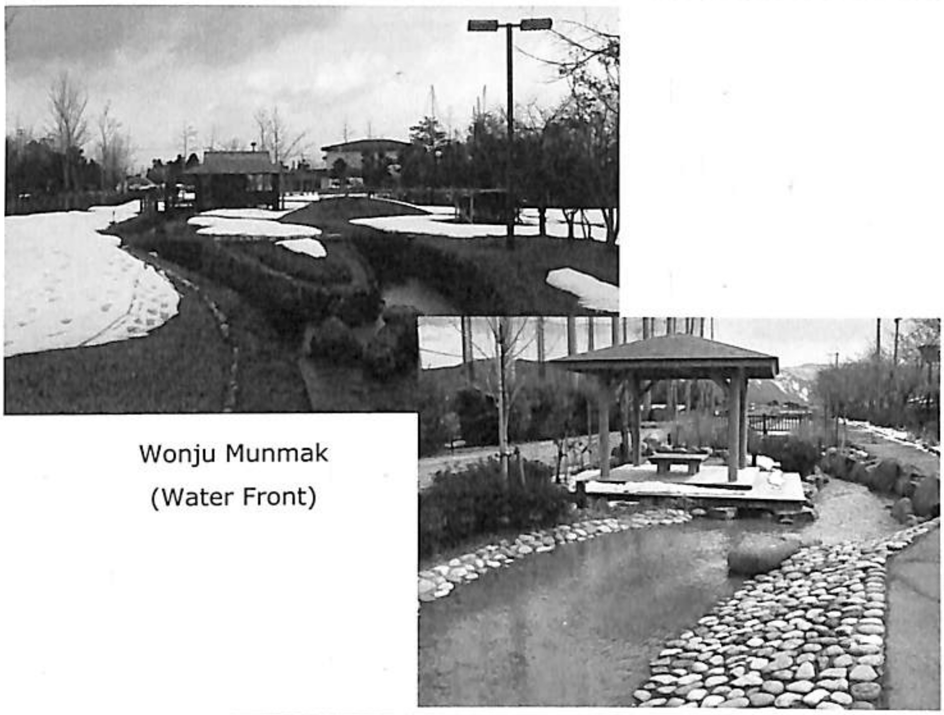
Iecheon Seolbong reservoir

Asan Masan Reservoir
(plant island)

Yongdeuk Osipcheon Barrage

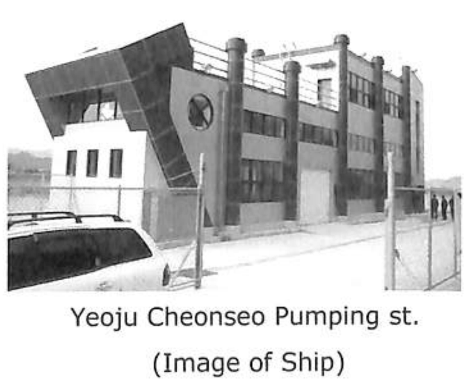
Yeoju Guyang
(Ecological passage)

Yeoju Yongeun
(Ecological passage)



Wonju Munmak
(Water Front)

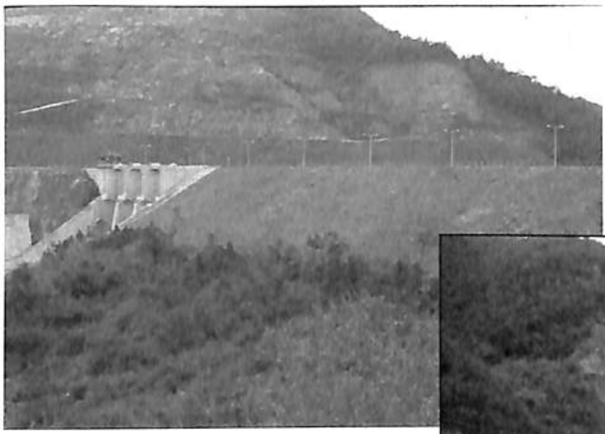
Yoncheon Dong-ie
(image of fall)



Yeoju Cheonseo Pumping st.
(Image of Ship)

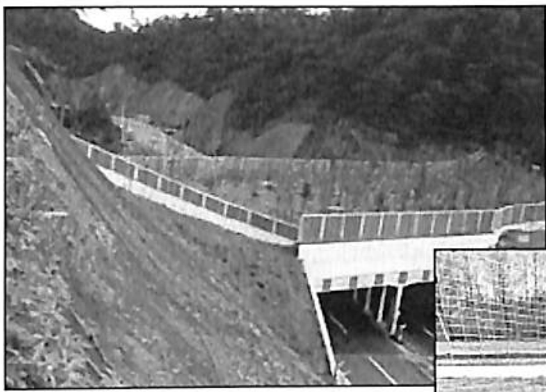
8. Environmentally Friendly Water Development and Management

- **Acquirement of Water for Environment**
  - Using return flow
  - Using surplus water in the sector where the paddy area was reduced because of urbanization
  - Increment of existing dams
  - Induction of water from other catchment areas



Planting trees on the slope of dam (Boryung dam)

Grass seeding on the cutting face(Donghwa dam)



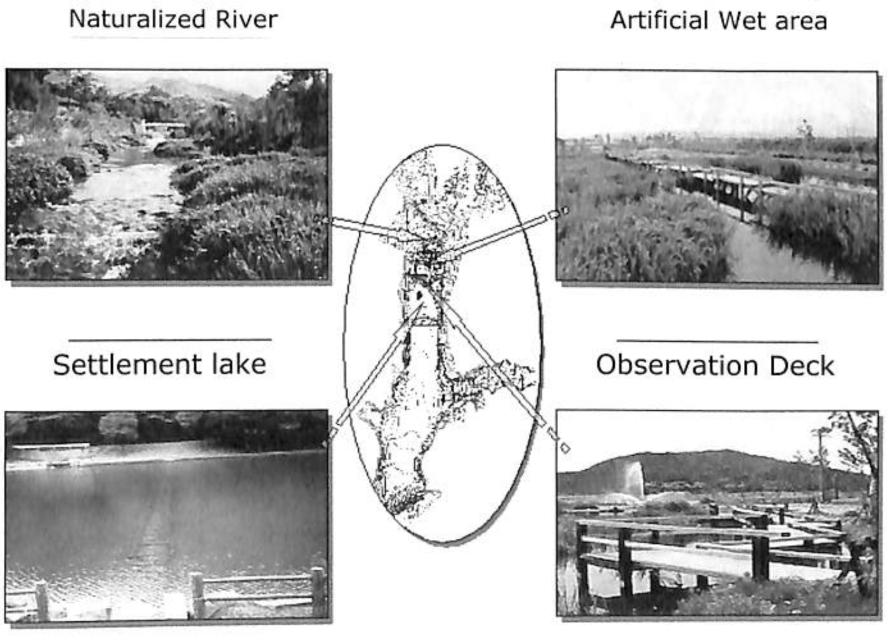
Passage for wild animals
(Bridge type)

Passage for wild animals
(Culvert type)

Walkway with cherry trees near reservoir

Platform for observation near reservoir

Environmental Water supplying for fish



Water quality improvement project (Gamdon area)

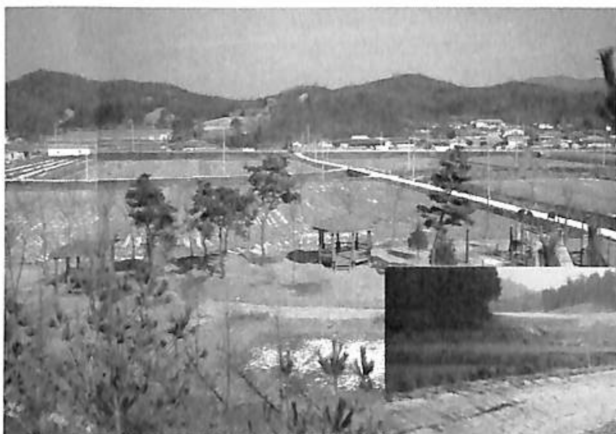
Walk way near drainage channel

Natural stone used channel

Stairs for Amphibia

Example case (Songsam Land Consolidation Project)

- Location : Yeoju Gyonggi-do
- Period : Nov. '99 ~ Oct. '00
- Area : 7,390㎡
- Drainage Channel : 490m
- Contents : Formation of Environmentally Friendly water front, drainage channel and small park



Small park

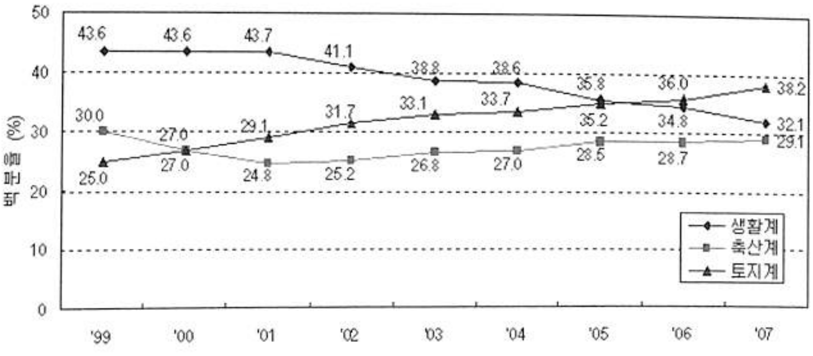
Geo-green cell in drainage channel

Habit for insects

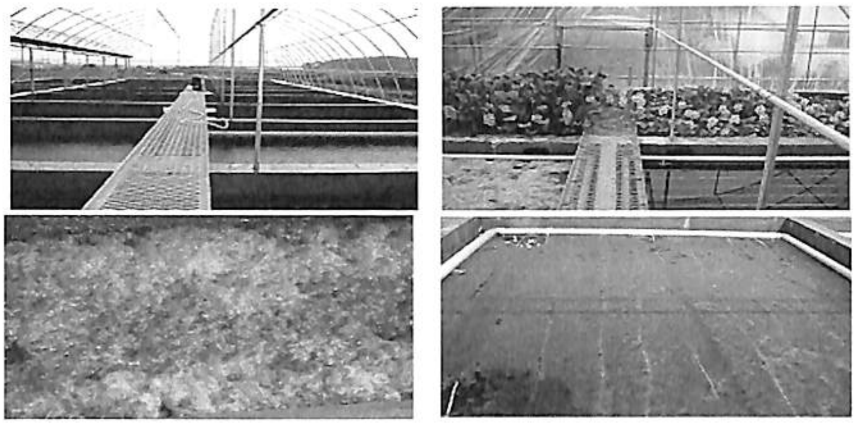
Natural Rock used channel

9. Improving Water Quality

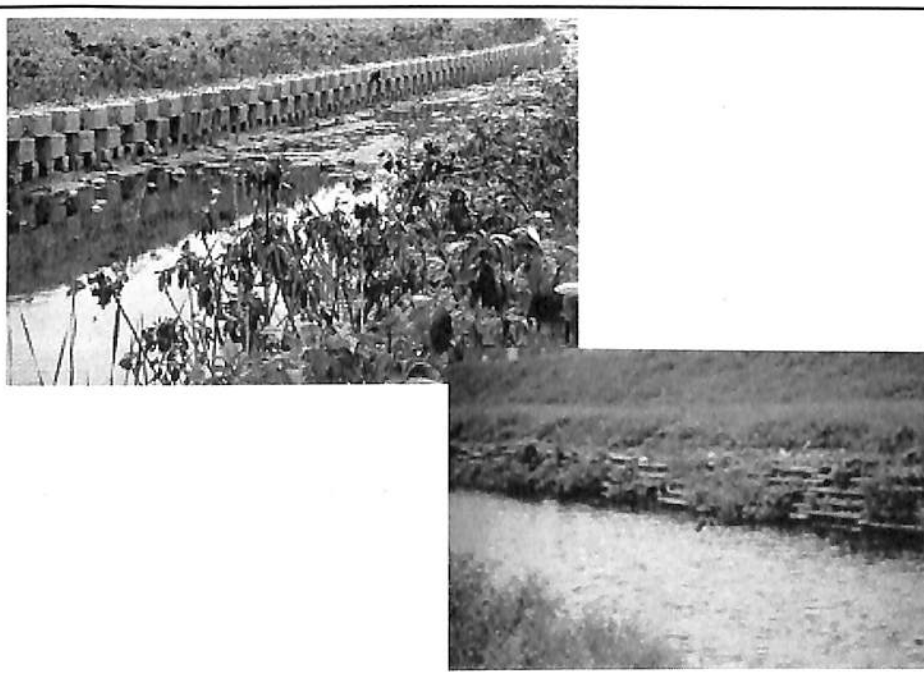
Change of source of pollution in agricultural reservoirs (2000~2007)



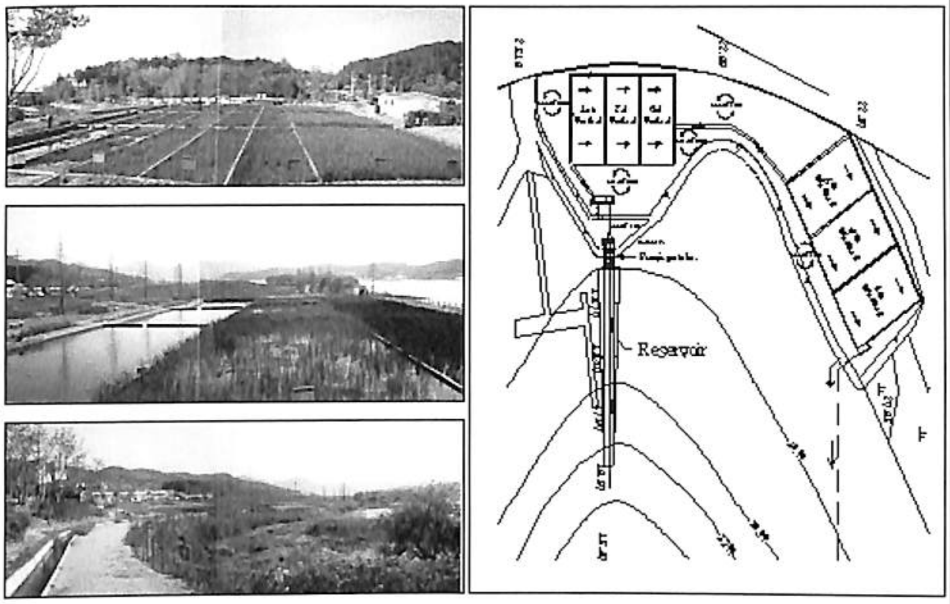
Water quality improvement



Water Quality Improvement using algal mat

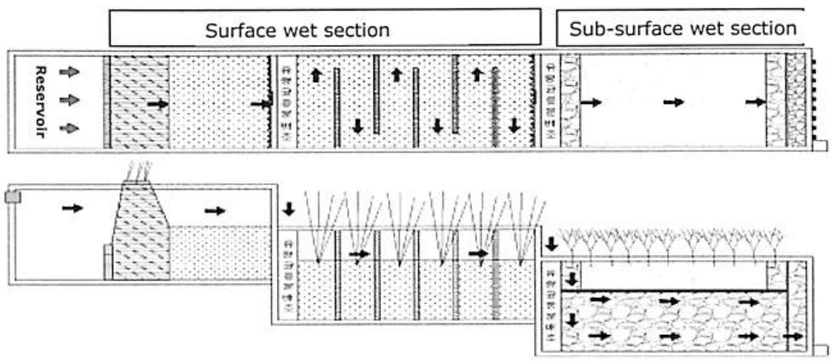


Water Quality Improvement using water plant



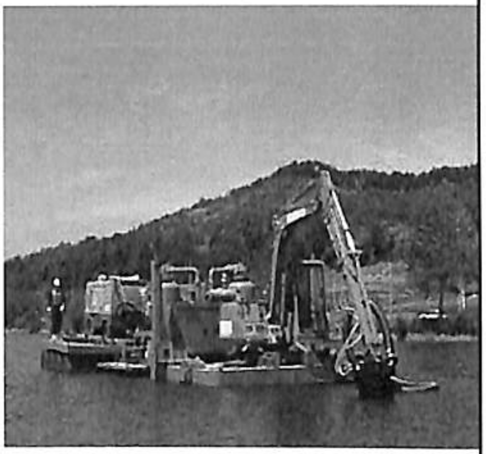
Bio-Park (Masan Reservoir)

Artificial Wet Area (Gamdon Reservoir)



Design of Artificial Wet Area

Artificial Plant island

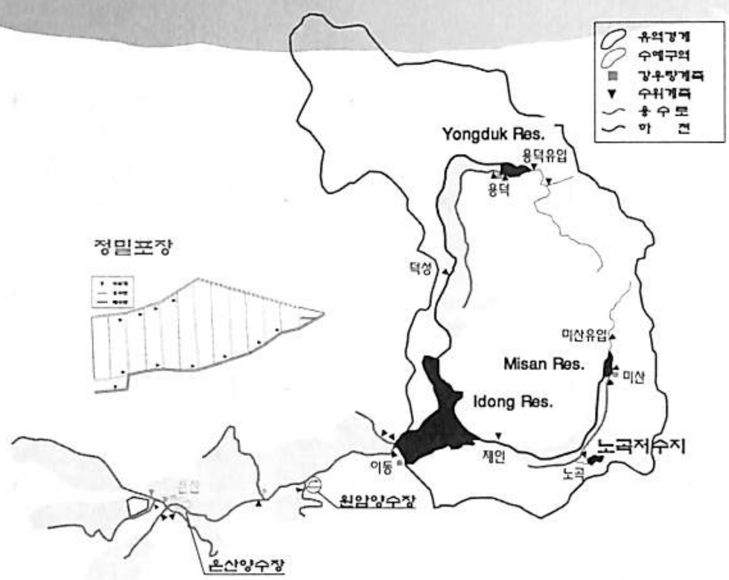


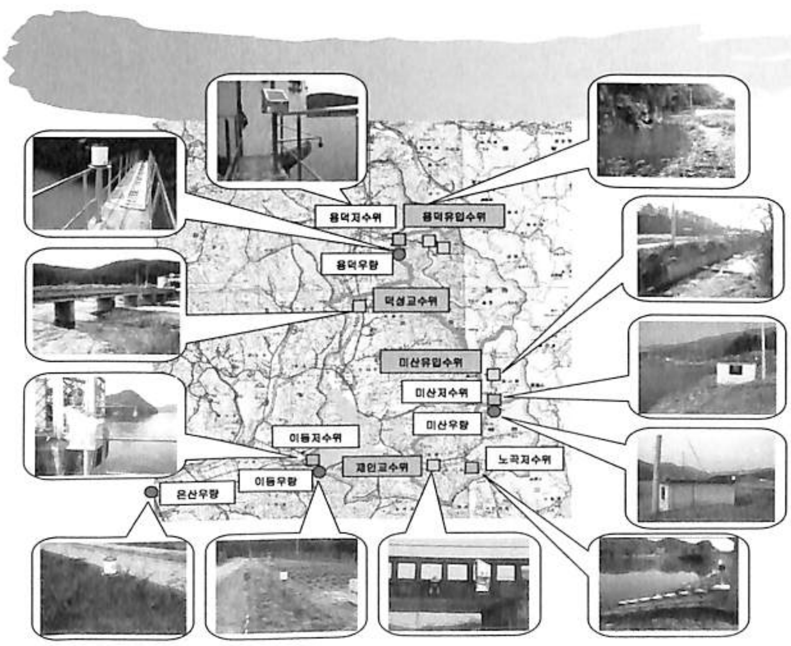
Dredging polluted materials from reservoir

10. Integrated Field Test Bed for Agricultural Water

- Purpose
  - Collecting basic field data for scientific water management through field measuring and analysis
- Location
  - Idong Gyonggi-do
- Period
  - 2001 - 2011

Outline of Test Bed





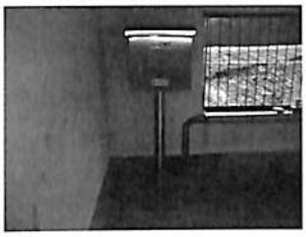
Water Level Measuring of Reservoir

Ultrasonic Type

Yongduk Reservoir

Idong Reservoir

Pressure Type



Misan Reservoir

Nogok Reservoir

Water Level Measuring of River

Deoksung Br.

Jaein Br.

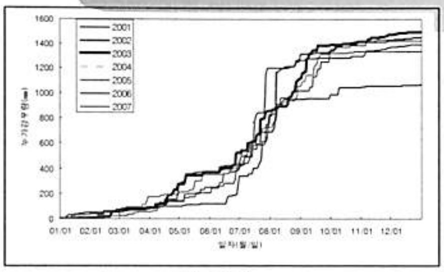
Misan Inlet

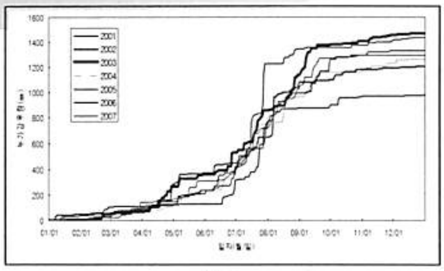
Mukbang Br.

Handeuk Br.

Myobong Br.

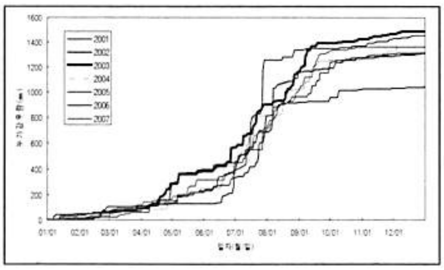
Rainfall

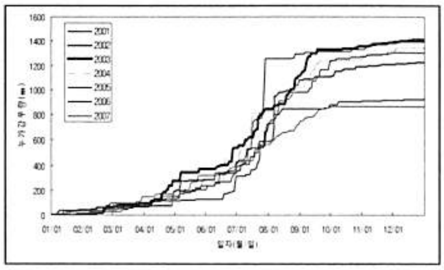




Yongdeuk

MIsan





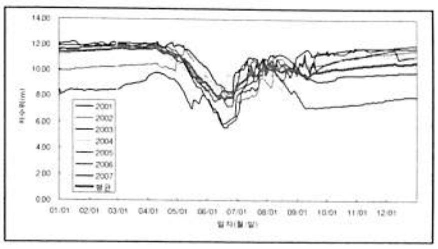
Idong

Eunsan

Reservoir

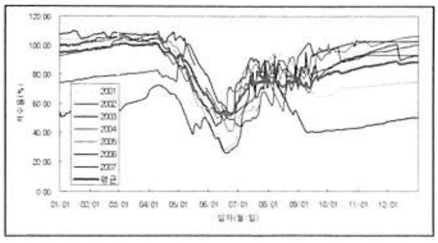
(unit :m)

구분	년도							평균
	2001	2002	2003	2004	2005	2006	2007	
1월	11.9	10.0	11.7	11.3	11.7	12.1	8.4	11.4
2월	11.8	10.2	12.0	11.6	11.8	12.0	8.4	11.6
3월	11.8	10.4	12.1	11.9	11.9	11.9	8.9	11.7
4월	11.7	10.3	12.0	11.3	11.9	11.6	9.6	11.5
5월	9.5	11.0	11.2	10.0	9.8	9.8	7.9	10.2
6월	6.6	8.1	9.0	9.0	8.0	8.2	6.4	8.1
7월	9.0	8.3	10.5	10.0	10.3	9.4	9.3	9.6
8월	11.0	10.2	9.9	9.9	10.3	9.2	10.5	10.1
9월	9.5	10.5	10.4	10.8	10.5	7.3	11.4	9.8
10월	9.5	10.9	10.9	11.1	11.5	7.3	11.6	10.2
11월	9.7	11.3	11.4	11.2	11.7	7.6	11.8	10.5
12월	9.9	11.5	11.3	11.2	11.9	8.0	11.8	10.6
평균	10.2	10.2	11.0	10.8	10.9	9.5	9.7	10.4

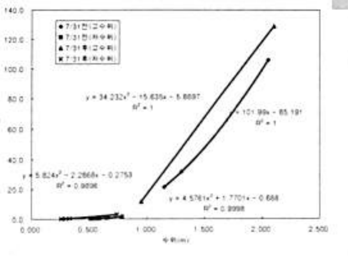


(unit :%)

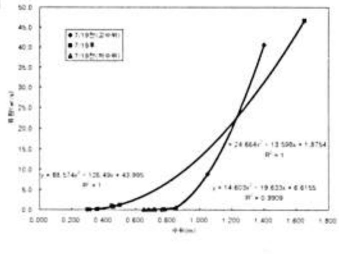
구분	년도							평균
	2001	2002	2003	2004	2005	2006	2007	
1월	104.2	75.4	100.6	94.6	100.5	107.3	53.4	97.1
2월	103.3	78.2	105.4	98.8	103.3	106.7	54.1	99.3
3월	103.4	80.3	107.7	104.2	104.8	104.4	60.4	100.8
4월	101.4	79.3	105.8	95.0	104.0	98.9	69.0	97.4
5월	69.2	89.8	93.7	74.7	72.8	72.1	48.5	78.7
6월	34.6	50.5	61.9	61.2	49.1	51.1	32.8	51.4
7월	62.4	52.8	82.2	75.6	79.7	66.7	66.6	69.9
8월	90.0	77.6	73.6	73.7	79.6	64.7	82.7	76.5
9월	67.7	81.8	81.3	87.4	83.1	41.7	96.2	73.8
10월	68.7	88.7	88.1	92.1	97.2	41.9	99.6	79.5
11월	71.4	94.4	95.5	92.3	101.1	44.8	0.0	83.3
12월	73.3	98.0	94.1	92.6	104.8	48.7	0.0	85.3
평균	79.1	78.9	90.8	86.8	90.0	72.8	60.3	83.1



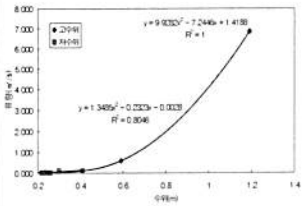
H-Q Relation in the Streams



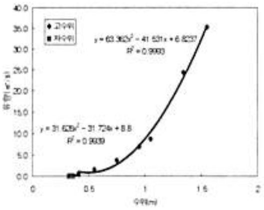
Deoksung Br.



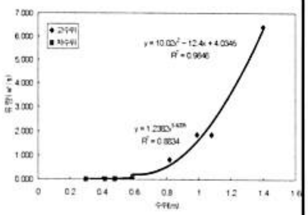
Jaein Br.



Misan Inlet



Mukbang Br.

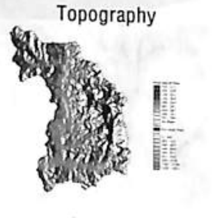


Handeuk Br.

Improvement of Hydrologic Model

SWAT (Soil and Water Assessment Tool)

Topography



- GIS Data
  - Elevation Data, Land Cover Data, Soil Data, River
- Climate-Hydrologic Data
  - Rainfall
  - Temp., Solar Radiance, Wind, Humidity
- Execution of SAWT Model

Coverage

DEM of Basin

Sub-Basin

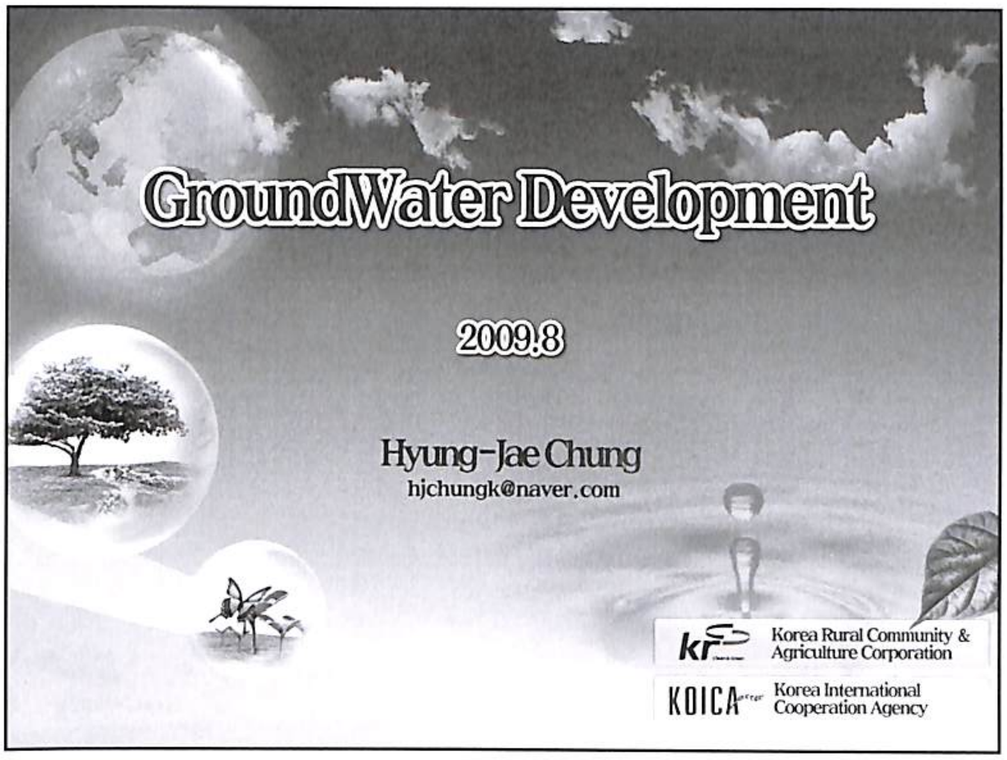
River

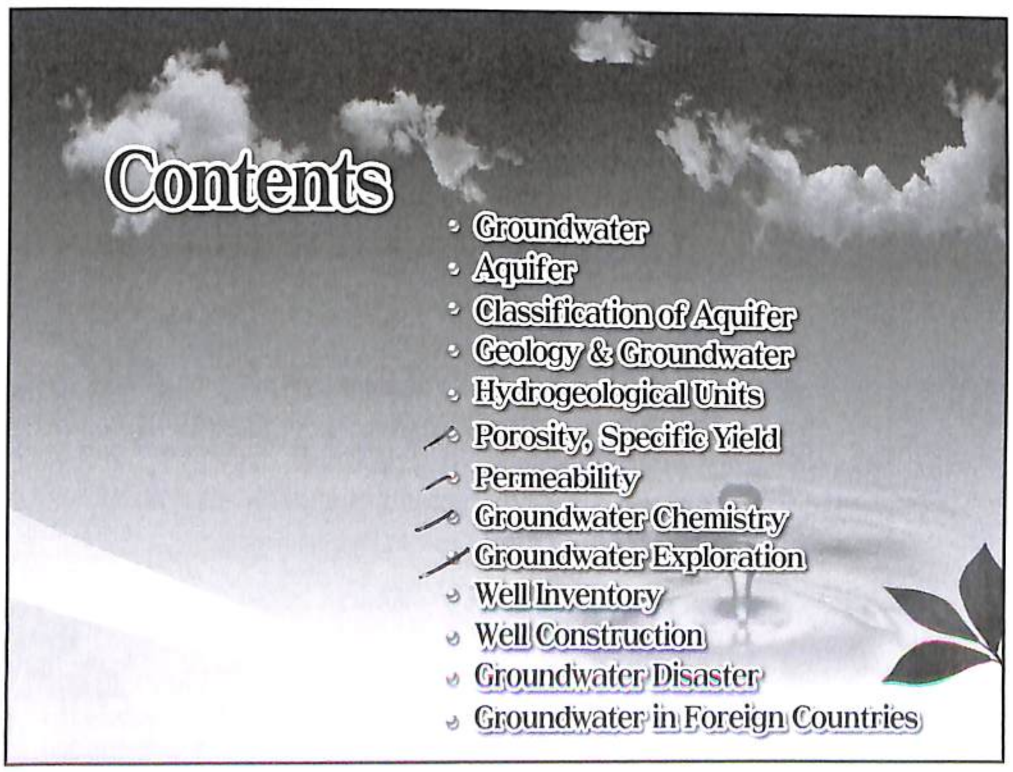
Groundwater Development

Mr. Chung, Hyung-jae

Former Section Chief

KRC


GroundWater Development
2009.8
Hyung-Jae Chung
hjchungk@naver.com
Korea Rural Community & Agriculture Corporation
KOICA
Korea International Cooperation Agency


Contents
Groundwater
Aquifer
Classification of Aquifer
Geology & Groundwater
Hydrogeological Units
Porosity, Specific Yield
Permeability
Groundwater Chemistry
Groundwater Exploration
Well Inventory
Well Construction
Groundwater Disaster
Groundwater in Foreign Countries

Groundwater

Sea Water : 97%, Fresh Water : 3%

Glacier : 69%, Groundwater : 29%, Surface Water : 3%

Groundwater is

about 94 % of the freshwater on the Earth (excluding the glaciers on the South and North Pole), and is very useful to Human Life & Environment

Groundwater

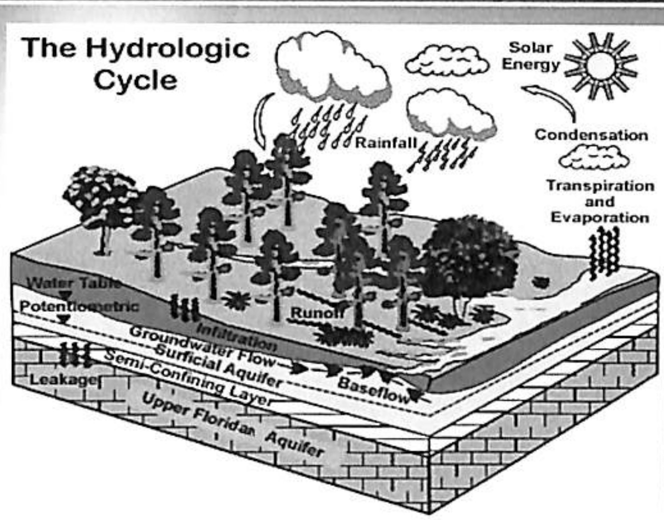
There are three kinds of water on the Earth (Atmospheric, Surface and Ground water : Hydrologic Cycle)

Groundwater is one component of the Hydrologic Cycle.

Groundwater is

the subsurface water that occurs beneath the water table in soil and geologic formations that are fully saturated.

Groundwater & Surface Water



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Advantages of Groundwater

- *Pure and Clean*
- *Easy to Use*
- *Cheap to Develop*
- *No Evaporation*
- *Mineral is Sufficient*
- *Temperature is Constant*
- *Safe from Contamination*
- *Small Area is Enough for Development*
- *There are Many Places for Groundwater*

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Groundwater Use

- Survey, Exploration, Drilling and Well Construction
- Water Quality (Standard is necessary)
- Maintenance of the Facilities
- Preservation of Groundwater for Perpetual Use

- **Well Yield : Pumping Test (safe and optimal yield)**
- **Location of Test Hole or Drilling Hole**
- **Data Base of Groundwater is very Important**

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Aquifer

An ***aquifer*** is a formation having structures that ***permit appreciable water to move through them*** under ordinary field conditions which ***stores, transmits and yields water***

Two important functions : storage, conduit function

Water Table is the **upper surface** of the zone of saturation of groundwater

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Types of Aquifers (1-3)

Shallow aquifer

- unconsolidated deposits : sand, clay, gravel
- depth : 2 ~ 30 m (mostly 10 ~ 15m), unconfined groundwater
- productivity : 30(0.02) ~ 800(0.56) m^3 per day (min)
- water quality is usually poor because of their vulnerability to stream and soil contamination
- distributed near the river

Deep aquifer

- weathered layer, primary cavity, fractures and faults in rock
- depth : several meters ~ several hundred meters
- productivity : wide range, depending on the fracture and rock type : 10(0.007) to 5,000(3.5) m^3/day (min)
- water quality is usually good

Types of Aquifers (2-3)

Aquifers may be classified as ***aquifer, aquitard, aquiclude*** and ***aquifuge*** **by the permeability**

An ***aquifer*** is a **saturated permeable** geologic unit that **can transmit** significant quantities of water : sand, gravel, sandstone, limestone and heavily fractured rock.

An ***aquitard*** is a **less permeable** beds : **clay, shale, and a little fractured dense crystalline rock.**

An ***aquiclude*** is a **saturated** geologic unit but is **incapable of transmitting** significant quantities of water under ordinary hydraulic gradients

An ***aquifuge*** **doesn't contain water and is incapable of transmitting** water : **fresh igneous rock, dense crystalline rock**

Types of Aquifers (3-3)

Aquifers may be classified as ***confined aquifer*** and ***unconfined aquifer*** depending upon the presence or absence of a water table

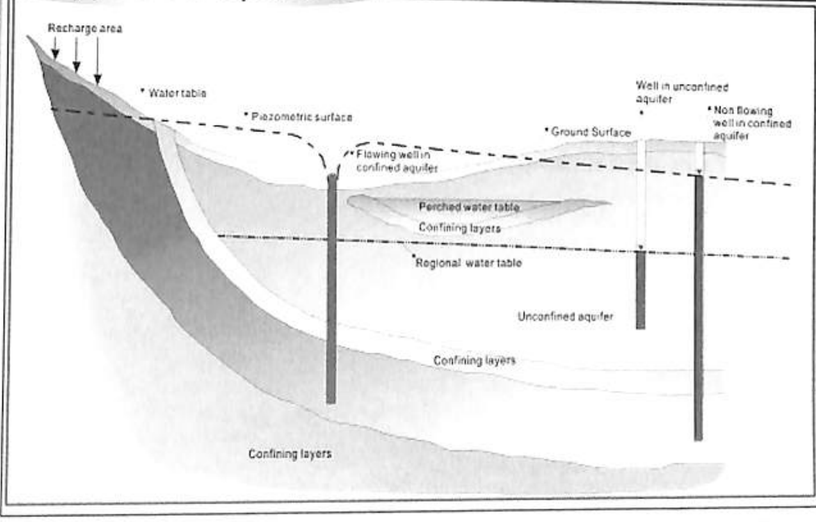
Confined aquifer is confined between two aquitards.
Confined aquifers occur at depth, and the water level in a well usually rises above the top of the aquifer.

Artesian well : the water level in a well usually rises above the top of the aquifer

Unconfined aquifer(water table aquifer) : water table forms the upper boundary, occurs near the ground surface.

Types of Aquifers

Types of Aquifers



Geology and Groundwater

- Lithology, Stratigraphy and Geological Structure
- Unconsolidated Sediments : deposit soil (clay, silt, ***sand, pebble***, tuff), residual soil, ***weathered rock*** (weathered soil)
- Sedimentary Rocks **:** ***sandstone***, shale, coal, conglomerate, ***Carbonate Rocks***(limestone, dolomite **:** ***solubility, cave***)
- Igneous Rocks :
  - volcanic : ***basalt*** (joint, tube), tuff, andesite, rhyolite
  - intrusive : granite, diorite, gabbro
- Metamorphic Rocks : gneiss, schist, marble, quartzite

Hydrogeological units : 8 units (1-2)

Units	Geologic age	Lithology	Topography	Openings	Yield
Unconsolidated sediments	Quaternary	Clay, Silt, Sand, Gravel	Plain, Valley	Primary pore	High
Porous volcanic rocks	Quaternary	Basalt, Tuff	Hill	Vesicle, Fracture	High
Semi-consolidated sedi. Rocks	Quaternary and Tertiary	Conglomerate, S.stone, shale	Hill	Pore, Fracture	Intermediate
Non-porous volcanic rocks	Tertiary to Cretaceous	Rhyolite, Andesite, Tuff	Mountain	Fracture	Intermediate

Hydrogeological units : 8 units (2-2)

Units	Geologic age	Lithology	Topography	Openings	Yield
Intrusive rocks	Cretaceous, Jurassic, Paleozoic to Triassic	Granite, Diorite, Gabbro	Hill, Mountain	Fracture	Intermediate
Clastic sedimentary rocks	Cretaceous, Triassic to Jurassic, Carboni to Trassic	Sedimentary rocks	Mountain	Fracture	Intermediate
Limestone	Cambro-Ordovician	Carbonate rocks	Karst	Cavern, Fracture	High
Metamorphic rocks	Carboni to Permian, Cambrian Precambrian	Gneiss, Schist	Mountain, Hill	Fracture	Low

Porosity and Specific Yield

- ***Porosity*** is the ratio between the void volume and the total volume of a rock mass, expressed as a percentage, can range from zero or near zero to more than 60%

- ***Specific yield*** is defined as the ratio of the volume of water that drains by gravity to the total volume of rock

- ***Porosity and Specific Yield*** depend on the grain size, shape, compaction degree and distribution of pores.

Representative values of porosity and specific yield (1-2)

Material	Porosity (%)	Specific yield (%)
Gravel, coarse	28	23
Gravel, medium	32	24
Gravel, fine	34	25
Sand, coarse	39	27
Sand, medium	39	28
Sand, fine	43	23
Silt	46	8
Clay	42~60	3

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Representative values of porosity and specific yield (2-2)

Material	Porosity (%)	Specific yield (%)
Sand stone, fine	33	21
Sand stone, med.	37	27
Limestone	30	14
Dune sand	45	38
Peat	92	44
Schist	38	26
Siltstone	35	12
Tuff	41	21

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Permeability

- **Hydraulic Conductivity**
- Permeability is a qualitative terms of flow velocity in suitable units.
- **Flow rates do not normally exceed a few meters per day**

- Flow velocities can be much higher when the GW flows through fracture systems (aperture or fracture network)
- Groundwater velocities can be measured in cm/sec :
  - limestone (with well-developed solution or karst area)
  - volcanic aquifers (with extensive lava tubes or cooling joints)

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Velocities of Groundwater

Classification	cm/sec	cm/day	m/year
Sand/gravel	$1*10^{-2}\sim10^{-4}$	864 ~ 8.64	3,153.6 ~ 31.5
Silt	$1*10^{-4}\sim10^{-5}$	8.64 ~ 0.864	31.5 ~ 3.15
Clay	$1*10^{-5}\sim10^{-7}$	0.864 ~ 0.009	3.15 ~ 0.032
Rock mass	$1*10^{-4}\sim10^{-8}$	8.64 ~ 0.001	31.5 ~ 0.003

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Representative values of permeability for various rock types(1-3) : Sediments

Material	Permeability (m/sec)	Material	Permeability (m/sec)
Gravel	$3x10^{-4}$~$3x10^{-2}$	Coarse sand	$9x10^{-7}$~$6x10^{-3}$
Medium sand	$9x10^{-7}$~$5x10^{-4}$	Fine sand	$2x10^{-7}$~$2x10^{-4}$
Silt, loess	$1x10^{-9}$~$2x10^{-5}$	Till	$1x10^{-2}$~$2x10^{-6}$
Clay	$1x10^{-11}$~$4x10^{-9}$	Unweathered marine clay	$8x10^{-13}$~$2x10^{-9}$

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Representative values of permeability for various rock types(2-3) : Sedimentary Rock

Material	Permeability (m/sec)	Material	Permeability (m/sec)
Karst & reef limestone	$1x10^{-6}$~$2x10^{-2}$	Limestone, dolomite	$1x10^{-9}$~$6x10^{-6}$
Sandstone	$3x10^{-10}$~$6x10^{-6}$	Silt stone	$1x10^{-11}$~$1.4x10^{-8}$
Salt	$1x10^{-2}$~$1x10^{-10}$	Anhydrite	$4x10^{-13}$~$2x10^{-8}$
Shale	$1x10^{-3}$~$2x10^{-9}$		

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Representative values of permeability for various rock types(3-3) : Crystalline Rocks

Material	Permeability (m/sec)	Material	Permeability (m/sec)
Permeable basalt	$4 \times 10^{-7} \sim 2 \times 10^{-2}$	Fractured igneous & metamorphic rock	$8 \times 10^{-9} \sim 3 \times 10^{-4}$
Weathered granite	$3.3 \times 10^{-6} \sim 5.2 \times 10^{-5}$	Weathered gabbro	$5.5 \times 10^{-7} \sim 3.8 \times 10^{-6}$
Basalt	$2 \times 10^{-11} \sim 4.2 \times 10^{-7}$	Unfractured igneous and metamorphic rocks	$3 \times 10^{-14} \sim 2 \times 10^{-10}$

Groundwater Chemistry(inorganic)

Major constituents(greater than 5mg/l)

bicarbonate, calcium, chloride, magnesium, silicon, sodium, sulfate, carbonic acid

Minor constituents(0.01~10.0 mg/l)

boron, carbonate, fluoride, iron, nitrate, potassium, strontium

Trace constituents(less than 0.1mg/l)

aluminum, antimony, arsenic, barium, beryllium, bismuth, bromide, cadmium, cerium, cesium, chromium, cobalt, copper, gallium, germanium, gold, indium, iodide, lanthanum, lead, lithium, manganese, molybdenum, nickel, niobium, phosphate, platinum, radium, rubidium, ruthenium, scandium, selenium, silver, thallium, thorium, tin, titanium, tungsten, vanadium, ytterbium, yttrium, zinc, zirconium

Organic : Carbon, Hydrogen and Oxygen

Hardness of Groundwater

Hardness : the sum of the **concentrations of calcium and magnesium ions,** varies depending upon rock type and overlying subsoil.

• ***soft***	<50 mg/ℓ as $CaCO_3$
• ***moderately soft***	51–100 mg/ℓ as $CaCO_3$
• *slightly hard*	101–150 mg/ℓ as $CaCO_3$
• *moderately hard*	151–250 mg/ℓ as $CaCO_3$
• ***hard***	251–350 mg/ℓ as $CaCO_3$
• ***very hard***	>350 mg/ℓ as $CaCO_3$

- ***Moderately hard to hard*** : overlying subsoil is ***limestone*** rich.
- ***Low concentration of ions*** in groundwater indicate a ***short residence time within the ground*** → sometimes similar to rain

Aquifer and Groundwater Chemistry

o **Aquifer contribute to the Groundwater Chemistry**

o Factors : ***rock type, residual time, water chemistry*** (e.g. pH)

- Limestone : hard water, high Ca, Mg, SO_2
- Basalt : pure, low TDS, good quality
- Tuff, Volcanic Ash : high TDS, high SO_2
- Granite : rich in Na, K, Fe common, good quality
- Sandstone : generally low TDS, good quality

Time factor : the older the higher the TDS and mineral contents

Quality of Groundwater Wells *(in Korea)*

- Contaminants : nitrogen, metals and nonmetals, organic substances
- Contamination : domestic sewage, industrial wastewater, livestock wastewater, land disposal of wastes and sewage, fertilizer and pesticides, petroleum leakage and spills

- 7 %(average) of groundwater wells show the value over the quality limit
- Shallow Aquifer : 13% over the limit
- Deep Aquifer : 6% over the limit

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Ozone Treatment (for pollutants)

Activated oxygen purifying water without chemicals

- **Ozone : O_3, Normal oxygen in the air : O_2**
- **O_3 (Ozone) reverts readily and naturally to O_2**

- As Ozone gives up its extra atom, it oxidizes the contaminants in water.
- Ozone leaves nothing in the water but dissolved oxygen.

- Electricity is necessary for this method : expensive

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Activated Carbon (for pollutants)

- Strong Adsorption Material (adsorption capacity)
- Mainly from Coal or Wood (granular texture)
- **Macro-pores : Coal or Wood**
- **Micro-pores : Coconut**

- Oxidizes the materials of flavor and odor, Fe, Mn, organic and etc.
- **Disinfection of Bacteria or Germ**
- **Diameter of Activated Coals : 0.5 ~ 2.0mm**

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Groundwater Development

- Exploration, Evaluation, Exploitation and Well Yield
- Investigation
- Geophysical Survey : surface and subsurface method
- Well Inventory
- Test Drilling
- Well Construction
- Pumping Test : permeability, aquifer yield (safe and optimal)
- Contamination Prevention
- Generator, Pump, Pipelines & Water Tank

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Investigation Items for Hydrogeological Map

- geology and topography
- remote sensing, lineament analysis, geophysical survey
- **well inventory**
- **drilling, logging and pumping test**
- groundwater modeling
- groundwater level and quality analysis
- **contamination source and related quality**
- **sustainable yield from water budget analysis**
- plan for supply, management, protection

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Well Inventory

- Management condition : Permit type, license number, related regulation for development
- Location : Location, owner, telephone, building name, coordinates
- Use : Main purpose (domestic, agri, indus, ...), Private or public, Period for use and days, Drinking or not, Amount of use per day, month, year (estimated or measured)
- Facility's condition : Well type, depth, diameter, pumping capacity, other equipments
- Groundwater quality : Fit or not, test date (yy-mm-dd), test type, test agency, others
- Well closure : Cause of closure, date (yy-mm-dd), closing method, others

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Procedures of Well Construction (1-2)

01. Reconnaissance
02. Review and Analysis of Existing Data
03. Geophysical Investigations
04. Preliminary Well Installation

05. Widen Well Diameter
06. Installation of Casing for Protection
07. Logging (Physical, CCTV)
08. Pumping Test

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Procedures of Well Construction (2–2)

09. Contamination Prevention
10. Installation of Well Casing
11. Air Surging

12. Installation of Water Pump and Connecting Pipes
13. Installation of Contamination Prevention Equipment

14. Well Protection Facilities
15. Water Tank and Treatment Facilities

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Test Drilling for Deep Wells

- **Mobilization**
- **Demobilization (85% of mobilization)**
- **Inter site Mobilization**
- Site clearing before and after construction
- Construction of camp facility
- **Drilling in formation, dia. 12" ~6"**
  (Soft, medium & hard formation, DTH bit)
- **Supply & Installation of Steel casings**
- Well cleaning by appropriate method
- Supply & weld-on iron cover on top of borehole
- Step draw down test(4 steps 2hrs each)
- **Conduct continuous test**
- **Conduct recovery test**
- **Conduct chemical & bacteriological test at approved laboratory**
- Unit, Quantity, Rate, Amount, VAT (10~15%)

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Deep Well Drilling and Complete Construction

- **Inter site Mobilization**
- **Wide Drilling in medium & hard formation, DTH bit dia. 6" to 10"**
- Supply and Installation of 8" pvc blind casing
- Supply and Installation of 8" pvc screen casing
- Well construction
- **Supply & Pack selected river gravels**
- **Well cleaning & development by appropriate method**
- **Grout with mass concrete & construct well head (0.7x0.5x0.4m)**
- Supply & weld-on iron cover on top of borehole
- Supply & installation 3/4" observation pipe (PVC or GMS)
- **Step draw down test(4 steps 2hrs each)**
- **Conduct continuous test, Conduct recovery test**
- **Generator, Pump & Water Tank (Pipeline)**
- Completion Report
- Unit, Quantity, Rate, Amount, VAT (10~15%)

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Water Purifier (by filtration)

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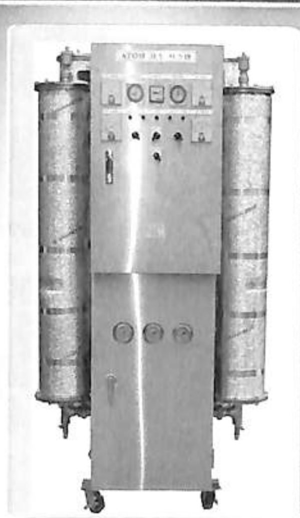
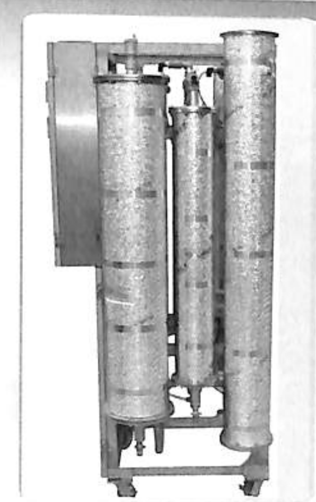
Front and Side View of the Purifier





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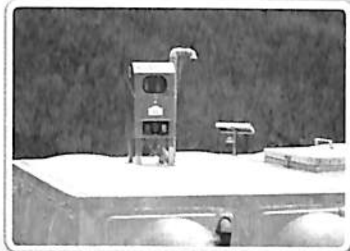
Disinfector



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Disinfector on the Water Tank

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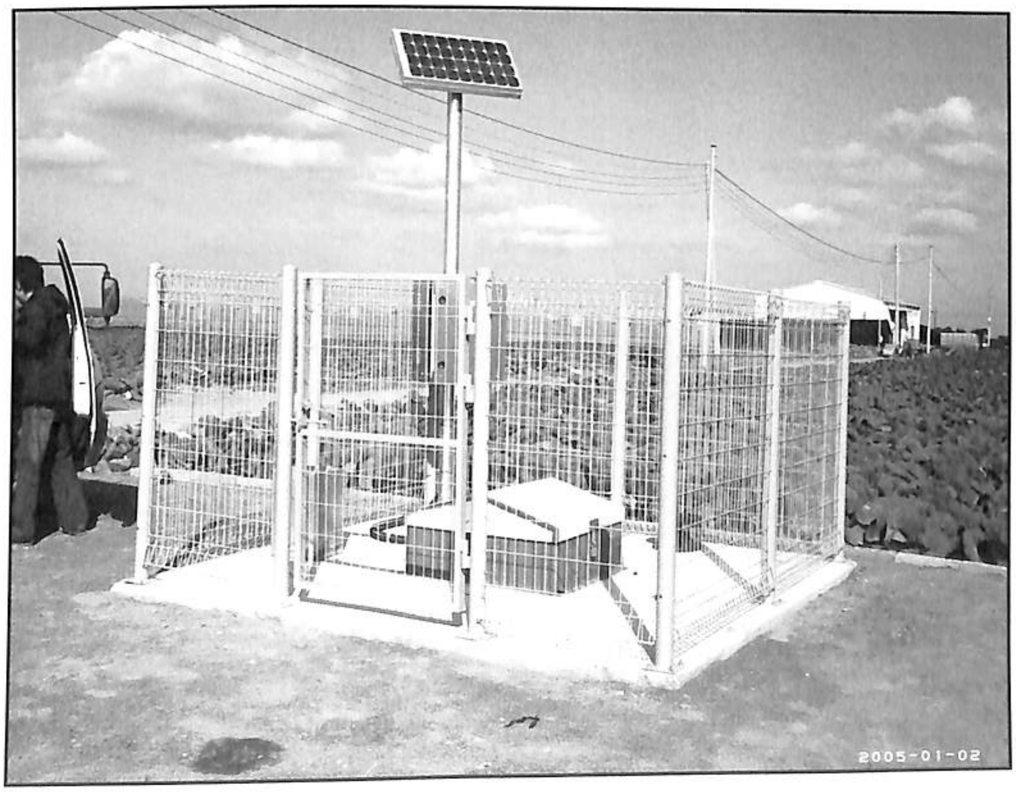
Monitoring Well
GeoGreen21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Groundwater Disaster

- o Drying up of groundwater : esp. in **OTR** groundwater
- o Collapse : limestone distributed area – **cave**, **karst** area
- o Subsidence : clay, silt dominated area, nothing in bed rock
- o Sea water intrusion : close to the coast or in island
- o Groundwater pollution

- o OTR(one time reserved) groundwater
- o Subsidence area : Bangkok, Manila, Mexico, Tokyo, Shanghai, Colorado Plain

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Cities : Water Shortage Problems

- Cairo, Tel Aviv, Beijing, Shanghai, Mumbai, Calcutta, Jakarta, St. Paolo, Mexico city, Huston, LA, etc.

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Water-related Disputing Countries

River	Conflict Countries
Jordan	Syria, Israel, Jordan, Palestine
Nile	Tanzania, Uganda, Kenya, Sudan, Ethiopia, Egypt
Ganges	India, Bangladesh
Indus	India, Pakistan
Mekong	China, Myanmar, Laos, Thailand, Cambodia, Vietnam
Euphrates	Turkey, Syria, Iraq(Tigris is in the same....)
Danube	Hungary, Slovakia, other 12 countries
Grante	Mexico, USA
Okavango	Angola, Botswana, Namibia

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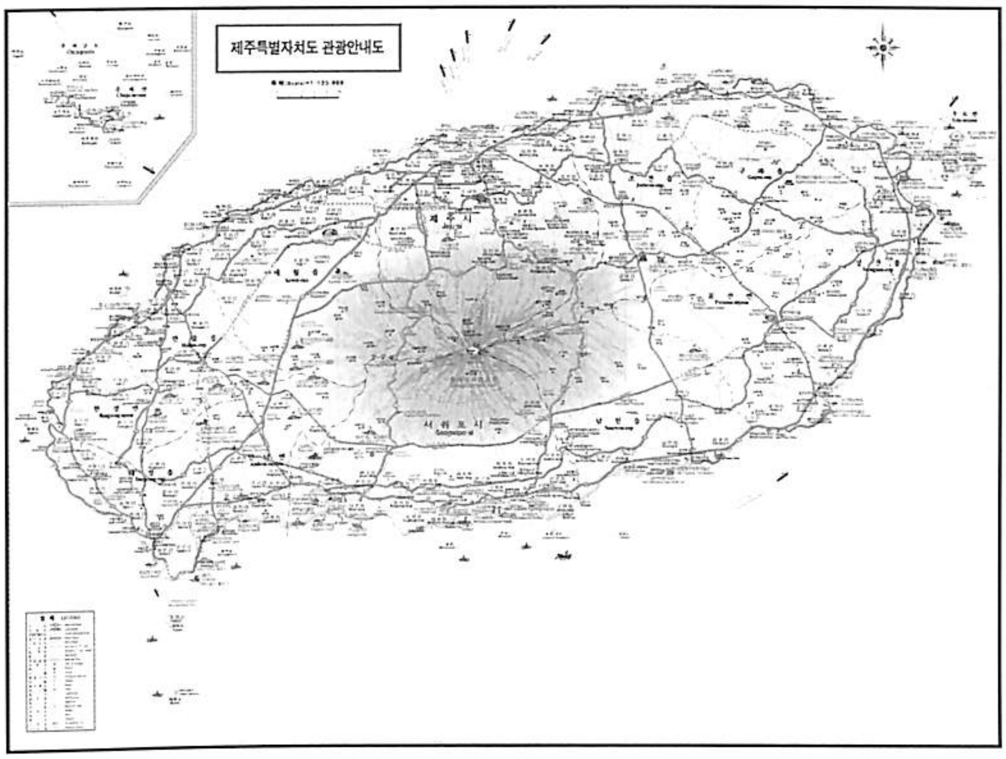
Geology and Groundwater in Jeju Island

Young volcanic island which was formed during the Pleistocene (2 mil. years ago) to Holocene.

- **The youngest flow occurred 3,000 years ago.**
- Countless lava flows and pyroclastics from Mt. Halla and the secondary cones(365 ea) formed the island.

- **A granitic basement and tuff occurs at depth**
- Basalt is distributed all over the island
- **Shrinking joints and the diastems are the best aquifers(1,000t/d)**
- Groundwater quality is excellent
- Rechargeable Groundwater (not OTR Groundwater)



Geology and Groundwater in Jeju Island

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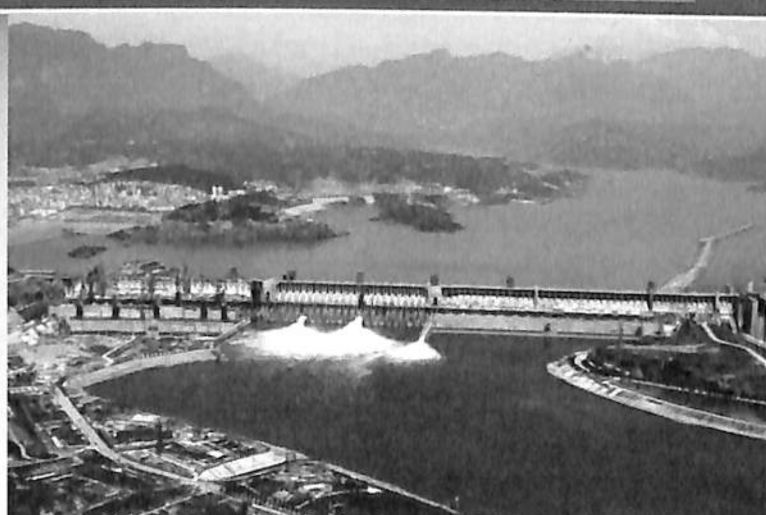
Sanxia Dam (in China)



KRC

Sanxia Dam (in China)

KRC

Sanxia Dam (1-3)

- o Sanxia Dam : the Largest Dam in the World
- o Sanxia : three big Canyon
- o Sanxia Dam crosses the Yangtze River
- o Yangtze River : Chang Jiang (Long River : 6,300km)
  (Amazon River : 7,025km, Nile River : 6,690km)
- o Period of Construction : 1992 ~ 2009
- o Electrical Power : 18 million kW/day(84.7 billion kW/year)
- o Head for Generating : 100 m

KRC

Sanxia Dam (2-3)

o Construction Cost : USD 27billion

o Benefit : USD 3.4billion/year

o Dimension of the Dam : Height 185m, Length 2,309m, Width 135m

o Depth of water : 175m

o Storage : 39billion tons

o Area of the Lake : 632km^2(Width 1.1km, Length 660km)

KRC

Sanxia Dam (3–3)

o Discharge : 102,500 ton/second

o Dock Size of Canal : 2 Ships(10,000tons) can move

o Silt, Clay and Sand through the Yangtze River : 700million tons/year(100m× 10m× 700km)

o Submerged Area

o Cultural Properties : 1,087 pieces

o Preservation : 207, Inundated : 880

KRC

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Great-Man-Made River (GMR)

PCCP (pre-stressed concrete cylinder pipe)

KRC

KRC

Libya : Great-Man-Made River (GMR)(1-3)

o Libya : area=1.76mil. ㎢, population=6.2mil.,
o Capital City=Tripoli
o Green Revolution in Desert

o G.W was found out through the oil prospecting in 1953
o Libya Desert (a part of Sahara desert) : 200m above sea level

o Ground water : depth=500m, 1,300wells
o Yield : 65million ton/day (50,000 ton/well/day)
o Geology = limestone, granite (base rock ?)

KRC

Libya : Great-Man-Made River (GMR)(2-3)

- o Fossil water : saturated between 14,000~38,000years ago
- o before 25,000~75,000year : glacial epoch (period)
- o OTR (one time reserved) water(100years ?)

- o Circular earth reservoir : capacity 4.7~6.8 million ㎥
- o Pipe : diameter= ∮ 4m, length=7.5m, weight=75ton
- o Depth (buried)=6 feet, inner pressure=4~26 bar
- o Depth (buried)=6 feet, inner pressure=4~26 bar

Libya : Great-Man-Made River (GMR)(3-3)

- o Total 5 steps : 1984~

- o PCCP (pre-stressed concrete cylinder pipe)
- o No. of pipes : 250,000 ea/1^{st} step, 190,000 ea/2^{nd} step

- o 1^{st} step ⇒ to Bengaji : 1,874 km, 2.0mill. ㎥/day
- o 2^{nd} step ⇒ to Tripoli : 1,652 km, 2.5mill. ㎥/day

- o 1^{st} step=$3.8bill., 2^{nd} step=$11.2bill.
- o Supply : 200mill. ton/day ≒ Tames River (in England)

Project Phases

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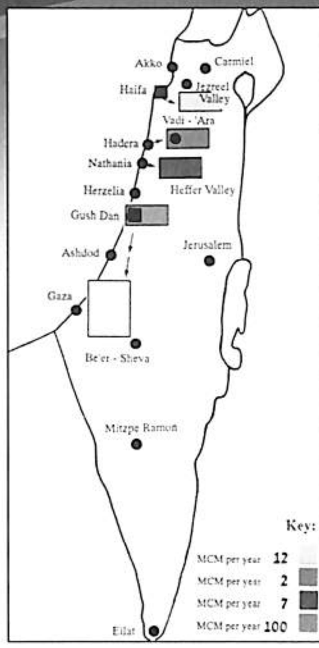

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Groundwater in Israel

- Israel : Water Management Skill is the best in the World
- Water Resources : Lake Galilee=25%, Groundwater=50%, Recycled and etc.=25%
- **Precipitation : Northern Area=600~800mm, Middle and Southern Area=5~300mm**
- **OTR Groundwater : 50 years(?)**
- Lake Galilee : (-)200m, Dead Sea : (-)400m
- Golan Height, Jordan River, Rift Valley
- **Kibbutz : Agriculture, Industry, Lodging, Restaurant, School, Laboratory, etc.**
- **Sprinkler and Drip Irrigation**

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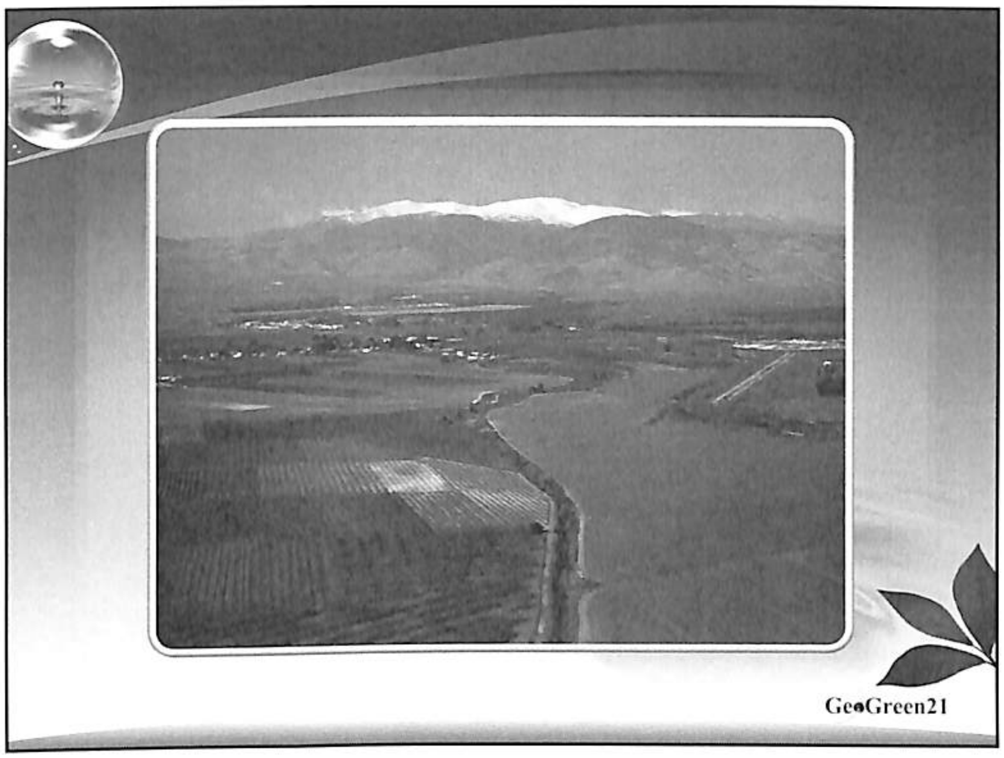
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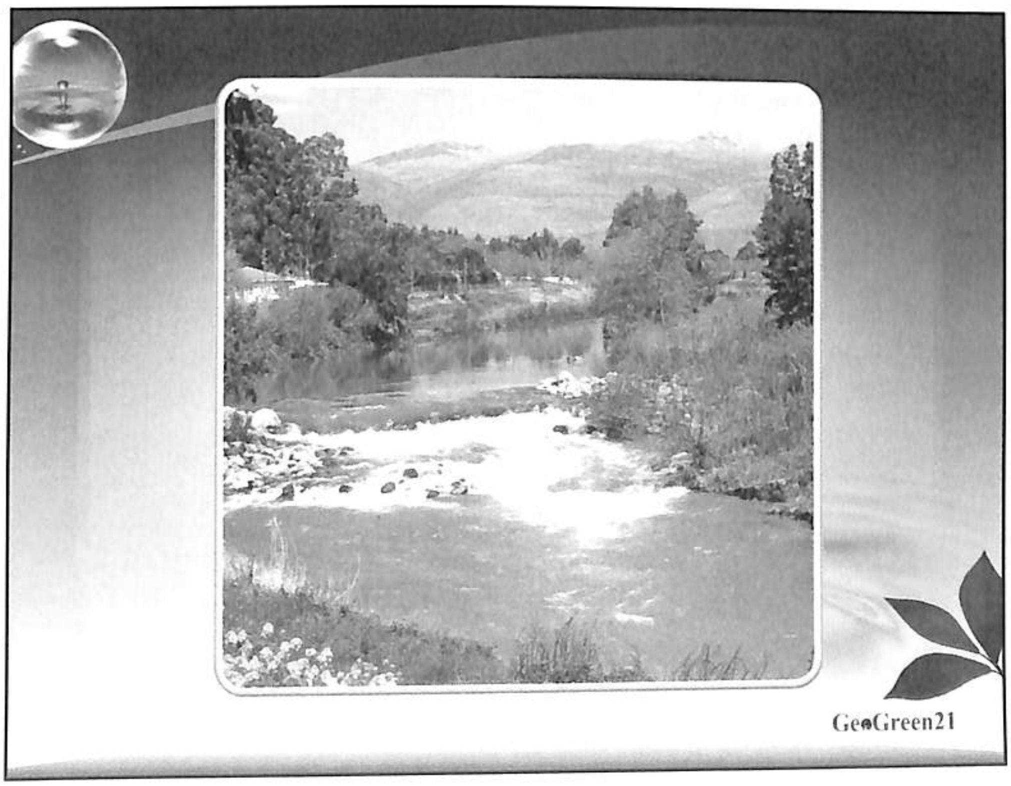
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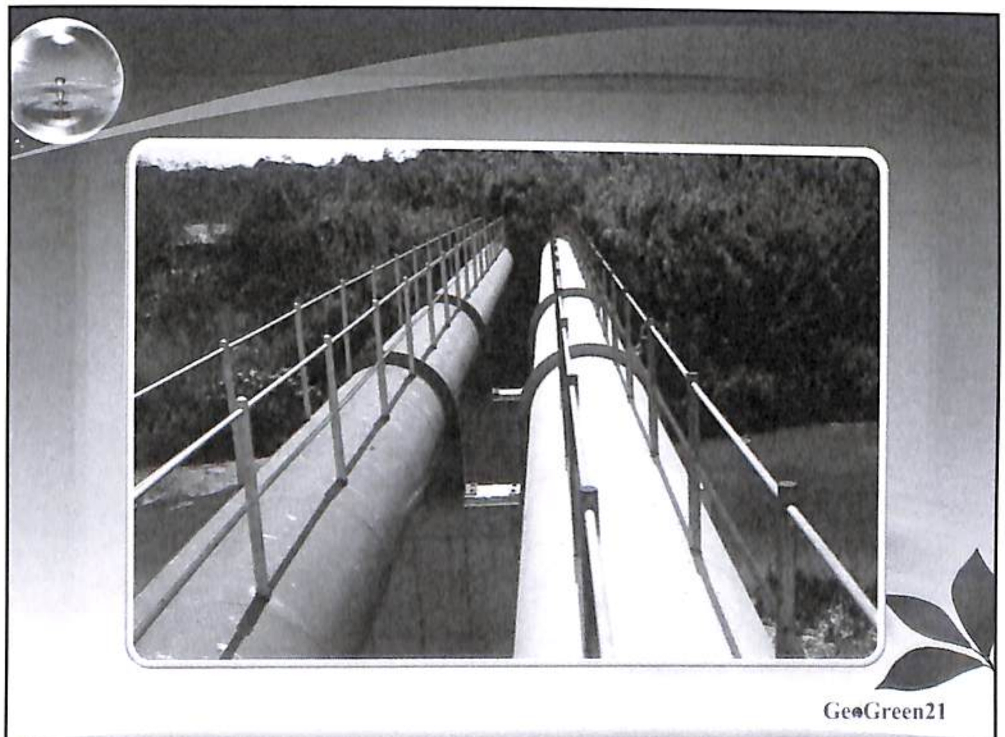
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Thank You!
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Water Supply System & Practice

Mr. Kim, Young-deuk

Deputy Manager

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Water supply system and practices

Young D. Kim

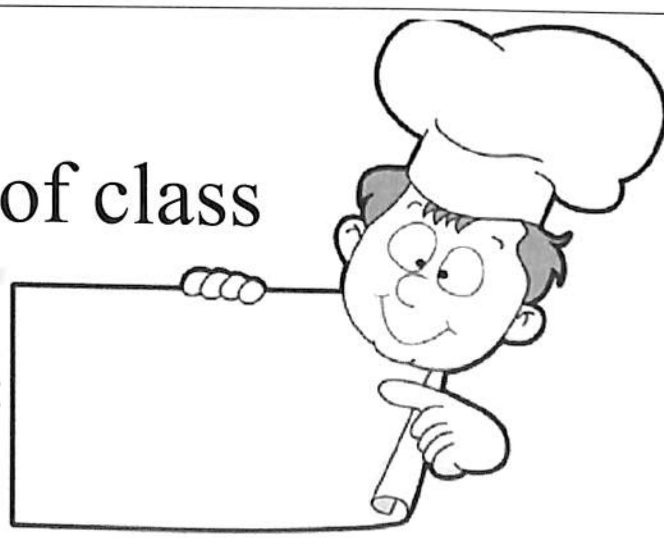
Email:

TEL: +82 31 400 1741

Professional Engineer, researcher

Rural Research Institute of KRC

Structure of class



1. Water issues in Senegal:
2. Technical approaches
3. Case studies in Africa
4. Case studies in Korea
5. Future oriented water supply scheme and DIY

Water issues in Senegal

Human development status

- Average life expectancy: 57.08 years
- 73.4% of total employed pop. for agriculture sector(forestry and fishery)
- Agricultural products: peanuts, millet, corn, sorghum, rice, cotton, tomatoes, green vegetables; cattle, poultry, pigs; fish

Source: http://www.nationmaster.com/country/sg-senegal/agr-agriculture

Environmental Health Risk

- Poorest drinking water and sanitation coverage (Government : 82%)
- Piped water 46% of pop (15 min return journey, urban 75%, Rural 17%)
- Major issues, water quality
  - Bacterial contamination from feces → diarrhea, skin disease
  - Arsenic contamination in tube well

Sources of contamination

- Fecal coli-form bacteria
- Inadequate protection of water source area
- Open defecation in water sources
- Poor protection of waterways,
- Poor maintenance leading to cross-leakage of sewers and water pipes in urban areas

Water and Sanitation Program for the Millennium (PEPAM)

- Provide sustainable water supply to an additional 2.3 million people, increasing access from 64% in 2004 to 82% in 2015.
- Allow 355,000 rural households to install an individual solution to manage their excreta and domestic greywater, increasing access from 17% in 2004 to 59% in 2015.
- Ensure the sanitation of the most important public buildings through the construction of 3,360 sanitary facilities in schools, health posts, markets and bus stations.

In urban areas:

- Provide house connections to water supply to an additional 1.64 million people, to reach an access rate of 88% in Dakar and 79% in towns in the interior in 2015, compared to 75.7% and 57.1% respectively in 2002.
- Allow 1.73 million additional people access to sanitation, increasing access from 56.7% in 2002 to 78% in 2015.

Waterborne disease

- **"It seems to me that the greater part of the population still doesn't really know [about] malaria, despite the sensitisation strategies and everything," Doctor Gueye said.**
- **"People have to understand that malaria is deadlier than AIDS. Every year it kills more people than AIDS."**

Source: SCIENCE HERO: GUEYE by Seck from Dakar

Innovative approaches

- Country-wide lease (affermage) contract,
- Public-Private-NGO-Community Partnership for standpipes in Dakar, and
- Use of small enterprises to maintain rural and small town water systems with the support of micro-credits stand out particularly.

Short discussion

Technical approaches

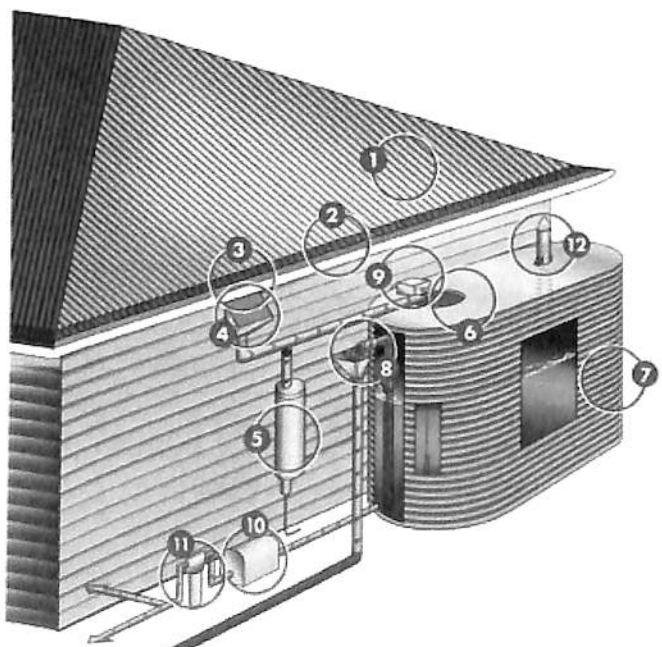
Water supply

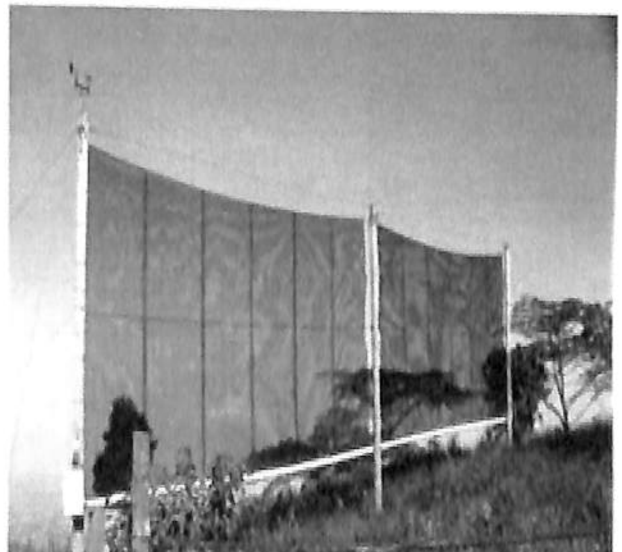
Innovative technologies for water resources

1. Rain water harvesting
2. Fog water harvesting

Household technologies

1. Kanchan Arsenic and Biosand filters
2. SODIS,
3. Piyush (chlorine solution),
4. Water test kits
5. Colloidal silver filters





Typical water quality problems and recommended treatment systems

Problem	Recommended Treatment Systems
Bacteria and other microorganisms	Disinfection
Taste and odor	Carbon filter
Hydrogen sulfide gas (rotten egg odor)	Oxidizing filter followed by carbon filter; chlorination followed by sediment filter
Sediment (suspended particles)	Fiber filter
Hardness (calcium and magnesium)	Softener
Dissolved iron	Softener for up to 5 milligrams per liter); Iron filter; chlorination followed by sand filter and carbon filter
pH (acid or alkaline conditions)	Neutralizing filter or chemical-feed pump
Organic chemicals (pesticides, fuel products)	Carbon filter
Metals (lead, mercury, arsenic, cadmium), and other minerals (nitrate, sulfate, sodium)	Reverse osmosis unit; distillation

Unit process and removal of pollutants

Objects	Filtration	Coagulation, sediment	AC	RO
FE	○	○	○	○
Mn	○	○	×	○
NH3-N	×	×	×	△
NO3	×	×	×	△
Bacteria	△	×	×	○
Solid	×	×	×	△
$KMnO_4$ consumption	○	△	×	△
Pesticides	×	×	×	○

Source: Rural Research Institute, 1997, Study on water quality of supply system and sewage treatment in rural area

Typical treatment process by WQ

- Only Disinfections

① coliform (50mlMPN) < 25

② bacteria (1ml) - <500

③ other items – below criteria

- Sand filter

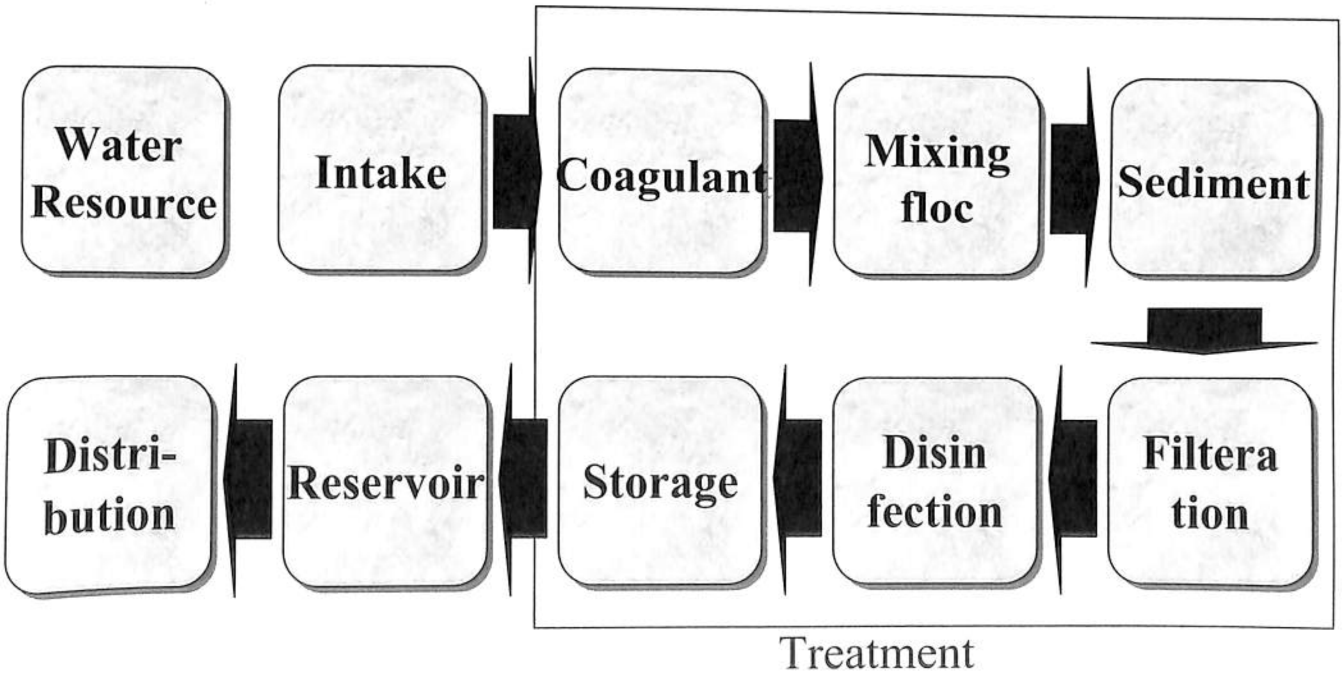
① coliform (50mlMPN) < 500

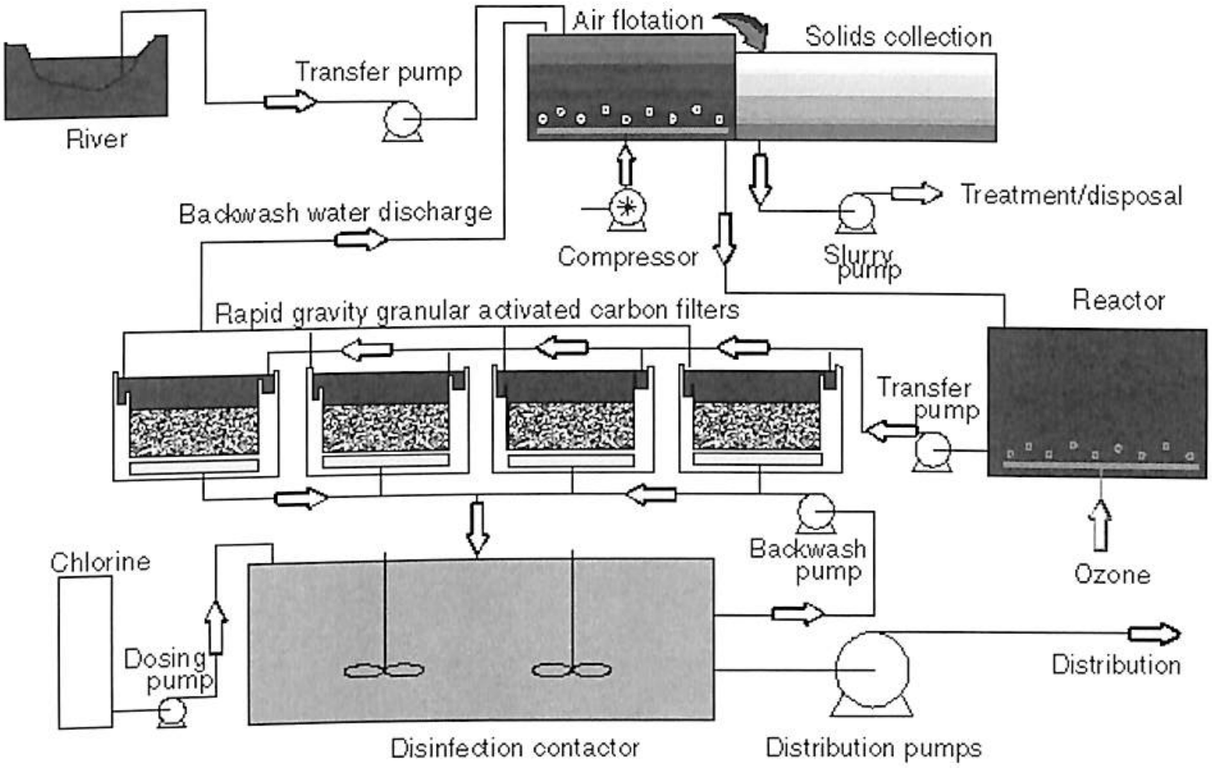
② BOD < 2ppm

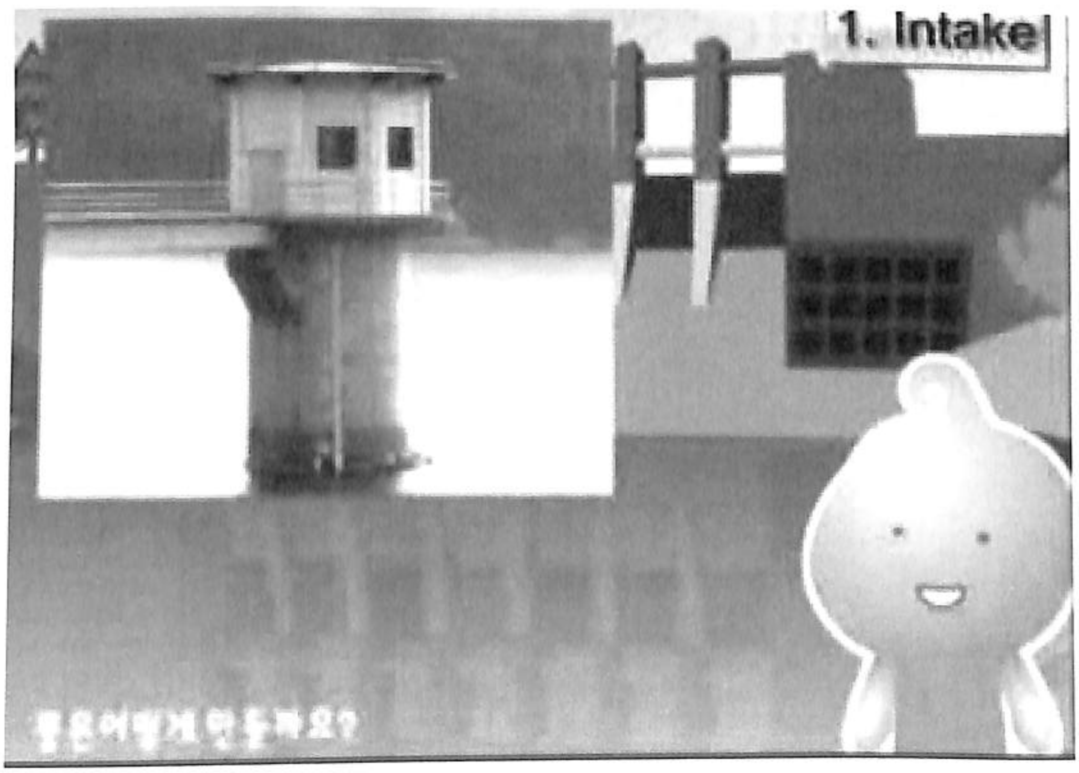
③ Turbidity < 10

④ NO_3-N < 20 (30-40 sediment, 40-50 sediment & coagulation)

Water supply system

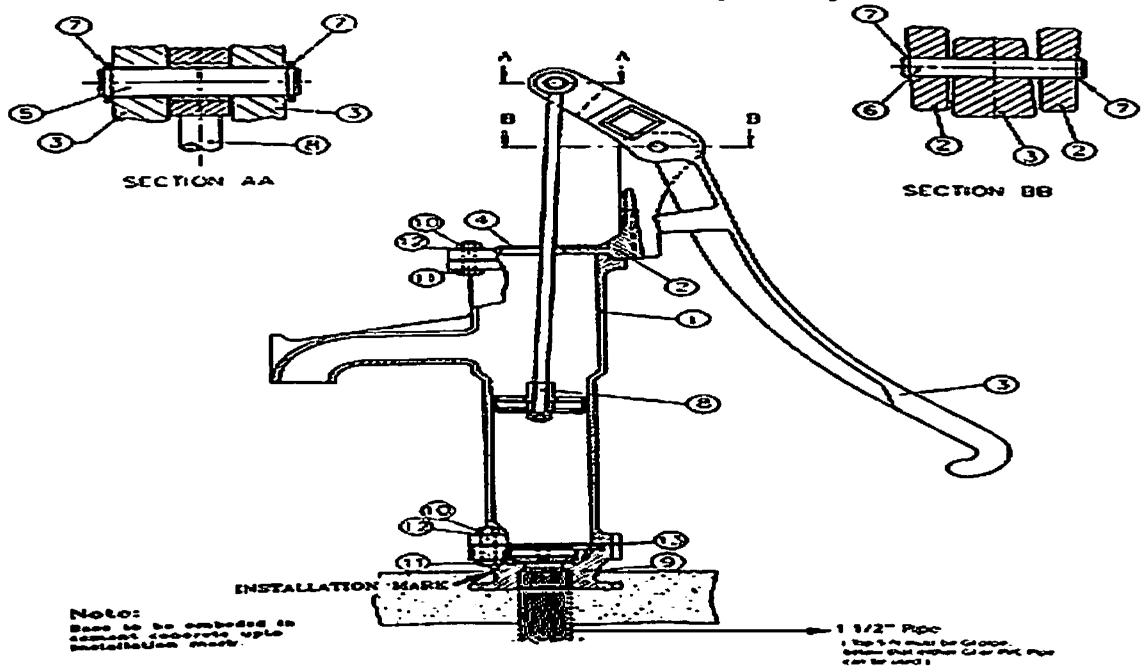



Air flotation
Solids collection
Transfer pump
River
Backwash water discharge
Compressor
Slurry pump
Treatment/disposal
Reactor
Rapid gravity granular activated carbon filters
Transfer pump
Backwash pump
Chlorine
Ozone
Dosing pump
Distribution
Disinfection contactor
Distribution pumps


1. Intake

Case studies in Africa

Shallowell Handpump




(Mogadishu)
Uganda
Kampala
Kisumu
Kenya
Nairobi
Victoria
Narok
Kigali
Bujumbura
Burundi
Pemba
Tanzania
Dodoma
Zanzibar
Dar es Salaam
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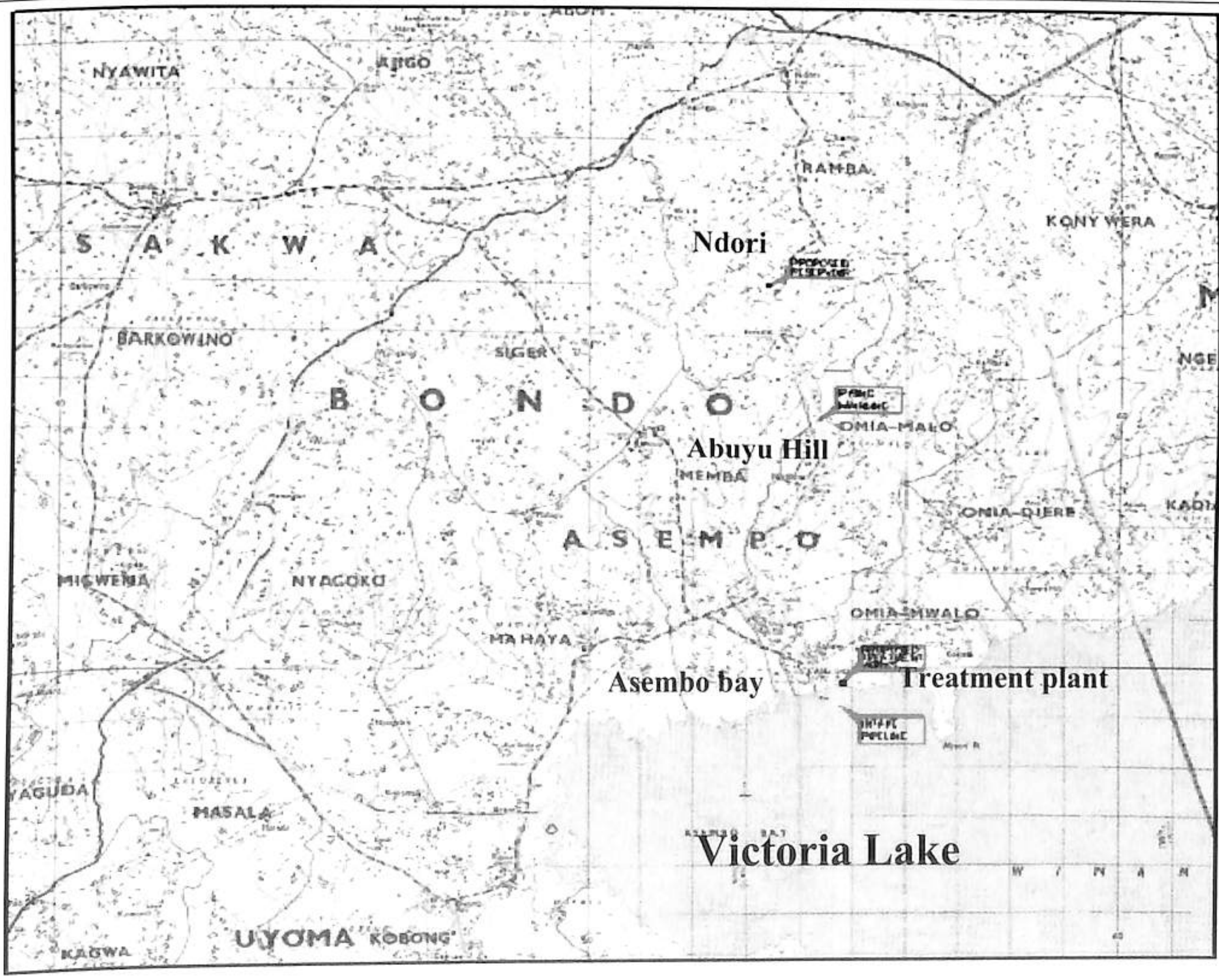
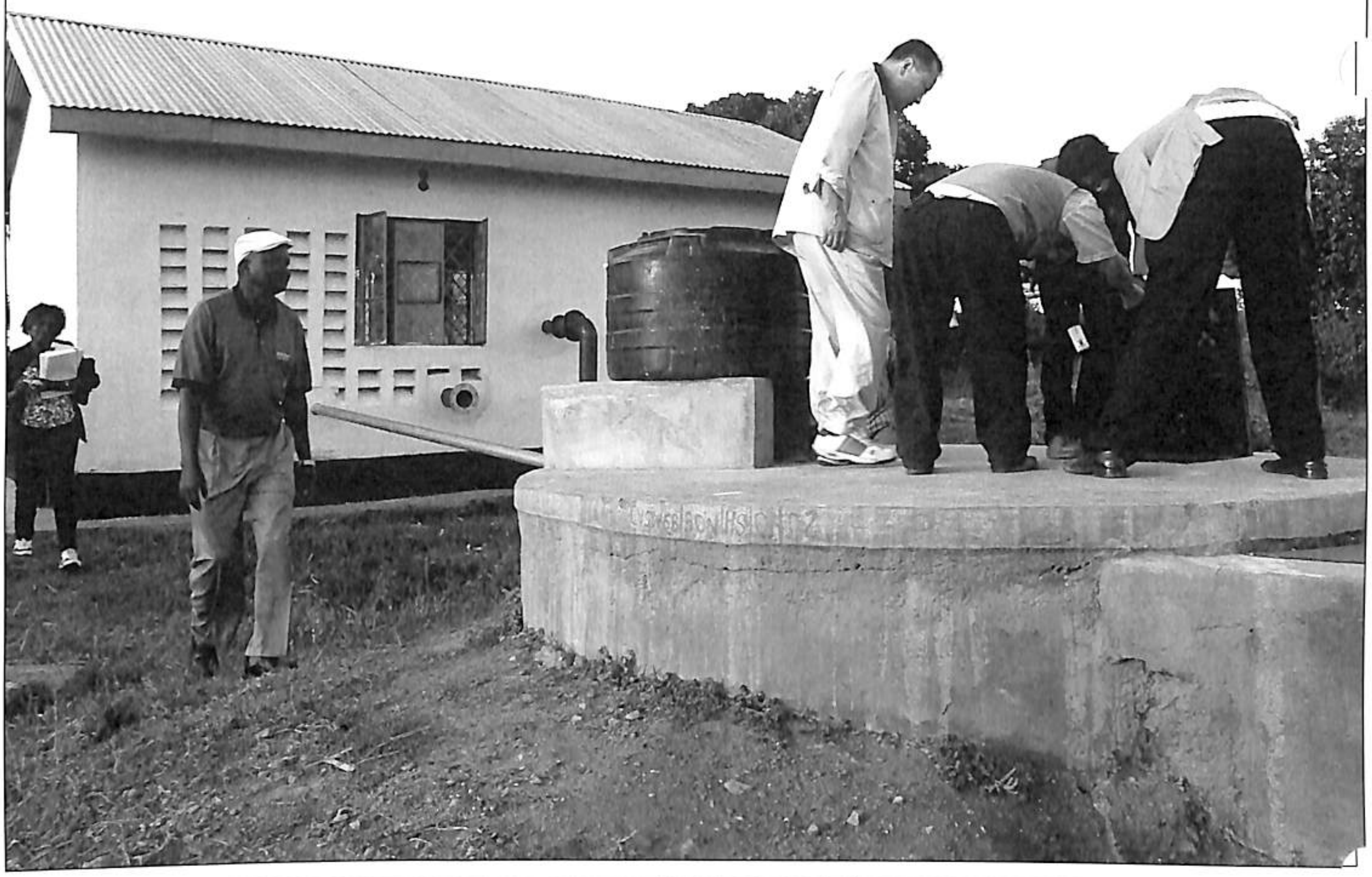

NYAWITA
RAMBA
KONY WERA
S A K W A
Ndori
BARKOWINO
SIGER
B O N D O
OMIA-MALO
Abuyu Hill
MEMBA
OMIA-DIERE
A S E M P O
MIGWENA
NYAGOKO
OMIA-MWALO
MAHAYA
Asembo bay
Treatment plant
MASALA
Victoria Lake
UYOMA
KOBONG
KAGWA

Investigation of sedimentation basin



PE pipe for construction

Design Concepts and Criteria

1. Design Horizon
2. Population
3. Intake works
4. Treatment works
5. Pumping station, rising main and reservoir

Source: Howard Hemphreys Ltd, 2006, Asembo Bay-Ndori water supply project

Water Consumption Rates

Category of consumer	Unit	Water con. rate
People with individual connection	l/h/d	50
People using communal water point	l/h/d	25
Boarding schools	l/bed/d	50
Day school with water cistern	l/h/d	25
Day school without water cistern	l/h/d	5
Hospitals (Medium Class)	l/bed/d	200
Hospitals (outpatient)	l/h/d	20
Dispensary and Health center	l/d	5,000
Medium class hotel	l/bed/d	300
Administrative offices	l/d	25
Bar/hotel	l/d	500
Shop	l/d	100
Livestock	l/LU/d	50

Design for Intake works

- Bell mouth intake
- Lake draw-off pipeline
- Raw water pumps
- Raw water pumping main: 20% more than the power required

Design for treatment works

- Treatment works
  - the inlet chamber,
  - mixing channel,
  - flocculation tanks,
  - sedimentation tanks,
  - filters and
  - clear water storage tank

Flocculating Chambers

Parameter	Criteria	Used
i) Detention period, **t,**	15 – 20 minutes	15
ii) Channel Velocity	0.1 – 0.3 m/s	0.2
iii) Slot Velocity	0.5 – 0.6m/s	0.5
iv) Velocity gradient, **G,**	30 – 60 s^{-1}	59.08
v) Product of **G x t**	30,000 – 60,000	53,175.45

Horizontal Flow Sedimentation tanks

Parameter	Criteria	Used
i) Surface loading, S	$1 m^3/m^2/h$	1
ii) Effective depth	2m	2
iii) Sludge storage	25% of tank volume	0.25
iv) Ration of width:length	1:3 to 1:6	0.737
v) Retention period	Calculated as	2.14hr

Rapid Gravity Sand Filters

Parameter	Adopted Standard	Used
Filtration Rate	$5m^3/m^2/h$	5
Filter Medium		Quartz Sand
Effective size	0.5 – 1.0mm	0.75
Uniformity Coefficient	Less than 1.5	1.4
Thickness of sand bed	0.7 – 1.0m	0.75
Thickness of supporting bed	55cm	55
Sand bed expansion allowance	40% of sand bed	400mm

Design of pumping station, rising main, reservoir

- Pumping station: power rating has been exceeded by 10%, to 138kW
- Rising main: velocity of flow in the pipeline is 0.9m/s
- Reservoir: ½ day storage

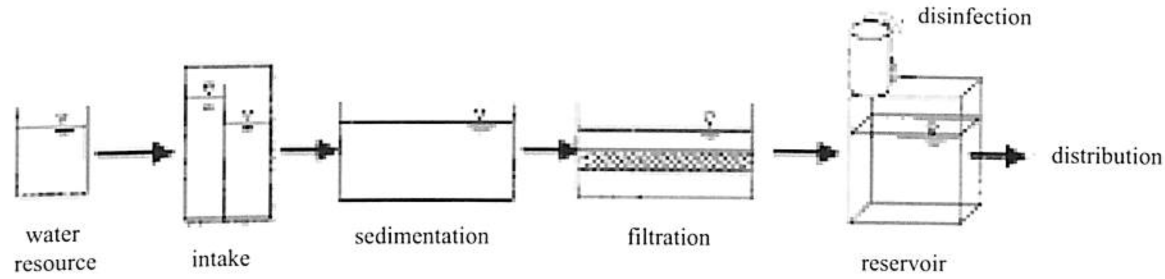
Unit: thousand USD

Class	Unit projects	Cost	Support	Remark
Total		4,527	1,500	
1. Intake works	- Q=175m³/hr, H=15m, P=4.29kw - D300, steel pipe, L=270m - D250, steel pipe, L=100m	94	-	Kenya
2. Treatment works		1,015	1,015	Korea
a. Construction	- Inlet works and flocculation Q=165.92m³/hr, V=5.53m³ 9.0m×9.0m×2EA(B×L×Nr) - Sedimentation tanks 17.2m×4.5m×2EA(B×L×Nr) - Filters Sand filter (t=0.75m), 11.7m×9.2m - Clear water tank V=100m³	450	450	
b. Ancillary works	- Administration building - Staff house - Gate house - Site water supply - Day works - Preliminary and general items	565	565	
3. Rising main	- Q=175m³/hr, H=250m, P=137.67kw - D250, steel pipe, L=12km	1,163	-	Kenya
4. Distributing works	- Reservoir V=1,500m³ - Pipeline D250 ~ D100, L=26km	1,770	-	Kenya
5. Water Service works	- Five (5) water kiosks.	18	18	Korea
6. Others	- Korean experts, training, 2 water trucks, 6 water tanks	467	467	Korea

Case studies in Korea

Small water supply system

- 30,000 systems all over the country
- Water requirement: 293L/pcd for rural area
- National average: 410L/pcd

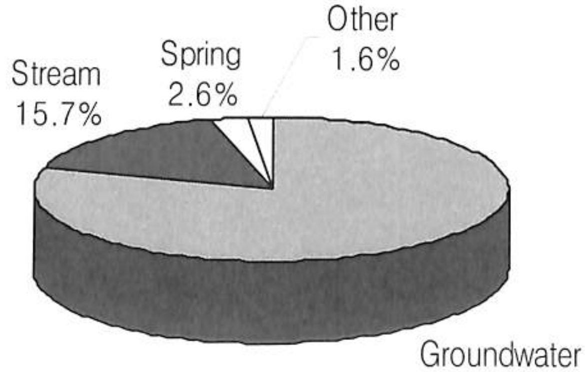


Small water supply system

Source: MOE, 1995, Guideline for small water supply system installation and management

Rural Water supply

- Water resources in rural area



Source: Rural Research Institute, 1997, Study on water quality of supply system and sewage treatment in rural area

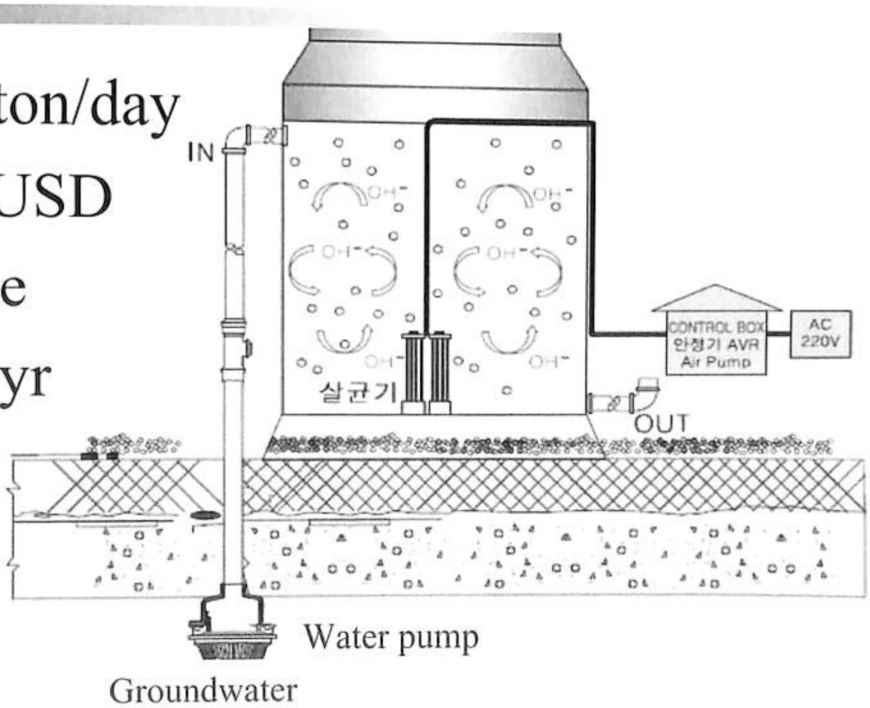
Challenges in SWSS

1. Unstable quantity and quality: 80% from GW
2. Not satisfy water quality criteria
3. Lack of understanding for using rural water supply
4. Lack of budget support for the improvement

→ Package system, outsourcing of the management

Package treatment system

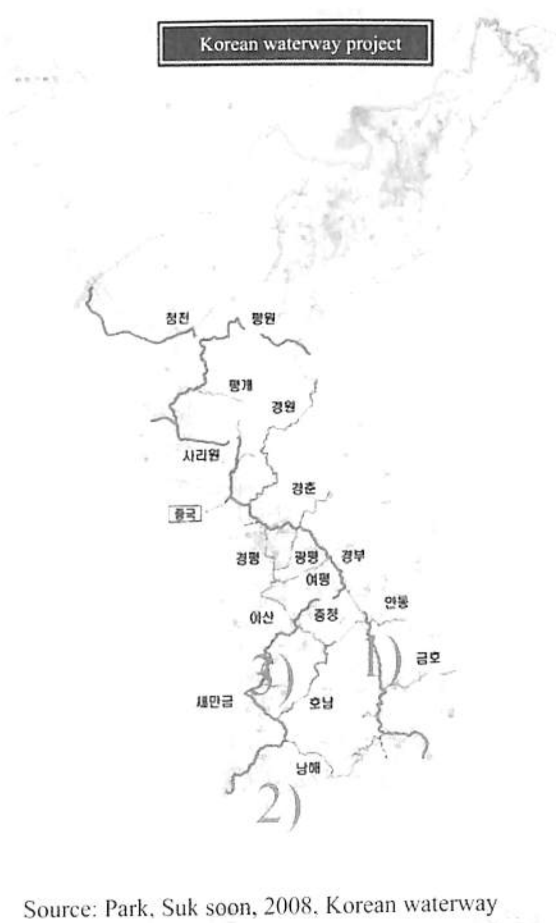
- Capacity: 5ton/day
- Install: 680USD
- Maintenance
  : 350USD/3yr



Source: AOP

Future oriented water supply scheme

Korean waterway project

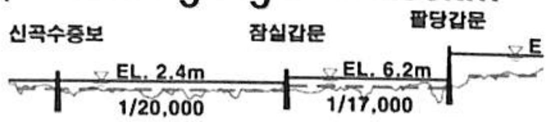


Source: Park, Suk soon, 2008, Korean waterway

1) Gyeong-Bu line: 540 km

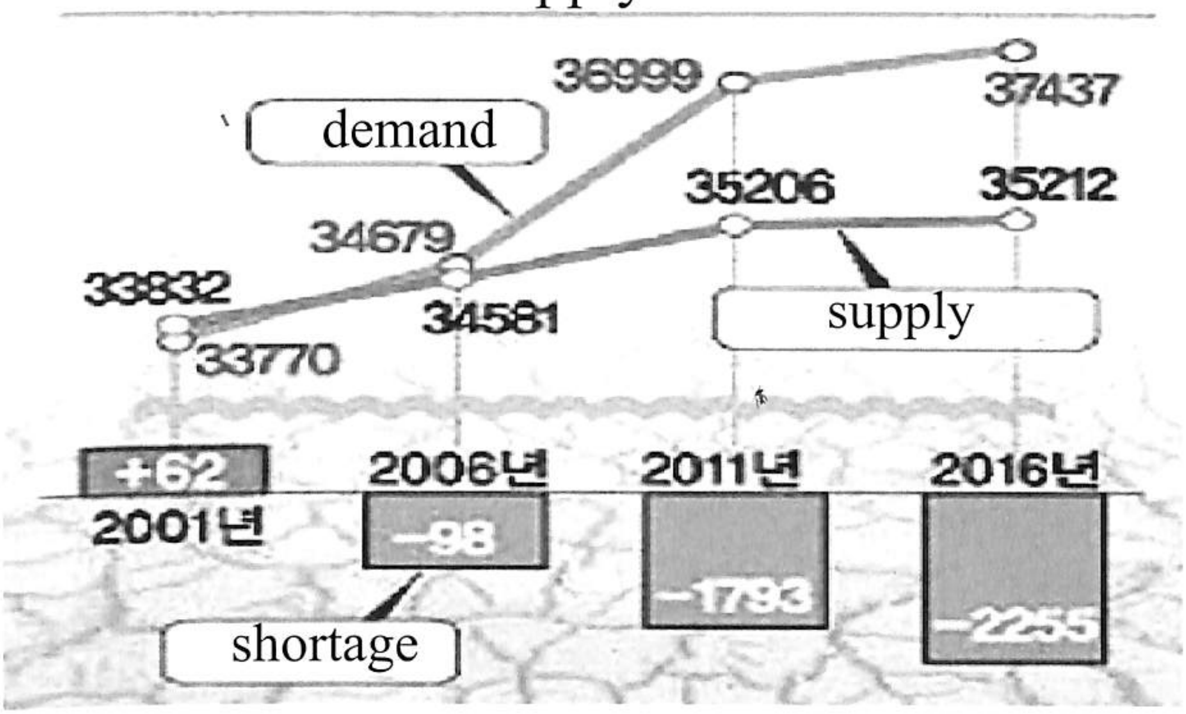
   Gumho line: 113km, Andong: 67km

2) Ho nam line: 378 km
3) Guem gang line: 200km

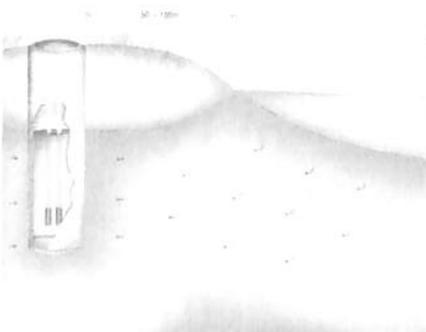


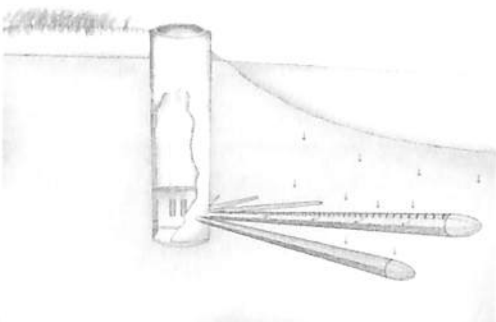
Relief of water shortage and flood protection

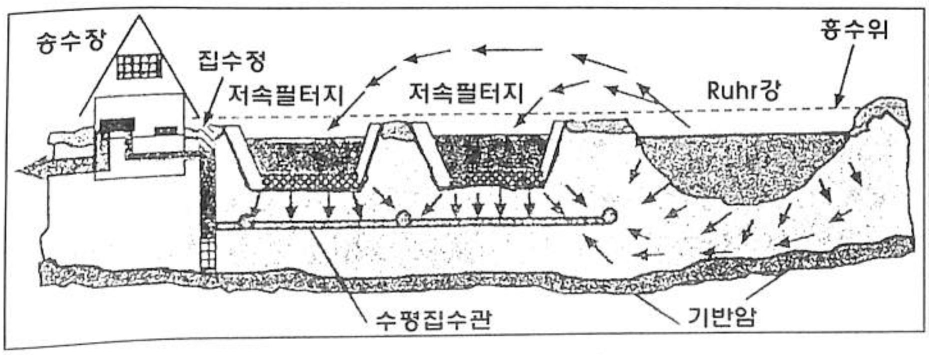
Water supply and Demand

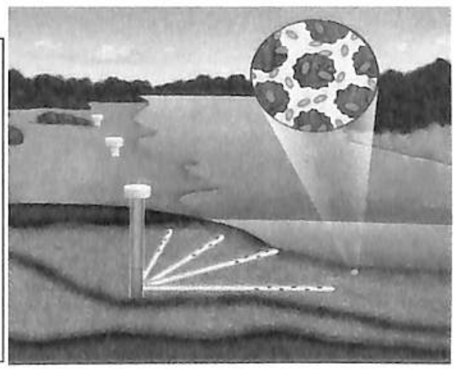


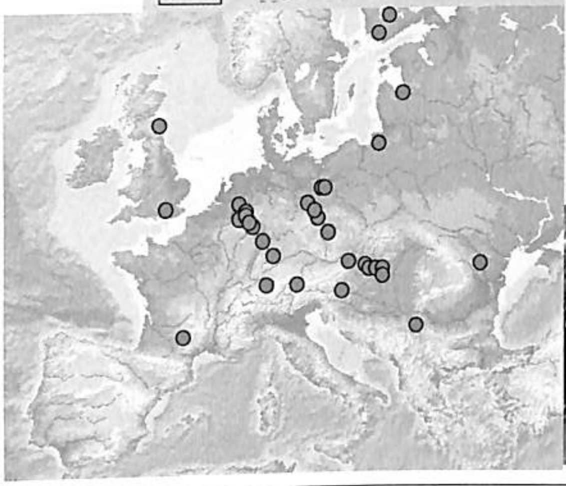
Riverbank filtration

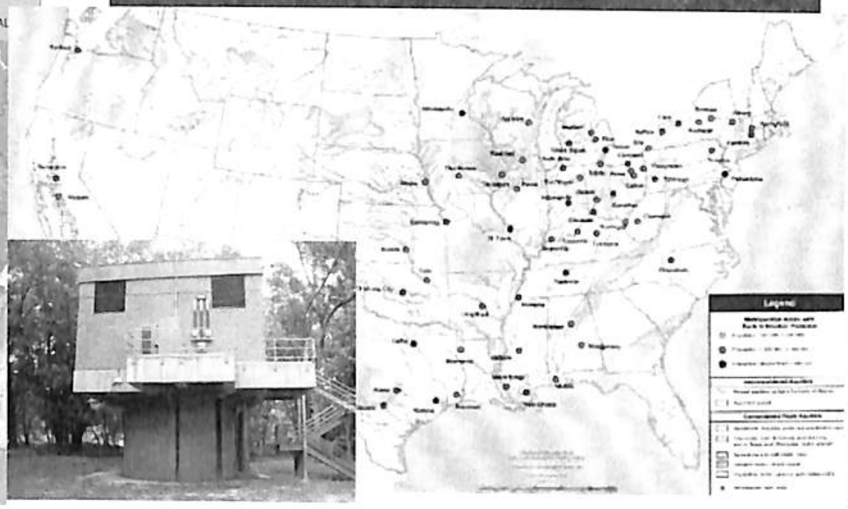




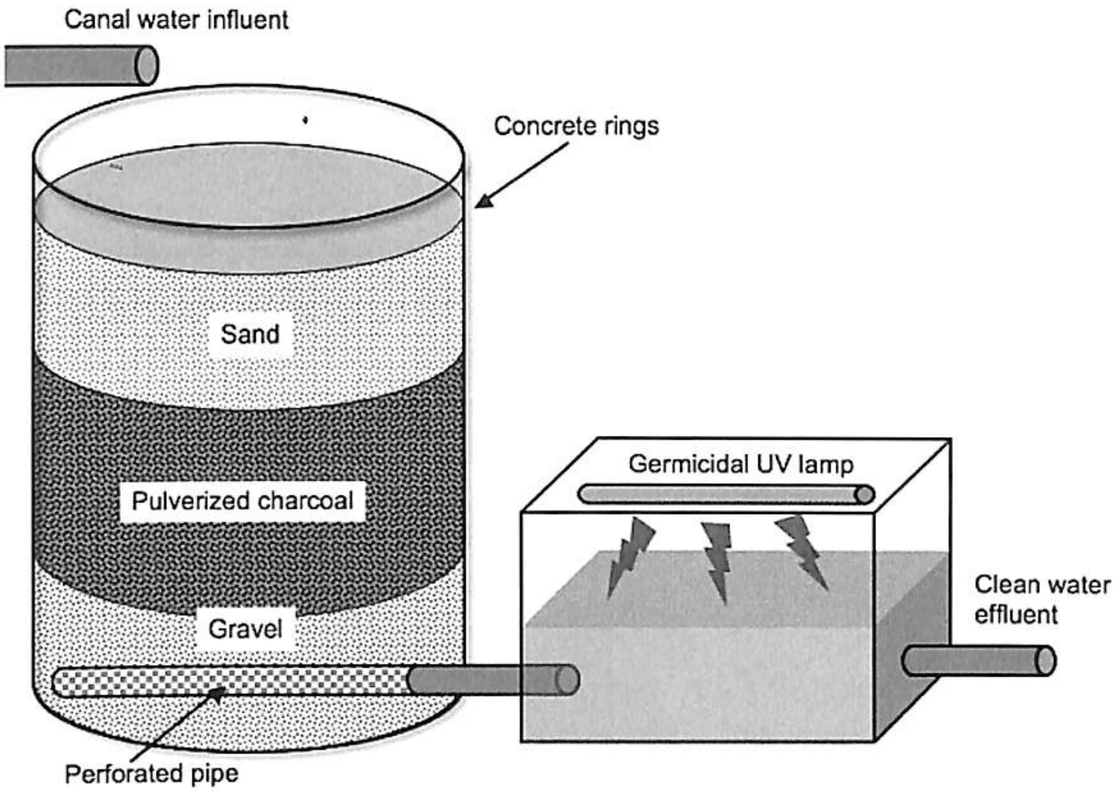








DIY water treatment design



Water treatment system design

Assumption

- 5 L/person-day
- 30 persons: average annual population
- 10 mg DOC/g charcoal
- 50 mg DOC/L: DOC concentration in natural surface waters

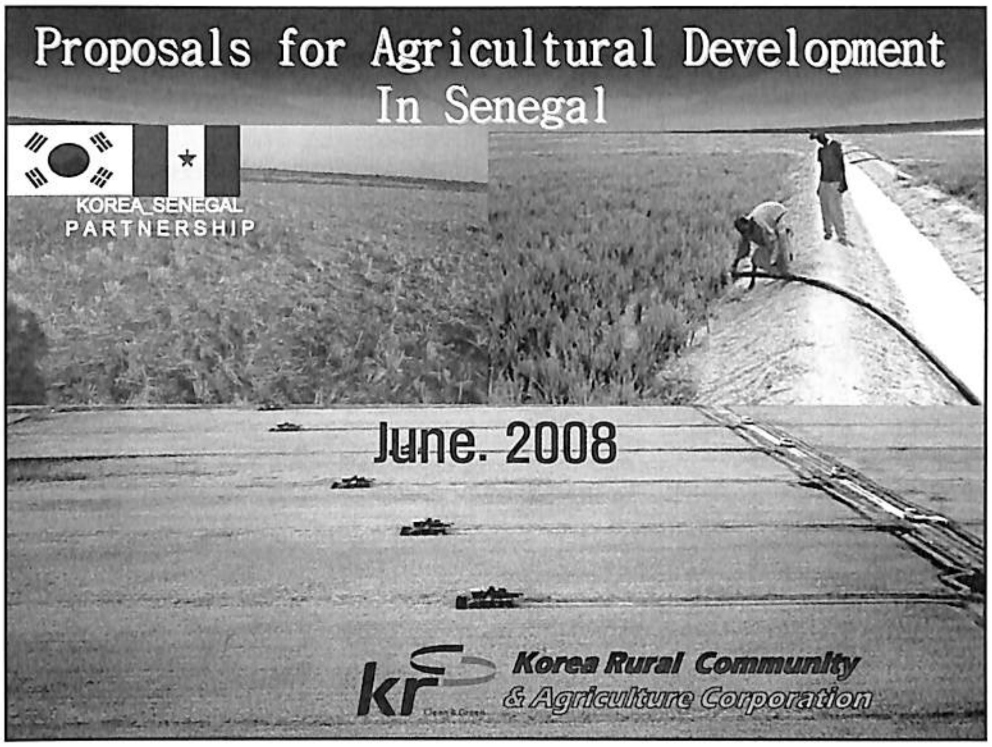
Thank you for your attention

Introduction of Rural Development

Mr. Lee, Ki-churl

Director

KRC



Agricultural Development, Senegal

Contents

1 Present Agriculture in Senegal

2 Development plan by steps

3 Infrastructure Development

4 1'st step of Development Plan

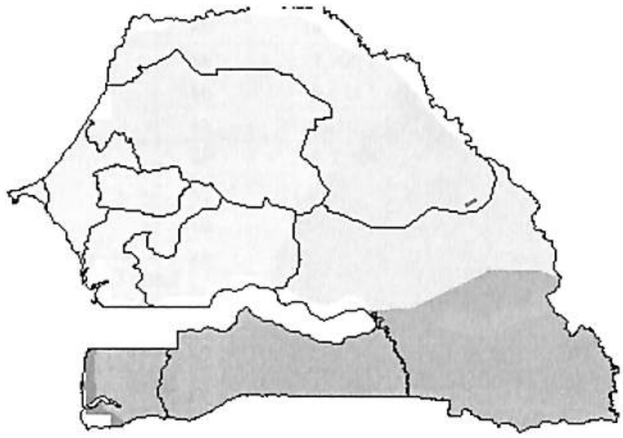
5 2'nd Step of Development Plan

Agriculture in Senegal

Agriculture in Senegal

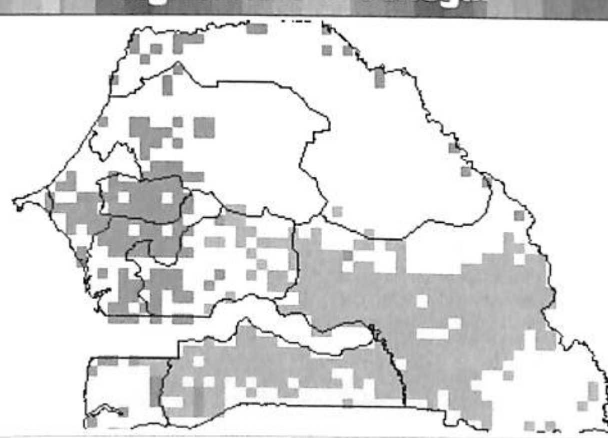
Area : 196,720㎢

Agriculture in Senegal



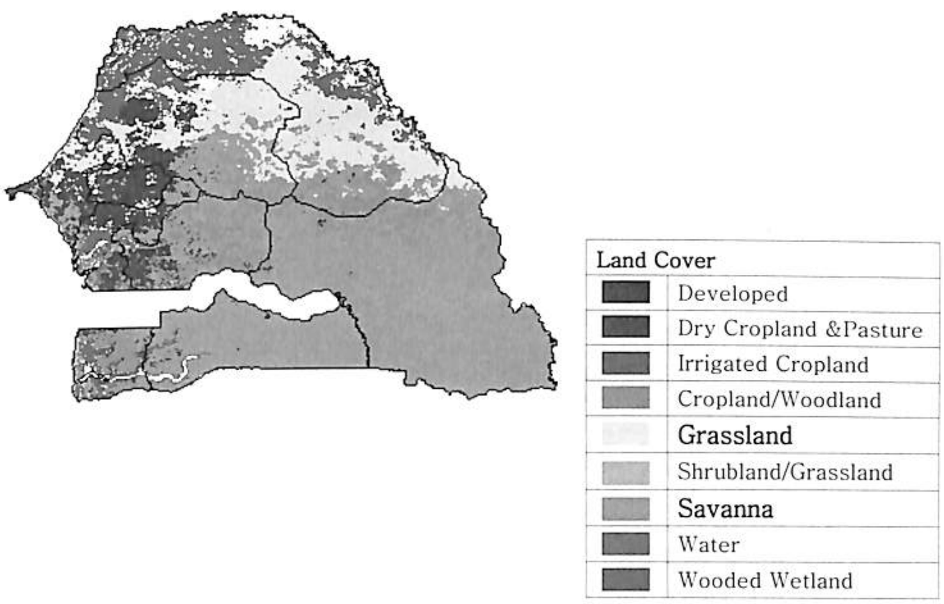
Farming Systems	
	1. Irrigated
	8. Cereal-root crop mixed
	11. Agro-pastoral millet/sorghum
	14. Coastal artisanal fishing

Agriculture in Senegal

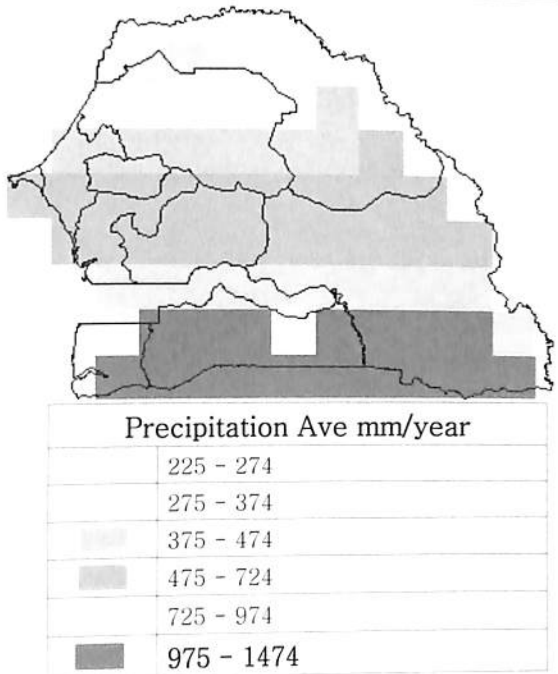


Permanent Crops &Arable Land (Percentage Intensity)	
	Sparsely Vegetated
	Undetermined (0 - 30)
	30 - 40
	40 - 60
	> 60
	Water

Agriculture in Senegal



Agriculture in Senegal



Exports of Agricultural products from Senegal

Commodity	Quantity		Value (000 US$)	Unit value (US$)
Cotton Lint	Mt	18,780	29,002	1,544
Oil of Groundnuts	Mt	22,700	25,967	1,144
Food Prepared nes	Mt	9,073	25,705	2,833
Rice, Broken	Mt	76,207	22,130	290
Malt Extracts	Mt	5,335	11,406	2,138
Cigarettes	Mt	707	6,166	8,721
Beans, Green	Mt	6,434	5,285	821
Tobacco Products nes	Mt	528	5,163	9,778
Tomatoes	Mt	5,068	4,587	905
Cake of Groundnuts	Mt	14,894	4,088	274
Dry Whole Cow Milk	Mt	1,286	3,218	2,502
Mangoes	Mt	4,895	3,155	645
Pastry	Mt	2,151	2,484	1,155
Other Resins	Mt	900	2,240	2,489
Tobacco Leaves	Mt	350	2,143	6,123
Food Wastes	Mt	13,257	2,092	158
Coffee Extracts	Mt	215	1,844	8,577
Hides Wet- Salted Cattle	Mt	2,431	1,620	666
Dry Skim Cow Milk	Mt	619	1,608	2,598
Molasses	Mt	29,619	1,434	48

Imports of Agricultural products into Senegal

Commodity	Quantity		Value (000 US$)	Unit value (US$)	New Arable land
Rice, Broken	Mt	799,863	236,494	296	200,000 ha
Wheat	Mt	313,777	78,595	250	100,000 ha
Dry Whole Cow Milk	Mt	23,535	52,657	2,237	
Oil of Soya Beans	Mt	72,420	46,918	648	
Food Prepared nes	Mt	19,204	43,789	2,280	
Malt Extracts	Mt	23,558	39,110	1,660	
Tobacco Leaves	Mt	2,669	26,417	9,898	
Chicken Meat	Mt	14,051	25,209	1,794	
Oil of Palm	Mt	37,470	23,649	631	10,000 ha
Sheep	Head	195,000	18,000	92	
Goats	Head	185,000	14,500	78	
Onions, Dry	Mt	76,341	14,107	185	20,000 ha
Maize	Mt	64,340	13,231	206	30,000 ha
Tallow	Mt	26,005	11,665	449	
Fat Preparations nes	Mt	4,341	9,469	2,181	
Sugar Refined	Mt	21,331	8,128	381	
Potatoes	Mt	42,389	8,124	192	20,000 ha
Sugar Confectionery	Mt	6,628	7,391	1,115	
Wine	Mt	8,904	7,028	789	
Tea	Mt	5,246	6,991	1,333	

Present Agriculture in Senegal

Present Situation

- Senegal has vast land size, high possibility of agriculture
  - enough land size, farmers, weather, water resources.
- In general, Primary stage of Agricultural techniques

  Need to improve technical advancement

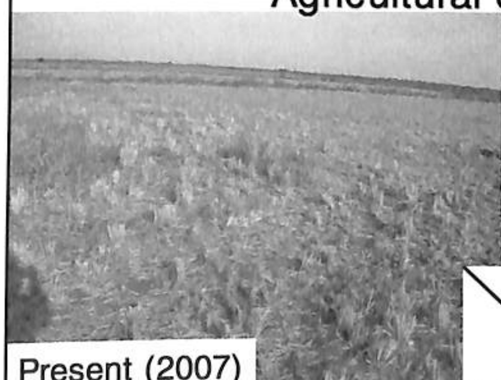
- Need to develop Infrastructure
  - Agricultural Sector : Irrigation System, Storage, Market, Farmland Consolidation, Trade
  - Industrial Sector : Rail road, High way, Food Processing
- Institutional Development

  Educational Centers, Training, Farmers Extension

  Capacity building

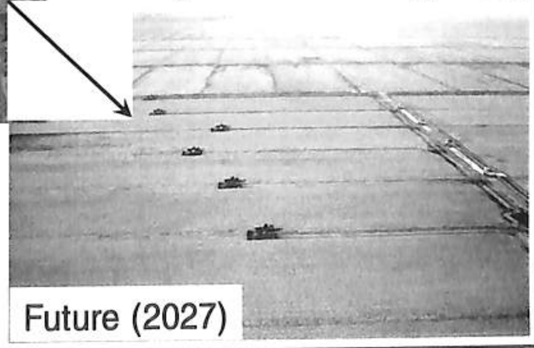
Agricultural Development, Senegal

Target : Self- sufficient of major crops and Agricultural development



Present (2007)

Irrigation System,
Farm land consolidation,
Farmers Training
Machinery
Agricultural Management



Future (2027)

★ Agricultural Development, Senegal

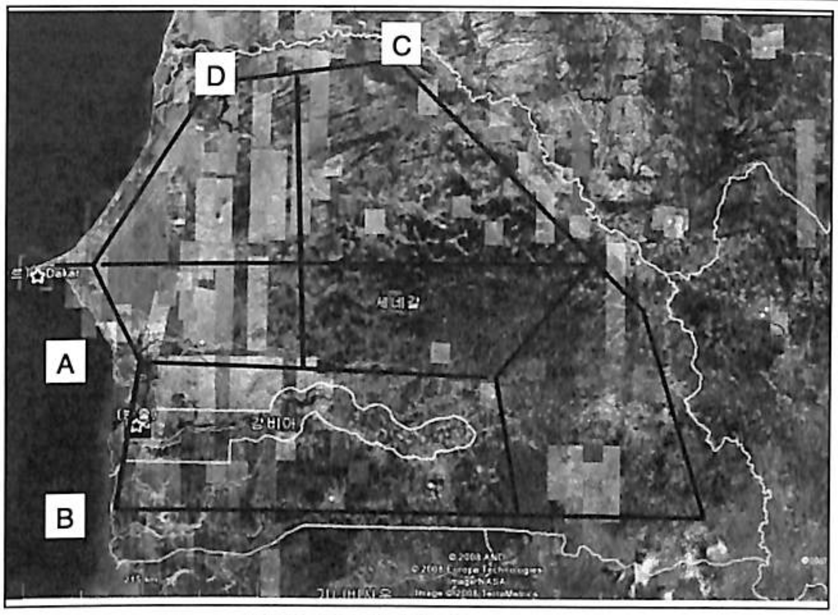
1. Institutional Development
   A. Farmers Training Center (Continuous Training)
      a. Rural Development
      b. Grain Cultivation
   B. Agricultural Research Institute
      a. New crop for High Quality, High Production
      b. Pesticide
      c. Food Processing
   C. Farm Machine Training Center
      a. Loan for purchasing farm machinery
      b. Training
   D. Farmer's Bank
      Farmer's Loan for farm land purchasing, Seeds, Fertilizer, Pesticide.
   E. Farmers Extension
      Cooperative work in purchasing any inputs and marketing

★ Agricultural Development, Senegal

2. Infrastructure Development

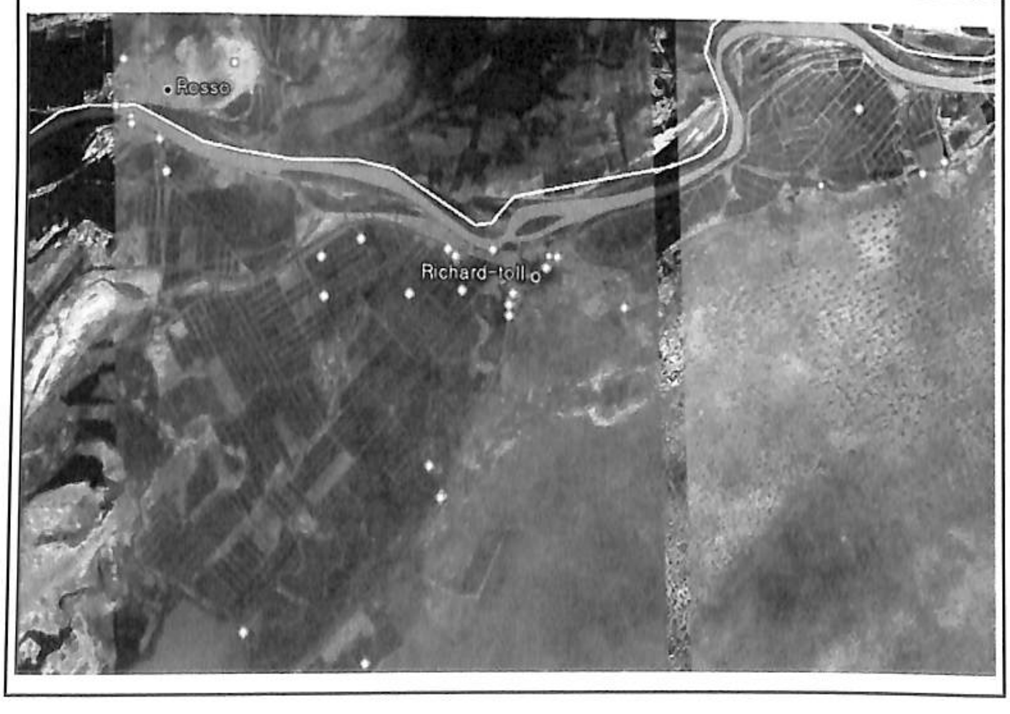
   A. Irrigation System and Land Consolidation, Canal system, Water pool or small reservoirs, Small dam
   B. Pumping Station with Irrigation system
   C. Fertilizer producing Factory
   D. Grain Processing complexes and Storage
      High quality products returns high benefits
      Increase value of products and farmer's income
   E. Packing & Marketing
      Develop various direct market and wholesale market
      Assists export
   F. Road (Rail road) and Trading system (Whole sale Market)

Agricultural Development, Senegal

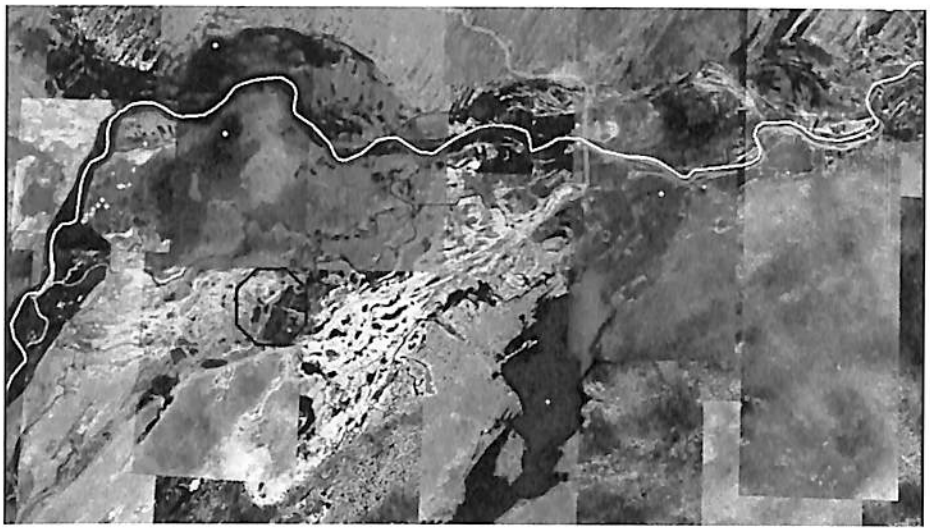


Rail road, High way

Existing irrigated farm land



★ **On-going KOICA project in Senegal**



The Project for Improvement of Agricultural Productivity in Dagana Region

★ **Agricultural Development, Senegal**

Target : Self- sufficient of major crops and Agricultural development

Rice (Imports 800,000 m^3/year : 236 mil US$, 300$)

⟹ needed to develop 200,000ha of paddy fields

Wheat (Imports 313,777 m^3/year : 78 mil US$, 250 $)

⟹ needed to develop 100,000ha of wheat farm

Oil of Soya bean (Imports 72,420 m^3/year : 47 mil US$, 650 $)

⟹ needed to develop 20,000ha of Soya bean

Maize (Imports 64,340 m^3/year : 12 mil US$, 210 $)

⟹ needed to develop 30,000ha of Maize

Total 300,000ha is needed

2. Small Dam and Reservoir

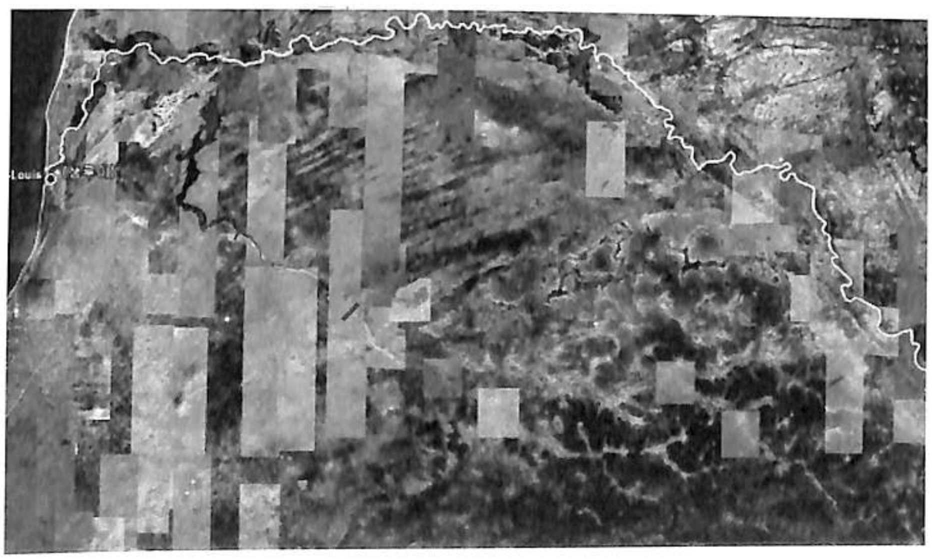
Objective

- River Water management and Flood Control
- Secure Irrigation water resources
- Domestic Water supply

Target

- 20 ~ 30 small dams and Irrigation system

★ Agricultural Development in Senegal



Small Dam, Small reservoirs, Water pond, Irrigation

★ Agricultural Development in Senegal

Small Dam, Small reservoirs, Water pond, Irrigation
Highway Construction

2. River Bank and land Consolidation

Objective

- **Protect low land from flood and storm surge**
- **Irrigated paddy field Development**
- **Increase agricultural productivity & transportation efficiency**
- **Guarantee stable & wealthy life with Rural Development**

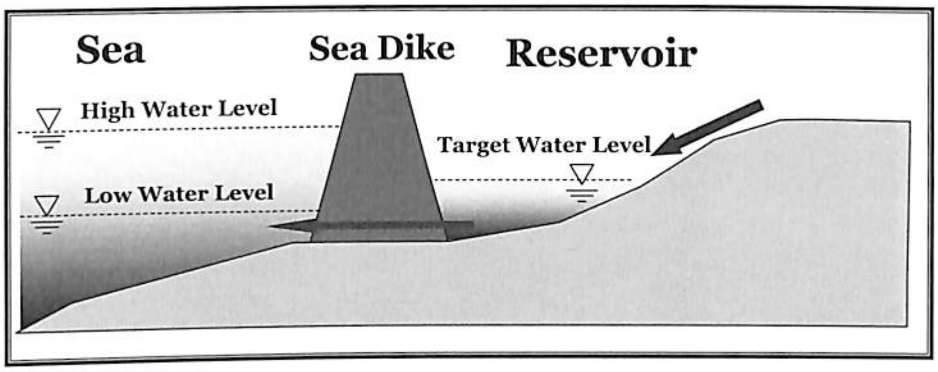
Target Area

A
- **Flood-affected area : 250,000ha**
- **Farmland Development : 200,000ha**

B
- **Flood-affected area in Casamance : 200,000ha**
- **Farmland Development : 155,000 ha**

Tideland Reclamation

Basic Concept of Tideland Recla

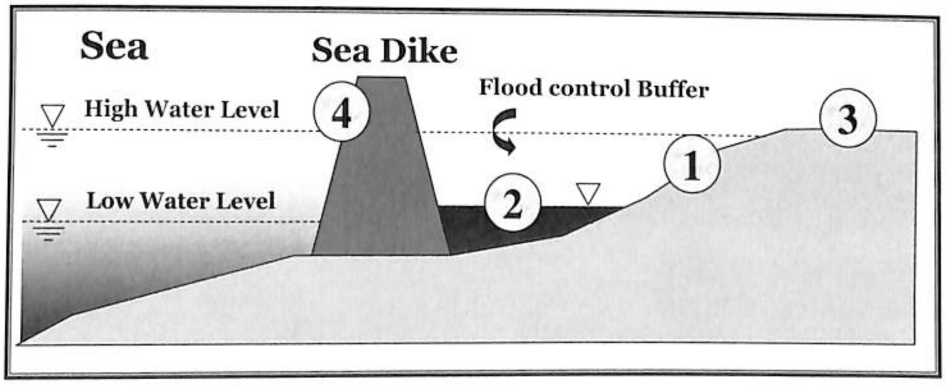


- Lowering the water level of inner reservoir

  ☜ **Discharge** if the water level of Reservoir > Sea
- Changing saline water into **fresh water** (reservoir)

Tideland Reclamation

Basic Concept of Tideland Rec



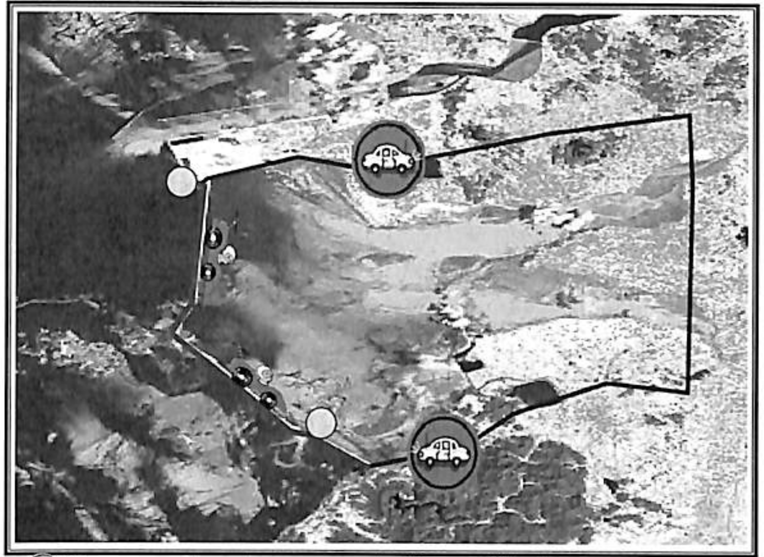
① New Land gained ② Water Resource (Fresh water)

③ Preventing inundation at low land

④ Protecting inland from storm surge

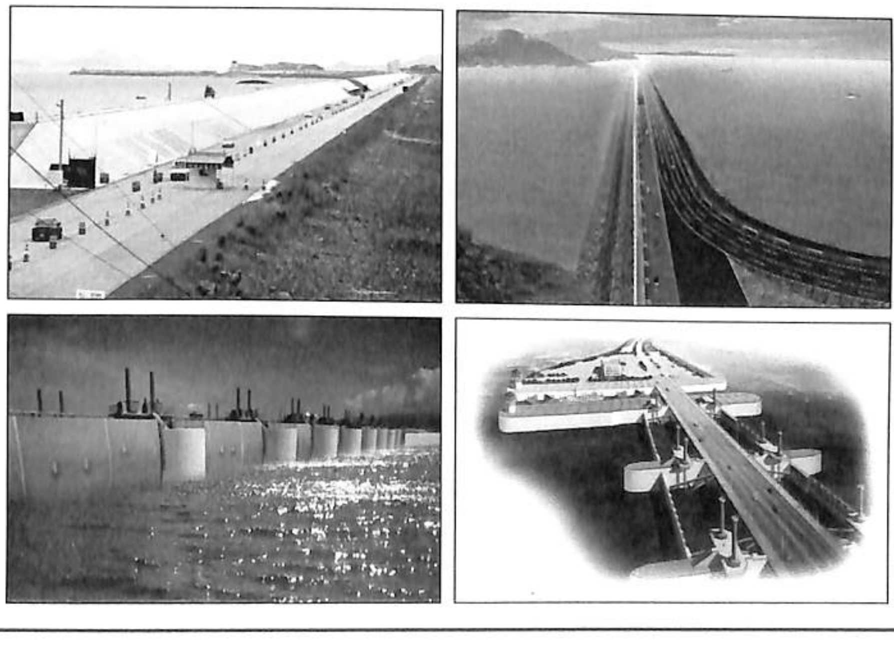
Tideland Reclamation

Basic Concept of Tideland Recla...



⑤ Improving transportation efficiency

Sample Model in Korea
(Saemangeum Project)



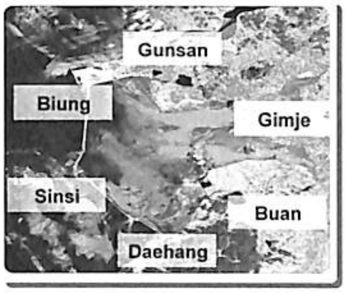
(Saemangeum Project)

1. Purposes

- Developing fertile farmland and industrial area
- Securing water resources
- Preventing natural disaster

2. What we do?

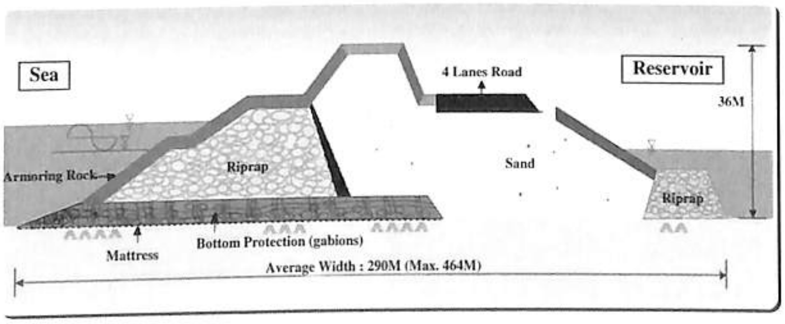
- Creating new land of 40,100 ha through constructing the sea dike of 33km in length at Saemangeum tideland
  - Catchment : 330,000ha
  - Reclaimed : 40,100ha
    - Land : 28,300ha
    - Reservoir : 11,800ha



(Saemangeum Project)

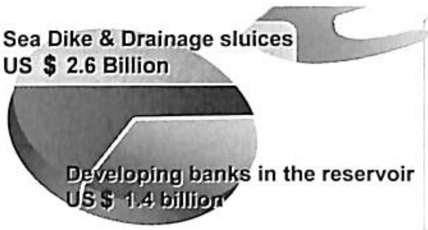
3. Major structures: Sea Dike

- Sea dike
  - Total length : 33km
  - Dike height : 36m(average)
  - Bottom width : 290m (max. : 464m)
  - Road : 4 lanes paved
  - construction materials: rocks, sand, and gabions



(Saemangeum Project)

4. Total cost : US$ 4.0 billion



Sea Dike & Drainage sluices
US $ 2.6 Billion

Compensation	Construction
US $ 0.5 billion	US $ 2.1 billion

5. Project period

1991 — 2008

Sea Dike & Drainage sluice : 1991~2008

Development inside: 2009~

(Saemangeum Project)

6. Expected outcome

VISIBLE EFFECTS

Land gained
40,100ha
(401 ㎢)

- Inland : 28,300ha (283 ㎢)
- Reservoir : 11,800ha (118 ㎢)

6. Expected outcome

VISIBLE EFFECTS

Fresh Water

- Total storage of reservoir : 535 mil. ㎥
  (10 bil. ㎥ is supplied for agriculture, industry and domestic use)

(Saemangeum Project)

6. Expected outcome

VISIBLE EFFECTS

Prevention of inundation at low land

- Protecting inland from surge and typhoon
- Preventing former farmed area of low land from inundation

(Saemangeum Project)

6. Expected outcome

VISIBLE EFFECTS

Road network enhanced tourism

- Improving transportation efficiency
- Role of fantastic resort for tourists & local people by linking land and scattered islands (estimated visitors after completion : 3.5 mil. persons annually)

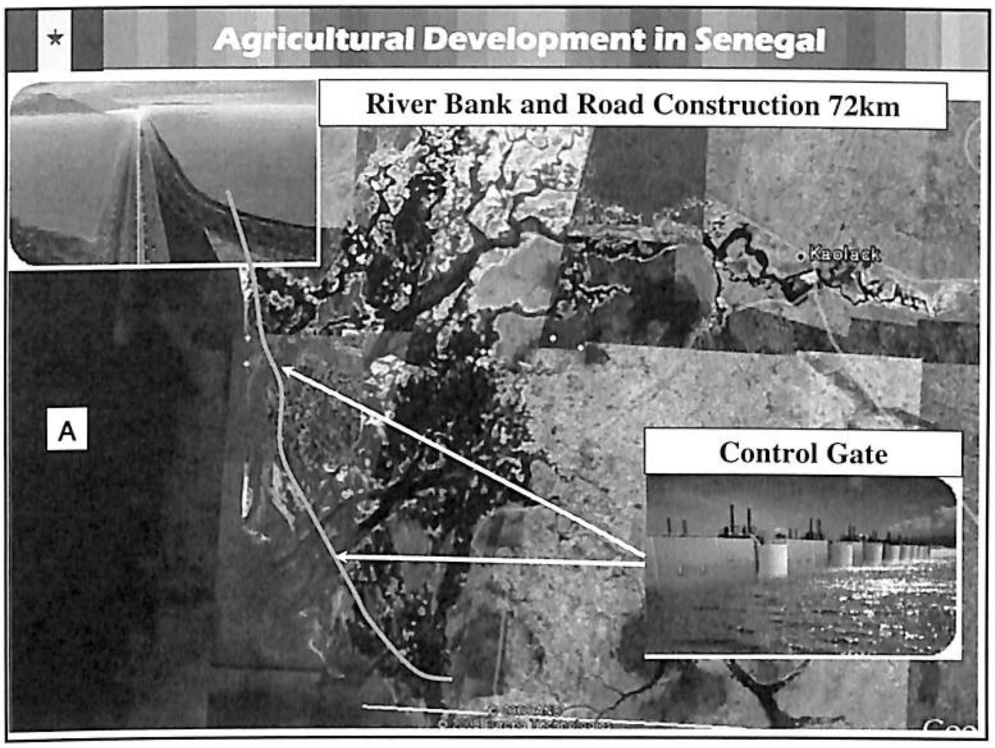
(Saemangeum Project)

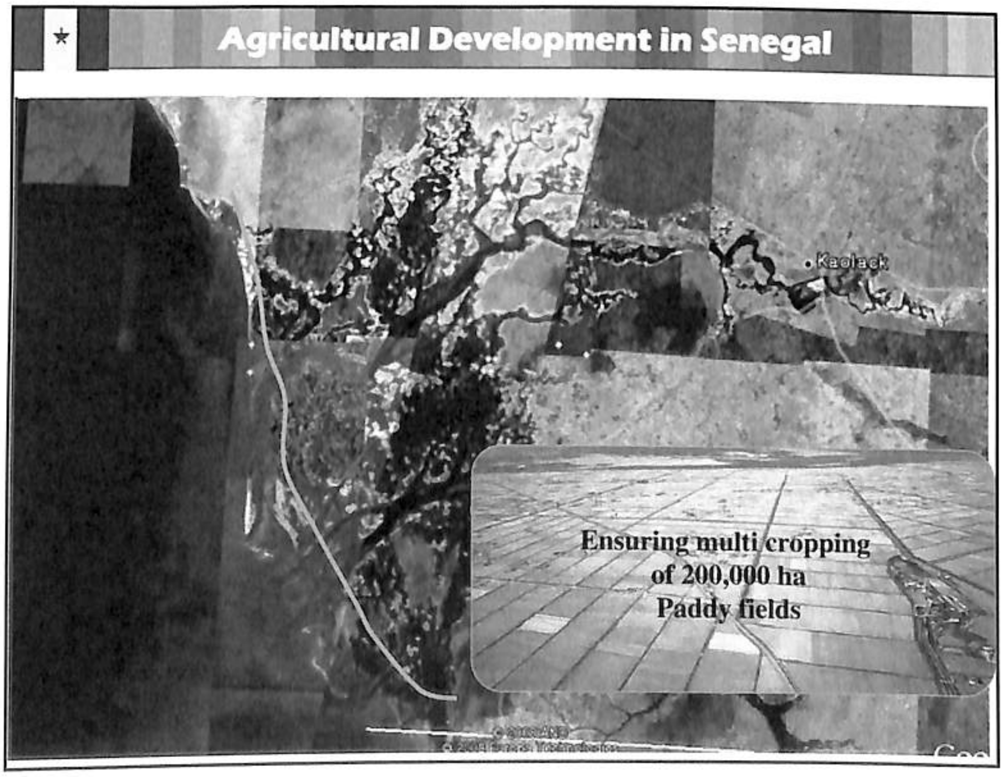
6. Expected outcome

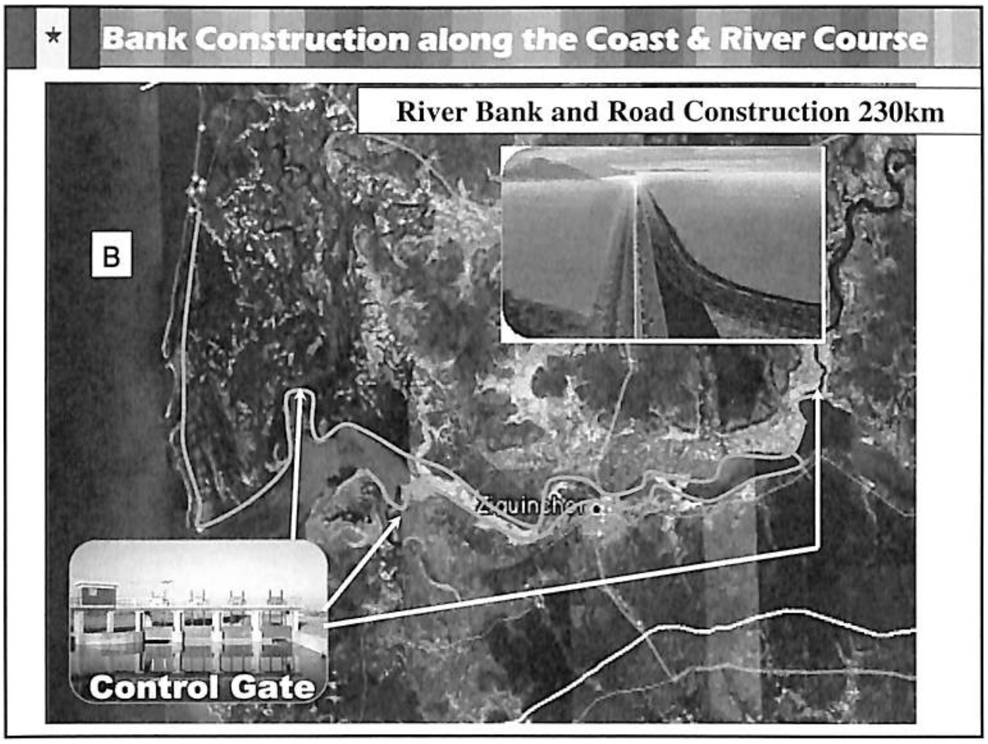
VISIBLE EFFECTS

Employment

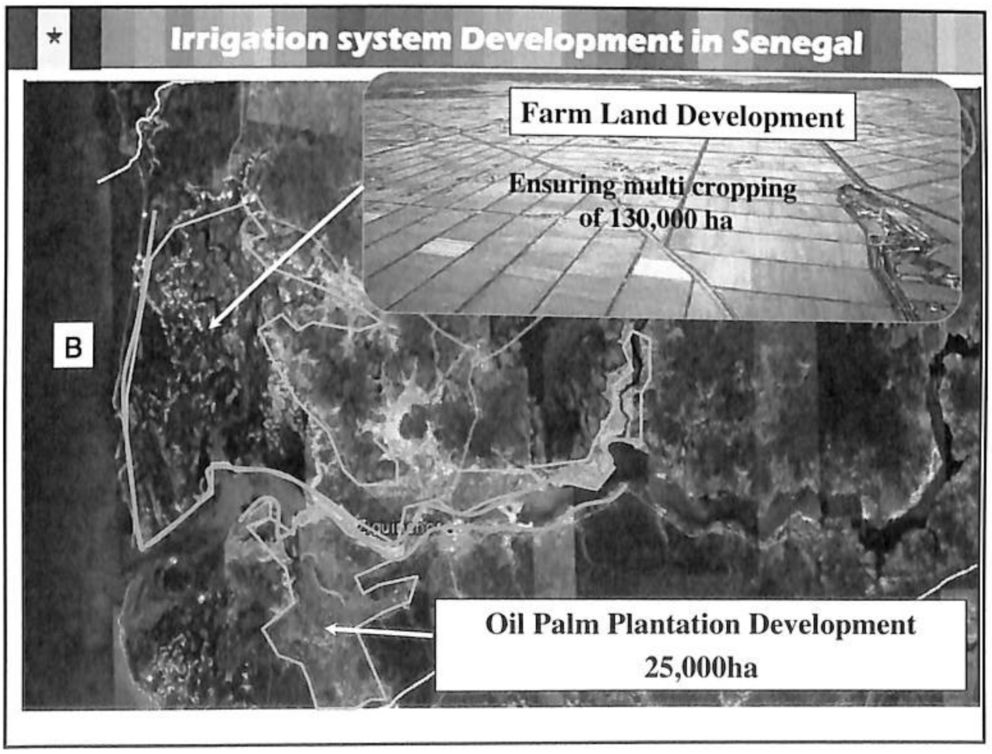
- Labour employment : about 13.4 million during construction stage


Agricultural Development in Senegal
River Bank and Road Construction 72km
Kaolack
A
Control Gate


Agricultural Development in Senegal
Kaolack
Ensuring multi cropping
of 200,000 ha
Paddy fields



★ Bank Construction along the Coast & River Course
River Bank and Road Construction 230km
B
Control Gate



★ Irrigation system Development in Senegal
Farm Land Development
Ensuring multi cropping of 130,000 ha
B
Oil Palm Plantation Development 25,000ha

Agricultural Development in Senegal

Irrigation System of 130,000ha

Agricultural Development in Senegal

Irrigation System of 400,000ha (Wheat, Maize)

★ Agricultural Development in Senegal

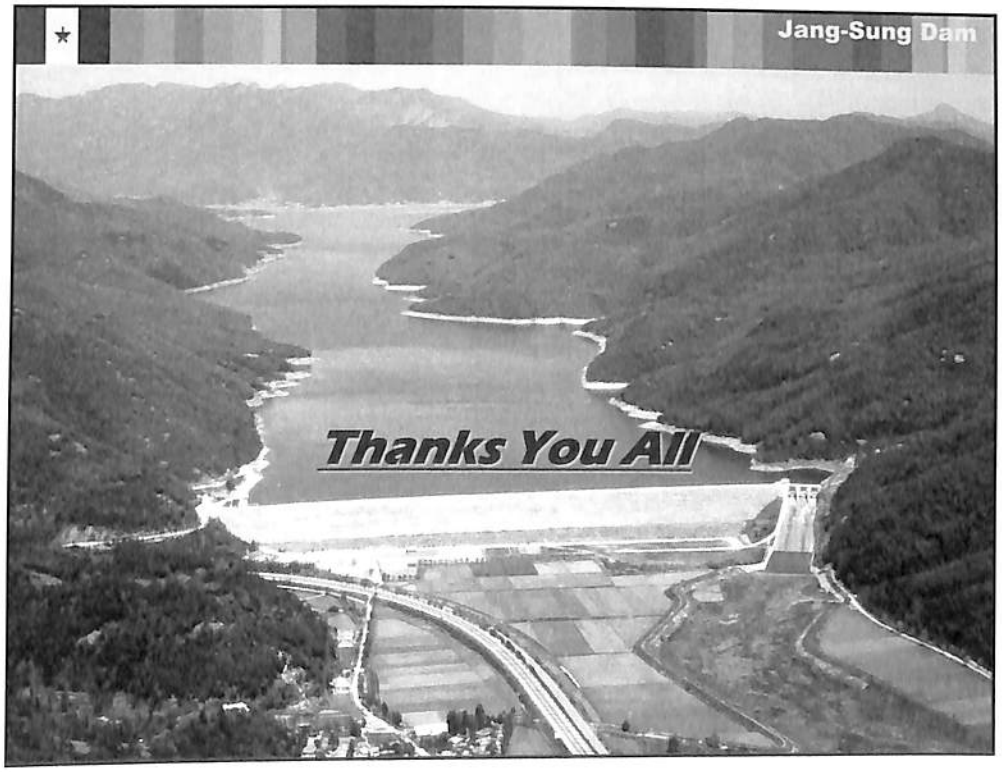
Missira 70 km x 70 km = 4,900km²

★ Agricultural Development, Senegal

1. Institutional Development
   - A. Farmers Training Center (Continuous Training)
     - a. Rural Development
     - b. Grain Cultivation
   - B. Agricultural Research Institute
     - a. New crop for High Quality, High Production
     - b. Pesticide
     - c. Food Processing
   - C. Farm Machine Training Center
     - a. Loan for purchasing farm machinery
     - b. Training
   - D. Farmer's Bank
     Farmer's Loan for farm land purchasing, Seeds, Fertilizer, Pesticide.
   - E. Farmers Extension
     Cooperative work in purchasing any inputs and marketing

6. Suggestion

Feasibility Study 2. Mil. US$ for each (A, B, C, D)	funded by KOICA or AfDB (1 Year/each)
Design & Construction 1. Bil. US$ for each (A, B, C, D)	funded by Government Source or Loan Application (ODA fund such as EDCF) (7 years/ each)

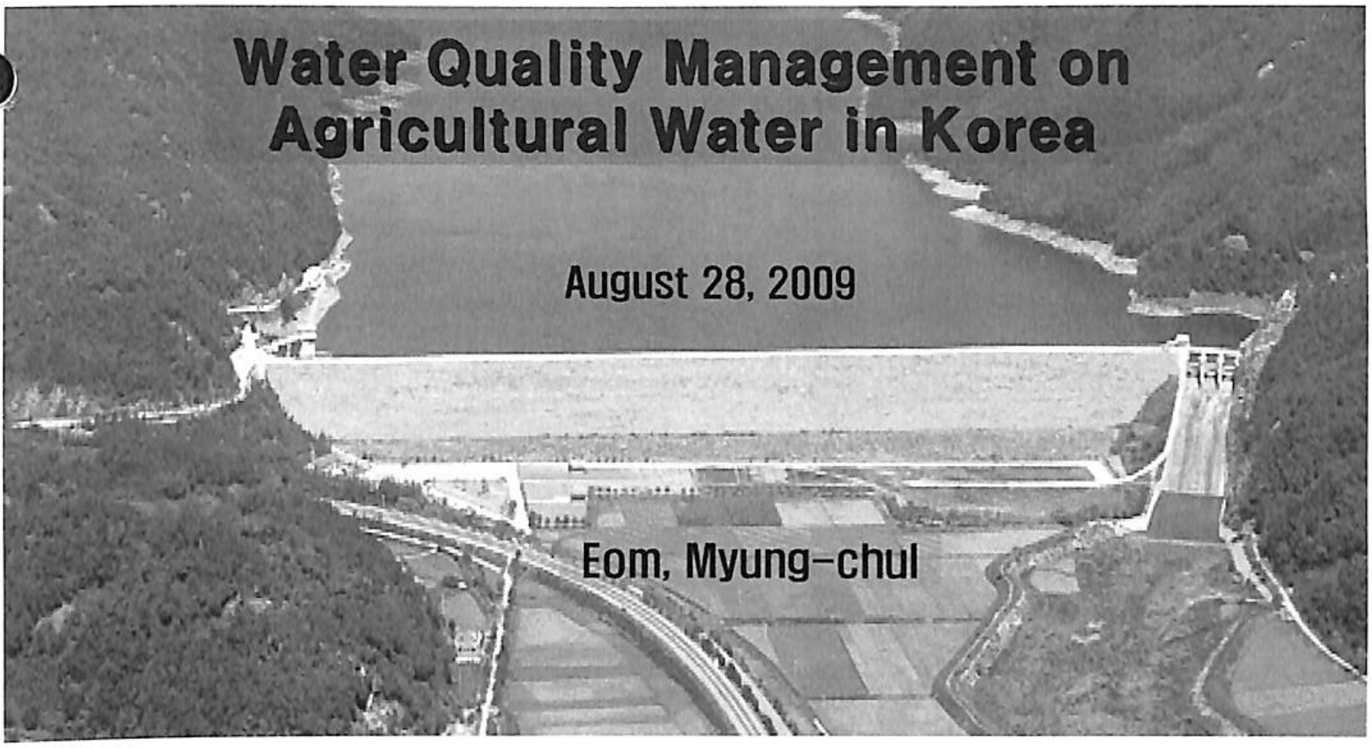


Water Resources Quality Management

Mr. Eum, Myeong-chul

Deputy Director

KRC



Korea Rural Community Corporation

Contents

1. Concept of water pollution

2. Water resources in Korea

3. Water pollution in agricultural water

4. Water quality management

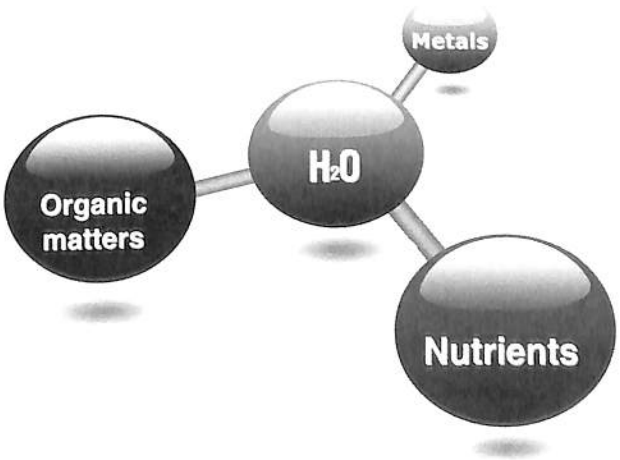
5. Strategy for water quality improvement

1. Concept of Water Pollution

1. Concept of water pollution

Water quality?

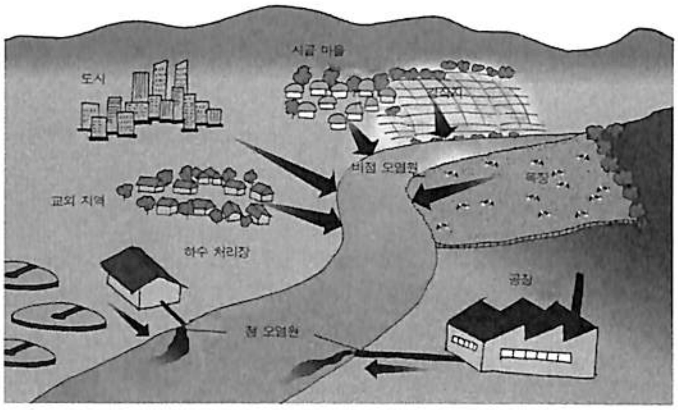
- Physical, chemical and biological characteristics of water
  - ❖ Caused by water containing various components



1. Concept of water pollution

Water pollution?

- Contamination of water bodies
  - ❖ Occurred when pollutants are discharged into water bodies without adequate treatment
- Damaging to human health or biological communities



1. Concept of water pollution

Causes of water pollution

Organic Pollutants
- Organic matters are discharged into water body
- Oxygen can be consumed during discompose
- ⇨ Gas, bad smell, decay, oxygen depleting

Heavy metals
- Source : Wastewater from company or mining
- Finally accumulated in human bodies
- ⇨ Minamata (mercury), Itai-Itai (cadmium), etc.

Inorganic matters
- It causes to eutrophication of lakes or oceans
- Nutrients : nitrogen, phophorus, etc.
- ⇨ Water bloom, decay

1. Concept of water pollution

Effect of water pollution

- Impaires plants or animals

<Withering of rice paddy by inflow of sewerage>

<Overturn of rice paddy by exceeding nitrogen fertilizer application>

1. Concept of water pollution

- Give unpleasant feelings

1. Concept of water pollution

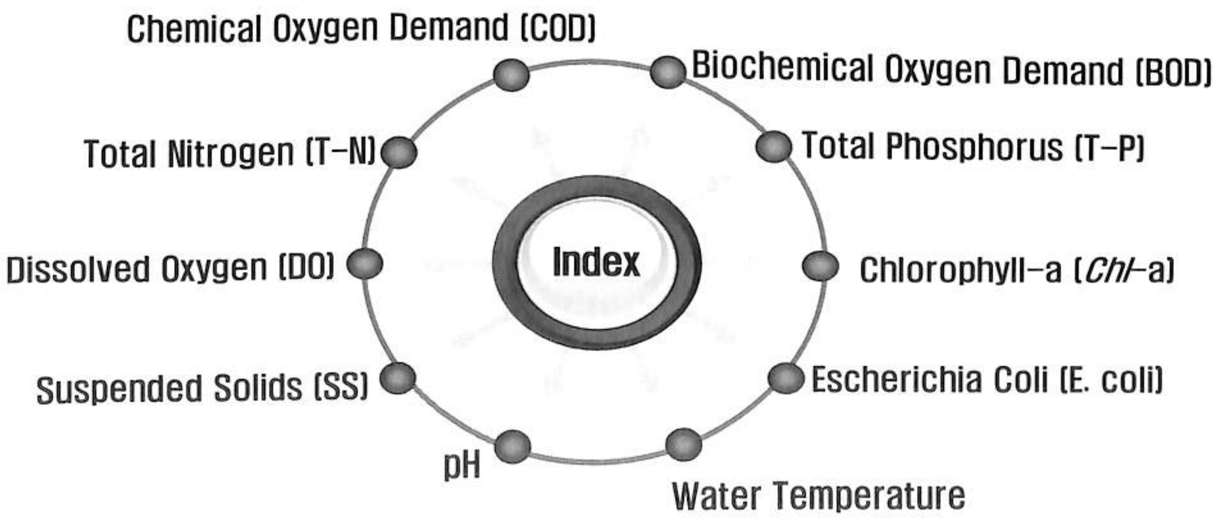
Cause to human health problem

<Minamata disease>

<Skin disease>

1. Concept of water pollution

Water quality index?



1. Concept of water pollution

- Water quality index related to human health

Heavy metals
- ✓ Cadmium (Cd)
- ✓ Mercury (Hg)
- ✓ Lead (Pb)
- ✓ Chrome (Cr^{6})
- ✓ Copper (Cu)

Light metals
- ✓ Arsenic (As)
- ✓ Antimony (Sb)

Nonmetal
- ✓ Cyanogen (CN)

- ✓ Volatile hydrocarbon

Organic phospohrus related Pesticide
- ✓ EPN
- ✓ Parathion

Others
- ✓PCB
- ✓ABS
- ✓DEHP

1. Concept of water pollution

What does water pollution cause?

Shortage of water resources

- Water shortage country (available rainfall in Korea is 1/8 of world average)
- Increasing water demand by urbanization or higher rates of water use
- Water resources are concentrated on specific region and season

Water pollution

↓

Acceleration of water shortage by cutoff resources

1. Concept of water pollution

The reason of water pollution

Increase human activities

Economic growth

Higher demand on natural resources

Industralization
- Industry, livestock, agriculture

Urbanization
- need more water
- create more pollutants

More pollutants from various sources

Water pollution by exceed natural self-purification

2. Water Resources in Korea

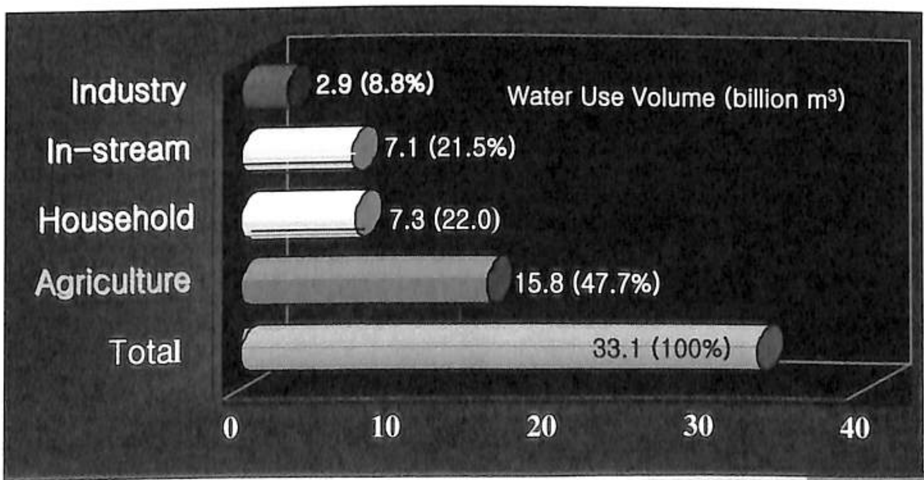
2. Water resources in Korea

- Korea is a densely populated country
  - 48 million population in less than 100,000 ㎢
- Rapid economic growth – environmental suffering
  - Restoration efforts over the last 20 years
  - Eutrophication problem yet to be improved
- TMDL started : 1st phase (2004 ~ 2010)
  - Unit load method, BOD
  - 2nd TMDL start from 2011, TN and TP included
- Monitoring from individual land uses needed

2. Water resources in Korea

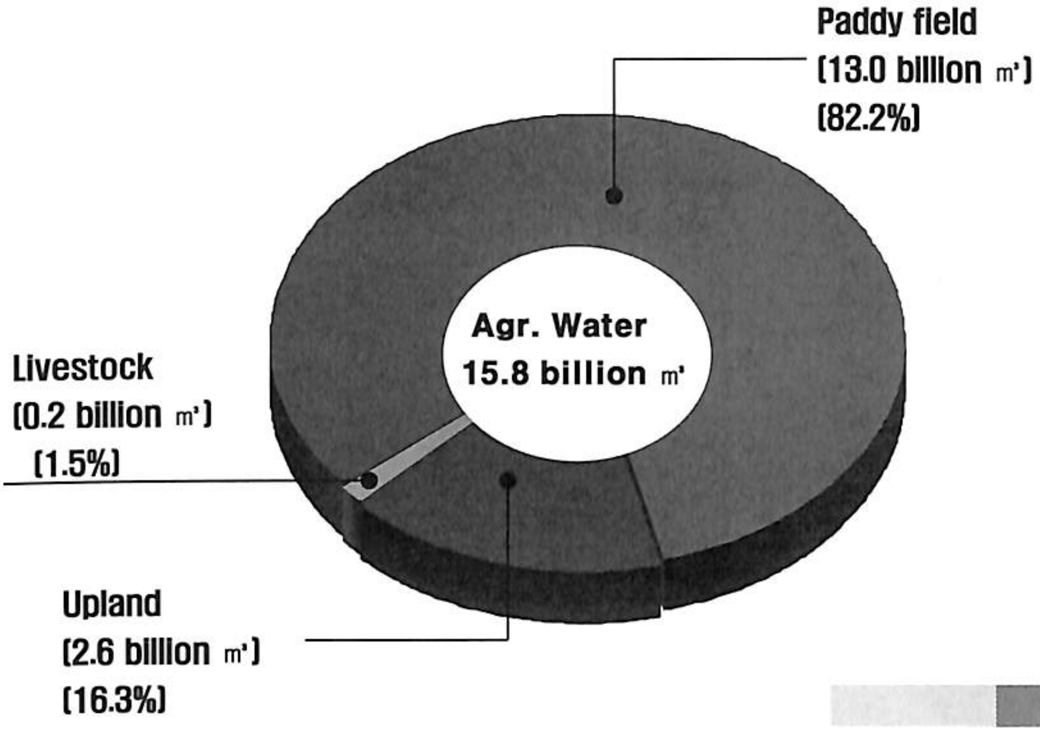
Current status of water resources and use in Korea

Total	Available water
128 billion m³/yr	33.1 billion m³/yr



2. Water resources in Korea

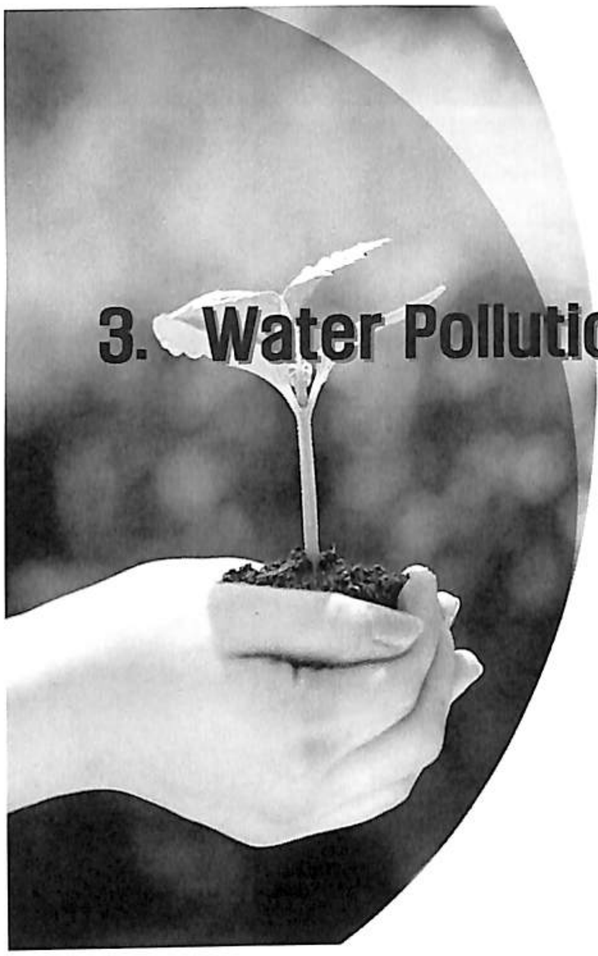
Current status of water use



2. Water resources in Korea

- Reservoirs and lakes supply 3.3 bn ㎥, or 21% of total agricultural use
  - ❖ Small stroage volume
  - ❖ Shallow depth
- Sewage system in rural area is about 22% in 2004

Vulnerable to water pollution



3. Water Pollution in Agricultural Water

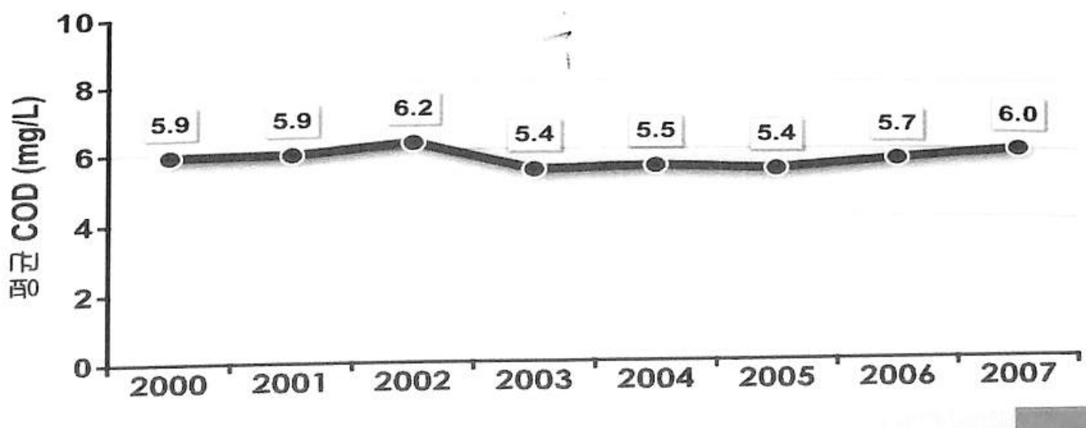
3. Water pollution in agricultural water

Current status of agricultural water quality

- The level of agricultural water quality (2007)

Number of facility	Ia	Ib	II	III	IV	V	VI
492 (100%)	- (-)	33 (6.7)	104 (21.1)	86 (17.5)	168 (34.2)	56 (11.4)	45 (9.1)

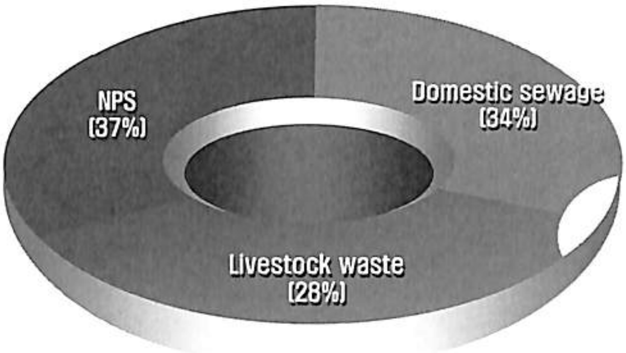
- Yearly variation



3. Water pollution in agricultural water

Pollution sources

- Main pollution sources on agricultural reservoirs
  - ❖ BOD: Domestic (34%), Livestock (28%), NPS (37%)
  - ❖ Nonpoint source (TN 70%, TP 56%) contribute to pollution on the reservoirs



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3. Water pollution in agricultural water

- Pollution sources on polluted reservoirs
  - ❖ Domestic 61.3%, Livestock 36.3%, NPS 2.5%
- Install rate of sewage treatment facility in rural area
  - ❖ Rural area : 21.9% (Nationwide 81.4%)

kr

3. Water pollution in agricultural water

Nonpoint source pollution

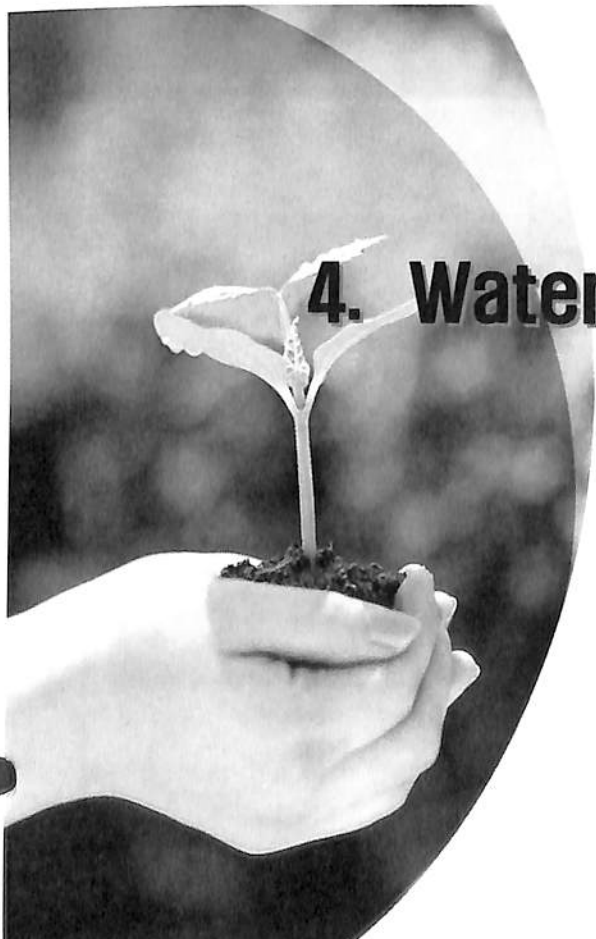
- Nonpoint source pollution (NPS)
  - Water pollution from diffuse or many different sources
  - With no specific solution to rectify the problem and difficult to control
  - To enter water body during rainfall
  - From agriculture, forestry, urban area, road, CSOs, etc.
- Agriculture is a major source of NPS pollution
  - Paddy : 60.7% of agricultural land (1.8 M ha in 2004)
  - Upland and others : 39.3% of agricultural land

3. Water pollution in agricultural water

NPS pollution in rural area

- NPS sources in rural area
  - Pesticide/herbicide : residuals after use
  - Livestock waste : field pile,
  - Forestry : Construction of forest road, fallen leaves
  - Sewage : Low installation rate of sewage treatment
  - Sediment : reclamation, farmland in mountainous area

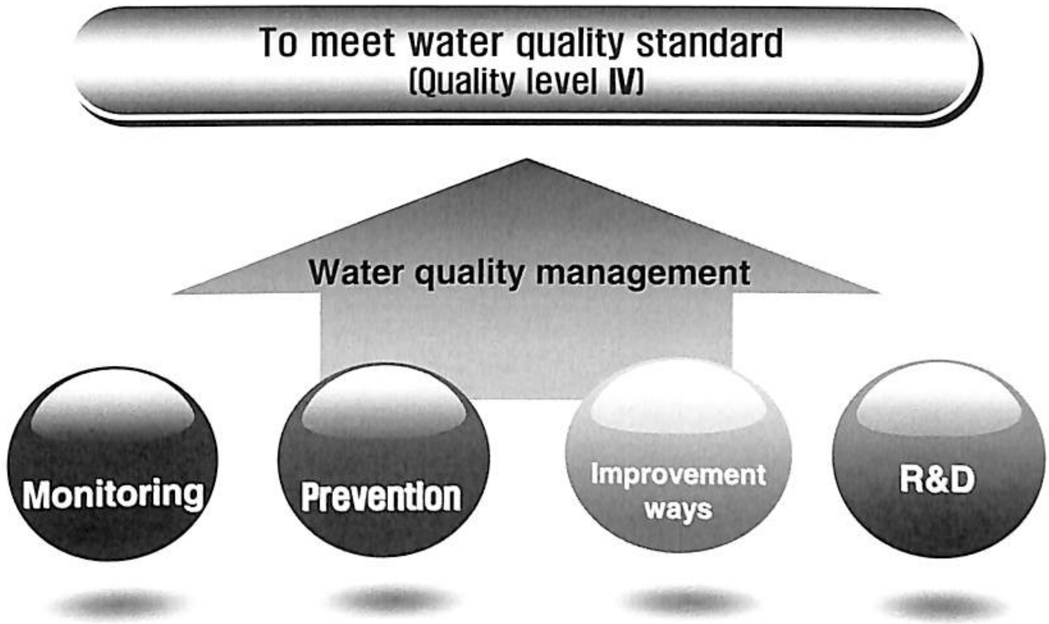
3. Water pollution in agricultural water



4. Water quality management

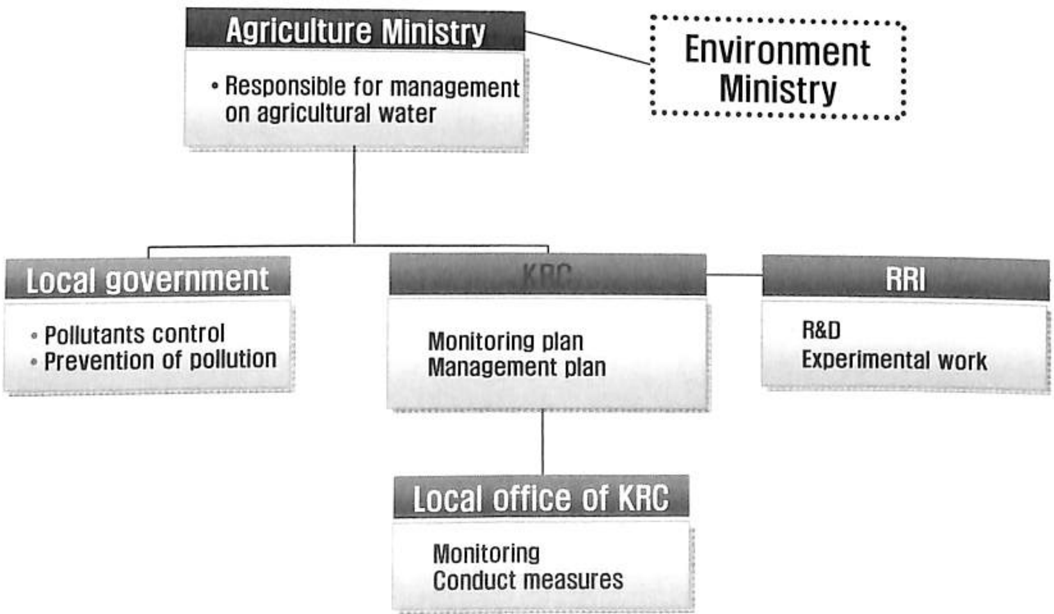
4. Water quality management

Aim of water quality management



4. Water quality management

Administrative system for agricultural water quality



4. Water quality management

Water quality monitoring

Purpose

- ❖ Fundamental way to control water quality
- ❖ To check the situation and find pollutant source
- ❖ Used as basic information to build measurement

Methods

- ❖ Network survey: regular monitoring on main reservoirs every year
- ❖ Comprehensive investigation : Reservoirs except the network

4. Water quality management

Water quality Monitoring

Network survey

- **500 agricultural reservoirs**
- **Frequency** : 4 times a year
- **Surveyor** : KRC
- **Investigation**

1) Water quality : 16 parameters

On-site (5)	WT, pH, EC, DO, BOD
Lab. analysis (11)	COD, T-N, T-P, SS, Chl-a, Cl Cadmium, Pb, Hg, As, Cu

2) Pollutant loads

Number of source, Treatment method

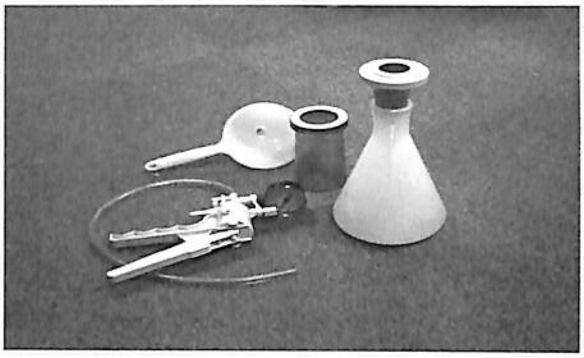
Treatment facilities, etc.

Comprehensive investigation

- **17,600 reservoirs and 400 irrigation/drainage pump station**
- **Frequency** : Biennial tous les 2 ans.
- **Surveyor** : KRC
- **Water quality** : 7 parameters

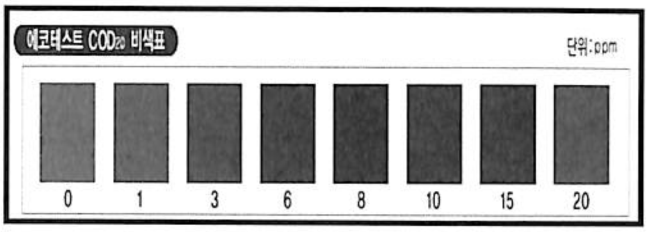
- pH, EC, COD, T-N, T-P, SS, Cl^-
- Simple test on sites

4. Water quality management



〈Transparency plate〉

〈SS filtering set〉



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4. Water quality management

Water quality improvement project

Background

- Many kinds of project established in 1998 by appointing 24 reservoirs and fresh water lakes nationwide
- Polluted rate of agricultural water exceed 30 to 40% within the network reservoirs in 1990s

No. of units in excess / No. of the agricultural water quality survey network

Time period	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
No. of unit (%)	63/150* (42.0)	61/161 (37.9)	44/186 (23.7)	75/336 (22.3)	91/436 (20.9)	85/492 (17.3)	114/492 (23.2)	78/492 (15.8)	80/492 (16.3)	81/492 (16.5)

4. Water quality management

- Pollutants reduction at paddy fields

부표식 자동물꼬

마개식 자동물꼬

볼을 이용한 자동물꼬

소형 전동기를 이용한 자동물꼬

Automatic drainage outlet

a) 과햇 배수물

Modified drainage outlet

Automatic water supply system

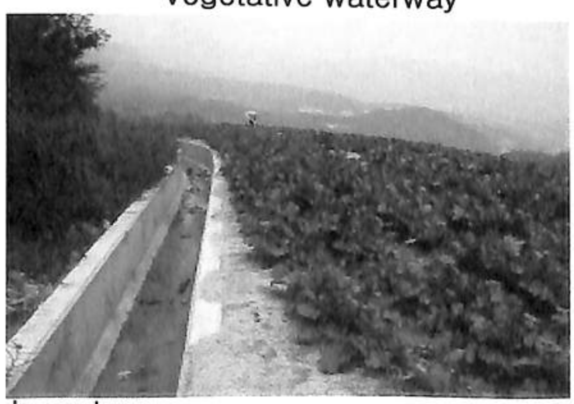
Management of drainage from paddy field

4. Water quality management

- Soil loss conservation at upland

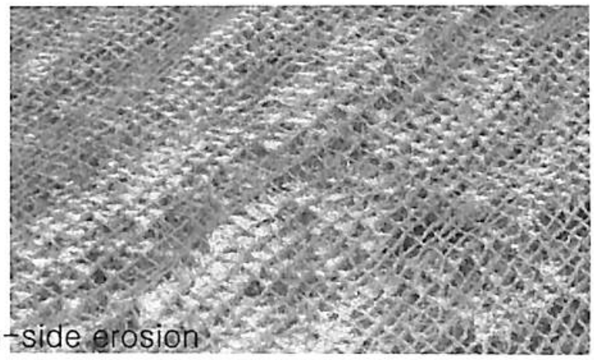
Vegetation

Vegetative waterway



Water supply system

4. Water quality management



Measure on slope-side erosion

Vegetative belt and waterway

4. Water quality management

- Artificial wetlands

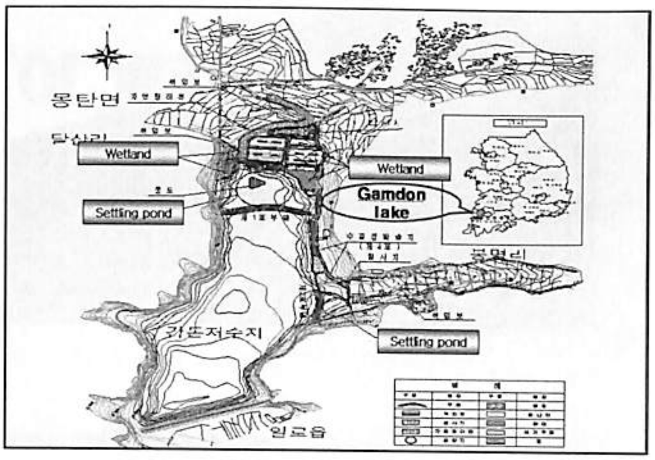
Wetlands by KRC

Location	Target	Area (m²)	Cost ($/m²)	Operation period
Mansan	NPS, Reservoirs	2,800	73	'99~'06
Seokmun	Irrigation and dralage wager	44,000	45	'02~'10
Gamdon	Stream water/Storm water	80,040	24	'04~'06

4. Water quality management

Gamdon Reservoir project

- Location : Gamdon reservoir in Muan, South Jeolla prov.
- Reservoir storage : 1.7 million ㎥
- Irrigation area : 384 ha
- 1999~2000 : Monitoring and facility design
- 2001~2003 : Operation of the facility
- 2004~2006 : Monitoring



4. Water quality management

- Pollutants reduction rate
  - ❖ Effect of implementation of water quality improvement project in the Gamdon Reservoir

Item (mg/L)	Starting of the project (2001) (A)	Goal of the water quality (B)	2006 (C)	Rate of the goal achievement* (%)
COD	12.5	8.0	8.1	97.8
T-N	2.08	1.00	1.98	53.1
T-P	0.18	0.10	0.07	132.9

* Rate of the goal achievement = {1-(B-C)/(A-C) x 100(%)

5. Strategy for water quality improvement

5. Strategy for water quality improvement

Future strategy

- Water quality condition getting worse
  - Pollutants increase due to urbanization
  - Global warming caused much rainfall, severe hot or cold weather

- Water quality management focus on
  - Reduction of NPS pollutants by enforcing control on pollution source
  - Water bloom control in reservoirs
- Improvement measures focus on eutrophication control in reservoirs
  - Reduction of nutrients in nitrogen and phosphorus
  - Promotion of water flow within water body of reservoirs

5. Strategy for water quality improvement

Strengthen monitoring

- Infrequent survey
  - Just 2~4 times a year survey the network reservoirs for agricultural use
  - Environment ministry monitor water quality once a month

⇒ Low reliance of survey data

- Increase number of network survey
  - 500 sites ⇒ 800 sites
  - Winter season monitoring added
- Increase project areas
  - 53 areas will be conducted by 2013
- To develop measures on sediment management in bottom regions of reservoirs

5. Strategy for water quality improvement

Administrative system

- Separate water quality management system
  - Pollutants management for upstream area : Environment Ministry
  - Management for agricultural reservoirs : Agriculture Ministry

⇒ Ineffective management

- Joint efforts established
  - A joint team organized by 4 related agencies in Aug. 2006
  - Monitoring sites for polluted lakes increased to 72 units
  - Setup of measures on water quality improvement according to result of investigation
  - Make plans for reducing pollutants in upstream area and on lake

5. Strategy for water quality improvement

Administrative system

- Innovation of agricultural water quality management system
  - ❖ Make a joint guideline for the water quality improvement between Environment ministry and Agriculture ministry
    - Roles of government and local residents
    - What do for water quality management
  - ❖ Organize central and local committee
    - Central committee: Prepare strategy, guideline, and long-term plan
    - Local committee: Monitoring pollution action and education & campaign

5. Strategy for water quality improvement

Research and development

- Research and development
  - ➢ Research and development on measures for water quality improvement are necessary

- Government plans to establish water quality management center for lakes

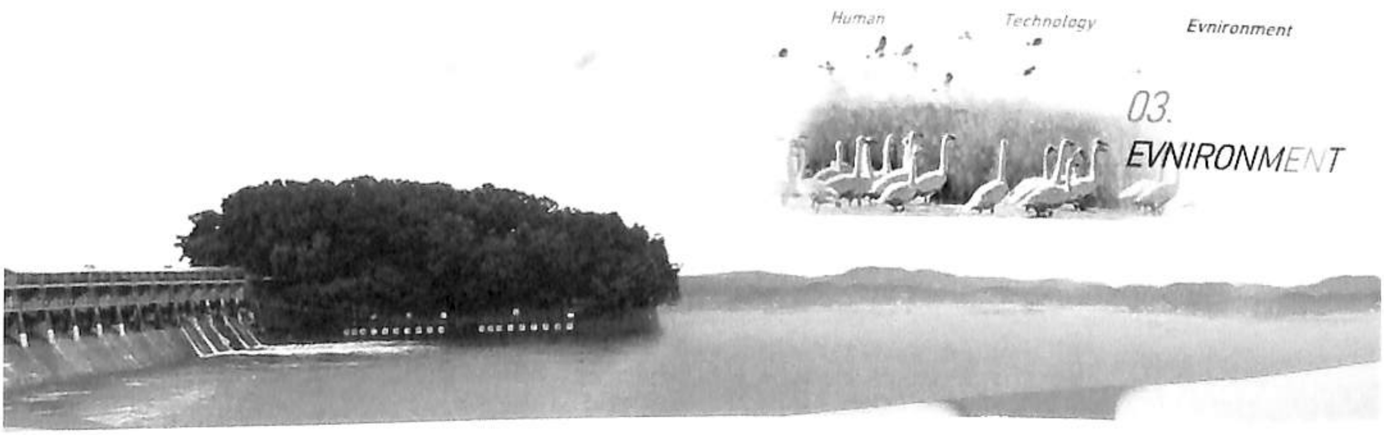
5. Strategy for water quality improvement

Conclusion

- Agricultural water quality management system must be changed to a collaborative system with related agencies and local residents
- Water quality improvement for lakes can be more effective when both upstream and in−lake measures would be done simultaneously
- More polluted lakes should be in priority for improvement projects
- Lakes with increasing population and large−scale lakes should be managed as a precaution

Thank you for your kind attentions

***KRC** is a public enterprise that carries out a rural improvement project, manages overall rural infrastructures, increases agricultural productivity by promoting the optimization of farming scale, and contributes to the economical and social development of rural areas*



Water Quality Management on Saemangeum Tidal Reclaimed Area

August 28, 2009

Eom, Myung-chul

Korea Rural Community Corporation

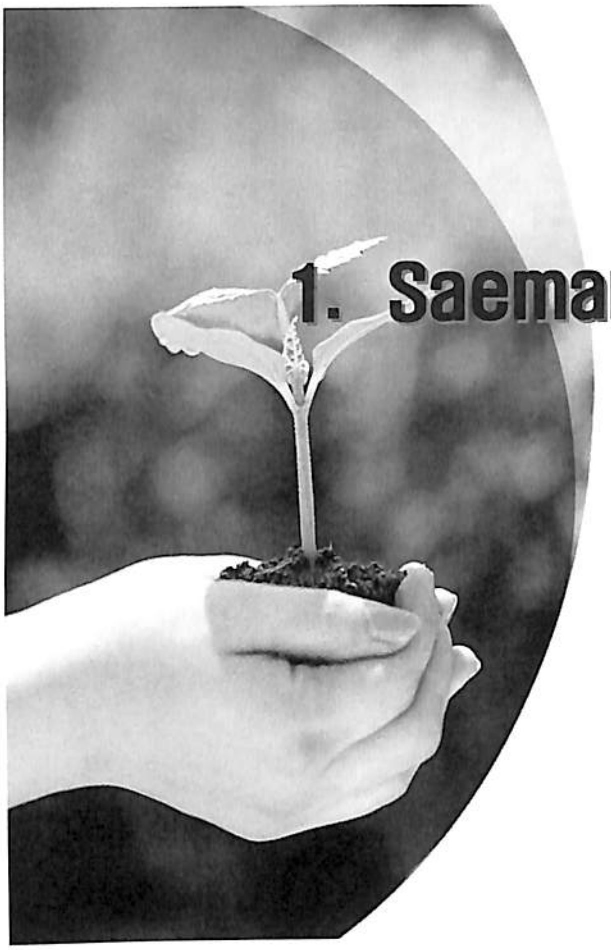
Contents

1. Saemangeum project

2. Measures on water quality conservation

3. Water quality improvement plan

4. Water quality prediction on future lake

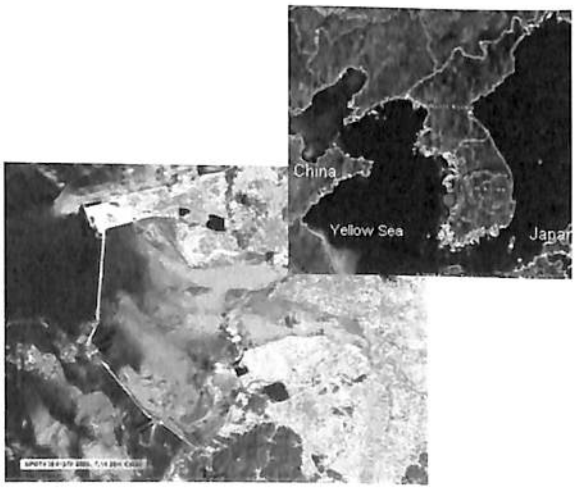


1. Saemangeum Project

1.1 Saemangeum Project Outlook

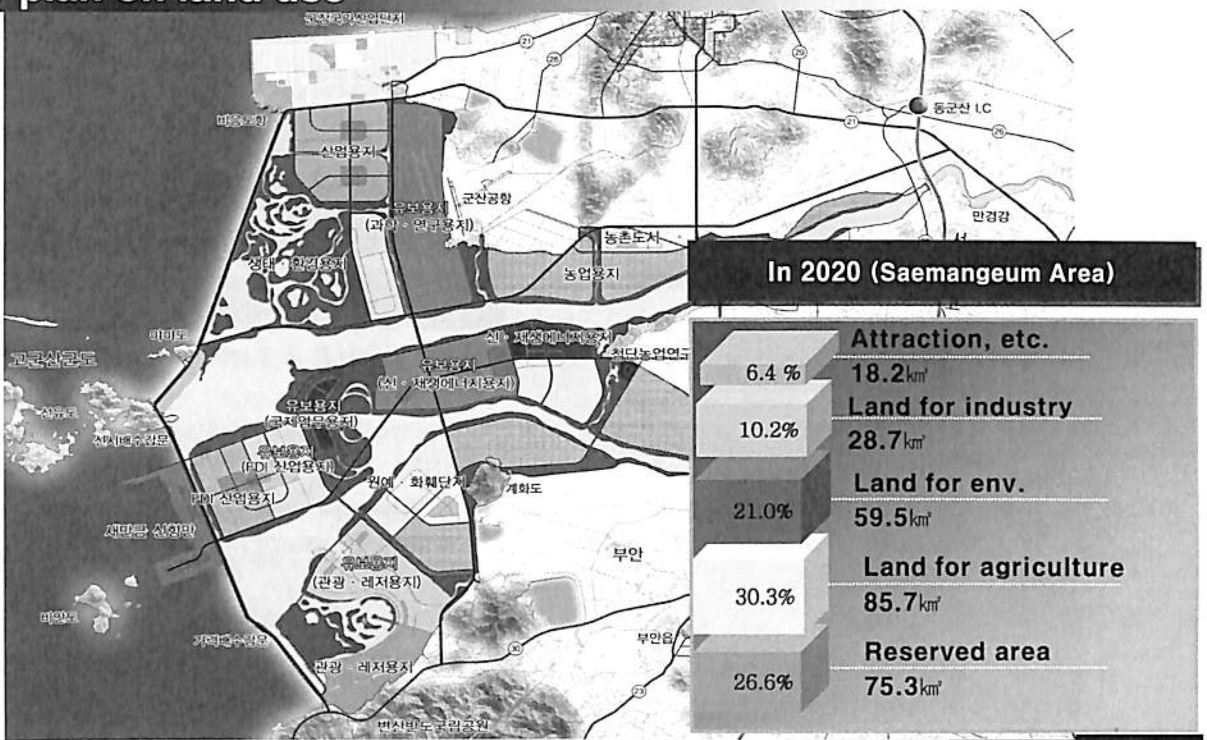
Project overview

- Total Area of Development : 40,100ha
  - Land 28,300 ha
  - Freshwater reservoir 11,800 ha
- Project Period
  - Sea-wall construction 1991~2009
  - Inside development starts on 2009
- Main Facilities
  - 33km of sea-wall
  - 2 sites of sluices
  - 138km of inside embankment



1.1 Saemangeum Project Outlook

Master plan on land use

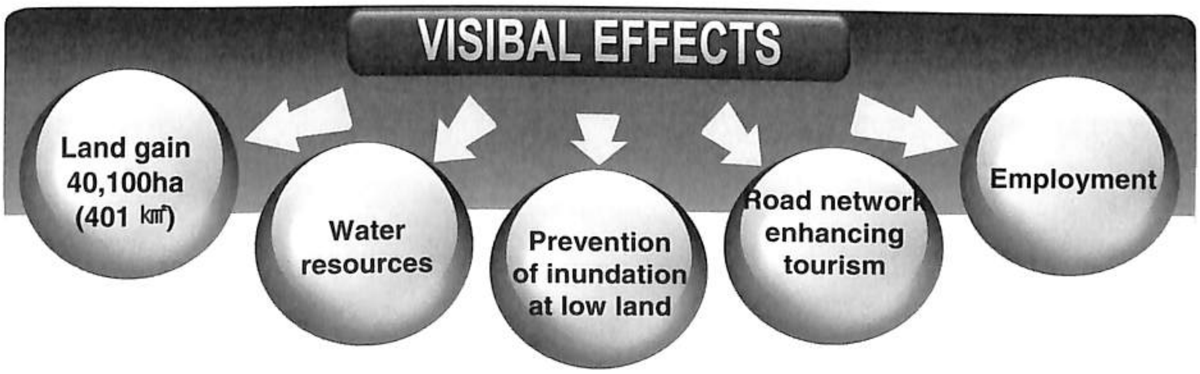


In 2020 (Saemangeum Area)

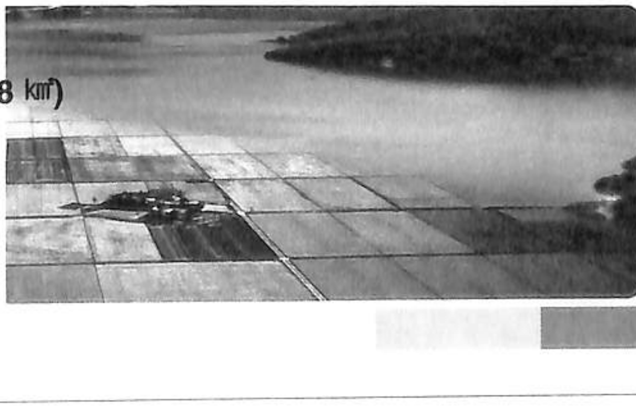
6.4 %	Attraction, etc.	18.2㎢
10.2%	Land for industry	28.7㎢
21.0%	Land for env.	59.5㎢
30.3%	Land for agriculture	85.7㎢
26.6%	Reserved area	75.3㎢

1.1 Saemangeum Project Outlook

Expected outcome

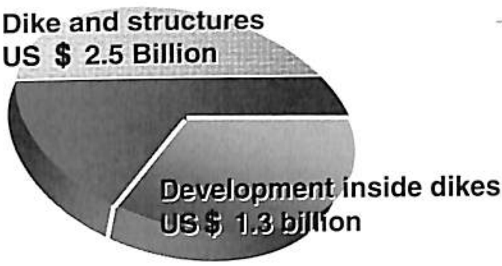


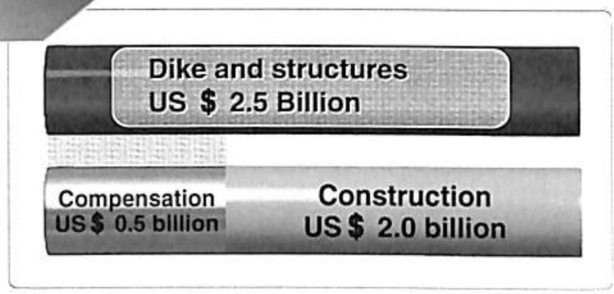
- Land : 28,300ha (283 ㎢)
- Reservoir : 11,800ha (118 ㎢)



1.1 Saemangeum Project Outlook

Total cost : US$ 3.8 billion

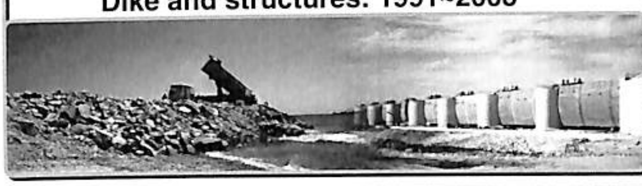




Project period

1991 2008

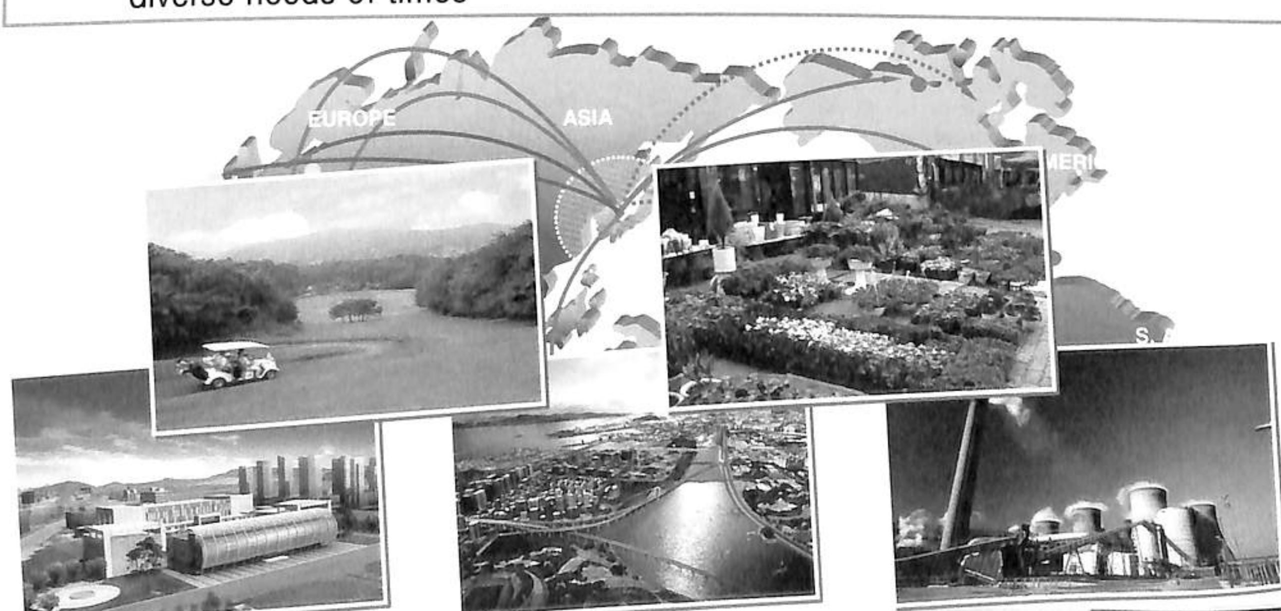
Dike and structures: 1991~2008 | Development inside: 2009~



1.1 Saemangeum Project Outlook

Future Plans

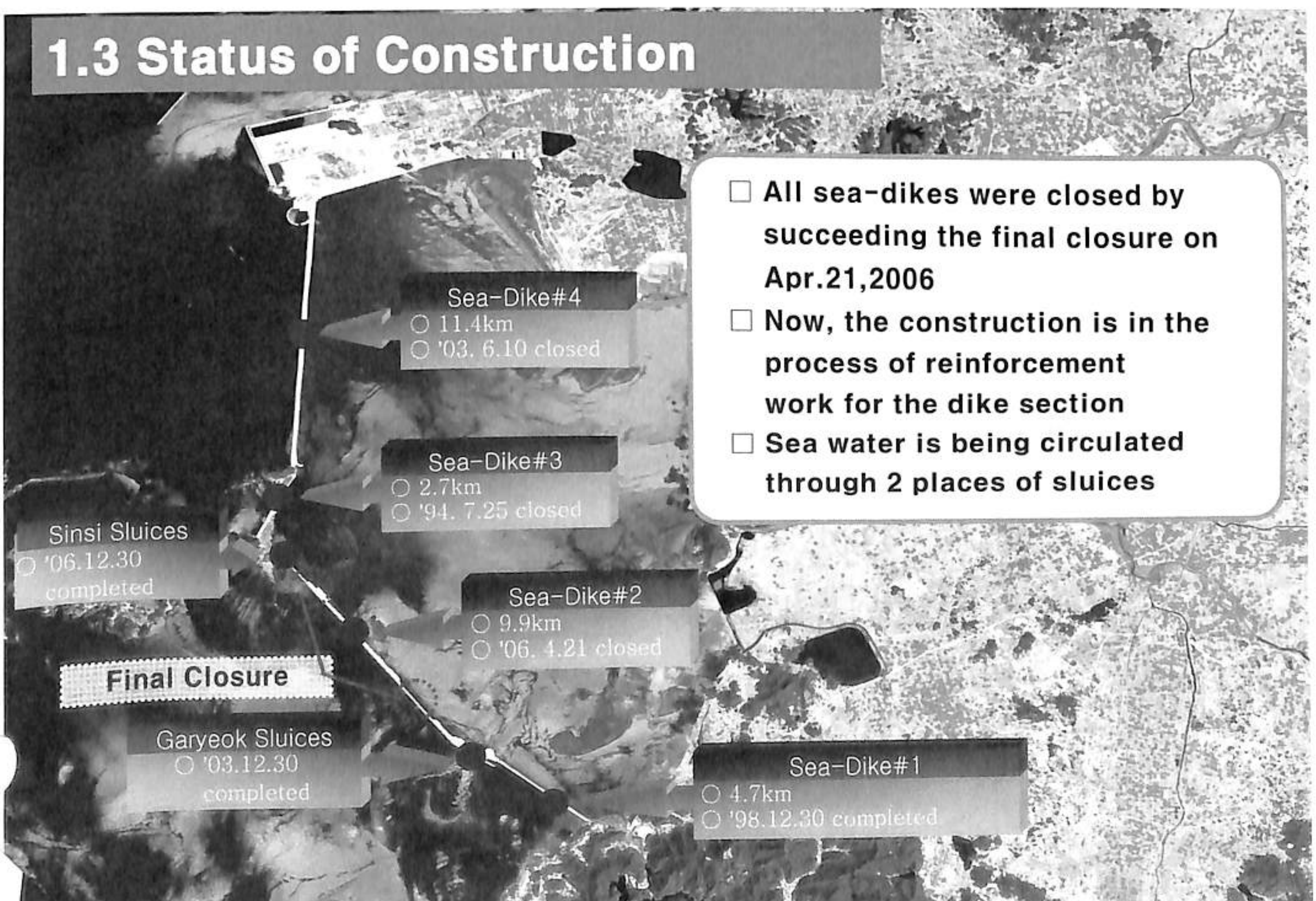
- Saemangeum will be developed as
  - Northeast Asian Economic Hub and Global Free Economic Zone to meet diverse needs of times



1.2 History of Project

- 1986~1991: feasibility study and EIA
- 1989.11: Detailed design and government approval
- 1991.11: commencement of construction works
- 1994. 7: Dike No.1 & 3 completed
- 2003. 6: Dike No.4 completed
- 2006. 4: Final closure for all sides
- 2006. 4~2009.12: Dike completion
- 2008.10: Final decision on land use plan

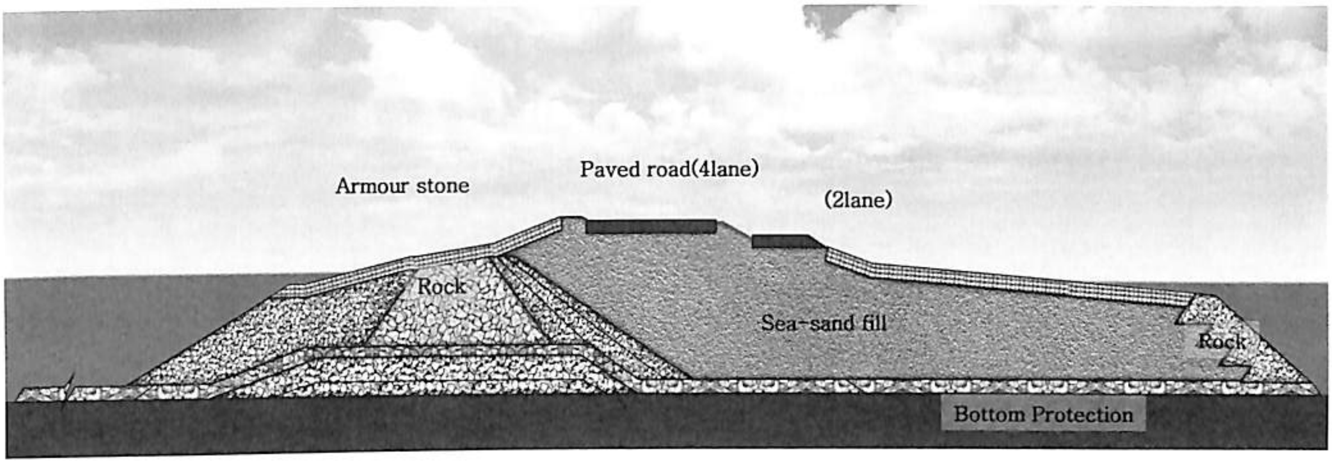
1.3 Status of Construction



- ☐ All sea-dikes were closed by succeeding the final closure on Apr.21,2006
- ☐ Now, the construction is in the process of reinforcement work for the dike section
- ☐ Sea water is being circulated through 2 places of sluices

1.4 Main Facilities

Sea-Dike : 33km



- Height : 36m in average
- Width : 290m in average(464m in maximum)

1.4 Main Facilities

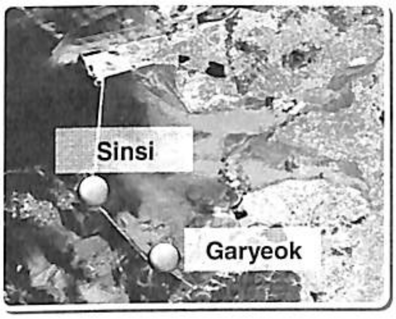
Discharge Sluice Gates

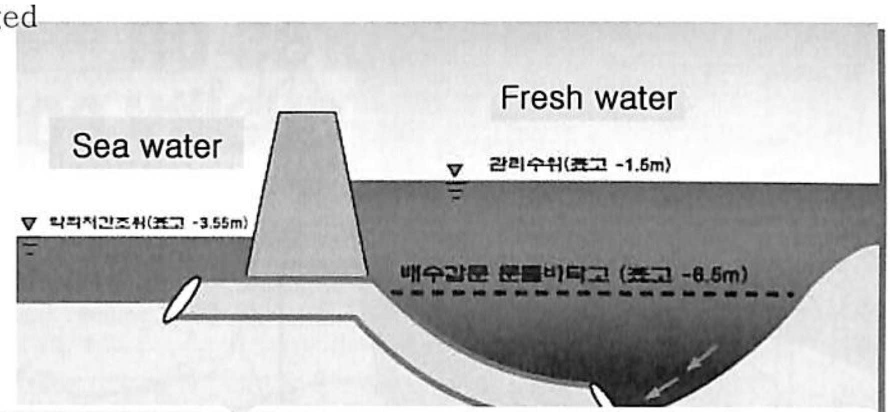
- Two gates(Garyuk, Sinsi)
- Number of gates : Garyuk 8 pairs, Sinsi 10 pairs
  - Specification : Width 30m, height 15m, weight 500 ton per gate

1.4 Main Facilities

Bottom water drainage facilities

- Pipe installed, submerged

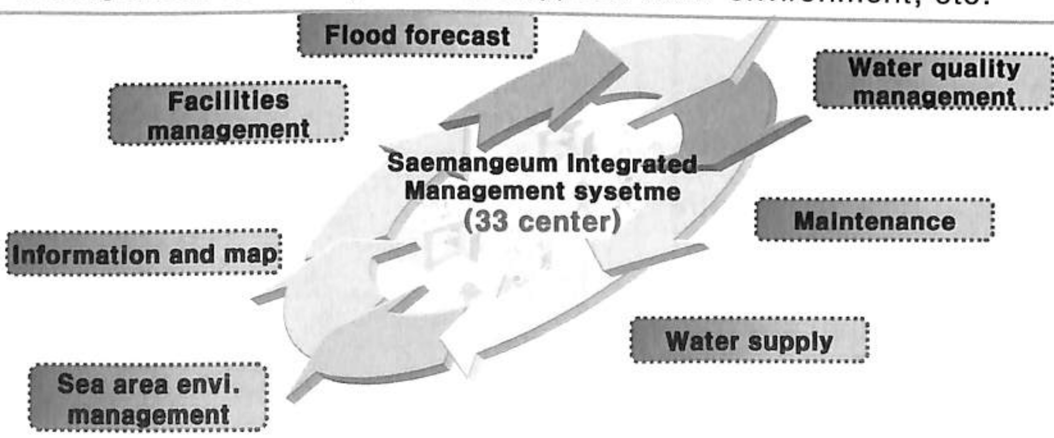




1.4 Main Facilities

Integrated management system

- Established integrated management system
  - ❖ Maintenance for sea−dike and sluice gates
  - ❖ Management for flood, water quality, sea water environment, etc.



Expection

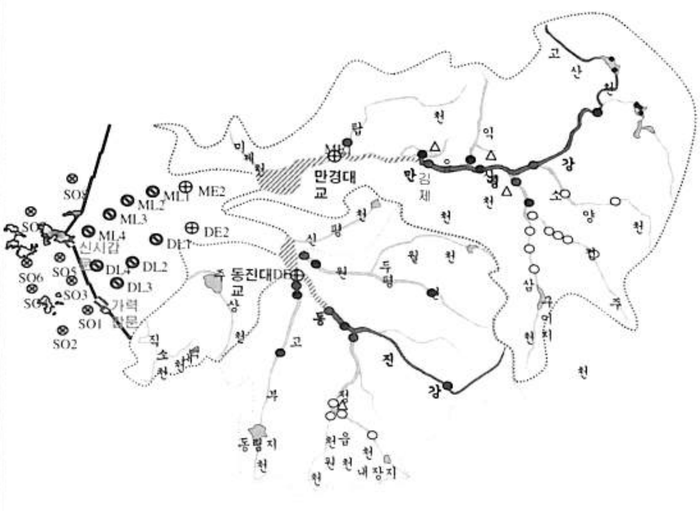
Prevention from disaster and effective maintenance

2. Measures on water quality conservation

2. Measures on water quality conservation

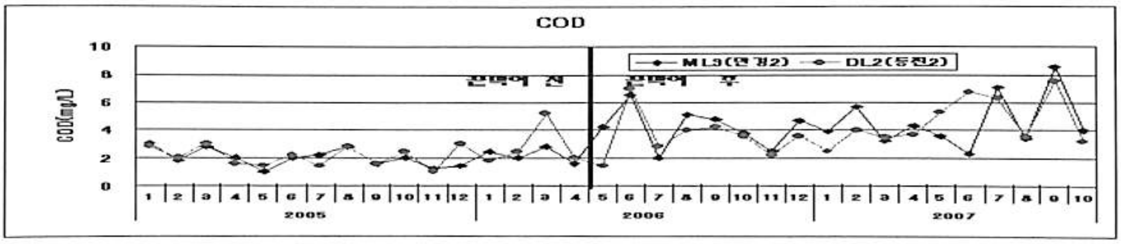
Water quality monitoring

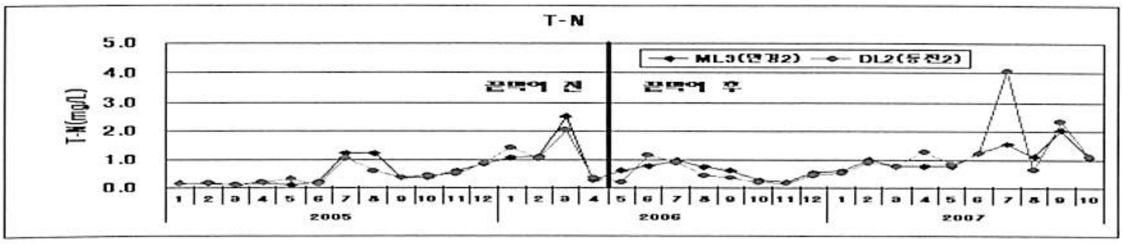
- Monitoring network : 62 sites
  - Upper rivers : 42 sites (Environment Ministry and local government)
  - Lake area : 12 sites (KRC)
  - Seawater area : 8 sites (KRC)
- Frequency : once per month
- 10 variables are measured
  - Water temperature, salinity, pH, COD, NH3, NO3, TN, PO4, TP and chlorophyll a

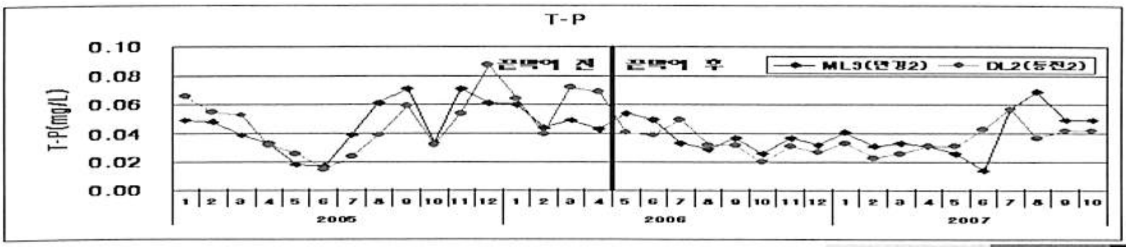


2. Measures on water quality conservation

- Variation of water quality in lake area





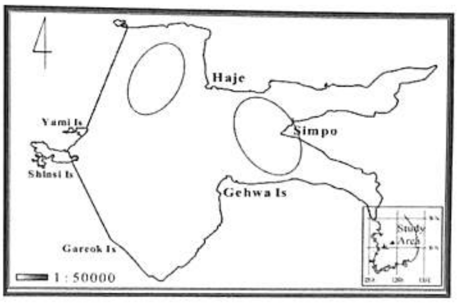


2. Measures on water quality conservation

Prevention lake area from red tide

Red tide in lake area

- Expected period
  - Apr.–Jun., Sep.–Oct.
- Location : Estuarine and retardation zone (near Simpo)
- Species : Harmful–dinophyte, diatoms



Countermeasure

Prevention
- Monitoring
- Inflow of seawater

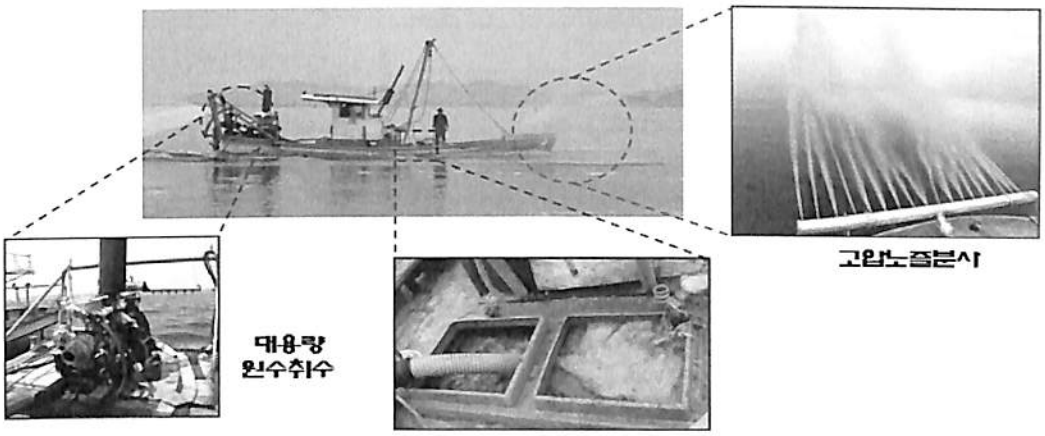
Decision making
- Location, harmful
- Construction procedure

Action
- Gate operation
- Sand application

2. Measures on water quality conservation

Application practice

- Purpose : Practice for instant application of yellow earth when red tide generated
- Using a ship to load yellow earth application system



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2. Measures on water quality conservation

Prevention from oil contaminati

Reserve for emergency

- Figures
  - Oil fence: 20 pack (400m)
  - Absorbing paper: 100 box
  - Chemical: 1,000L
- Reserving region: 2 areas
  - Garyuk gate region
  - Simpo region


<Garyuk gate region>


<Simpo region>

Application practice

- Practice according to expected scenarios

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2. Measures on water quality conservation

Water quality management system

Water quality management system

- DB management
  - System install
  - Program install
- Modeling system
  - Program install
- Decision making
  - Install model program

Maintenance for monitoring system	Pollutant source management Management of water quality data	Integrating water quality simulation model	Decision Support Syste

2. Measures on water quality conservation

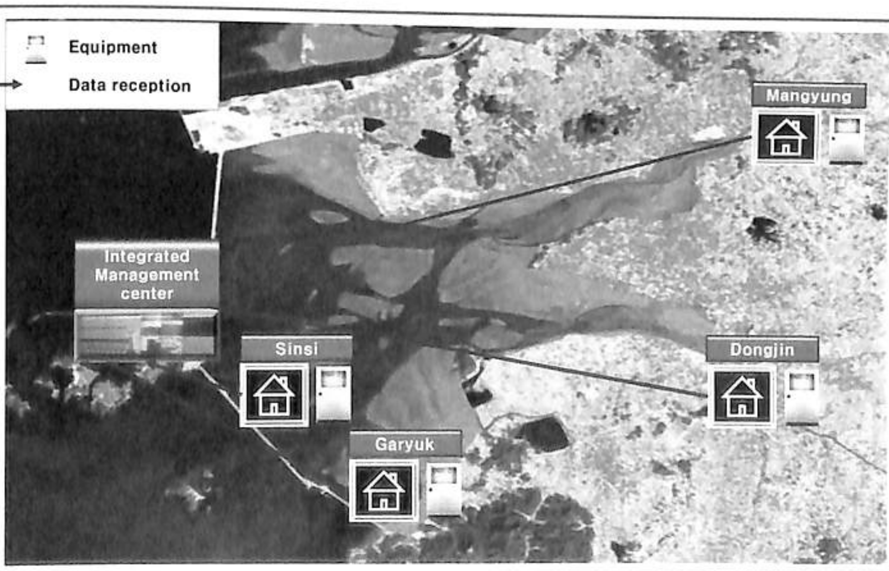
Automated water quality monitoring

- Water quality monitoring on real-time (Hourly data acquisition)
- Providing data to water quality simulation model

Water quality parameters

Sinsi/Garyuk	Mangyung/Dongjin
Simple kit COD T-N T-P	Simple kit COD BOD T-N T-P

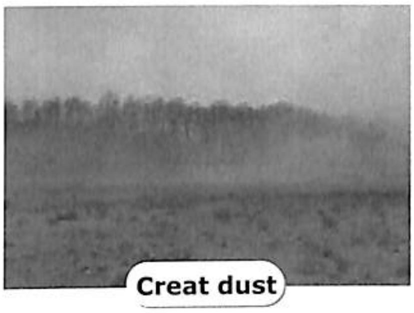
Automatic measurement system



2. Measures on water quality conservation

Reduction of fly dust by plantation

- Fly dust



Creat dust

Near plant

- Reduction by plant

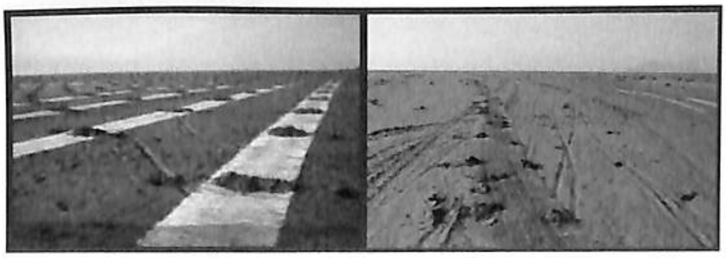
1 plant

1 Row

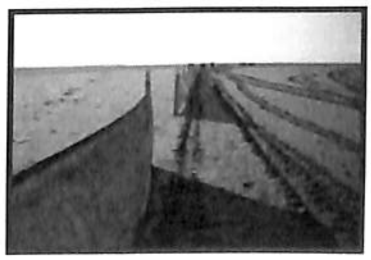
군락지

2. Measures on water quality conservation

☐ Winter measures by facility setup ('06~'07)

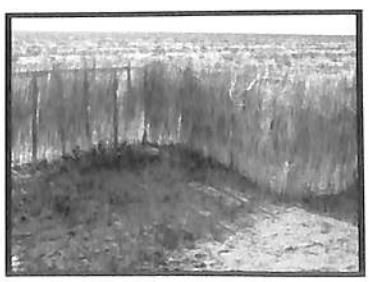


Surface covering 3ha



Net 3km

Protection fence 2km



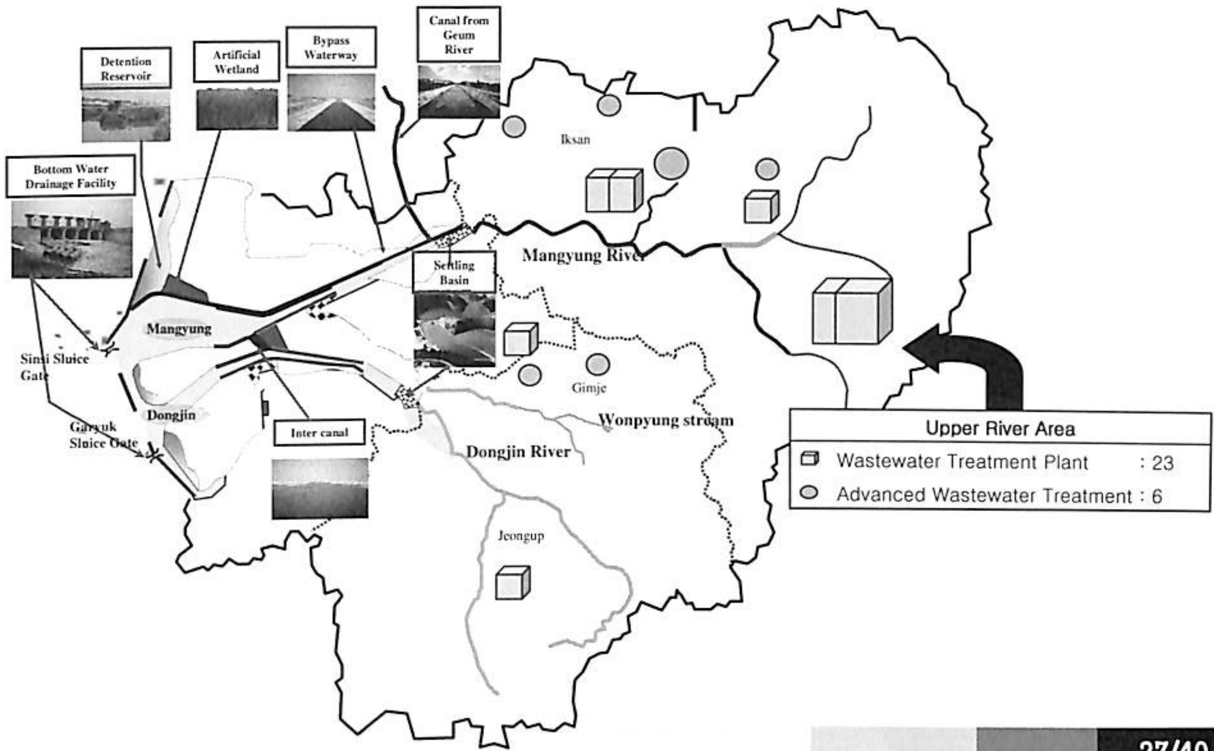
Fence for sand 1km

3. Water quality improvement plan

3.1 Measures on water quality improvement

Item	Facility	Details	Admin.
Upper River area	Wastewater treatment plant	23 (213,000㎥/day)	Env. ministry and Local gov.
	Advanced wastewater treatment	6	
	Sewage pipe	2,820km	
	Treatment of livestock waste	Disposal facility : 315 Compost facility : 622	Agriculture ministry
Lake area	Bypass waterway, Inter Canal between two lake area, Artificial wetlands, Wastewater Treatment Plants, Detention ponds, Canal from Geum River, Artificial Water Plant Island, Bottom Water Drain Facilities		Agriculture ministry
Marine area	Sea water monitoring Protection of red tide Automated Water Quality Sampling Setup of Geographic Information System for sea water management		Marine ministry

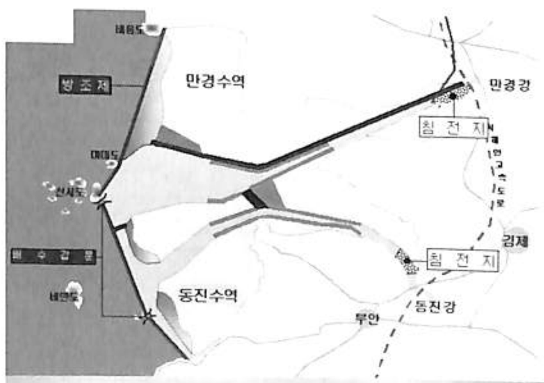
3.2 Outline of measures



3.3 Water quality improvement facilities

Settling basin

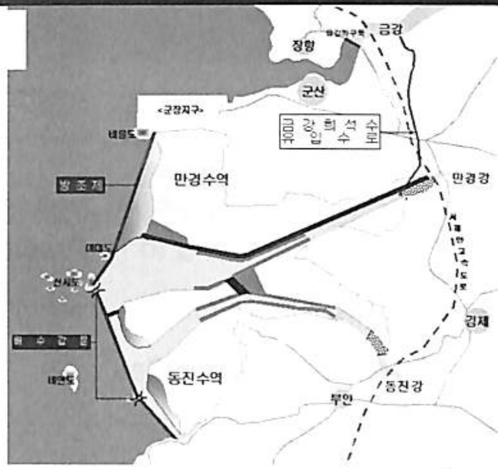
- Purpose
  - ❖ Settling of sediments to reduce nutrients flowed from upper rivers
- Mangyung Settling Basin
  - ❖ Location : 0.5km ~ 4.0km up from Mangyung Bridge
  - ❖ Width 400m, Depth 5m, Length 3.5km
  - ❖ Detention time : 4.2 days
- Dongjin Settling Basin
  - ❖ Location : 0.5km ~ 4.0km up from Dongjin Bridge
  - ❖ Width 300m, Depth 5m, Length 3.5km
  - ❖ Detention time : 5.4 days



3.3 Water quality improvement facilities

Canal from Geum-gang Lake

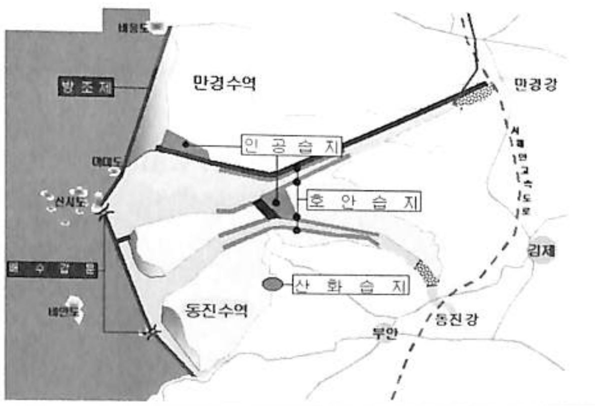
- **Purpose**
  - ❖ To introduce clean water from Geum River to dilute polluted water of Saemangeum Lake
- **Location**
  - ❖ Geum River ~ Mangyung River outlet
  - ❖ Canal : Length 14.2㎞, Width 14.4m,
  - ❖ Flow rate : 520,000,000㎥/yr
  - ❖ Canal capacity : 20㎥/s



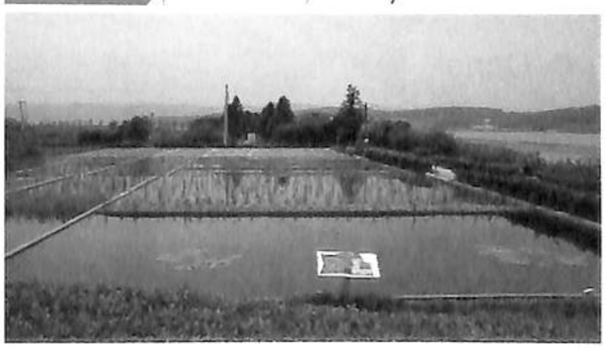
3.3 Water quality improvement facilities

Artificial wetlands

- **Purpose**
  - ❖ To improve water quality of upstream river before entering to Saemangeum Lake
  - ❖ To create habitats for wild animals and plants
- **Wetland : 5 places, 1,090ha**



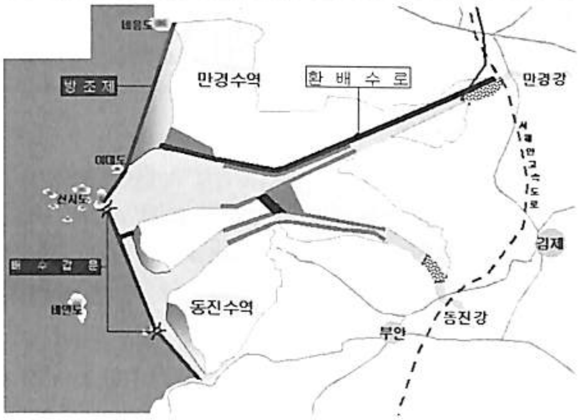
Classification	Location	Facility area (ha)	Plant area (ha)
Total		1,090	849
Wetland on reclaimed area	Mangyung Area	400	280
	Dongjin Area	200	140
Lakeshore wetland	Mangyung Area	270	243
	Dongjin Area	180	162
Oxidation pond	Gyehwa	40	24



3.3 Water quality improvement facilities

Bypass waterway

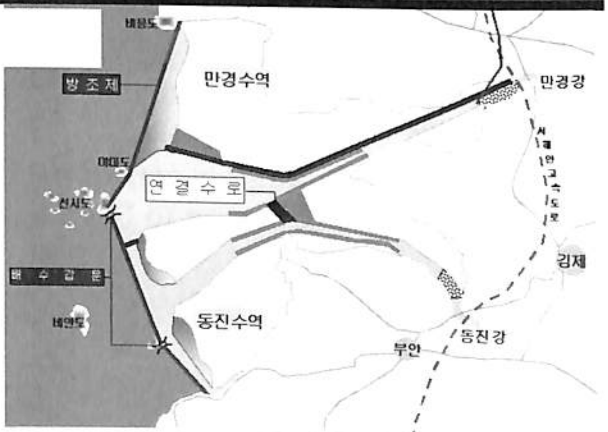
- **Purpose**
  - ❖ Discharge polluted water from Mangyung River into sea side directly without entering to freshwater lake
- **Location**
  - ❖ Settling Basin ~ Sea dyke
- **Bypass Waterway**
  - ❖ Length : 28.0km
  - ❖ Flow rate : 11.0m³/s(Max. 30.0m³/s)



3.3 Water quality improvement facilities

Inter canal

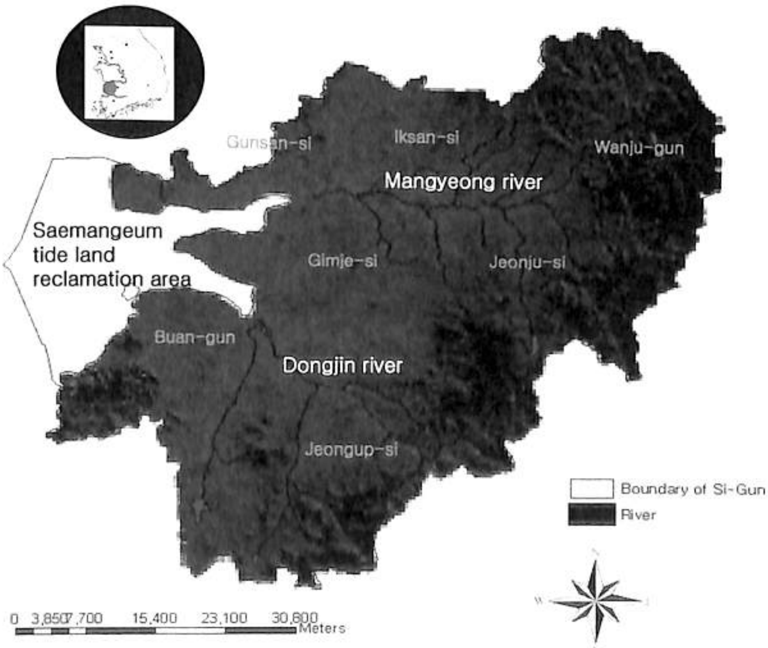
- **Purpose**
  - ❖ To introduce clean water of Dongin area into polluted water on Mangyung area
- **Location**
  - ❖ Mangyung Lake area – Dongjin Lake area
- **Canal**
  - ❖ Width : 14m
  - ❖ Depth : 4m
  - ❖ Length : 3km



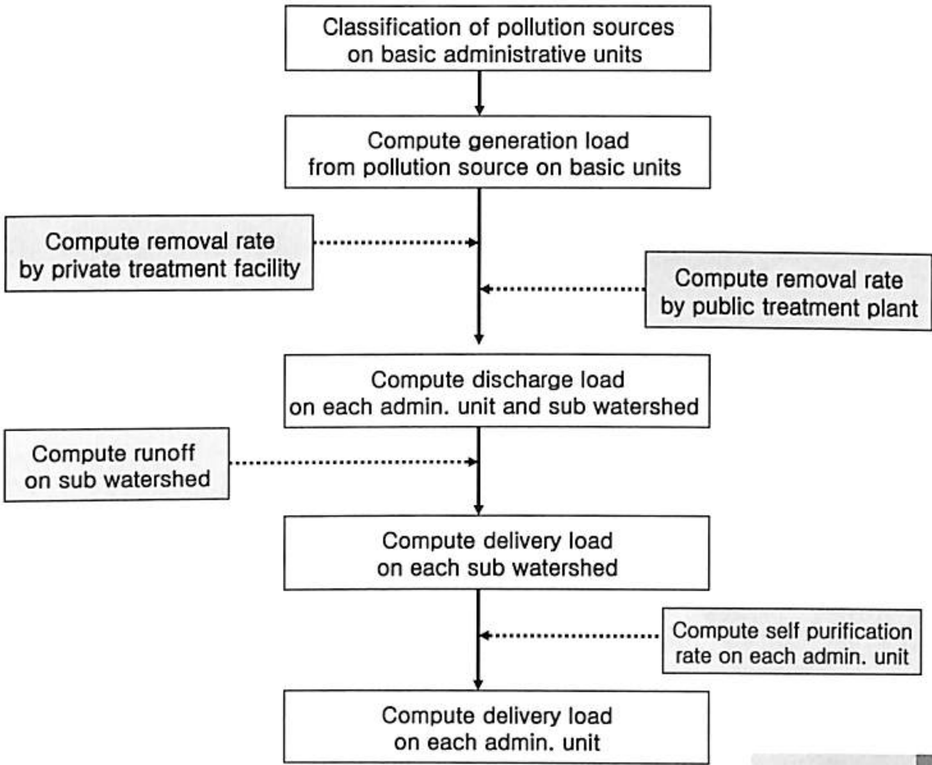
4. Water quality prediction on future lake

4.1 Saemangeum Watershed

- Saemangeum Watershed
  - Watershed area : 3,319km²
  - Reclaimed area : 401km²
  - Main River : Mangyung River and Dongjin River

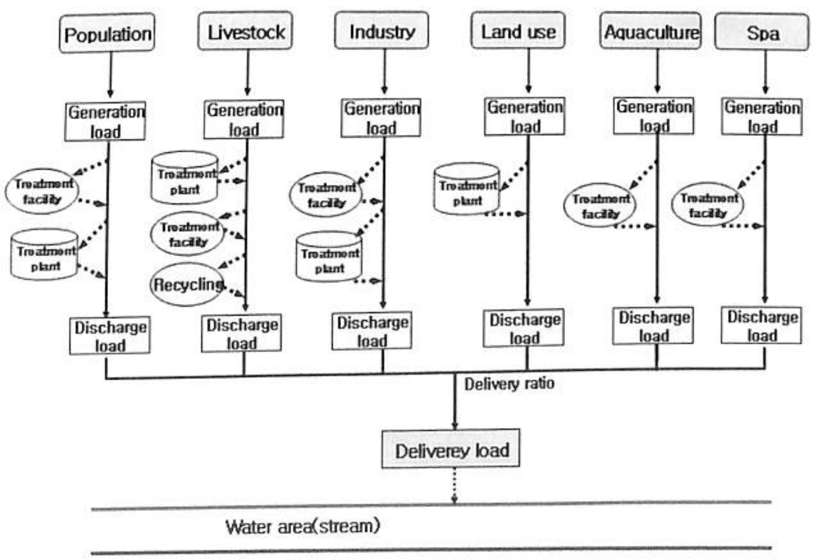


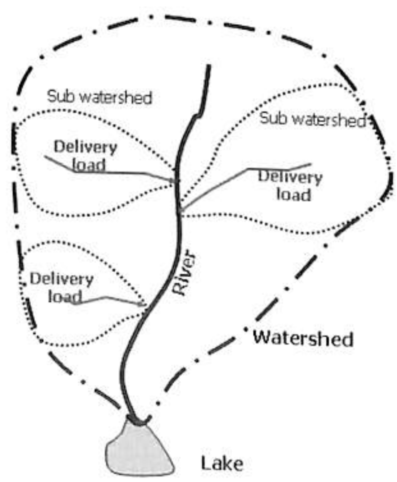
4.2 Pollutant load calculation



4.2 Pollutant load calculation

Procedure for loads calculation

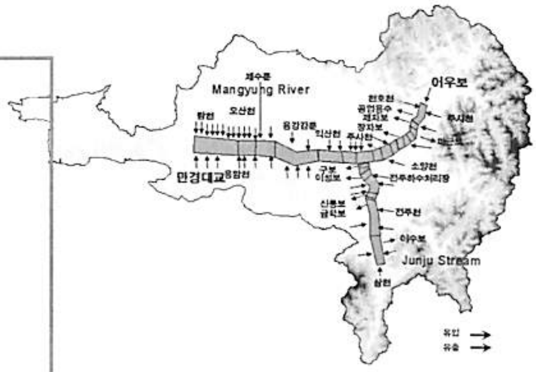




4.3 Prediction of water quality

River

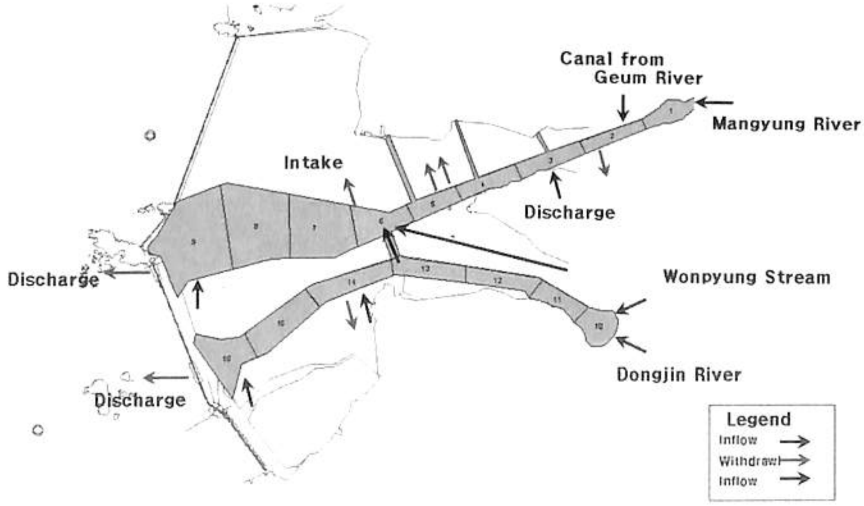
- Model : QUALKO
  - ❖ Modified QUAL2E model
- Prediction for each 3 river
  - ❖ Mangyung River, Dongjin River and Wonpyung Stream
- Monthly base simulation (1−12)



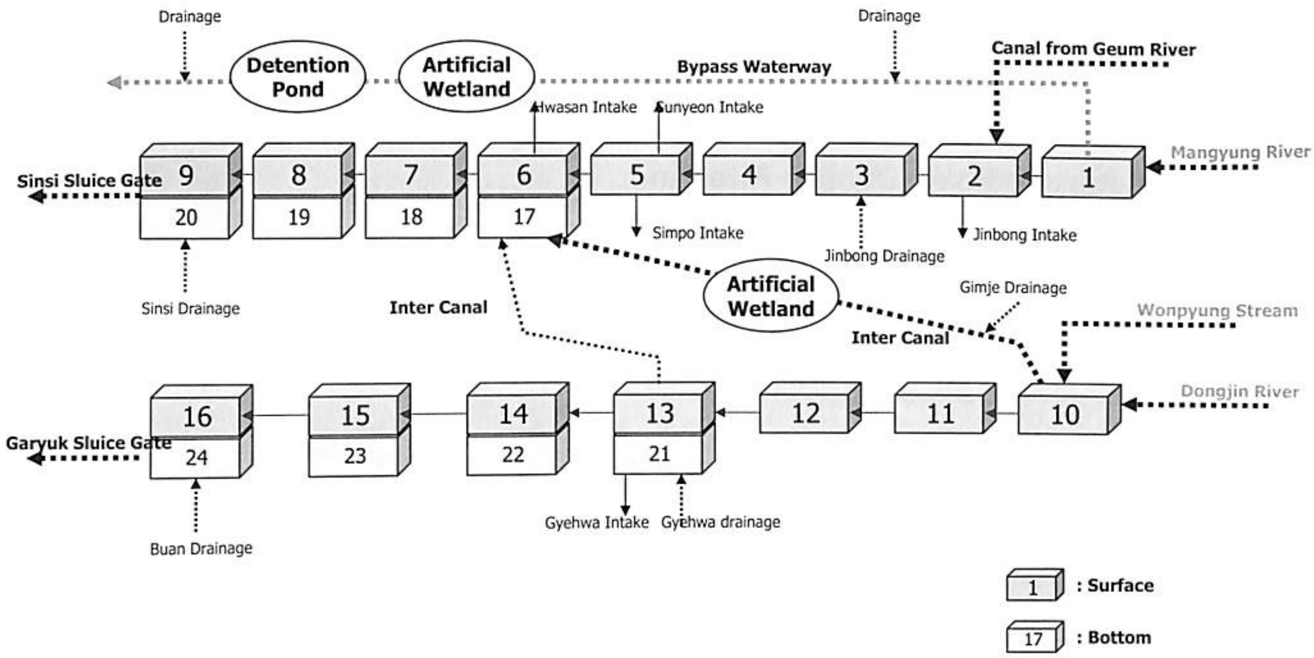
4.3 Prediction of water quality

Lake

- Model : WASP5
  - ❖ DYNHYD5(hydrodynamics) + EUTRO5(water quality)



4.3 Prediction of water quality

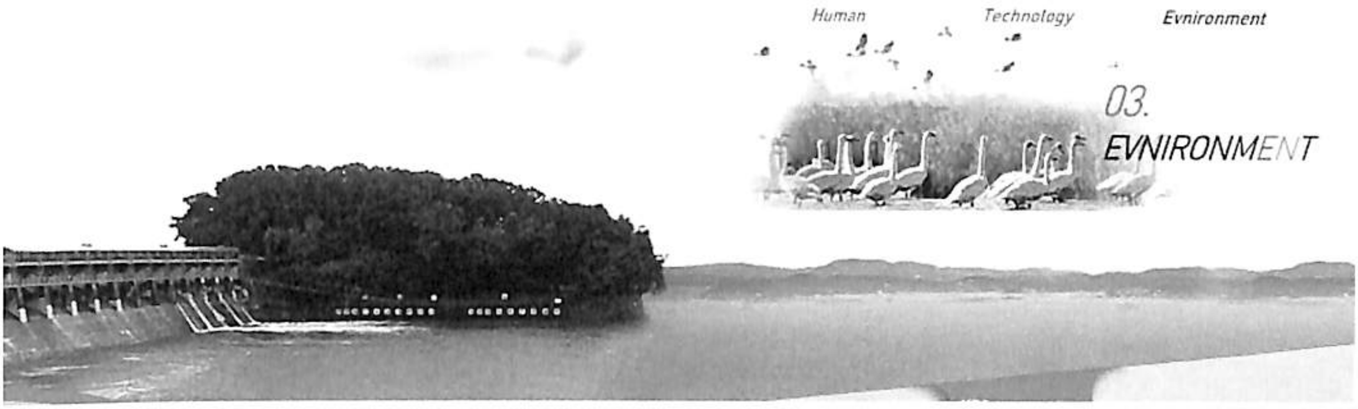


4.3 Prediction of water quality

Variable	Unit	Standard level	Predicted Value	
			Mangyung Lake area	Dongjin Lake area
COD	mg/L	Under 8	5.5	3.8
T−N	mg/L	Under 1.0	3.44	2.33
T−P	mg/L	Under 0.100	0.103	0.070
Chl−a	µg/kg	−	38.8	25.9

Thank you for your kind attentions

KRC is a public enterprise that carries out a rural improvement project, manages overall rural infrastructures, increases agricultural productivity by promoting the optimization of farming scale, and contributes to the economical and social development of rural areas



The Water Managemenrt using GIS

utilisato des coord géographique dans le management de l'EAU.

OK.

Mr. Kim, Dong-in

Deputy Director

KRC

Rural and Agricultural Water Management using GIS

September, 2009

Mr. Kim Dong In P.E

Contents

1 What is RAWRIS?

2 Background and Objective of RAWIS

3 Status and Characteristics of Using Water Resources

4 Status and Characteristics of Using Water Resources

5 System Architecture

6 Vision and Strategy

7 Status of RAWRIS

8 Main functionalities of RAWRIS

9 Plans for Practical Use

1. What is RAWRIS?

- Rural & Agricultural Water Resource Information System (http://rawris.ekr.or.kr)

- A System to support agricultural water resource management across all of Korea's water zones including administrative districts, to estimate demand and supply of agricultural water such as livestock water and to develop plans for needed water resource

- Allow government officials to promptly and accurately handle spatial information of facilities like reservoir, pumping station and weir having location, irrigated area, irrigating canal and notes for management, to plan supply for water resource, to control real-time water level and to manage information for water rate

2. Background and Objective of RAWRIS

Background

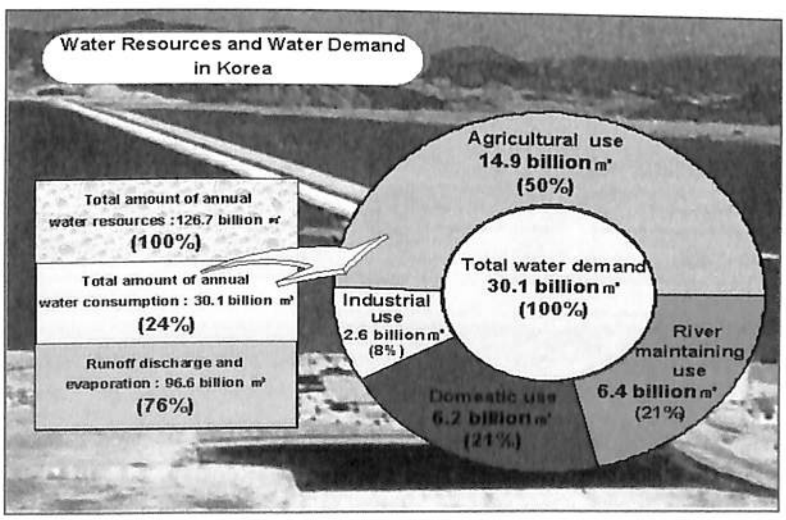
- Raising need to prepare frequent drought by an unusual change in the weather and increasing demand for agricultural water
  - Increasing demand for living and industry water by improved living environment in agriculture area as well as increasing income
  - Increasing demand for agricultural water with developing agriculture method like direct sowing cultivation
- Increasing water pollution in agriculture area by industrialization
- Efficient use for limited water resource

Objective

- Develop the basis for water management along with national water management information system
- Allow Rational use for water resource and improving water quality
- Prevent multiple investment through steps of water management information

3. Status and Features of Using Water Resources

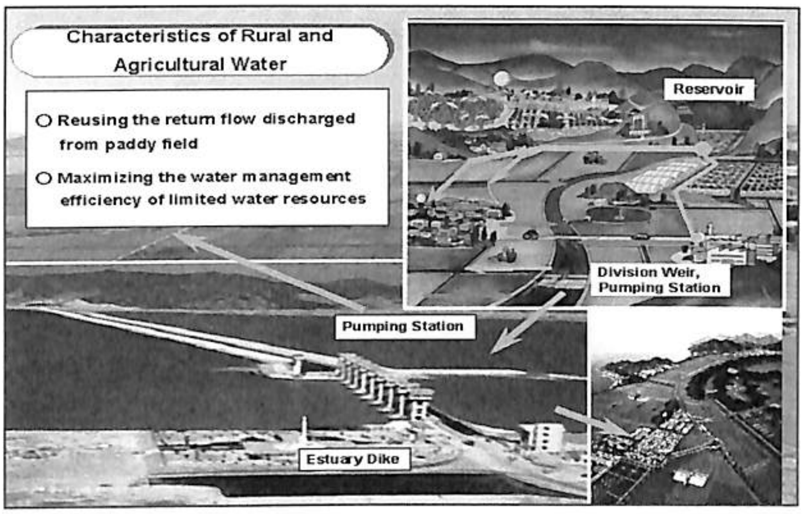
Status of Using Water Resource in Korea



Characteristics of Agriculture Water

Characteristics of Rural and Agricultural Water

- Reusing the return flow discharged from paddy field
- Maximizing the water management efficiency of limited water resources



4. Plans of National Water Management Information System

A basic guide of the information oriented National Water Management on Dec. 1999

- Building web-based integration system for water quality, water level and agricultural water information in Ministry of Construction & Transportation, Ministry of Environment, Ministry of agriculture and forestry, each ministry is able to share the information and provide water information to users

National Water Management Information System Architecture

Ministry of Construction & Transportatic (Korea Water Resource Co.)	Ministry of Environment (Korea Environment Institute)	Ministry of agriculture and forestry (Korea Rural Community & Agriculture Corporation)
System for water Level	System for water quality	System for agriculture water

Water Management Information Networking System (MOCT)

Share

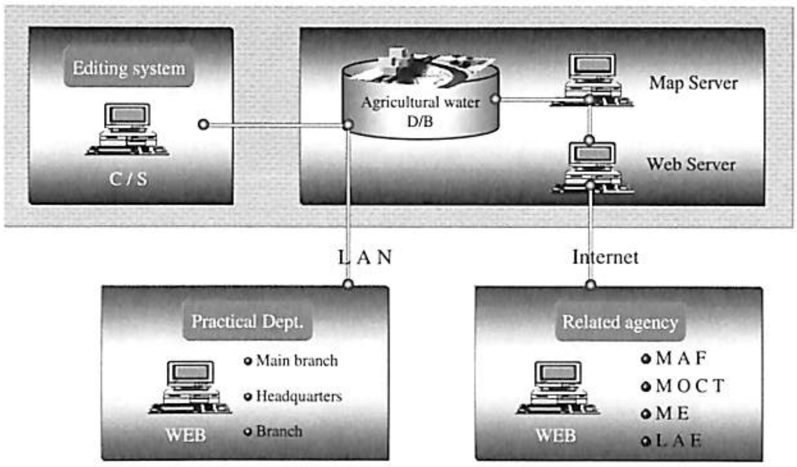
MOCT | ME | NEMA

Internet

- General agency
- Local government
- General users

5. System Architecture

- System architecture forming 3tire structure as C/S-GIS and WEB-GIS uses



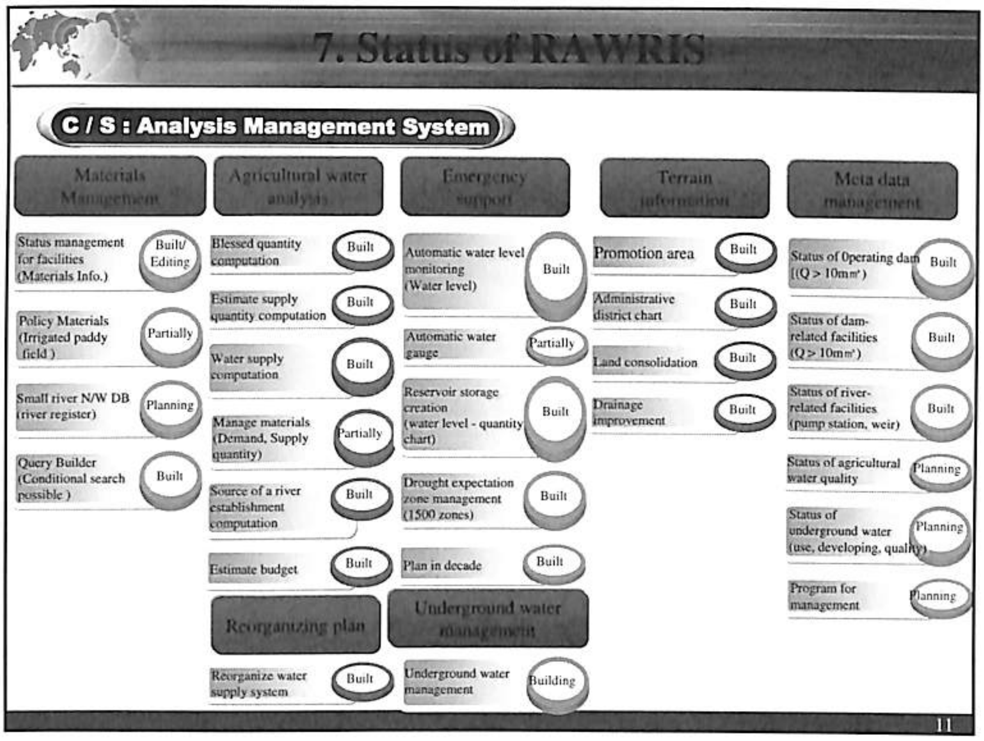
6. Vision and Strategy

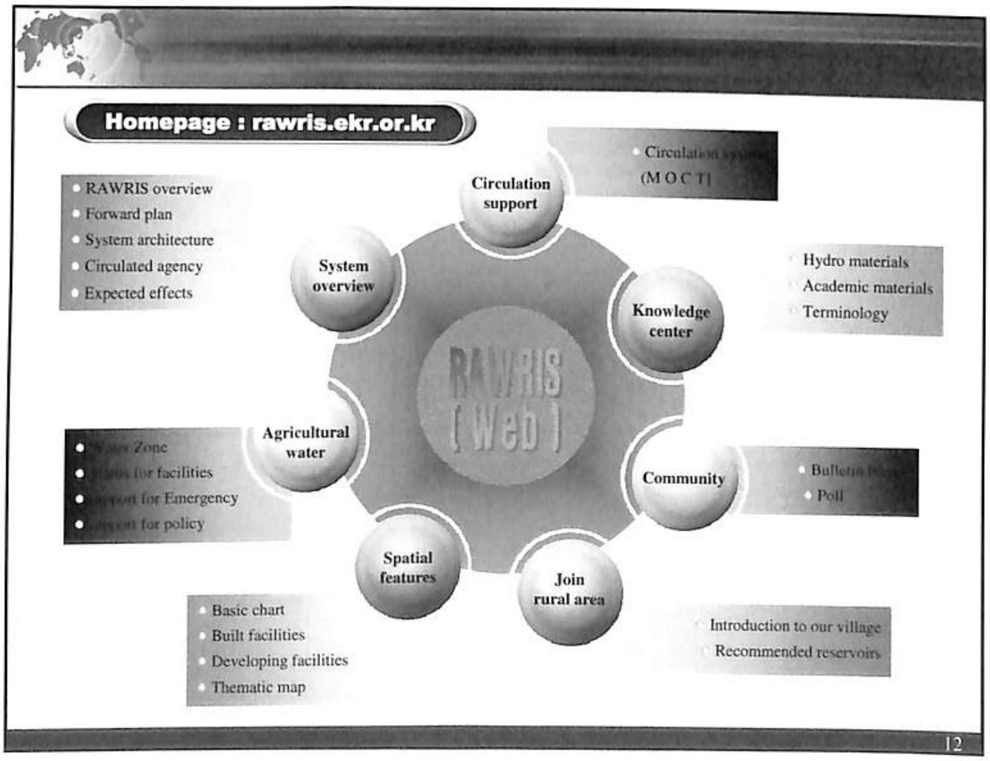
- **Vision of agricultural water resource information system**

Build agricultural water resource information system for rational development,
Use and conservation of water resource,
coming to insufficient water resource.

- **The forwarding strategy**

- Organize data groups of agriculture water management information
- Estimate demand for scientific and systematic agriculture water management information
- Build a system which leads to share information between agencies
- Build a system providing information service to farmers

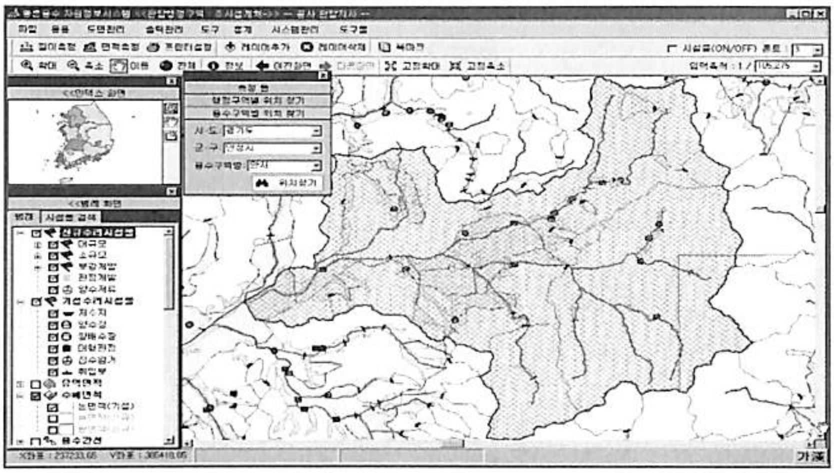

7. Status of RAWRIS
C / S : Analysis Management System
Materials Management
Status management for facilities (Materials Info.)
Built/ Editing
Policy Materials (Irrigated paddy field)
Partially
Small river N/W DB (river register)
Planning
Query Builder (Conditional search possible)
Built
Agricultural water analysis
Blessed quantity computation
Built
Estimate supply quantity computation
Built
Water supply computation
Built
Manage materials (Demand, Supply quantity)
Partially
Source of a river establishment computation
Built
Estimate budget
Built
Reorganizing plan
Reorganize water supply system
Built
Emergency support
Automatic water level monitoring (Water level)
Built
Automatic water gauge
Partially
Reservoir storage creation (water level - quantity chart)
Built
Drought expectation zone management (1500 zones)
Built
Plan in decade
Built
Underground water management
Underground water management
Building
Terrain information
Promotion area
Built
Administrative district chart
Built
Land consolidation
Built
Drainage improvement
Built
Meta data management
Status of Operating dam [(Q > 10mm')
Built
Status of dam-related facilities (Q > 10mm')
Built
Status of river-related facilities (pump station, weir)
Built
Status of agricultural water quality
Planning
Status of underground water (use, developing, quality)
Planning
Program for management
Planning
11


Homepage : rawris.ekr.or.kr
RAWRIS (Web)
System overview
RAWRIS overview
Forward plan
System architecture
Circulated agency
Expected effects
Circulation support
(M O C T)
Knowledge center
Hydro materials
Academic materials
Terminology
Community
Poll
Join rural area
Introduction to our village
Recommended reservoirs
Spatial features
Basic chart
Built facilities
Developing facilities
Thematic map
Agricultural water
for facilities
for Emergency
for policy
12

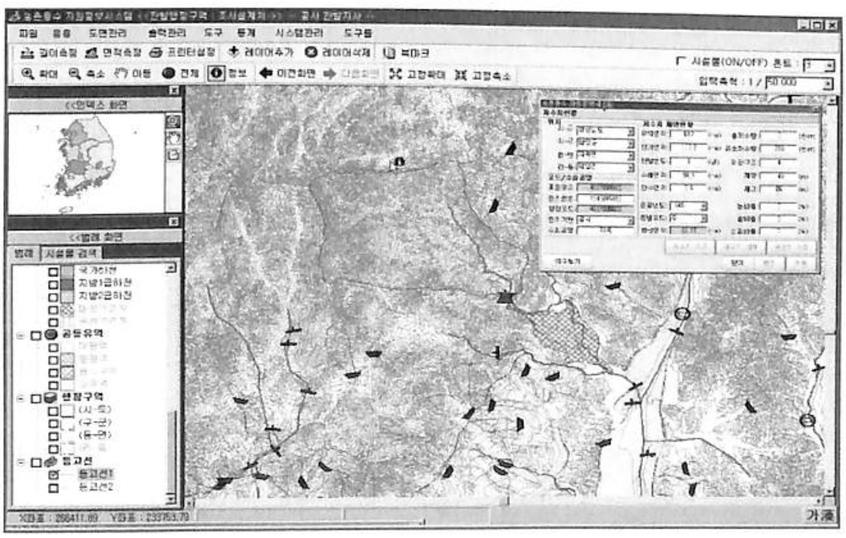
8. Main functionalities of RAWRIS

Information search function for materials

- Search for all of Korea's 464 agricultural water zones



- Status search of built reservoir within water zone



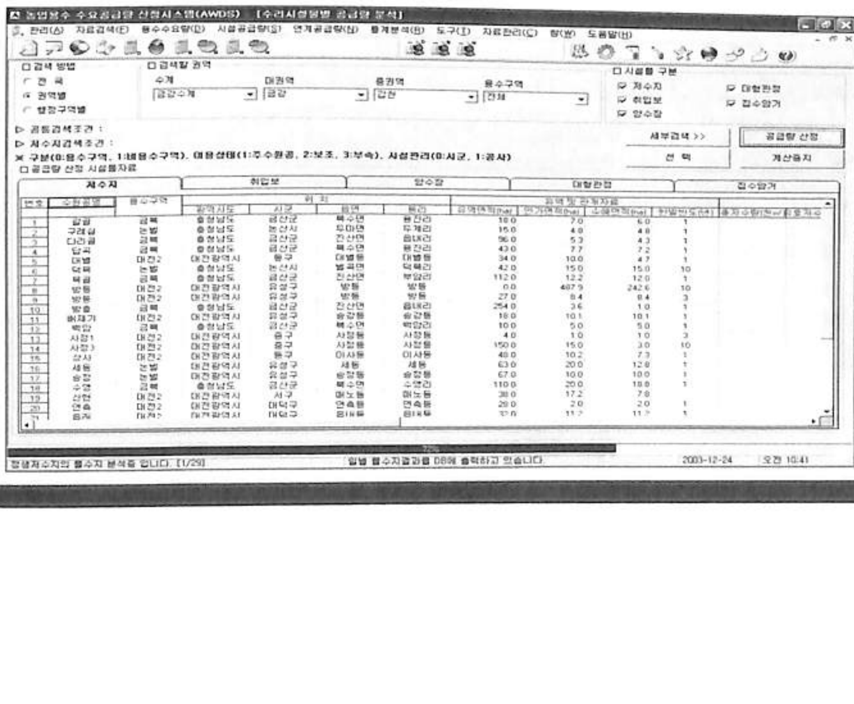
Search for`developing new reservoir plan within water zone

Search for production-based infrastructure like farmland consolidation, drainage improvement and agriculture promotion area

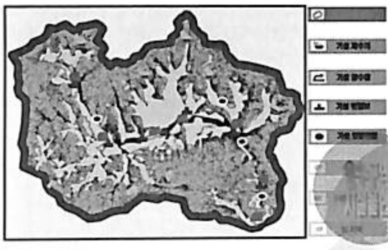
- River information search for river improvement plan and preparing emergency by an unusual change in the weather

Agricultural water analysis function

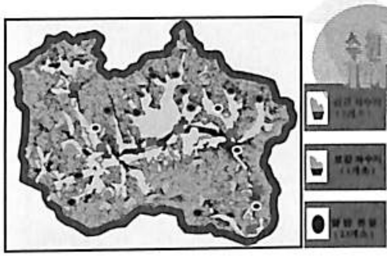
- Estimating blessed quantity, demand, supply and insufficient quantity within all water zones



Using of a development scenario planning



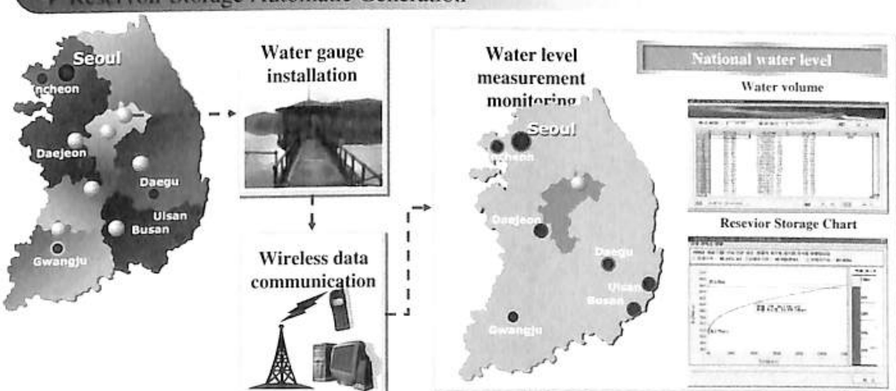
수원공	개수	총공급량	농업용수		공업용수		생활용수	
			수혜면적	공급량	면적	공급량	인구	공급량
계	302	백만㎥/년 31	ha 4,165	백만㎥/년 29	ha 10	백만㎥/년 1	인 12,455	백만㎥/년 1
저수지	158	22	3,219	22				
양수장	78	2	22	1			12,455	1
[illegible]	102	6	924	6				
관정	4	1			10	1		



[illegible]	공급대상	수요량	기공급수량	공급계획수량
[illegible]		68 백만㎥	31 백만㎥	37 백만㎥
농업용수 답 전	5,970 ha 5,202 ha 768 ha	54 50 4	29 29 -	25 21 4
생활용수	44,482 인	5	2	3
공업용수	24 ha	3	-	3
축산용수	43,796 두	1	-	1
하천유지용수		5	-	5

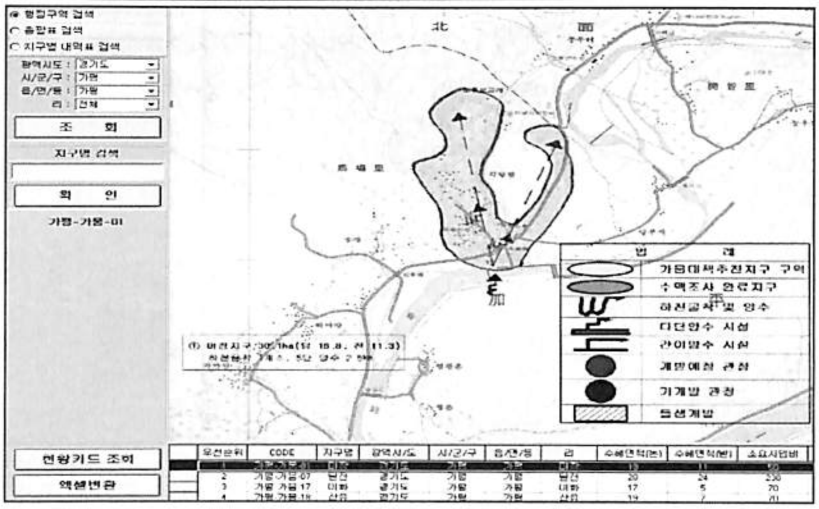
Response

- Automation of water level measurement
  : Real time search for water level, water rate and water volume of reservoir
- Automatic water gauge installation Project
  : Reservoir having valid water volume over 10 Million ㎥
- Reservoir Storage Automatic Generation



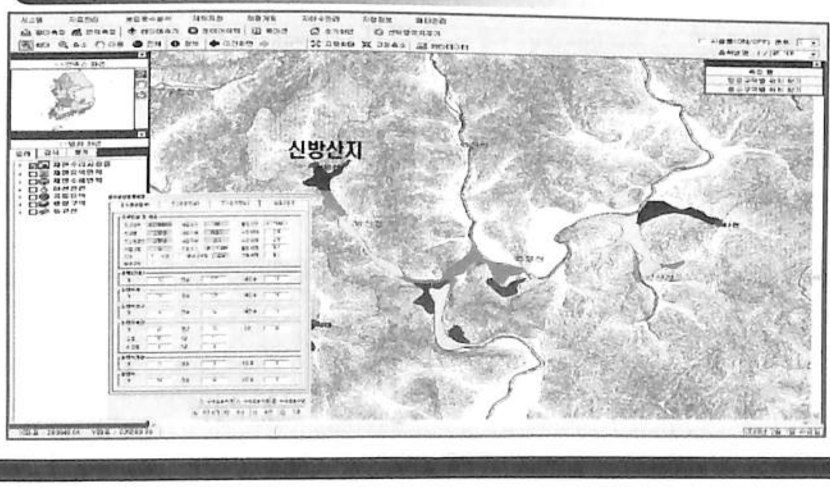
Management of a drought expectation zone

Short term drought preparedness for 1,500 district



Analysis function of agricultural water re-utilization system

- After investigating all the conditions on water resource for rural water sectors, 464, then we maximize the usage efficiency of water resource with re-establishment of water supply system by re-developing preexistent facility and equipment

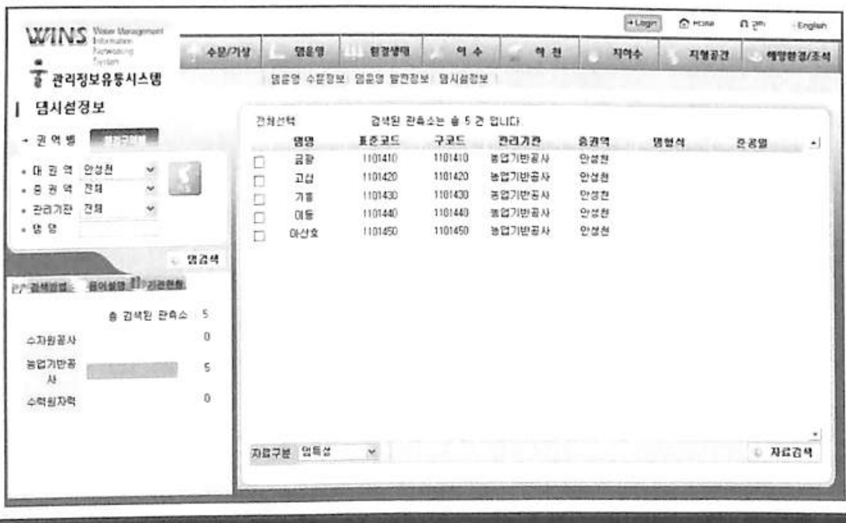


Linking to underground water management system

- Water vein , Management for underground water of rural area on the web

Provided Meta data

- Water-storage dam, River facility, and Underground water data



The web page of RAWRIS

URL – http://rawris.ekr.or.kr

9. Plans for practical Use

- Formulate the basis of scientific and organized water management system

Korea Rural Community & Agriculture Corporation
Departure

Technical support for rural business

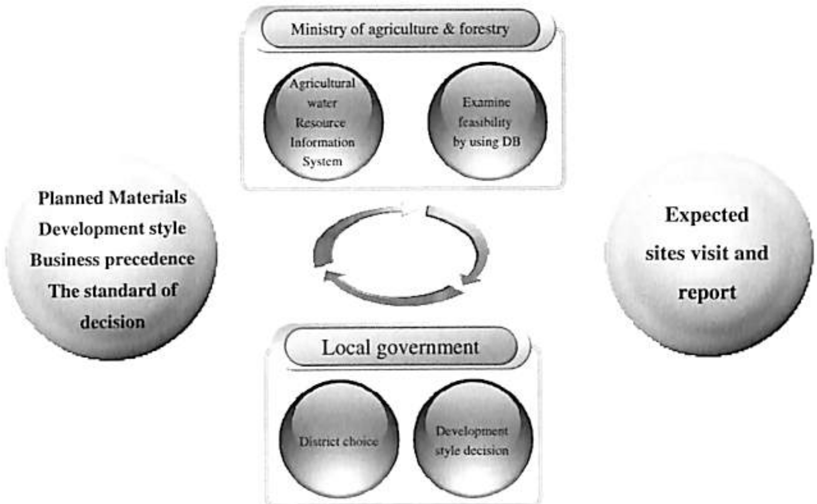
Maintenance & Management of agricultural production facilities

→ Korea Rural Community & Agriculture Corporation

Professional human resources for tech support
and site experiences can make scientific
and organized water management

➡ Provide farm workers higher quality service

- Make and forward a plan for production basis maintenance business



- Information sharing between organizations in order to prevent multiple investment fulfill public rights to know.
  (Status of facilities, irrigation district, water rate information and etc)

- Develop and expand to a rural maintenance information and use that to devise comprehensive rural development plan and facilities maintenance management.

- Have a good grip of the status of agricultural water supply per irrigational districts, per administrative districts. After that, build optimized agricultural water development plan & preparation for drought.

Thank you very much!

orient1211@hanmail.net